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Water movements in the central part of the Norwegian Sea based on recent material.

by

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The material which here is studied originate in a cruise of "G.O.Sars" carried out in March this year. The field of investigation was the central part of the Norwegian Sea including the banks off Lofoten - Vesterålen and the Vestfjord.

From erlier investigations, especially in 1954 and in the International Geophysical Year we know that the currents in the deeper part in this area are complicated. As oceanographic observations taken during wintertime is relatively scarce in the western part of the area, we planned to get material with reasonable distance between the sections and the stations so that it could be suitable for dynamic calculations and also allow to study the water exchange between the Vestfjord and the open sea, and how oceanographic conditions might influence the fisheries which were going on in the Vestfjord and on the banks.

Observations in the standard depths between surface and bottom were taken at 102 full stations of which 28 to depths between 2000 and 3100 meter. In addition a bathythermograph and a sea surface thermograph were operated. At an ancerstation direct current measurements and observations of temperature and salinity for internal wave studies were made.

The samples for determination of oxygen and phosphate were analysed on board. The salinity samples (2186) were analysed at the Institute. A double set of 300 samples were analysed on board and for the sake

of control also at the Institute with 2 different salinometers. All together 3137 samples were taken.
Conserning the dynamic treatment we have had good help of an electronic calculation machine which also has listed the material. As the main sections which reached maximum 275 nautical miles of the coast were completed in 7 days only, and in fair weather, the material should be suitable for synoptic studies.

The net of stations is seen in fig. 1. Open circle is full station, a dot in a circle repeated station, X is bathystation only, and a cross in a circle is ancerstation.

From the surface temperature chart (Fig. 3.) will be seen that the maximum temperature between 6 1/2° and 7° is found above and near the slope. The current towards north-east has here maximum speed which will be seen from the surface current chart. The strong temperature gradient in the north-western part is due to the fact that the iceborder was not far away. The temperature gradient is also strong in the outer part of the Vestfjord and near the coast off Lofoten and Vesterålen, just in that area, where a good herring fishery then took place. In the central area the isotherms form tounges which could indicate that cold water from north divide the warm water flow from the south in two main branches. The salinity here is relatively uniform, the dynamic of the system demand that the streamlines rather will follow the contour of the tounges. The surface current chart relative to 2000 db (Fig. 15) will show that this is the case. Also the temperature chart in 125 meters (Fig. 4) shows the tounge shape of the isotherms more clearly. This is also clear in 500 m depths (Fig. 5). Just off the slope there is a very strong temperature gradient in this depth.

In a relatively narrow area the temperature is below 2°C while it increases to 5° on both sides. As will be seen from the vertical sections it is due to an upwelling of cold and less saline water. According to the rule that the water of the lowest density must be found on the right hand side of the current in the Northern Hemishere the temperature gradient indicate strong current towards north-east along the slope and in the opposite direction on the western side of the temperature minimum. The salinity distribution (Fig. 6) reduce this to a certain degree. The salinity in the upwelling area has a minimum just as well as the temperature. Also the isohalines in this depth have the same toungeshaped form.

In the vertical sections the depth scale below 800 meters is of practical reasons one fourth only of that above. The Røst - section stretches over the mouth of the Vestfjord and in the direction towards Jan Mayen. The length is about 300 nautical miles. The most striking feature in this section is the upward bend of the isotherms just outside the edge but over the deeper part of the slope, and there is a minimum temperature in the whole watercolumn up to the surface Compared with the watercolumns on both sides (Fig. 7). The isohalines (Fig. 8) and the isosteres have a corresponding course. The isotherms from 1200 m - 3000 m have a slope towards east. And as the salinity is very uniform here it indicate current towards south - west which also the course of the isosteres ($10^5\Delta\alpha$) tells.

The current computation is made according to the Bjerknes' theorem of circulation in the special way showed by Helland - Hansen (1905). The reference depth is 3000 meters (3000 db). The solid lines show current component towards north - northeast and broken lines component towards south - southwest. As the sections are about right angel to the current direction there should be relatively small deviation from the resultant. Over the shelf and just outside the edge the direction of the current is towards north - northeast with a maximum speed of 28 cm per sec. in the surface decreasing to 20 cm per sec. in 300 m depths and to 6 cm per sec. in 600 m (Fig. 9). Over the deeper part of the slope the current is going in the opposite direction with a maximum speed of 26 cm per sec. decreasing to 16 cm per sec. in 500 m and to 1,2 cm per sec. in 1000 m depth. In the western part of the section the direction of the current is also towards south - southwest. Between the last 2 mentioned areas the direction is towards north-northeast except in a smaller area where the current is going to the south - southwest between 100 m and the bottom.

Also in the Gimsøy - section about 85 nautical miles farther to the north-east we find the same bend of the isotherms and the isohalines over the deeper part of the slope and we have here currents towards north - east and south - west(Fig. 10 - 11). The reference depth for current calculation of this and the Andenes - section (Fig. 12 - 14) is 2000 m.

Comparing the 3 current sections it will be seen that the eastgoing current over the edge and over the slope increases towards north-east with maximum speed of respectively 28,61 and 77 cm per sec. This is in good accordance with the fact that the shelf narrow towards north-east. In all 3 sections we will see that the current is going to the south-east in practical the whole watercolumn off the slope. Conserning the surface current this is in good agreement with the finding of the captain on board our researchship during the cruise. By help of the Lorang System of Navigation he got exact positions and could derive that the ship drifted towards southwest in this area. Also in other parts of the sections he made the same experience.

The current sections show that even in 500 and 600 meters depths the speed of current is considerable.

3 charts of the approximate currents at the surface, in 500 and 1000 m depths relative to 2000 m are given in Fig. 15 - 17. These figures show the geopotensial topography of the sea surface, the 500 db surface and the 1000 db surface relative to the 2000 db surface. Contour-lines are drawn for every dynamic cm (10^2 D) in figure 15 and 16 and for every o,5 dynamic cm in figure 17, except for an area in this last mentioned chart were the speed of the current is weak. There is only small differenses in the direction of the current in the surface and in 500 m depths. But the current is much stronger in the surface. In 1000 m depths the current is mainly going to the south-east just off the slope and brings cold artic water to the south. This is in good agreement with the results of the working up of the 1954 material and the IGY material from the Norwegian Sea which I have had the honour to speak about in this committee at an earlier opportunity. It has been showed that cold deep and bottom waters is flowing to the south off the Norwegian Continental Platform(Eggvin 1961).

The previous mentioned bend upward of the isohalines in the Røst- and Gimsøy-section may be due to the following: The cold deep and bottom water from the North turn against the deeper part of the slope, which here bend towards south-west, and is forced upward off the upper part of the slope, above 1400 m

Summary.

The movements toward south of water in parts of the Norwegian Sea is much more pronounced than what is usual anticipated. This seem to be the case not only conserning the deep- and bottom water but also water in the upper strata.

Literature.

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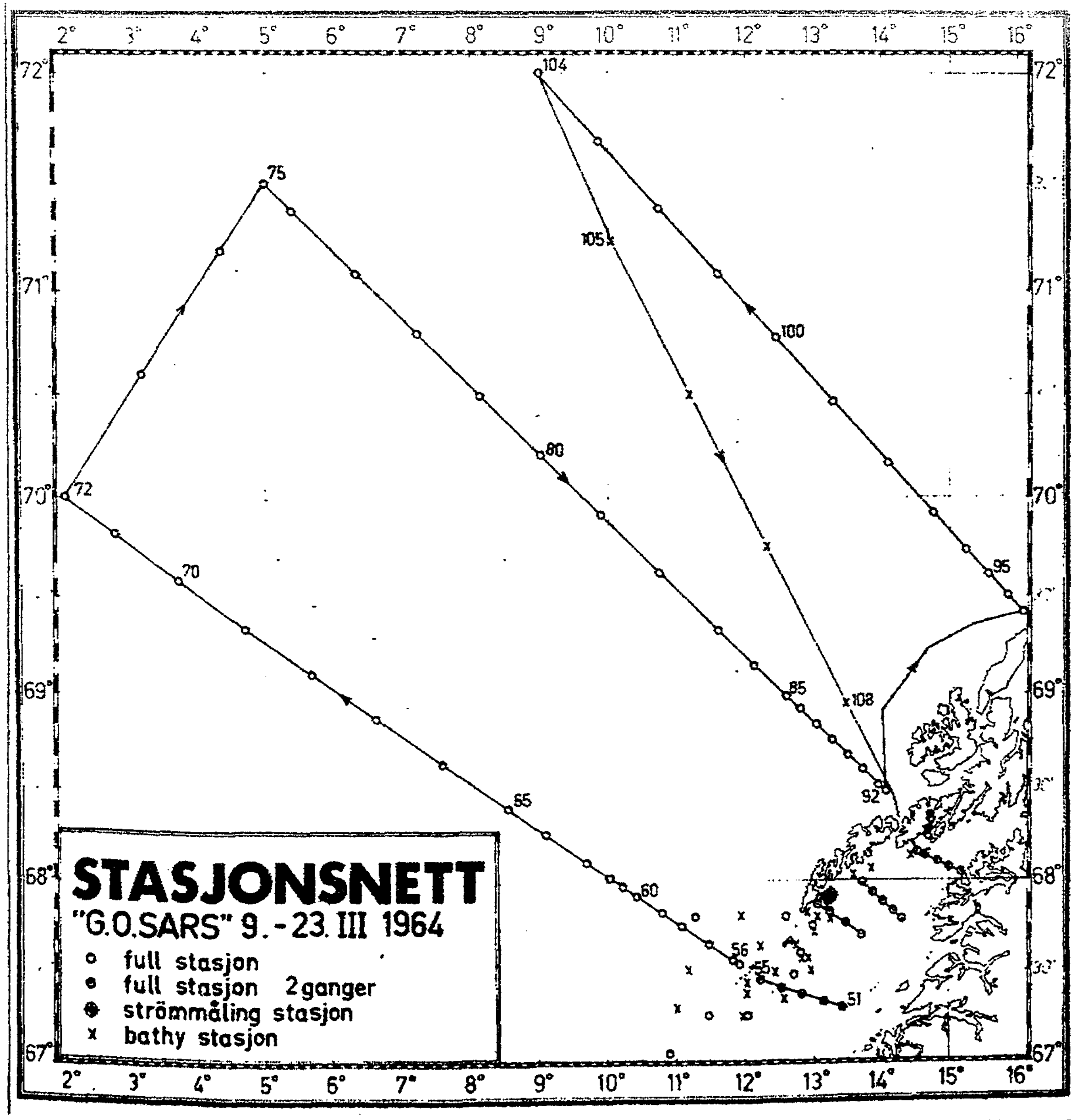

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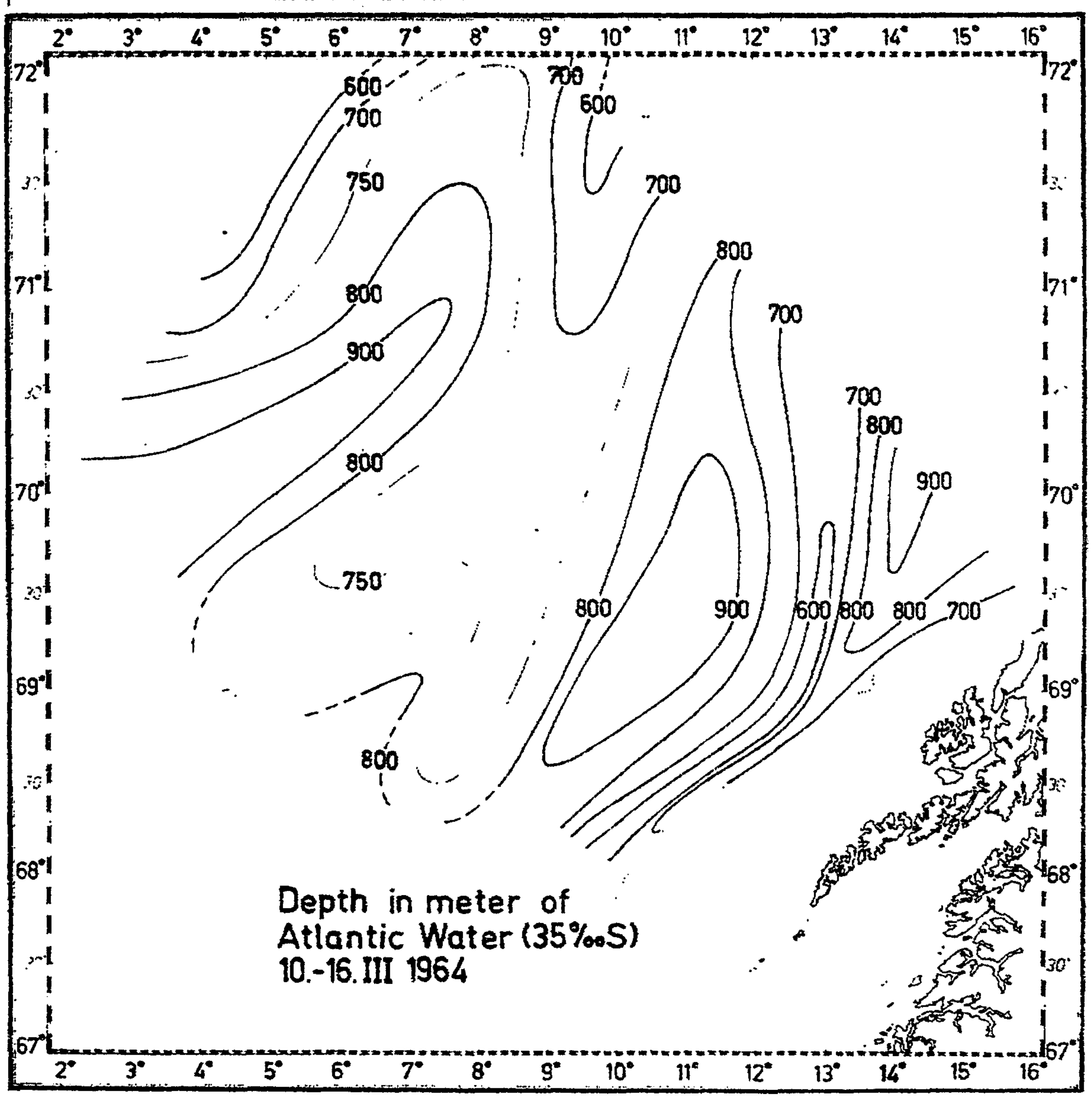

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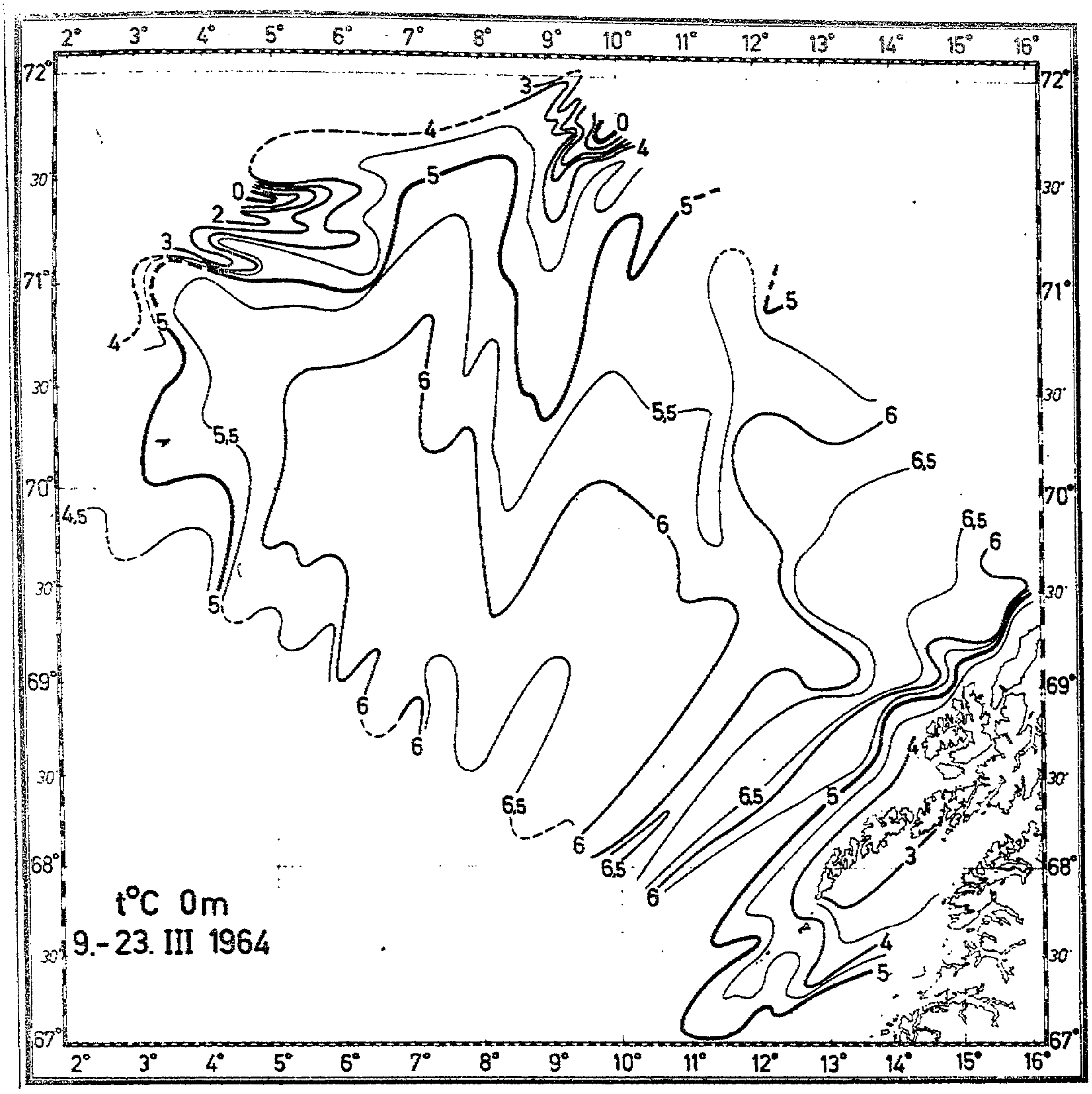

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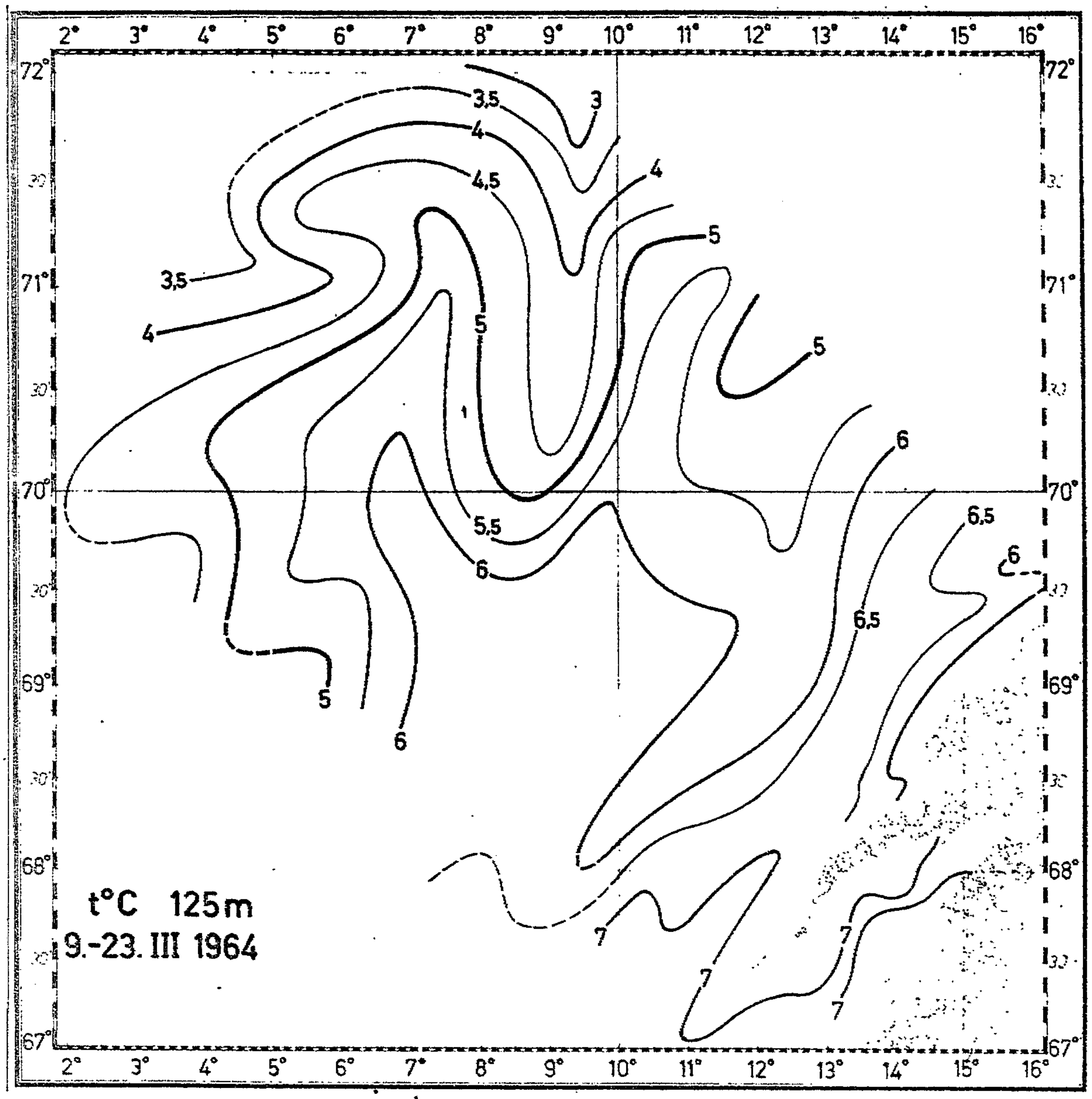

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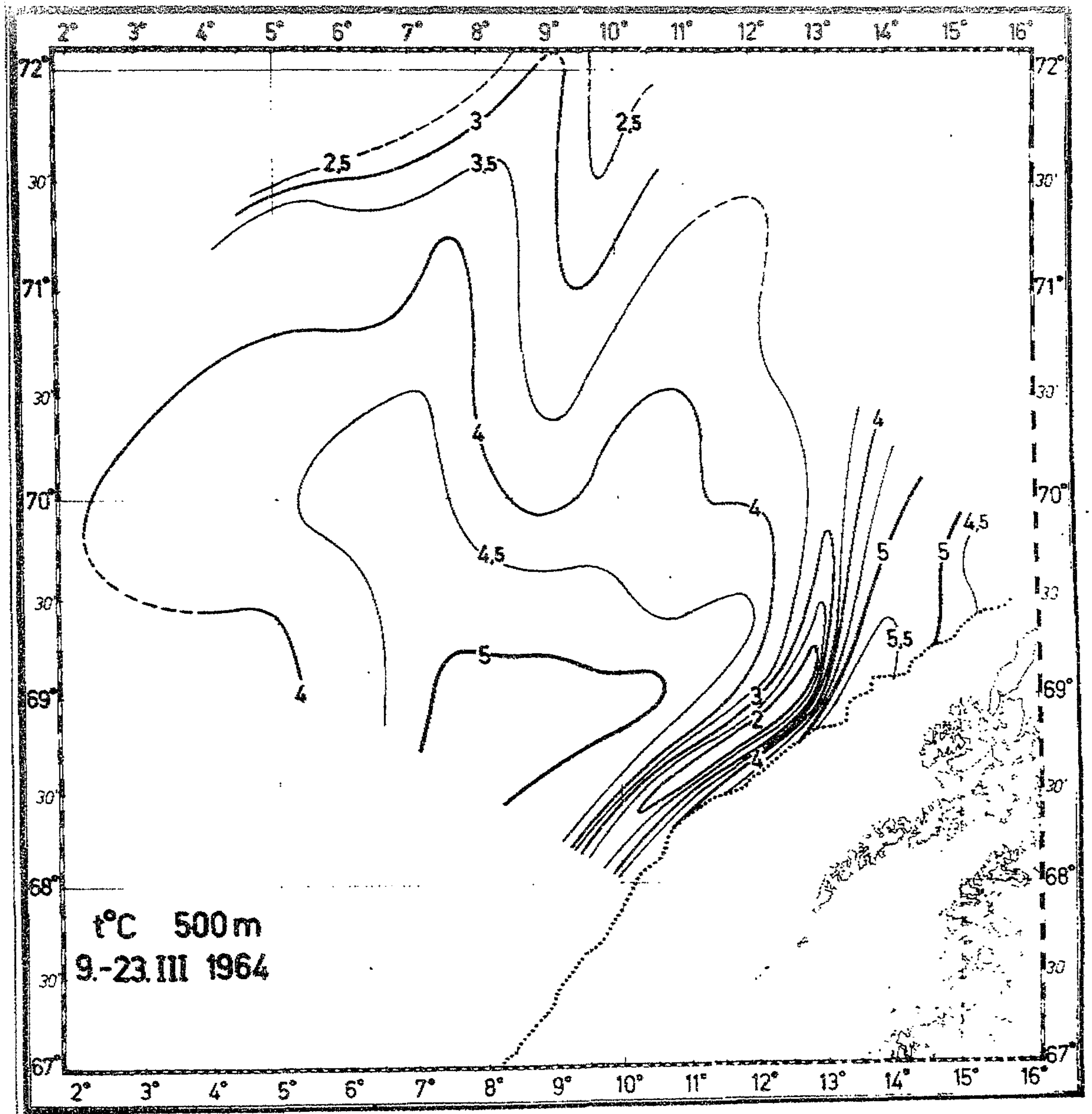

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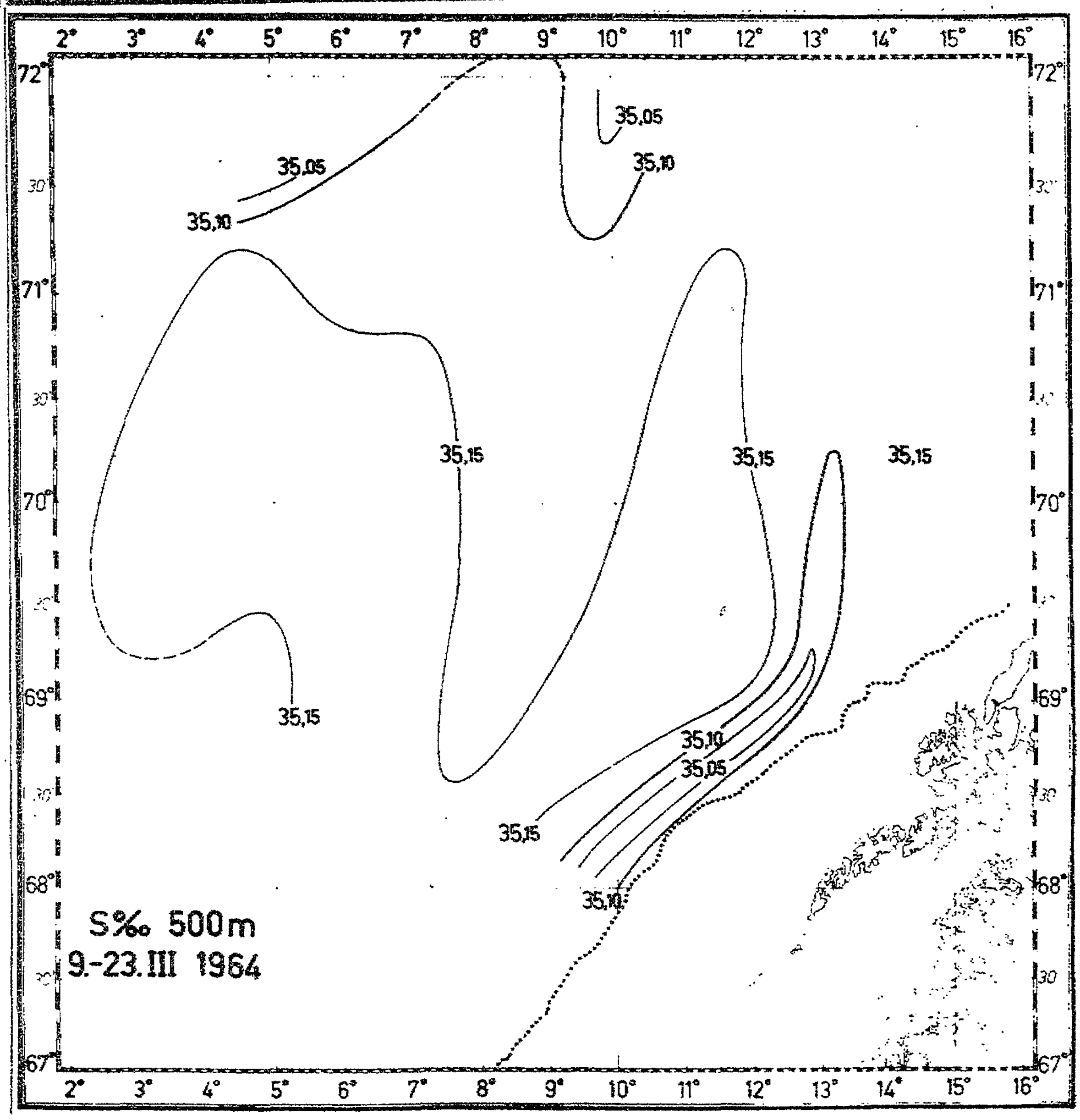

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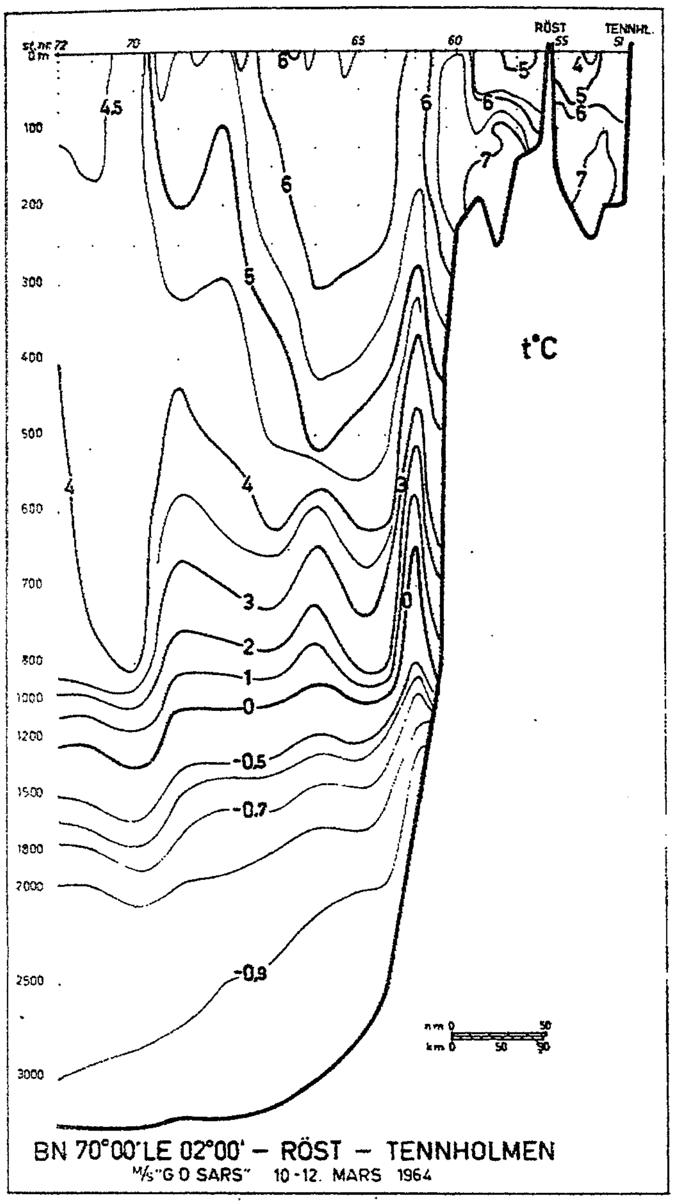

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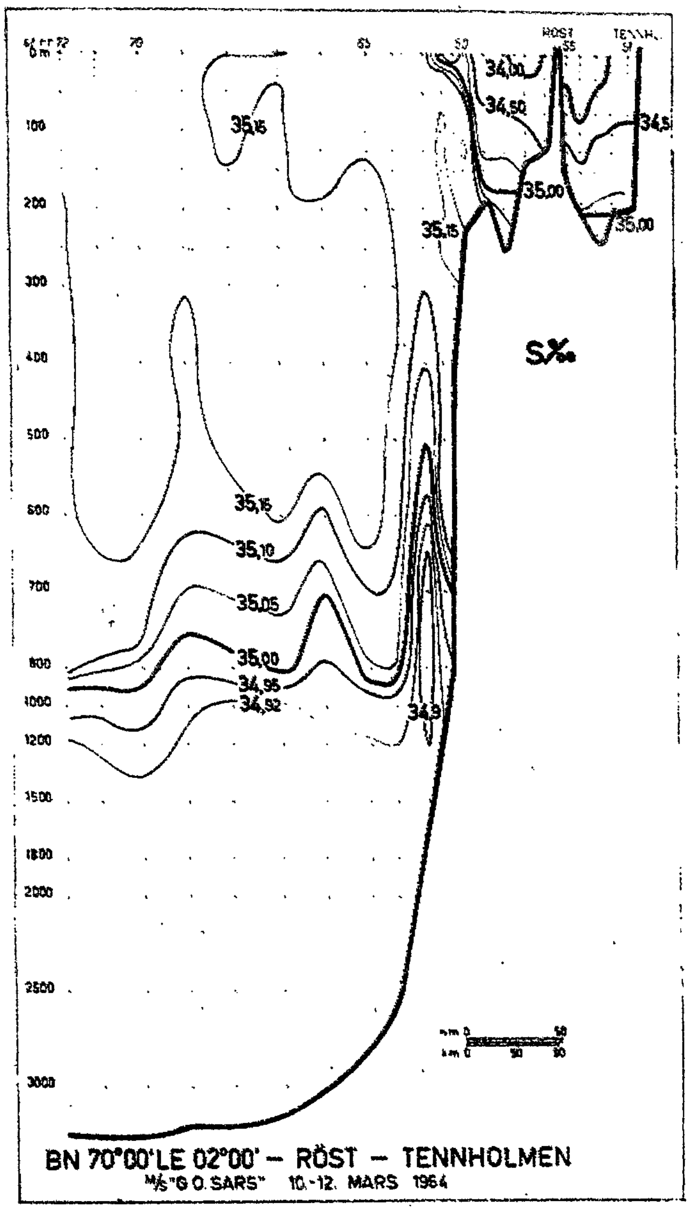

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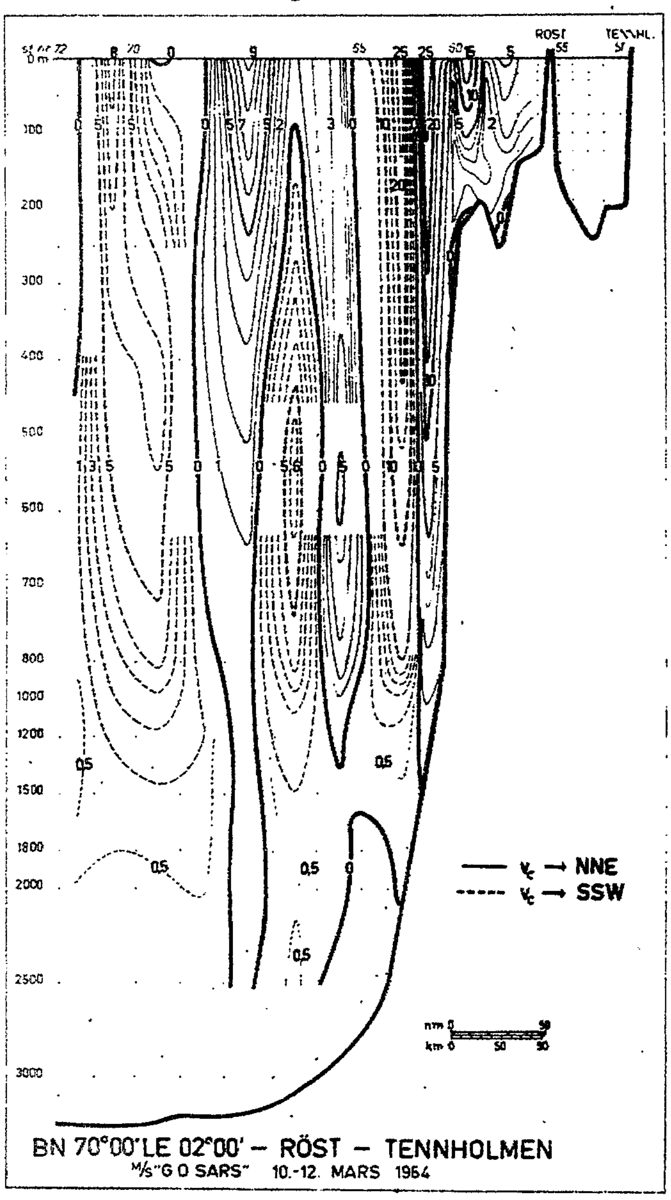

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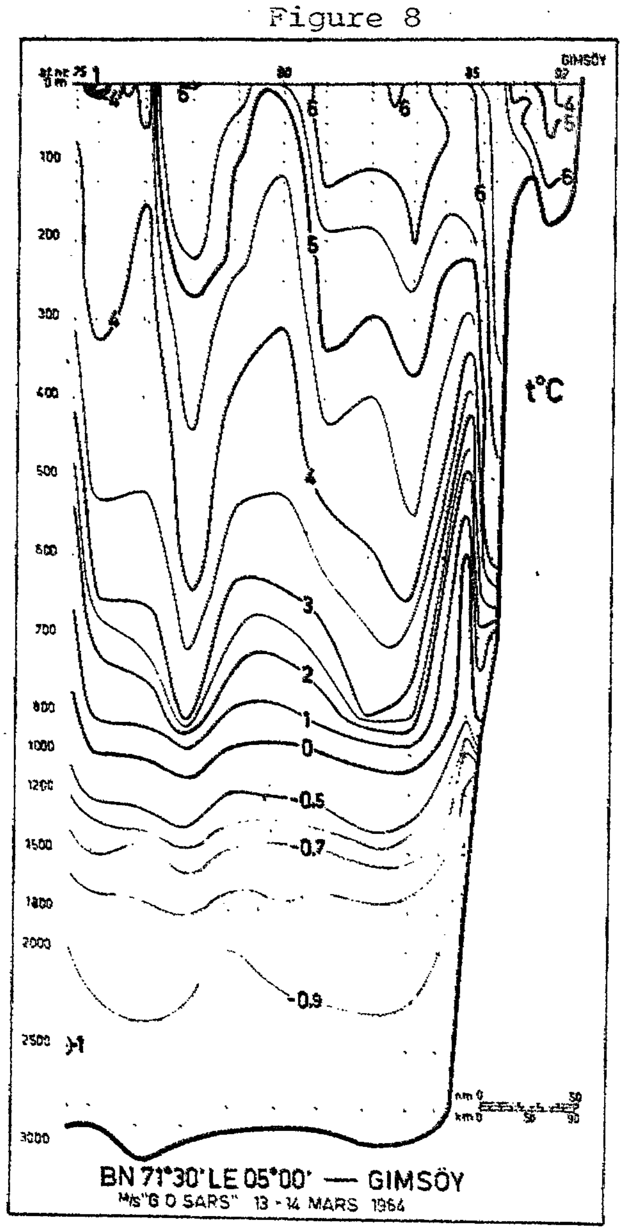

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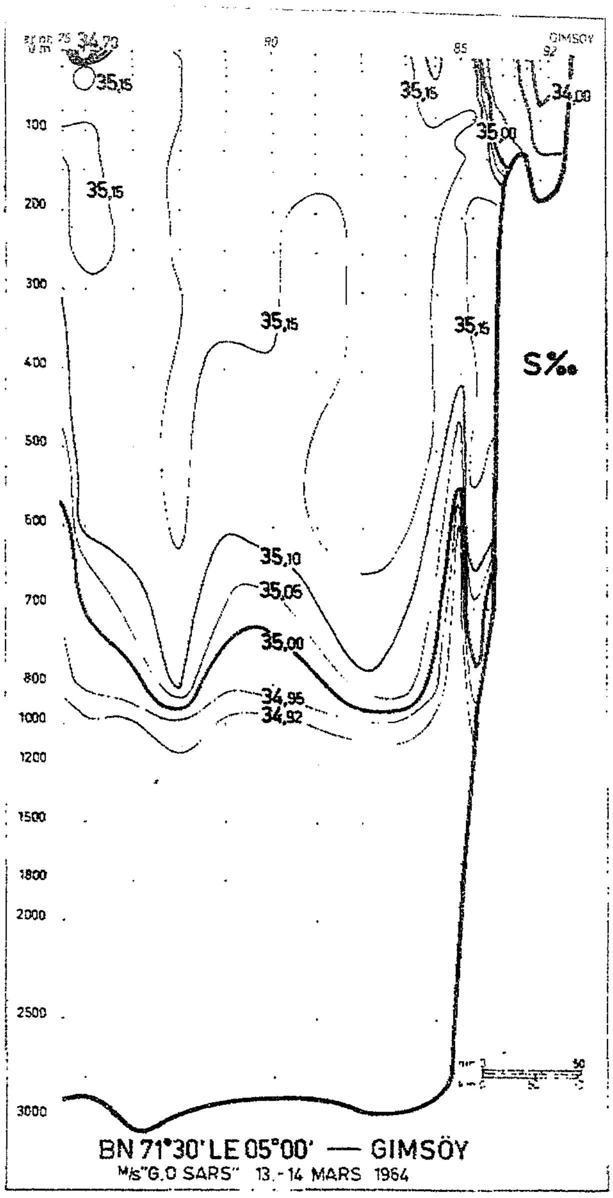

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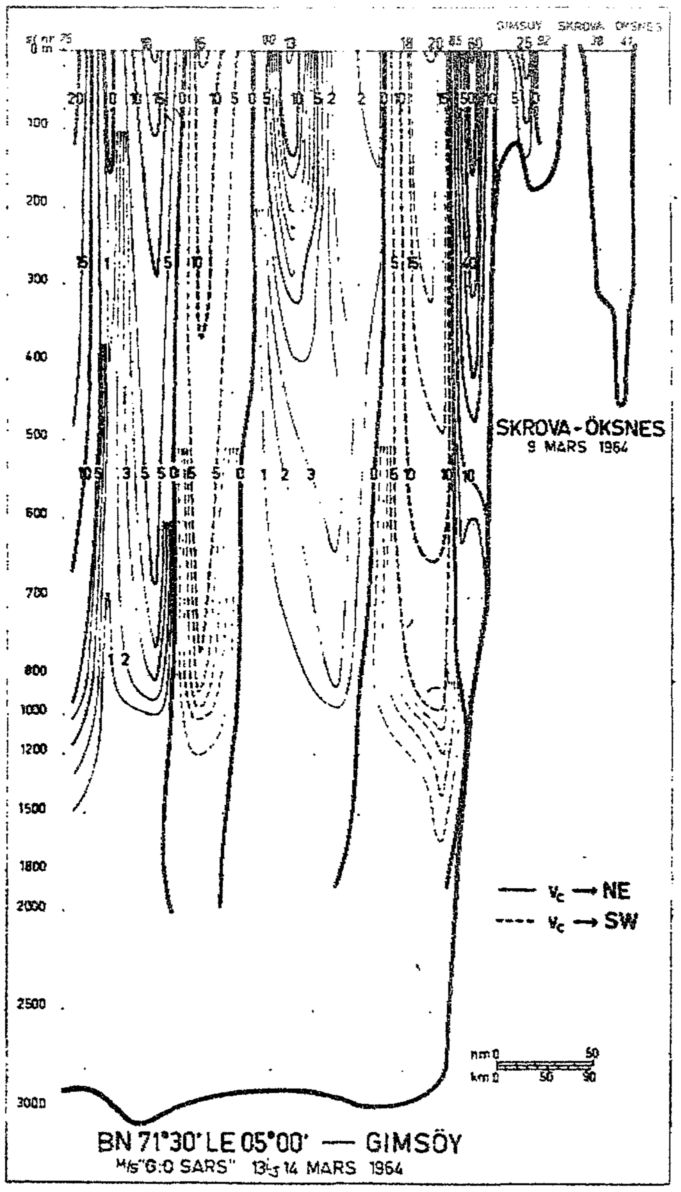

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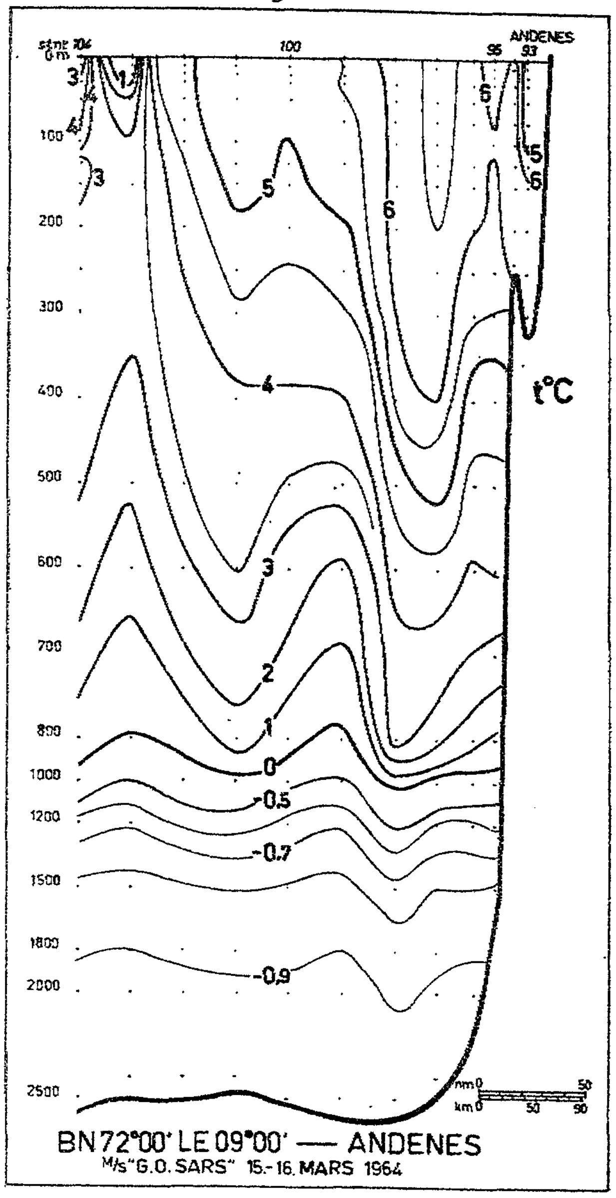

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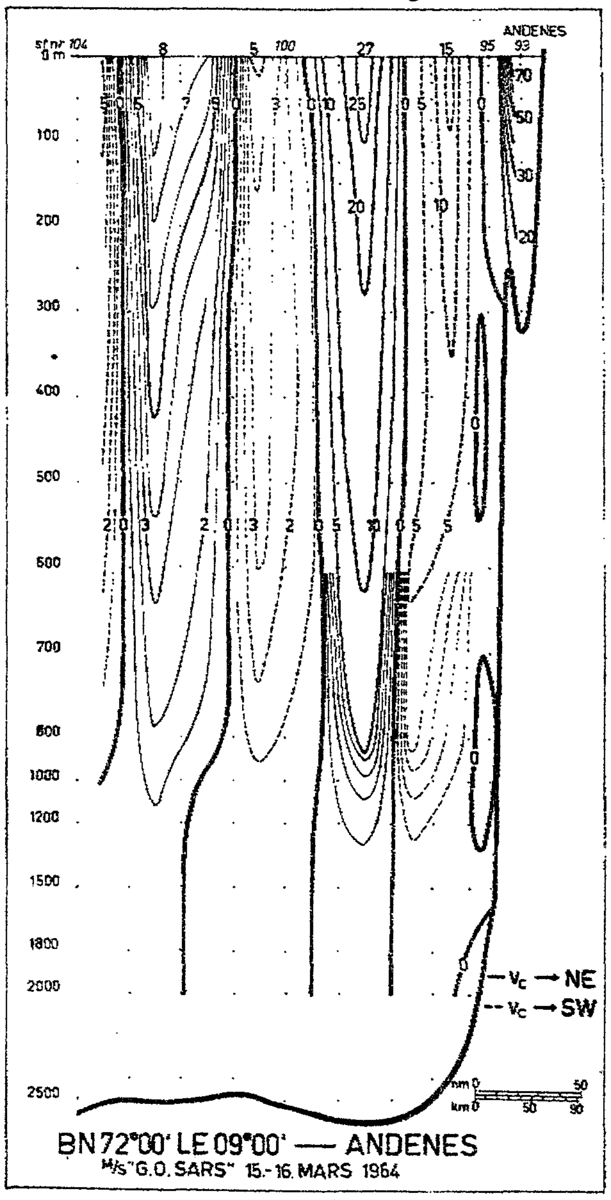

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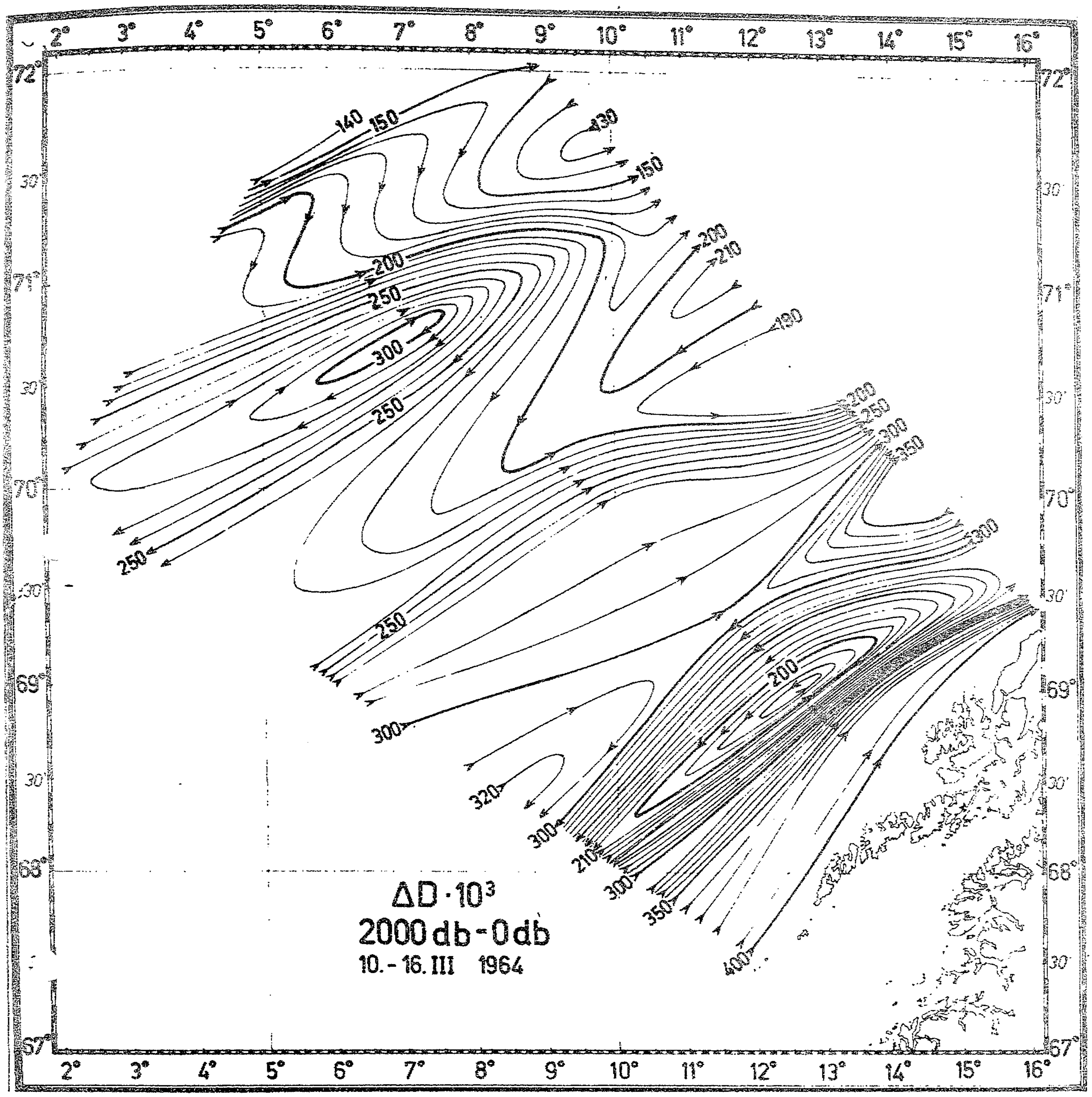
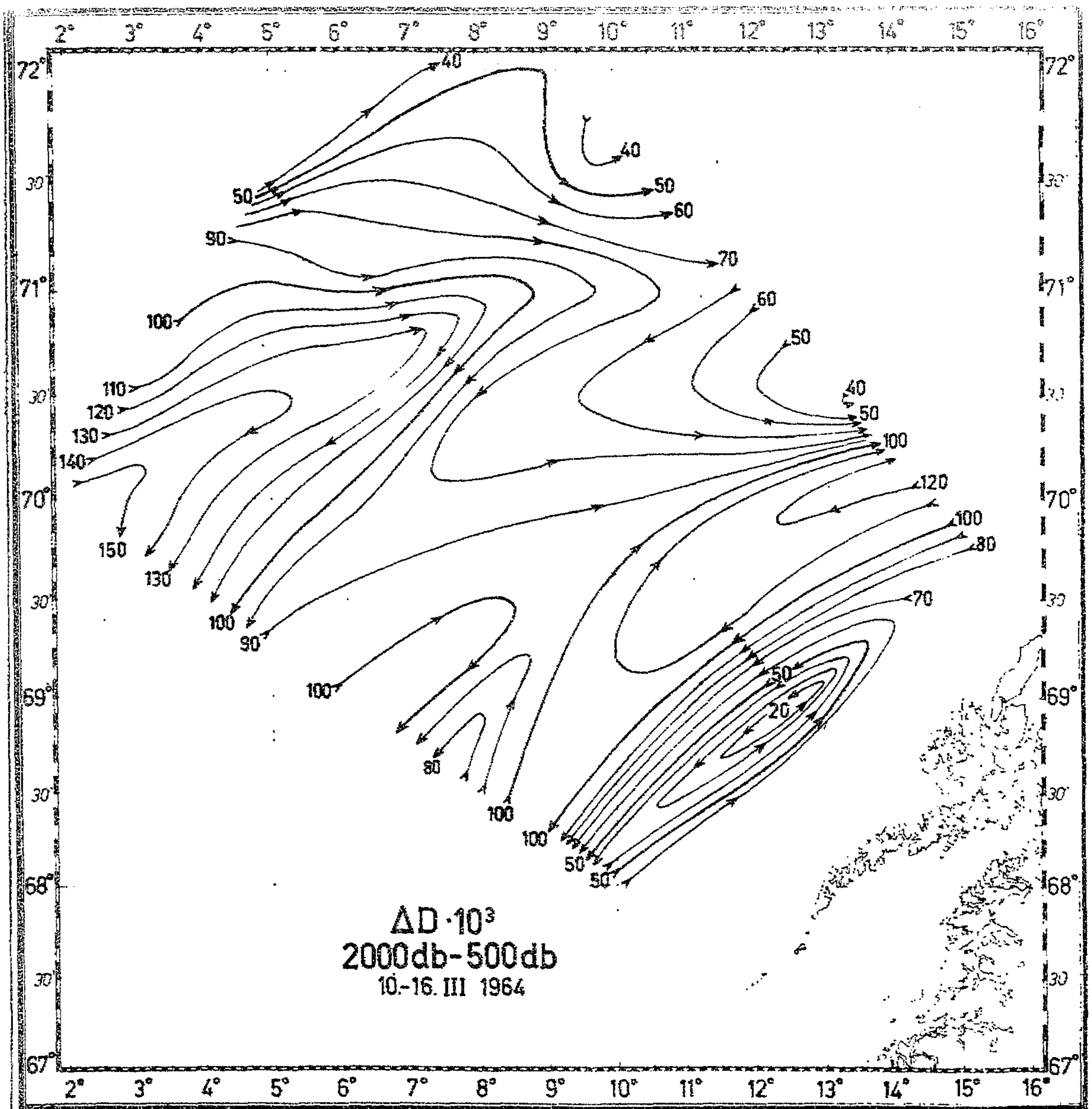


Figure 15



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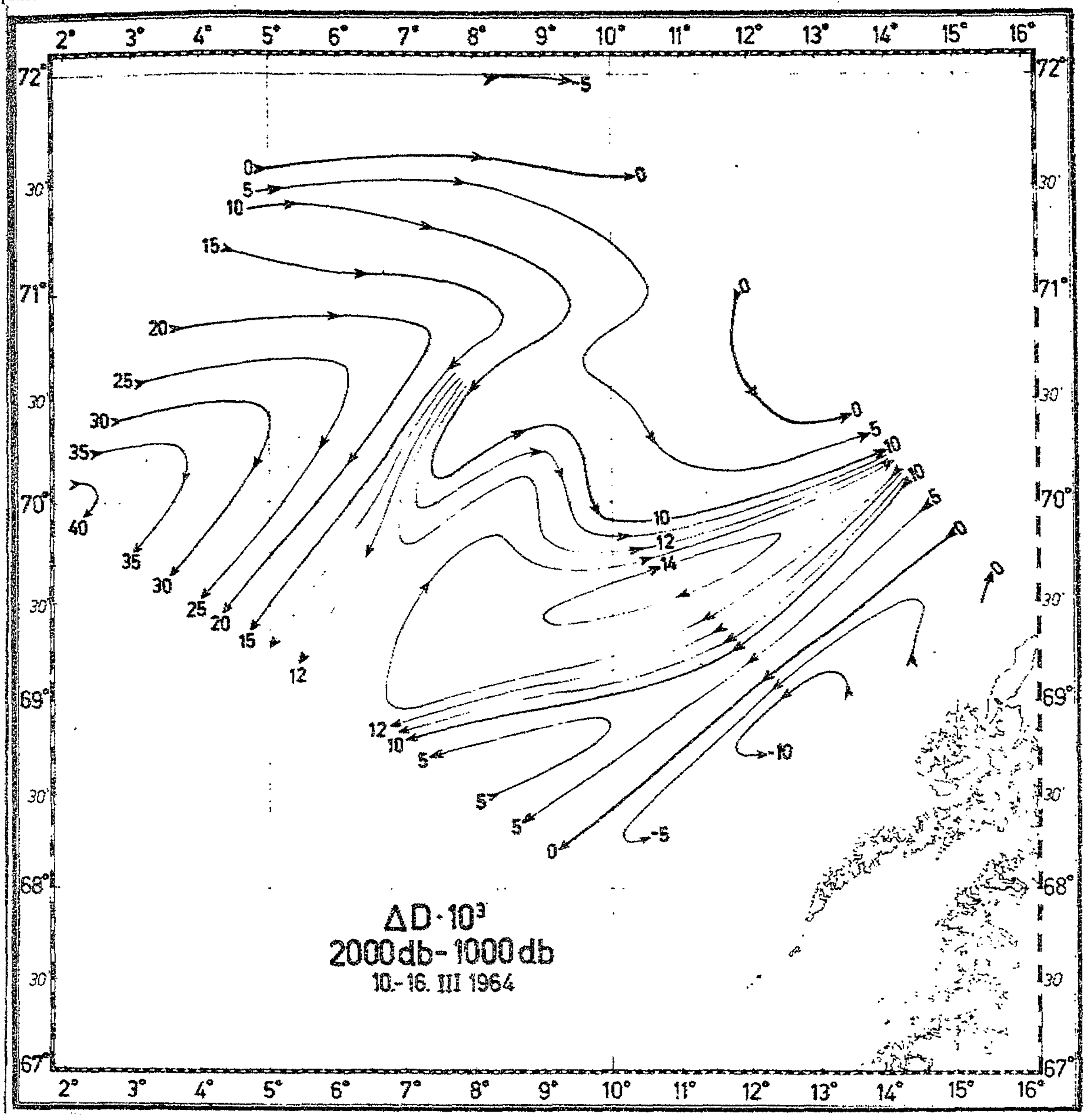

Figure 17