THE NORWEGIAN HYDROGRAPHIC OFFICE AND THE MAGNETIC SURVEY OF NORWAY

(Based on a lecture given by Mr Rolf KJAER, Director of the Norwegian Hydrographic Office, at the VIth International Hydrographic Conference, Monaco, April-May 1952).

The subject can best be introduced by a brief account of the pre-war status of magnetic surveying in the Nordic countries.

Denmark was the first to undertake and complete a fairly detailed magnetic survey of its national territory. Between 1890 and 1905, the activities of the Danish Meteorological Institute resulted in the establishment of a network of more than 230 stations distributed throughout the country and its home waters. Declination (*D*), horizontal intensity (*H*) and inclination (*I*) were observed at all stations. A few years later, the net was supplemented by the observation in 1928-1930 of a number of base stations. A magnetic observatory had already been set up by Denmark in 1906, located at Rude Skov, near Copenhagen and known as well as appreciated by magneticians all over the world.

Magnetic research in Finland was undertaken by the Central Meteorological Institute, which over a period of ten years (1910-1919) observed magnetic elements at 900 stations. Observations were repeated later at a considerable number of these stations for the purpose of acquiring information regarding secular variation. The magnetic survey of Finland was based on the Magnetic Observatory at Sodankylä in Northern Finland. Maintained by the Finnish Academy of Science, this observatory was founded in 1914; it was completely destroyed during the Second World War, but rebuilt in 1948.

Two separate institutions shared in the magnetic survey of Sweden: first, the Royal Hydrographic Service, which up until 1936 determined *D* at about 1200 stations and *H* and *I* at approximately 500 stations on land and in Swedish territorial waters. There are now 95 main stations (or repeat stations) in the Swedish Hydrographic Office network, all of which are well distributed over national territory. The Swedish Hydrographic Office's observatory is located at Lovö, about fifteen kilometres outside of Stockholm, and it was founded in 1927.

Then, as a sole undertaking in this field, the Geological Service of Sweden carried out a detailed magnetic survey of Sweden's mainland, including the determination of all magnetic elements at 2400 stations, between the years 1928 and 1934.

The results of the above mentioned magnetic surveys by the three Nordic Countries were published several years before the war.

In an issue of the review *K. Krigvest. Akad. Hanlingar,* published at published at Stockholm in 1936, the author wrote as follows:

« As regards terrestrial magnetism, the survey of Norway is extremely inadequate... »

This statement was unfortunately strictly in accordance with the facts.

During the last century and the first fifteen years of the present century, some degree of magnetic research had been carried out sporadically in Norway by hydrographers, scientists, or staff members of the National Geographic Service. In 1913, the Norwegian Hydrographic Office (at that time a subdivision of the Geographic Service) constructed a rather incomplete magnetic chart showing lines of equal declination. It may safely be asserted, however, that the scattered observations of this period were not part of any overall plan for the systematic investigation of terrestrial magnetism over Norwegian territory.

The Oslo Observatory, which had supplied data throughout the years on periodic variations of the terrestrial magnetic field, went out of existence after 1930. Almost at the same time the Oslo Observatory records ceased to be available, Norway received a grant of $75 000 from the Rockfeller International Education Board to install and equip an auroral observatory at Tromsö, i.e. at about 70° N. A Magnetic Bureau was also set up at this period at Bergen. Both the Tromsö Observatory and Bergen Magnetic Bureau are run by a board called the Norwegian Institute of Cosmic Physics. However, the schedule of the Tromsö Observatory, which is located fairly near the maximum zone of aurora, did not include the magnetic survey of the country. Moreover, an attempt in 1928-1930 by the Norwegian Geographic Service (of which the Hydrographic Office yet remained a part) to reach some sort of cooperative agreement for magnetic surveying purposes with the Institute of Cosmic Physics failed.

As regards magnetic declination and its secular variation along the shores of Norway, the former Hydrographic Division had naturally considered for years that the subject required investigation in the interests of navigation. Magnetic declination observations had thus been included in hydrographic operations for the past 150 years, ever since the time of Lieutenant Grove, the well-known cartographer. But as I have stated already, none of the observations carried out during the course of more than a century by hydrographers belonged to any definite project for a magnetic survey.

Prior to the establishment in 1932 of our national independent Hydrographic Office, the latter's magnetic activities were considerably curtailed partly because hydrographic surveys were restricted to certain limited sections of the coast. Since none of the other organizations in the country showed any perceptible sign of activity in carrying out a systematic survey, the Hydrographic Office was finally compelled to step in and take action. According to its way in thinking, the Hydrographic Office was of the opinion that magnetic research was of the highest importance, and that such an undertaking was closely bound up with coastal hydrographic operations.

The Hydrographic Office therefore began laying plans for a magnetic surveying programme in 1936-1937. Initial purchases of modern magnetic instruments were made from the French firm of Chasselon, and a communication was also addressed to the Norwegian Institute of Cosmic Physics inviting its participation in a complete magnetic survey of Norway. The Hydrographic Office proposed that the project should comprise a net of approximately 50 km. density, i.e. 120 base stations at which each magnetic element -- D, H and V (vertical component) -- should be observed. The agreement as to joint operation of the Norwegian Institute of Cosmic Physics and the Hydrographic Office of Norway was signed at Oslo University in 1938. Owing to circumstances, various clauses of the agreement could not strictly be complied with during the years that were to follow.

NORWAY

MAGNETIC STATIONS

The Variation of the Compass

Magnetic Declination
1950,0

⊙ REPEATSTATION

• DETAILSTATION

1 : 4 000 000

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The Hydrographic Office hoped that once the observational work had been started by the jointly operating organizations, the two teams could cover the entire national territory with the 120 base stations within the space of a couple of seasons. The Hydrographic Office considered basing the northern Norwegian net (north of 67°) on the auroral observatory at Tromsö, and the southern net on a modern magnetic observatory that would have to be set up.

By the time both seasons had elapsed, however, the teams had only been able to carry out two-thirds of the 1938 project, i.e. 73 stations out of the 120. Then in 1940 all magnetic work was suspended on account of the war. The Hydrographic Office's observer, the late Hydrographic Surveyor Frederik Vogt, was called to active duty and left for Great Britain; a year later, in 1941, his ship went down with all hands in the Atlantic. In 1941 magnetic survey was resumed by both co-operating Institutions. A demobilized officer of the Royal Navy, Commander Erling Kjaer, was appointed to take his place. For various reasons, it was decided that the Magnetic Bureau (a subdivision of the Norwegian Institute of Cosmic Physics) should be shown as being in charge of operations for the duration of the war. Observation by Commander Erling Kjaer of the remaining 47 magnetic stations out of the 120 secular stations covering the country followed.

Observations carried out during the 1938-1941 seasons were corrected and reduced to the annual mean at the Magnetic Bureau following data obtained from the observatories at Tromsö, Sodankylä (Finland), Lovö (Sweden), Rude Skov (Denmark), and a former Norwegian magnetic station at Dombas. A publication by M. Trumpy, containing charts and discussing results derived from the observation of the magnetic base (or secular) station net, appeared just after the war.

As soon as observation af the base station net had been completed, the Hydrographic Office and Magnetic Bureau jointly set to work to add a nationwide detailed magnetic survey to the net - a huge but essential undertaking. Detailed operations were begun by the two organizations in 1942, but were suspended in 1943. Work could not jointly be resumed until 1946, and then lasted continuously until 1950. Since 1951, the Norwegian Hydrographic Office has been continuing the magnetic survey independently. The end of operations is now is sight, although they were considerably held up by the war and conditions arising from the German occupation.

After observing about 240 magnetic stations along the west coast of Norway, Commander E. Kjaer was arrested in August 1943 and sent off to a concentration camp. Temporarily, however, operations had been appropriately systematized. Then Captain Kjaer, who following his internment in Germany was no longer fit for duty, was replaced in 1946 by another magnetic observer, a member of the Hydrographic Office, who received the aid of assistant-observers. The detailed survey of the net proceeded acording to plans devised by Captain Kjaer and the Hydrographic Office (1946-1947); from 1948 to 1953 the Hydrographic Office's own programme was followed. Observations were carried out fairly regularly during the seven-year period dating from 1946, and by the end of 1953 the detailed magnetic survey covering northern and southern Norway was almost completed, with a total of 1 170 stations. Approximately 680 stations were surveyed by the Hydrographic Office's chief observer, and the remaining 490 stations by his assistant-observers.

Magnetic data of the detailed net during the four-year period 1942-1943 and 1946-1947 were corrected at the Magnetic Bureau from data supplied by the

former Dombas magnetic station, and partially from records of the Swedish observatory at Lovö (1942-1943). However, the Hydrographic Office itself has been correcting all magnetic observations for *D* obtained in 1948-49-50-51-52 and 53, not by using Dombas, but from information obtained from the following observatories: Lerwick (British), Rude Skov (Danish), Lovö (Swedish), Sodankylä (Finnish), and Tromsö (Norwegian). These observatories have also furnished the Hydrographic Office with all the reduction data for referring the detailed net observations to the epoch 1950.0.

On the basis of observations of *D* at the 120 repeat stations and approximately 1 120 detailed survey stations distributed at even 18-20-kilometre intervals throughout the country, the Hydrographic Office has constructed a chart showing isogonic lines every half of a degree. In compliance with the I.H.B. resolution on the subject, the epoch 1950.0 was adopted for the chart. The Hydrographic Office has considered increasing the density of the detailed survey net in areas of magnetic disturbance along the coast, in order that anomalous cases may more clearly be illustrated, and it has secured connection with Sweden's magnetic survey net by observing stations on the Swedish frontier.

An understanding has been reached with the Danish, Swedish and Finnish magnetic institutes regarding the joint publication in the near future of a set of magnetic charts covering the four Nordic countries. An Inter-Scandinavian Committee has compiled the first chart of the series, showing declination, and this has already been issued. (See chart herewith).

As I said before, the magnetic surveying operations in which the Hydrographic Office took part were carried out under fairly trying conditions owing to the war and occupation, and the considerable amount of work involved weighed heavily on such a small hydrographic organization as Norway's. Trained and skilled magneticians, essentially required in obtaining satisfactory results from such surveys, were lacking to an appreciable degree. Then appropriate modern instruments had to be acquired, not to mention transportation facilities for the observers. A motorboat -- a very slow one -- which was used by the magnetic observers in 1938 and 1939 was confiscated by the occupation in 1940. In 1941, however, the Hydrographic Office managed to purchase a new small-sized, low-powered decked craft, barely able to carry a crew of three men, consisting of the observer and two assistants. This small motorboat was nevertheless used during 1942 and 1943 for a fairly detailed survey of the west coast of Norway. Finally, as the northern part of the coast, which offers little shelter, was approached, it was felt that the boat was too small and even dangerous, and in 1944 it was given up.

During recent years, two survey ships have been detached by the Hydrographic Office for magnetic surveying work. The larger of these two vessels is about 100 feet long, is equipped with a 280 HP engine, and carries a crew of eight. It has been specially reinforced with ice-fenders for navigation through ice. The second vessel is only 75 feet in length, is provided with a 150 HP engine and carries a crew of five. Both vessels rendered excellent service during the laying down of a net consisting of several hundred stations, with special reference to the Arctic coastal area of the country.

Due to the kindness of the Royal Norwegian Navy authorities, a powerful Plymouth automobile was placed at our disposal and most of the country's interior could thus be covered. The field-party working in the interior travelled over a

distance of more than 70 000 km. during these operations -- a considerable feat in view of the occasional poor condition of the national highways and minor roads in such a mountainous country as Norway.

As I said before, the instruments first used by the Hydrographic Office were supplied by Chasselon, a French firm; to these were added Bamberg equipment. Within a short time, however, the Chasselon instruments were replaced by Danish instruments developed by the late D. la Cour and his co-workers. I imagine all magnetic experts are well-acquainted with the Danish equipment. They consist of the quartz-H-magnetometer (or QHM instrument), which in combination with any type of magnetic theodolite, enables measurement of the horizontal field H values and of declination D. The other Danish instrument, a zero magnetometric balance (the BMZ), serves to determine the Z (vertical) component. Eminently satisfactory results were obtained from both instruments. They are easy to operate, uncomplicated, and sturdily built; moreover, they are conveniently transported. I shall not, however, attempt any description of Danish magnetic instruments, which are dealt with in various articles published by the Danish Meteorological Institute, and reference to which is suggested. Suffice it to say that they have amply proved their worth during operations of the Hydrographic Office, as well as the Bamberg theodolite.

The magnetic survey of Norway was a costly undertaking, and expenditures of the Hydrographic Office amounted to nearly 200 000 kroner (about $ 30 000). The project, now nearing completion, presented many problems and difficulties. If the final results are satisfactory and if they meet the requirements and specified goals of ten years ago, it is largely due to the valuable aid afforded the Hydrographic Office by the magnetic establishments of our neighbours. The noted magneticians of the observatories at Sodankylä (Finland), Lovö (Sweden), and especially at Rude Skov (Denmark) where calibration of the instruments usually took place, rendered invaluable services through their good advice and their unfailingly courteous willingness to help. It is with great pleasure, in closing this short address, that I most gratefully acknowledge their kind assistance.