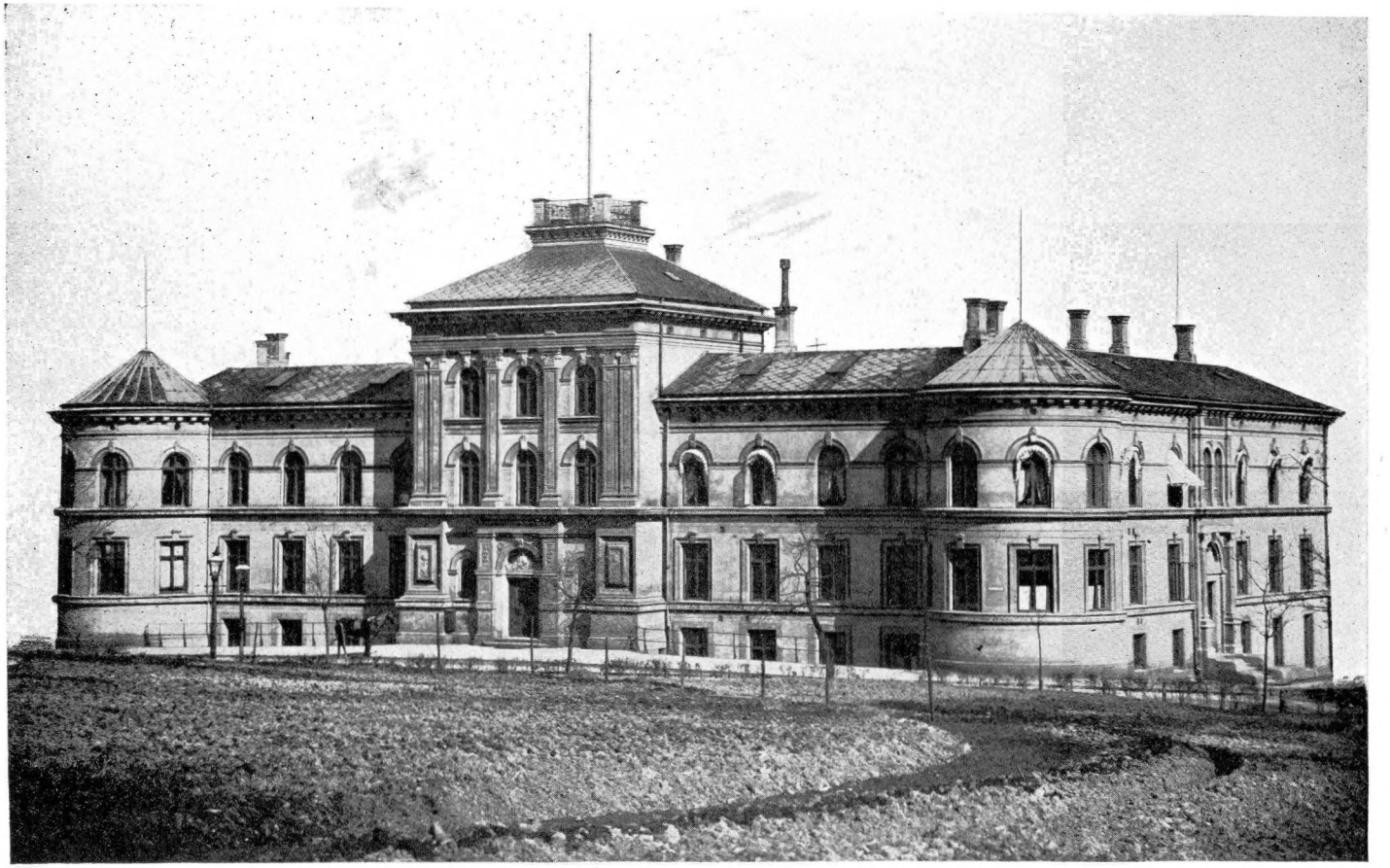

NORGES SJÖKARTVERK
occupies the right hand part of this building

LE NORGES SJÖKARTVERK
occupe l'aile droite de ce bâtiment

THE NORWEGIAN HYDROGRAPHIC OFFICE

by

COMMANDER EYVIND BJÖRSET, HYDROGRAPHER.

(Extract from the *Den Norske Sjöfarts Historie* published by the *Norges Rederforbund*, page 173.)

EARLY MARINE CARTOGRAPHIC WORK UP TO THE TIME OF THE OFFICIAL ESTABLISHMENT OF THE SJÖMAALING.

Instructions for navigating in Norwegian waters are to be found in the in the *Lodsböker* (Sailing Directions) referring to Nordic navigable waters (issued during the first half of the 16th. century). One of the earliest of these books is the Hamburg *Seebuch*, which, undoubtedly, was published as far back as the 15th. century.

But it is principally the Dutch nautical books which give the most satisfactory, and also the most interesting, information on the subject of the early cartography of Norway.

However, these older nautical works (amongst these the Hamburg *Seebuch* already mentioned) are silent on the subject of navigable waters further north than Bergen (Cf. ARNOLD RAESTAD: *Kongens Strömme (Norway's water courses)*, Christiania, 1912, page 95).

One of the very earliest charts of Norway, entitled: *Chart of the Eastern and Western Seas, printed at Copenhagen by* LAURENTZ BENEDICT *in* 1568, gives a few details, principally from information obtained from Norwegian and Danish seamen, of a small portion of the coast to the northward of Bergen as far as the latitude of Nordmöre.

The *Carta Marina* of OLAUS MAGNUS, which dates from 1539, is the first chart of Norway which gives a more or less correct configuration of the coast. In later times this chart was gradually retouched and corrected from information provided by seamen.

During the 16th. century, and until about the middle of the 17th., the Dutch became the protagonists of all cartographic work throughout the world; in the sphere of cartographic literature CORNELIUS ANTHONISZOON, GERHARD MERCATOR, LUCAS WAGHENAER, and others, must be mentioned, and even in our days they still are part of that group of the greatest cartographers whose important fundamental work is for ever to be remembered.

The chart of Scandinavia produced by the Danish cartographer ANDREAS BUROEUS in 1626 became the prototype for drawing up charts of Norway until late in the 18th. century.

It is during the latter half of the 17th. century, in the reign of CHRISTIAN V (1670-1699), *that the first official work in connection with the Norwegian coast* was undertaken by the *Director of Charts*, JENS SÖRENSEN and *"some of the Officers of the Royal Navy"*.

JENS SÖRENSEN (also called SÖFRENSEN) was both a merchant and a ship's captain, and it was while making numerous voyages on board his own vessels that he felt the urgent need for good charts; the bottoms of his ships, when fully loaded, frequently touched the shoals, and this, in the long run, became expensive! However, during his early voyages he showed a lively interest in everything connected with navigation and he never missed an opportunity of taking observations and making research as to distances, in order to improve the very imperfect charts which were available for navigators at that time. Thus he was led in 1689 to make a petition to the King « *that he sould order new charts to be made, seeing that the Dutch charts of the period* (*the only ones available*) *contained many serious inaccuracies* ». This petition received immediate favourable consideration, and SÖRENSEN, being a man of action, set to work with rare energy and undertook systematic surveys in Norwegian and Danish waters. However, before commencing this work he maintained, from his private purse, some copper engravers, and it was only after he had been appointed to the post of Director that he was given permission to work « at the King's expense ». He took his observations on board warships belonging to the Fleet. It is given as a characteristic trait of this energetic surveyor that he was always in disagreement with his colleagues and assistants on board ship. The surveying vessel had no sooner put into port than he brought all his assistants up before a Tribunal accusing them of having « *undeservedly and unjustly assaulted him, their innocent Director* ». His character was so difficult that he even sought a quarrel with his own son, « his obstinate son STEFFEN ».

It appears that there was only *one* officer, Sub-Lieutenant R. JUELL, with whom he got on; this, however, did not prevent this officer from abandoning his work as SÖRENSEN'S assistant on board the surveying vessel without authority, on account, as he said, « *of the strange humour* » of the latter. It is quite true that, during surveying work, incompatibility of temperaments may appear, and this can only have a bad effect on the work; this point should be considered by all of us hydrographers.

In order to make his surveys and measurements of distance on land SÖRENSEN used his « *mile carriage* » (perambulator) on which a bell, by the action of the wheel, rang after a certain number of revolutions had been completed, *i.e.* a certain definite distance had been passed over.

SÖRENSEN was, undoubtedly, the first hydrographic surveyor to make cartographic marine surveys with an accuracy unknown until then. However, on his charts, information as to latitude and longitude, and also as to distance, was always wanting; besides they were turned out without a trigonometrical basis and on no accurate projection, which certainly was not compatible with the growing developments in the art of navigation. Though his charts were recommended by the Admiralty as being better than the Dutch charts actually in use, they were never engraved or printed, which certainly seems very strange. It seems that the drawings of these charts were forgotten in the Admiralty archives until after the establishment of the *Soekort Archivet* in 1784 when they were transferred to it. It is probable that military considerations may have been the principal cause for this, for

it was undesirable that the safety of the country should be compromised by the publication of such good and accurate charts. SÖRENSEN'S work was not continued and no successor was appointed as Chart Director.

Amongst the charts made by SÖRENSEN showing the Norwegian coast line the following may be mentionned :

The General Chart of the Danish Fairways with the Christianiafjord (1709) ;

The General Chart of the Norwegian coast from Trondhjem to Denmark and the Baltic Sea.

Then :

From Skagen and Götenorg to Christiania and Arendal.

From Risör to Christiansand. The Western Harbour of Christiansand.

From Sireaaen to Stavanger (1708). Drawn by his assistant R. JUELL.

In connection with this, a man who is well worthy of being mentioned is JOHAN HEITMANN of the Helgeland coast, a contemporary of SÖRENSEN'S, to whom is due the cartographic work in connection with the Christianiafjord and the North Sea. Another of his contemporaries, JENS HEUCH, also drew up, in the middle of the 18th. century, a chart of the North Sea and and Skagerak.

THE FIRST OFFICIAL CARTOGRAPHIC WORK.

GROVE'S CHARTS.

Meanwhile, however, frequent wars broke out between Denmark and Norway, in coalition, and Sweden, and it is due to this situation that the first steps towards the *official creation of the Norges Opmaaling* were taken ; it was the Chief of the Artillery and of the Corps of Engineers, General WILHELM v. HUTH, who did good work foi his country in other directions also, who obtained the allocation of the necessary funds in 1773 for the carrying out of a military survey along the Swedish frontier (namely over that part comprised between Enningdal and the Fort of Stene in Verdal).

In the meantime navigation, developments in which had been considerable during the war of American Independance on account of the neutrality declared by the King of Denmark, had been feeling more and more urgently the need for more detailed charts.

The Soekortarkiv, established in 1784, as stated above, immediately took note of this and initiated cartographic work with the object of filling the needs both of the Navy and of the Mercantile Marine. A committee including General v. HUTH and Professor BUGGE, besides two Naval Officers, was appointed to discuss and organise the work.

This committee reached the following decision :

« *That it is necessary to survey the Norwegian coast with all its inlets, and the channels which lie along it from Haltenö, the extreme Northern part of the*

district of Trondhjem, as far as Fredrikshald; good charts for this area are entirely inexistant. » It was decided besides to « *publish special separate charts on large scales for the above mentioned stretch of coast together with descriptions thereof.* »

This survey was to be based on the triangulation which had been commenced in 1779 by order of General V. HUTH, at which time it was laid down that " *from now on surveys should be based on astronomically determined points* ".

For calculating the surveys of the coastal areas on the basis of the trigonometric points the coördinates between Trondhjem and Bergen were referred to the *meridian of the Cathedral of Trondhjem*; and in this connection it should be mentioned that an azimuth observation was taken at Graakallen. Between Bergen and Christianssand the *meridian of Bergen Cathedral* was used, and between Christianssand and Iddefjord *that of the Cathedral of Christianssand.*

After VIBE had worked several years on the survey of the coast this work was taken up by Lieutenant F. C. GROVE of the Danish Royal Navy, who carried it on without interruption until 1800. In this incredibly short period, taking into account the work to be done, he made a complete survey of the whole of the extent of coast from Haram near Aalesund to Christiania and Svinesund.

The coast-line was usually done by local surveyors independently, which, to a certain extent, explains the rapidity with which the work was carried on. It should not be forgotten either that the work was to include particularly the principal roads (main roads) whereas the other details were only to be dealt with summarily, and in the form of a sketch survey.

The result of this first hydrographic work, which was really official and covered the coast between Haltenöy and the Swedish frontier, was the publication of 7 new charts engraved on copper. They were issued in Denmark from 1791 to 1803 and they are still known under the name of *De groveske drafter* (Grove's charts). These charts were made on a scale of 1:72,000 but they were published on a scale of 1:225,000; for many years they were the only charts of this coast which were on sale; right up to the 70's these charts were used for navigation.

When each chart was issued a description was added to it. They were published as follows:

In 1791, Trondhjem Channel with the Udöer and the channels lying outside the Halten Channel to Christiansund.
1793, Christiansund to Stadtland.
1795, Stadtland to Blomöe.
1798, From 60°30' to 58°50' North latitude, the whole of the Bergen Channel to the Southward, including the approaches to Stavanger.
1800, From Egefield and Jaederen to Christianssand.
1801, From Christianssand to the approach to Langesunds Fjord.
1803, From Jomfrueland as far as the Swedish frontier, including Langesunds Fjord as far as Skeen as well as the whole of the Christiania Fjord.

It is not astonishing that these charts were somewhat defective, taking into consideration the extremely short time taken in producing them and the fairly primitive instruments then available; besides, the value of this work should not be judged by the results obtainable in our days. For their time, they were undeniably sufficient for requirements, particularly for the outer navigable channels which were used in those days, and thus they were a valuable guide to navigators. In truth the seamen of those days were by no means familiar with the idea of the Government taking steps to advance the science of navigation. Moreover in 1785 there were but five lights on the whole of the coast, namely *Foerder*, *Lindesness*, *Markö* (near Lindesness), *Hvitingsö*, and *Rundö*.

SECOND CARTOGRAPHIC PERIOD, 1828-1848

Survey of the coast of Nordland and Finnmark.

When, at the beginning of the 19th. century, Commander Grove completed his imposing undertaking, every consideration was due to him in recognition of the efforts which he had made to push forward the hydrographic survey of the coast. In spite of this, however, complete darkness yet veiled numerous stretches along the national coasts. The whole of the coast of Nordland, which was wooded and wild with numerous islets and reefs and thousands of shoals, and which was generally known under the name of Northern Norway, was still entirely unknown and thus formed inaccessible territories; and it was not until after 1814, at which period the need of charts of this part of the country was clearly felt, that the Director of Hydrographic Surveys of those days, d'Aubert, drew up a plan of preparatory work for the *first coastal survey of Nordland*, at the suggestion of State Councillor Th. Fasting.

As a reason for putting this work in hand it was stated particularly that it was of great importance to navigation, that it was desirable to establish *a definite frontier with Russia*, and, finally, that it would be extremely useful to know something about these neglected countries.

However, it was not until 1824 that the Storting voted the necessary funds for putting this work in hand, and as soon as the instruments had been obtained and the preparatory work had been completed, work in the field for carrying out the practical survey was begun in 1828. From 1828 to 1841 the chain of triangulation was made and acted as a basis for the coastal survey; it commenced at the mouth of Trondhjemsfjord and extended northward along the coast as far as the Russian frontier. Accurate astronomical and geodetic observations for checking purposes being non-existant and the shape of the triangles being not particularly good, it was natural that there were some errors in the sides of these triangles. To the South of Tromsö it seems, however. that the geodetic and astronomical determinations of points was such as to give an accuracy which sufficed for all practical needs, but to the east of Tromsö such a large error occured that very considerable displacement of the trigonometrical stations resulted. That there was no serious error in the triangulation of Eastern Finnmark must be attributed to the fact

that the observations made here depended on the common side Roaurocaerro-Berlogaisa, near Tanafjord, in which a difference of 168 feet appeared in a length of 38,000 feet.

As a basis and check on this work Professor HANSTEEN made *azimuth observations* near Trondhjem. The determination of astronomical positions was carried out by Lieutenants HAGERUP and DUE, R.N. *A check base* was measured in the spring of 1836 on the ice at Jaegervand, near Ulfafjord, the length of which was 6,379 feet.

A coast survey based on this triangulation naturally would no longer correspond to present requirements, and the coast line was found later to be considerably dislocated in parts.

However, this dislocation being fairly uniform, within larger areas, with a nearly constant difference in latitude and longitude, the navigator experienced only trifling errors or none when navigating within sight of land.

A good astronomical position would deviate somewhat from a terrestrial position obtained simultaneously, but little attention seems to have been paid to this.

All the charts mentioned above have now been replaced by new editions based on modern triangulation and up to date hydrographic surveying.

Charts were drawn on a scale of 1:100,000 and were accompanied by a description and views of the coast.

This survey was the basis of the first issues of printed charts of the Geografiske Opmaaling (charts of the northern territory of the Kingdom), and formed the beginning of the great activity displayed later by this establishment.

In 1844 a hydrographic survey of the whole of the coast of Nordland and Finnmark was satisfactorily completed.

The coastal charts of Nordland and Finnmark which were issued on a scale of 1:200,000, drawn up on Mercator's projection, are the following:

1. Haltenö-Lekö, in 1835.
2. Lokö-Donnaeso, in 1835.
3. Donnaeso-Fleina and Sandkornet, in 1837.
4. Fleina and Sandkornet to Tranö, in 1839.
5. Tranö-Gisund, in 1842.
6. Gisund and Andö-Kvalö, in 1842.
7. Kvalö-Söröen, in 1844.
8. Söröen-Nordkap, in 1845.
9. Nordkap-Tanahorn, in 1847.
10. Tanahorn-Russian Frontier, in 1848.

These charts were issued with views and descriptions and they were completed later by two general charts on the scale of 1:800,000, one of which extended from Trondhjemsleden to Tromsö, and the other from Tromsö to the Russian frontier.

Several of these charts are still on sale, but in the form of revised editions based on resurveys.

With reference to the special charts of the " ports of Finnmark " which

were issued later, it may be stated that they are a good guide for the coasts of Finnmark and they are kept up-to-date to the extent which the scale of such general charts permits. As new hydrographic surveys advanced they were, however, replaced at the same rate by new and modern general charts on the same scale.

This coastal survey of Nordland and Finnmark was more a battle than a work, and its completion indicates an energy and a devotion worthy of admiration.

In connection with the survey of Nordland various other works, such as an examination as to the light to be established at Röst, and an examination as to the projected cutting at *Hopseid* between Laksefjord and Tanafjord were carried out.

In 1835 in addition, on the suggestion of the British Government, *observations of flow and ebb* all along the coasts of the North Sea were taken. On the Norwegian side observations were taken on the coast of Vardö, Andenes and Salta. These observations were taken in accordance with instructions received from Great Britain.

Another point of interest in connection with the coastal survey of Nordland was the *deep-sea sounding off the coast,* which was undertaken during the last year of that period.

At the end of the 40's the whole extent of the coast had been hydrographically surveyed and charted, and thus the most urgent requirements were met. Just at this period sea-traffic developed very rapidly; daily new channels and new approaches were used. GROVE'S charts no longer fulfilled the requirements which cartographic progress gave a right to expect from charts. The invention of the steam-engine had caused a complete revolution in the sphere of communications, and it commenced to be realised that GROVE'S charts drawn up in 1775-1800 were not up to the standard of the Nordland survey in certain connections, and thus the need was soon felt for the *complete revision of the surveys of our southern coasts.*

In 1849 the necessary funds were granted to enable the new hydrographic surveys to be undertaken on the run from Christianiafjord to Jomfruland, of which area it had been decided that a chart should be published on the same scale as the charts of Nordland. This chart, however, likewise did not give satisfaction to seamen for any length of time. One of the reasons which contributed to this is to be found in the fact that, at that time, charts were not *kept up-to-date,* where it was a question of inserting new lights or new hydrographic details, or anything else; they were thus out of date even before their issue.

It was considered that it would be of advantage to draw up charts on a large scale for certain runs and it was with the chart of Christianiafjord-Jomfruland that a commencement was made. This was to include three special charts on a scale of 1:100,000.

Little by little the use of this scale was extended along the southern coast as far as Stavanger, which was reached in 1857; it was Lieutenants C. F. DIRIKS and H. WILLE who carried out this work. In connection with this it should be noted that, in these same surveys, the field plotting sheets

were made on twice the scale (1:50,000) and this eventually became the scale which was adopted as the standard scale for our special charts.

It was the hydrographic surveyor, Lieutenant H. WILLE, who was the first to support the publication of our charts on this scale, viz. 1:50,000, and in his reports attached to the fair sheets of the survey of the Stavanger district in 1857 he pleaded the advantages which would accrue if the special charts of fishing districts were issued on a scale larger than 1:100,000, and pointed out that a great number of fishing vessels navigated without pilots and that for this reason "*the charts should be of such accuracy that, without any other aids, ships should be able to navigate and find a port*".

On the strength of the above it was finally decided to issue special charts of Tananger and to the Northward, on the same scale as that used for the field plotting sheets; this constituted *the prime basis on which our present principal cartographic work stands* and this scale has met with general approval as being particularly suitable for the greater part of our sea-coast.

At the beginning of the 60's it was necessary to make a re-survey in the Christianiafjord, at the same time as the survey was pushed to the westward, the means for carrying on of which had been increased.

By 1870 the survey had nearly reached Florö, the most modern methods of surveying having been used. It should be noted that the outline on the coastal charts of this period was frequently full of serious inaccuracies, and they appear to be in proportion to the size of the scale used. It seems that this must be connected with the projection errors due to the use of the *Cassini projection* at that time; these projection errors entailed a departure of 20 metres per mile at a distance of 30 miles from the original meridian, the meridian of Kongsvinger; and this departure not only caused irregularities in the outline but also in the inscription of hydrographic details which depended upon it.

At first the engraving of coastal charts on stone was done by private persons; then the lithographer FEHR did this work until the time when Lieutenant SCHWENZEN undertook to do it in 1855 by the job. The actual printing was done on the lithograph press belonging to the Opmaaling. In 1857 a trial was made by engraving the *Kragerö-Arendal* chart on copper and, from this time on, this method of reproduction came more and more into use. The first copper-plate printing press was purchased in 1855.

By the end of 1869 the following charts had been published:

On a scale of 1:50,000: From Christiania to Bömmelen (a total of 19 special charts), (this covers the period 1861-1868).

On a scale of 1:1000,000: From Jomfruland and Kragerö to Hellisö (including 2 charts of the Hardangerfjord) and three special charts of the area from Christianfjord to Jomfruland, in all 13 charts (Period 1852-1868).

Later on the pair of *General Coastal Charts* on a scale of 1:350,000 was published, From Faerder to Utsire (in two sheets), and three general coastal charts (Christiania-Egersund) on a scale of 1:200,000.

Meanwhile the *remaking of the hydrographic surveys covering the area of* GROVE'S *first charts* was carried out unceasingly working Northward, until in 1881 this work approached the Southern limit of the general chart of Nord-

land and Finnmark. The original sheets were sent, as they were finished, to the Sjökartverk where they were assembled and corrected and where the frame of the chart was fixed; thereafter the reproduction and printing was carried out by the Technical Section of the Opmaaling.

The hydrographic revision of Nordland and Finnmark, which was undertaken at the beginning of the 80's has, at the present moment, reached the vicinity of Cap Voriemsky, the Finnish outpost near the frontier between Jakobselv and OSCAR II's Chapel, close to the Russian coast, at the point where the outline of Finland and Murmansk cannot be separated by the eye, and where it is difficult clearly to draw its outline and its appearance.

It is thus that we finally reached our modern special charts and that the whole of the Varangerfjord is covered by up-to-date charts; and, in this, the most important part of the development of our work has reached a final conclusion. All of the coasts covered by adequate charts! hence full security for the seaman who has to find his way amongst the dangers and the reefs in unknown channels by day and by night, and, besides, great satisfaction for our hydrographic surveyors, for they see, at last, that no part of the coast is not covered by these indispensible aids to navigation.

Taking into consideration the necessity to obtain a more perfect representation of conditions in harbours, and in view of the intense traffic both entering and leaving *Christianiafjord*, wherein the chart is so fully used in its smallest details, it was finally decided recently to re-survey the inner part of this fjord and a chart thereof has been published on a scale of 1:25,000, *i.e.* on double the scale adopted for our main charting.

This scale is used also for the greater part of the new survey of the sea and for the coastline which has been started in Vestland, from Jaeren to Trondhjemsfjord; this work is based on a new and modern triangulation which will have the effect of suppressing the embarrassing projection error.

In 1867 deep-water soundings were carried out between Faerder and Mandal; this work extended 14 to 16 miles off-shore and two or three soundings were taken in each mile.

In 1868 the sounding out of the Vestfjord was undertaken and from this it was hoped to make considerable contribution to the organisation of fisheries. From the soundings thus taken the contour of the sea-bottom was shown by depth lines at every ten fathoms, and it was decided to put this chart on sale.

Besides the soundings proper, the taking of which was much facilitated by mechanical hauling in of the line by steam power, *observations for magnetic declination* were also undertaken, as were also those to determine the nature of the bottom, and finally various meteorological observations. In this manner every opportunity was seized to complete the charts by research and by careful revision in connection with newly discovered shoals, etc.

The area sounded had gradually spread as far as 48 to 54 and even 60 miles off shore and, owing to the more substantial appliances which were utilized later, deep-water soundings became a separate heading in the Geografiske Opmaaling's estimates.

It was decided to sound out the Varangerfjord and this was carried out in 1875 and 1876.

Soundings around the coasts were taken in accordance with the programme until in 1895 the Russian frontier was approached and where, as the result of various petitions sent in and representations made meanwhile, further examination was made in 1899 for the purpose of obtaining all data necessary to show the nature of the sea-bottom in connection with the " egger " and fishing banks; this necessitated special sounding work at various points off the coast.

From the information obtained from these soundings it was possible to determine the form of the submarine relief and the nature of the bottom to act, particularly, as a guide for fisheries. As mentioned above, the first official chart of *Vestfjord* was published in 1868 in five sheets and from this, so far as possible, the results of deep-sea soundings have been transferred every year to the corresponding general charts.

REVISION OF OUR OLD CHARTS.

If we look back at the development of our charts since the first early sketches and as they still were at the end of the 18th. century, to the modern hydrographic work in all its detail, carried out by means of the steel wire sounding line and the submarine sentry together with the best instruments of precision, it may well be asked whether the extreme limit of perfection in this connection has not been reached, thus giving these charts an everlasting value; in other words it seems that, thanks to the use of modern technical auxiliaries, hydrography has become so perfect that revision can be indefinitely put-off.

Apart from the fact that it has always been difficult to survey that which is invisible, it should be remembered that in surveying our coastal areas but few marks exist which are useful for the purpose of acting as guides to find dangerous shoals. The discovery of these is nearly always accidental and unexpected. Great depths alternate closely with submarine peaks nearly as sharp as needles, which frequently approach close to the surface of the water and this without the lead showing any pecularity which would give an indication of the presence of the treacherous danger. Under these conditions hydrographic surveyors must depend to a certain extent on information obtained from fishermen and others with local knowledge; the results are, therefore, quite independent of the nature of the work, and it is evident that it may frequently happen that surveyors miss pinnacles (bottle-noses), however closely and carefully the sounding may have been done (*).

Vessels began to draw more water. It is barely half a century ago that surveyors considered that more than 12 feet draft was something very rare, and thus on several of our oldest charts the critical limit (the dotted line

(*) The new method of systematic sounding on lines close together, which has always been employed in recent years, provides the best chance of obtaining a perfect survey of the waters. Also wire sweeping has been brought into practice in order to be able to guarantee the chart.

which shows the boundary between navigable and non-navigable areas) is shown at a depth of two fathoms.

It was never expected that " deep shoals ", with 25 to 30 feet of water over them, would one day be regarded as dangerous to navigation; yet this is the case in our days when in actual practice cargo vessels, built to transport ore, when fully loaded draw as much as 10 metres of water. This is a new consideration to be taken into account, and it necessitates a careful revision of bathymetrical data in connection with shoals and dangers.

Wrecks have also to be taken into consideration. They are not so very rare, and frequent accidents have occurred off coasts because a wreck had placed itself across a route since the latter was surveyed. These treacherous submarine obstacles should, where possible, be removed or made innocuous; but it must be remembered that this type of shoal may drift under the influence of strong currents or of the tides, it may change its place in any direction and thus careful observation of its movements should be taken in the interests of navigation.

In addition to which attention must also be paid to the frequent existence of sand-bars outside the mouths of rivers and these may assume different aspects from year to year and besides they may be shown on charts in different ways; this applies also to land-slips and the breaking-up of ice and snow during a part of spring. It may happen even that the aspect of the sea may be modified on account of the effects of an earthquake.

From the above it will be seen that a critical examination and a revision of charts, and particularly of those of older date, is an integral part of satisfactory keeping up-to-date. Taking into consideration that, on the greater part of the old charts, only the particular characteristics revealed by the soundings of the period have been inserted, it is evidently our duty to complete these charts by inserting the missing hydrographic details, which are important to navigation, by means of the most reliable information obtained from pilots and local fishermen; by questioning and by checking the answers, and by taking soundings, obscure points concerning dangers and shoals may be cleared up with rapidity. In addition, while taking check soundings we should try to obtain better sounding-out of fishing banks and more complete information as to depths over both interior and exterior dangers, particularly in areas in the vicinity of the principle navigable waters where it is customary to anchor or to take shelter in foggy weather or during storms. Finally, what may not occur in the future to upset the present ideas of biographic surveyors? The successful use of submarines may even extend to peaceful navigation and a day will arrive when the relief of the bottom of the sea must be clearly shown on the chart, and when this happens the data must rest more than ever on accurate and authentic sets of profiles.

Thus a careful revision of the charts has always provided further information as to dangers and shoals previously known; and also, daily reports of pilots and experts are received with reference to groundings in places where, on the chart before them, they believed that they could navigate in safety. It is certain that in the future it will be necessary to revise and to

take check soundings for even future hydrographic work as this is the only means of keeping charts satisfactorily up-to-date, for hydrographic work is human handiwork and therefore imperfect, even though carried out always with a full sense of the heavy responsibility entailed; this sense of responsibility has been a great stimulant to conscience, for every error on a chart may react on human life and material goods.

MODERN MARINE CARTOGRAPHY.

A course and the navigable route in the middle of the dangerous " fald " and amongst the breakers was sought by means of the submarine sentry, a remarkably ingeniously constructed explorer of the bottom which has so often been of inestimable utility to surveyors, both to assure themselves of a given minimum depth while cruising and to examine and sweep out an area wherein large differences of depth are an omen of possibly foul ground. How many times has the alarm bell of the submarine sentry sounded in our ears giving notice of doubtful shoals in waters which are reputed to be navigable, and a smile of satisfaction spread over the faces of all when a mark-buoy was dropped over the stern?

All data with reference to depth must be reduced to low water level and observations should be taken as often as occasion arises. A thin galvanized steel cable is usually used as a sounding line or else a soft iron wire; in very shallow waters and in work connected with the outlining of a danger zone a hemp sounding line is usually used.

The danger zone just mentioned, or more accurately the safety line, represents the depth curve which forms the limit between navigable and unnavigable waters; for *passages between rocks and coasts* this depth is generally 6 metres and this can be also considered as the usual limit for ordinary coasting. In places, however, where the swell may attain considerable proportions the safety line must represent a clear depth which will give full security — 10, 20 and even up to 30 metres — in other words the safety line should be extended to the greatest depth up to which it may be expected that bottom dangers might exist (*).

Observations for magnetic declination are taken and these form an important branch of hydrographic work; they are taken whenever occasion arises all along the coast. For this purpose the instrument used is the *declinometer*, whereas to obtain the direction of the meridian, observations of the sun are employed. *N. B.* We have done our best during this work to obtain a reliable value of the *annual decrease*.

When the work of making a hydrographic survey in a district has advanced to such a point that sufficient material is in hand for the publication of a new chart, the plotting sheets are examined and adjusted in the offices

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(*) The constant increase in the draft of ships in the meanwhile causes that the 10 metre depth line will be shown in future in passages between rocks and the coast in such places where it is likely that heavy draft vessels will pass.

of the Sjökartverk. As the chart is the representation on a plane of a small portion of the surface of the Earth, and as a spherical surface cannot be exactly developped on a flat surface, it is but necessary to see that essential conditions are carefully observed.

For charts, this means that the lines representing courses may be drawn as straight lines. Courses or rhumbs are really spiral curves (loxodromic spirals) which cut all the meridians, through which they pass, at the same angle, seeing that all the meridians meet at the pole. But, if they were drawn in this way, it becomes immediately evident that practical difficulties would arise in laying off courses and in laying off and measuring distances. For this reason a representation is sought on which the meridians are *parallel*, and this condition is fulfilled by the *Mercator* or *increasing projection* in which all the meridians are straight and parallel lines perpendicular to the parallels of latitude, which likewise are represented as parallel straight lines. The parts of the parallels of latitude comprised between the meridians are of the same length as the corresponding parts of the Equator; they must, therefore, be increased in proportion to the secant of the latitude of the part of the parallel, and this condition must likewise apply to the parts of the meridian. Consequently the distinguishing character of Mercator's chart is that the distances between the meridians are equal all over the chart, whereas the distances between the parallels of latitude increase gradually from the Equator to the Pole. This condition anyway is necessary in order that the courses between any two points should be correct and should give the right distances.

The Mercator chart is constructed on this principle. This projection is used by the Sjökartverk for all charts on 1:100,000 and on smaller scales.

Smaller areas on the surface of the earth are frequently shown by means of other projections. For our later special charts on large scales the polyconic or polyhedric projection is now used; in these the surface of the earth is assumed to be divided up into zones by the parallels, about twenty minutes, for example, apart. The conic projection is used for each zone, the cones being tangent to the earth's surface along the zone's parallel of middle latitude. These conical surfaces are so small that they may be taken practically to coincide with the earth's surface. The middle latitude parallel of the conic surface is equal to the latitude parallel of the earth's surface multiplied by the scale. The other parallels are slightly bigger on the charts but the difference is imperceptible. It should be noted that, in this projection, the meridians are convergent straight lines meeting at the summit of the cone, whereas the parallels are not straight lines but arcs of circles which are concentric with the parallel of mean latitude. In practice, in constructing these charts, the portions of parallels are represented as broken lines, and in reality only the points where the breaks occur coincide with the arc. In this projection which, as stated above, is used for our large scale charts and principally for the draft charts, the so-called " drafter " (charts on the scale 1:50,000), courses and bearings may be laid off as straight lines without introducing an appreciable error as is also the case with the Mercator chart; it is necessary, however, in certain special cases, where particular accuracy is required, to use the nearest compass rose for the laying off of ma-

gnetic bearings, and the nearest meridian for laying off coördinates and distances. *The reproduction of charts and their printing* is carried out by the Technical Section of the Geografiske Opmaaling.

For *copper engraving*, which is the best from the point of view of fineness and accuracy, besides giving clearer reproductions, the original hydrographic work is transferred mechanically by tracing on to the polished laminated copper plate and the drawing is engraved directly thereon. After this the part to be printed is inked with printer's ink. In order to obtain a perfect impression which adheres to the paper it is necessary that the paper should be damped before being placed in the press (copper plate press). Besides it is necessary to clean the copper plate carefully and ink it again for each new copy, and this naturally requires considerable time. For this reason, within recent years, transfers on to stone of the charts engraved on copper are used, or more frequently of charts engraved on aluminium, and this made it possible to do the printing with a rapid printing press. In order to make a transfer the copper plate is inked with printing ink of special composition and then a proof is struck off on thin unsized paper which is then pressed against a plate of polished aluminium. The paper is then removed from the plate which is treated with a *solution of gum, lithophine and colophane*, and *talc* until the drawing shows up again in sharp and clear lines; the plate is then ready for printing in the rapid printing press (*).

As will be easily understood, engraving on copper takes a relatively long time and, as it is necessary to make the publication of charts the most rapid process possible in order to keep them in agreement with the information received, *heliogravure and photoalgraphy* are used for reproduction of large scales, and in these the reproduction is carried out by a *chemical* process.

For heliogravure the finished drawing of the chart is transferred on to a copper plate by the following method:

After having photographed the chart, a gummed sheet of paper impregnated with gelatine and colouring matter (pigmented gelatine paper), which has been sensitised beforehand by immersion in a bath of potassium bichromate, is applied on to the back of the photographic negative. The paper is then exposed for a few minutes to the action of light, after which it is taken off the plate and stuck on to a polished silver-plated copper plate on which the drawing is developed by placing the plate into tepid water which is gradually warmed to a temperature of about 50° C (122° F). The paper is detached after about a quarter of an hour and soon afterwards that part of the gelatine-pigment which has not been subjected to the influence of light - thus remaining soluble in hot water — detaches itself.

As a result, a true copy of the chart appears on the copper-plate in raised gelatine relief.

The copper plate is made electrically conductive by covering it with graphite and it is then used as a *cathode* in a bath of copper sulphate in which

(*) A new method of transfer — the Velox method — has recently been worked out by the Technical Section of the Opmaaling.

another plate of laminated copper is used as anode. When an electric current is passed through the bath galvanoplastic copper is precipitated on to the alto plate until, after three or four weeks, it is sufficiently thick to make it possible to separate it from the alto plate and to use it as a printing plate.

In this way, in about a month, the fair sheet can be transferred galvanically on to the copper plate.

Another and distinct method which is quicker and less costly, though it does not give as fine a reproduction, is the so-called *photoalgraphic* method in which a photographic negative reversed is reproduced directly on to an aluminium plate covered with *chromic albumen*, after which the drawing is developed by placing the plate in cold water which dissolves the parts of albumen which have not been exposed to the light, whereas that which has been exposed, *i.e.* the drawing itself, remains on the plate.

The plate is then dealt with as in heliogravure with the same solution and after one or two days it can be used for printing in the rapid press.

It should be remembered , however, thet the above two methods of chemical transfer require careful correction (a correction which is inherent to the process) seeing that differences may very easily develop during the process of reproduction.

During the last 2 years our charts have been stamped with the " autoengraver ", a copper punching machine recently invented by the lithographer, Inspector PETERSEN, of the Norges Geografiske Opmaaling — by means of which names and soundings are *punched* into the copper plate with unusual speed and with both accuracy and good appearance, while the contours are engraved by hand.

PROVISIONAL CHARTS.

With the object of more rapid issue of the results of hydrographic work for navigation and fishery purposes along our coasts we have, within the last five or six years, started the publication of certain charts which are known as " provisional charts ". These are a sort of accelerated issue of the results of the latest surveys.

Naturally these provisional publications are likewise constructed from the original work of the surveys, but they are not examined in any way with the object of improving the appearance of the drawing, which may be homogenous or somewhat sparse ; it is necessary to do this on ordinary charts before they are put on sale. A small direct copy suffices ; a photographic reproduction of the results of the survey is obtained and arrangements are made so that the meridians and the parallels are reproduced by the photolithographic (photoalgraphic) method. This process takes from two to three days.

On the other hand it is customary to provide charts with a graduated frame, with a scale, with compass roses, and to add notes as to magnetic declination and all sorts of information concerning lights, permanent objects, etc. ; in other words these details complete the final chart, yet the document thus obtained has no greater value than the provisional chart.

By this method it is possible to issue the chart much more rapidly; the chart can be on sale within a month or two after the completion of the field work whereas, before this system was introduced, lengthy operations including corrections, improvement of the drawing, etc. had to be done. For this reason this method has been generally approved.

INTERIOR ORGANISATION.

With reference to the question of *organisation* pure and simple, it was only at the end of the 60's that the so-called Hydrographic Section was created with a Naval Officer as its chief. This gave a concrete and systematic form to both surveying for, and publication of, charts. It had become evident that, if the organisation were to be appropriate, technical men should be at the head of the section. The results given during the years immediately following showed that the direction of the work was in the hands of experts, who alone are in a position to judge what should be hastened and to estimate the quality of the work carried out. In the plan which was drawn up it was proposed to make a hydrographic survey of the whole coast, for GROVE's surveys and those of Nordland and Finnmark, having been carried out hastily in order to meet the urgent needs of navigation (which at that time had not sufficient charts), no longer fulfilled the requirements of the traffic which was growing exceedingly rapidly. Shipping had the right to require that navigable waters should be opened to it; careful research should be carried out in the future in connection with such an indispensible aid to seamen as charts; but development proceeded but gradually. Before long the issue of charts was accompanied by the publication of the corresponding Sailing Directions. *Notices to Mariners* were published in monthly parts; systematic observations to determine magnetic declination were again undertaken, as stated earlier, and these researches were started mainly in order to keep the charts up-to-date, which is absolutely indispensible in order to give us their full value when in use.

Appointed as Chief of the Hydrographic Section, the expert who became Director was really but the Director of work connected with marine cartography, on whom rested the moral responsibility of the undertaking. But for administrative and disciplinary purposes it was the Chief of the Geografiske Opmaaling (military Staff Officer) who was responsible. This abnormal condition gave rise to various proposals to detach hydrographic surveys completely from the Geografiske Opmaaling, and this proposal was frequently brought forward. Following on the decision made in 1911 by the Defence Department, Colonel BULL was appointed Chief of the Service and it was thought that the change was about to take place. But the Military Department offered strong resistance, maintaining that the organisation, which was already of long standing, could in no way interfere with activities in connection with hydrographic surveys, besides maintaining that the change would entail an increase in expenditure. As a final result, and in accordance with order

given in 1912, the Hydrographic Section had its name changed to the " *Norges Sjökartverk* ". Rules were drawn up to govern the connection between the Geografiske Opmaaling and the Sjökartverk, and these gave to the latter complete independence with reference to everything in connection with the organisation of the work and its execution.

The Chief of the Sjökartverk organises and directs, on his own responsibility, everything in connection with the preparation of the charts, their revision, their issue, and all the administrative and financial part of the work. The Sjökartverk's budget, which a few years ago stood at 420,000 Kr., was considerably reduced this year (1928) by the Department and reached about 292,000 Kr. only although the Sjökartverk put forward an estimate of 335,000 Kr. for ordinary expenditure, and 400,000 Kr. including the extraordinary expenditure intended for the acquisition of a modern surveying vessel and a modern sounding sweep.

The Chief of the Sjökartverk is responsible, also, for the publication of Notices to Mariners and Sailing Directions. He obtains from the Director of the Opmaaling the fundamental trigonometric data for the bases of marine surveys, as well as all *technical* work in so far as their execution belongs to the Technical Sections of the Opmaaling (engraving, printing, photo-galvanoplastic sections). With reference to the collaboration with the different sections of the Opmaaling, such as fixing the hours of work, etc., he bases his orders on those given by the Director. A new system which embodies some change was drawn up in consequence of the Royal Decree dated 20th. May, 1927 (*).

The work of the Sjökartverk is divided into the following sections:

1. The practical carrying out of hydrographic surveys in the field, including coast-lining and sounding of all the coastal zones, as well as deep-sea sounding, revision of such work and the making of magnetic observations.
2. Calculation, construction, compilation and drawing of new charts.
3. Secretarial work, in which is included the supervision and maintenance of surveying vessels, their provision with crews, and the drawing up of general charts and all catalogues.
4. Revision of charts and their maintenance up to date including the control of the chart depôts, and the colouring on charts (colouring of the light sectors).
5. The gathering of information from , and the revision of " Den norske Los " (coastal Sailing Directions in ten volumes). To this is added the inspection of instruments and of all the special cartographic documents of the Navy. Charts and maps are sold to the public.

Seven Hydrographic Surveyors are regularly employed in carrying out this work, and these are either permanent or temporary Naval Officers, and one or two other officers are engaged temporarily when need arises. Lately the office employed two cartographers and two assistants as well as a large number of minor employees for the colouring of charts.

(*) In 1930 Parliament decided that " the Sjökartverk " (*Hydrographic Office*) *shall hereafter be separated from the Norges Geografiske Opmaaling and be organized as an independent institution under the Navy Department.*

For practical work at sea, ten or twelve Hydrographic Surveyors are employed usually, who with the necessary crews, make up a total of about fifty men serving in a total of 20 surveying vessels, of which two are large sea-going steam launches, and 4 are smaller steam launches; there are also one large motor-boat, 5 smaller motor-boats, and 8 cutters for housing purposes.

It may be of interest to say a few words on the more specialized work which the Sjökartverk has carried out.

At the suggestion of Professors MOHN and SARS, the " Norwegian Expedition in the North Sea " was fitted out in 1876. The programme of this expedition included deep-sea sounding in the above sea, meteorological observations, determinations of the temperature of the sea-water, its chemical composition and zoological research. This expedition ended in 1878, according to programme, and the waters appertaining to Norway, the Færoes, Jan Mayen and Spitsbergen had been covered. The steamer *Vöringen* was hired for the purpose and placed under the command of Captain C. F. WILLE, with Lieutenant R.M. PETERSEN as second-in-command; J. GRIEG who, until the vessel was hired, had been in command of her, was appointed as Navigator; the scientific party of the expedition included Professors MOHN and SARS, Chief-Surgeon DANIELSEN, Mr. FRIELE, and Mr. SVENDSEN, student in chemistry, and finally, as draftsman, the landscape painter SCHIERTZ.

In 1896, the then chief of the Section, Captain S. H. MÜLLER accompanied the Swedish expedition which made hydrographic research in the Skagerak and the Kattegat, under the leadership of Professor PETTERSON and Civil Engineer EKMAN on board the gunboat " *Svensksund* ", which had been placed at their disposal, and was commanded by Captain ULFF. In 1903 Captain MÜLLER went to France and Germany in order to visit the Hydrographic Offices of these countries. In 1904 Captain MÜLLER was appointed as member of the boundary Commission, in collaboration with the Swedish Inspector of Pilotage STEENBERG, on the Norwegian-Swedish Commission for the fixing of the boundary channel from the head of the *Iddefjord as far as the mouth of the " Soekken " near Herföl.* For this particular part of the boundary waters between Norway and Sweden, the Grisebo Fairway, the limits were submitted to arbitration at the Hague in 1910. This boundary commission included also the Chief of the Section of Hydrography, Captain LUNDQUIST, who had surveyed the Grisebo Fairway.

Navigational charts are reproduced and printed by the Geografiske Opmaaling. The price of these charts has varied very considerably; special charts (so-called draft charts) for example have risen in price from 1.00 Kr. to 3.00 Kr., which is the present sale price. The price of 4.00 Kr. has been fixed for the new general charts, and the chart of the North Sea in 3 sheetsnow costs 8.00 Kr.

Attention of sales agents and users of charts is directed by the Sjökartverk to the following:

With reference to the numbering of charts:

Numbers 1 - 200 are reserved for special charts on the scale of 1:50,000.
Numbers 201 - 300 are reserved for special charts on the scale of 1:100,000.
Numbers 301 - 400 are reserved for general charts on smaller scales.
Numbers 401 - 500 are reserved for special charts on the scale of 1:25,000.

All the charts of 1:100,000 and smaller scales (constructed on Mercator's projection, charts whose scale increase with the latitude) cannot be joined together unless they are based on the same parallel. In cases where the joining of charts has been specially considered, a notice to this effect is inserted on the charts. Charts on the scale of 1:50,000 and on larger scales (constructed on the polyconic or the Cassini projection) may always be joined together.

Notice should be taken of the following with reference to the keeping of charts up-to-date.

All Norwegian charts are corrected and stamped with the date of the beginning of the month when they left the sales office of the Geografiske Opmaaling. Corrections subsequent to this date are made known by means of Notices to Mariners. Large corrections include those due to the establishment of new lights, beacons and other sea-marks and changes made in those already existing. On all charts in stock the Opmaaling makes these corrections when it receives information of the change in system of lights and other marks, *i.e.*. usually during the second six months of each year.

In addition to these corrections which are more or less regular, the annual results of new surveys and work of revision carried out by the Sjökartverk (Hydrographic Office) are also inserted on the charts as far as possible. Even the results of harbour improvements carried out by the port service are included when they are complete, as also are the results of more extended research when information received makes this necessary.

On account of the fact that charts must be continually kept up-to-date in this way, it happens sometimes that the same chart has to undergo correction several times during the year, consequently it is evident that the sales agents should only maintain a small stock which should be filled up by frequent orders. It is particularly enjoined on the sales agents that they should not keep stocks of such charts as experience has shown that the sale is next to nothing.

Should it occur that the chart has to be withdrawn on account of extensive corrections, the agent's stock in hand of this chart remains on deposit until it is exchanged.

Generally speaking there are no other cases which require a change of charts.

When a chart is bought, note should be taken of the month stamped on the chart, as showing that it has been corrected to that date ; then, by means of the Notices to Mariners, it may be determined how far the charts have received the latest corrections. Every purchaser of Norwegian charts, on which corrections have been inserted since the date shown by the stamp, has the right to receive gratis from the Sales Office in question, or from the Norges Sjökartverk, copies of the necessary material for the monthly correction of these charts.

The more important hydrographic information is brought to the notice of those interested as quickly as possible by means of Notices to Mariners, and, should occasion arise, by wireless, through the press, or by printed notices.

Attention is directed to the fact that the great increase in detail of lights within recent years has made it impossible for charts, even those on a scale

of 1:100,000, to show all the details without impairing the accuracy of the charts. It has been found that, under these circumstances, it is better not to show the sectors of lights and merely to put a circular yellow spot to mark the light.

For the details of the lights recourse should be had to the Norwegian Light List, and to the Notices to Mariners, which documents should always accompany the charts.

Captains, pilots and other competent persons who are in a position to give information affecting navigation, are urgently requested to send such information as soon as possible to the Norges Sjökartverk at Oslo. For the purpose of keeping our charts up-to-date information with reference to the discovery of new dangers and shoals, as well as any other hydrographic information which can be used for that purpose, is particularly useful. All correspondence on this subject which emanates from within Norway may be sent in an unstamped envelope.

The number of charts consumed has undergone considerable variations; thus during the last two or three years a by no means negligible decrease has occurred, whereas from 1890 to 1925 the increase was very considerable (from about 10,000 to 60,000 per annum). The explanation of this increase is natural, at any rate for the greater part, in that the number of individual charts was increasing, but it is connected, also, with the fact that, from one end of the country to the other, every seaman and fisherman was anxious to own for himself the charts which interested him.

The days are past when the valuable documents such as navigational charts lay forgotten in the archives of the Admiralty, as was the case in the happy days of JENS SÖRENSEN. In our days a chart is one of the indispensible auxiliaries which must be on board every ship; it is also an object of criticism when judiciously employed, both on the part of those whose custom it is to plough the seas and of the small fishermen and boatmen.