DEEP SEA ECHO SOUNDINGS AND THEIR IMPORTANCE FOR NAVIGATION

(Extract from an article by W. MÖCKEL in Der Seewart, Vol. 10 Hamburg, 1938.)

(Translated from the German.)

The echo sounding apparatus has experienced a technical transformation which insures high accuracy of measurement in shallow water and therefore adequately fulfils the requirements of practical navigation. On the other hand, the needs of the navigator who requires deep sea soundings as a daily procedure on board ship have not been met. Reference to the lack of such a sounding apparatus, which should find a wide field of application in ocean shipping, appears necessary because, among other things, practically all publications on the subject of echo sounding seem to be preoccupied with the question of the scientific value of echo soundings and do not touch upon their importance to navigation. This tends to give the manufacturers the impression that there is no practical field of application for the deep-sea echo sounder, that it is not desired, and that consequently the "surveying type" is suitable for this purpose. This point of view is erroneous. On the contrary, such an apparatus would be assured of a benevolent reception and would, from the economic standpoint, rapidly acquire a correspondingly large market provided — presupposing the technical solution of the problem — the nautical requirements could be met.

First of all the apparatus must be put on the market at a reasonable price. Possibly the present-day rather high price of the apparatus has something to do with the fact that up to date only four large German merchantmen are equipped with this important device. The apparatus, comprised in a single instrument, must be capable of measuring all depths from the greatest to the least. Further, it must be capable of functioning in all weathers, and must operate quietly and perfectly under all conditions as well as give accurate results. For great depths, however, an exaggerated accuracy of measurement is not required : thus at a depth of 1000 metres a discrepancy of the order of ten metres is of slight importance. This does not mean, however, that the results should not be as perfect as it is technically possible to make them.

From the following descriptions of a few individual cases of stranding which have actually occurred, the manufacturers of the echo sounding apparatus should realise that the navigational importance of echo sounding must be indicative of the future line of development and that, further, the usual present-day "navigational types" which are serviceable only to 500-1000 metres cannot meet the requirements of sea-going vessels. This is shown by the fact that in practice, on approaching a steeply shoaling coast in thick weather the sounding apparatus, which only goes to 500 metres, is switched on while the ship is still in very deep water for the sole purpose of obtaining soundings the moment the coast is approached, so that constant checks on the navigational fix can be obtained. Given the present-day state of technical development this procedure, which reveals a real desire for a deep-sea sounding apparatus, should be considered as a make-shift and not as a condition which should obtain permanently.

In connection with the accuracy of measurement there is the problem of the variation in the velocity of sound-waves in sea water in the various regions of the oceans resulting from differences in the physical constants of density, salinity and temperature. Since, however, as stated above, for purposes of navigation a very high degree of accuracy in the measurement of depth is unnecessary, the question of such variation in velocity can be neglected. In many cases such regions of nearly equal sound velocity in the oceans might be delimited on the charts or indicated in some other more practical form, if it is desired to increase the accuracy of the echo soundings. In the publication *Lehrbuch der Navigation* (Text-book of Navigation) by MELDAU/STEPPES, is a proposal to draw on the marine charts certain lines of so-called "equal sound velocity".

The liquid filaments which flow alongside the ship's hull have also a particular influence on the result of the sounding. Above all when the ship is labouring hard, the reception of the echo may suffer notable perturbations, because water mixed with air opposes an extremely high resistance to sound. It follows that the *choice of emplacement* for the apparatus to be mounted in the bottom of the ship must be made with great care and competence. As, on the

other hand, experts hold that it is possible to find on each ship a suitable place for the echo-sounding plant, the mounting of reliably working echo-sounding gear in ships, whose models have been towed at the model testing basin of the Hamburg Shipyards, could be perfected by extending the research to the determination of the most favourable location for these apparatus in the ship's hull.

In the following examples cited from the accounts of the stranding of various ships, we shall demonstrate the great advantage accruing from the use of deep-sea soundings off a steep coast while navigating in thick weather, as well as the nautical value of good bathymetric charts of such steep coasts.

A freighter bound from San Francisco to Mazatlan stranded on Castle Rock in a thick fog as a result of the set of the current and an erroneous application of too much easterly deviation. This rock lies off San Miguel Island on the West Coast of the United States. (See point 2 on Bathymetric Chart : Plate page 118). Owing to the uninterrupted fog no fix could be obtained after leaving San Francisco Lightship (point 1 on chart). The ship was navigated by dead reckoning (patent log full out), and at the time of stranding the D. R. position was some 34 miles SW 3/4 S of the place of the accident (point 3).

Had the Bathymetric Chart of the Hydrographic Office been used in connection with the deep-sea sounding apparatus, immediate indications of an abnormal easterly set would have been obtained on passing the wedge-like gully which projects into Monterey Bay. The distance between the two 1000-fathom lines converging to the eastward is about 23 miles measured along the vessel's course. In between, the depth suddenly increases to more than 1500 fathoms, while at a point representing a set of only three miles to the eastward the distance between the 1000-fathom lines is only nine miles and the greatest depth in between the lines measures only 1400 fathoms. If the easterly set is greater than three miles the discrepancies become even more striking. But even had these warnings passed unnoticed, the navigating personnel would have soon been made aware of the dangerous easterly set as the echo sounding apparatus would have indicated rapidly shoaling water which would soon have amounted to 1000 fathoms less than the depth shown on the chart at the assumed position. On the other hand, had the navigation been directed towards steering for certain well-defined points on the ocean bottom, somewhat as shown by the dotted course line on the chart, certain very definite points could have been determined which would have been of inestimable value in checking the position under the prevailing conditions of visibility.

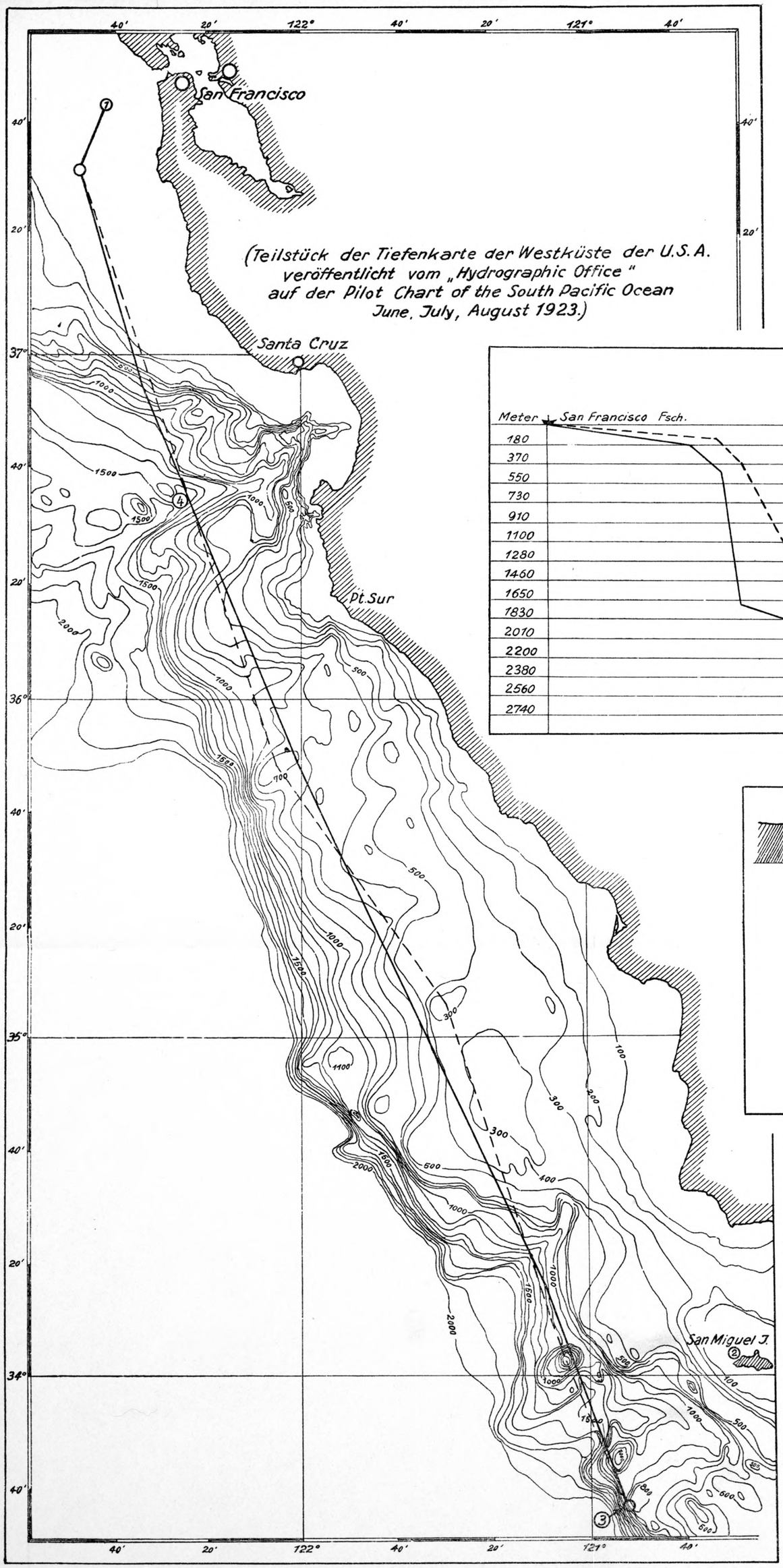
After having crossed the eastern end of the 1500-fathom limit of the steep, pointed gully projecting into Monterey Bay (point 4) and following the straight line course plotted, one reaches a flat shoal of 700 fathoms lying within a bay of some 800 fathoms' depth. A change of course of —17° then leads to a shoal of limited extent, with least depth of 300 fathoms after passing along the 400-fathom line. If the course is then changed +17° one passes along the edge of a 300-fathom shoal and later traverses a sharply indented bight whose greatest depth is 1300 to 1400 fathoms, and which is about 23 nautical miles from the last 300-fathom shoal. A certain fix is then given by steering for a mountain peak which rises abruptly from the 1100-fathom ocean floor and within three miles reaches a height of 500 fathoms below the surface at its peak. If this mountain peak should not be found then it is easy to determine on which side one has passed it. With an easterly set one finds depths of 1000 fathoms and less, while with a westerly set one obtains soundings of 1300 fathoms and more. The above description shows clearly that had the navigation been based on deep-sea soundings the stranding could not have occurred. A detailed explanation of piloting a ship using the deep-sea sounding apparatus and the radio direction-finder together with the above-mentioned bathymetric chart, has already been given by Captain C. Schubart in the publication *Der Pilote* N° 15/1925.

To be sure, few carefully prepared bathymetric charts based on thorough systematic soundings of the coasts are available to the navigator, and he is generally obliged to resort to the meagre depth indications found on the ordinary marine chart. Even then such areas are not entirely lost for the purpose of navigation based on deep-sea soundings since one can always derive from them certain information which is of value in helping to fix the ship's position. For example, if one studies the ordinary chart of the California coast extending along the above mentioned region, it is readily apparent that had this chart been used in connection with deep-sea echo soundings the accident need not have occurred.

The representation in Figure 1 is the profile of the ocean bottom (full line) along the probable course shown on the chart (dotted line) drawn from data obtained from the ordinary marine chart. Depth lines are drawn through the representation at intervals of 100 fathoms. (To the left the depths are in metres and to the right in fathoms). In spite of the scarcity of data on this older chart, the imposing formation of the ocean canyon in Monterey Bay

Courses steered as shown on the American Bathymetric Chart N° 5194 of March 1923.

Routes suivies d'après la Carte Bathymetrique Américaine N° 5194 Mars 1923.



(Teilstück der Tiefenkarte der Westküste der U.S.A. veröffentlicht vom „Hydrographic Office" auf der Pilot Chart of the South Pacific Ocean June, July, August 1923.)

Abb. 1

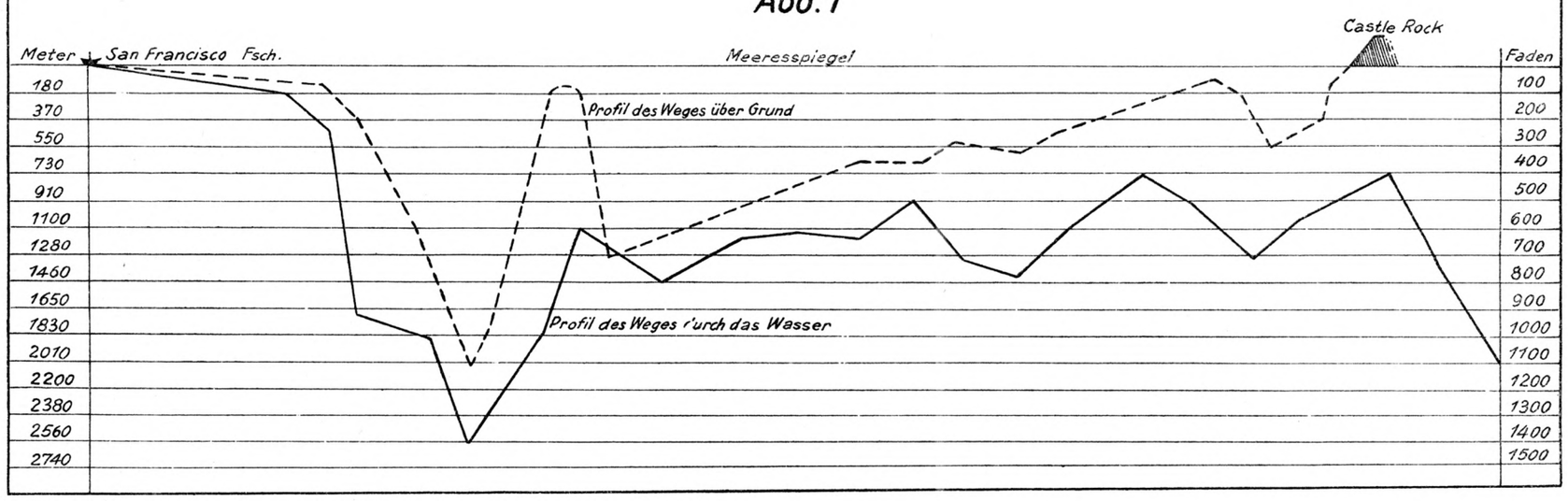


Abb. 2

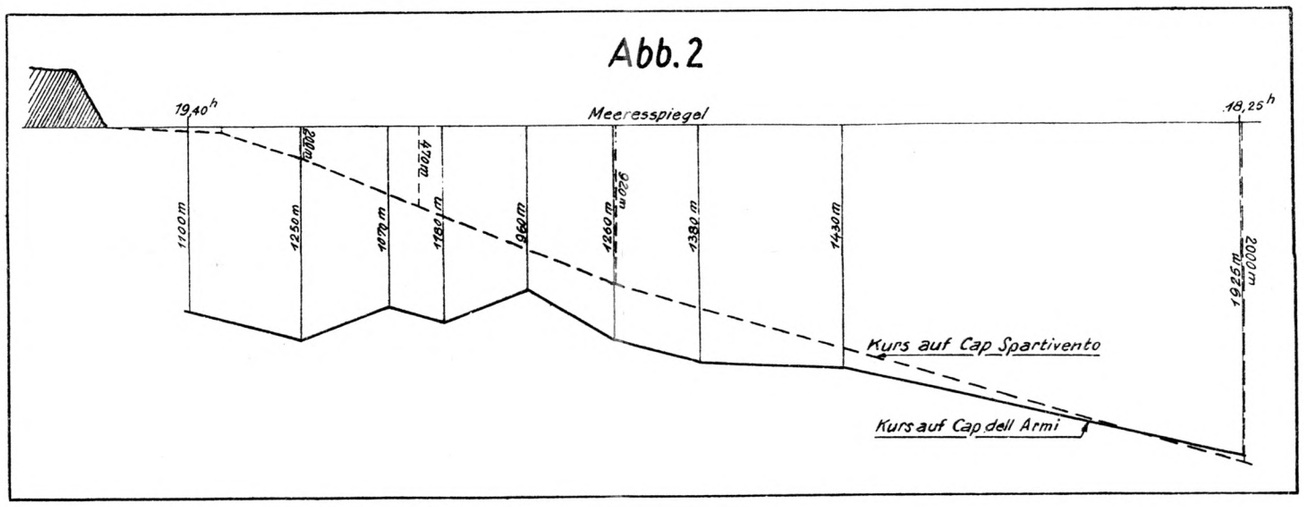
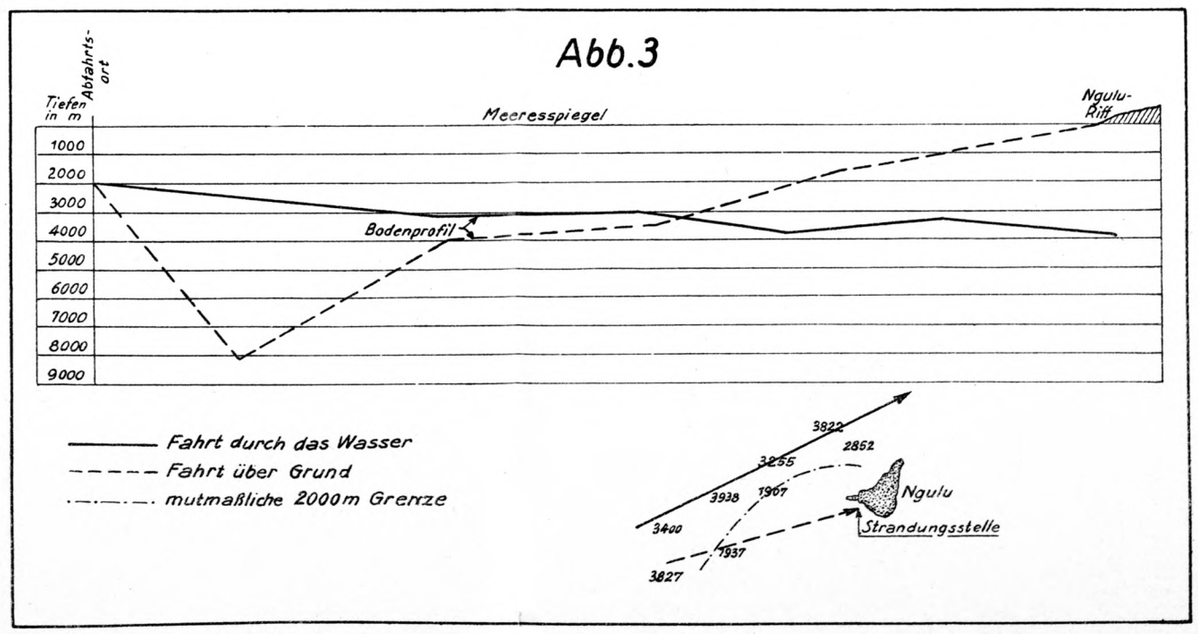


Abb. 3



stands out distinctly, and permits as easy a determination of the easterly set of the current as when the bathymetric chart is used. If one glances at the gully tapering off to the eastwards one sees how much greater are the intervals between the 1000-fathom curves along the course in the foreground than those of the eastwardly displaced course over the area in the background. The subsequent differences in the shape of the ocean bottom profile in the two cases would, in accordance with the chart data, have clarified the question as to which course was actually being steered.

The following narrative of another stranding not only shows clearly that the disaster might have been avoided by the use of deep-sea echo sounding apparatus, but enables its utility to be clearly recognised when making for certain points in thick weather : in this case the Straits of Messina.

A passenger steamer coming from Port Said bound for Genoa stranded near Cape Spartivento (Southern Italy) owing to the erroneous assumption that the lighthouse sighted ahead was that of Cape dell'Armi (Southern Italy). On the day of the stranding the ship sighted a lighouse at 17^h50^m, between two rain squalls and under generally poor visibility conditions, which was at first correctly taken to be Cape Spartivento and then later erroneously assumed to be the light-house of Cape dell'Armi. The subsequent navigation of the ship was based upon this fatal assumption. At 18^h25^m the distance from the light was 20 miles ; course was changed to NW1/2W which, had Cape dell'Armi lighthouse been ahead, ought to have led into the Straits of Messina but which, as it was, led the ship towards the shore. At 19^h40^m, course was again altered to 335° at a distance of about 2 miles. The steamer was then headed about at right angles to the coast which, owing to the darkness and the poor visibility, was sighted too late. Shortly after the ship ran aground.

Even a very casual examination is sufficient to show the differences in the profile of the ocean bottom on the course leading to Cape Spartivento (Fig. 2, pecked line) and the course to Cape dell'Armi (full line) and to demonstrate the fact that a reliable sounding apparatus would have shown with certainty at a point at least half-way between the 18:25 position and the 19:40 position (the latter being near the locality of the stranding) that the ship was not in the deep water of the Straits of Messina but was headed for the shore. Bearings taken to supplement the information obtained from the echo soundings would have sufficed for an exact fix of the ship's position : which never could have been off Cape dell' Armi but only near Cape Spartivento, since the ocean bottom rises very gradually near the latter while off Cape dell' Armi the shoaling is very abrupt. Off Cape Spartivento the 200-metre line is about 3.5 miles off the coast while near Cape dell'Armi it is only 0.5 miles offshore.

For purposes of clarity, in Figure 2 as in the other examples, the scale of the depths is many times exaggerated in relation to the scale of horizontal distances.

In Hansa N° 26/1926, Captain Schubart further emphasizes his summons to the seafaring world to introduce the deep-sea echo sounder in the service of navigation, by the convincing narrative of three strandings on steep coasts, tried in the Maritime Courts. This concerned the steamers *Bound Brook*, which ran aground on the Rum Cay Island, *Madelaine Rickmers*, which was lost off Vries Island during a voyage from Tokyo to Kobe and, finally, *Prinz Waldemar* which, on a voyage from the Palau Islands to Yap, ran on the Ngulu Reef on 2nd May 1911, but managed to get clear with considerable damage to the bottom of the ship and a broken stem. Of these three cases we shall take up the last ; it deserves special attention because it brings out with extreme clearness the utility of deep-sea echo sounding for navigation in general and especially in the vicinity of reefs.

Subsequent to the last fix in sight of land off the Palau Islands the course of the steamer was set to pass clear of Ngulu Reef — about 24 miles to starboard. Contrary to the experience gained on preceding voyages, where a regular westerly set had been noted, the steamer was this time set to the East and ran aground on the reef, which in the darkness and by a mirror-smooth sea could not be made out. A glance at Figure 3 shows that an easterly drift (pecked line), existing from the beginning of the voyage, manifests itself by strikingly great depths which range between 3500 and 8100 metres, whereas the steamer according to the chart (continuous line) ought to have found only some 2000 to 3000 metres. After the first half of the distance from the Palau Islands to the reef had been covered, the depth conditions should have been reversed. According to the chart, soundings between 3000 and 4000 metres were to be expected, whereas the ship was passing over depths of less than 3000 metres. But lesser depths here point to a dangerously unsuspected easterly set and show that the westwardly extending shelf has been reached and that the reef is critically close. As the chart sketch shows, the 2000-metre line running West is, in this case, an excellent warner. Under no circumstances should it be crossed if the ship is not to run the risk of stranding on the reef, because courses which lead over water deeper than 2000 metres clear the reef quite well.

This stranding shows with particular clearness how decisively deep-sea echo sounding can come into play when navigating in the vicinity of reefs ; and the Captain's allusion before the Court to the fact that no soundings can be obtained in this region on account of the great depths, indicates positively that, now that the echo sounder is invented, modern high-seas navigation in presence of existing possibilities can, finally, no longer afford to dispense with the navigational data obtainable in deep water. The same opinion was previously expressed by Captain L. SCHBART in the *Ann. d. Hydr.*, etc. 1924, p. 75, where he states that :

> "After the invention of the echo sounder, ocean going steamers will in time be compelled to utilize the great ocean depths for navigational purposes. In this connection it must be particularly emphasized that the technical effort should be directed towards the design of reliably-operating instruments. As the problem is solved, there is no doubt that this effort will be successful. As soon as the echo sounders are introduced in service, the nautical charts will gradually fill with depth data which will offer the navigator greater security."

The preceding examples based on information gathered from marine charts also confirm the opinion that seamen should not let themselves be discouraged by the gaps in the knowledge of the ocean depths off many of the steep-coast stretches, and, above all, should not let themselves be misled into dispensing altogether with the deep-sea echo sounder. This ignorance, which will gradually disappear when the deep-sea echo sounder has been adopted on a large scale for navigation on the high seas, will on the contrary be a stimulant to the navigator to co-operate actively in the sounding out of such regions, in order to reduce existing deficiencies. Each deep-sea sounding taken in an accurately known position, after it has been sent to the *Deutsche Seewarte* for further analysis, enhances the value of future charts, the wealth of reliable depth data which returns with profit to the navigator in the shape of a solid groundwork for navigation with the deep-sea echo sounder off steep coasts. As a handsome subsidiary result, one may cite important disclosures in the realm of maritime geography, which presents many problems the general aspect of which were outlined by Captain E. RÖMER in *Der Seewart*, Heft 3/1938. While the nautical chart data may suffice for navigation with the deep-sea echo sounder, efforts must be made for the gradual publication of good bathymetric charts, because they alone offer the possibility of simple and sure orientation in thick weather.

However, the fact that the configuration of the ocean floor is steep on rare occasions only, as shown by the bathymetric chart, involves the question as to whether directed or non-directed sound propagation is appropriate for deep-sea echo sounding. The characteristic of non-directed sound propagation in providing too small a figure on sloping bottom surfaces may be considered, from a navigational point of view, as immaterial, because the ship's staff is incited thereby to greater attention and to keeping off the coast. On the other hand, however, erroneous conclusions as to the ship's position may be drawn. This question is finally answered by considering the purpose, which is to obtain measurements resulting in the highest degree of accuracy within the frame of technical possibilities. The solution of this problem is associated with the nautical requirements set out above for the purpose of future systematically-directed construction of the deep-sea echo sounder, and it is thus to be hoped that technical navigation, which precisely in periods of thick weather must carry out its difficult task reliably, will soon be enriched by a deep-sea echo sounder which will not only meet the needs of the nautical world but also correspond to the financial situation. The shipowner also must realize that a reliably-operating deep-sea echo sounder considerably facilitates navigation under unfavourable circumstances, thereby contributing essentially towards the ship's safety and efficiency — whereby the initial high outlay becomes remunerative. For enhancing the ship's safety any possibility must be thoroughly exhausted, and for this reason also the deep-sea echo sounder must no longer lead a modest life as "surveying type" but must become, in accordance with its nature and value, a constant apparatus of high-seas navigation.