# PROFILE, PLAN AND SECTION : THREE DEVELOPMENTS FOR SEA-BED SURVEY

by M. J. P. HEATON
(Smith's Industries Ltd., Kelvin Hughes Division)

The purpose of this article is to offer a response to some of the requirements, indicated in previous contributions, in underwater measurement and detection. The instruments described here were demonstrated to delegates during the International Hydrographic Conference in April 1967. Most of the accompanying records were taken during the course of the Conference.

## AUTOMATION IN DEPTH MEASUREMENT

Several schemes have been outlined for the automatic and rapid collection of hydrographic data. Being of a general nature, these ideas have not dwelt on matters of technical detail, so that problems arising in each information category may not have been fully recognised. This is particularly the case in depth measurement. Years of familiarity have enabled the surveyor to observe a recorded sea-bed profile in a highly selective manner. His interest is concentrated on the profile itself, and marks appearing in the mid-water zone of the record are ignored. These irrelevant signals are reflected by aeration, fish, turbulence or weed. Their appearance on the record depends upon their strength and the gain setting of the echosounder receiver. Therefore, although such signals are likely to be present, they are not necessarily recorded. It will be seen that the conversion of soundings to digital form requires more than the simple measurement of a time interval between transmission and reception.

Systems now exist in which soundings are digitized. In a system demonstrated at Monaco in April 1967 particular attention has been paid to the problem of selecting the sea-bed echo amongst extraneous signals, and in making the system completely automatic in signal selection and associated adjustment. Briefly, this is achieved by recognising the persistence and predominating amplitude of sea-bed echoes. The first of these qualities allows the use of a closely controlled self-adjusting time gate that restricts signal selection to only a small portion of the sounding cycle; the second quality is exploited by means of amplitude selection and gain control. These functions are completely automatic and the system locks on to the sea-bed a few seconds after switching on. " Automatic Digital Output " (A.D.O.) is fully described elsewhere [1].

It is considered essential to retain the conventional echo sounder record because this will contain other useful information. In addition, the record is used to monitor the performance of the signal selection and digital system. This monitor takes the form of a " white line " immediately following the sea-bed profile; the origin of the white line lies in the echo selection system itself. If an error does occur, the white line is interrupted at that point.

The rapid depth changes found in waters near Monaco offered impressive evidence for the automatic properties of A.D.O. In this case the echosounder was a shallow water hydrographic equipment having a maximum scale range of 100 metres. Continuous soundings and digital presentation were repeatedly made to 100 metres and beyond without attention.

Three sections of record are reproduced :

**Figure 1**

Near Monaco. This shows correct signal selection although strong mid-water echoes were present.

**Figure 2**

The approach to La Grenille. This record is of some technical interest in showing the response of the system to a steep rising gradient; taking the vessel's speed into account, the average rate of decrease in depth is 25 cm per second and at the steepest part the rate decreases at 83 cm per second. This is well within the theoretical maximum of 3.75 metres per second.

**Figure 3**

The approach and entrance to Monaco Harbour. A dense mid-water target has been recorded during about 200 soundings; two signal selection errors have occurred, as indicated by two interruptions in the white line.

## RELIABILITY OF SIGNAL SELECTION SYSTEM

It is interesting to compare the success rates of the system under two widely differing circumstances. In the first case actual survey operations were carried out in an area where the depth of water did not exceed 20 metres, but aeration due to shipping was particularly dense. Soundings were logged on a printer at a rate of 12 per minute. An analysis of the printed record showed a success rate of 97.7 per cent which is considered satisfactory under the severe conditions.

Operations in waters near Monaco were of a quite different nature. No shipping was present, but fish shoals and disturbances in the water were observed on a number of occasions. Furthermore, the system had to contend with very rapid changes in depth to the scale limit of the equipment. Examination of the " white line " monitor on the recorded trace shows a success rate in the order of 99.6 per cent.

## SIDE-SCANNING SONAR

This technique has been the subject of previous articles in the *International Hydrographic Review*. Great progress has been made during the past few years and inexpensive instruments are now available for general use. One of these was demonstrated during the 1967 conference. This design is simple and highly adaptable and offers scale ranges that are useful to the hydrographer.

The utility of the instrument has been quickly recognised, and there is no doubt that the information contained on the records is always useful and often dramatic. The rectilinear plan presentation and the good resolution of the system frequently allow immediate identification of natural and " man-made " targets, and the location of wrecks, pipe-lines and similar objects is now quick and reliable. The value of the instrument in " sweeping " between sounding lines is obvious. Rock outcrops are instantly recognisable by the complex pattern of strong signals and white shadows; individual rocks can be seen; changes in the grain size and texture of sand cause a change in the marking density of the record and the rectilinear presentation displays the shape and extent of such features.

The hydrographer will probably prefer to use the instrument in a negative sense, i.e. he will be content to sweep an area and accumulate featureless records. In some areas this will no doubt occur, but in others he may be confronted with a record similar to figure 4. This shows a rocky coastline, and the hydrographer may be perplexed at the sight of so many apparent obstacles. In this record the white shadows at the top extending to extreme range (275 metres) are caused by small islands or promontories above sea level. Other rock formations can be seen to cast acoustic shadows giving an indication of the height. The sea-bed is mud.

When the echo sounder was the only means of underwater investigation an isolated obstacle could be missed during a survey unless there were other reasons for making a sweep, or a sounding line happened to pass over it. The subsequent discovery of the obstacle would not reflect on the professional competence of the survey officer, but would rather emphasise the short-comings of methods available to him. Whilst the instrument mentioned here can effectively remove this uncertainty, an additional burden may seem to be placed on the surveyor who may find himself committed to examine all targets in detail and can no longer claim ignorance of their existence. However, this burden need not arise, for two reasons; first, the height of an obstacle can be quickly assessed from the simple relationship between shadow length, range and depth of water beneath the ship. Secondly, the instrument can equally well show those areas not requiring closely spaced sounding lines. Thus the surveyor can deploy his time and effort in proportion to the topographical complexity.

The records reproduced here show several matters of interest.

**Figure 4**

The track of the survey vessel lies along the left edge of the record (transmission zero line). The range across the record is 275 metres. The first signals are received from the sea-bed directly below the vessel so that a depth profile is obtained to a rather coarse scale. After each transmission signals are continuously received to one side of the vessel's track. Recorded scans accumulate to form a slightly distorted plan view of the sea-bed. The large white shadow near the middle of this record (A) is caused by a protruding rock formation and the shadow shows the height to be about 5.5 metres. It will be noted that the same rock feature appears in the vertical sea-bed profile and this confirms the approximate height of the feature.

Three conspicuous objects (B) appear close together in the centre portion; their shadows show the height to be about 8 metres.

At the left hand end of the record the seaward extension of Cap Drammont is clearly shown.

**Figure 5**

The white areas on the right are caused by rock formations rising above sea level. The point of interest is the tone contrast. The darkest markings are caused by rock formations. Faint markings indicate a soft sea-bed of mud. The mid-tone markings indicate areas of dense weed which lie at depths down to 40 metres. Patches of mud can be seen amongst the weed.

**Figure 6**

This shows a sweep past the Chretienne Light (C) which stands on a rock outcrop. The shadow caused by this small lighthouse illustrates the good angular resolution of the instrument. Towards the bottom there is a large object whose shadow indicates a height of approximately 2.5 metres. At the top an irregular area can be seen suggesting a deposit of fine material.

**Figure 7**

This record contains two points of interest. It shows that the apparatus is capable of useful work in a water depth of 195 metres. Also, it serves to

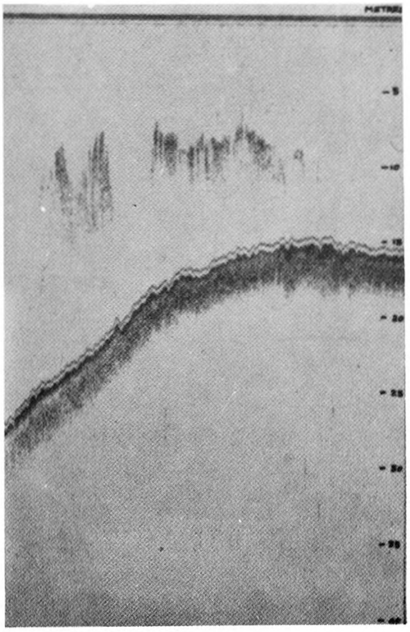



FIG. 1

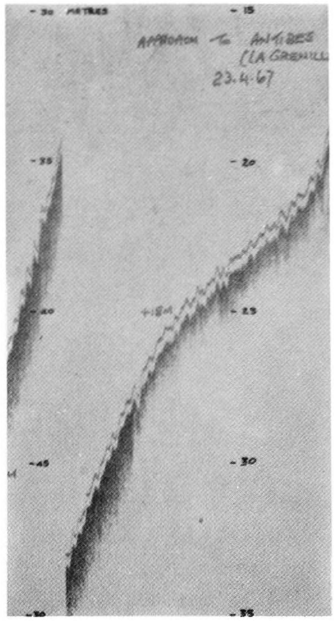



FIG. 2

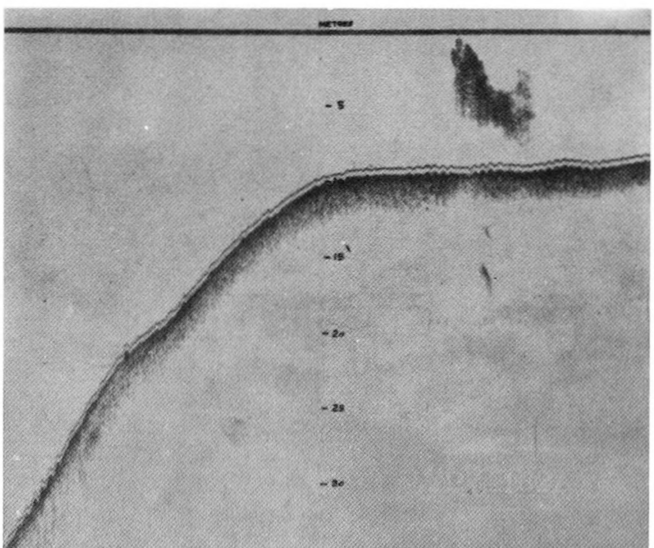



FIG. 3

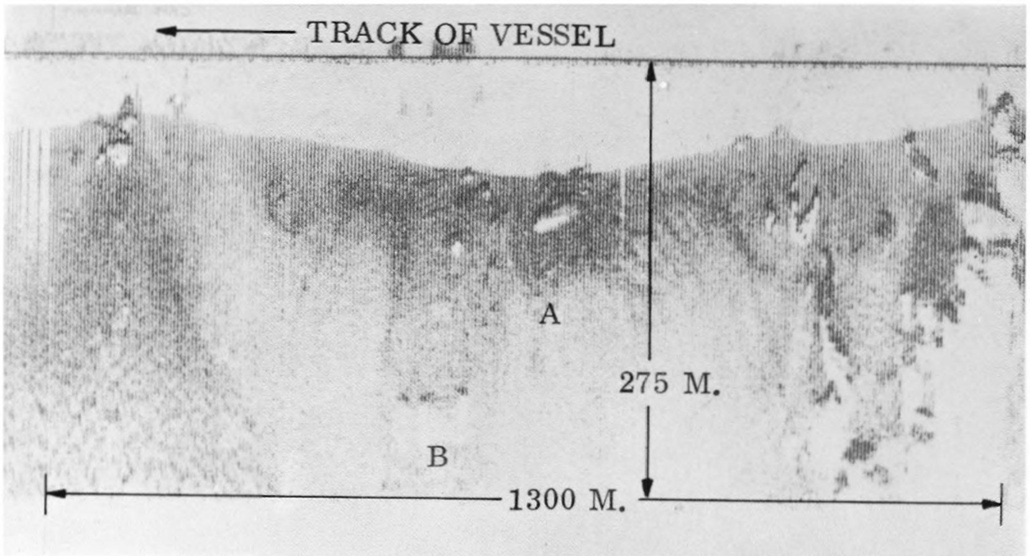
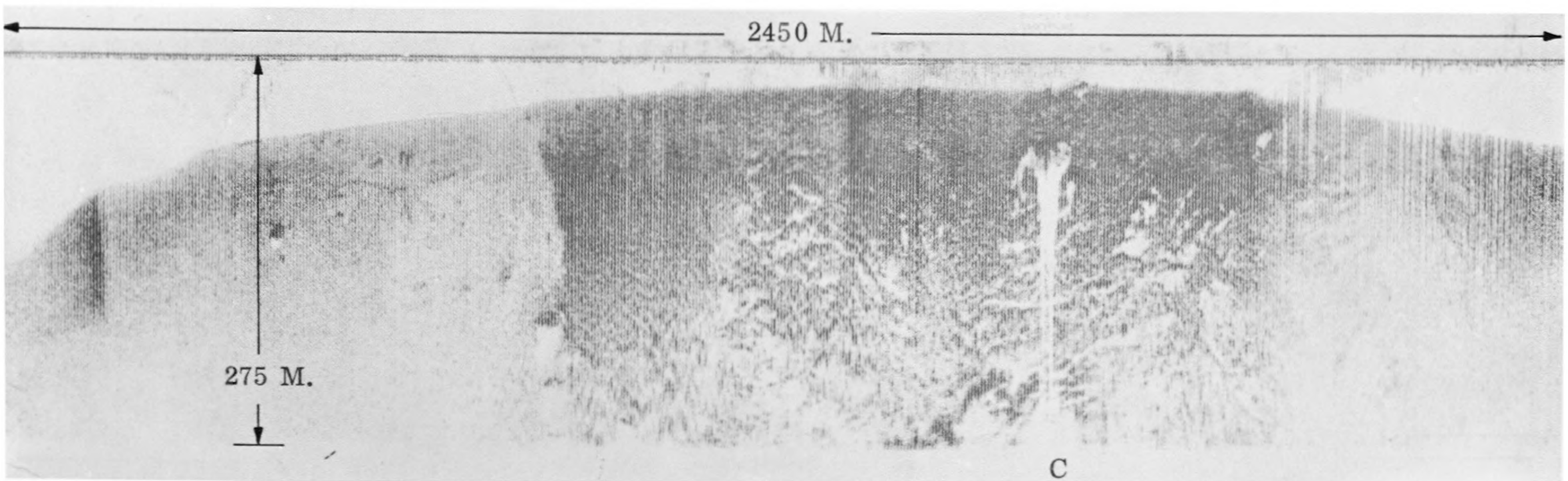



FIG. 4

FIG. 5



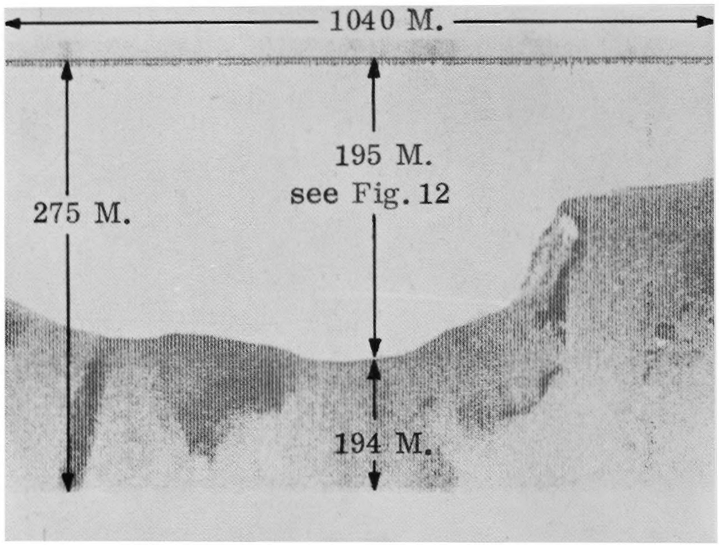



FIG. 7

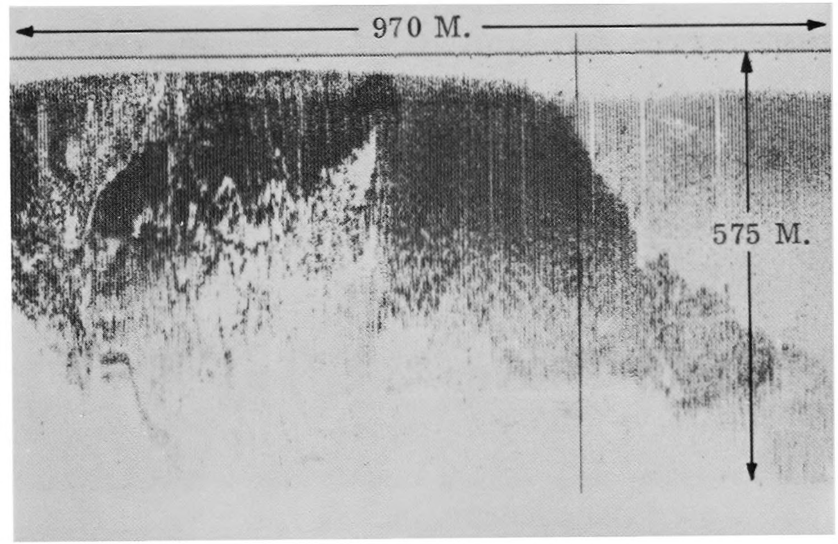



FIG. 8

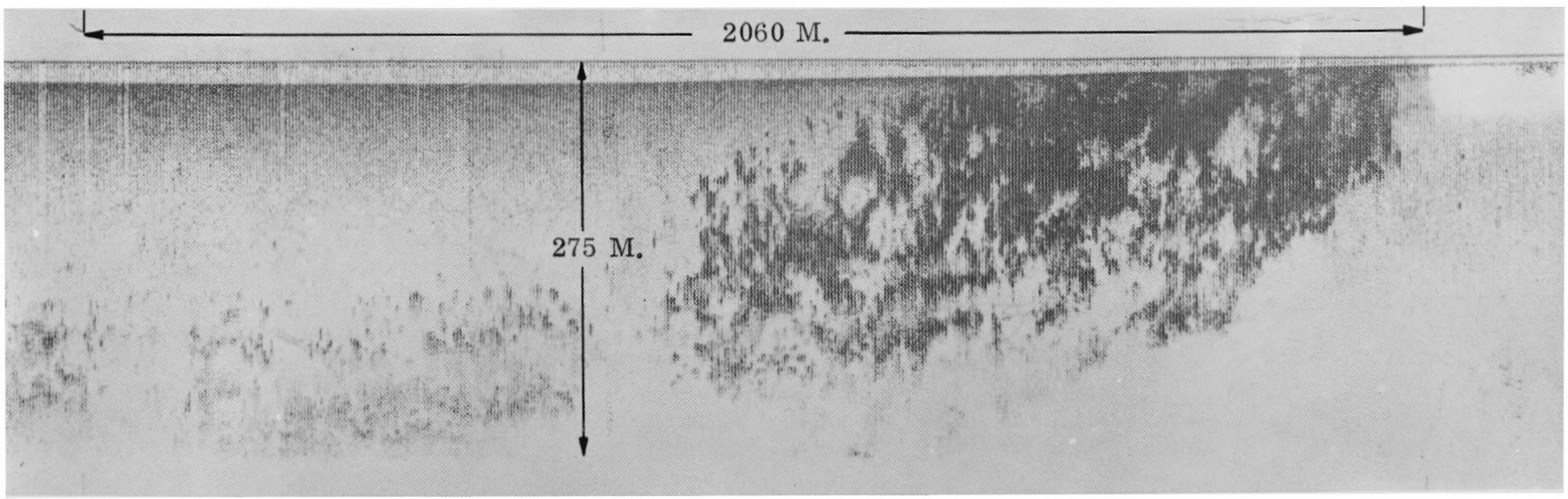



FIG. 9

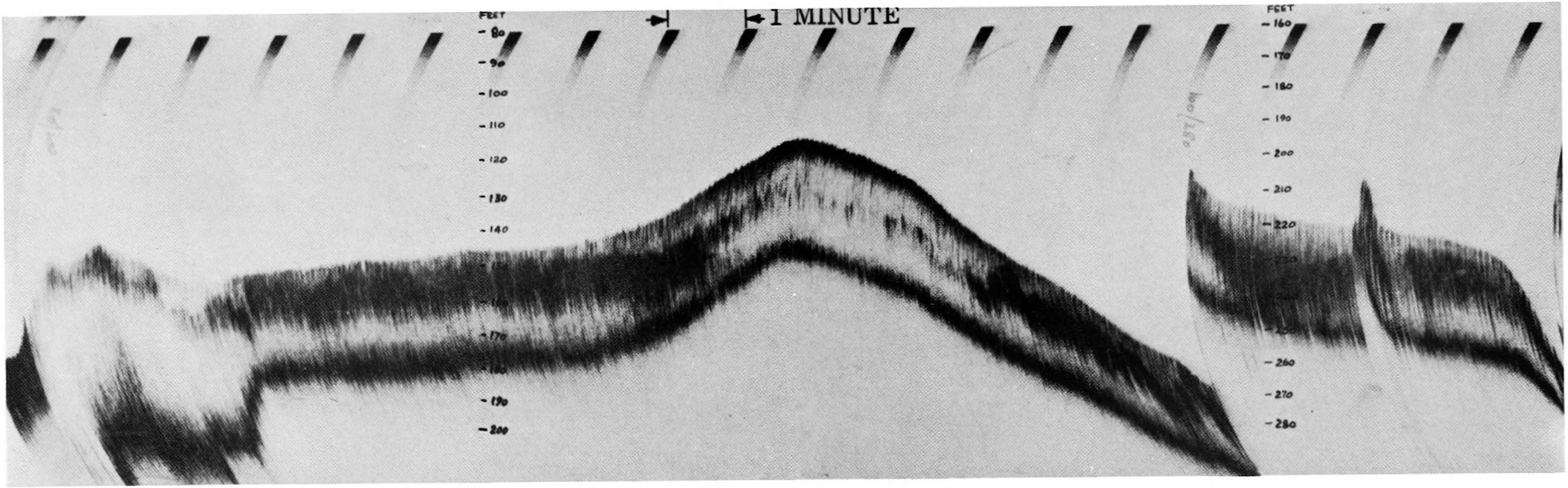
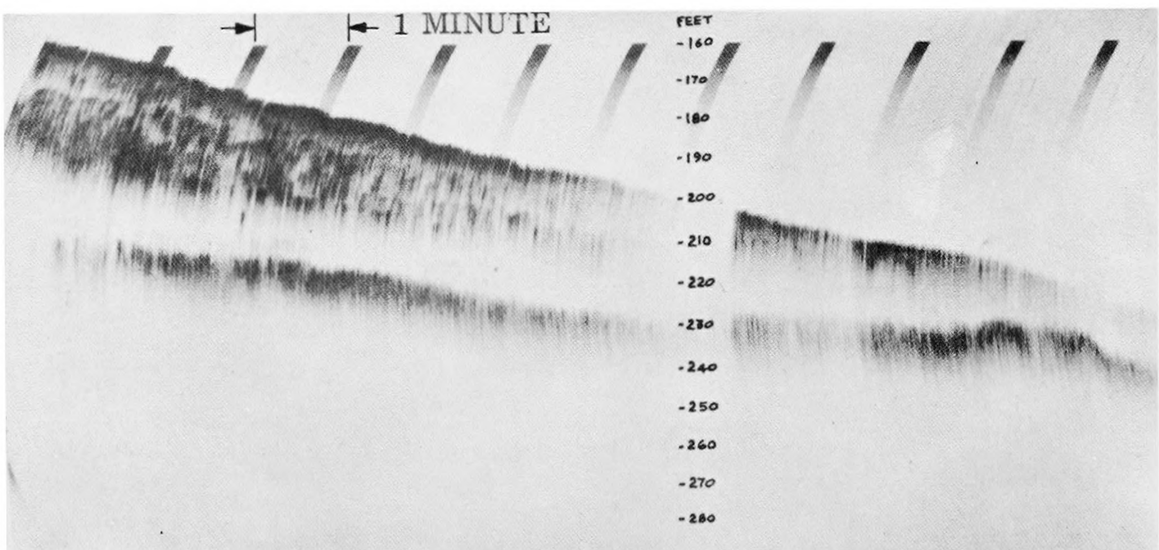

1 MINUTE
FEET
-80
-90
-100
-110
-120
-130
-140
-170
-190
-200
FEET
-160
-170
-180
-190
-200
-210
-220
-260
-270
-280

Fig. 13


1 MINUTE
FEET
-160
-170
-180
-190
-200
-210
-220
-230
-240
-250
-260
-270
-280

illustrate the distortion of measurement that is unavoidable in this type of instrument. (See figure 12).

**Figure 8**

A rock outcrop surrounded by deposits of mud is seen in this record where the range displayed is 575 metres. This feature was observed in Roquebrune Bay near Monaco.

**Figure 9**

In contrast to the deep water performance, this record was made between 5 metres and 14 metres depth and shows patches of hard, coarse sand amongst fine sand. It is worth noting that no change was made in the transducer mounting between this shallow recording and the deep recording shown in figure 7. There is in fact a preferred transducer setting for a given depth of water, but comparison between figures 7 and 9 shows that this is not critical when using the short range. It also supports the fact that results are not lessened when the vessel is rolling.

**Figure 10**

This shows the locations and sequence of Transit Sonar records selected from a continuous scan along the coastline. Using the short range scale at a speed of 5 knots, the area was scanned at a rate of 2.5 $km^2$/hour.

## A NOTE ON RECORD SCALES AND RANGE DISTORTION

In general it is found that the measurement of actual distances is less critical in this technique than it is, for example, in echo sounding. The primary value of the instrument lies in its ability to display an area in a nearly rectilinear manner. The range scale of the instrument shows the actual distance between the transducer and a given object, irrespective of water depth.

In shallow water of, say, 20 metres the situation can be represented as in figure 11 (not drawn to scale). It will be seen that the difference between slant range and horizontal range is negligible at ranges greater than about 100 metres.

It is in shallow waters associated with wreck location, dredging, hydraulic studies, pipe laying etc., that the instrument is most generally used, but it is shown to have an application in deeper water as represented in figure 12. This reproduces the condition arising at maximum water depth shown in figure 7, and where the short range (275 m) was in use. The marked portion of the record width represents approximately 194

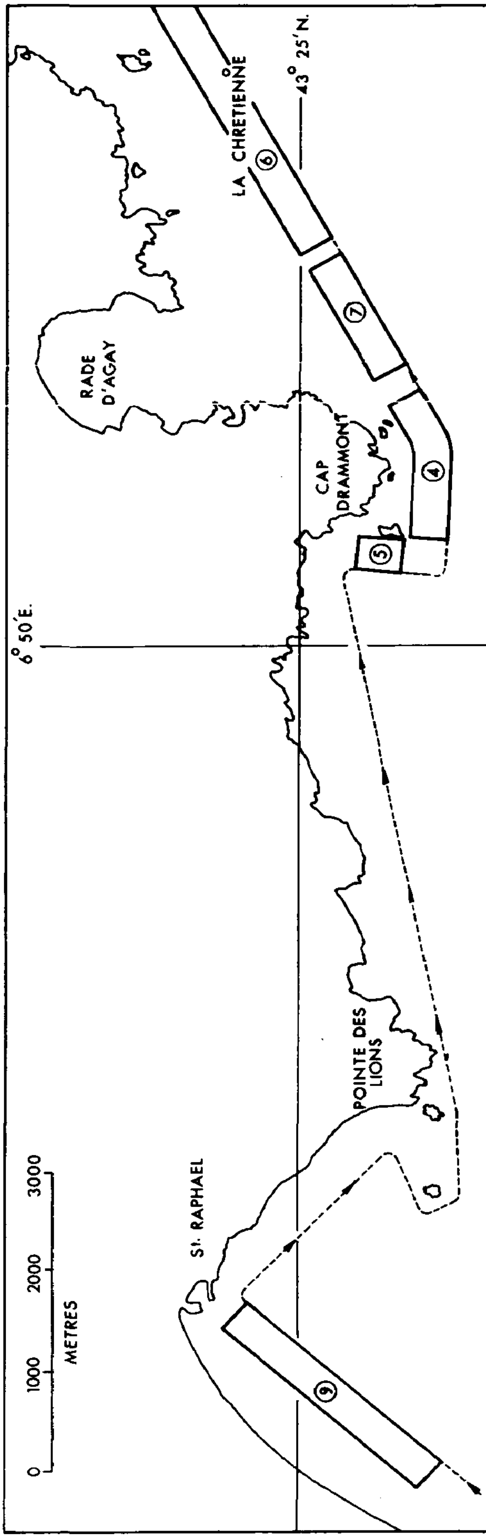



FIG. 10 Sketch plan showing track of vessel and location of Figs. 4,5,6,7,and 9.

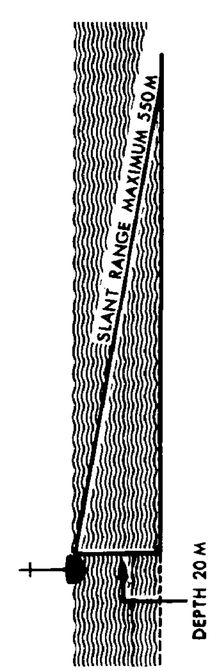



FIG. 11

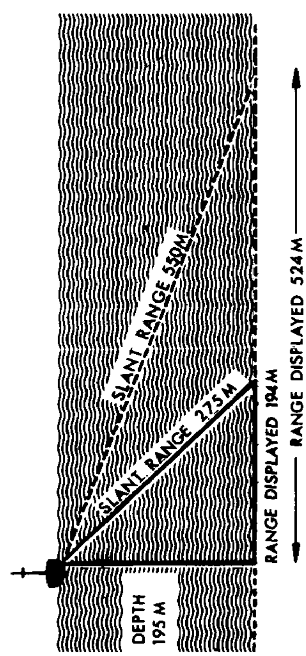



FIG. 12

metres. If the long range (550 m) were used, then the marked portion of the record would have represented 524 metres. (These figures assume that the sea-bed is sensibly flat in the direction of the scan).

## SEA-BED STRATA RECORDER

The increasing draught of tankers and bulk carriers has drawn repeated attention to the need for shallow water surveys to be brought up to date. One result of this demand is that the areas known as " port approaches " are extending seawards, and port engineers' interests are expanding accordingly. In addition, structural works connected with port extensions require original investigations of sub-bottom conditions.

For these purposes an instrument is required to reveal the upper layers of the sea-bed with good resolution of detail. A continuous profile can then be recorded showing details not otherwise obtainable, and greatly reducing the time and effort expended in taking numerous core samples. An instrument designed for this purpose has been under continuous development. It is in use in many parts of the world and a prototype was demonstrated at Monaco in April, 1967. The apparatus is reasonably portable and can be fitted to a launch or vessel without difficulty. A technical description is given elsewhere [2].

Some records are reproduced here showing results obtained in the vicinity of Monaco.

**Figure 13**

This is a portion of record taken in Roquebrune Bay. Maximum penetration to the bed rock is about 15 metres in a water depth of 42 metres, and a continuous profile is obtained to a depth of 70 metres, including a conspicuous protrusion towards the right. Numerous records were obtained near Monaco showing mud over rock.

**Figure 14**

This record was taken in Frejus Bay about 65 kilometres West of Monaco. It shows deposits of silt and mud, and pockets of fresh water can be seen. In this area sub-strata were recorded at 7 metres in 90 metres water depth.

**Figure 15**

This record was taken elsewhere with the final version of the apparatus, which displays 40 metres across 25 cm paper width in a " straight-line " recorder.

**Acknowledgement**

The author wishes to thank Mr. C. AGARATÉ and Mr. G. PAUTOT (Laboratoire de Geodynamique Sous-Marine, Villefranche-sur-Mer) for their advice on the identification of sea-bed materials shown in the sonar and strata records.

## REFERENCES

[1] COOKE, C. H. : " Digital Read-out Echosounder ". *Journal of the Institute of Electronic and Radio Engineers*. Vol. **33**, No. 6, June, 1967, p. 353.

[2] HASLETT, R. W. G. and HONNOR D. : Simultaneous use of Sideways-Looking Sonar, Strata Recorder and Echo Sounder. *Proceedings of the Conference on Electronic Engineering in Oceanography*, Southampton, September, 1966, paper No. 17.