IDENTIFICATION OF PATTERNS ON ASDIC RECORDS

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ABSTRACT

An asdic record obtained to give information about one facet of the underwater environment can also provide information about other facets and the record can be confused by acoustic and electrical noise from a number of sources. This paper indicates the origin of some of these signals and attempts to promote an awareness in those concerned with asdic records of the unusual aspects that may arise.

INTRODUCTION

The civil use of asdic type equipments has lagged behind the use of echo-sounders. This may be due to the fact that not all asdic records give the "immediate appreciation" aspect of an echo-sounder record. This is undoubtedly true when the asdic beam can be positioned by an operator on to any desired bearing. Experience has shown that an asdic beam fixed to point sideways from a ship has a distinct advantage over a forward pointing device, especially if the beam is narrow in the plan view. The record obtained tends to provide an "immediate appreciation" display since it is an acoustic map showing objects in their correct positions relative to the ship.

Such a system [1] has been used by the British National Institute of Oceanography for geological surveys on the continental shelf [2-5], and to some extent for work on fish problems [6-7]. The transducer (Fig. 1) has a vertical fan-shaped beam directed sideways from the ship (Fig. 2). The main beam is 10° deep and $1\frac{1}{3}$° wide in the plan view. The beam pattern can be positioned as required between the horizontal (on the starboard side) and the vertical and is stabilised so as to be unaffected by the ship's roll.

This paper provides interpretations for echo patterns on asdic records which can be produced by objects and effects associated with the equipment, the ship, the sea and its boundaries. It is hoped that the evidence presented here may lessen the uncertainties and reduce the false interpretations that are bound to arise. *There is however, as usual, no substitute for experience.* Successful interpretation of a record can only be achieved when all the

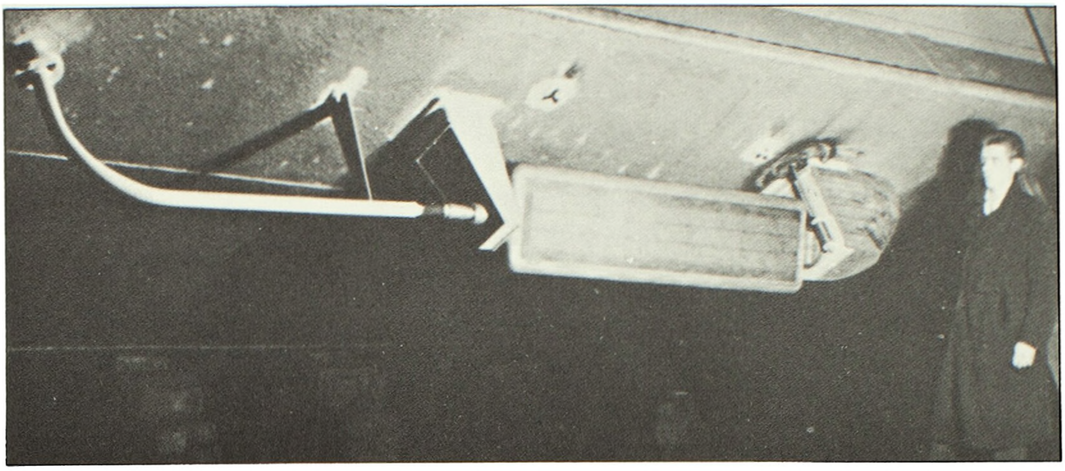

FIG. 1. — The Transducer assembly mounted on the hull of R.R.S. " Discovery II ".

parameters of the system are born in mind, together with a broad knowledge of the locality and the prevailing conditions. This is especially true when dealing with echo patterns which are the exception rather than the rule.

INTERPRETATION OF A TYPICAL RECORD

A typical record is shown in Fig. 3 with the ship steaming from left to right across the top, the beam pattern being at right angles to the direction of motion. The position of the echoes from each beam should be compared with Fig. 2.

The bottom echo shows that the sea floor in this area is substantially flat except where *rock outcrops* occur as shown on the right-hand side of the record and extending to the first side lobe. Other patches of rock are indicated by the main beam. The one on the right-hand side is fairly high as it casts an acoustic *shadow* on the sea floor, this is shown by the white patch directly beyond it. (Note that the scale is not the same along and across the chart).

The long white streak stretching across the left-hand side of the record can be caused in one of two ways, either by a *change* of *bottom texture* or by a *change* in *sea bed slope*. The rougher the bottom material the stronger will be the echo and conversely for soft materials; also a slope

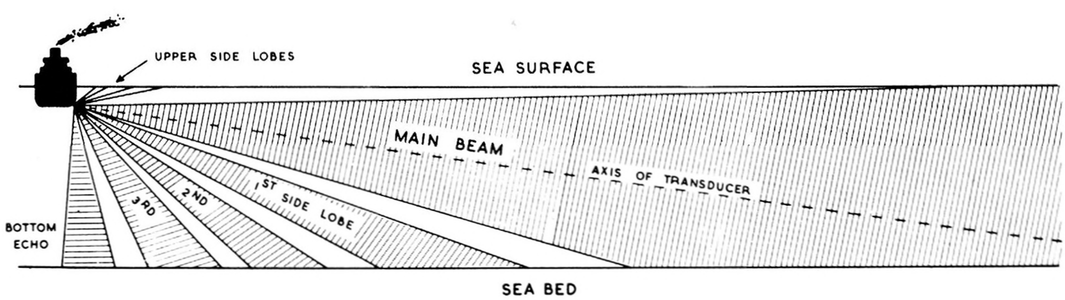

FIG. 2. — A diagrammatic arrangement of the vertical beam pattern.

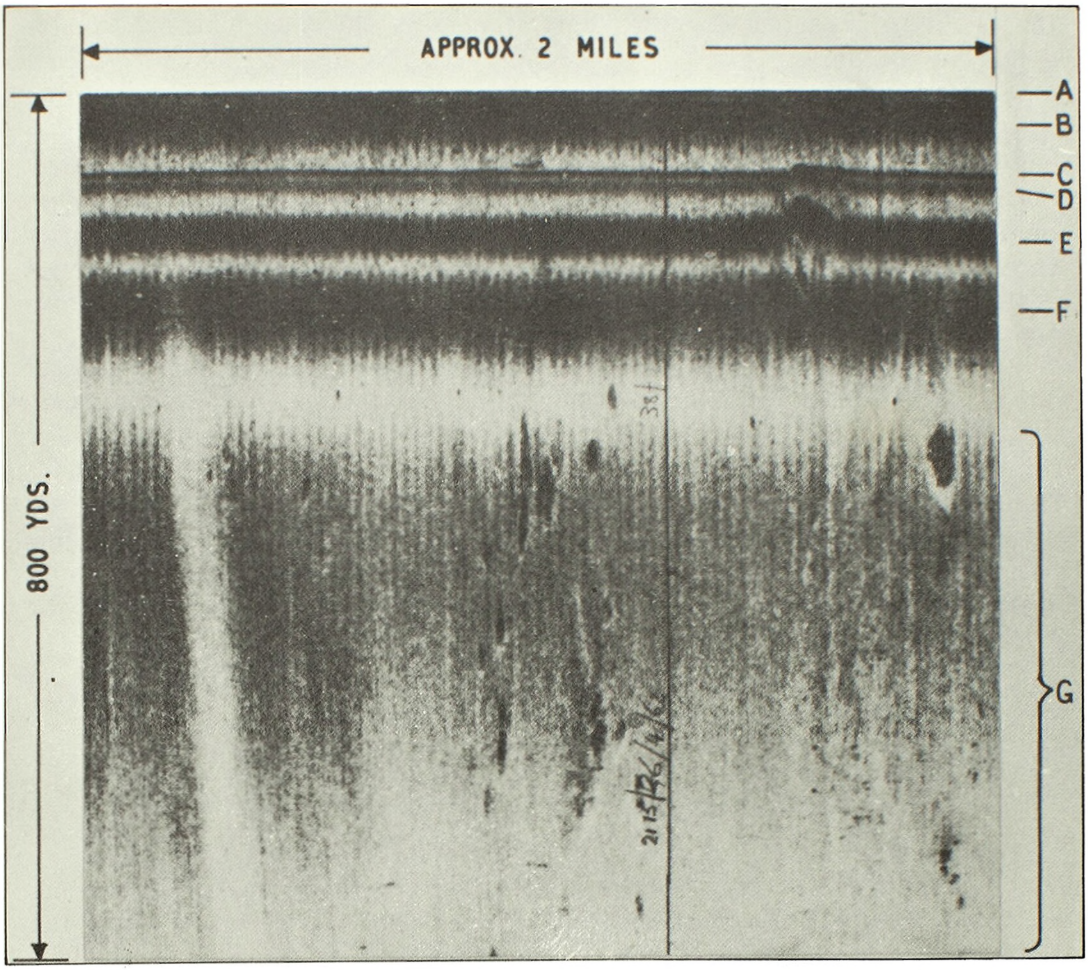

Fig. 3. — A typical record showing the position of echoes from each beam, features on the sea bed, the effect of T.V.G. and Tilt angle.

A. Transmission
B. Upper side lobes
C. Bottom echo
D. 3rd side lobe
E. 2nd side lobe
F. 1st side lobe
G. Main beam

facing the ship will return a stronger echo than will a flat floor, and conversely for a slope facing away from the ship. There is no way of telling for certain from the record which applies in this case. Echo-sounder profiles or bottom samples are needed to decide which explanation applies.

Echoes from near objects are much stronger than those from distant objects, so the receiver gain is low immediately after transmission and increases with time as the more distant echoes are received. The optimum law for this time varied gain or "T.V.G." is not the same for all circumstances and is set empirically to produce an "even tone" across the record. The law employed in Fig. 3 across the ranges which correspond to the main beam is almost correct. *Rocks* produce a black marking, the general background a half-tone appearance, while detail can still be seen within the white streak on the left-hand side of the record. It would appear that the law is not correct for the short ranges as the side lobe echoes are displayed too dark.

Examination of Fig. 2 will show that if the beam pattern is tilted upward the lower edge of the main beam will reach a point where it does not strike the sea bed at all. Further, if the beams are tilted downward, the upper edge will strike the sea bed at a point which has a range less than the effective range of the recorder. So for either case the recorder width will not be used to the best advantage. A similar effect is produced if the beam pattern is kept fixed and the transducer is used in different depths of water. It is therefore important to use the correct *tilt angle* for a given depth. For the present equipment a rough rule is about $1\frac{1}{2}°$ tilt down for every 10 fathoms of water, thus the centre of the main beam will strike the sea floor at about the maximum range of the recorder. For Fig. 3 the water depth is 38 fathoms which requires a tilt angle of about 6°. Calculations using the side lobe echoes and angles show that the actual tilt angle was 8°. This would account for the white region at the extreme range. If the tilt angle had been found to be correct the white region could have been caused by (a) softer material (b) a slope facing away from the ship or (c) the wrong gain law.

The *saw tooth* appearance displayed at the edges of the beams is caused by a malfunction of the transducer stabiliser equipment.

INTERPRETATION OF SPECIFIC PATTERNS

Fig. 4 illustrates very clearly an effect produced by having the wrong *tilt angle*. When the angle is 3°, *surface wave* echoes are received from the main beam which are displayed at the same time as the lower side lobe echoes; further, the main beam is not used effectively for bottom echoes. A change of tilt to 10° remedies both of these faults.

Fig. 5 is a record obtained with the *horizontal beam angle* increased to 13° instead of the usual $1\frac{1}{3}°$. The distance along the slant edge of a beam is longer than that along the axis of the beam. This apparent change in range is not detectable when the beam is narrow, but is easily seen when it is wide. This gives rise to the small *crescent* shaped *traces* displayed on the lower half of the record. They are also called *plume, comet* or *finger nail traces.*

The pattern of dots over the lower half of the record are the *transmission pulses* picked up from the ship's *echo sounder* which has a much higher sweep speed.

Fig. 6 is a record obtained while the *ship* was *changing speed.* At the top of the record *surface waves* are recorded which apparently experience a change in direction and character. The strong echoes at extreme range are from small *fish shoals* which appear to undergo a change in distribution and size. All these changes are caused by the features being illuminated by the beam for a longer time as the speed is reduced.

Fig. 7 indicates the marked change in appearance that can occur when outcropping rocks are viewed from different directions. On the left the

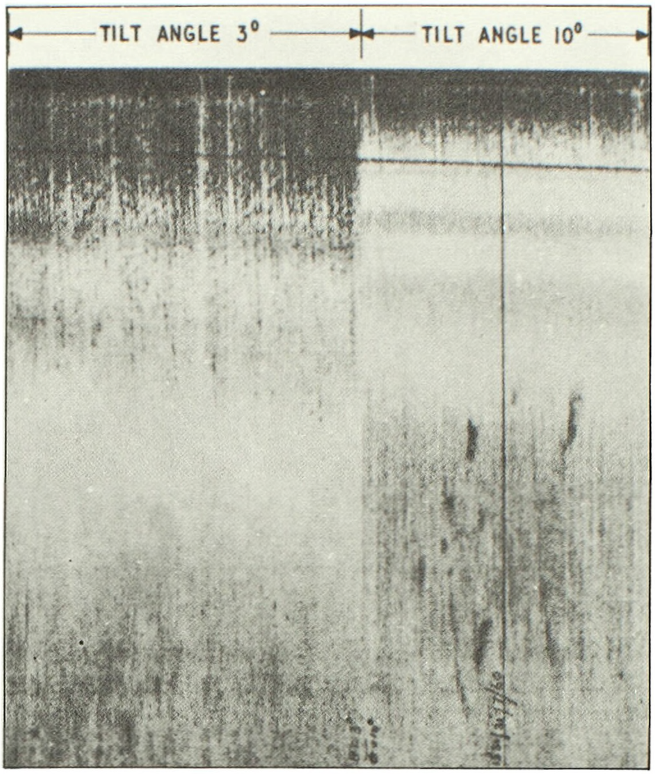

FIG. 4. — A record illustrating the effect of using the wrong tilt angle.

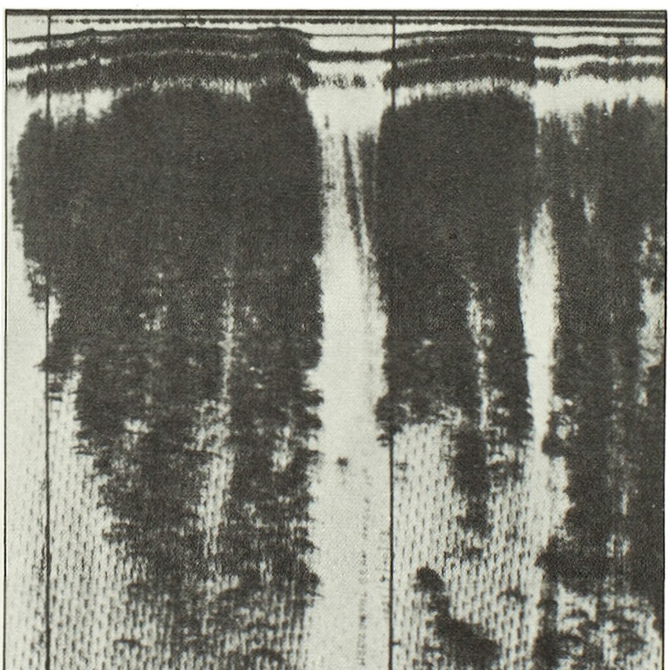

FIG. 5. — A record obtained when the Horizontal beam angle was increased from $1\frac{1}{3}°$ to 13° and so producing crescent shaped traces.

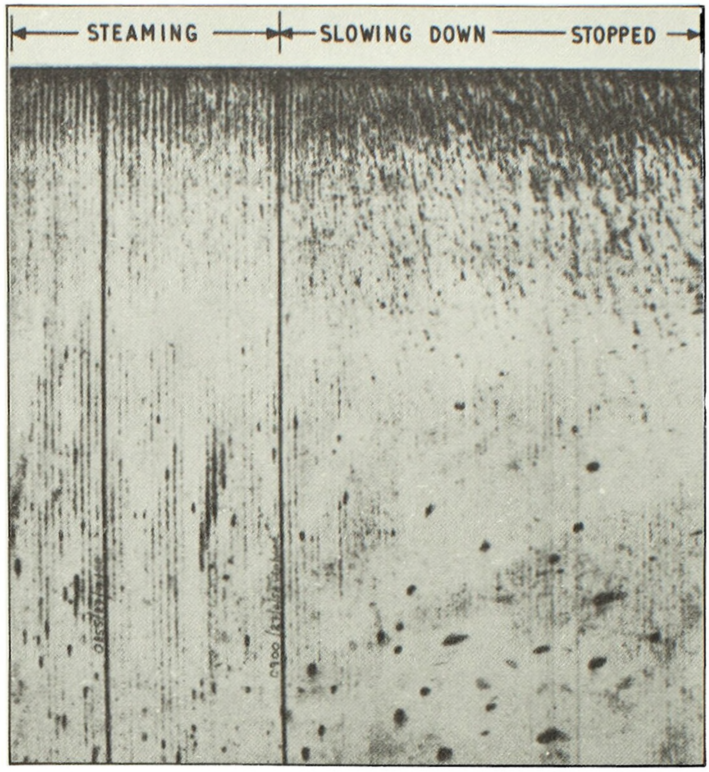

FIG. 6. — Sea wave and fish shoal traces change in appearance as the ship slows down.

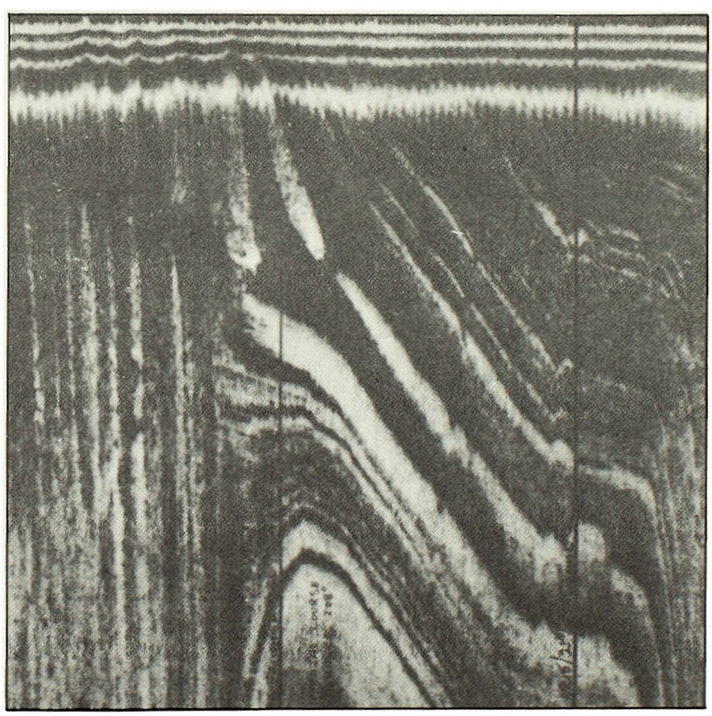

FIG. 7. — A reversal of course by the ship was responsible for the marked change in appearance of the sea bed features.

pattern suggests the presence of *sand waves,* whereas in the middle where there is a 90° *change of course,. layers of rock* are easily recognised. It is readily apparent that to get the best record for the work in hand the course must be chosen with care.

Fig. 8 shows the type of record obtained when another ship passes through the beam. The echoes from the *ship* itself are at "S" and the *wake* [8] extends to "W". The wake is composed of three lines of echoes, the outer two from breaking *bow waves* and the inner one from streams of *bubbles* produced by a *cavitating propeller.* On the right-hand side the more distant bow wave is not recorded as it is screened by the propeller bubbles, the latter being very close to, or even breaking, the surface.

The ship's *propeller noise* is also received and is displayed across the record at "N". The noise is a continuous signal and of fairly constant magnitude, a darker marking is displayed at the greater range due to the T.V.G. law employed. The setting of the *constant gain* channel has been altered at "A" and "B". A common fault is to have the *gain* controls set too high.

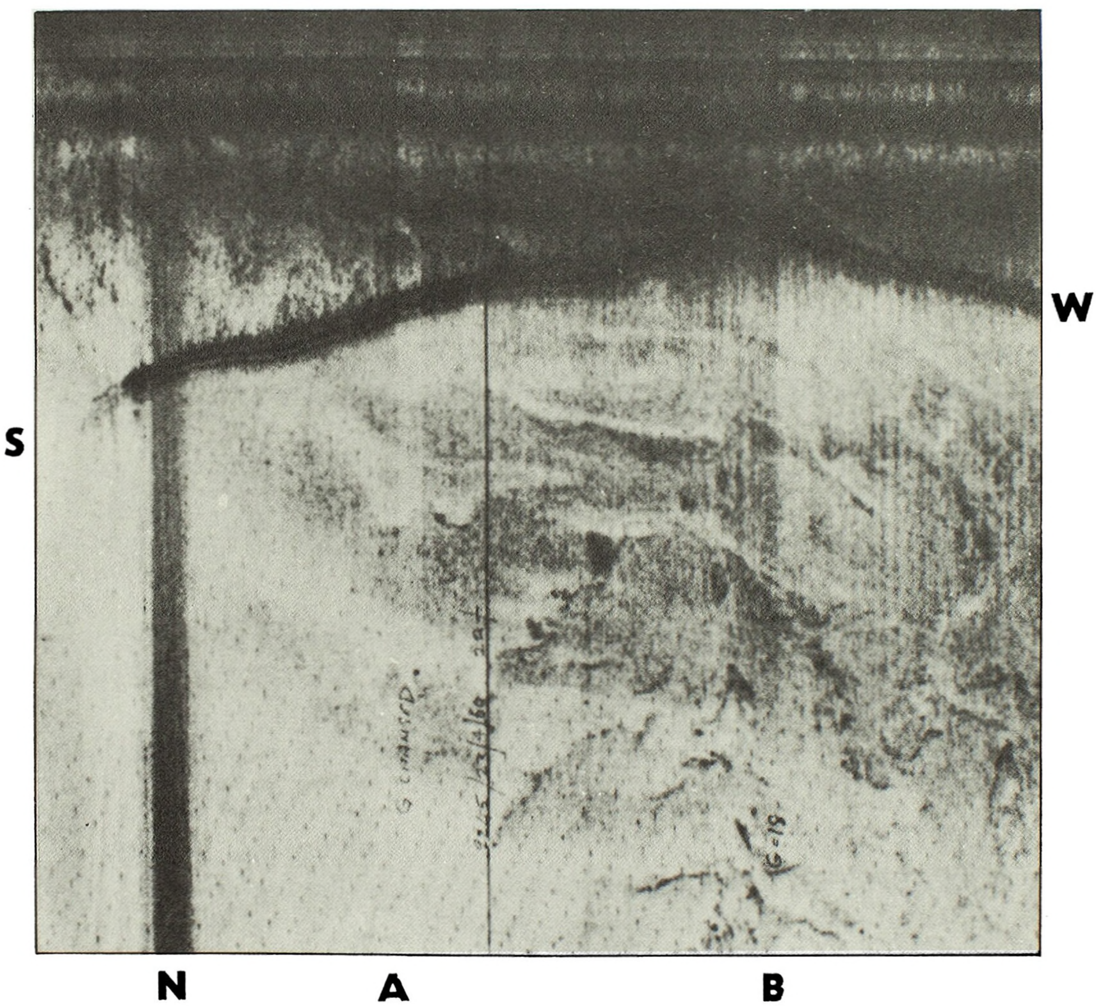

Fig. 8. — A record showing a ship, its noise and its wake. The change of course at 'B' was made by the survey vessel and not the passing ship.

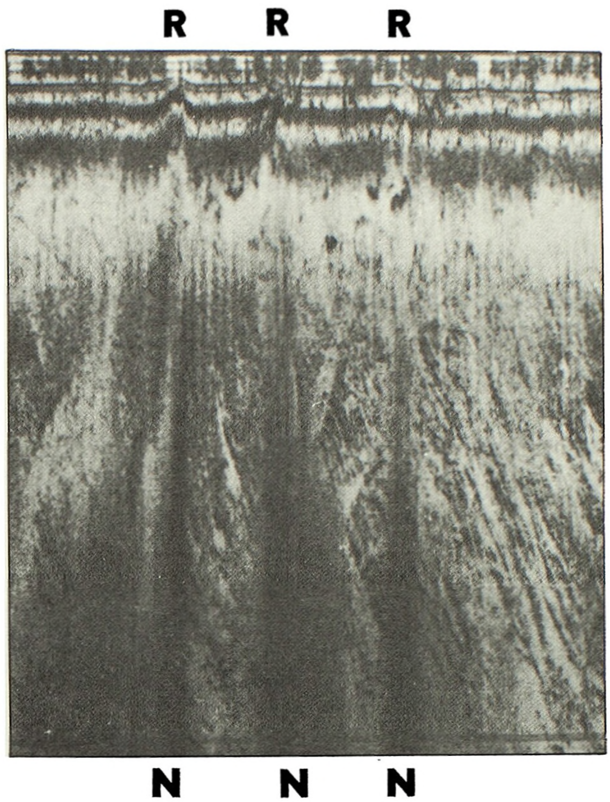

Fig. 9. — Noise is displayed from upwelling water around the Horseshoe rocks in the Bristol Channel.

The ship appears to *change course* at "B", but an examination of the sea bed features shows that these appear to change direction at the same time. Thus the survey ship must have altered course instead. *Echo sounder transmission pulses* are again in evidence.

Fig. 9 shows an example of *random noise* being received by the transducer. This noise is produced by *disturbed water* caused by upwellings around the Horseshoe Rocks in the Bristol Channel. The bottom profile and side lobes indicate the presence of three peaks "R", and corresponding with these are three bands of noise "N" which are displayed at extreme range. Noise from *disturbed water* can also be obtained from "*white horses*", breaking waves in *tide races* and from upwellings associated with some sand waves.

Fig. 10 is a record taken while a school of *porpoises* was playing round the ship. The transmission was turned off and the transducer used as a hydrophone to receive the noises made by the porpoises. The T.V.G. is not effective when the transmission is off, so that the signals are displayed with equal intensity over the full width of the record.

Fig. 11 shows an interference pattern known as the Lloyd mirror effect [9]. It is made evident by the series of dark lines which run along the record. These are produced by the summation of echoes which have travelled by different paths to reach the transducer, one of which is a reflection of an echo from the sea surface. The shorter period saw-tooth

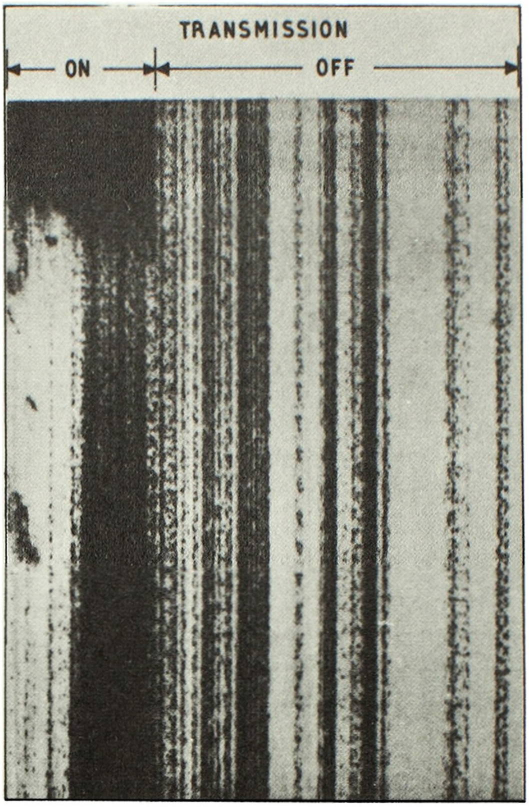

FIG. 10. — Noises from Porpoises are displayed across the record. The T.V.G. is inoperative when the transmission is switched off.

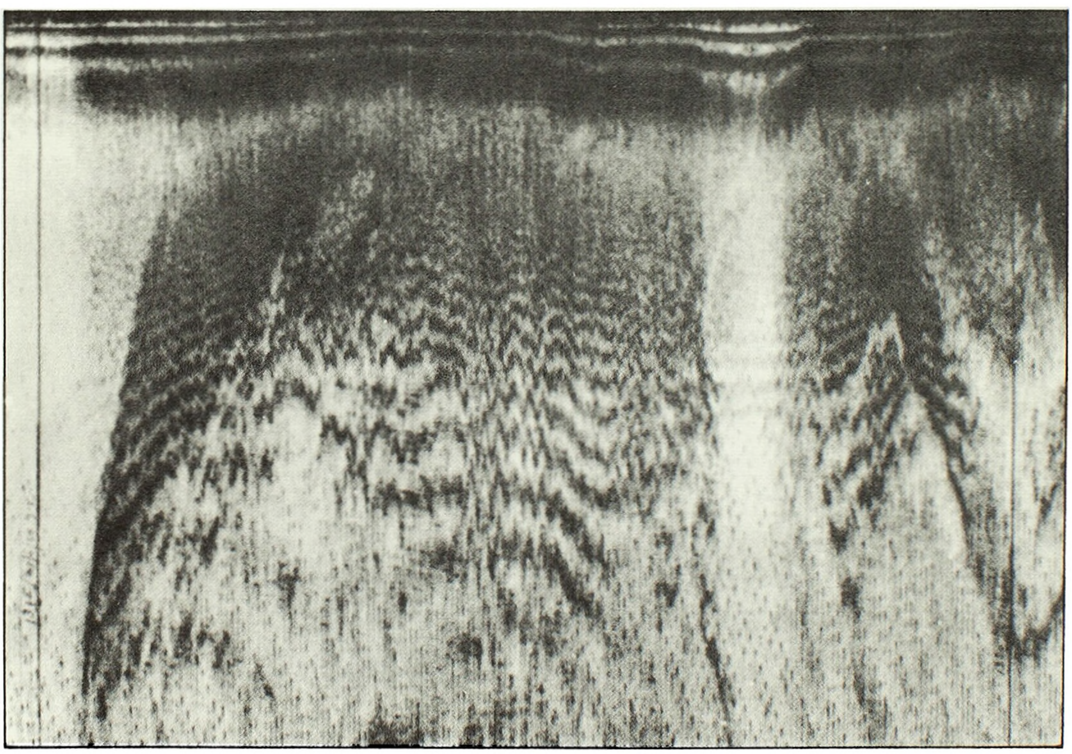

FIG. 11. — A record exhibiting the Lloyd Mirror Effect. The pattern is affected by changes in water depth and sea bed slope.

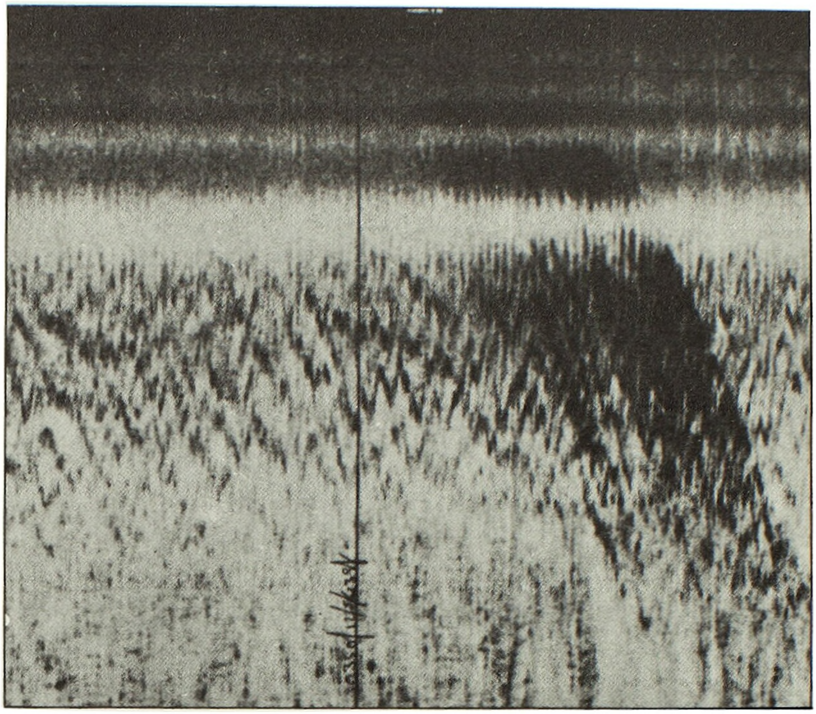

Fig. 12. — An interference effect called Focusing, probably caused by Internal Waves, is displayed across the record.

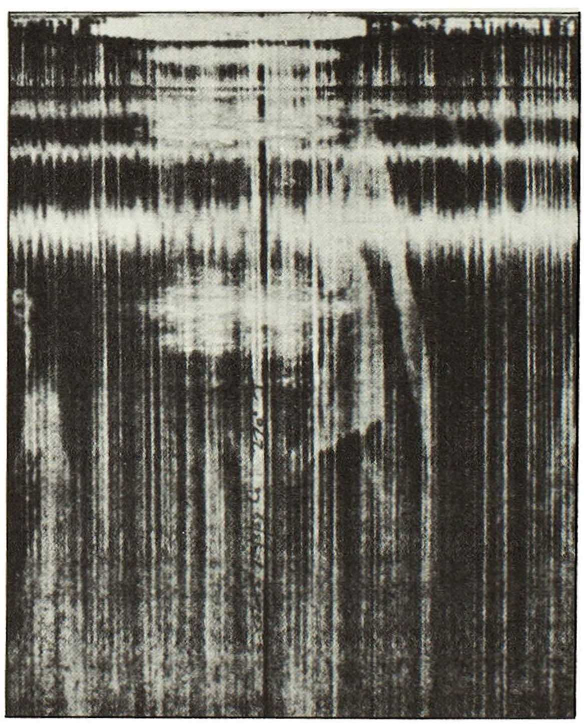

Fig. 13. — A " dirty " record caused by dry paper and quenching.

appearance of the lines is caused by the heave of the ship changing the lengths of the paths. For the phenomenon to be observed the water must be fairly shallow and the sea surface reasonably flat. It will be noticed that the spacing between lines increases with range, a characteristic of the effect. *Changes* in *sea bed slope* or *water depth* vary the spacing; hence the effect can be used to give some indication of the relief to one side of the ship. *Echo sounder transmission pulses* are again evident on this record.

Fig. 12 provides an example of another interference pattern called *focusing* displayed as the sharp-peaked lines along the record. *Internal waves* are usually responsible for this type of distortion [10], the sound rays being refracted by varying amounts due to the *changes of density*.

Fig. 13 is called a "Dirty" record since it shows two effects which make interpretation difficult. The first is shown by the horizontal, irregular edged, white patches in the middle of the record and is caused by *dry paper*.

The second effect is shown by the thin vertical white lines caused by *quenching*. This is the name given to the blanketing of the outgoing pulse or the returned echoes by air *bubbles* around the transducer. This condition will exist when the ship draws down air whilst rolling or pitching in bad weather (as in the case here). Passing through another ship's wake will cause quenching of limited duration.

Fig. 14 shows equipment fault where the polarity of the *paper voltages* has been inadvertently *reversed*. The uniformity of the pattern independent of range indicates that the trouble is in the equipment and is not an acoustic effect.

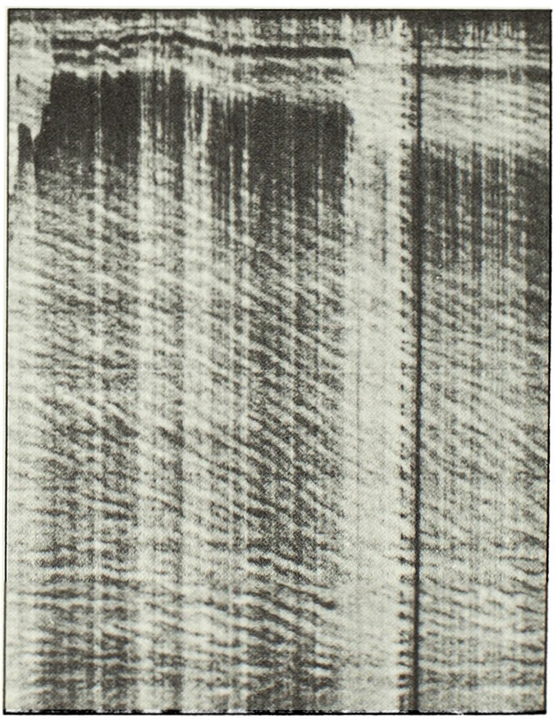

Fig. 14. — The paper voltage being reversed was responsible for the noise pattern across the record.

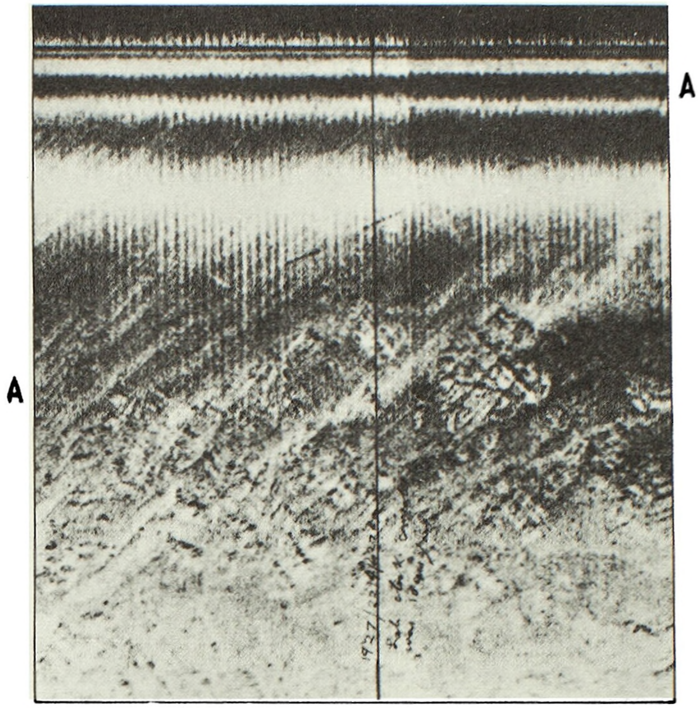

FIG. 15. — A Telephone Cable is recorded across a sea floor of rock and sand, the cable being partly buried by the latter.

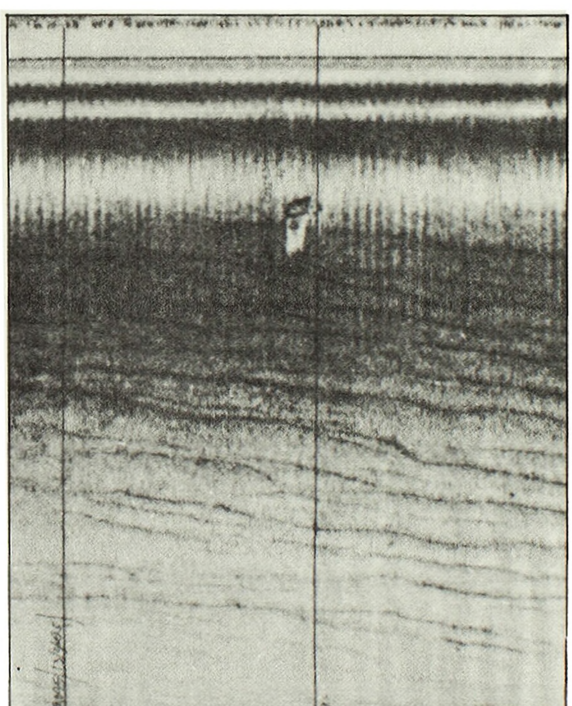

FIG. 16. — A Wreck 350 feet long and 30 feet high is shown casting a shadow on a sea floor of sand and rock ridges.

Fig. 15 shows a floor of *sand* with *outcrops of rock*. Extending across the area is a *telephone cable,* "A-A", which is buried at several places.

Referring back to Fig. 3 it would appear this also has a cable extending along the first side lobe. It is, however, the *transmission pulse* of a *thumper* sub-bottom profiler which was being operated at the same time. The sweep speeds of the two recorders were not quite identical.

Fig. 16 was taken over an area of *sand* and *rock ridges*. Here the isolated black and white feature in the middle is a *wreck* [11-12]. The black patches are strong echoes from the ship itself, the white areas indicate the *shadow* zone behind it. This wreck was marked on the chart, but even without this evidence the character and isolation of the echo pattern is sufficient identification.

Fig. 17 shows a series of four *sand waves* with a large number of small *fish shoals* in mid-water extending from about each peak to part way down each gentle slope. Sea bed echoes cannot be received from between the side lobes (see Fig. 2) so features appearing in these positions on the record *must* be in mid-water. The pattern of marks on the lower half of the record is again due to *echo sounder transmission pulses*.

Fig. 18 provides a good example of the "acoustic map" aspect of these records. The *harbour walls* and *entrances* are easily distinguished, the only echoes received from inside the harbour being those obtained through the entrances. A *ship* and its *wake* are shown outside the harbour to the North, the ship *propeller noise* apparently coming from inside the harbour as it is only recorded, as usual, at the extreme range. The pattern of thin wavy lines on the left-hand side is caused by *mains interference*.

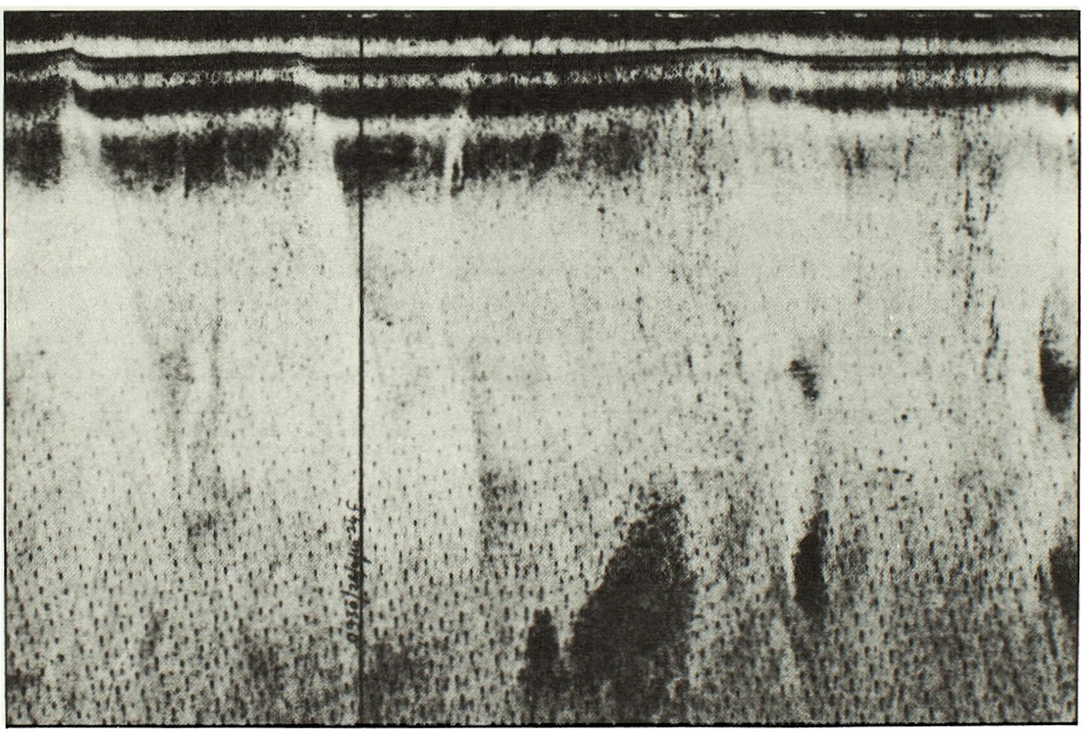

FIG. 17. — Fish shoals in mid-water are shown corresponding with a series of sand waves.

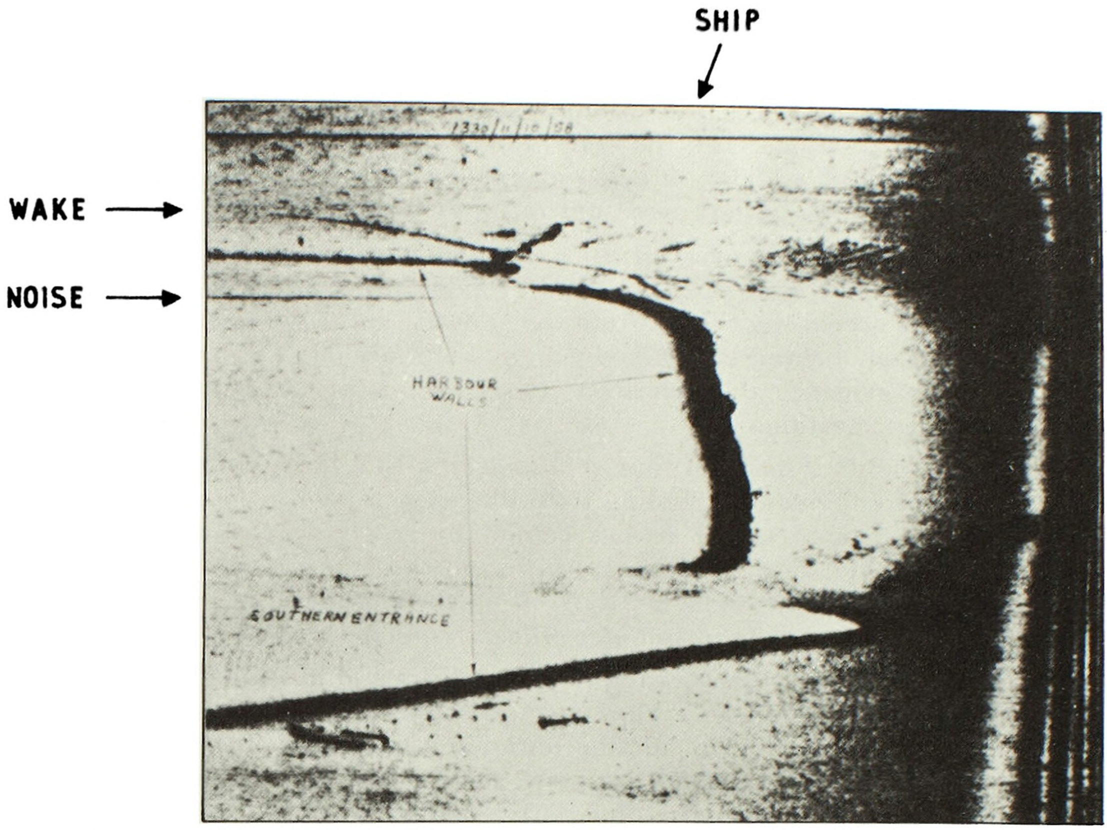

FIG. 18. — An acoustic map of a harbour.

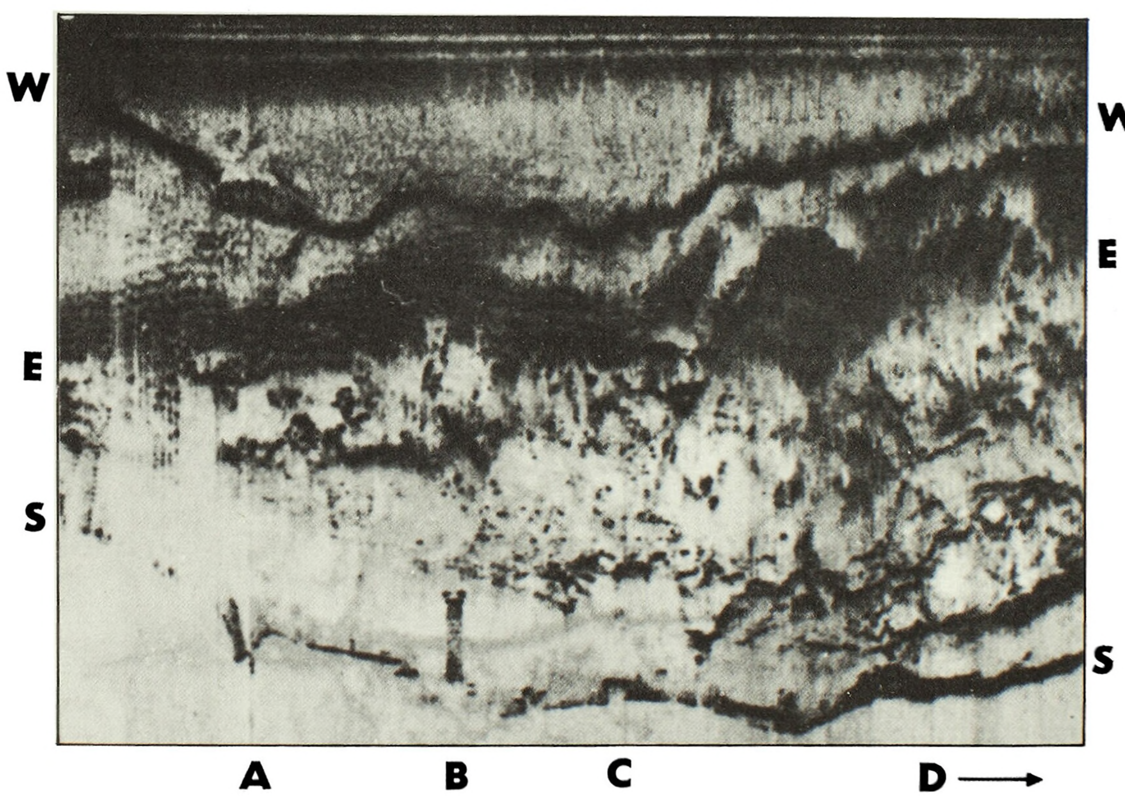

FIG. 19. — An acoustic map of the south bank of the River Thames at Gravesend.

Fig. 19 is a more complex acoustic map taken along the south side of the *River Thames* at Gravesend from the Royal Terrace Pier to Milton Rifle Range.

Along the ***shoreline*** "S-S", echo patterns are easily correlated with their corresponding targets. The inlet at "A" is the entrance to the Thames and Medway canal. The series of echoes at "B" are from a *slipway,* the "bars" across the feature are probably due to the *Lloyd mirror effect.* At "C" a ***ship*** lies alongside a *jetty* and from "D" extends the wall adjacent to Milton Rifle Range.

The wide band of echoes "E-E" show where the river bed slopes down to the deep water channel, *Lloyd mirror effect* is again evident on the left-hand side of the record. The line of traces "W-W", weaving along the record, are echoes from the *wake* of a ship travelling up river. (The echoes are more diffuse on the right-hand side). The confused series of echo patterns between the shore and "E-E" are produced by a number of mooring buoys and fixings, ships, unidentified objects, banks on the river bed and wakes on the surface.

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