A GATING SYSTEM FOR DEEP WATER SOUNDING

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When sounding in very deep water it is important to obtain information at as high a rate as possible. With increasing depth the comparatively slow speed of sound in water becomes more and more significant. At a depth of 5 000 fathoms, for example, an echo is not received until 12 seconds after transmission. This is equivalent to 20 echoes per mile for a ship steaming at 15 knots, by any standards a very meagre information rate.

Nevertheless, this is the best that can be achieved with a conventional echo-sounding system where the interval between transmissions is greater than the time taken for a pulse of sound to reach the sea bed and return to the ship, so that each echo is received before the next transmission is made. If the interval between transmissions is decreased so that more than one pulse of sound is travelling through the water at the same time new difficulties arise. The bottom echo may be masked by reverberations of greater amplitude being received at the same time as a result of a more recent transmission than the one responsible for the bottom echo. These so-called reverberations are the sum of many small echoes from air bubbles, micro-organisms, deep scattering layers and so on. Their amplitudes decrease with depth and by about 400-500 fathoms they are usually below the level of the background noise caused by the flow of water past the transducer, and so no longer limit the performance of the set. It follows from this that a " multiple transmission system ", that is, one in which several transmissions are in the water at the same time, can be used without adversely affecting the signal-to-noise ratio provided that a transmission has not been made within the preceding period equivalent to at least 500 fathoms, when the bottom echo is received.

To take a concrete example, we can select a transmission interval equivalent to 500 fathoms. If the depth of water is between 4 500 and 5 000 fathoms, 10 successive transmissions will have been made before the echo from the first one is received. This echo would be masked by reverberations from the 10th transmission unless it is cut out. Similarly, the echo from the second transmission would be masked by reverberations from the 11th, and so on. It will be evident that in this particular case a gating sequence of 9 transmissions " on " followed by nine " off " will give the best results. The arrangement will yield nine echoes during the echo time equivalent to 9 000 fathoms (21 3/5 seconds), or one every 12/5 seconds which is an improvement in the information rate by a factor of five.

The optimum gating system thus depends on the depth of water and would have to be altered each time the depth passed through a multiple of the distance represented by the transmission interval. This could be done automatically by a computer which could, at the same time, give a direct indication of the actual depth by adding the chart reading to the appropriate multiple of the chart scale. For the other disadvantage of a multiple transmission system is that the actual depth of water cannot be read directly from the recorder chart. A computer of the kind referred to above would involve a digital read-out for the bottom echo which, itself, would be something very difficult to achieve with reliability in deep water.

In a recently introduced oceanographic echo-sounder (the Kelvin Hughes MS 38) incorporating a P.D.R. and multiple sounding system a good compromise has been achieved by the use of a fixed gating system. This has the merit of simplicity and though not ideal for all depths is designed to give the maximum advantage to the deeper echoes at the expense of the shallower ones. The provision of six depth scales gives reasonable flexibility. These are :

0 - 200 fathoms 0 - 400 " 0 - 800 "	Shallow Scales	0 - 1 200 fathoms 0 - 2 400 " 0 - 4 800 "	Deep Scales

In practice, the three shallow scales would normally be used in conjunction with the gating system, the particular scale selected depending on the depth of water. For depths within 1 200 fathoms the 200 fathoms scale would be used, and so on. A direct check on the depth can be obtained at any time by switching to the appropriate deep scale. The recorder also does this automatically once every hour.

The facsimile type of recorder used with this instrument records the echo at the point of intersection between a rotating helix and a straight edge and there is no wasted time between the completion of one recording trace and the start of the next transmission.

With a transmission interval equal to the echo time for 800 fathoms the deeper part of the chart will be free of the interference referred to earlier, since reverberations die out at a depth of 400-500 fathoms, assuming high gain setting for reception of echoes in very deep water. When the echo trace is appearing in this area it will be possible to dispense with transmission gating altogether, but this could only be done with safety while the chart is under continuous surveillance, as it would have to be re-introduced as soon as the trace moved into the upper half of the chart. This does not apply to the medium scale in which the whole of the chart may be " reverberation-controlled ". When using the shallow scale, relatively deep echoes will not be seen unless the preceding two transmissions have been gated.

As will be seen from the diagram (figure 1) the optimum condition occurs between 4 400 (approx.) and 5 600 fathoms (deep scale) when all echoes will be free of reverberations interference. Above and below this depth, the proportion of lost echoes will progressively increase. The corresponding optimum for the medium scale is from 2 400 to 3 200 fathoms. In the type of recorder used with this instrument the echo mark

on the chart is achieved by means of a deposit derived from the writing edge. This edge is therefore gradually eroded and has to be replaced periodically. In order to reduce the erosion rate as far as possible and to display the echoes against a white background, the receiver is also gated for a fixed interval representing the first four reception periods in each sequence of 12. Under the optimum conditions for which the gating circuit has been designed all echoes will be received during the 'open' periods of the receiver so that no loss of information can occur. Echoes received at other times during the periods when the receiver is cut off would normally be masked by reverberations in any case.

The diagram in figure 1 illustrates the principle of the gating system used, and the reproductions of sections of chart ($\frac{1}{4}$ original size) obtained with this instrument (figures 2-6) show how it works in practice.

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The records which are reproduced in this article are the property of Kelvin Hughes.

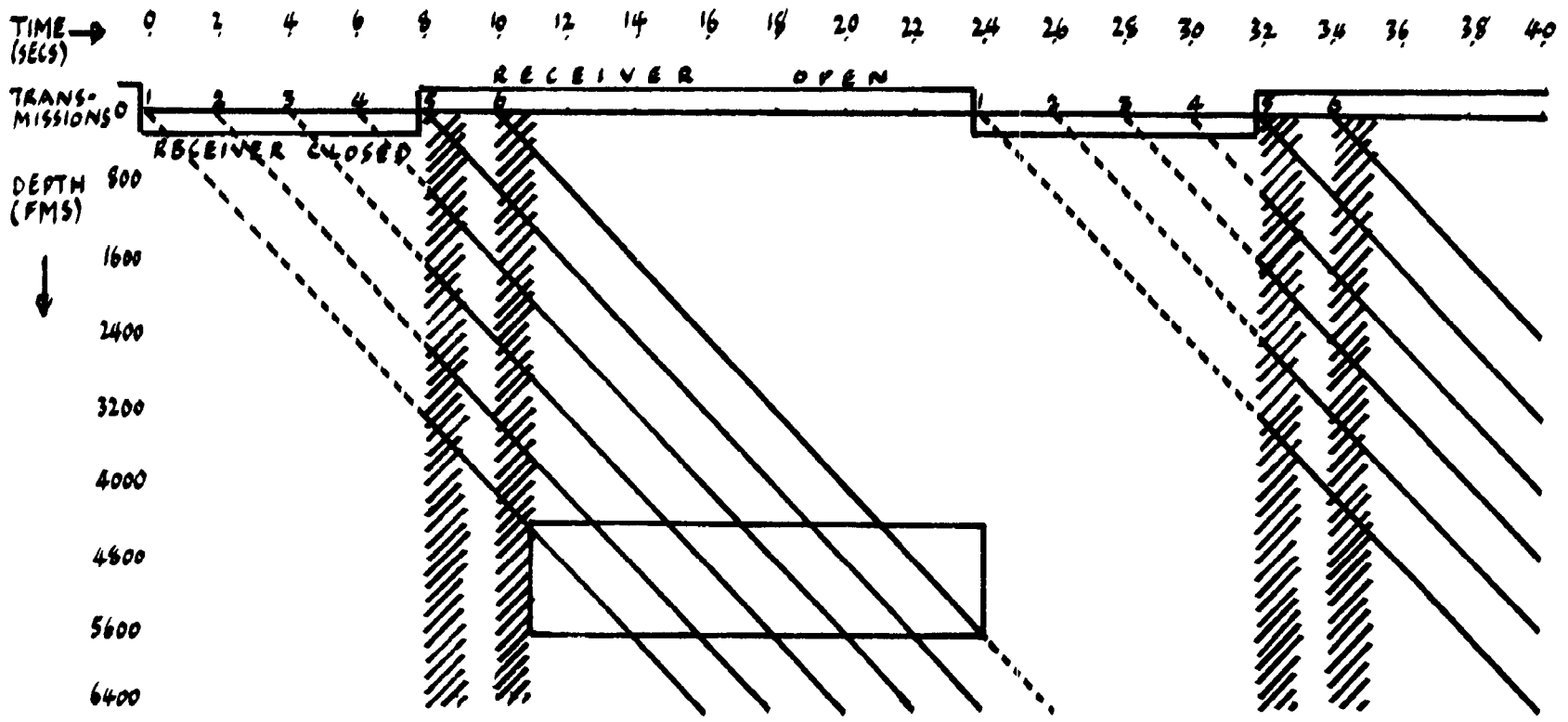

FIG. 1. — The operation of the Transmitter and Receiver gating system as used in the Kelvin Hughes MS 38 echo-sounder is shown diagrammatically. The 800 fathoms scale is in use. The diagonal lines indicate the displacement in time of the echoes in relation to the transmissions, as the depth increases. The shaded areas show approximately the limits of reverberations, when deep echoes from the bottom will be obscured. The optimum depths for this scale, when all echoes will be recorded, are those lying within the rectangle.

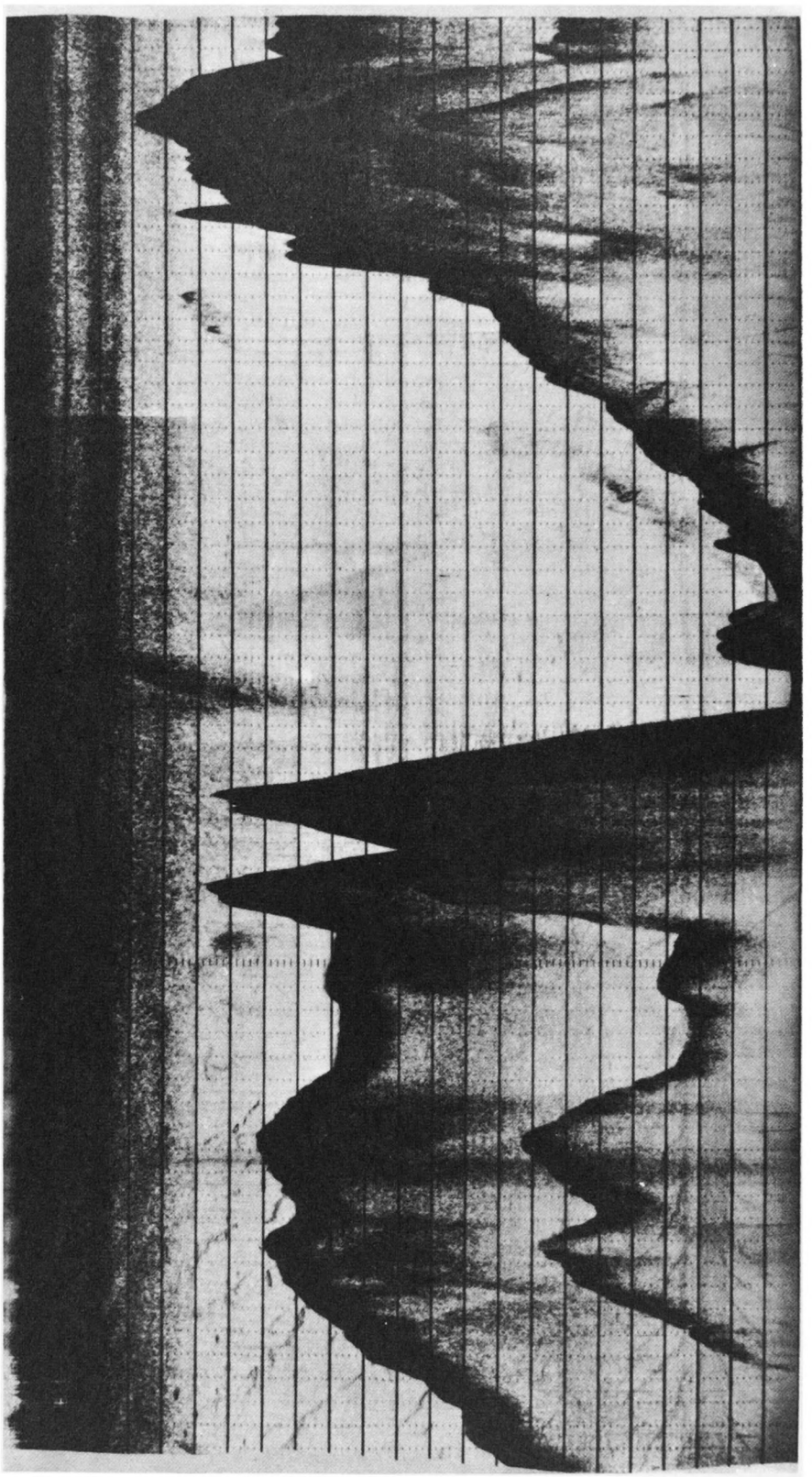

FIG. 2. — In this example the 0-2 400 fathoms scale has been used. Continuous lines are at 100-fathom intervals. The amplifier gain has been reduced towards the right-hand end to ensure clear marking of the shallower peaks.

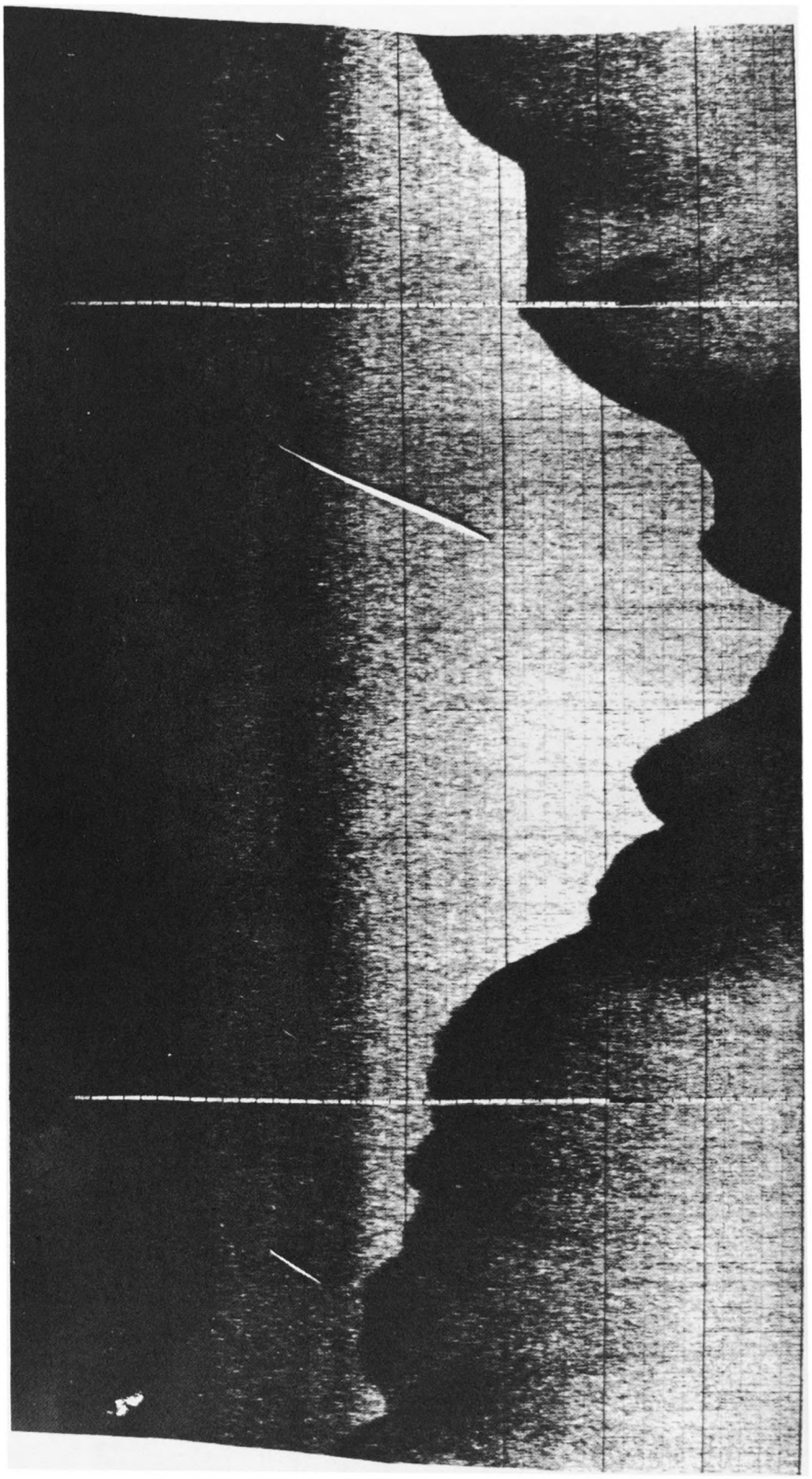

FIG. 3. — The scale of the chart is 800 fathoms except where the recorder has been automatically switched to the corresponding deep scale of 4 800 fathoms. The heavy depth lines represent 100-fathom intervals showing that the depth at each of the two check points is slightly greater than 3 600 fathoms. The expanded scale of 800 fathoms enables the depth to be read accurately and this is seen to be varying across the chart from 3 560 to 3 990 fathoms (i.e. $4 \times 800 + 360$ and $4 \times 800 + 790$). As the echoes are in the lower half of the chart it was not necessary to gate the transmitter.

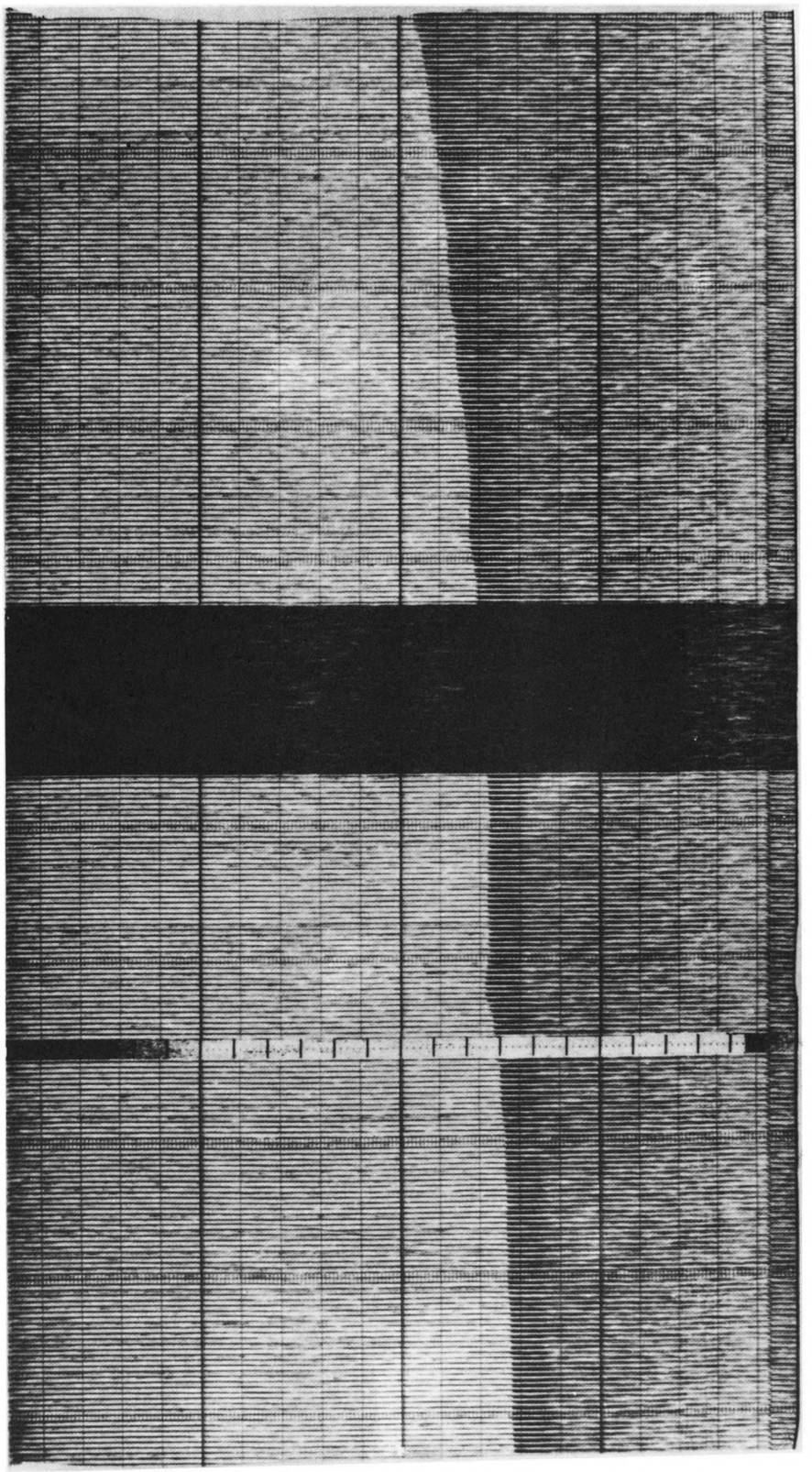

FIG. 4. — Expanded scale 400 fathoms. The check scale (0-2 400 fathoms) indicates that the depth is varying between 2 256 and 2 210 fathoms ($5 \times 400 + 256$ and $5 \times 400 + 210$). In this case 'gating' is needed and the effect of this is shown by comparison with the ungated portion at the centre of the record.

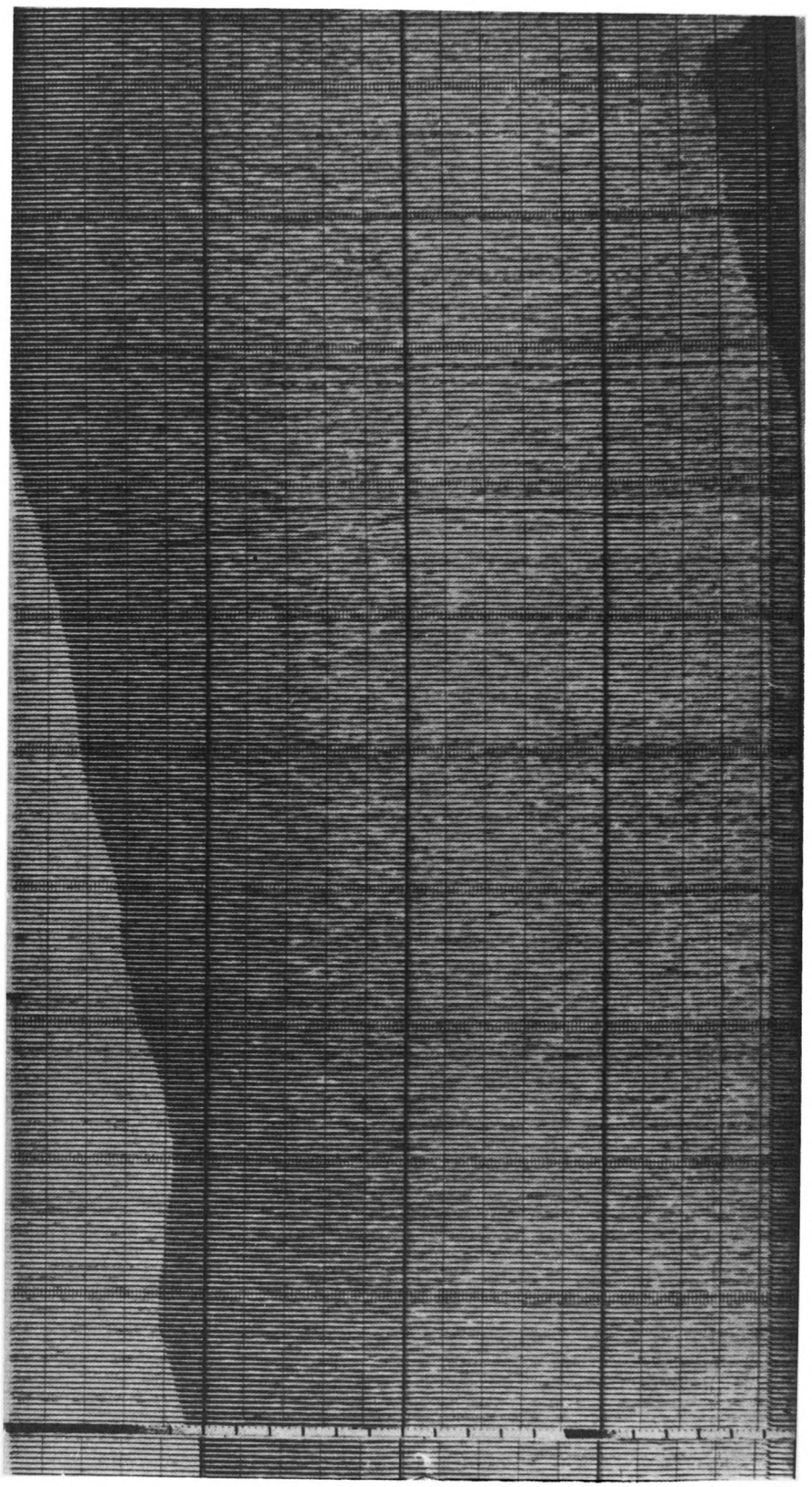

FIG. 5. — This example illustrates the case in which the depth is passing through a multiple of the expanded scale, in this case 4 × 400 fathoms. Readings to the left of this point are slightly more than 1 600 fathoms and those to the right slightly less.

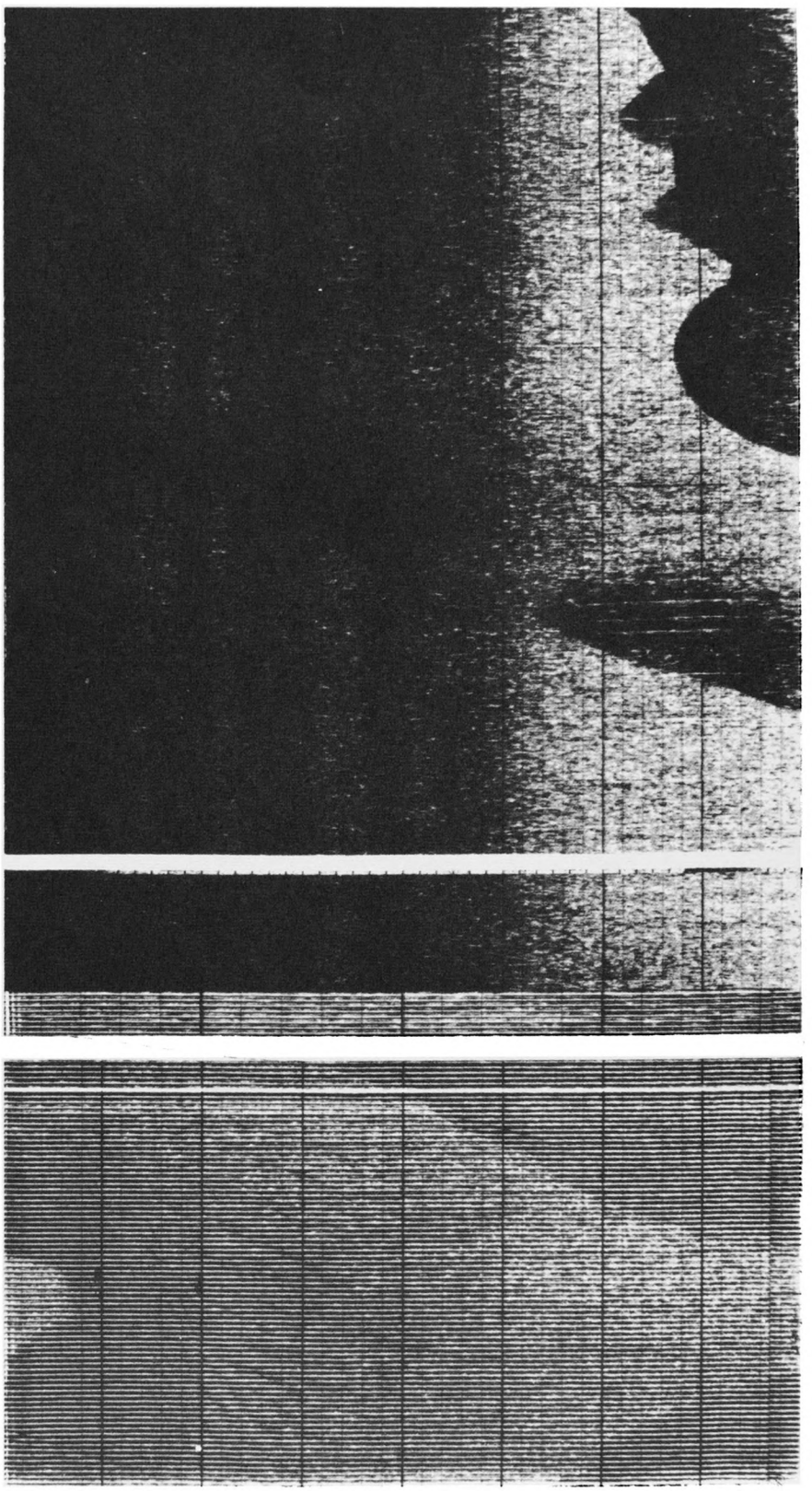

FIG. 6. — Expanded scale 800 fathoms. The depth at the time of the check sounding (six times the expanded scale) is seen to be about 4 100 fathoms. On the expanded scale this sounding should show at 100 fathoms ($5 \times 800 + 100$) but as the transmitter was not being gated at the time it is lost in the reverberations. On the left-hand part of the chart, with gating in operation, the bottom is seen to be shelving rapidly through the 800 fathoms scale, showing briefly at the top of the chart in the next multiple at a maximum depth of 4 870 fathoms ($6 \times 800 + 70$).