ECHO SOUNDING

XI

RECENT FORMS OF THE BRITISH ADMIRALTY ECHO SOUNDER

The Hydrographer of the British Navy has kindly supplied the International Hydrographic Bureau with a description of some of the recent forms of the British Admiralty Echo Sounder.

The instruments, without the Recording Gear, are fitted in all British surveying vessels, two to each vessel. Those which are employed away from home waters are fitted, in addition, with a Deep-Water Recorder similar to the *Challenger* type.

The British Admiralty has decided to fit an Echo-sounding instrument of the latest type in nearly all ships of the Royal Navy and the Hydrographer states that this gear is superseding the KELVIN sounding machine and that echo sounding is rapidly becoming the standard method throughout the British Navy and a large part of the Mercantile Marine.

This method has been used with great success in British submarines and has, indeed, become a definite safety device in them and a preventative against striking the bottom in waters of unknown depth.

BRITISH ADMIRALTY ECHO SOUNDER FOR C. G. S. *ACADIA*

In Vol. VII, N° 2, 1930, of the *Hydrographic Review*, in an article entitled *Charting of Hudson Bay and Strait*, communicated by the Director of the Canadian Hydrographic Service, which refers to surveys carried out by C. G. S. *Acadia*, reference is made on page 47 to the then latest type of British Admiralty pattern Echo sounder.

This instrument was specially designed for the purposes of the expedition and the equipment supplied to the C.G.S. *Acadia* was the following :—

Hammer, electro-pneumatic, controlled electrically from the instrument, the power being compressed air at 100 lbs. per sq. inch (6.8 atmospheres).

Hydrophones of the usual inboard type for Shallow Water and outboard type for Deep Water.

The instrument consisted of the Admiralty standard governed motor, running at 1800 r.p.m., fitted with the usual high speed and slow speed rotary switches controlling the hammer, the slow speed switch operating every half-second, corresponding to 200 echo-fathoms. This gave a telephone scale of 200 fathoms on a wheel 10 inches in diameter.

The instrument was fitted with recording gear which gave a continuous scaled trace of the soundings by means of a stylus connected in the anode circuit of a valve amplifier which ran across a paper roll sensitised with starch iodide.

The grid bias of the amplifier was adjustable so that no trace was recorded during the run of the stylus except when the hydrophone was disturbed by an incoming vibration of any kind whatever. Whenever the hydrophone was disturbed by a vibration of any kind the anode current liberated iodine which gave a stain record on the paper.

The paper was 6 inches wide, and the effective part which the stylus traversed was 5.354 inches, giving 46.7 fathoms per inch or 1 fathom = .0214 inch.

The total range which could be put on the Recorder at any one time was 250 fathoms.

The Recorder stylus was driven by a chain running over sprocket wheels driven by suitable gearing from the shaft carrying the slow speed rotary switch, in order to obtain the range of 250 fathoms; the length of the chain was such that the stylus traversed the paper at intervals of 2 ½ seconds.

From one sprocket shaft, a five to one reduction gear was arranged to drive a third rotary switch around which were 5 equally spaced brushes, the wiring from these brushes being led through a five position selector switch marked 0, 200, 400, 600, 800, to the hammer control circuit.

The wiring of the three rotary switches in the hammer control circuit was in parallel, the hammer control operating whenever the circuit was broken.

The times of rotation of the three switches in echo fathoms was 13 1/3, 200, and 1000 respectively.

Thus, the circuit was really broken at intervals of 1000 echo fathoms (2 ½ seconds) only and by means of the selector switch the break could be made to occur earlier by successive steps of 200 echo fathoms when desired.

By this arrangement the hammer blow which, with the selector switch set to 0, coincided with the passage of the stylus over the zero point of the paper, could be ante-dated by steps of 200 echo fathoms.

Thus, the navigator in a ship with this gear in use, and proceeding from say 30 fathoms in steadily increasing depths, sees the stain record on the paper move gradually to the right; when the record has passed the 200 fathoms mark on the scale, the selector switch is turned from 0 to 200 and the record jumps back 200 fathoms on the scale, and so on by steps of 200 fathoms up to 800 echo fathoms advance of the hammer blow.

In this way, although still retaining the reasonable scale of 46.7 fathoms per inch, the range of the instrument has been extended from 250 fathoms up to very nearly 1000 fathoms.

The telephone gear was the same as in the normal British Admiralty Echo Sounder, the telephone being cut out except for a very small period of time, the time elapsing between the emission of the signal and the opening of the telephone circuit for reception being controlled by the scale wheel. In order to measure the depth by telephone, the scale wheel is advanced slowly until the echo is heard; the lowest wheel reading at which the echo is heard gives the depth of water. It is seen at once that the advance given to the hammer blow, as shewn by the selector switch, is to be added to the reading given either by the Recorder or by the telephone scale.

ADVANTAGES OF THE RECORDER IN ELIMINATING INTERFERENCE.

Earlier in this article stress was laid upon the fact that whenever any vibration, from any source whatever, reaches the hydrophone, a stain record will appear on the paper.

At first sight this would seem to be a disadvantage; in reality it enables the observer to distinguish at once between the signals sent out, and which it is desired to record, and any other kind of interference.

The signals sent out by the hammer are synchronised with the instrument and no other source of disturbance is so synchronised; consequently the received signals form a continuous belt of stain which may maintain its position on the paper or move to one side or the other, always maintaining its continuity, but interferences recorded will consist of isolated short stain streaks which occur anywhere on the paper and do not form a continuous trace.

In actual practice, an echo trace can be readily identified through persistent interference, the strength of which may be equal to or even rather greater than the strength of the incoming signal.

In shallow water, when the incoming signal strength is more than is required, the interference can usually be prevented from appearing on the paper by increasing the negative grid bias of the amplifier, which reduces all incoming disturbances by a definite amount.

An alternative method is to insert a variable resistance in the hydrophone circuit, thus weakening all incoming signals in the same proportion.

DEEP SEA RECORDING ECHO SOUNDING GEAR FOR H.M.S. *CHALLENGER.*

The next step in the development of the British Admiralty Echo Sounder was the production of the *Deep Sea Recording Gear* for H.M.S. *Challenger.*

This instrument was designed by the Admiralty and constructed by H. HUGHES & Son, Ltd., 59 Fenchurch Street, London E.C. 3. It has been installed and thoroughly tested on preliminary trials in H.M.S. *Ormonde.*

It is confidently expected that it will reach its maximum of 6000 fathoms, for the old Deep Sea telephone instrument reached 4500 fathoms and it is known that the Recorder, with amplifier, is considerably more sensitive than the telephone.

In this instrument, for the first time, the telephone became definitely an auxiliary, the Recorder being the main instrument; the telephone shorting system and scale wheel were dispensed with and the rest of the instrument re-arranged.

The motor, gear box and governor are mounted horizontally in the top of the case; from the gear box a short vertical shaft runs downward and has on it, first, the Recorder chain sprocket wheel and, below that, a reduction gear of 4 to 1 to the hammer control circuit brushes.

This shaft revolves in an echo time of 250 fathoms and the hammer brushes in an echo time of 1000 fathoms or 2 ½ seconds.

The stylus is chain driven, as in earlier types, but the details have been much improved by the introduction of a stylus carriage running on ball bea-

rings in metal guides and an improved return gear, the stylus being off the paper on the return stroke.

The hammer control circuit is broken each time the rotating brushes pass the gaps in the two segments of the stationary disc. This disc can be rotated by hand from the outside of the case and the various step by step advances in the emission of the signal are obtained as before. The dial is engraved from 0 to 1000 fathoms and the 200 fathom steps are obtained very accurately by a special clicker catch arrangement.

Driven from the back of the rotating brush shaft is a Maltese Cross motion which operates a rotary selector switch controlled from a small selector switch which can be mounted at any convenient place near the instrument; this enables the operator to regulate the interval between successive signals, the intervals available being 2 ½, 5, 7 ½ and 15 seconds respectively, corresponding to 1000, 2000, 3000 and 6000 fathoms.

The signal emission arrangements thus permit of a signal every 2 ½ .....15 seconds with either 0, 200, 400, 600 or 800 fathoms advance with regard to the moment when the recording stylus passes zero.

The Recorder amplifier is accommodated in a separate box.

The telephones are arranged to plug into the amplifier and are used to locate the echo, which can then be brought on the Recorder range.

By setting the selector switch to knock every 15 seconds, the hammer control dial being set to 0, and listening with the telephones, the observer hears the hammer knock every sixth time the brushes cross the gap; at some later time (the lag depends on the depth of water) he hears the returning echo and by noting the reading of the moving brush pointer on the circular thousand-fathom scale, he obtains the approximate depth; thus, if the brush pointer revolves two whole turns and gets to 290 on the scale before the echo arrives, the depth will be 2290 fathoms.

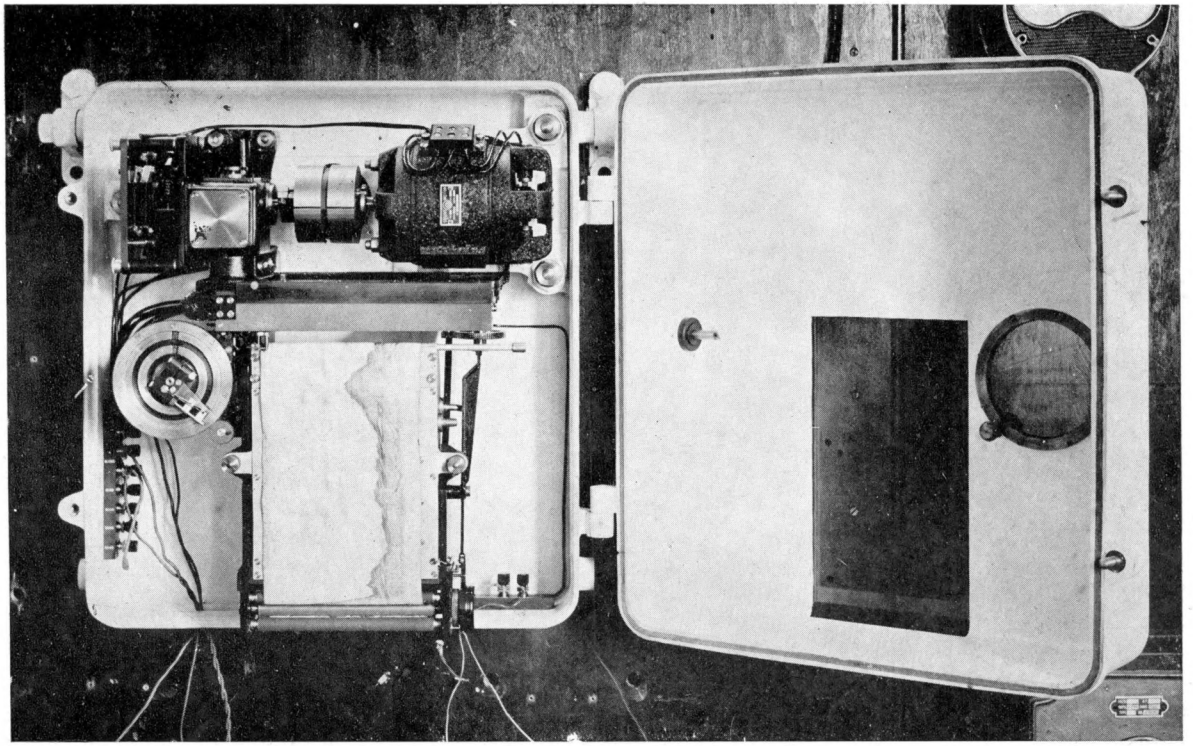
The selector switch is then set to the 1000 fathoms or 2 ½ seconds knock, the dial turned to 200 and the echo will be recorded at 90 on the recorder scale.

The telephone is used only as an auxiliary to locate the echo for the Recorder and the actual measurement is made on the Recorder.

As the Recorder operates every 2 ½ seconds there will be a few small ranges around each 1000 fathoms of depth where interference occurs due to the fact that the next or some other later knock would be recorded when emitting every 2 ½ seconds. Whenever this occurs the signal interval is changed, and thus the interference is cut out immediately. Of course changing to 15 second interval would do so in any case, but it may be desired to sound at closer intervals than 15 seconds.

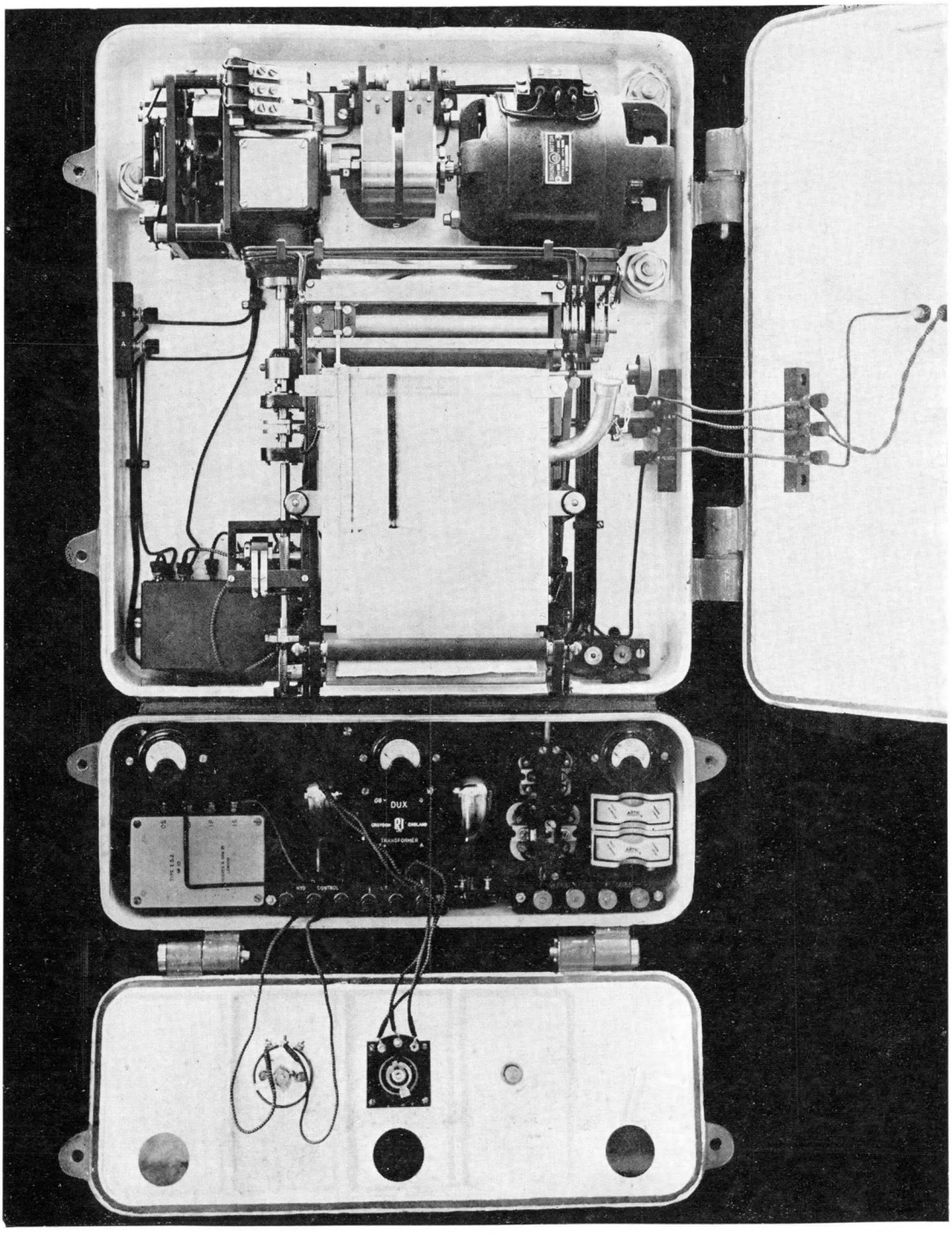
The following short table illustrates this :

Region of possible interference.	*Other intervals which remove the interference.*		
around 1000	2000	6000	
» 2000	3000	6000	
» 3000	2000	6000	
» 4000	3000	6000	
» 5000	2000	3000	6000



Echo Sounder
for H. M. S. Challenger

Sondeur par écho
du Challenger



Challenger Type
Trawler Echo Recorder

Enregistreur d'écho
pour chalutier, type Challenger

As the *Challenger* instrument was found to give extremely good results during trials at sea, it was decided to bring out a new series of instruments based thereon for use in normal shallow water work.

As it was desired to make the Recorder scale as open as possible a special cam drive was adopted instead of the sprocket wheels and chain, as otherwise the speed of the chain would be too high for satisfactory working.

The main features of the *Challenger* instrument were retained, viz :— the horizontal motor, vertical paper with large window, advancing the hammer stroke by rotating the break gap disc, and so on.

The amplifier and main control switches have been fitted in a separate box just below and bolted to the main instrument box, so that the whole forms a complete unit.

A series of models for different purposes have been prepared and the instruments can be supplied either for recording only or for recording and with telephones as well, as desired ; the telephone system employed is the original system with the telephones cut out except for a definite and very short period of time.

The first of these new instruments was for use in trawlers and recorded up to 286 fathoms, without hammer blow advance, on telephones. For such purposes simplicity and low cost are essential, so the slow break was arranged just above the gear box.

The cam drive consists of a cylinder with an endless channel cut in its circumference in which a roller may run. The roller axis pin is secured to the stylus carriage which runs on ball bearings between fixed guide bars and provision is made to lift the stylus off the paper on its return run.

A simple rotary switch, wired into the grid bias circuit of the amplifier, serves to mark the zero to which the scale can be set.

The scale is divided to 286 fathoms, at 2 fathom intervals, and very great simplicity both in construction and operation has been attained.

When a greater range than 286 fathoms is desired, as is very often the case, a simple alteration in the bevel gear which drives the cylindrical cam increases the range to 426 fathoms.

For ordinary use in the Mercantile Marine, a more open scale is desirable, even though it is necessary to sacrifice the simplicity of construction to a certain extent.

In these instruments there is still a definite demand for the provision of telephonic means of observation, but this, no doubt, will disappear as the advantages of the Recorder become more widely known.

The more open scale is obtained by increasing the travel speed of the stylus, the cam method of operation being quite able to cope with the increased speed, and the total range is recovered and extended by advancing the instant at which the hammer is operated by steps exactly as is done with the *Challenger* gear.

The large telephone wheel of Pattern 752 Instrument (*) is replaced by a

(*) The description of which is given in Vol. VIII, N° 2 of *Hydrographic Review*, November 1931.

disc of smaller diameter, and the telephone cut out brushes are revolved at a higher speed to give a scale equal to the range shown on the paper by the Recorder.

In the *new Mark VI* machine the range on the Recorder is 60 fathoms which occupies 5 inches of paper giving 12 fathoms per inch; the telephone dial gives 60 fathoms, and the total range of the instrument is 250 fathoms. The echo is recorded every 1 1/4 seconds.

The *old Mark VI* instrument recorded up to 130 fathoms on 5.35 inches of paper, thus a definite advance has been made by making the scale twice as large and, at the same time, almost doubling the total range.

The new Recorder scale of 12 fathoms per inch is ample for most navigational purposes and the new *Mark VII* machine has 120 fathoms on the Recorder and telephone dial at one time which, combined with step advances of 100 fathoms, give a total range of 500 fathoms.

In some machines of earlier series, where two different scales were required, this had to be obtained by a two speed gear box; such machines are no longer required as the more open scale and the extension of the total range in the latest types give larger ranges and more open scales than does any machine in the two speed range.

At the same time it is recognised that special demands for particular purposes may always arise and these can be quite easily met by introducing slight modifications in the above types.

In conclusion, the latest types of the British Admiralty Recording Echo Sounder embody the following advantages :—

1. The Recorder distinguishes absolutely between the Echo and all impulses arriving from any external source whatever.

2. The Recorder can now be made to give a large open scale combined with a large total range.

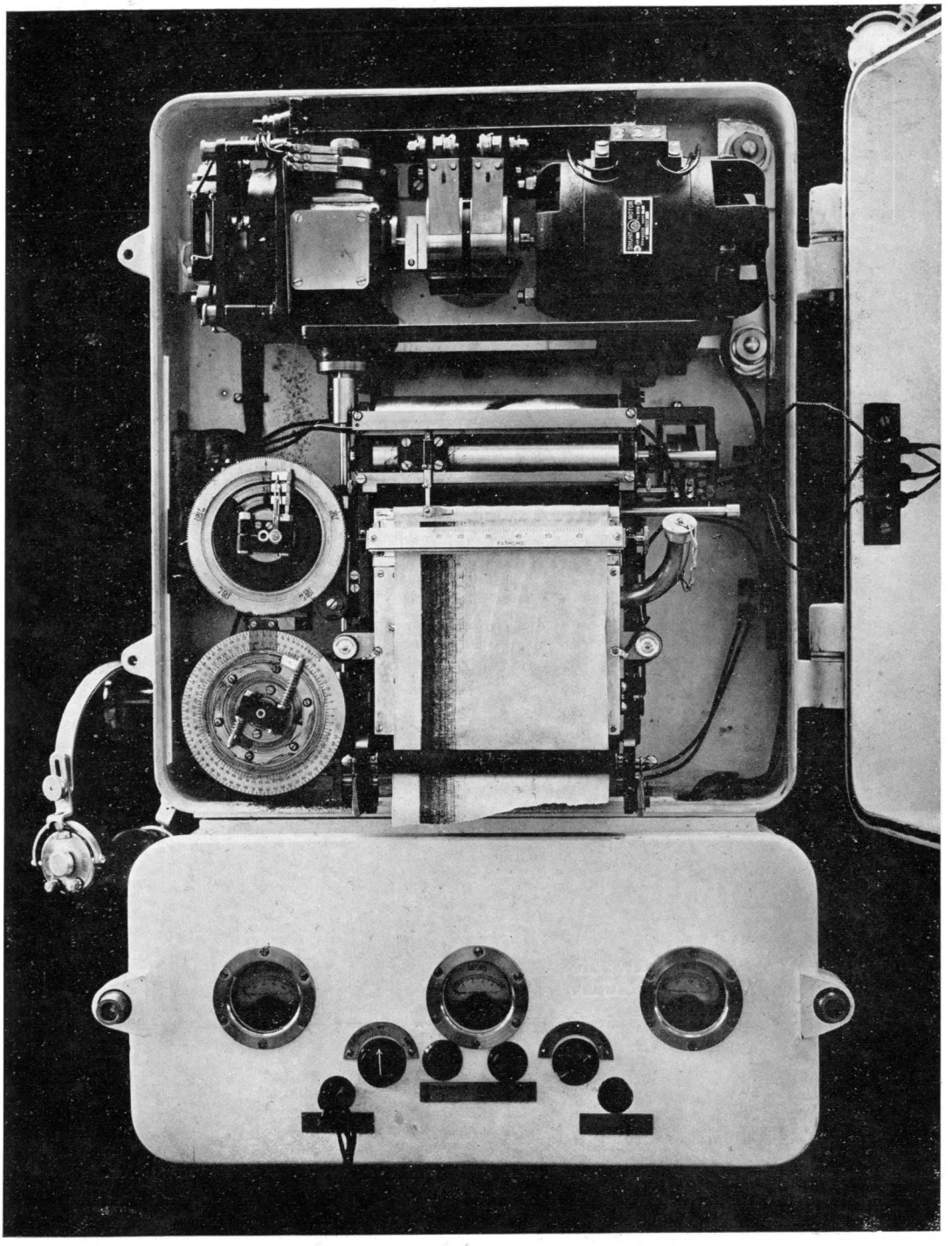
3. It is simple to operate.

4. The records are of a semi-permanent nature and can be stored for some considerable time in darkness; this is very convenient in that one is able to work out the results at times other than that at which the soundings were taken.

5. The record is completely visible from the instant at which it is made and shews the depth which can be immediately read off the scale; the contour of the ocean bed also is continuously visible.

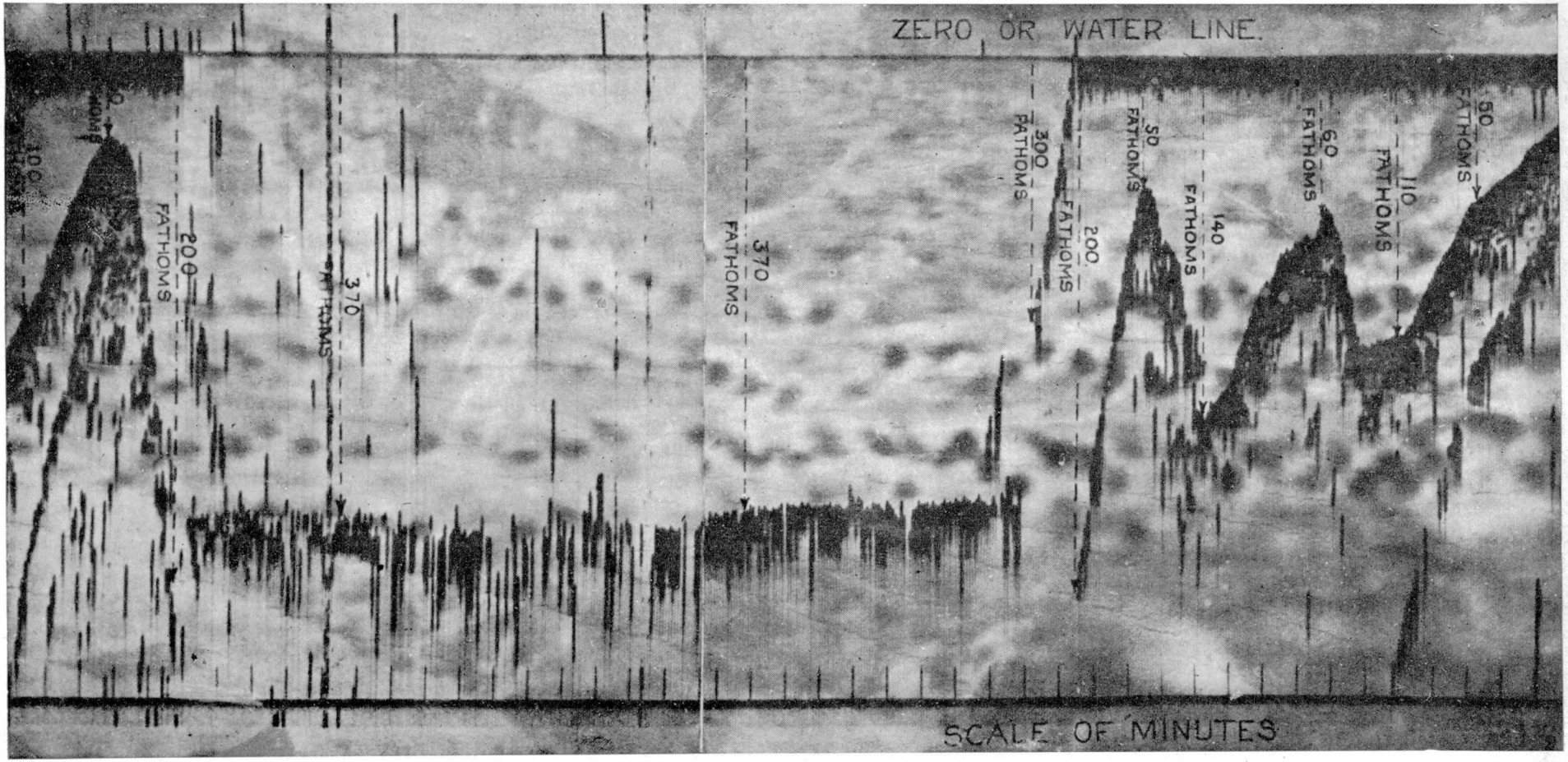
6. Notes can be made on the record itself while it is being made, so that absolute correlation between the soundings and all other observations can be maintained with certainty, and an extra fitting enables time marks to be made on the record automatically each minute.

7. Direct telephone observation can be fitted, if desired.



Special Echo Gear Mark VI
for cross Channel Steamer

Sondeur par écho Mark VI
pour vapeurs traversant la Manche



Record of Mark VIII
British Admiralty Echo Sounder

Enregistrement du Sondeur par écho
de l'Amirauté Britannique Mark VIII

DESCRIPTION OF SPECIAL ECHO GEAR, MARK VI, FOR CROSS CHANNEL STEAMER.

GENERAL DESCRIPTION.

The motor runs at 2880 r.p.m. and the gear box has a ratio of 10 to 1.

From the gear box a vertical shaft leads downwards driving the cam shaft through a 2 : 1 bevel reducing gear, the slow break through a 3 : 1 reducing gear and the telephone shorting brushes through a 4 : 3 gear, the latter being geared up.

The stylus is driven to and fro in its guides by means of the cam and roller.

The slow break is so arranged that 1 revolution corresponds to an echo time of 250 fathoms and the brushes rotate. The segment is mounted on a circular plate which can be set round by hand control from the outside of the case by amounts corresponding to 50 fathoms at a time and accuracy of setting is obtained by means of a clicker device. By this means phasing steps of 50 fathoms are obtained and the exact advance is visible through a window and shewn by figures engraved on the break plate.

The telephone scale engraved 0 — 62 ½ fathoms is visible through another window just below the phaser window and is rotated by means of a knob on the outside of the case.

The telephone brush speed and the interval during which the telephone circuit is open are made to correspond exactly to the Admiralty Pattern 752 Echo Gear by using a 3/32 inch segment at 1.06 inch radius, so that telephone brush trouble is avoided.

RANGES OF ELECTRO-MAGNETIC HAMMER.

Phase :	*Chart :*	*Telephones :*
0	0 — 59 fathoms	0 — 62 ½ fathoms
50	50 — 109 »	50 — 112 ½ »
100	100 — 159 »	100 — 162 ½ »
150	150 — 209 »	150 — 212 ½ »
200	200 — 250 »	200 — 250 »

At 250 fathoms interference occurs, due to the next hammer blow.

DETAILS.

Motor speed : 2880 r.p.m.	1 rev.	—	8 1/3 fathoms
Vertical shaft : 288 r.p.m.	1 rev.	—	83 1/3 »
Cam shaft : 144 r.p.m.	1 rev.	—	166 2/3 »
Slow break shaft : 96 r.p.m.	1 rev.	—	250 »
Telephone shaft :	1 rev.	—	62 1/2 »

Interval between successive blows : 250 fathoms — 5/8 sec.

RECORDING.

From this it is clear that the stylus will traverse the chart three times during an echo time of 500 fathoms during which time the hammer break operates twice.

When the phasing dial is set to zero, the second hammer blow would not be recorded as the stylus would be off the paper in the act of turning for its second return journey.

On phase 50 the second hammer blow would record about 33 on the second run of the stylus; on phase 100 the hammer blow would occur while the stylus pen is off the chart, but its interference might persist sufficiently to show on the second run of the stylus; on phase 150 the first hammer blow occurs at about 17 on the third run of the stylus of the previous cycle, while the second hammer blow occurs when the stylus is off the chart; on phase 200 interference from the first hammer blow may last long enough to record on the third run of the stylus of the previous cycle and the second hammer blow comes in direct at about 50 on the first run of the stylus as mentioned in the *General Description.*

In order to avoid recording these unwanted effects the recording current through the stylus and paper is interrupted except during the first run of the stylus in its cycle of three runs. The switch gear for this purpose is mounted on the right of the cam shaft from which its drive is taken so that it cannot get out of step.

So far nothing has been said about the echo from the second hammer blow which always occurs at an echo time of 250 fathoms before or after the first echo. A little consideration will immediately show that this can never occur during the first of the three runs of the stylus cycle and consequently will not be recorded.

LISTENING ON THE TELEPHONES.

In this case the echo of every blow of the hammer can be heard, as 62 ½ fathoms is exactly one quarter of 250 fathoms, the echo time between successive blows.

The gear is fitted to receive the echo on the shorting system so that the dial is rotated until the echo is heard. Now the divided circle of 3 inches diameter which is used revolves 4 times exactly during the interval between successive blows and is the equivalent of a 12 inch diameter wheel with 4 telephone segments 62 ½ fathoms apart, the whole wheel representing 250 fathoms and revolving at one quarter the speed. In order to avoid having to distinguish between the four telephone segments in this theoretical wheel, we restrict ourselves to the first quarter of it which is one revolution of the 3 inch disc and get rid of the other three segments by removing them, the 62 ½ fathoms of scale retained being quite sufficient for measuring up to 250 fathoms as we have the benefit of the phasing gear utilised for the recorder chart which will advance the hammer blow by steps of 50 fathoms.

Instead of spreading the 62 ½ fathoms round one quarter of the 12 inch wheel, we spread it round the entire circumference of the 3 inch disc which

gives the same scale of fathoms per inch, and we also provide an extra shorting switch which shorts out the telephone brushes during three of the four revolutions of the wheel which make up the 250 fathom period and so reproduce the equivalent of the removal of the three unwanted telephone segments on the theoretical 12 inch wheel.

By this means the succeeding hammer knock is not heard in the telephone but only the echo we are seeking and this only when the phasing dial has been set to the appropriate phase. The sole exception is that for phase 200 and telephone dial 50 we must hear the succeeding knock, which is of no consequence as the effective range of the instrument is 250 fathoms and we are then at the end of the range. This corresponds exactly to the case of phase 800 fathoms, wheel 200 fathoms, total 1000 fathoms, on the echo gear supplied to the *Acadia* early in 1931, when the succeeding hammer blow could be heard at that point.

SCALING.

The separation between the hammer and hydrophone causes a shift of the lower end of the 250 fathoms scale to the right and this effect dies out in less than 50 fathoms. In the original echo gear, *Mark II*, without Recorder, this was compensated by a special cam.

In the instrument supplied to the *Acadia* early in 1931 a correction chart was provided.

In the present instrument the difficulty is overcome by the use of two alternative scales for the Recorder and telephones respectively.

The Recorder scales are mounted so as to be easily turned over to bring the appropriate scale convenient to the chart; the one scale for use with phase 0 has noticeably uneven dividing at its left end to compensate for the separation; the other scale for use with all other settings of the phasing dial has a + mark engraved on it to remind the operator that the phasing dial must be added.

The telephone scales on the telephone disc are duplicated and read against long index mark, the outer scale being used for phase 0 and the inner for all other phases.

The operator is again reminded which to use by the engraving "up to 60" and "over 60" engraved on the index plate.

Thus, the necessity for a correction chart is avoided.

METHOD OF OPERATION.

Recorder gear.

The instrument is switched on and the water feed brought to the paper. In a short time the moistened paper is seen to be drawn into the track of the stylus; as soon as the stylus is seen to be travelling over moistened paper, which is quite readily seen as the zero mark then becomes visible on the record, the phasing dial is revolved by steps of 50 fathoms allowing an interval of about 5 seconds between each step till the echo is seen recorded.

Telephone gear.

Switch on the gear as before and search slowly round the telephone dial; if the echo does not come in, the phasing dial should be advanced one step and the search repeated; this process is to be continued till the echo is found.

A much better method is to take the reading from the Recorder and set the telephone dial to this when the echo should be at once heard.