B. — ECHO SOUNDING IN MOTOR BOATS. A DESCRIPTION OF THE BRITISH ADMIRALTY SUPER-SONIC SHALLOW WATER ECHO SOUNDING GEAR. (*)

The large number of soundings required for survey work in shoal waters, and the need for accurate soundings in shallow channels, provide an important field for the application of echo sounding methods, but the existing systems of echo sounding are unsuitable for fitting in small craft such as motor boats and usually fail to give the required accuracy when the depth below the boat is only a few feet.

A new system has been devised recently by the British Admiralty which solves the problem of obtaining echo soundings in small motor boats even in water less than one fathom in depth.

The essential features of this system consist of : —

1. A transmitter which emits a damped train of high frequency pressure waves in the form of a wide beam.

2. A receiver tuned electrically and mechanically to the same frequency and having similar directional properties to the transmitter.

3. An electrochemical recorder similar to that employed with the Sonic Shallow Water and Deep Water sounding gear.

The transmitter and receiver are fitted inside the hull with a separation of about 2 feet, so that the correction for separation error is negligible as it amounts to only 3 inches when the depth below the hull is 2 feet. In spite of the proximity of the transmitter and receiver the direct interference is insufficient to mask the echoes in the shallowest depths, and by the use of the tuned high frequency system, no interference from propeller or water noise is experienced.

The directional properties of the transmitter and receiver have been designed to give a wide beam so as to avoid the inaccuracy or loss of echoes that occurs with the highly directional beams usually employed with supersonic sounding systems.

The electrochemical recorder possesses the great advantage that it records the received impulses without any lag and responds, with varying degrees of tint, to a wide range of echo strength.

The contour of the bottom is recorded in rectilinear co-ordinates, and as successive echoes may be recognised when spaced only one sixtieth of an inch apart, rapid changes in gradient are shown without employing very lengthy records.

For soundings in shoal waters the stylus crosses the record at a rate

(*) This information has been provided by the British Hydrographer ; it is stated that although this set has not yet received Admiralty approval, it has already been installed in several ships and boats and appears to be giving every satisfaction ; it is hoped in the near future that this will be standardised sufficiently for general use in H.M. Surveying Service.

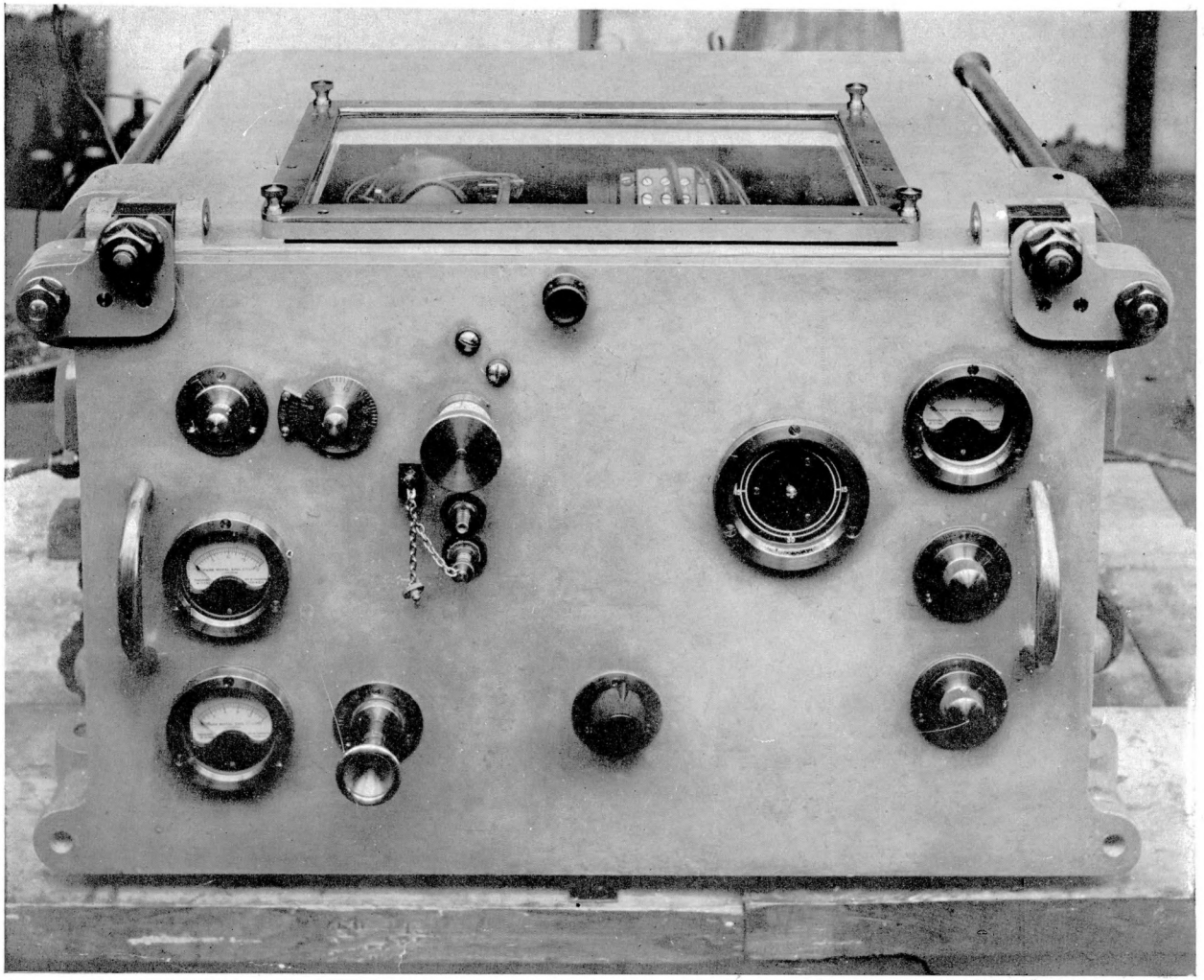
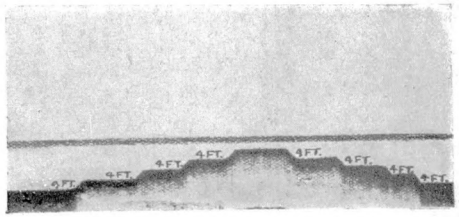
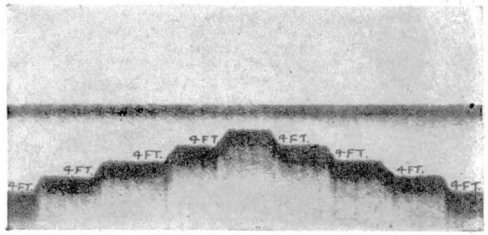


FIG. 3

Photograph of Recorder Unit (closed) *Photographie de l'enregistreur (fermé)*

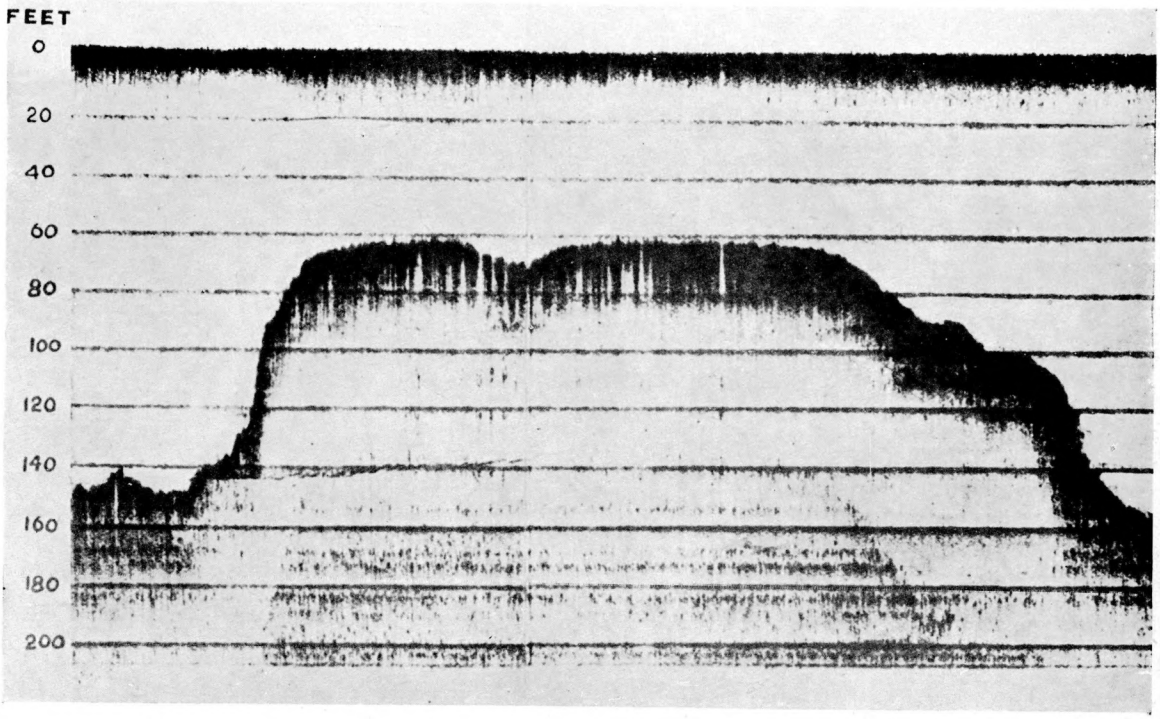


A



B

FIG. 4



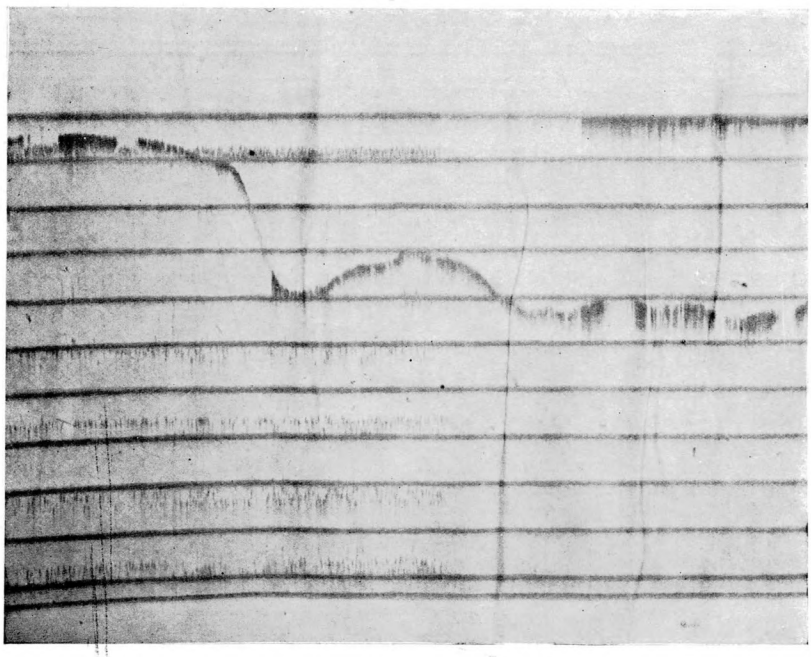


FIG. 5

Reproductions of typical records — Reproductions d'enregistrements typiques

giving a scale of about 1/2 $\frac{m}{m}$ per foot of depth and covers a range of 0 to 200 feet on a record 6 inches wide. For greater depths the phasing system is employed as in the case of the Admiralty sonic recorders.

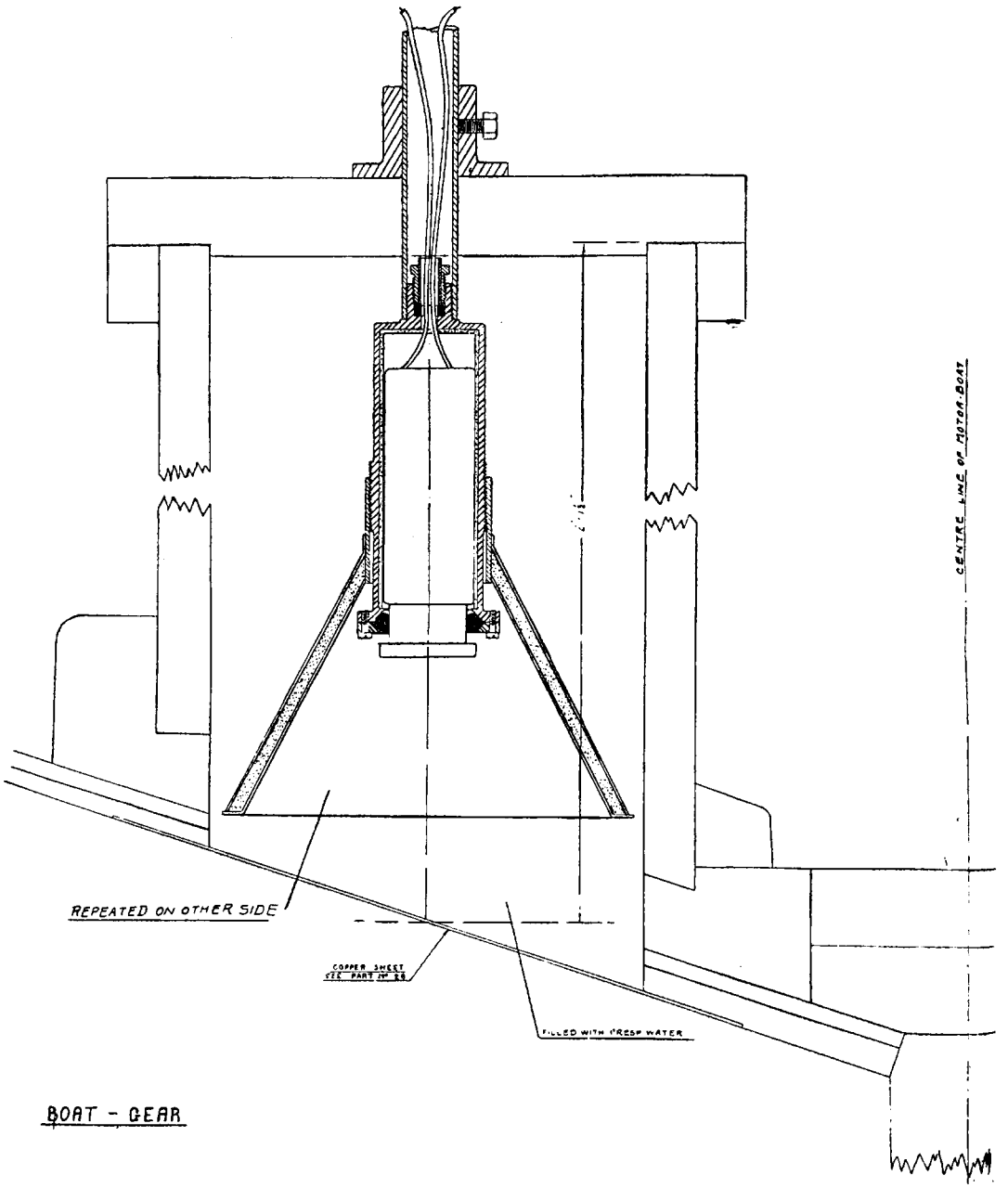


FIG. 1
Sectional Arrangement showing transmitter and reflector (in tank).

MAGNETOSTRICTION TRANSMITTER.

For the production of the high frequency waves, use is made of the magnetostriction principle. A pile of laminated nickel stampings in the form

of a ring are wound toroidally with a rubber insulated cable to form a closed magnetic circuit, which is excited by a high frequency current in the winding. The oscillator magnetic field produces radial stresses in the stampings which contract the diameter of the ring and set it in vibration at a frequency equal to twice that of the high frequency current in the winding. The transmitter is designed to operate at its natural frequency for radial resonance.

The transmitter is immersed in water and surrounded by a conical reflector (as shewn in Fig. 1) designed to emit the pressure waves in the form of a wide beam. The high frequency current for energising the transmitter is provided by discharging a large condenser through the windings and the circuit employed is shewn in Fig. 2. Immediately the single pole contactor switch is closed the *oscillatory current* and the vibrations of the transmitter build up to their maximum amplitude in a few oscillations and then decrease exponentially in amplitude.

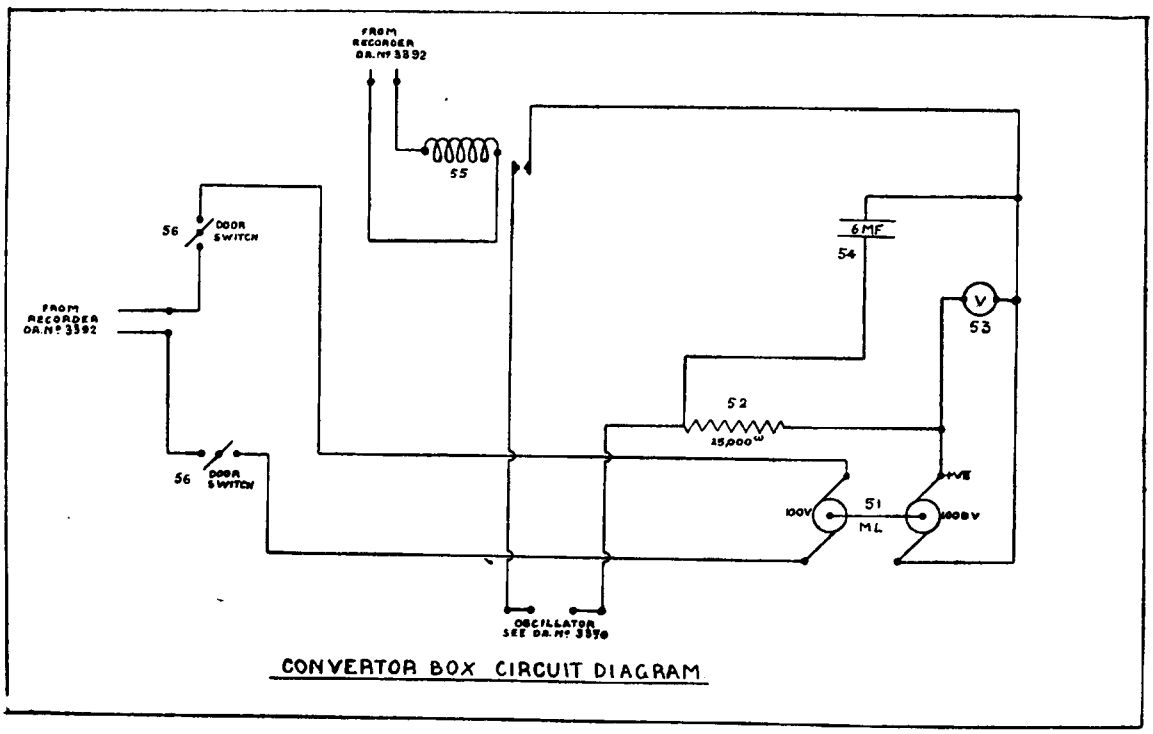


FIG. 2
Circuit diagram

MAGNETOSTRICTION RECEIVER.

The receiver is identical with the transmitter except that it is polarised by remanant magnetism. The pressure waves from the echo are collected by the reflector and set the nickel stampings into vibration. The resulting stresses in the magnetic circuit produce a current in the winding having the same frequency as that of the transmitted wave. The winding of the receiver is joined through a step-up transformer to the input of a high frequency ampli-

fier. Both the transmitting and receiving circuits are electrically tuned by fixed condensers and no tuning adjustment is necessary in practice.

In motor boats the transmitter and receiver are usually fitted in separate water filled trunks arranged on opposite sides of the keel. In larger vessels these trunks are replaced by small cast tanks bolted on to the hull and the waves are transmitted and received through the hull plating.

RECORDING UNIT.

The motor boat installations consist of only three units, namely, the transmitter, the receiver and the recording unit. The latter is shown in Figure 3 and consists of the following items : —

(1) *The Recorder.* The stylus slides on a ball bearing carriage and is given a to and fro motion across the record by means of a scroll gear cut on a rotating cylinder, driven by a governed motor. The scroll is designed to give the stylus a constant velocity throughout the width of the paper and to lift the stylus off the paper on its return stroke. The paper is driven at a constant speed by gearing to the motor drive. The transmitting switch, which controls the moment of transmission, is operated by a cam coupled to the motor. A depth scale is provided by means of a commutator, also coupled to the motor shaft, through which impulses pass to the stylus at constant intervals and produce series of parallel lines spaced say 20 feet apart, and the exact moment of making a "fix" can be recorded on the paper by numbered index mark.

(2) *The Amplifier,* with adjustments for "Volume control".

(3) A small *motor generator* which supplies L. T. and H. T. current for the amplifier and also provides the necessary voltage for charging the condenser used to operate the transmitter.

The whole installation can be arranged to work on a low voltage accumulator and consumes about 60 watts.

Coupled also to the motor is a transmitter switch which is definitely fixed in relation to the pen, thus ensuring correct phase relationship between transmission and pen position on recording chart.

The 200 foot range of instrument extends over four inches of recording paper, this scale being automatically marked off in 20 ft. divisions by a time marking switch in conjunction with the pen.

The 125 ft. range of instrument extends over four inches of recording paper, this scale being automatically marked off in 10 ft. divisions by a time marking switch in conjunction with the pen.

These ranges can be suitably converted into metres.

Transmission is arranged to take place immediately the pen has marked the first and zero depth line, and it follows that any signals arriving later than the time of transmission will be recorded by the pen at some point during its traverse providing they arrive within 1/12 sec.

Signals received by Magnetostriction type oscillator are passed on to a carefully tuned amplifier, magnified several thousand times, and finally passed on to the recording pen.

Investigation of the application of Echo Sounding to River Survey and Shallow Draft Work has recently been conducted by well-known Civil Engineers to determine the accuracy which could be obtained with the British Admiralty High Frequency Shallow Water Echo Sounder. Tests were made on 2 machines with scales of : —

A. 200 ft. to 4" — 1/50" to a foot.

B. 125 ft. to 4" — 1/32" to a foot approx.

The tests were made in the experimental tank of the manufacturers, Messrs Henry HUGHES & SON LTD. at Husun Works, Barkingside, and pictures at the scale of 2/3 of the records made show the proportion of the readings taken (Fig. 4).

Readings were made of 4 ft. steps which are sufficient to show the accuracy and proportions of the 4 ft. step when indicated on the records.

The maximum error found did not exceed 6" on *A* scale and 3" on *B* scale. This means that readings of depth can be taken on the Boat Echo Sounder within the limits of accuracy possible at the present time with careful lead measurement. But it must be pointed out that if check measurements are taken with the Echo Sounder at beginning and end of the run and provided the speed dial is observed during the run, the whole of the soundings shown on the record, 3/4" to a minute, are of the same consistent accuracy, and the continuous contour line of the bottom provided by the Recorder gives the most accurate and reliable indication of differences in depth over the whole run. There can be no startling or disturbing errors due to occasional bad measurement by lead, but the whole record is to be in strict proportion.

Navigation of bars appears to be one of the most critical purposes to which Sounding Apparatus can be applied.

A rise or fall of tide to at least 3" on the Bar must be observed, in order to allow a vessel to pass over with 1 ft. under the bottom or even less.

The same order of accuracy can be applied to ships working in muddy harbours and rivers where it is required to record daily the change of bottom. Extensive tests have been made in England, Canada and Italy with the British Admiralty Gear and the generally good results achieved provide a good basis for confidence that the new method of Echo Sounding will enable the use of the lead to be almost entirely replaced in all river and harbour work.

The continuous record made with the British Admiralty Gear at the rate of 3/4" to a minute will save an enormous amount of time and heavy labour. The boat can be run at speed up to 8 knots and thus if the machine were working for six hours a day records of 50 miles a day could be made on the scale of 100 ft. to 1" of chart approx.

The High Frequency Echo Sounder gives 96 signals per minute, and the close mesh which this almost continuous emission makes on the record, entails most complete detail in the record.

Comparing this with the lead, it is obvious that at least 200 or more soundings are taken between every possible cast of the lead.

RECORDS.

Some typical records obtained with this gear fitted in a 28 feet motor

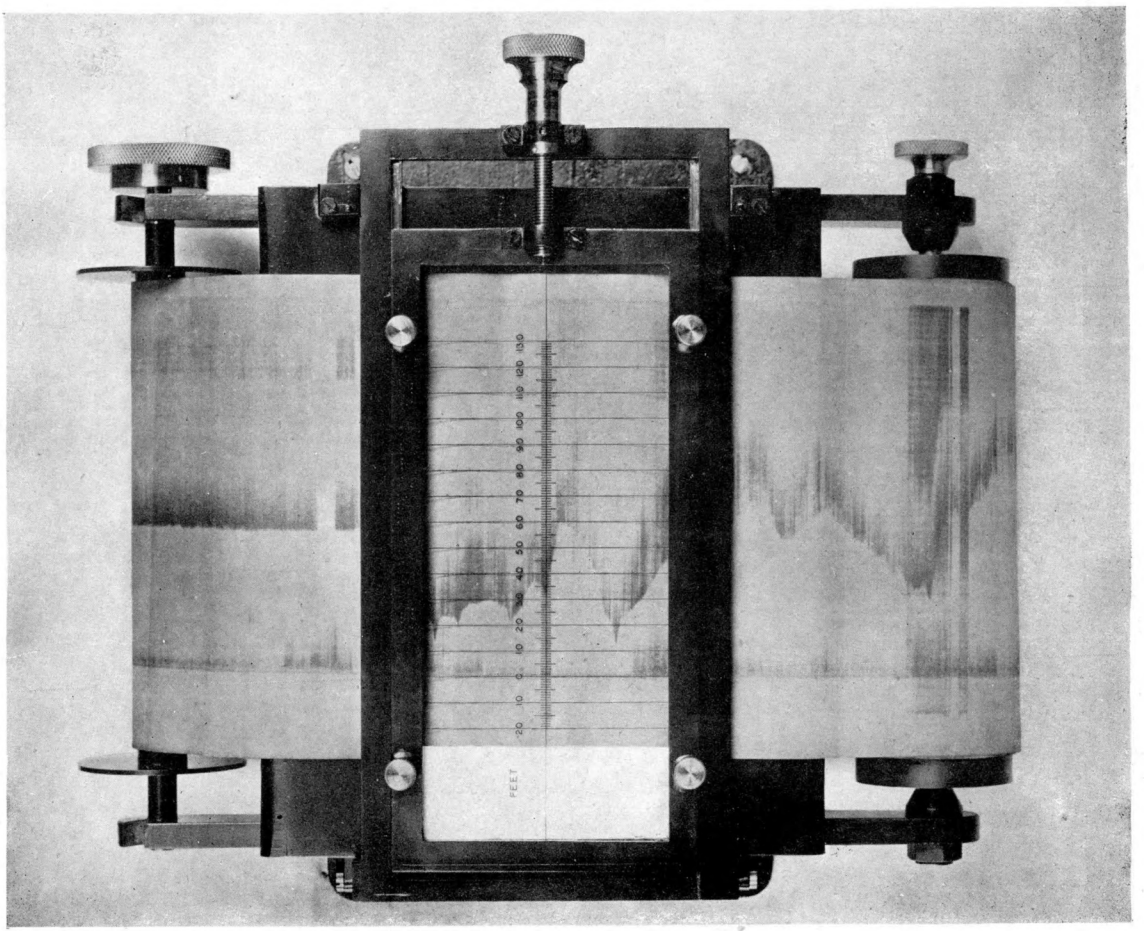


FIG. 6

Photograph of record scaling machine — Photographie de la machine à lecture d'échelle

boat are shown in Figure 5. In one of these records the depth marks are spaced 20 feet apart and the range covers 0 to 200 feet. The traces seen near the zero lines are due to direct interference from the transmitter. In the second record it will be seen that these traces can be eliminated by adjusting the volume control, and that echoes in a depth of 4 feet are clearly recorded. In this record the depth scale marks have been temporarily removed.

Owing to the absence of "time lags" in any portion of this system zero setting presents no difficulty. The commencement of the transmission coincides accurately with the moment at which the condenser switch is made. With the switch in this position the stylus is set at one foot below the zero line, when the faces of transmitter and receiver are one foot below the water line.

To assist accurate interpolation of the records between the 20 foot depth marks a scaling machine, shown in Figure 6, is provided. It is intended that this scale should be used for direct tidal reduction, as will be seen by the markings on either side of zero.