A MINIATURE ECHO SOUNDER FOR INSHORE NAVIGATION AND SURVEY

IBH Note. — Brookes and Gatehouse Ltd. of Lymington, Hampshire, England, sent us the article below, which we thought would be of interest to States Members.

The development of Hecta was undertaken during the winter of 1958-1959 with a view to producing a portable yet robust echo sounder of high accuracy that might be used in the smallest fishing boats, surveyors' dories and sailing yachts in depths up to 30 fathoms. In order that an endurance of at least 100 hours should be obtained from a small dry battery, the power consumption was to be limited to 0.1 watt, which is about five hundred times less than that of conventional short-range echo sounders. It was shown that this specification could be achieved by the use of transistors instead of thermionic valves and by the use of a meter-type display instead of the customary rotating lamp or cathode-ray tube. The success of the project depended upon whether the meter pointer could be made to give a steady indication of depth in the presence of sea noise, such as is experienced in strong tidal streams and breaking seas, and of spurious echoes from small objects suspended in the water. The major part of the development programme was therefore concerned with the investigation of these effects and of the reflectivity of various types of sea bed. The boats used in the trials were a 19-ft auxiliary sailing yacht (fig. 1) and a 40-ft motor-vessel. The area in which the investigations were made comprised the West Solent and the English Channel between Cherbourg and the Isle of Wight.

All observations were made on a carrier frequency of 175 kc/s, which appeared from the available data to be the most suitable for this application. Extrapolation of the results to other frequencies was done on the basis of relationships established by other investigators.

Trials Results

These have been presented in a separate article [1], together with the derived curves for relative echo power and sea noise power, each as a function of frequency, over the range of frequencies between 100 and 250 kc/s. For a fixed angular width of the acoustic beam, echo power decreases with frequency at a greater rate than does the power of sea noise. Consequently, an upper limit to frequency is set by consideration of the minimum

FIG. 1

permissible ratio of echo-to-noise power. For a peak radiated power of 0.01 watt, which is all that the specification allows, and a receiver bandwidth of 200 c/s, the carrier frequency has an upper limit of about 200 kc/s if disturbance of the pointer by noise pulses is to be avoided.

Another important result that was obtained is that the amplitude of echoes from suspended matter in the sea very seldom exceeds that of the bottom echo, if the latter were at the same range. Consequently it is possible to reject these spurious echoes by means of a system of time-varying, or *swept*, gain which keeps the receiver sensitivity just above the minimum value for detection of the bottom echo at all times during each pulse cycle.

Description of Hecta

(a) *Principle of operation* (See fig. 2)

Hecta is a pulsing echo sounder operating on a carrier frequency of 175 kc/s. This is close to the maximum permissible value of 200 kc/s and was so chosen in order to reduce the transducer aperture to a minimum. The instrument contains no moving parts, except for the pointer and coil of the indicating meter, and operates entirely by means of transistor circuits. A transmitting oscillator generates a continuous train of pulses at a fixed rate of 12.5 per second. The transducer is a barium titanate disc 23 n. m. in diameter, and one only is used for both transmission and reception. The angular width of the conical acoustic beam is 30° between the half-power points, this value being considered high enough to tolerate the ship's roll in a seaway. The peak electrical power input to the transducer is 0.5 watt. An electronic switch is used to disconnect the receiving amplifier from the transducer during the transmission periods. The receiving amplifier has a peak power gain of 80 dB. For the reason given above its gain is *swept* during each cycle, starting from a very low value at the beginning of each period of reception. This is achieved by means of a *sawtooth* time-base circuit which controls the bias current to one of the transistor stages. After detection, the signals are passed through filters which increase their amplitude in relation to the noise background. They then reach the range-measuring circuit, which is a bi-stable electronic relay. It is driven into one of its two *states* by the leading edge of each transmitted pulse and is re-set by the leading edge of each echo. This action is caused to start and stop the flow of current through the meter, the value of which current is accurately maintained at a fixed value. Since the time interval between transmitter pulses is constant, the mean meter current is proportional to echo delay. The time-constant of the meter movement is made much greater than the period between pulses, and so the pointer takes up a steady displacement proportional to range.

The accuracy of the system depends upon the constancy of the pulse repetition rate, of the amplitude of the current pulses in the meter circuit, and the accuracy of calibration of the meter. The latter is specified at ± 1 %. By the use of high-stability components and silicon transistors in critical parts of the circuit, the overall error is held within ± 3 %. or 6 inches, whichever is the greater.

Two interesting and valuable features of Hecta are : —

1. The provision of two range scales. One extends from 2.5 ft to 32 ft; the other from 2.5 fathoms to 32 fathoms. (Metric equivalents are also supplied). Thus, when operating in shoal water the range switch is set to *feet*. Each scale division is one foot and variations in depth of only 3 inches are discernible.

2. The provision of a socket to which may be connected a remote 8 in wide, 4 ⅛ in high and 2 ⅛ in deep, which is protected against corrosion meter. This instrument may have any size of dial (up to about 8 inches in diameter) or it may be of the recording type. The latter is described in more detail in the final section.

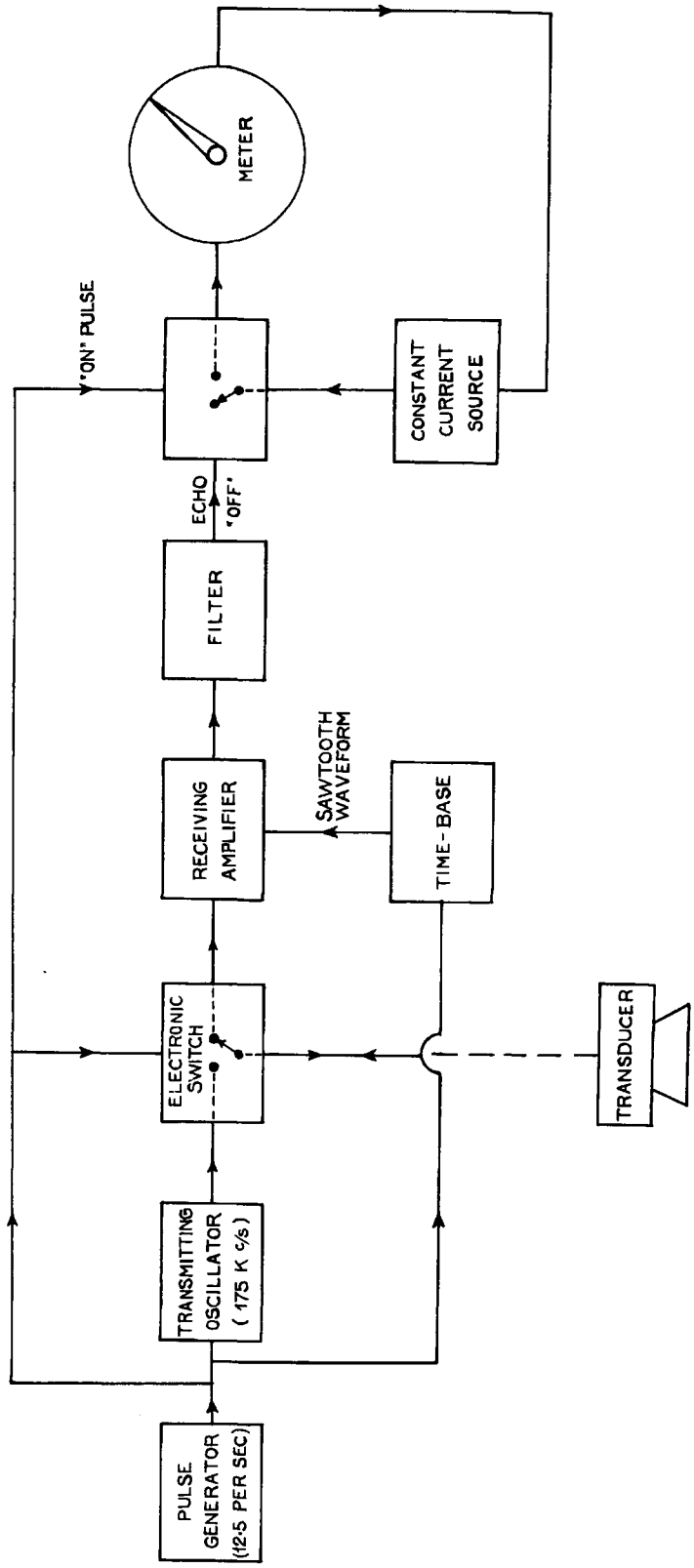
METER
"ON" PULSE
CONSTANT CURRENT SOURCE
ECHO
"OFF"
FILTER
SAWTOOTH WAVEFORM
RECEIVING AMPLIFIER
TIME-BASE
ELECTRONIC SWITCH
TRANSDUCER
TRANSMITTING OSCILLATOR (175 K c/s)
PULSE GENERATOR (12·5 PER SEC)

Fig. 2

(b) *Mechanical Design* (See figs. 3 and 4)

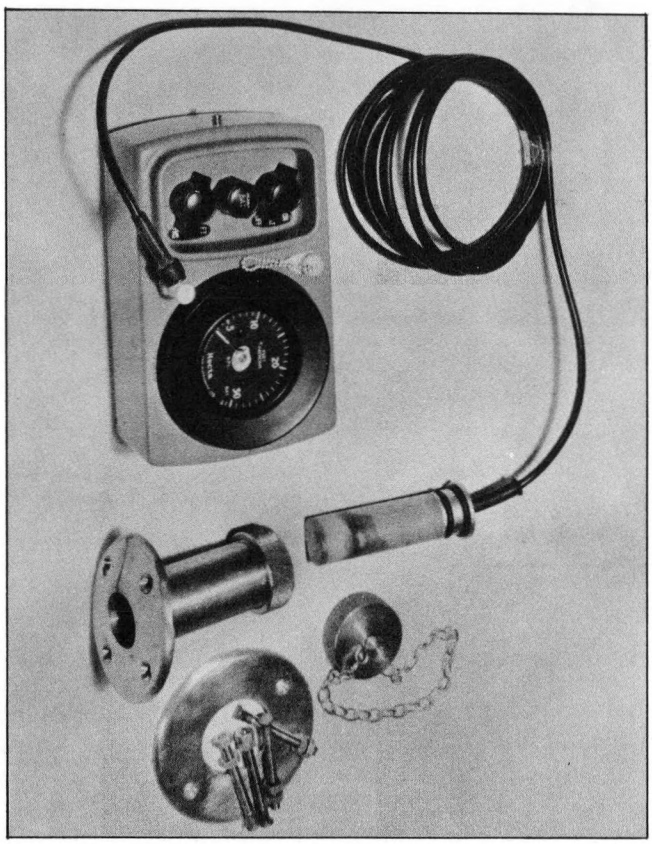

FIG. 3

THE TRANSDUCER

This is contained in a tube of *fibreglass* 3.5 in long and 1.2 in in diameter, which also houses a transformer that matches the oscillator output to the resonant resistance of the transducer disc. The complete assembly is *potted* in epoxy resin. A brass top-cap contains synthetic rubber 0-rings, fitted into grooves, which create a tight seal when the unit is pushed into its tubular gunmetal housing. This housing is fitted in the bilge of the boat, the tube passing through a 1⅛ in diameter hole in the planking. A screw-cap is provided to seal off the top of the tube when the transducer unit is not in place. When used on board dinghies the transducer may be inserted in a special housing screwed to the end of a short spar which is clamped to the transom or gunwale.

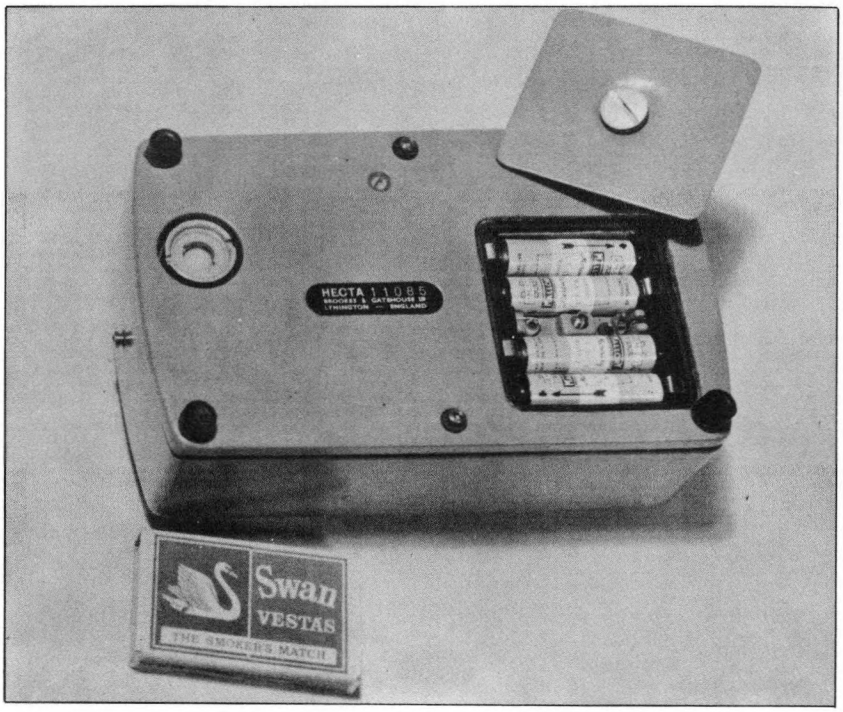

FIG. 4

THE INSTRUMENT

This is housed in a hermetically sealed case of silicon-aluminium alloy 8 in wide, 4⅞ in high and 2⅞ in deep, which is protected against corrosion by a film of nylon deposited by a fusion process. The meter window is of toughened glass. Its rim, the control shafts and sockets are all fitted with sealing glands, and a removable desiccator with indicator window is provided to prevent internal condensation in case of seal failure. The controls are recessed into the case to protect them from damage.

The battery comprises four Mallory RM. 522 R hearing-aid cells and is housed in a compartment in the rear cover of the case. This compartment is isolated from the rest of the instrument, so that failure to secure its cover-plate properly can at the worst result only in a wetting of the cells. The instrument is fixed to a bulkhead, when necessary, by means of a back-plate with spring clips which engage with studs on the sides of the case.

The instrument is designed to withstand shock loading up to values of 40 g.

Special Adjuncts for use in Survey

(a) *Pen Recorder.* Hecta may be used in conjunction with any recording milliammeter having a full-scale sensitivity of 2 mA. This is connected to the upper socket on the instrument panel. One recorder that has been used successfully is the *Record* portable, which has the following specification :

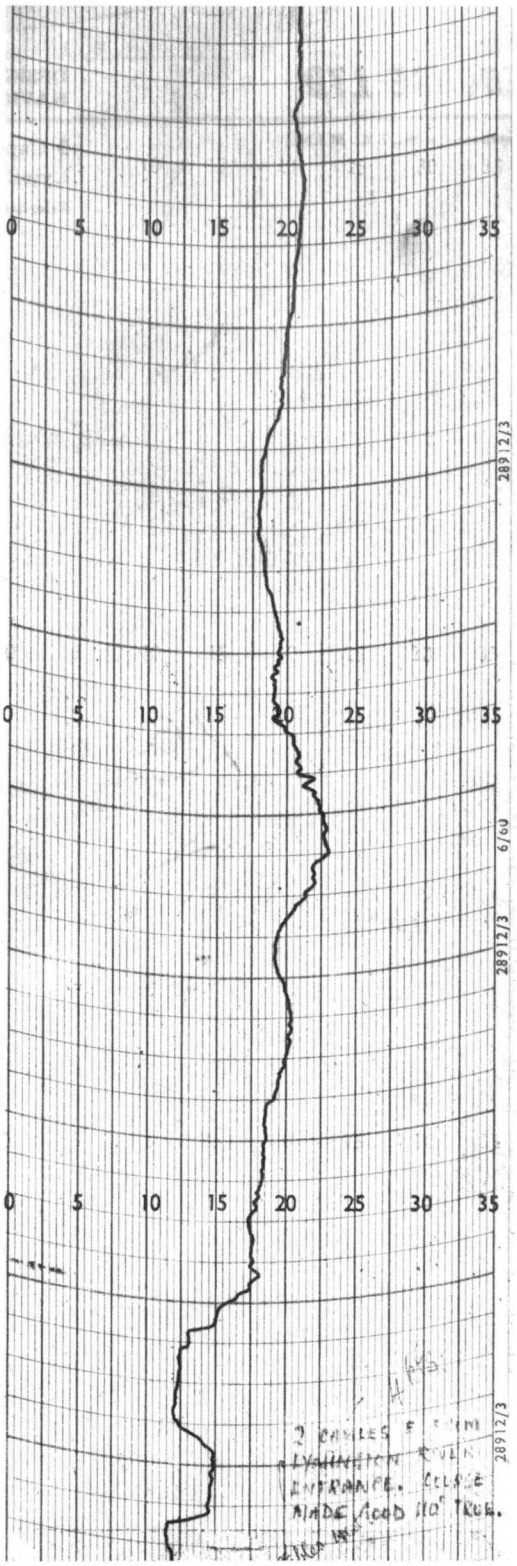
0 5 10 15 20 25 30 35
28912/3
0 5 10 15 20 25 30 35
6/60
28912/3
0 5 10 15 20 25 30 35
28912/3

FIG. 5

Drive	Clockwork.
Paper width	3″.
Paper speed	A wide range of speeds is available, and may be changed by the replacement of gear wheels. 1″ per minute has been found best for speeds of about 4 knots.
Ink feed	Capillary tube from trough.
Weight	26 lb. (11.8 kg).
Size	10.8 × 8.2 × 6.3 (27.5 × 20.8 × 16.0 cm).

Fig. 5 shows a section of chart record obtained on the *feet* scale when the boat was making 4 knots over the bottom. It can be seen that depth variations of only 3 in are discernible on the trace.

Circuits can be fitted in the recorder to extend the range of readings on the feet scale by the method of *suppressed zero*. For example, on the first position of a switch the instrument reads, as usual, from 2.5 ft to 35 ft. On the second position it reads from 35 ft to 70 ft, and on the third from 70 ft to 105 ft. The advantage of this arrangement over the standard feet and fathoms scales is that the accuracy at depths greater than 32 ft is much increased.

The connection of a remote meter to Hecta does not increase its power consumption, and it is of interest to note that whereas the power consumption of a conventional short-range recording echo sounder is 100 watts, that of Hecta is 0.1 watt.

(b) *Narrow-Beam Transducer.* A special transducer having a beam-width of only 10° between the half-power points is manufactured for use by surveyors.

The advantage of this over the standard 30° unit is that it enables finer detail of the bottom profile to be obtained. This transducer is 2.8 in in diameter and operates at a frequency of 200 kc/s.

The cross-sectional diameter of the beam at the sea bed should not be more than about one-quarter of the width of the narrowest valley that is required to be charted. A 10° beam, for example, has a diameter of about 3 feet at a range of 18 feet, and so would give reasonably faithful reproduction, in that depth, of undulations which are 12 ft wide between crests.

Specification of Hecta

(*a*) Maximum range	32 fathoms over mud.
(*b*) Minimum range	2.5 ft.
(*c*) Battery supply	4.8 to 6.0 V (four hearing-aid 'A' cells, in instrument case).
(*d*) Battery endurance ...	This is 150 hours (average) when using Mallory RM. 522 R cells.
(*e*) Accuracy	± 3 per cent or 6 in, whichever is the greater, over the range of ambient temperature between — 20° C and + 60° C, subject to correction for extremes of sea temperature and salinity.

(*f*) Scale of display	5 ft per inch of scale on shoal setting. Scale and pointer are luminized for night use.
(*g*) Repeater	A distant meter of any size may be connected to the instrument, and this may be of the pen-on-paper recording type, clockwork driven, for survey use.
(*h*) Weight	5 ½ lb, including transducer.

REFERENCE

[1] GATEHOUSE, R. N. B. : A miniature transistorised echo sounder. *Electronic Engineering*, Vol. 32, No. 388, June 1960.