A COMBINED ASDIC/ECHO - SOUNDING SET FOR USE IN FISHING VESSELS AND AUXILIARY CRAFTS

BY

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List of illustrations.

C o n t e n t s .

1.0 SUMMARY.

1.1 General.

This report gives a brief description of a combined asdic/echo sounding set developed at Norwegian Defence Research Establishment (N.D.R.E.) The set is primarily designed for installation in ocean going fishing vessels down to about 8o ft length.

A short introduction is followed by a chapter giving the main principles of operation and basic design considerations.

The next chapter is devoted to a more detailed description of the various components of the set and their operational functions. The text is illustrated by block diagrams, sketches and photographs of the respective units.

The results obtained on preliminary trials with the research vessel M/L "Tustna" and on an actual fishing expedition with M/S "Ramoen" are summarized in a separate chapter. A curve is given of water noise versus speed, and echo traces of herring shoals are reproduced.

1.2 Specifications.

The combination of asdic and echosounder in one set involves the use of the same pulse-transmitter, receiver and range recorder for both purposes.- The set consists of two major units as illustrated in Fig. 1:

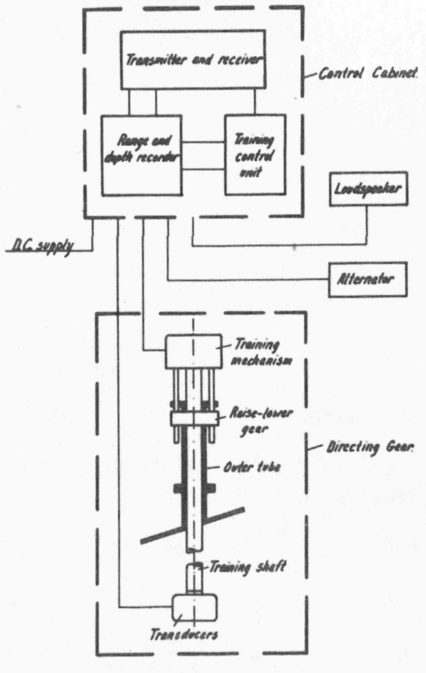

Fig.1. Block diagram of combined asdic/echo sounding set.

Directing Gear (for details see fig. 2), whereby the two transducers can be raised and lowered in the vertical plane and trained electrically in the horizontal plane.

Control Cabinet (see fig. 3), containing range and depth recorder, pulse-transmitter, receiver and training control unit.

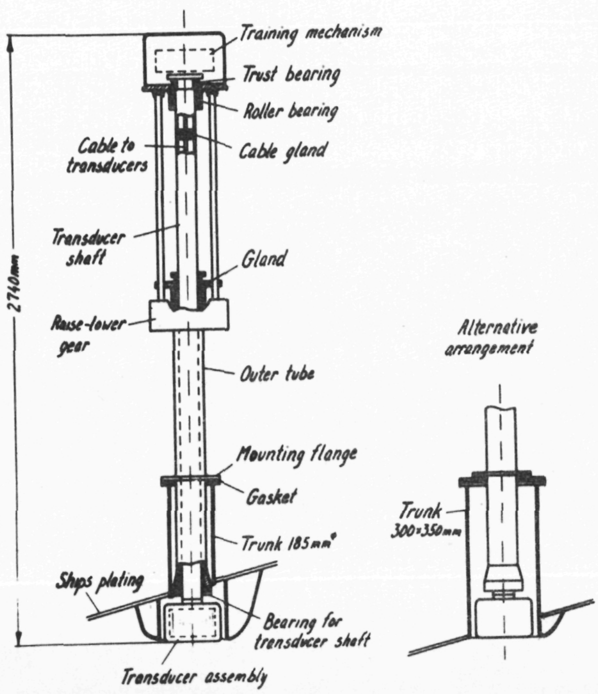

Fig 2 Directing gear.

Weight of directing gear (with transducers, raise-lower gear and training mechanism)	25o kg
Total height	274o mm
Diameter of hole through bottom	185 mm
Overall width of directing gear	4oo mm
Maximum operating speed	12 knots
Operating frequency	3o kc/s
Beamwidth of polar diagram: vertically 22°, horizontally 8°	
Control cabinet, weight complete	5o kg
Control cabinet, outside dimensions (see fig. 3): height 57o mm, width 47o mm, depth 26o mm	
Transmitted power	22o watts
Pulselength 3 m.sec. and 3o m.sec.	

Amplification	2×10^{6}
Recorder ranges	1800 m and 180 m

Training control: manual or automatic in 5^{o} step.

Power requirement: 400 watts, 24 V, 110 or 220 V DC.

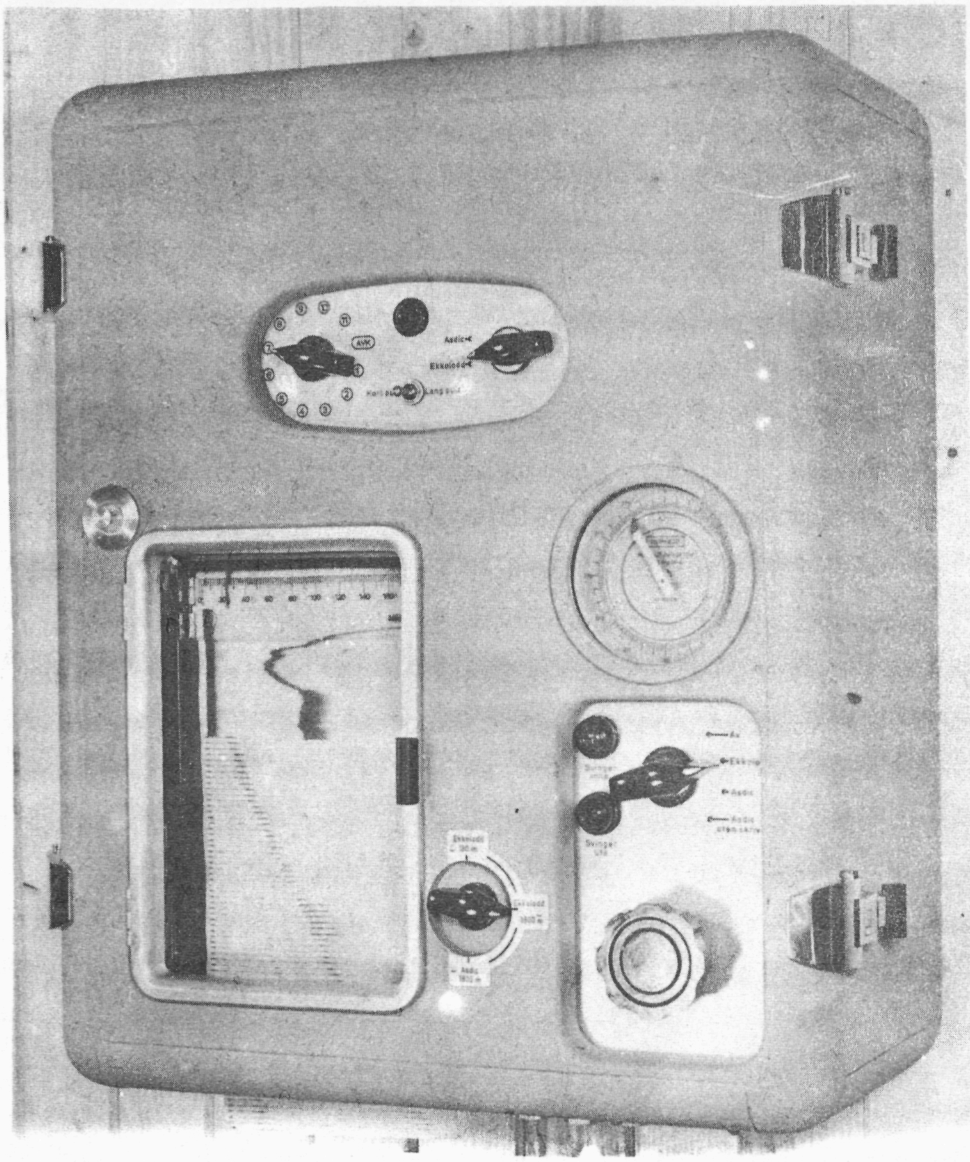

Fig. 3. Control cabinet.

2.0 INTRODUCTION:

The first systematic investigations of the suitability of asdic equipment in detecting shoals of fish in Norwegian waters were carried out during the spring-herring season in February 1946 (1).

The results were rather promising and provided sufficient material for the subsequent specification and layout of the asdic equipment for the ocean going fishery research vessel "G.O.Sars", operated by the Director of Fisheries, Bergen, Norway.

Since this ship was completed in 195o the asdic equipment has been in use for more than 1o.ooo houres on various research expeditions under the leadership of Mr. Finn Devold.

Based om his practical experience with the asdic equipment on "G.O.Sars", Mr. Devold concluded (2) that an asdic set would be of considerable value in an ordinary fishing vessel. Mr. Devold suggested that the possibility of constructing a small combined asdic/echo sounding set should be investigated.

Preliminary work on the project was taken up at this laboratory in October 195o. The first sea trials were carried out during the spring of 1951 and a laboratory model of the equipment installed in the research vessel M/L "Tustna" in January 1952. A prototype of the combined asdic/echo sounding equipment - as described in this report - was completed in the last months of 1952 and installed in the fishing vessel M/S "Ramoen" in January 1953.

3.0 PRINCIPLE OF OPERATION.

The principle of echo ranging as applied to underwater location is well known (3) (4), and needs no further comment.

In absence of such basic information as the reflecting properties of fish shoals for various frequencies, the choise of operating frequency for an installation of this kind has to be based primarily on previous experience.

For echo sounding purposes frequencies between 1o kc/s and 5o kc/s have been in use in the fishing fleet with fair results.

In a critical comparison of echo sounding installations of different frequencies it would be necessary also to consider the other factors contributing to the quality of the sets i.e. beamshape, transducer gain, transmitted power, amplification, noise level, bandwidth and method of presentation.

No attempt has been made to compare the results obtained by the various installations. It is felt that, in spite of the claims put forward by the makers and owners of the sets, the available information does not justify any spesific conclusions as regards choice of frequency.

For asdic purpose - with the normally much greater range - the attenuation has to be considered. A brief calculation assuming the same transmitted power, transmitting surface and target strength for various frequencies, seems to indicate that a working frequency of about 2o kc/s would give the highest echo level for ranges of the order of 2ooo metres. For ranges less than 1ooo m, 3o kc/s would be superior.

The asdic installation on the fishery research vessel "G.O.Sars" is working on 3o kc/s. In view of the satisfactory results obtained with this installation 3o kc/s was chosen as a working frequency for the combined asdic/echo sounding set.

With this frequency it was possible to obtain a reasonable transducer gain without having to accept a too cumbersome transducer size.

The beamwidth of the polardiagram down to half power points was chosen 25-3o° in the vertical plane and 8-1o° in the horizontal plane. The rather wide beam in the vertical plane will make it easier to keep contact with a deep target. It will, however, also introduce bottom echos in shallow waters. An identical transducer is employed for the echo sounding purpose.

In order to simplify the problem of mounting, the two transducers are bolted together and mounted on the same shaft.

Experience with asdic equipment on larger ships seem to indicate that water noise due to the ships' movement, sets a speed limit at about 12 knots for operating without a streamlined container (dome) around the transducer.

Since the maximum speed of the fishing vessels for which this equipment is designed is 1o-12 knots, the dome was omitted altogether.

The measurement of range is done by a range recorder employing current sensitive recording paper. The range scales are 180 metres and 1800 metres both of which can be used for echo sounding purposes.

Training of the transducer in the horizontal plane is accomplished by a simple selfaligning on - off servomechanism with an accuracy of $\pm 1^{\circ}$.

The set employs a valve transmitter and a tuned, A.V.C.-receiver of standard design. The valve transmitter is keyed in syncronism with the movement of the recording stylus on the range recorder, or alternatively the transmitter may be keyed by a self-oscillating relay circuit when the range recorder is not in use.

In the receiver provisions are made for heterodyning the received supersonic signal down to an audible frequency. The output stage supplies power for loudspeaker, headphones and recording stylus.

4.0 DESCRIPTION OF THE VARIOUS COMPONENTS.

4.1 Directing gear.

The principal components of the directing gear can be seen on the sketch in fig. 2.

An outer brass tube is by a central flange bolted to a built up trunk on the inside of the ships structure. This tube serves as a supporting pillar for an inner tube or transducer shaft to the lower end of which the transducer assembly is bolted.

The transducer shaft is suspended by a trust bearing and guided by a roller bearing both mounted in a platform, which rests on the top of the outer tube when the transducer is lowered to its working position. The platform also serves as a mounting position for the training mechanism.

Additional bearing for the transducer shaft is provided at the lower end of the outer tube.

The platform, shaft and transducers can be raised and lowered as a unit. In the housed position the transducer assembly fits into a recess in a streamlined protective cover or alternatively is completely housed in the inboard trunk.

The echo sounding transducer is at the bottom of the assembly and the equipment can be used for echo sounding purpose with the transducers in either position i.e. housed or lowered.

The trunk and both tubes are free-flooded and water tightness is secured by gascets at the mounting flange, at the top end of outer tube and at the top end of the inner tube where the cable to the transducers passes through a rubber gland inside the shaft.

4.2 Training equipment.

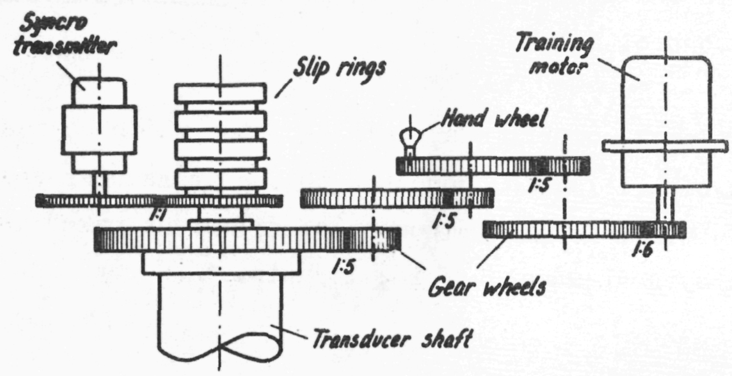

Fig. 4a Training mechanism
schematical sketch.

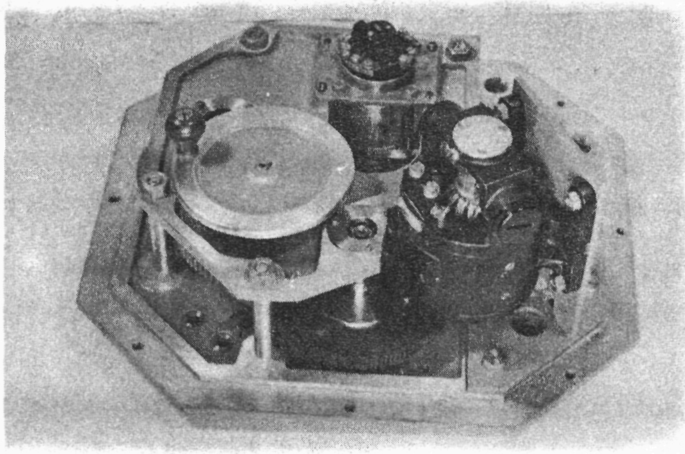

Fig. 4b Training mechanism.

The training equipment consists of two units (see fig. 6) i.e. the <u>training mechanism</u> (fig. 4) with motor and gear box, mounted on the platform on top of the training shaft and the <u>training control unit</u> (fig. 5) in the control cabinet.

The training mechanism comprises a training motor which by means of a gear reduction of 1 : 7oo is connected to the transducer shaft. A Syncro transmitter (or similar component of different make) is coupled to the shaft by gear wheels of 1 : 1 ratio.

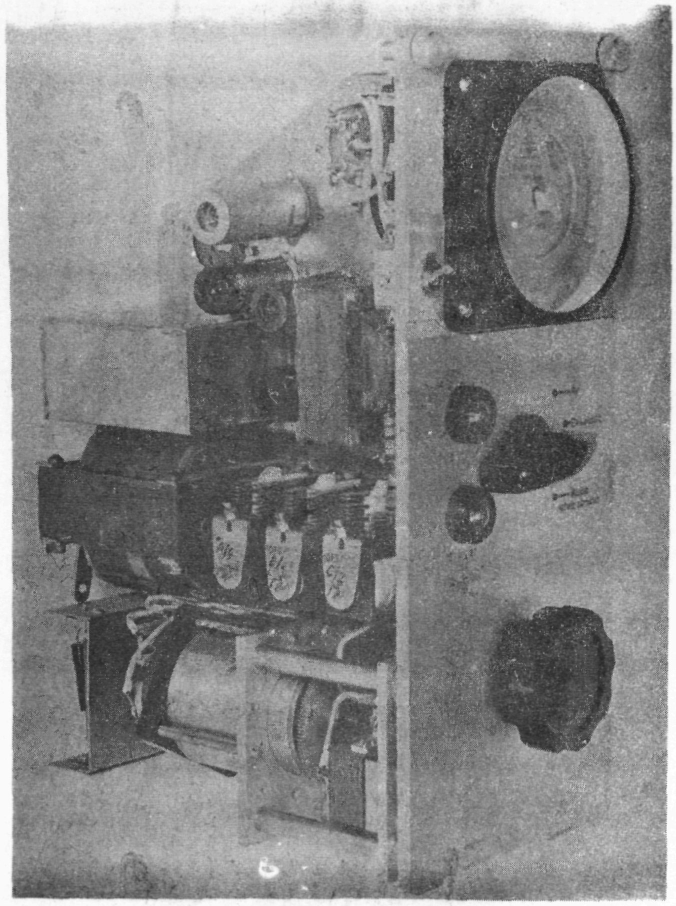

Fig. 5 Training control unit.

The servo amplifier with syncro control transformer and bearing repeater is part of the training control unit which also comprises a training handwheel and an automatic training and transmission unit. The stator of the control transformer is connected to the syncro transmitter in the training mechanism in the directing gear position.

The rotor terminals of the control transformer is connected to the servo amplifier. The rotor shaft can be rotated either by turning the training handwheel or by energising the automatic training mechanism, which then by means of a pulsating relay, turns the rotor shaft in a step-wise manner. The automatic training mechanism will train the transducer through a predetermined cycle in correspondence with ordinary asdic sweep procedure.

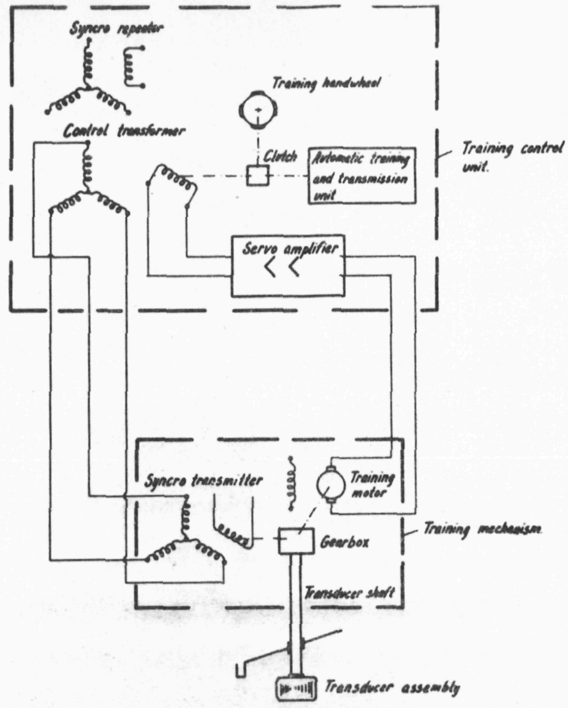

Fig.6. Training equipment, block diagram.

The automatic training sequence is initiated by a training contact in the range recorder or by contacts operated by cams moving in syncronism with the rotor of the control transformer. A syncro repeater indicating the relative bearing of the transducer position, is also included in the training control unit.

Provisions are made for stabilising the transducer in connection with a repeating compass. The training system is selfaligning.

The power consumption is 4o VA, 22o V, 5o c/s.

4.3 Transducers.

Two identical magnetostriction transducers (5) working on 3o kc/s are employed. The two transducers are bolted to a common mid section which also serves as a junction box and mounting flange for the assembly.

To provide a smooth surface and reduce cavitation and water noise, thermosetting Marco resin, strengthened with nylon fibres, is moulded in all outward recesses and screwed to the metal frames of the assembly. The vibrating surface of the transducers is 1oo x 24o mm.

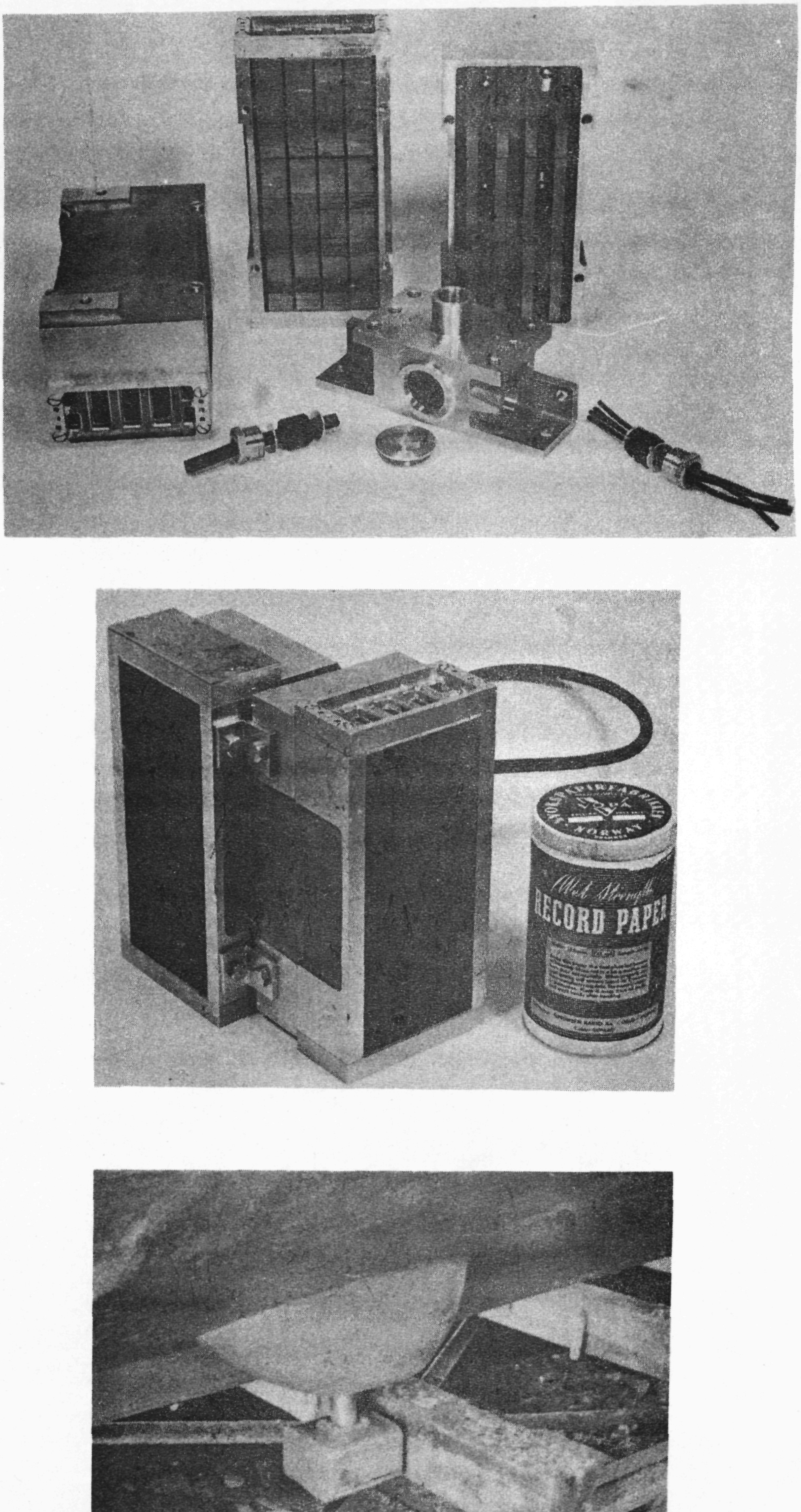

Fig. 7 a. Transducers and hull fitting.

The components of the transducers are shown on the top of fig. 7a with the assembly without fairings below.

On the lower part of the picture is illustrated the transducer and streamlined protective cover as installed on the research vessel M/L "Tustna". When not in use for asdic purposes, the transducer can be completely housed in the protective cover.

Impedance diagram is measured in air and in water and reproduced in fig. 7b. From these diagrams the motional impedance is found to be Z_{res} = 22.5 + j6o, and the conversion efficiency about 4o %. The directional curves in the horizontal and vertical plane as plotted to a logaritmic scale in fig. 7b ixhibit a beamwidth down to half power points of 8^o and 22^o in the two planes respectively. The maximum of the secondary lobes is 15.5 decibel below the main beam in the vertical plane and 12 decibel in the horizontal plane.

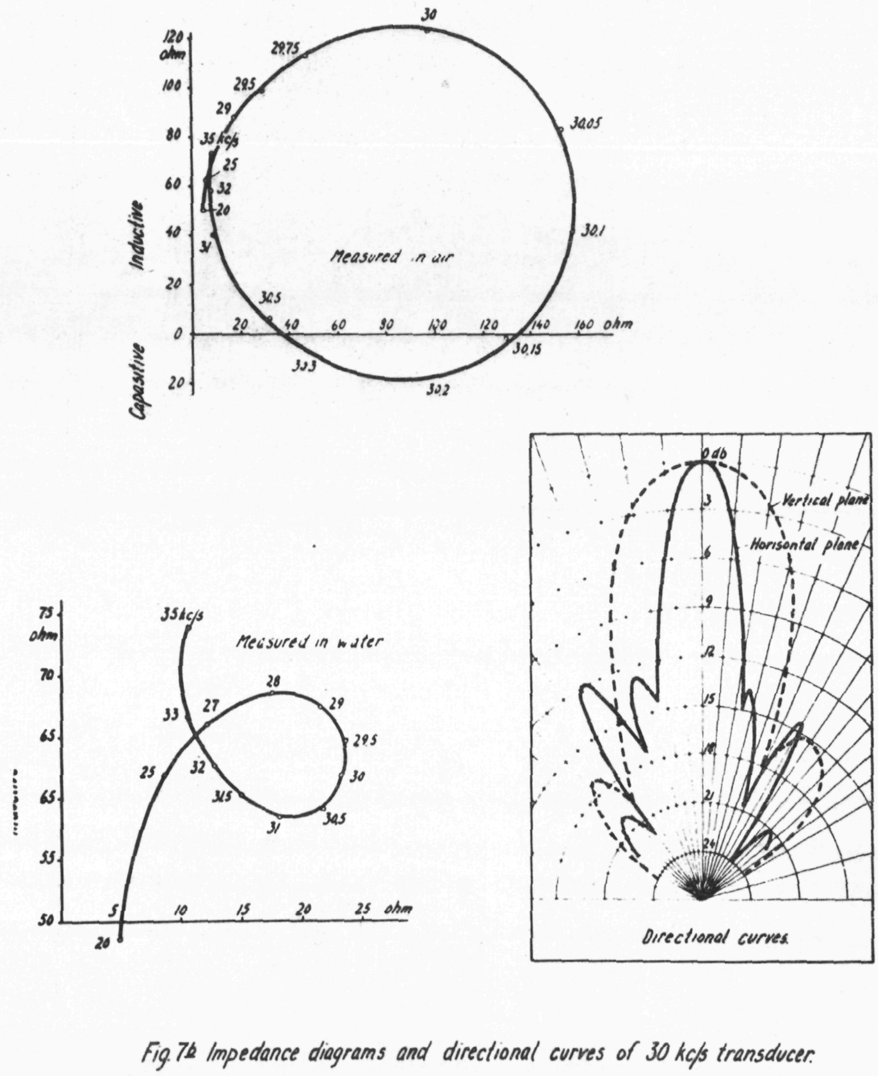

Fig. 7b Impedance diagrams and directional curves of 30 kc/s transducer.

The transducers are wound independently with single core rubber insulated cable of 4 mm diameter and the windings are joined in the junction box to a tough four core cable which passes up the hollow training shaft to slip rings at the top end of the shaft.

4.4 Transmitter and Receiver.

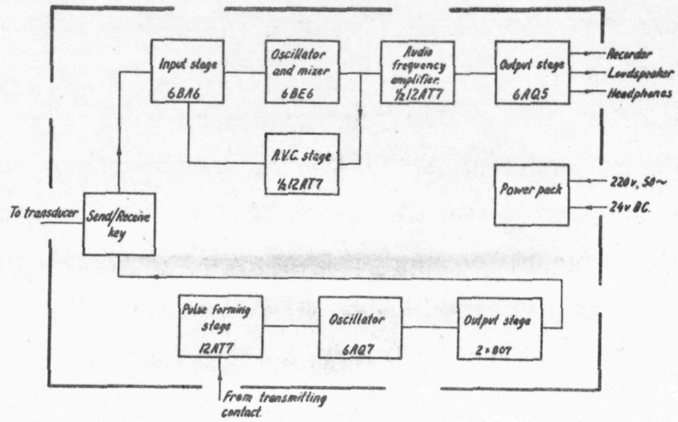

Fig.8. Block diagram of transmitter and receiver.

A block diagram of transmitter and receiver is given in fig. 8, and a photograph of the common chassis is shown in fig. 9. The transmitter is tuned to 3o kc/s. The pulse length is variable in two steps and controlled by a one shot multivibrator. Two type 8o7 valves are employed in the output stage giving 22o watts peak power in 3o millisec. or 3 millisec. pulses.

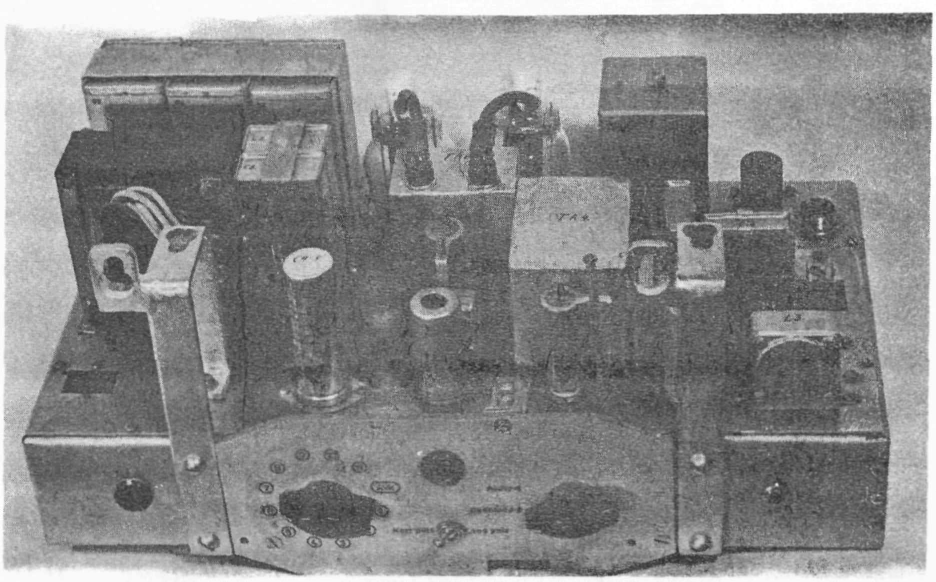

Fig. 9 Transmitter and receiver panel.

In fig. lo b is shown a photograph of a transmitted pulse of 2o millisec. duration as measured across the transducer terminals. looo c/s from a tuning fork is superimposed on the screen. On the lower half of the picture the timebase is expanded in order to illustrate the curve form.

The receiver comprises a tuned input stage, an oscillator and mixer stage and an automatic volume control stage. The beat frequency oscillator is tuned to 29.2 kc/s and the audio frequency output of 8oo c/s is further amplified in two stages.

When used for echo sounding or listening purposes the automatic volume control is replaced by a manual control. The overall amplification is about 2 x lo^6, as can be seen on fig. loa where output voltage with and without A.V.C. is plotted for various input signals.

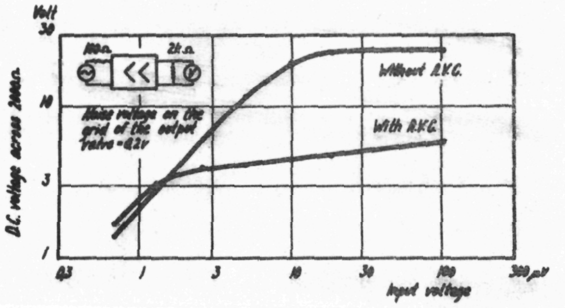

Fig. 10a Amplification of receiver.

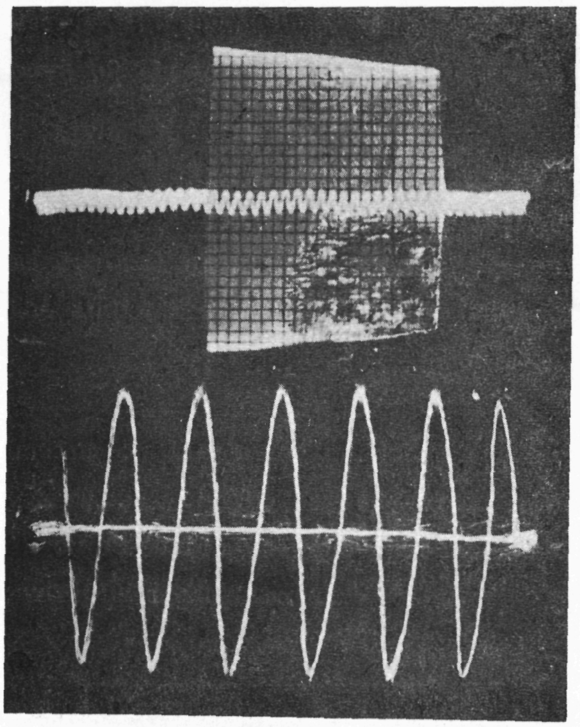

Fig. lo b. Transmitted pulse.

4.5 Range- and Depth Recorder.

The range recorder employs two travelling styli moving along a calibrated range scale. The two styli are fixed at opposite points to an endless rubber belt resting on two pullies one of which is driven by the recorder motor.

A roll of moist recording paper is contained in a tank and the paper is by motor driven rollers pulled out through a slit in the lid, and passes underneath the styli at right angles to their movement.

During its passage across the paper the stylus is guided by a metal bar which also serves as current supply bar for the styli.

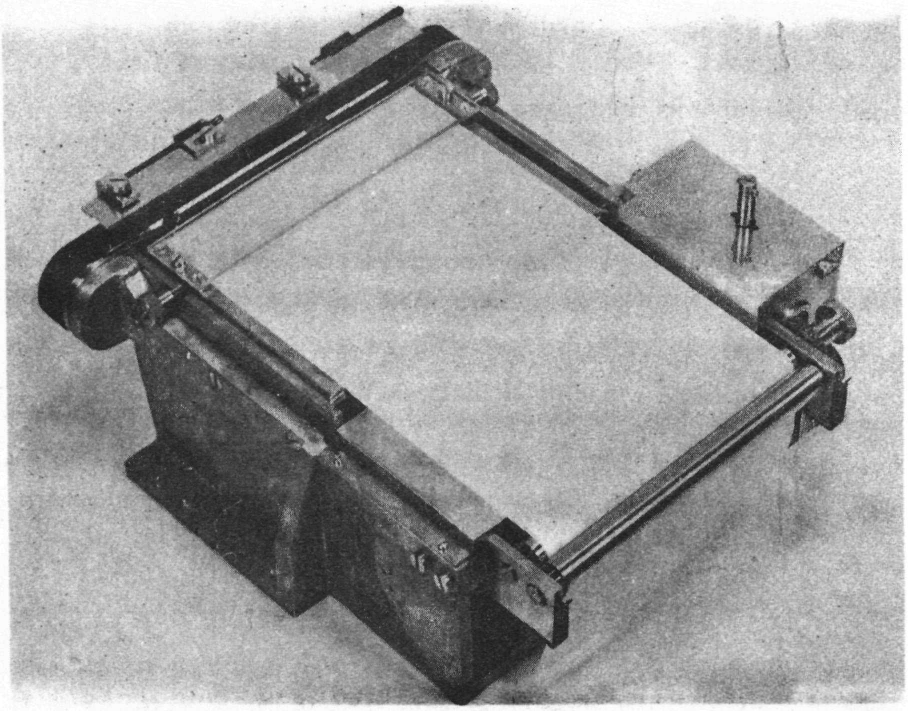

Fig. 11. Range and depth recorder.

All gears in the gearbox are in constant mesh and alteration of range scale and paper speed is secured by friction clutches. Two scale ranges are provided, 0-180 metres and 0-1800 metres. The former is principally for echo sounding, the latter is intended for both purposes.

Two paper speeds are also provided, lo mm/min. and 4o mm/min., both of which can be used in connection with the 0-1800 meter scale.

A transmitting or keying contact is operated by the stylus at the instant it passes the zero mark on the range scale. When automatic training is desired, a training contact is operated by the stylus at the end of its travel across the paper and 5° training of the transducer is completed before the next keying of the transmitter is initiated.

To meet the requirement for a simple means of measuring relative speed between asdic ship and target the recorder is equipped with a small mechanism for this purpose.

The mechanism is fixed underneath the lid covering the recorder, and consists of a lamp house and lens assembly throwing a narrow beam of light on the recording paper. The lamp house is mounted on an axis coinciding with the zero mark on the range scale, and can be turned by a control knob on front of the lid.

When the beam of light is parallel to a line formed by succeeding echos the relative speed can be read off from a calibrated scale.

4.6 Accessories and general layout.

The necessary A.C. power is supplied by a motor alternator delivering 13o VA, 22o V, 5o c/s. The alternator is controlled by the four position of the main switch in the training control unit. These are:

A. "OFF"- D.C. supply off, Alternator stopped.

B. "Echo sounder" - D.C. power on, Alternator supplying transmitter and receiver.

C. "Asdic with recorder" - D.C. power on, Alternator supplying transmitter, receiver and servo amplifier.

D. "Asdic without recorder" - D.C. power on, Alternator supplying transmitter, receiver and servoamplifier. Recorder stopped and keying of transmitter is done by the automatic transmission and training unit.

Ranges on the recorder, pulselength, gain and method of operation, i.e. automatic or manual, can all be selected independent of the position of the main switch.

To facilitate servising, the units in the control cabinet are connected with plugs and flexible leads of sufficient length to allow partial removal of the panels while the power is on.

The set is equipped with electrodynamic loudspeaker and two pairs of low impedance headphones.

5.0 TRIALS.

5.1 Measurement of water noise.

These measurements were carried out at an early date before the directing gear was ready for installation.

For this reason the transducer assembly was bolted to a 4" steel tube fixed over the bow of M/L "Tustna", and lowered to a depth roughly corresponding to that of a permanent installation.

A sketch of the arrangement together with a block diagram of the measuring circuit is given on fig. 12a.

Noise voltage was measured with a diode voltmeter at the grid of the output valve. The minimum detectable signal was observed by injecting a small voltage in series with the transducer winding. A pair of headphones was connected at the output terminals of the amplifier and the injected voltage regulated until the signal was just audible above the noise level. The mean value of the observations by two operators was taken.

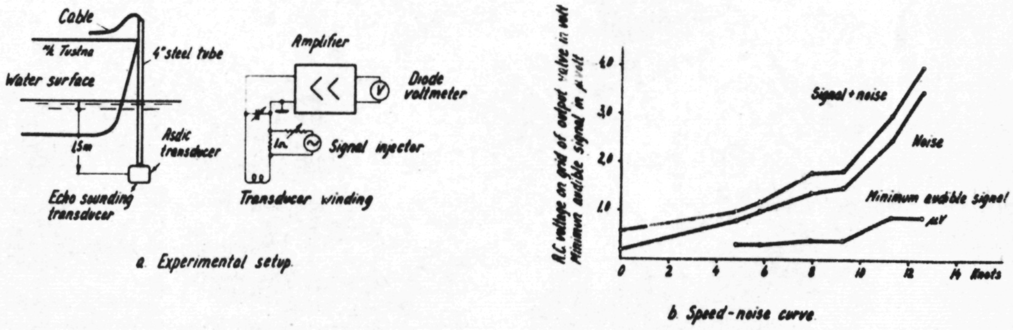

Fig.12. Measurement of water noise

The speed-noise curve as given in fig. 12b is the mean value of several runs. There is a marked increase in the noise level for speeds exceeding 9 knots, and at 12 knots detection was difficult.

During the fishing expedition with M/S "Ramoen" the noise level did not seem to impede detection at 11.5 knots which was the maximum speed of the ship.

This indication of a lower level of water noise in M/S "Ramoen" as compared to the research vessel M/L "Tustna" was confirmed by measurements similar to those just described.

The higher noise level in M/L "Tustna" is contributed partly to the shallow position of the transducer and partly to the rather severe noise and vibration from the ship's high speed diesel engines.- Photographs of M/L "Tustna" and M/S "Ramoen" are reproduced in fig. 13.

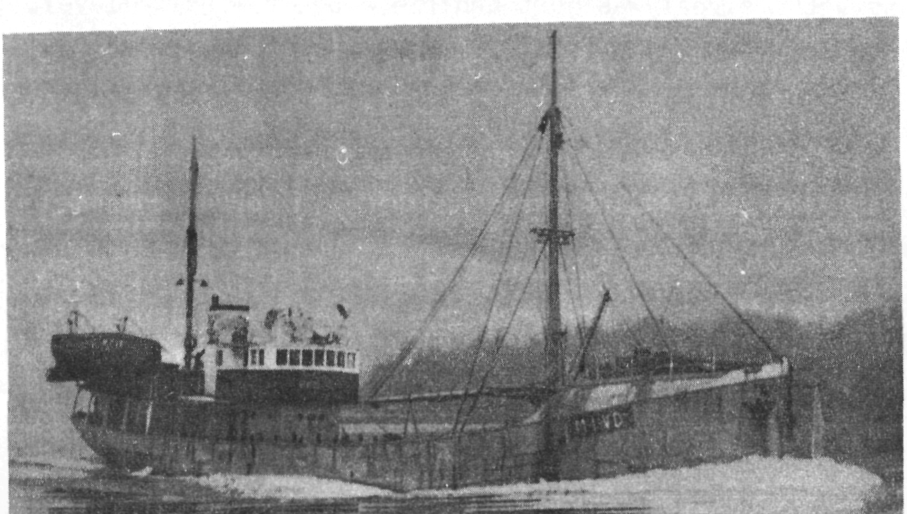

Fig. 13 M/S "Tustna" M/S "Ramoen"

5.2 Recorder traces.

For the purpose of fish location a normal asdic search procedure is carried out. When contact with a target is obtained, the ship is steered by asdic and if possible brought over the target in order to classify the reflecting object by echo sounding.

Extent of target at right angles to the sound beam can be found by training the beam across the target and observing the angles right and left where the echo disappears.

The registration obtained on the echo sounder when passing over the target gives the dimension of the target in direction of the ship's movement, and also some indication of the thickness of the target in the vertical direction. From the three dimensions thus obtained an estimate can be made of the volume of the reflecting object. This information is, however, of limited value in calculating the number of fish in a recorded shoal unless the volume density of fish is known. A figure of two herrings pr. cubic meter has, with due reservation, been mentioned in the literature. (1)

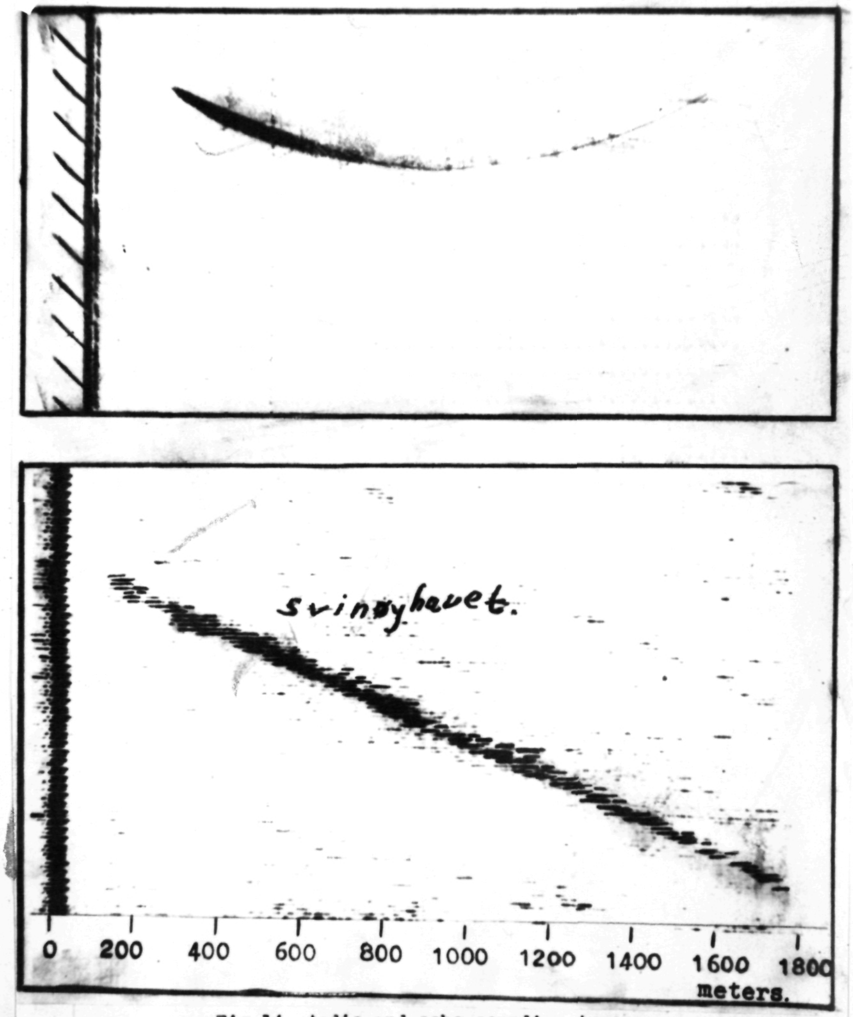

Fig.14. Asdic and echo sounding traces.

The recording shown on fig. 14-16 were obtained on the fishing expedition with M/S "Ramoen" in the early spring of 1953. It should be pointed out that the ship was engaged on an ordinary fishing expedition, the principal object of which was to catch herrings.

No restrictions whatsoever were imposed on the ship's movements in order to favour any experiment as to the usefulness of the equipment as a detecting aid.

The shoal recorded on fig. 14 was detected at a range of 17oo meters and contact maintained by asdic until the ship passed over it, and the registration on top of fig. 14 appeared on the ship's echo sounder. The combined set was not switched over to echo sounding on this occasion.

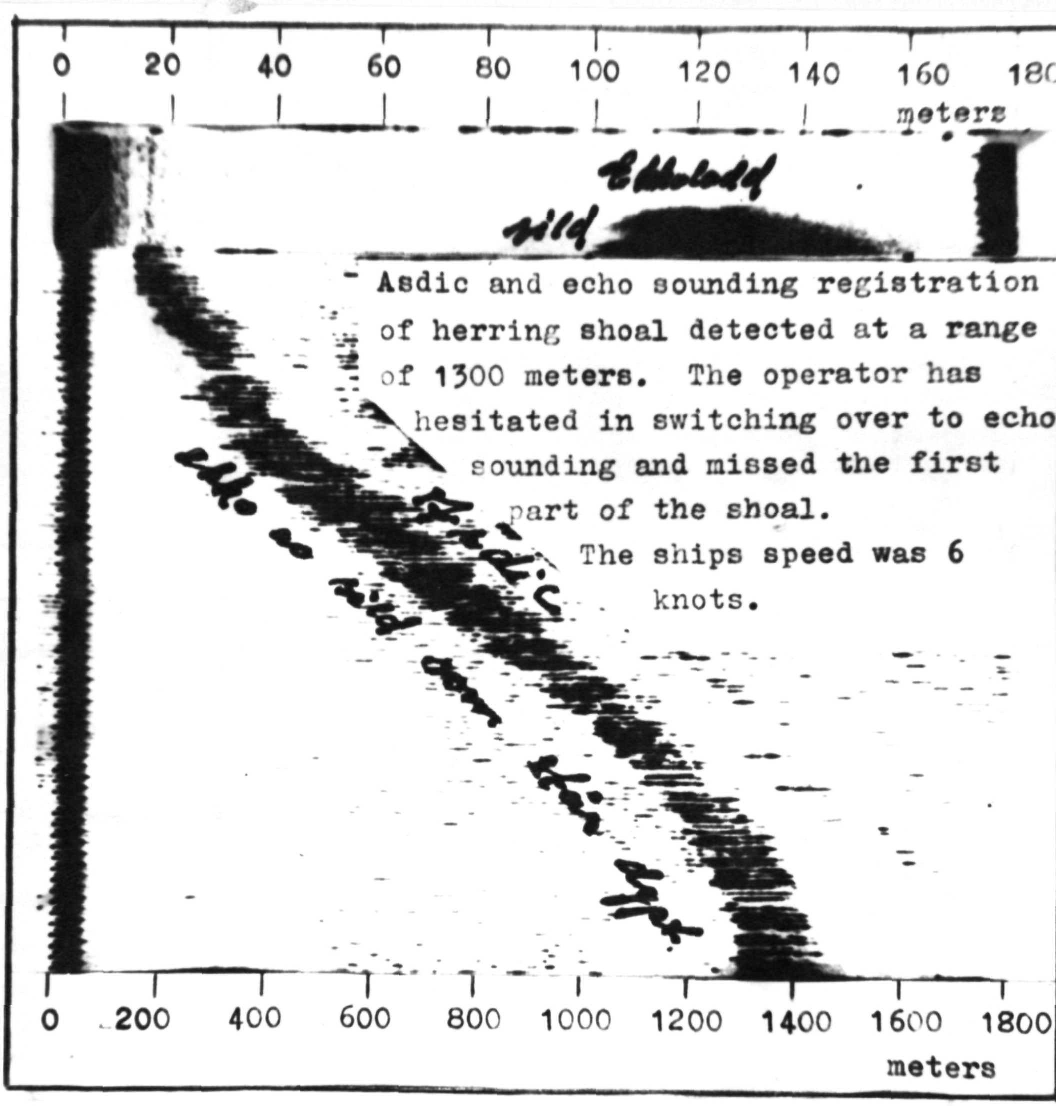

Fig.15. Asdic and echo sounding traces.

On fig. 15 is shown asdic and echo sounding registration of a shoal first detected at 13oo meters. Apparantly the operator has misjudged the time of crossing the target and hesitated in switching over to echo sounding thereby missing the first part of the echo sounding registration.

When searching for herring shoals close to the shore in the middle of the vast collection of vessels the set was principally used for echo sounding purpose, interference from other ships rendering asdic detection difficult.

Fig. 16 is a typical example of one of the numerous recordings obtained on these occasions.

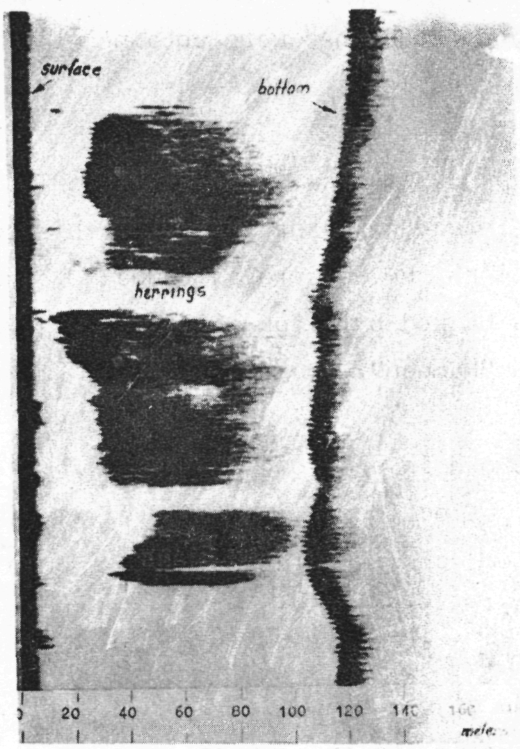

Fig. 16. Echo sounding trace.

6.0 CONCLUSIONS.

The winter herring fisheries 1953 were harassed by extremely adverse weather conditions which kept the fleet idle in harbour for weeks at a time. In spite of the unfavourable weather several interesting facts emerged, one of which was that the equipment can be used without weather interference under conditions prohibiting the safe handling of boats and nets.

The useful range of asdic equipment is subject to large variations due to changing water conditions. (3) It is therefore impossible to give any definite figure as regards working range of the equipment.

On several occasions, however, shoals were located by asdic at ranges of 1200-1800 meters, and soundings were obtained at full speed at a depth of 1500 meters which was the greatest depth encountered.

The features of the equipment was exhibited to its best advantage when operating well off shore with the fleet searching over a large area. Under these conditions the set proved to be a valuable aid in location. This impression is backed by favourable reports by the skipper and members of the crew of M/S "Ramoen".

When operating inshore in shallow waters and in close proximity of the main fleet, where collection of 500-1000 vessels over a limited area is quite common, bottom echos and interference from other ships restricted, as was anticipated, the proper use of the asdic equipment.

Minor modifications of certain details of the described equipment indicated themselves during its operational use. These modifications will be included in the final specifications of the set.

7.0 REFERENCES.

(1) T. Gerhardsen: "Sildeleting ved hjelp av asdic og ekkolodd" Teknisk Ukeblad nr. 51, 1946.

(2) Finn Devold: "Sildetokt med "T.O.Sars" i Norskehavet 5/7-24/8 195o". Særtrykk av Praktiske fiskeforsök 195o.

(3) S.J.Brookfield: "Science in the Naval War." Discovery, December 1945.

(4) Richard J. Evans: "Echo Ranging Sonar". Electronics, August 1946 pp. 88-93.

(5) Henrik Nödtvedt: "Electromechanical analogies applied to magnetostrictive systems". Forsvarets forskningsinstitutt årbok 1947, pp. 69-154.