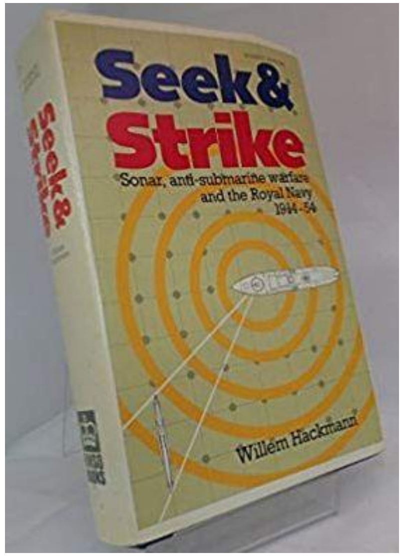
Asdic to Sonar and the Cross-over to the Science of Underwater Acoustics

HMS P59 received the world's first operational ASDIC set in late 1918. Post card from C.&S. Kestin, Weymouth, England.

Willem Hackmann

Origins of the Words ‘Asdic’ and ‘Sonar’



The title is the motto of AUWE. The dust jacket design is based on the electrical version of the game *Battleship* popular at that time.

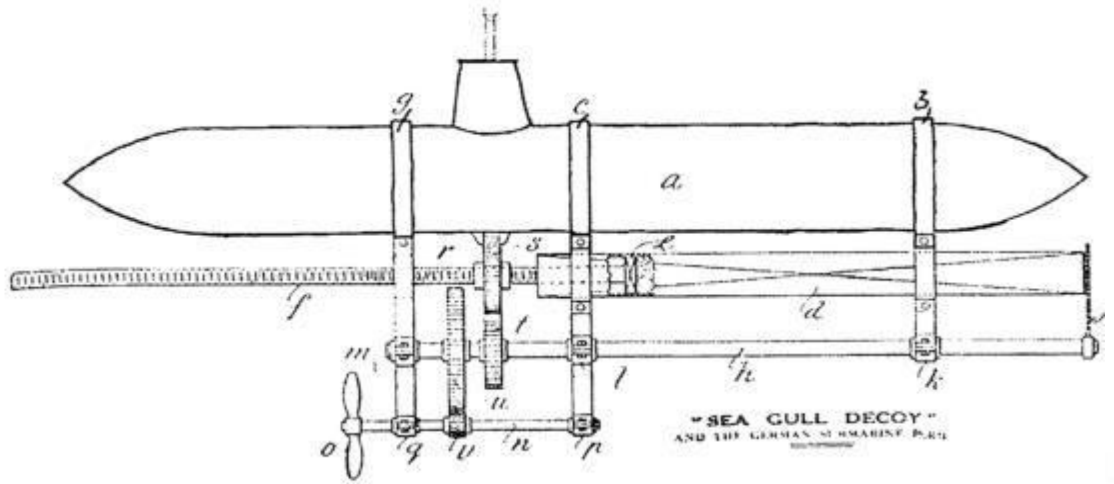
‘Asdic’ Acronym Definitions

- **1939:** First definition *OED*: the acronym of **A**llied **S**ubmarine **D**etection **I**nvestigating **C**ommittee set up in WWI. No such committee in the archives.
- **6 July 1918:** First reference in the ‘Weekly Report of Experimental Work at Parkeston Quay’ (Harwich), where ‘Asdic’ replaced ‘Supersonics’.
- **1924:** First historical reference is in a non-technical internal history in the first yearly R & D report of the Torpedo Division of the Admiralty, Naval Staff: ‘pertaining to the Anti-Submarine Division’ (that is **A**nti-**S**ubmarine **D**ivision-**ic**s), the Admiralty department (ASD) set up in 1916 to oversee this work.
- **1961/5** A.B. Wood confirmed this in his the *J. Royal Navy Scientific Service*.
- **1984** Willem Hackmann, *Seek and Strike* confirmed the ASD definition and reproduced in the later editions of the *OED*. In the early inter-war years this Asdic research was considered so secret that the quartz of the transducers was code-named ‘asdivite’!

‘Sonar’ Acronym Definitions

- **1941:** ‘sodar’ as phonetic analogue to ‘radar’ (**S**ound **D**etection and **R**anging instead of **R**adio **D**etection and **R**anging) by F.V. (Ted) Hunt Director of the wartime Harvard Underwater Sound Laboratory.
- **1942:** ‘sonar’ according to Hunt sounded better and found an acronym to fit this - first decided on: ‘**S**ounding, **N**avigation and **R**anging’- later changed to ‘**S**ound **N**avigation and **R**anging’ to make it the acoustic equivalent to radar.
- **November 1943:** ‘sonar’ adopted by the *US Fleet A/S Bulletin* and its given its modern generic definition: ‘the science and the art of transmission and reception of underwater sound’. It no longer (unlike asdic) referred to specific hardware but to the science of sonar and one could also correctly refer to passive and active sonar.
- **1948:** ‘sonar’ adopted by the Royal Navy in line with NATO.

Thomas Mills’ Attacking Seagulls



Mills’ technical drawing of floating sea gull decoy, and patented sea gull decoy suspended at stern from his boat. These trials were not taken seriously by the BIR and disliked by Captain Ryan who would not let the BIR scientists use the submarine under his command for the feeding trials!

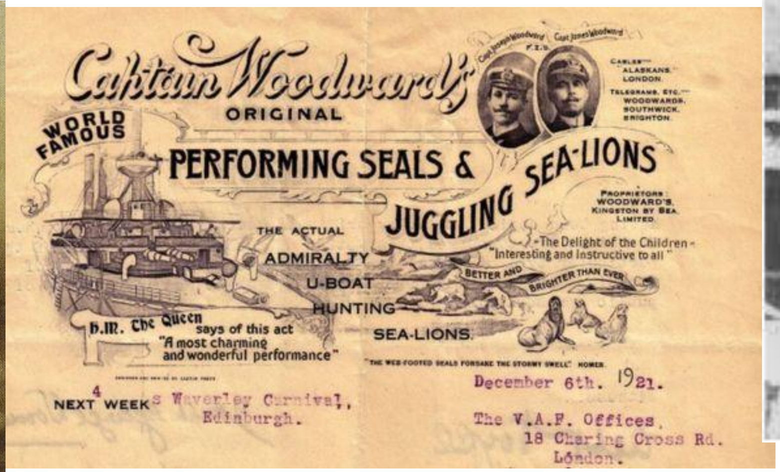
IF Noah had been German!’

The decoy dispensed strips of sausage-like meat which floated on the sea. Cartoon from the ‘Bystander’, 29 August, 1917, by W Heath Robinson.

Thomas Mills in April 1917. His book: *The Fateful Sea-Gull* (Reading: Bradley & Son, Ltd, 1919).

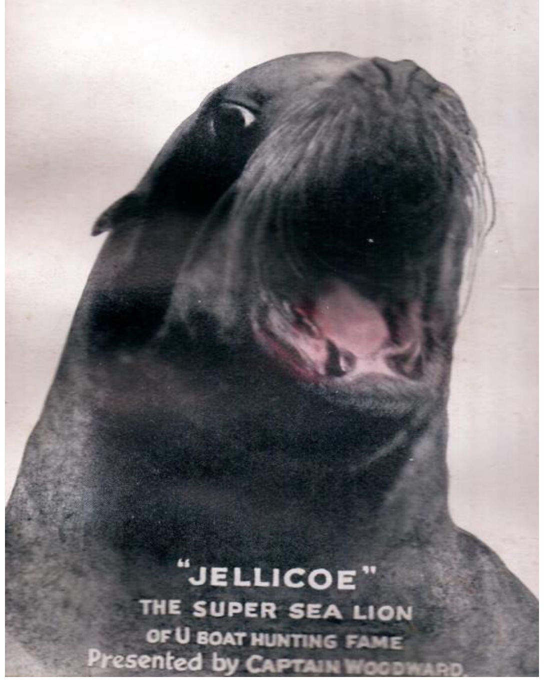
'Captain' Woodward's Performing Sea Lions

'Captain' Joseph Woodward (1850-1933) in stage uniform. Was assisted by his younger brother Fred (on right).



Letterhead used by Joseph Woodward in his correspondence with A.B. Wood, January 1917. It is overprinted with the proud reference to the sea lion for the Admiralty. The project was under the general supervision of Dr E. J. Allen, F.R.S., Director of the Marine Biological Association laboratories in Plymouth.

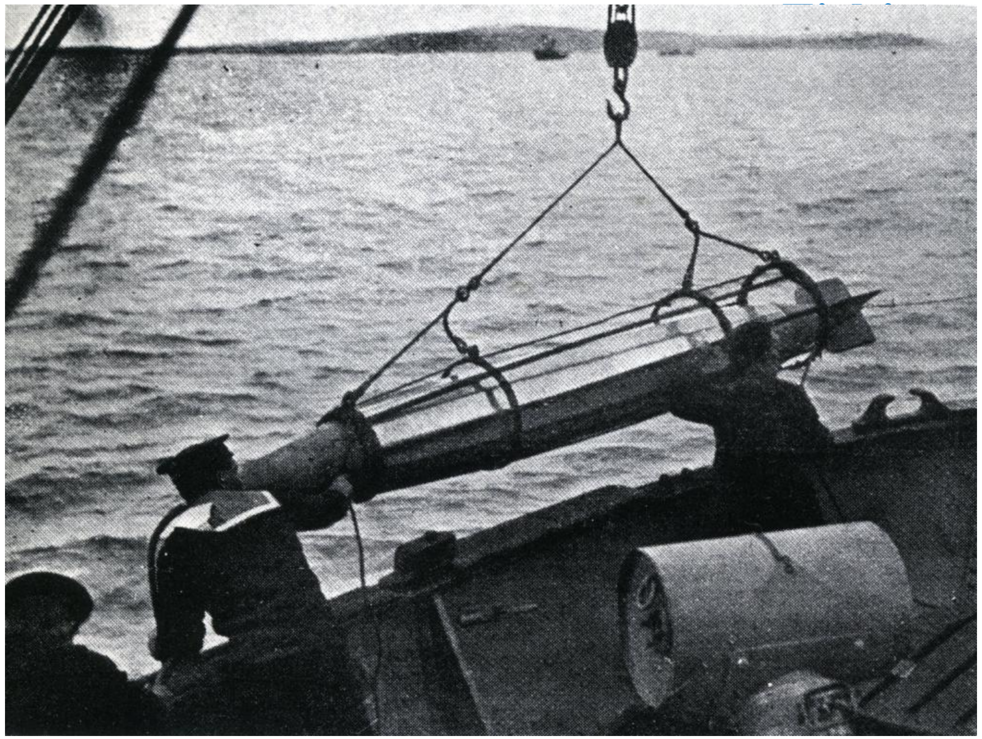
Sea lions being fed at Lake Bala, Glanlylyn, North Wales, during trials, March –July 1917. The facilities could house 60 sea lions. A.B. Wood wrote a BIR report on these trials: 'Behaviour of sea-lions towards subaqueous sound' (1917).

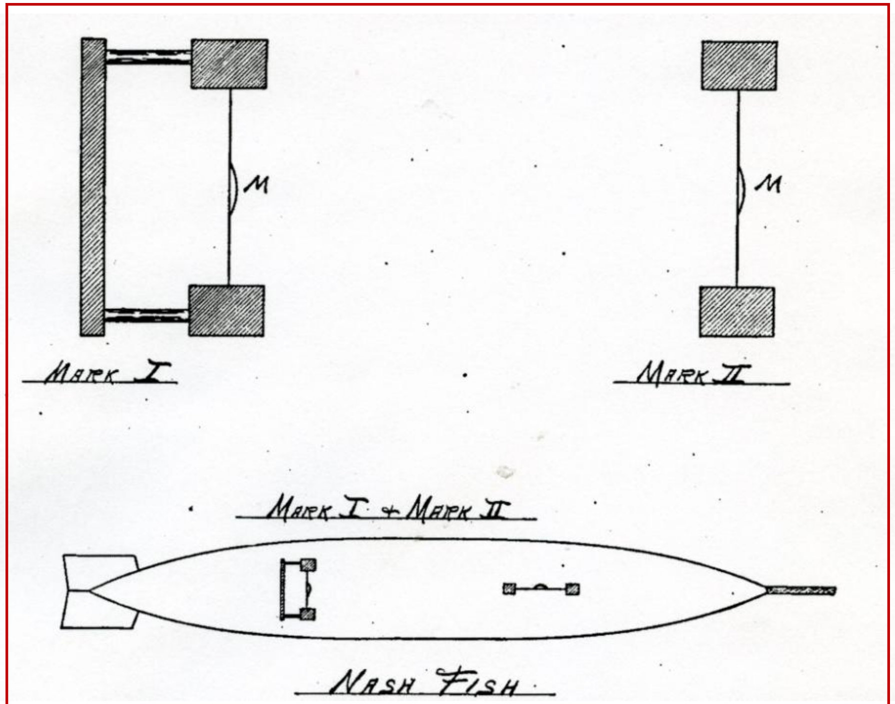


The other Jellicoe!

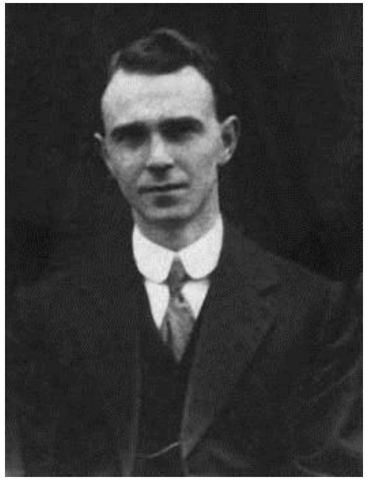
Muzzled sea lion, 'Queenie' or 'Billiken' on submarine *C15* during trials on the Solent, 6, 8 or 9 June 1917 fed by the commanding officer the appropriately named Lieutenant Dolphin.

WW I Towed Hydrophones: The ‘Nash





Internal arrangement of the ‘Nash Fish’.



A.B. Wood as Hon. Vice-President of University of Liverpool Physical Soc. 1914-15.

‘Nash Fish’ lowered over the side during the official trials in October 1917 (From DER *Report on the Detection of Submarines by Acoustic Methods* (1918), Fig. V. B. 16).

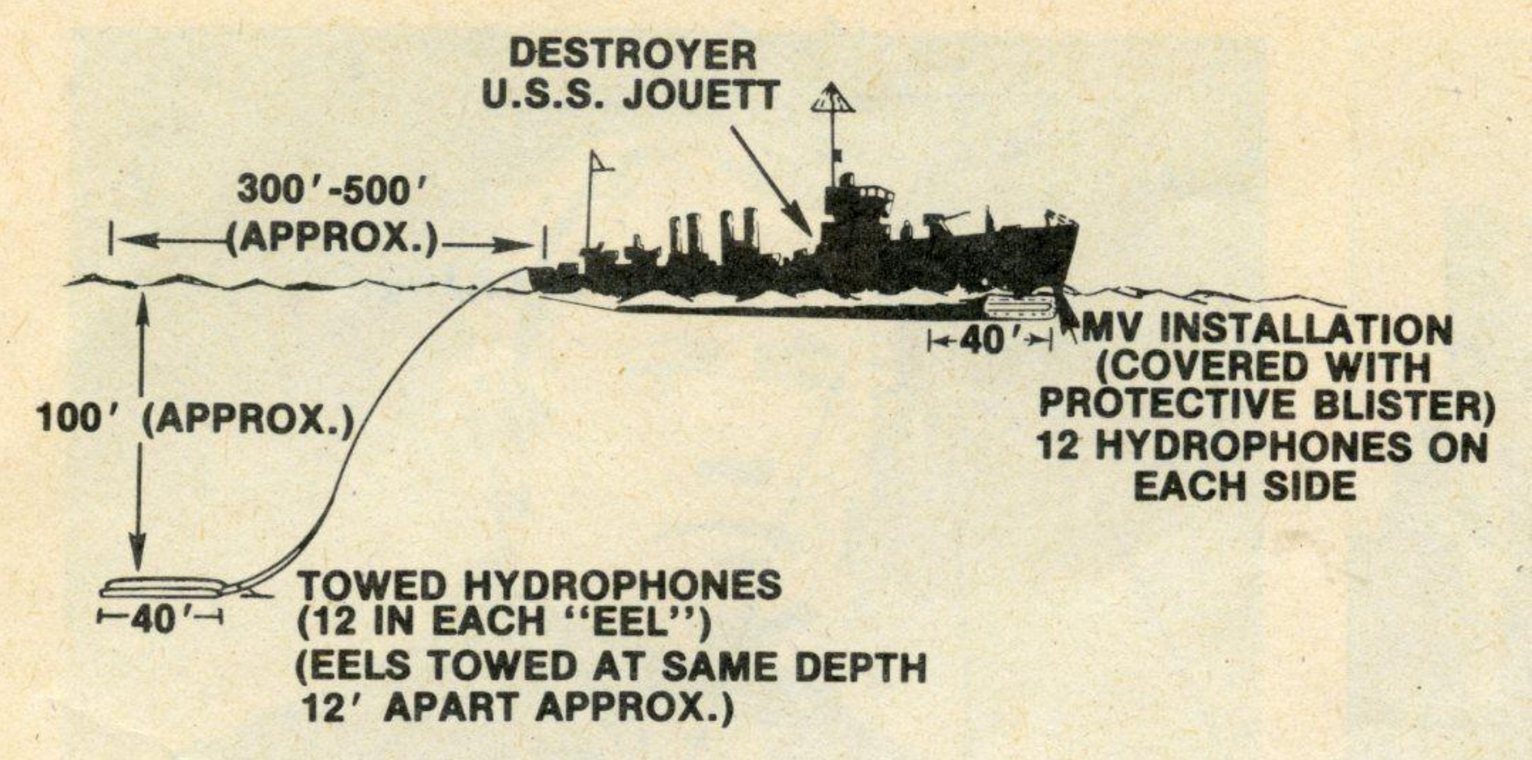
‘Captain’ Woodward claimed that the noted silence of his sea lions under water contributed to the development of towed hydrophones, of which the most successful was the ‘Nash Fish’. To increase the sensitivity of the hydrophones they were enclosed in streamlined bodies, including a stuffed seal’s body to see if the animal’s shape or a peculiar property of its skin assisted the reception of underwater sound.

Captain C.P. Ryan on HMS *Tarlair*, Hawkcraig.

WWI 'Dunking' Hydrophone and Hydrophone Arrays

Hydrophone watch at the Otranto Barrage, 1917.

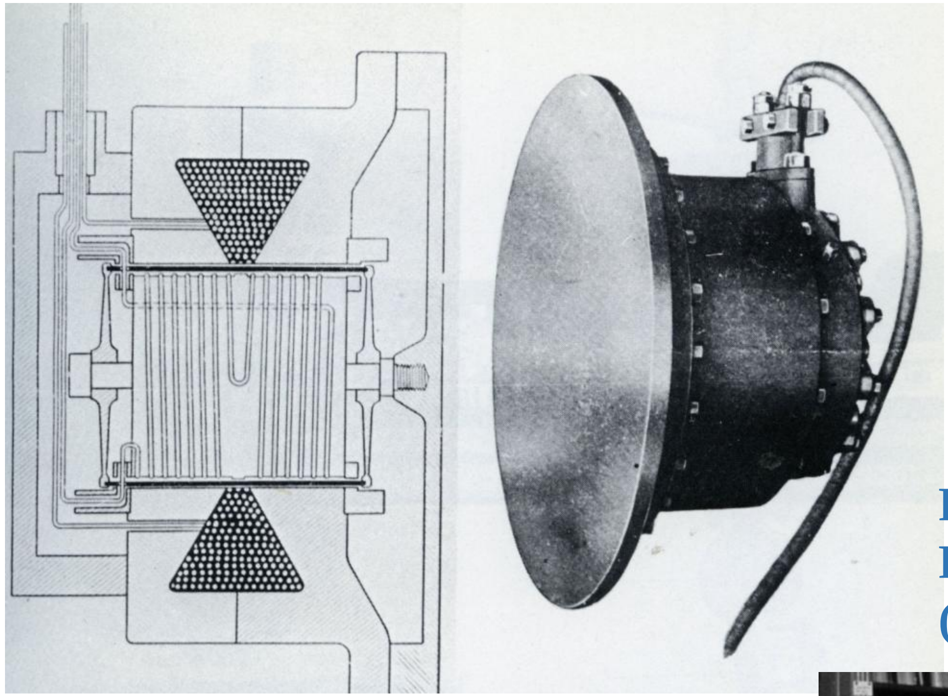
The training of U-boat detectors on the drifter *Thrive*. The sailor in the foreground is dunking a non-directional PGS hydrophone overboard; two hydrophones were suspended from the boom in the background (probably a unidirectional PDH I and a bi-directional PDH II). The hydrophones were connected to the earphones by the electrical boxes on the deck which contains batteries and transformers.



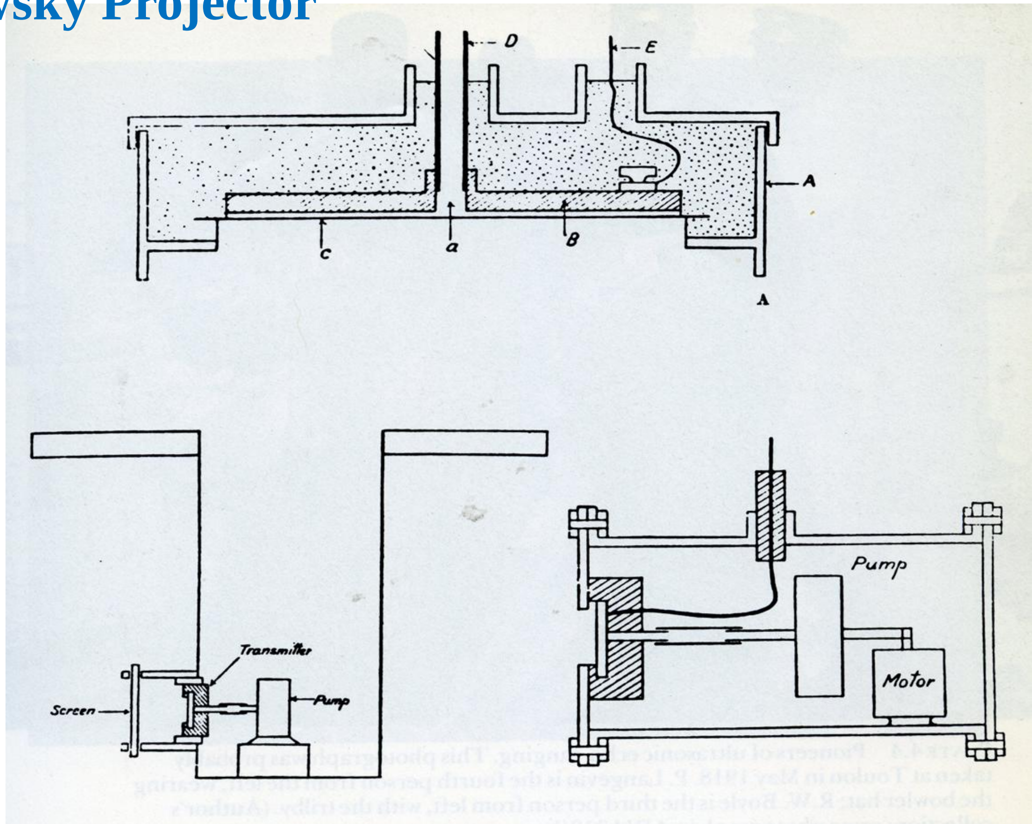
Experimental passive sonar installation, 1 April 1918.

Hull-mounted MV-tube installation and a towed pair of MV-'eels'. This was replaced in 1919 with the electrical MV-tube. 12 hydrophones on the port side and 13 on the starboard side were used binaurally with electrical delay-line steering. The development of electrical (as opposed to acoustical) compensation has made it possible to use long lines containing many receivers. They abandoned this system in the interwar years for searchlight sonar developments.

Fessenden's 'Oscillator' and the Langevin/Chilowsky Projector



Radio pioneer Reginald A. Fessenden (1866-1932).



Fessenden sonic 'oscillator', 1913 (Blake, *The Electrician*, vol. 74 (1914).

Continuous oscillation and a broad sound beam at 540 cps but increased by HM Signal School to 1000cps for their submarine fitting programme.

Paul Langevin (1883-1955).

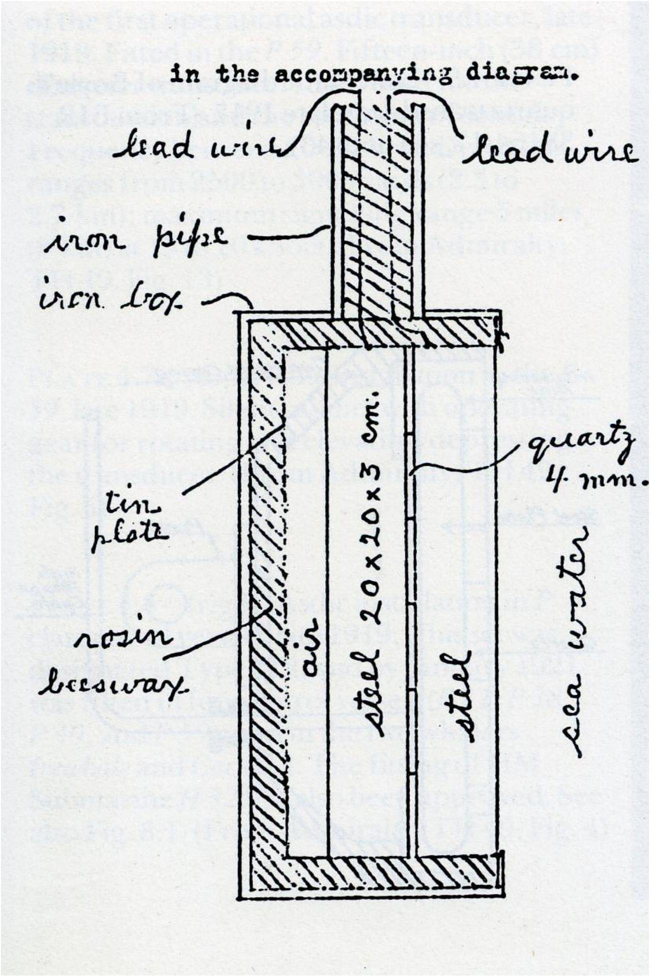
Before he moved to Toulon Langevin collaborated with Constantin Chilowsky, a Russian émigré.

Langevin's mica dielectric 100 kc/s projector, late 1915.

Top drawing depicts the projector or transmitter: circular metal disc (B), sheet of mica (C), tube (D) through which the vacuum is maintained, and the box (A) filled with insulating resin. The lower two drawings show the complicated onboard arrangement of transmitter and Gaede vacuum pump with its electric motor.

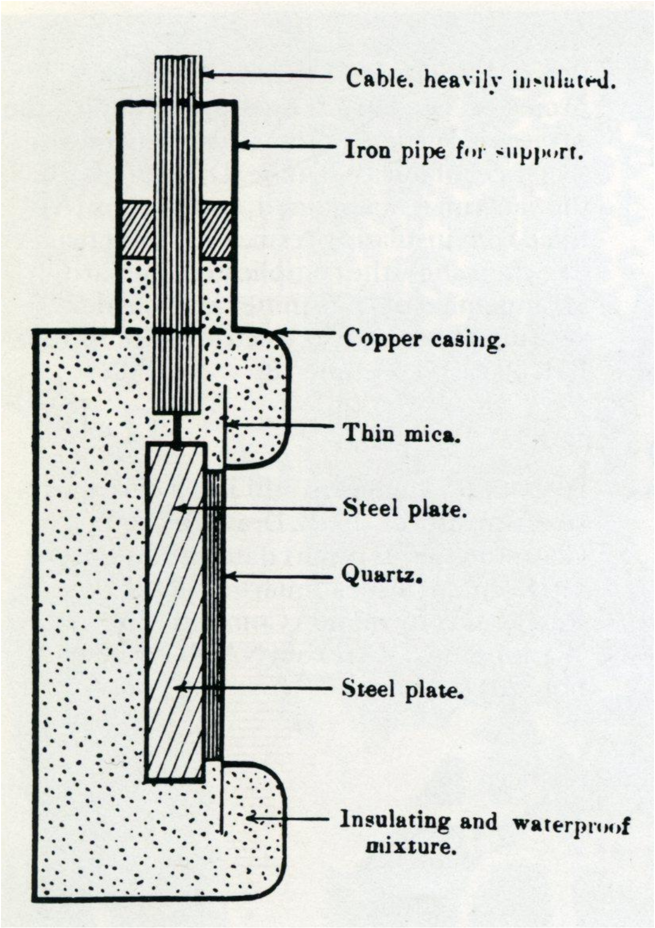
P. Langevin, 'Note of Apparatus for the Detection of Submerged Objects by Acoustic Waves of High Frequency', BIR 3929/17. Communicated by M. de Broglie 12 February 2017.

First Quartz Transducers 1917-1919



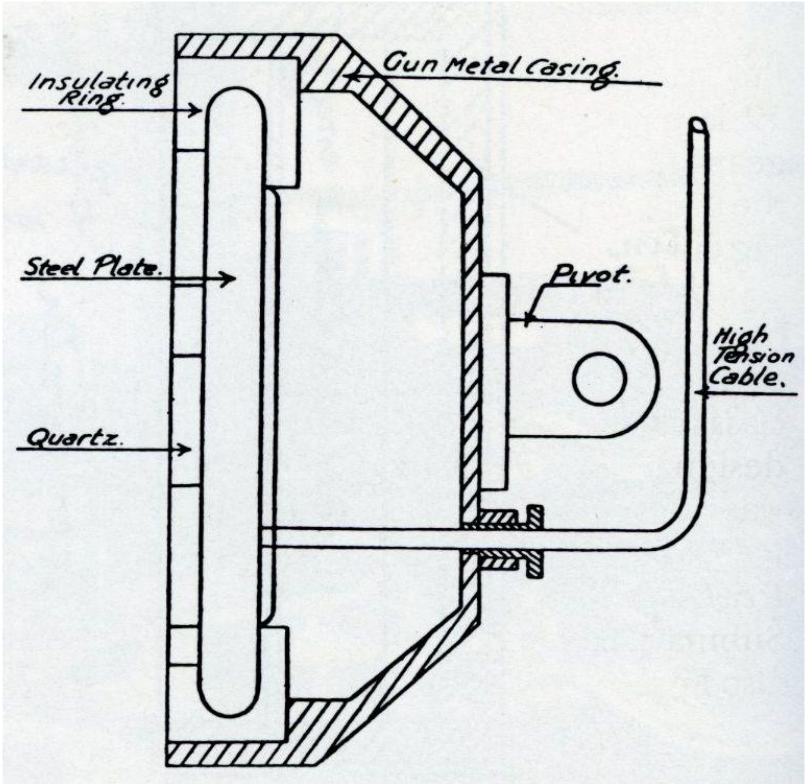
Langevin's quartz transducer, 1918.

40 kc/s steel-quartz-steel transducer drawn by K.T. Compton for his report dated 18 August 1918, went to the headquarters of the Research Information Committee in Washington, DC.



Schematic diagram of Boyle's quartz transducer, late 1917.

In July 1918 the word 'Asdic' appears in the weekly reports and its quartz is called 'asdivite'.



First operational asdic transducer on the P59, 1919.

Fifteen inches diameter transducer, both for transmission and reception of sound; frequency between 20-50 kHz; detection range from 2,500 to 3,000 yards; maximum signalling range was 5 miles. The basis of the transducer used throughout WW II.

Pioneers of 'Supersonics'

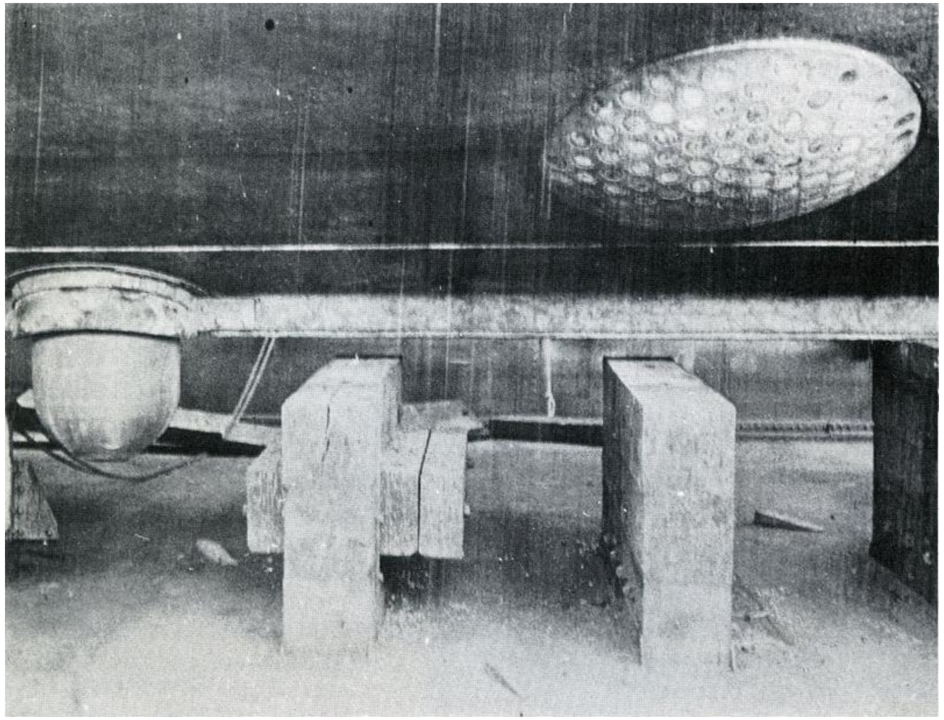
Pioneers in ultrasonic echo-ranging, photo probably taken at Toulon in May 1918.

P. Langevin is the fourth person from the left wearing the bowler; R.W. Boyle is the third person from the left, with the trilby.

Parkeston Quay.

The team under R.W. Boyle was expanded to include W.F. Rawlinson (always fondly known as 'Jock'), *B.S. Smith and Sub-Lieutenant J.S. Nightingale RNVR. Breakthrough came in March 1918, when asdic echoes were obtained from a submarine at 500 yards. **Smith was interviewed for my book.*

First Operational Asdic Sets



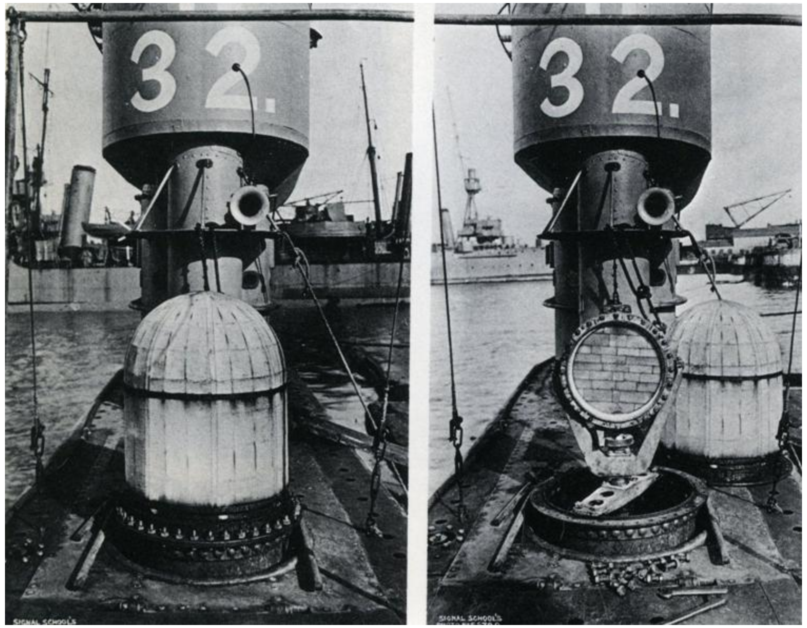
Underwater acoustics probably of *Ebro II*, late 1918.

The trawler *Ebro II*, first ship to be fitted with an inboard asdic set (Type 111). Only the starboard blister of the French Walser gear is shown. The Royal and US Navy decided that the Walser system was too complicated for full-scale installation even though it was an effective acoustic system. It was reported that the internal gear was never fitted in *Ebro II*!

Set designated Type 112.

By January 1921 was fitted in 4 patrol vessels (*P31, P38, P40* and *P59*) and in the whalers *Icewhale* and *Chatelot*, and the fitting of HM Submarine *H32* has been approved.

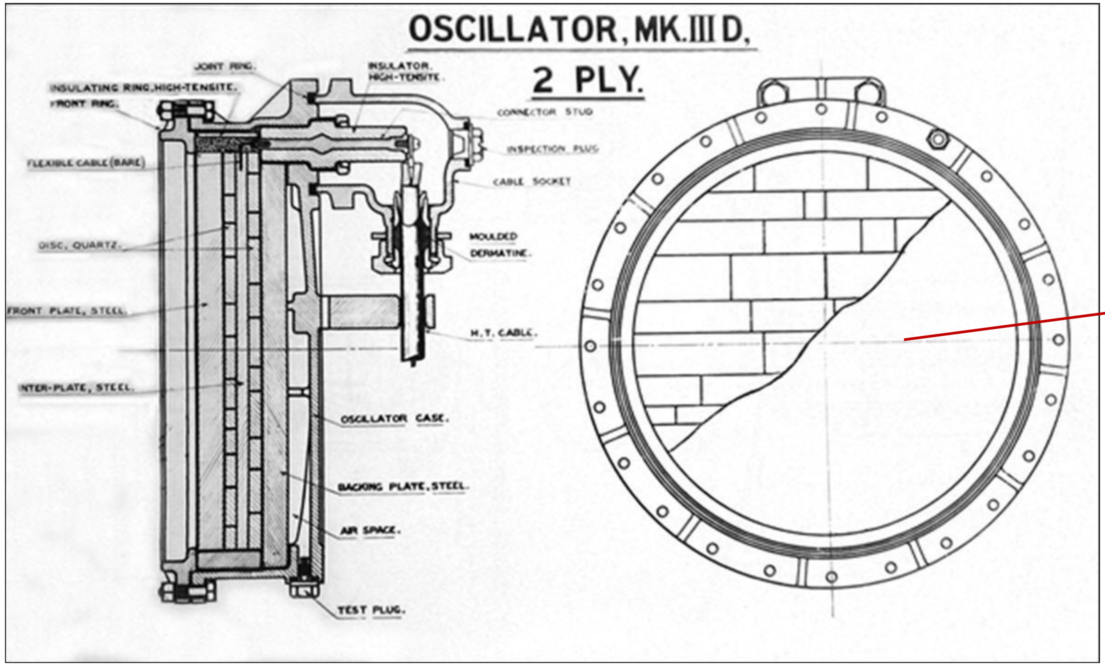
The 15-inch quartz transducer is suspended above the trunk taking it below the keel.

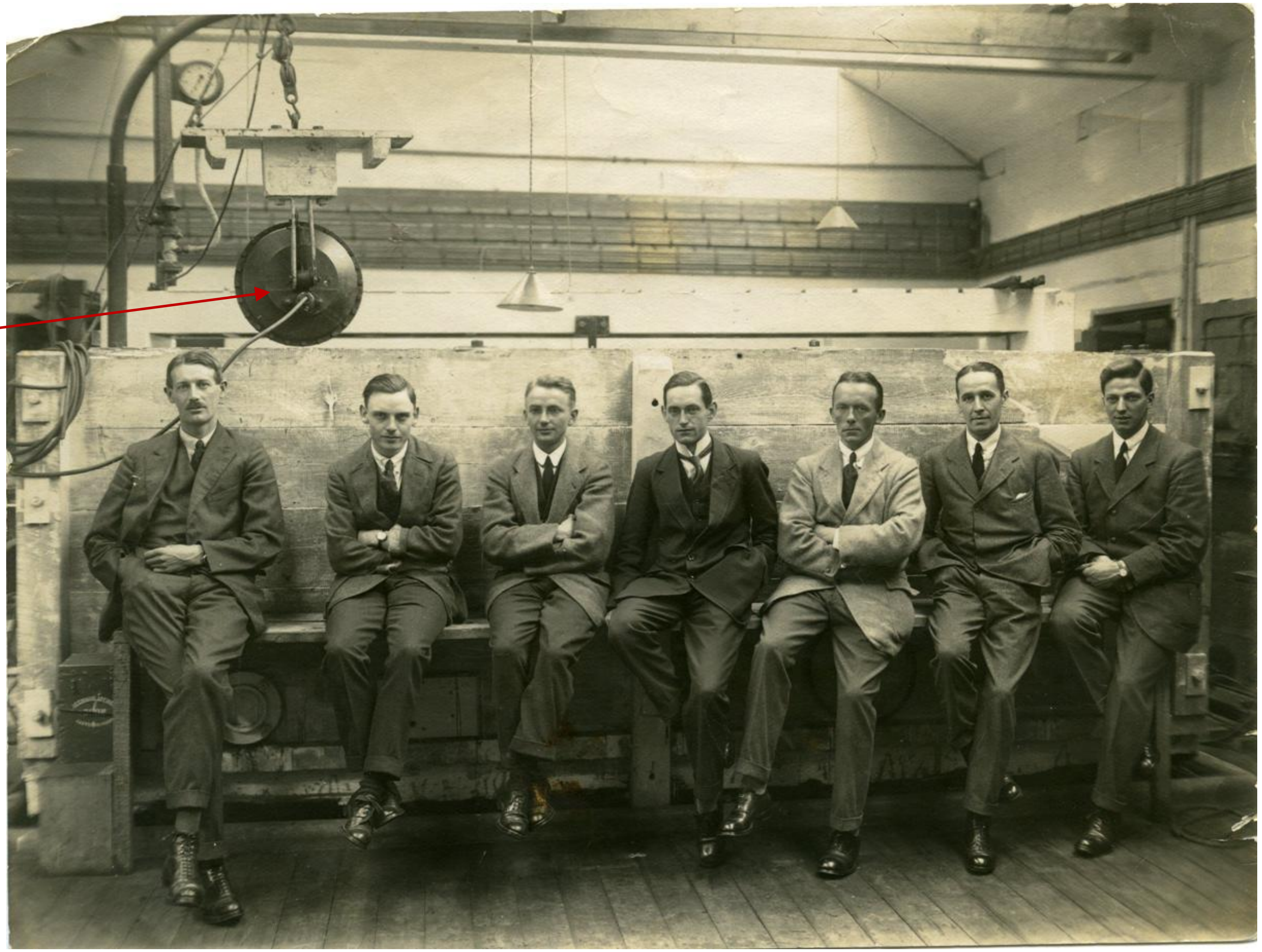


HM Submarine *H32* (trial submarine), 1922.

Canvas dome of *H32* with in the second picture the dome removed to show the quartz mosaic of the transducer. Dome could be retracted; set designated Type 113. As the canvas took an hour to wet thoroughly (stopping air bubbles) it was replaced by a copper dome which defaulters were made to polish for punishment!

First Asdic Design Team at HM Signal School



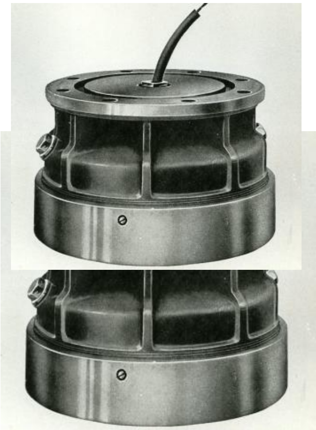


Asdic design team at the Signal School, Portsmouth, early 1920s.

Caption in ink on back of photo: From left to right are L.S. Alder and E.A. Logan (assistants), *J. Anderson (chief assistant), W.F. Rawlinson (team leader), and A.E.H. Pew, S.E. Trigle and W.R. Kent (engineering designers). Rawlinson and Anderson were assistants to R.W. Boyle at Parkeston Quay, Harwich, when the first asdic echoes were obtained 1918. The 15-inch transducer suspended in the left-hand corner is what became the standard 15-inch asdic transducer – the mainstay of World War II.

***Anderson was interviewed for my book.**

Inter-War Echo Sounder Developmen



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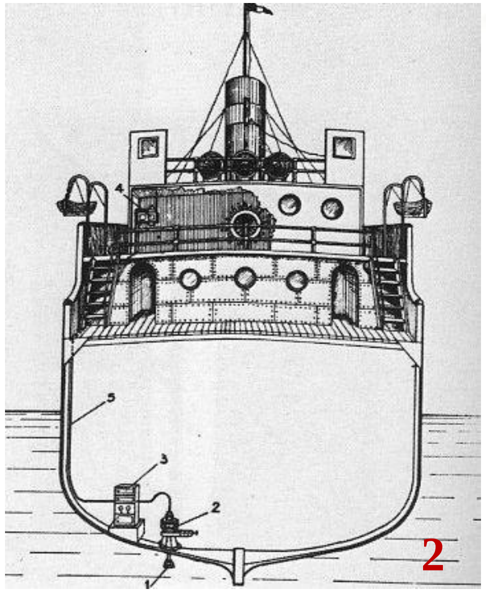

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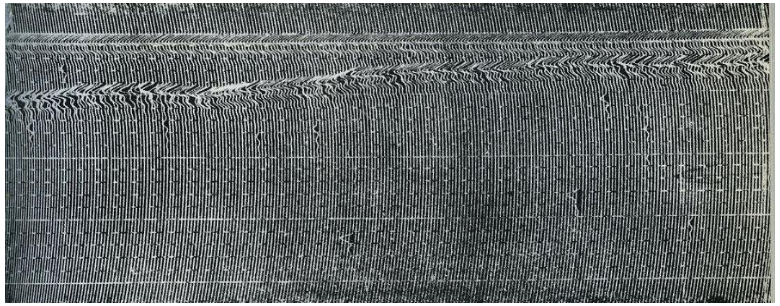

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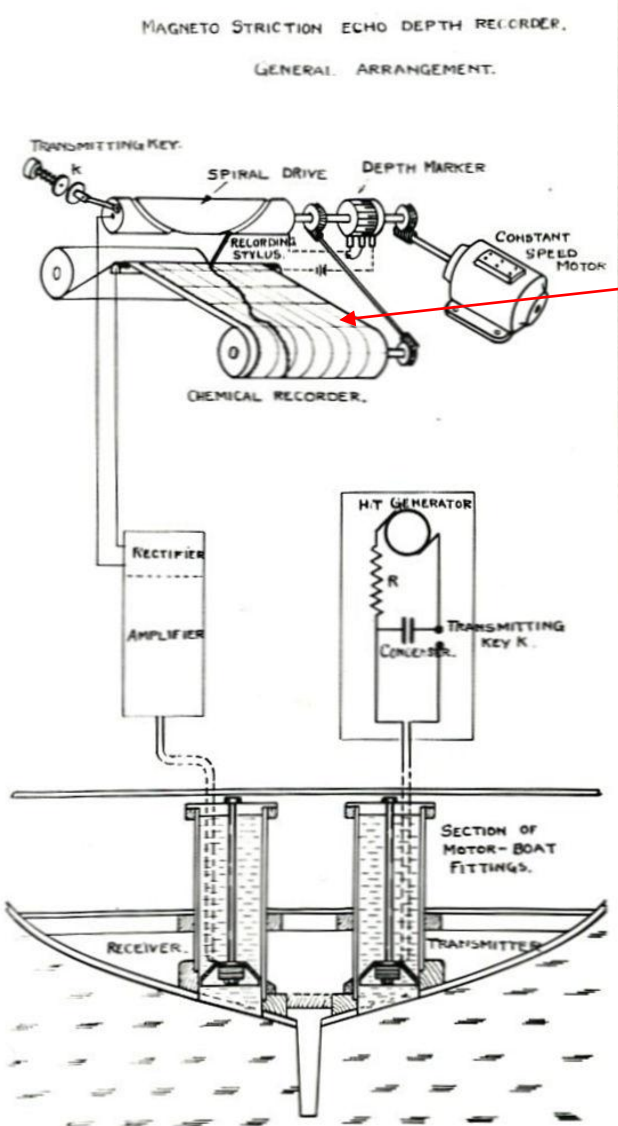
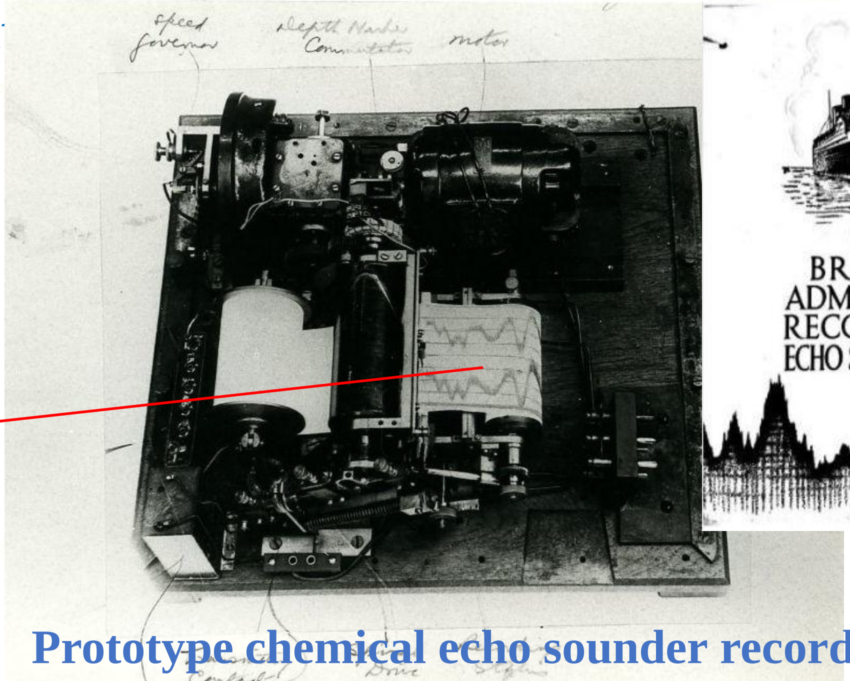
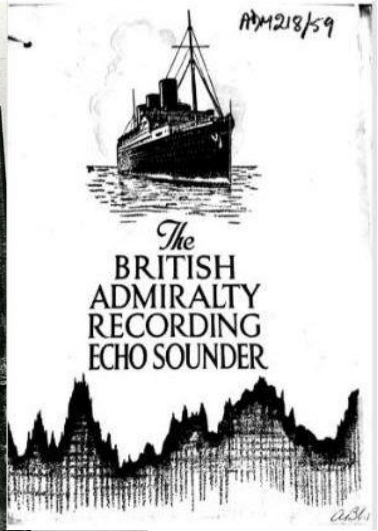


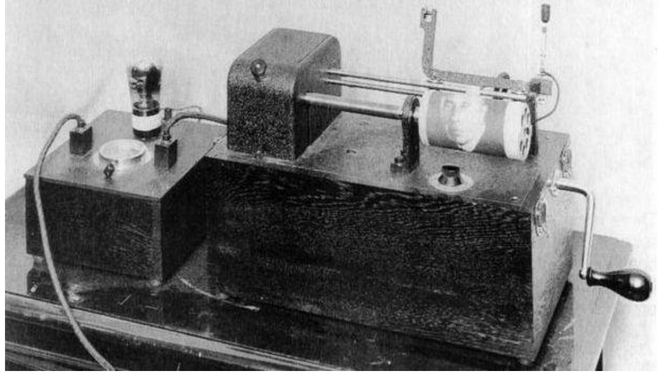




Prototype chemical echo sounder recorder, 1929-30. Maximum recordable depth 420 fathoms (768 m) depended on the speed of the traversing stylus and Kelvin Hughes Brochure.

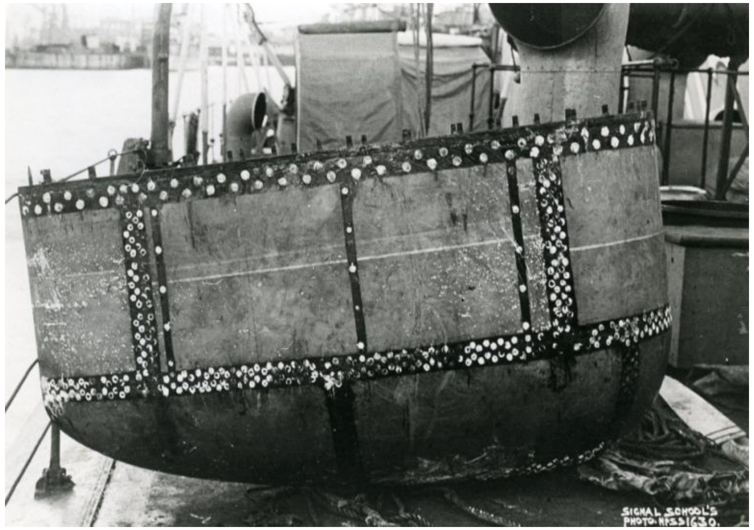
Langevin-Florrison echo sounder.
1. Quartz projector.
2. On board French naval vessel *Ville d'Y* which ran a line of soundings between Norway and Iceland in 1922.
3. Marti smoked paper trace in 1922.

Admiralty magnetostriction echo sounder fitted in HMS *Flinders*, 1930-32. General arrangement.

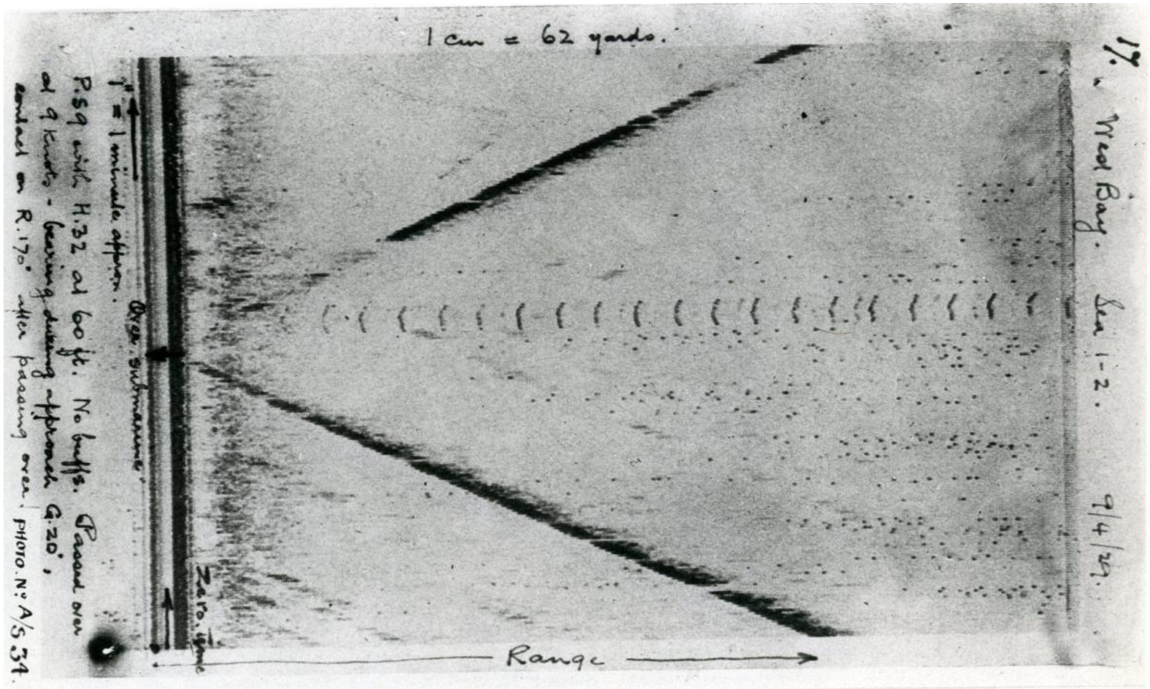


Fultograph 1929. Invented by Otto Fulton. Electrochemical process of the paper treated with potassium iodide.

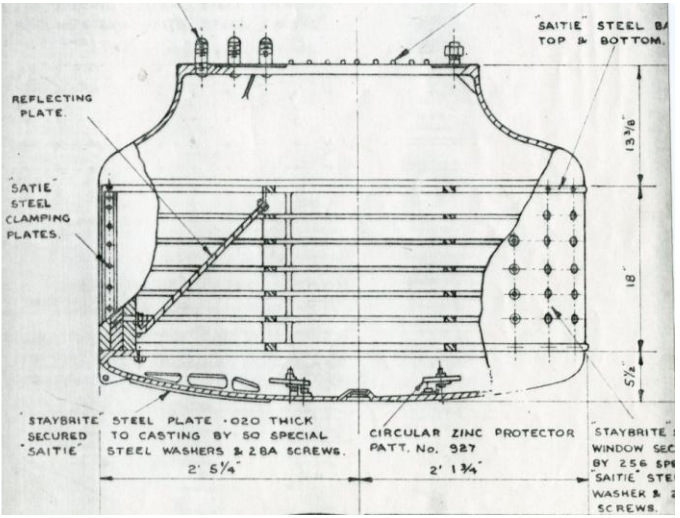
12 Interwar Streamlined Dome and Range Recorder



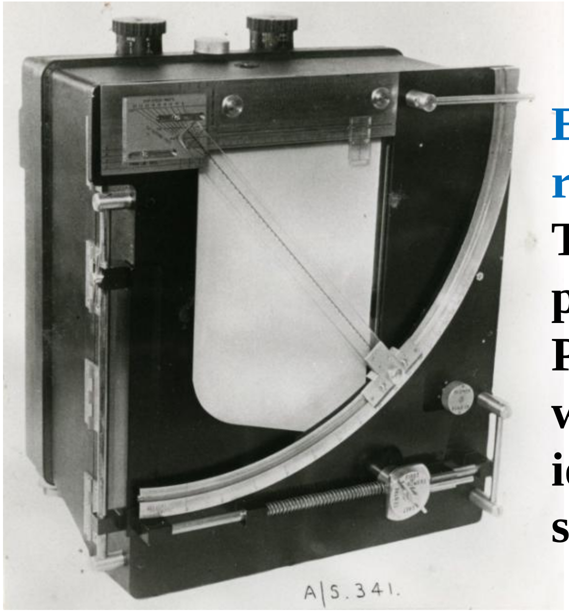
Prototype duralumin streamlined dome, 1925. External view showing the external rivets.



Dummy attack of *P59* on HM Submarine *H32*, 9 April 1929.
Submarine echoes at the minimum range of 25 yards (23 m). Echo duration about 1/50th of a second. After crossing over the submarine, the echo was picked up on approximately the opposite bearing, proving that *P59* had passed over *H32*.

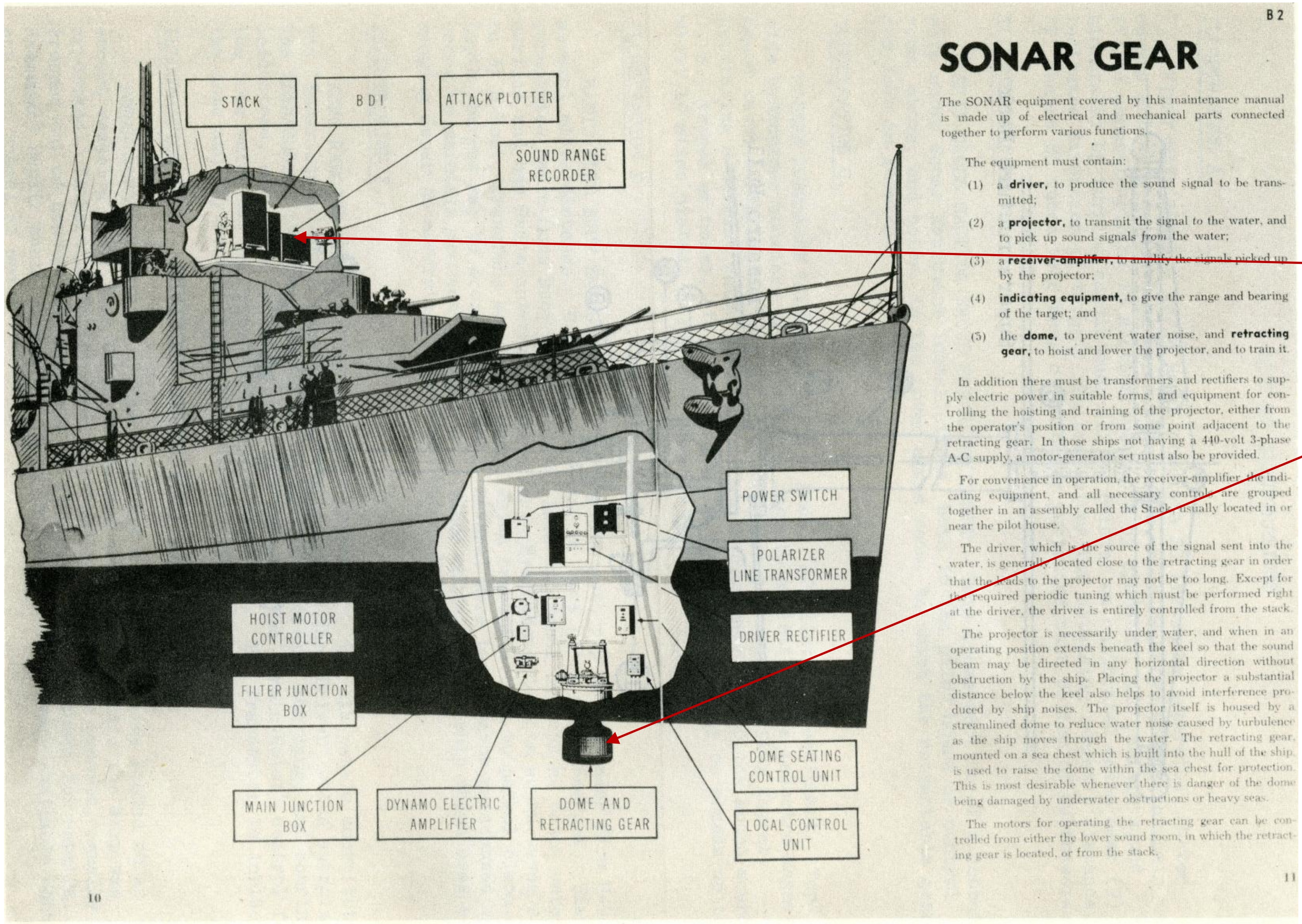


Technical drawing of a typical interwar dome.
Before the days of wind and water tunnel tests on models, one of the researchers, E.B.D. Mackenzie, was put down the trunk and inside the dome to read and record the 60 pressure gauges inserted in the dome skin!



Electrochemical range recorder, 1934. This is the first production model. Paper impregnated with potassium iodide starch solution.

World War II British-US Asdic-Sonar Gear



SONAR GEAR

The SONAR equipment covered by this maintenance manual is made up of electrical and mechanical parts connected together to perform various functions.

The equipment must contain:

(1) a **driver**, to produce the sound signal to be transmitted;

(2) a **projector**, to transmit the signal *to* the water, and to pick up sound signals *from* the water;

(3) a **receiver-amplifier**, to amplify the signals picked up by the projector;

(4) **indicating equipment**, to give the range and bearing of the target; and

(5) the **dome**, to prevent water noise, and **retracting gear**, to hoist and lower the projector, and to train it.

In addition there must be transformers and rectifiers to supply electric power in suitable forms, and equipment for controlling the hoisting and training of the projector, either from the operator's position or from some point adjacent to the retracting gear. In those ships not having a 440-volt 3-phase A-C supply, a motor-generator set must also be provided.

For convenience in operation, the receiver-amplifier, the indicating equipment, and all necessary controls are grouped together in an assembly called the Stack, usually located in or near the pilot house.

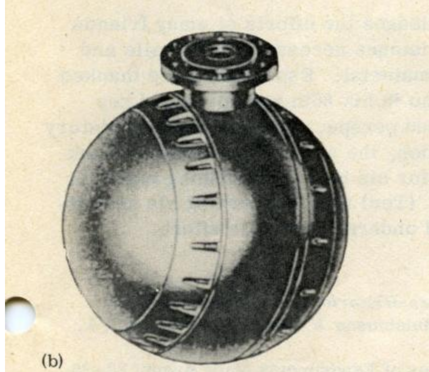
The driver, which is the source of the signal sent into the water, is generally located close to the retracting gear in order that the leads to the projector may not be too long. Except for the required periodic tuning which must be performed right at the driver, the driver is entirely controlled from the stack.

The projector is necessarily under water, and when in an operating position extends beneath the keel so that the sound beam may be directed in any horizontal direction without obstruction by the ship. Placing the projector a substantial distance below the keel also helps to avoid interference produced by ship noises. The projector itself is housed by a streamlined dome to reduce water noise caused by turbulence as the ship moves through the water. The retracting gear, mounted on a sea chest which is built into the hull of the ship, is used to raise the dome within the sea chest for protection. This is most desirable whenever there is danger of the dome being damaged by underwater obstructions or heavy seas.

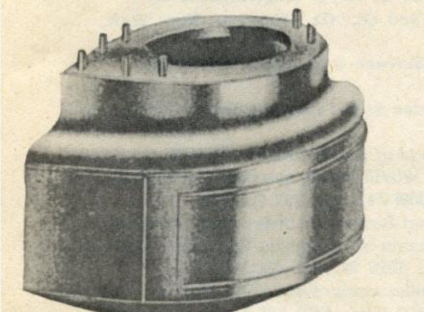
The motors for operating the retracting gear can be controlled from either the lower sound room, in which the retracting gear is located, or from the stack.

11

Taken from a booklet produced as a press release by the US Navy Office of Public Information for release to the Press on 6 April 1946 which shows the Royal Navy's range recorder and streamlined retractable dome which were passed on to the USA in 1940.

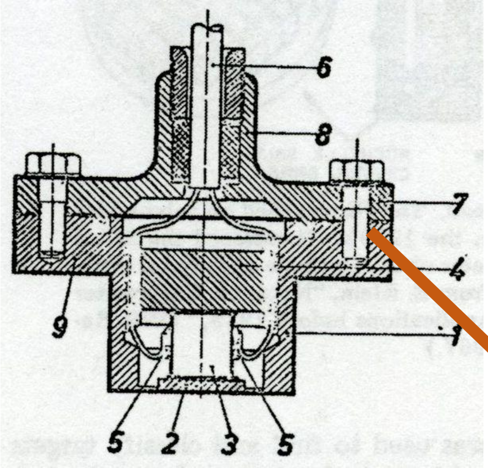

(b)

US pre-war spherical dome for QC set.


(c)

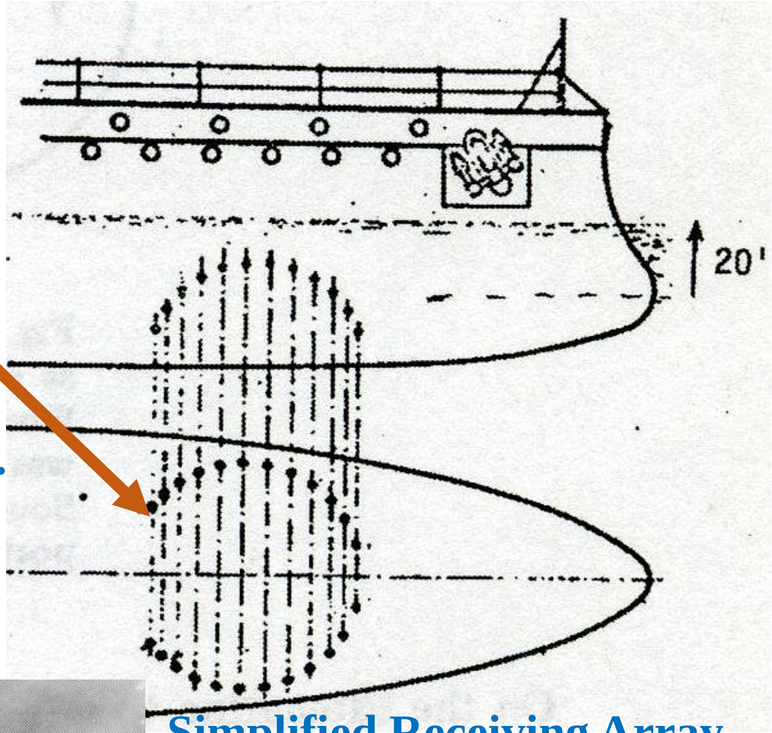
Wartime streamline US dome based on British design with sound baffle to minimize own propeller noise.

Hydrophone mounting arrangement on the Prinz Eugen, *c*. 1938.



Cross Section of GHG Hydrophone.

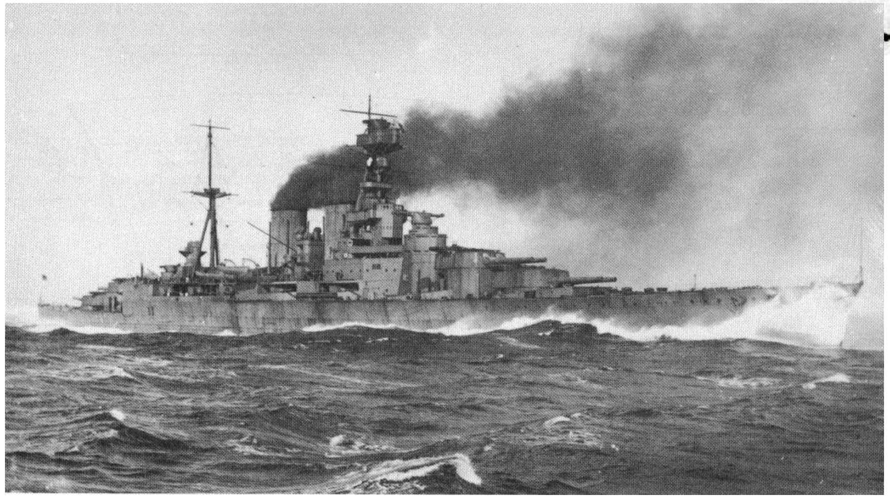
Assembly carefully vibration isolated and flush mounted to hull. Crystal receiver of Rochelle salt crystals.



Simplified Receiving Array.

Horizontal projection of the array in the shape of an ellipse. The *Prinz Eugen* had 60 GHG hydrophones on either side. She detected the HMS *Hood* over the horizon so the guns were all set up when the *Hood* was spotted and hit with the first salvo.

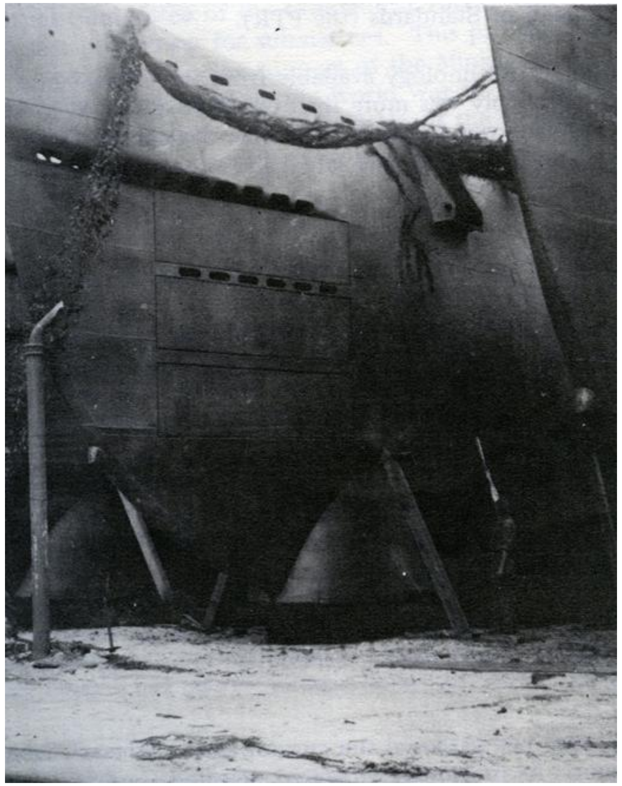
The *Prinz Eugen* anchored in the Baltic in the spring of 1941. Survived two nuclear tests in Bikini Atoll but later found to have sustained damage at the second test, the underwater test 'Baker' (25 July 1946) Towed later to Kwajalein Atoll, she capsized on 22 December 1946.



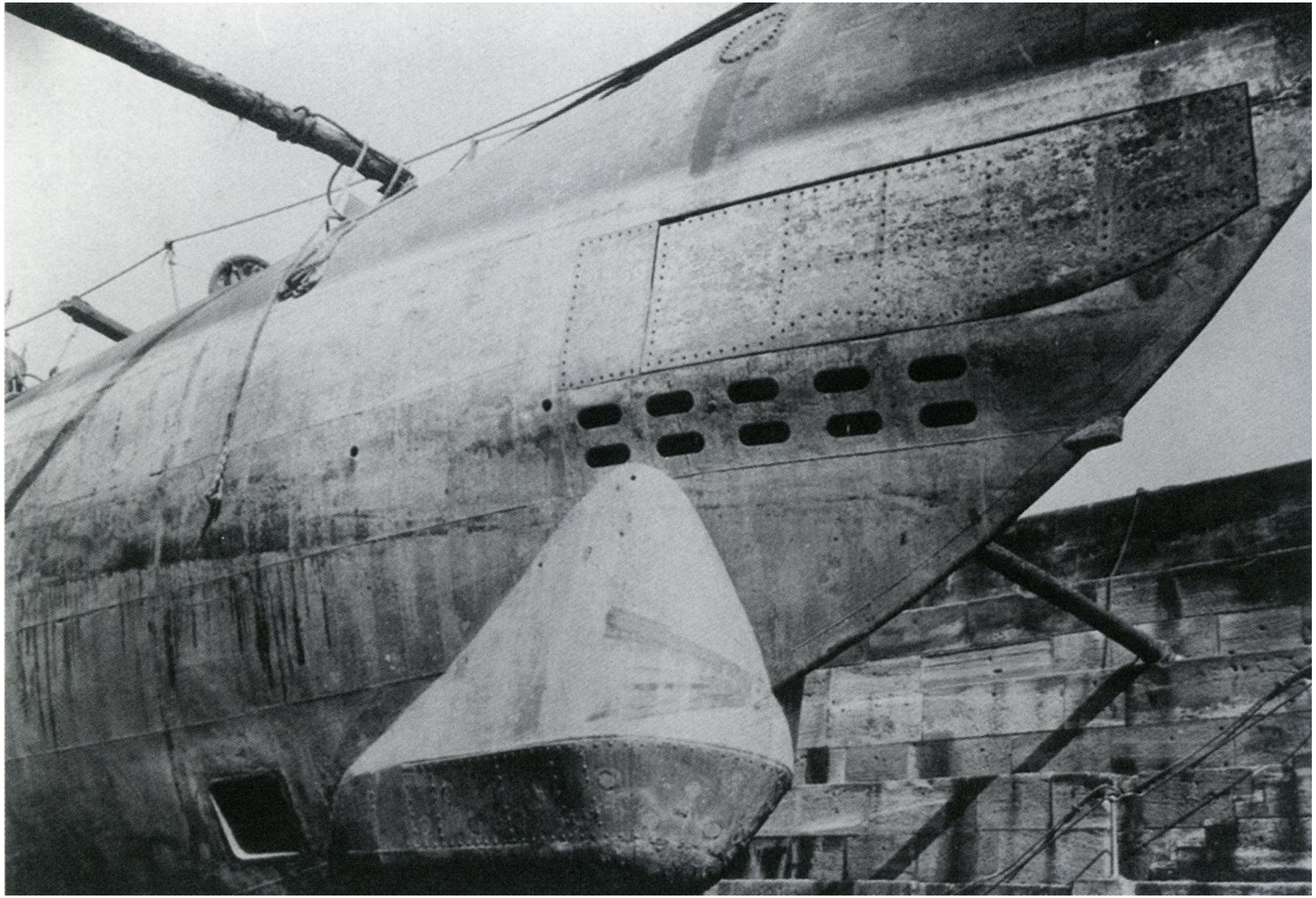
Battle cruiser HMS *Hood*, built 1917.

The exploded wreck of HMS *Hood* as seen from *Prinz Eugen* on 24 May 1941.

U-Boat Passive Sonar: Balkongerät



Bows of two Type XXI (side by side). To the bottom left the 'Balkon' in which the bow bulge below the water line: 48 hydrophones in the form of a horseshoe about 162 cm across at widest point and 220 cm long. Most advanced U-boat of the Second World War. The first of the 'Elektroboote' designs, 1943.

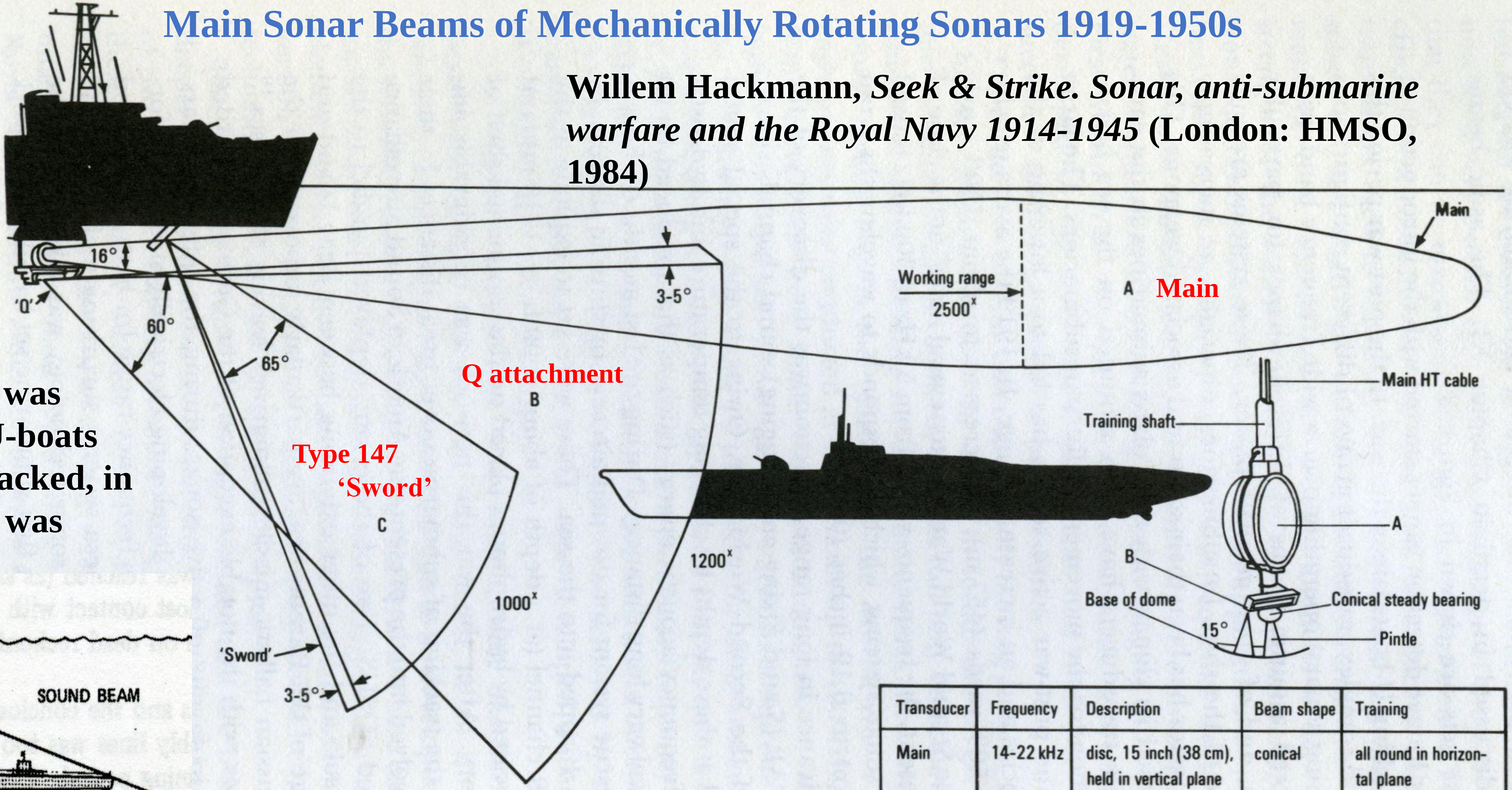


Balkon of U 1497, Type XVII B fast attack boat with Walter propulsion system, 1943.

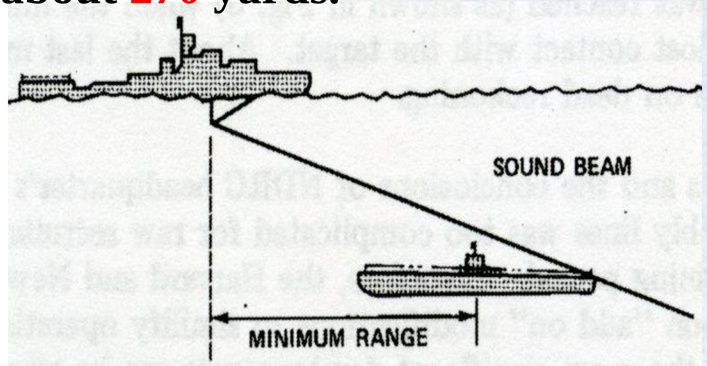
See: L. *Batchelder, 'Sonar in the German Navy', US Technical Mission in Europe', TR No. 530-45, and Heinrich Maass's 'Lectures on History of German Sonar Techniques and Current Sonar Developments', NUSC Publication, No. NL-3004, 7-8 October 1965, *I interviewed Batchelder for my book.

Main Sonar Beams of Mechanically Rotating Sonars 1919-1950s

Willem Hackmann, *Seek & Strike. Sonar, anti-submarine warfare and the Royal Navy 1914-1945* (London: HMSO, 1984)



In 1942 the minimum range for lost contact was about 170 yards. As U-boats went deeper when attacked, in 1945 minimum range was about 270 yards.

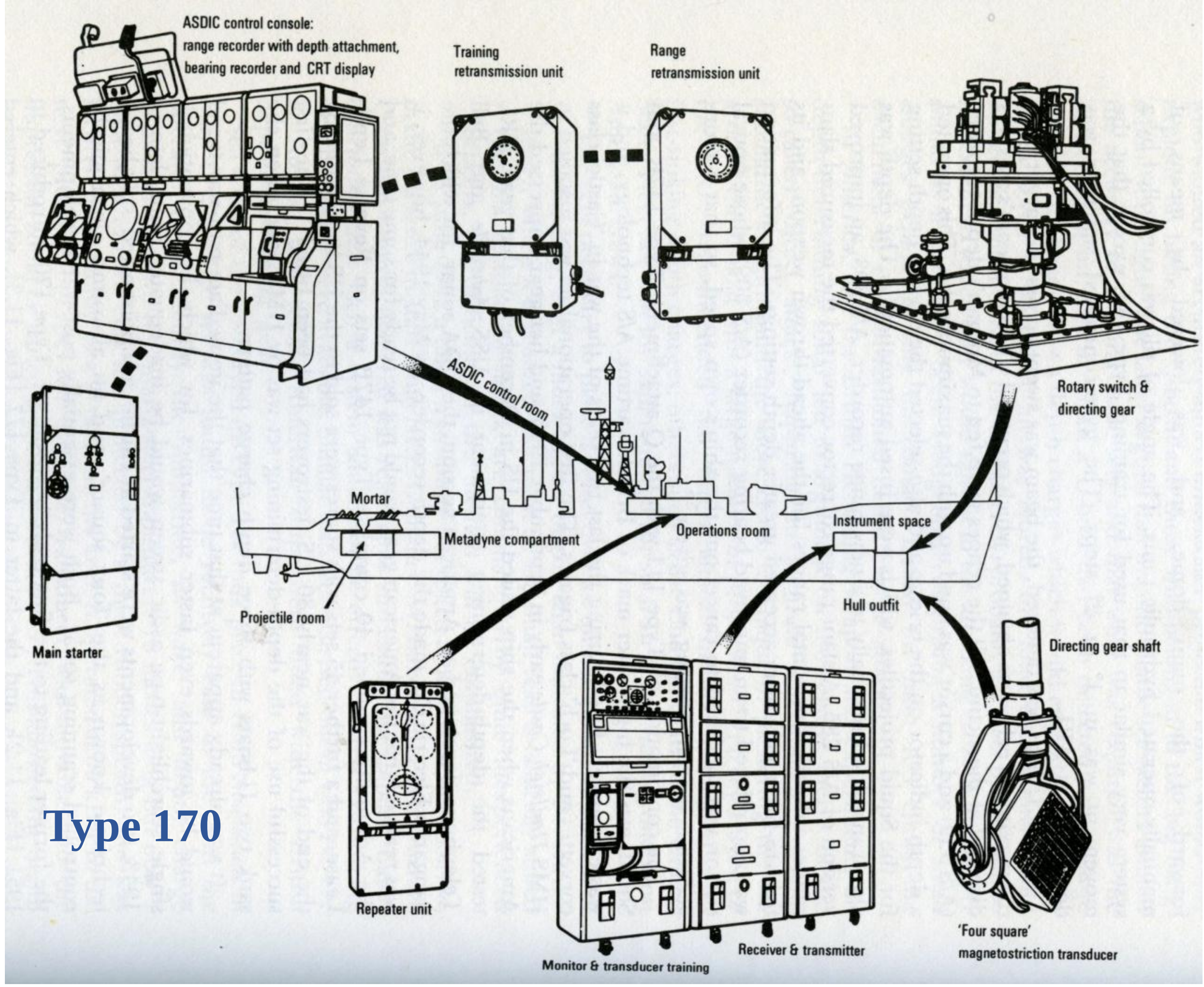


Transducer	Frequency	Description	Beam shape	Training
Main	14-22 kHz	disc, 15 inch (38 cm), held in vertical plane	conical	all round in horizontal plane
'Q'	38½ kHz	strip, 12x1 $\frac{6}{10}$ inch (30½x4.6 cm)*	wedge in horizontal plane	same; attached beneath main transducer
'sword' Type 147	50 kHz	strip, 18x1¾ inch (45 x 4.3 cm)*	fan in horizontal plane	tilts 45° backwards in vertical plane

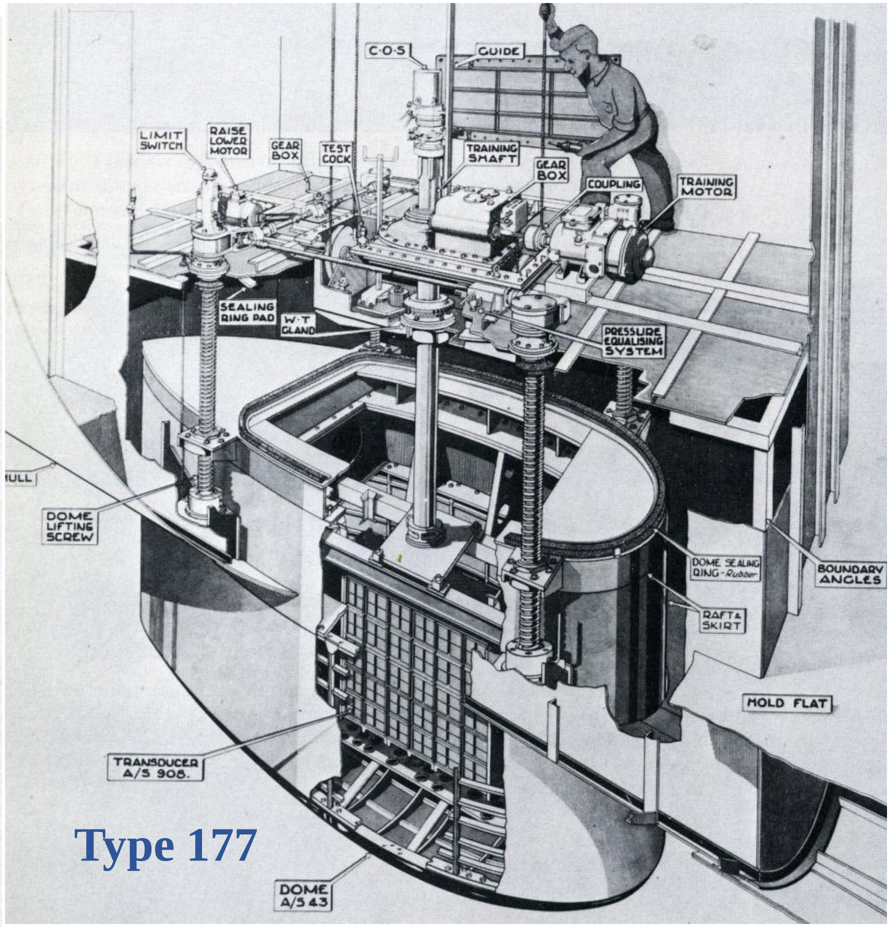
*Dimensions changed slightly with later sets.

Fig. ii The three asdic beams developed during the period covered by this history.
A. Main 'searchlight' beam for long-range detection developed at end of World War I.
B and C. Secondary sets for maintaining contact with deep diving submarines developed in World War II. **'Q' attachment and Type 147 the 'Sword'.**

Royal Navy Asdic/Sonar Attack Sets: 1950s and 1960s



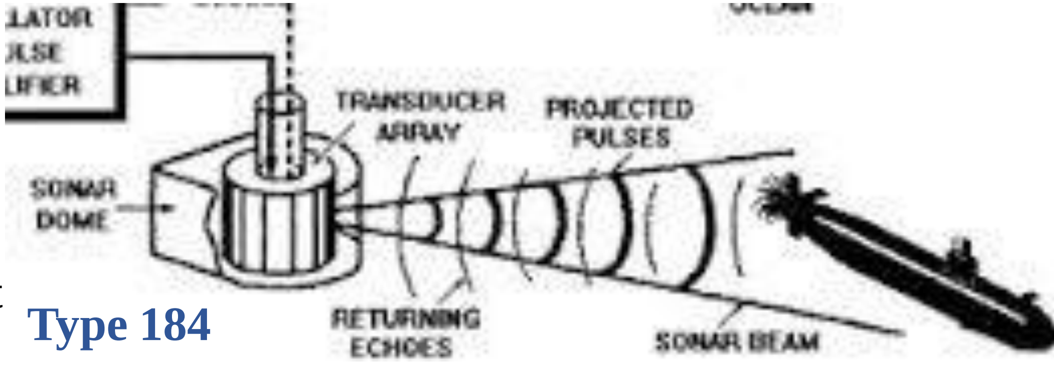
Type 170



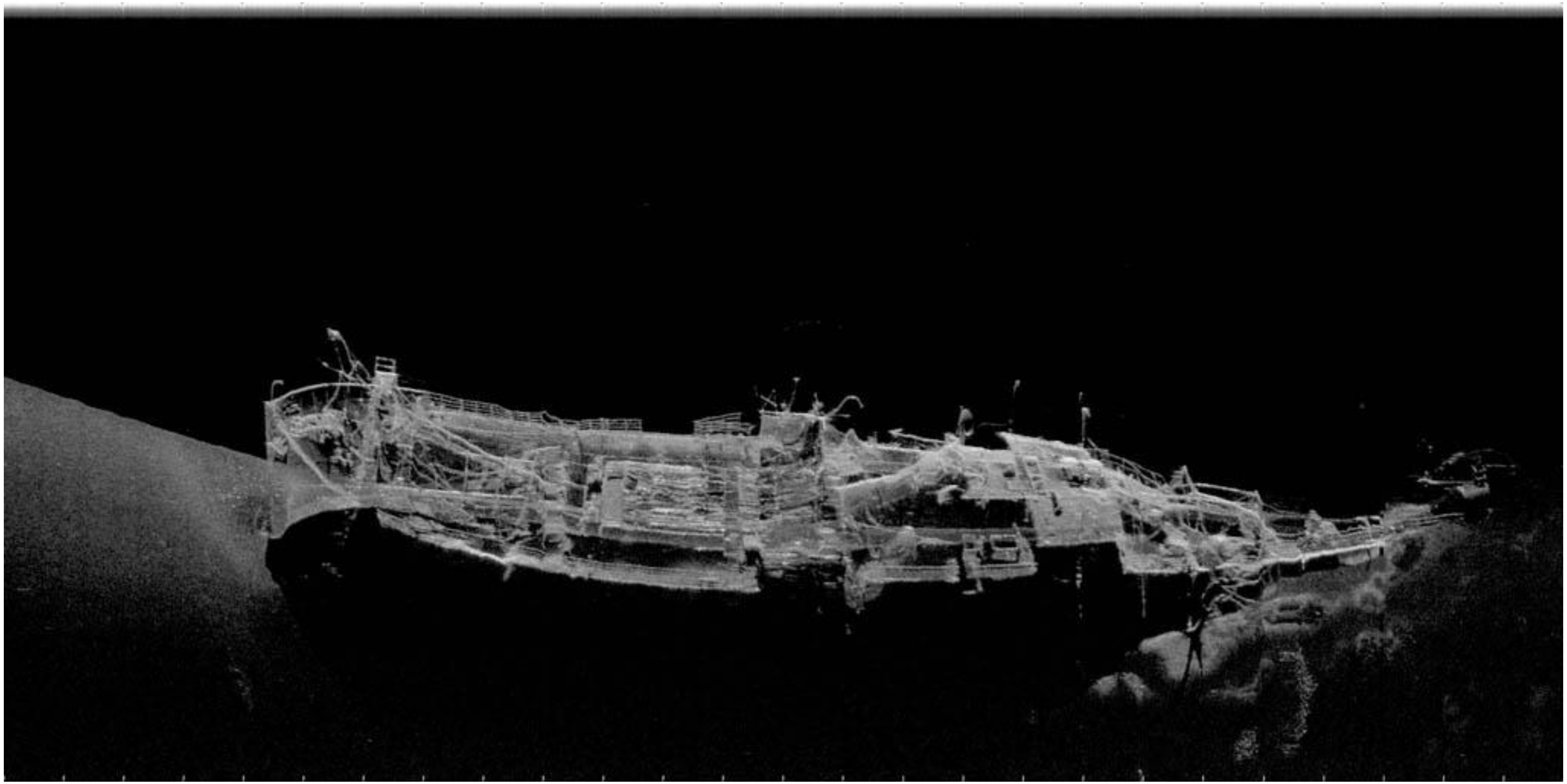
Type 177

Two-ton magnetostriction transducer, four feet square consisting of four elements, were electronically phased and housed in a one hundred-inch streamlined dome. It operated at the low frequency of 7½ kHz.

Type 170 with 'Four square' magnetostriction transducer (1950s) magnetostriction transducer of four equal parts: the horizontal ones for bearing, the vertical ones for depth, and Type 177 'sector scan' sonar (1960s). The last set described in the narrative of my book. Type 184 first generation of cylindrical transducer array for tracking fast submarines.



Type 184



Sonogram of the wreck of the Jürgen Fritzen off the Swedish Coast

Taken with a towed side-scan sonar by Sture Hultquist. German, 124 m long, cargo ship loaded with coal. On April 20, 1940 she sank on 73-80 m depth about 1 nautical mile from Landsort.