THE BEHM " LIMNOLOT " SOUNDER

HISTORY OF DEVELOPMENT.

The problem of measuring the depth of water by means of acoustic vibrations was first taken up by MAURY, an American, in 1855, but he failed in his endeavours, while efforts in the same direction made later in other countries were equally unsuccessful ; it was only in 1912 that BEHM, without having knowledge of preceeding unsuccessful experiments, conceived the same idea and succeeded in solving this problem.

For his method of sounding he invented the name of "Echo-Sounder" which, in the meantime, has become a familiar designation all the world over for a special type of Acoustic Sounding Apparatus. When his first echo soundings were made in Kiel Harbour he succeeded already in measuring a minimum depth of three metres under a vessel's keel, this measurement differing from the real depth by one quarter of a metre only, and this still represents the standard value of any echo sounding. Further developments of the echo sounding method have proved that, in the ocean, there is no depth which it is impossible to ascertain by means of the Echo-Sounder, and this instrument operates much more quickly and more accurately than a line sounder.

The high speed of travel of sound impulses in water, *i.e.* 1500 metres per second, entails great accuracy in measuring time intervals. The photographic time-recording method used by BEHM for his first echo-soundings would have been too complicated for practical use on board vessels and, therefore, he designed the well known BEHM Time-Indicator, a time indicating apparatus of the greatest precision and simplest construction. This apparatus has, in the course of time, undergone various alterations, both in its exterior shape and in the method of taking readings, without however changing the original principle of time measurement. Various types of the BEHM Echo-Sounder have been developed for use on board ship, as well as in airships and aeroplanes.

THE BEHM "LIMNOLOT" SOUNDER (*).

Hitherto, the Echo-Sounder has been used solely for taking soundings in

(*) See "*Internat. Revue der Ges. Hydrobiologie und Hydrographie*", 1926, volume XV, sections 5/6 : *Proposal for the use of Behm's Echo-Sounding Method for ascertaining the depth of inland waters*, by Friedrich Kurt REINSCH, who also suggested that the apparatus be named "BEHM Limno-Sounder".

the oceans, as previous types could be operated only from large vessels with the apparatus in a fixed position. The first echo soundings in fresh water were taken by BEHM in 1912 in the Ploen Lake, with the assistance of the Hydro-Biological Station at Ploen. For these soundings he used the new Type VI BEHM Sounder which, being constructed as a BEHM Limno-Sounder of light metal, may be operated even from small craft, such as small motor-boats or rowing-boats. The special design of this instrument and the particular mode of sound-wave transmission in water, along the surface of contact of water and air, made it possible to take soundings with apparatus from ships which do not permit the transmitter and receiver to be sufficiently screened by the ship's hull, even in smaller depths ; so far, this could be done only from large vessels with full utilization of the hull's maximum screening action.

EMPLOYMENT OF THE APPARATUS.

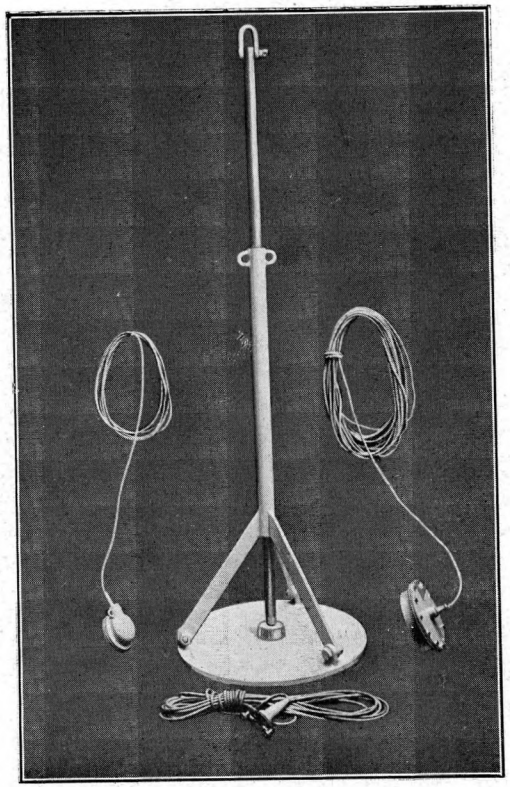
The BEHM Limno-Sounder does not require any source of high voltage, it being operated with 12 volts only and about 1.5 ampere consumption of energy supplied by dry cells or a storage battery. Owing to its light weight it may be carried permanently fitted or portable, on board of the smallest vessels. In the case of a vessel where transmitter and receiver can be permanently fitted to the ship's side or bottom, echo soundings may be taken while the vessel is moving at her normal speed. If, however, the receiver only is fixed, and the sound transmitter, which may be operated by hand, is slung overboard suitably suspended by a rope, echo soundings can be taken only at reduced speed. Even if transmitter and receiver are slung over the side, echo soundings are possible, but in this case they must be taken with the vessel stopped. The range of the BEHM Limno-Sounder is between a very few metres under the keel and 200 metres and more, the instrument indicating directly the depth of water in metres. Soundings may be repeated at intervals of a little less than one second. When the vessel is stopped the range of sounding is greater than when the ship is under way. In depths up to about 100 metres and a little more, the use of a cathode valve amplifier may be dispensed with, but in greater depths its use is necessary.

OPERATION.

The operation of the BEHM Limno-Sounder is extremely simple. After the main switch is turned on and the instrument is correctly adjusted by means of the two revolving knobs, the apparatus shows the depth of water at every stroke on the transmitter plate. The sound impulses may be transmitted at any desired rhythm, as the indicator is automatically actuated by a sound receiver placed in the water near the sound transmitter.

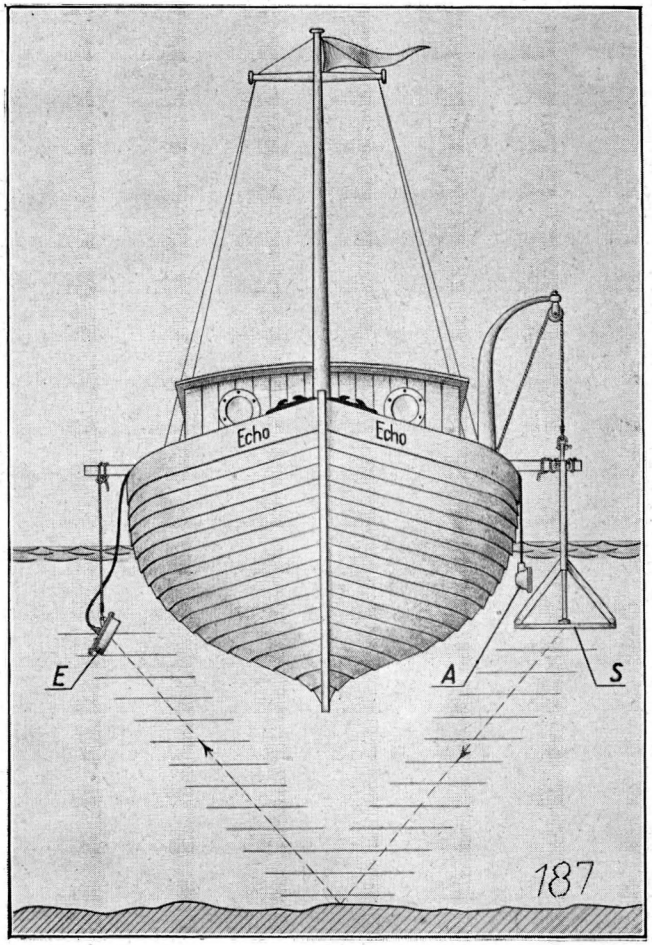
INSTALLATION.

On board ship the apparatus may be fitted on a bulkhead bracket or on a tripod fixed to the deck.



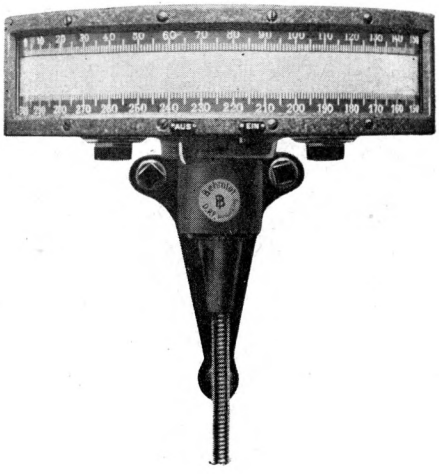
HANDOPERATED
EMITTING-HAMMER
TO BE SUSPENDED OVERBOARD
to the left : *starting microphone.*
to the right : *microphone receiving echo.*
at the bottom : *firing apparatus for cartridges.*

PERCUTEUR-ÉMETTEUR A MAIN
POUR SUSPENDRE HORS DU BORD.
à gauche : *microphone de départ.*
à droite : *microphone récepteur d'écho.*
en dessous : *dispositif de mise de feu des cartouches.*



MOVABLE EMITTING
AND RECEIVING APPARATUS FOR
SMALL CRAFT.
S. *Hand operated emitting-hammer.*
A. *Microphone starting the time-indicator.*
E. *Echo-receiver.*

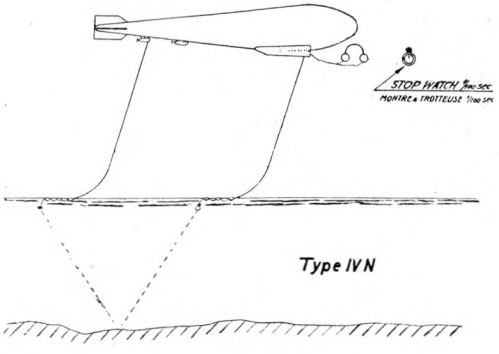
DISPOSITIF AMOVIBLE
ÉMETTEUR RÉCEPTEUR POUR PETITS
BATIMENTS.
S. *Percuteur-émetteur à main.*
A *Microphone mettant en marche le sténochronomètre.*
E. *Recepteur d'écho.*



Behm Limnolot
Type VI

Behm Limnolot Type VI
with stand.

Behm Limnolot Type VI
avec trépied



Schematic sounding installation for Behm Sounder Type IV *N*.

Installation schématique de sondage avec le Sondeur Behm Type IV *N*.

READINGS.

When readings are to be taken, the apparatus should, if possible, be protected against sunlight falling directly on the indicator scale. If this be not possible, a black cloth such as is used for focussing when taking photographs will answer the purpose.

The depth of the water is shown by the reflection of a light. In the position of rest the reflected light is visible as a point of light on the zero of the indicator scale. By actuating the sound receiver which is placed near the sound transmitter, this point of light moves rapidly and precisely along the two indicator scales of the apparatus, thus appearing as a horizontal line of light. At the moment of the arrival of the echo, this line breaks suddenly and takes the shape of a curve. The length of the line of light is the measure of the depth, and readings of this depth may be taken from the indicator scale — which is marked in metres of depth — provided that the transmitter and receiver are placed in the water with the required space between them of 10 and 15 metres. After this movement, the point of light returns to its zero position, but is invisible to the observer on its way back, and remains there until it is again set in motion by actuating the transmitter. Readings of depths which are greater than those measurable by the upper indicator scale of the apparatus may be read on the lower scale. For this purpose, the switch lever, fitted on the right hand side of the casing, must be turned to the lower scale. Then the line of light indicating the depth runs in the opposite direction and is equally visible to the observer.

A special advantage of the BEHM Limno-Sounder, Type VI, is that a correct measurement of time is possible, even when the intensity of the echo is reduced to the lowest limit of distinctness, and another advantage of this type of sounder is that it can be ascertained by the intensity of the echo, whether the sounding has been satisfactory or not; the lack of this quality in the older types might possibly result in incorrect measurements. Therefore, although it makes reading more simple, the method of indicating by means of a retarded stationary line of light, as used in Type I BEHM Sounder, has been abandoned in Type IV of the BEHM Limno-Sounder on account of the greater accuracy obtained in sounding.

ICE SOUNDINGS.

In addition, the BEHM Limno-Sounder is particularly useful for echo-sounding from the ice of inland and coastal waters. For this purpose, the apparatus is suitably mounted on a tripod. If the depth to be measured is within moderate limits and the ice is not too thick, it is necessary only to lower the echo receiver into the water through an opening cut in the ice, the sound impulse being transmitted by a stroke or blow on the ice by means of a bar or hammer at a proper distance from the echo receiver. Echo soundings taken in this manner will give the best results, for the ice, owing to its large surface, oscillates as a membrane and sends an intense sound wave to the bottom in the same way as the impulse transmitter. The first soundings of this nature were made by BEHM in December 1928 at a depth of 21 metres

in Kiel Harbour. The advantage of ice echo soundings over soundings with a line-sounder is obvious, as echo soundings may be carried out even at very low temperatures, when any sounding line will become an icicle in a very short time, particularly if great depths are to be measured.

DEEP SEA SOUNDINGS.

The range of Type VI BEHM Limno-Sounder may be increased beyond that obtainable with the impulse transmitter and amplifier, by using a BEHM Sounding Cartridge instead of the impulse transmitter. The range is then simply dependent upon the detonating force of the cartridge used However, this detonating force is limited in practice. Type VII BEHM Limno-Sounder is constructed with a special device for deep-sea soundings up to the greatest depths. This type differs from Type VI in that, with the former, BEHM tube-soundings may be taken, the echo being received by ear and the apparatus being stopped by hand at the moment of arrival of the echo. As in the case of Type VI, the apparatus is actuated automatically by transmitting impulses. While in Type VI the indicating reflected light moves to and fro once only, in Type VII it makes continuous accurately timed movements which are counted. The depth measurement is then obtained from the time-value of all full movements of the indicating light plus the time-value of the last incomplete movement read from the indicator scale. Soundings of this kind may also be taken by means of the impulse transmitter. For depths beyond the range of the apparatus, a BEHM Sounding Cartridge may he used. Within the range of directly indicated soundings, Type VII operates in the same manner as Type VI.

FIELDS OF EMPLOYMENT OF THE BEHM "LIMNOLOT" SOUNDER.

IN EXPLORING EXPEDITIONS.

Owing to its small weight and the many possibilities of its use, the BEHM Limno-Sounder is an instrument of incalculable value to scientific exploring expeditions.

The methods of ascertaining the depths of inland lakes and coastal waters in distant and unexplored districts of the Arctic and Antarctic, and as well as of the tropics, are placed by it on an entirely new basis. The simplicty of its operation allows thousands of echo soundings to be taken within a period of time during which but few soundings with a lead and line would be possible. The ice sounding method, also invented by BEHM, is specially important for Arctic regions. Even aeroplanes may carry a BEHM Limno-Sounder on board and use it when they alight on waters of tropical districts or on the ice of the Polar regions, the apparatus being equally resistant to high and low temperatures. Its simple and durable construction are additional features

which make the apparatus specially suitable for expeditions in uninhabited districts where it may meet with rough handling, etc. When on expeditions a small hand-driven generator may be used with advantage as a source of electric energy for charging the small storage battery.

SURVEYS.

The BEHM Limno-Sounder is not only useful for expeditions but it may be employed successfully also for regular surveys of inland and coastal waters, river mouths, bays and gulfs, as for such purposes there are, in the majority of cases, only small vessels available, large ships being frequently unsuitable for this work, owing to the restricted depth of the waters.

FISHERIES.

For purposes relating to exploration in connection with fishery, the BEHM Limno-Sounder is of equally great value. Trawlers and other fishing vessels are able, by means of this apparatus, to maintain their position continuously and exactly over a depth which they have found to be favourable for their work. Experiments made by BEHM in November 1928 (on board the experimental vessel *Grille* of the German Navy) in the Skagerrak, seem to indicate that it is not at all improbable that evidence may be obtained of the existence or non-existence of shoals of fish by means of the BEHM Limno-Sounder.

DEEP SEA SOUNDING FROM AIRSHIPS.

In 1927 BEHM was the first to design a Special Echo-Sounder (Type IV N BEHM Sounder) with which it is possible to measure even the greatest ocean depths from airships.

This apparatus was constructed for General NOBILE'S expedition with the airship *Italia*. The transmitter and receiver of this appliance are lowered into the water by means of cables provided with floaters, the airship being stopped or moving but slowly at an altitude of 100 to 200 metres ; soundings may easily be taken in this manner.

The BEHM Limno-Sounder may be employed for the same purpose on board airships, it being superior to the older type, inasmuch as with it even the very smallest depths of water may be ascertained and are directly indicated by the instrument. Cartridges are not used for such sounding, unless great ocean depths are to be measured.

SUMMARY.

The BEHM Limno-Sounder is able to render valuable services in all the cases described above relating to exploration and surveys, its chiefs features being the following :

(1) It may be used from vessels of the smallest size.

(2) Soundings may be taken when there are but very few metres of water under the keel.

(3) Echo sounding is possible with a portable transmitter and receiver by simply slinging them over the ship's side.

(4) It is suitable for exploring expeditions, its small weight and strong construction permitting it to be carried by small boats, sleighs, aeroplanes, or road vehicles.

(5) It is entirely independent of any source of high voltage.

(6) The Sound impulses may be transmitted by hand.

(7) The depth of shallow water and the greatest ocean depths may be measured by Type VII.

(8) It is simple to operate.

(9) It is uninfluenced by low or high temperatures.

(10) The indications of depth, even in shallow water, are of the greatest accuracy.

EXPLORING EXPEDITIONS PROVIDED WITH BEHM SOUNDERS.

The BEHM Sounder was successfully used by a number of exploring expeditions, viz:

(1) In 1926, AMUNDSEN used Type IV A BEHM Sounder (designed for deep sea soundings only; weight 9 kilos) in the vicinity of the Pole, 3750 metres being the greatest depth sounded by him. Referring to these soundings he states: "As fortunate possessors of this apparatus we were able to take deep sea soundings from our landing place. It is obvious that on board of our aeroplane we could not carry any sounding leads and lines used for the customary soundings. Without your excellent device we would have had no means of obtaining this interesting information".

(2) In 1927, by means of a Type IV A BEHM Sounder, Captain WILKINS ascertained the greatest depth ever sounded in the Polar regions, *i.e.* 5.625 metres.
In this connection he states: "Through a hole cut into the ice, here 3 1/2 feet thick, soundings were taken with the light portable type BEHM Sounder which had been furnished by the American Geographical Society. The echoes received showed a depth of 5.625 metres or 18,450 feet, which is the greatest depth ever ascertained in the Arctic".

(3) In 1928, the American Geographical Society procured an additional Type IV A BEHM Sounder for soundings in the Polar Regions.

(4) In the same year the airship *Italia*, of General NOBILE's Polar Expedition, was equipped with a Type IV N BEHM Sounder which was specially designed for this Expedition. With this sounder, deep sea soundings may be taken from an airship 100 to 200 metres in the air.

(5) In 1929, Dr. SANDSTROEM's Swedish Expedition was equipped with

a Type VII BEHM Sounder. This expedition will use it in surveying the depth on the edges of the Polar ice between Nova Zembla and Greenland.

(6) Dr. KRUEGER'S German Arctic Expedition also was equipped with a Type VII BEHM Sounder with which this expedition contemplates surveying the Shelf District of the East Coast of Greenland during the present year, and in 1930 it will take soundings in The Arctic north of Alaska.

Dr. COLLINDER expressed himself as follows with reference to the BEHM-LIMNO-SOUNDER :

"I can report that the BEHM LIMNO-SOUNDER has worked during the whole journey to my greatest satisfaction. We have had comparatively good weather, thus it was always possible to take soundings. I have sounded by day and night every third hour, when we were under way. The depths were considerably greater than I had expected. The average depth was about 1500 to 2000 m. ; the greatest depth of 3750 m., confirms the existence of a deep trench lying in a north-south direction, westward of North-West Spitzbergen. A deep trench, of a depth of 3000 m., unknown until now, was found by sounding with the BEHM-LIMNO-SOUNDER in 73 to 75° North latitude and close to the shelf of Greenland. (1)

(1) Details on these soundings will be published in the *Hydrographic Bulletin.*