There is a likelihood that these crossbow floats may be made by a firm of instrument makers. Anyone interested in them could learn whether they are procurable ready-made, on writing to the author of this article.

Acknowledgements. — I wish to express my sincere thanks to Professor A.C. Hardy for his great kindness in drawing the diagrams, and to Mr. H.H. Goodchild of the Lowestoft Fisheries Laboratory for allowing me to use his crystal bag releasing device.

ADDENDUM.

It will have been realised that the float constructed as described would ride at anchor as shown in Fig. 5 in a weak stream only, even using an anchor line three times as long as the water was deep.

To ensure that it was not pulled under when it had anchored itself in a stream running at 2 1/2 knots and more, would require the attachment of cans having considerable buoyancy. This in turn would require the use of a fairly weighty anchor to make the float sit deep enough in the water when drifting.

The experimental model which met these needs is rather more cumbersome than was desired and is convenient — but experiments are being continued to get over this. It is of course possible to economize with weight by adding lift to the anchored float — by making it sheer upwards after the manner of the head-line otter-board of certain herring trawls. In other words, it could be made to ride a bridle or crow's-foot something like a kite. It remains a matter for further test to decide upon the most convenient arrangement.

A very convenient and cheap way of attaching the alarm clock has been found. All that is necessary is to slip it into a length cut from a discarded inner-tube of motor-car size. The length of tube used needs to allow for the rolling up of a few inches at both ends. Then it becomes an easy matter to hold the rolled ends down on to the plank by means of screwed-on battens. It is very simply arranged that one screw only has to be drawn in order to get at the clock.

With this arrangement, it has been found more convenient to let the peg concerned be snatched upwards by the ascending mop pole.

ELECTROMAGNETIC HYDROPHONES, OR " MAGNETOPHONES "

by

DR. HERBERT GROVE DORSEY, PRINCIPAL ELECTRICAL ENGINEER
U.S. COAST AND GEODETIC SURVEY.

(Reprinted from "Field Engineers Bulletin" N° 12, Washington D.C., December 1938, page 209.)

"Necessity is the mother of invention" and one of the difficulties of radio acoustic ranging was the noise which developed in the cable from the hydrophone to the shore station, due to leakage, since a small current was necessary in the cable to operate the carbon button of the hydrophone. The carbon button itself, also produced some electrical noises, called drying or burning, especially if the applied voltage was too high. It was desirable, therefore, to have some method whereby an electromotive force would be generated in the hydrophone itself, by the bomb sound, without the use of auxiliary voltages.

Back in the days when minds were working on these ideas there were several kinds of loud speaker units on the market. One type was meant to be used with a horn, in which the currents from the radio receiver caused a diaphragm to vibrate and set air in motion; another type was built to be fastened to a thin sheet of wood, such as the sounding board of a piano, and cause the board itself to vibrate. The inertia of the unit caused the board to vibrate more than the unit itself. This was called a piano unit and apparently was more common in the West than on the East Coast. Nathaniel Baldwin of Salt Lake City built very good units of both types. While each of these instruments had been designed to produce sound when currents of electricity flowed through their magnetic windings, it was also true of each, that if the movable part were vibrated an electric voltage would be generated in its windings.

In any design of instrument in which the volume decreases with pressure, it is necessary to avoid any construction in which the voltage generating element is fixed to one part of the container and has the movable part actuated directly by another part of the container. This is because the voltage generating element would be either crushed or rendered inoperative when the entire instrument is lowered into the water and the external pressure begins to deform the container. To avoid this in the case of the rubber hydrophones with the carbon microphone button "inertia type" mounting is used. In this the button is mounted so that the pin "inertia type" mounting is used. In this 'he button is mounted so that the pin of the unit is attached to the diaphragm of the container. The heavier portion tends to stand still so that the front and back plates of the button alternately approach and recede, thus changing the pressure on the carbon, altering its resistance. This type was used in the Navy hydrophones and in the hydrophones used with the Type 312 fathometer. The Baldwin piano unit, when used as a loud speaker, is the inertia type mounting, and it was this type of instrument which Senior Chief Radio Operator Almon M. Vincent used when he designed, on the Ship GUIDE in about 1928, the first magnetophone used in radio acoustic ranging.

The container was simply a large dipper or stew pan, about seven inches in diameter, borrowed from the galley. A Baldwin speaker unit was soldered to the bottom and a brass plate soldered over the top. The wires were brought out through the side by using the brass tube of a Navy hydrophone as a stuffing box. This tube was soldered into the dipper. A bicycle tire valve was also soldered into the side so that it could be tested for leaks by air pressure.

Figure 1 gives an idea of the appearance of this historical instrument. The unit is now broken loose from the bottom, which served as a diaphragm, so that it is no longer serviceable, but it served its purpose in the early days and forms the basis of all the West Coast designs of magnetophones since that time.

Meanwhile, on the Atlantic Coast, the writer had been working on a magnetophone utilizing the other type of Baldwin loud speaker unit. Direct connection of the unit to the external diaphragm was avoided by using air as the connecting link. When the diaphragm of the case is vibrated by the bomb signal, the internal air vibrations are communicated, through a hole in the middle, to the diaphragm of the unit in the rear portion. Figure 2 shows the parts of the magnetophone. At the left is the diaphragm with a flange which fits loosely in a groove in the base, shown at the right. When the rubber gasket is placed in the groove and the diaphragm bolted tightly to the base so that the metal surfaces at the edge touch each other, the rubber gasket is sufficiently compressed to form a watertight joint. Only a small air space is left between the diaphragm and the base so that if the water pressure is great, the diaphragm will be forced against the base and will not be distorted. The loud speaker unit, shown next to the diaphragm, is screwed into a threaded hole in the middle of the rear side of the base, and finally, the rubber plug is inserted in the tubular portion, the tyrex connecting cable passing out through the middle of the plug. The threads for the speaker unit are left a bit loose so that slow changes of air pressure will be equalized in the front and rear portions, while sudden impulses actuate the speaker diaphragm.

This magnetophone case is made entirely of rolled brass, the back tubular portion being sweated to the base with soft solder, as shown on the working drawing, Figure 3. After assembly in the Instrument Division the cases are tested with an air pressure of 15 to 20 pounds to find any leaks. During this test a thick plate is clamped over the diaphragm so that it will not be permanently bulged.

Fig. 1
Vincent Type Magnetophone, original Model.
Magnétophone, type Vincent, Modèle original.

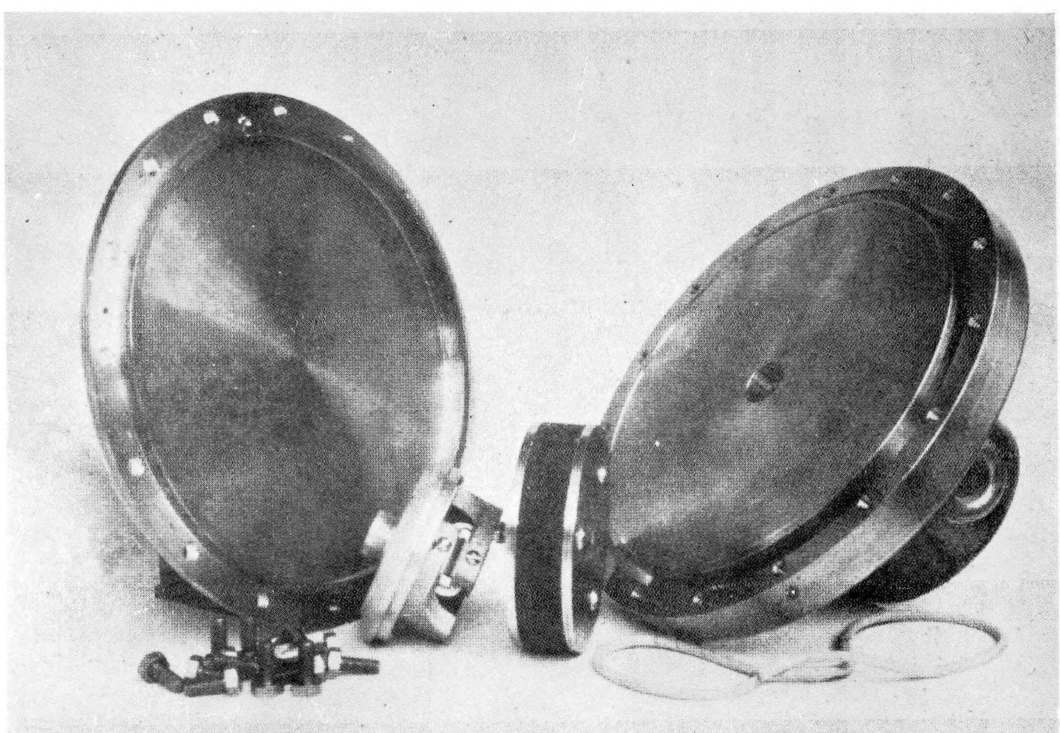


Fig. 2
Parts of Dorsey Type Magnetophone.
Parties du Magnétophone, type Dorsey.

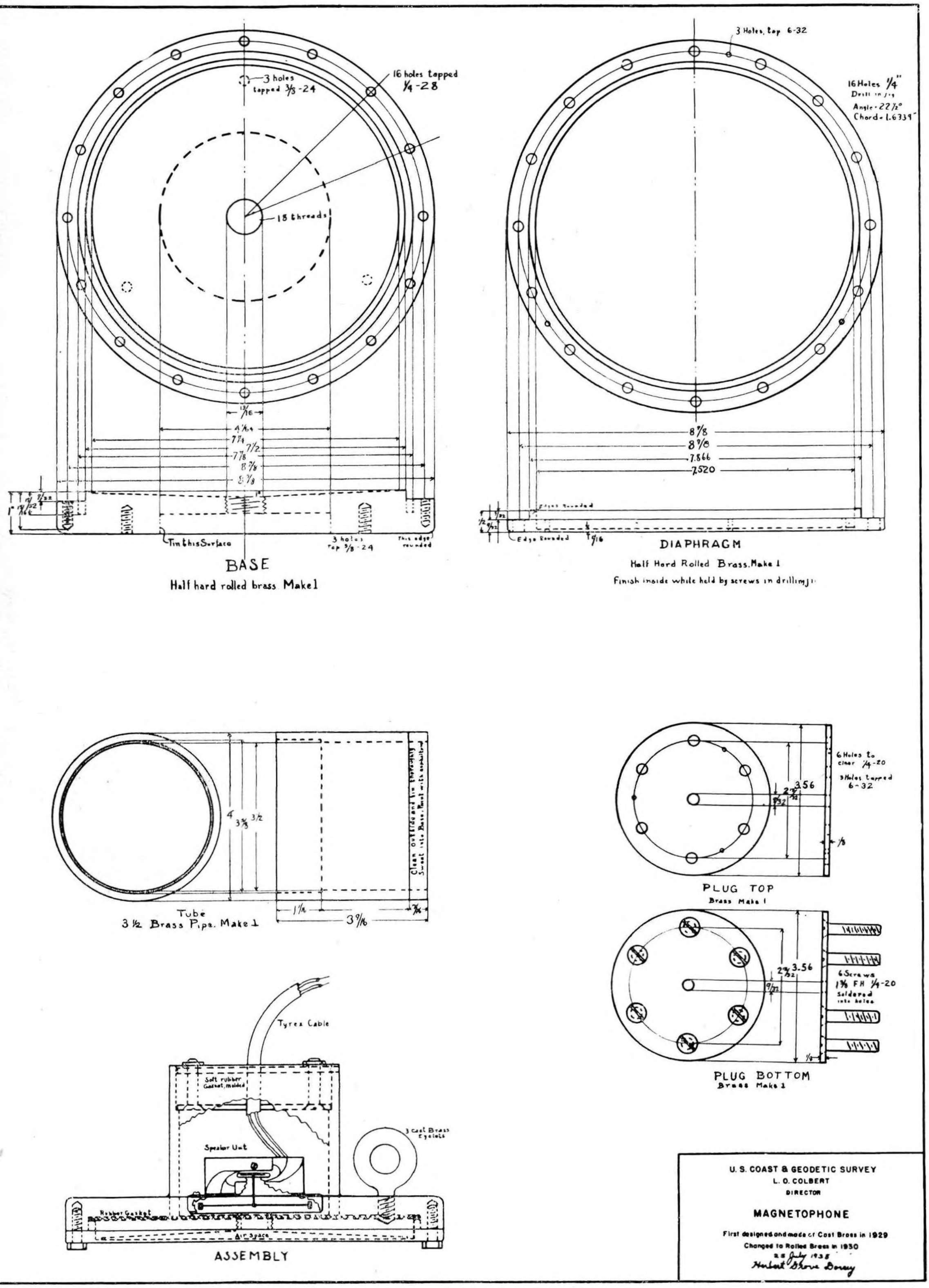

3 holes tapped 3/8-24
16 holes tapped 1/4-28
18 threads
Tin this Surface
3 holes Tap 3/8-24
This edge rounded
BASE
Half hard rolled brass Make 1
3 Holes, tap 6-32
16 Holes 1/4"
Angle - 22 1/2°
Chord - 1.6339"
Edge Rounded
DIAPHRAGM
Half Hard Rolled Brass. Make 1
Tube
3 1/2 Brass Pipe. Make 1
6 Holes to clear 1/4-20
3 Holes tapped 6-32
PLUG TOP
Brass Make 1
6 Screws 1 3/8 FH 1/4-20 Soldered into holes
PLUG BOTTOM
Brass Make 1
Tyrex Cable
Soft rubber Gasket, molded
Speaker Unit
3 Cast Brass Eyelets
Rubber Gasket
Air Space
ASSEMBLY
U. S. COAST & GEODETIC SURVEY
L. O. COLBERT
DIRECTOR
MAGNETOPHONE
First designed and made of Cast Brass in 1929
Changed to Rolled Brass in 1930

Fig. 3

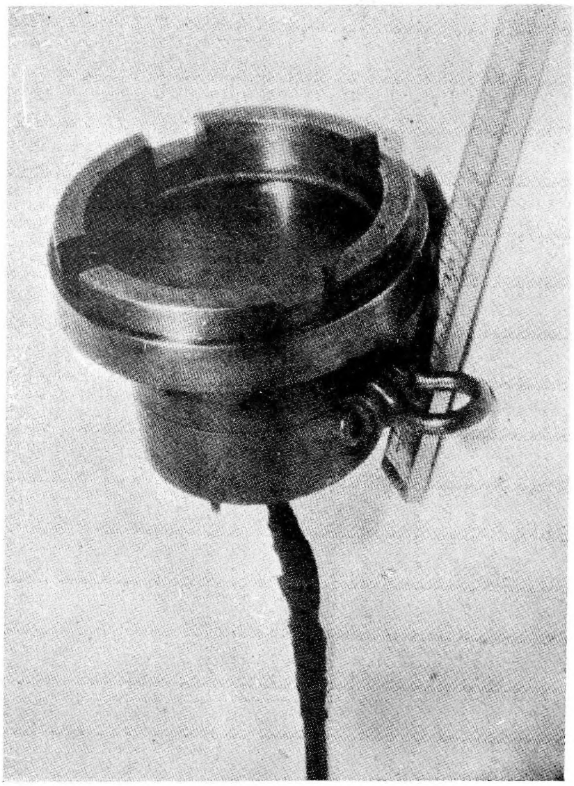


Fig. 5
Davis Type Magnetophone.
Magnétophone, type Davis.

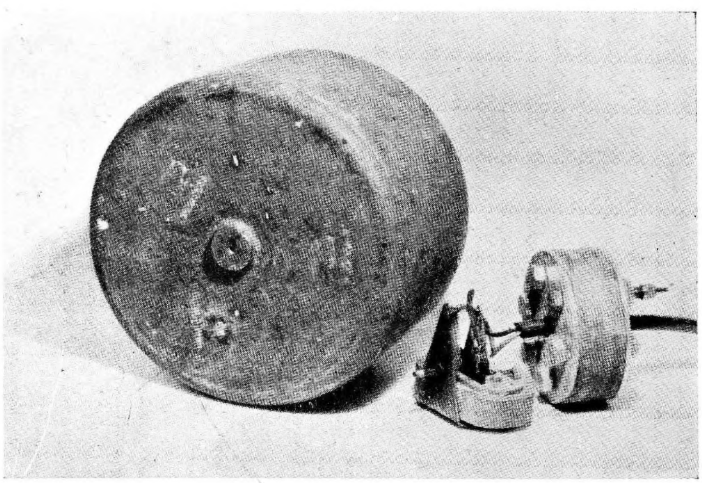
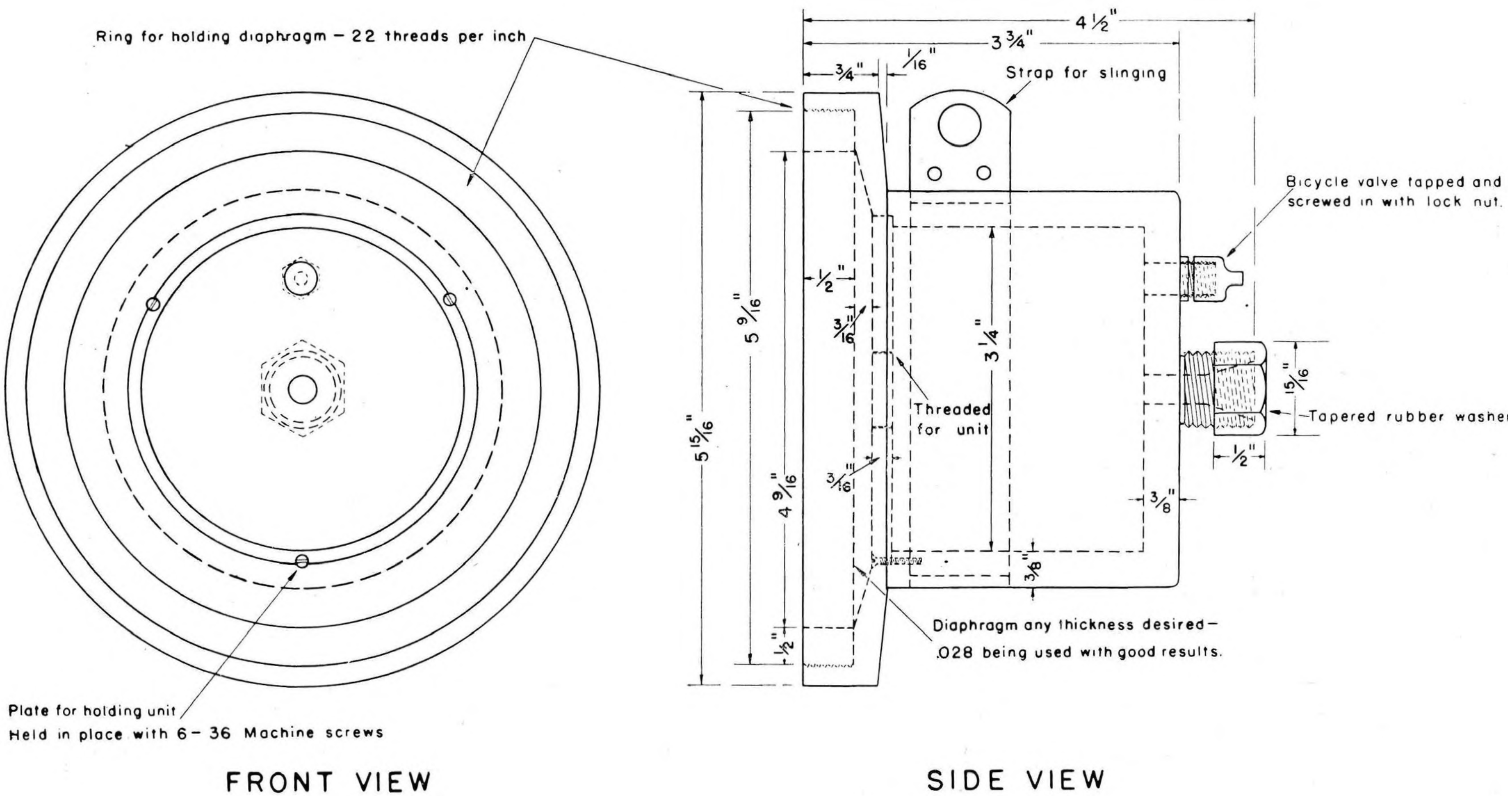


Fig. 6
Vincent Magnetophone with speaker Unit.
Magnétophone Vincent avec haut-parleur.



U. S. COAST AND GEODETIC SURVEY

L. O. COLBERT DIRECTOR

MAGNETOPHONE

DESIGNED & MADE OF
6" TOBIN BRONZE SHAFTING

BY S. N. DAVIS & J. W. SMITH
SHIP LYDONIA, 1930

There were lots of headaches in its early development. One looks at it and naturally asks, why not use a brass casting ? And that is just what was used at the beginning. From a wood pattern some castings were made at the Washington Navy Yard on a hurry-up order. Never thinking of the casting leaking, the diaphragm was soldered in as well as the back and the tyrex cable was brought out the side through a stuffing box. No one suspected but that it would be watertight and serviceable for long periods, but the brass casting leaked almost like a sieve. Solder was applied, with some benefit, and later on the cases were dipped in melted tin, but even then they were not entirely tight.

The first tests were made on the Launch ECHO, attached to the Ship LYDONIA, in September, 1929, to determine the feasibility of radio acoustic ranging using launches for station ships. The original model from the GUIDE was also tested and proved to be slightly more sensitive. Both were tested in comparison with a carbon button hydrophone, which was much more sensitive than either magnetophone. This, however, soon showed its inferiority when the distance between the LYDONIA and ECHO necessitated more amplification. The carbon noises in the hydrophone then became greater than the bomb signal while the magnetophones would still give good returns.

With the troubles of leakage through the brass castings, it was natural that several different methods were proposed to make something better, and on the LYDONIA, Engineers S.N. Davis, now Chief Engineer of the Ship EXPLORER, and J.W. Smith, designed and built magnetophones from 6-inch tobin bronze shafting. A hollow cup was turned in the shafting, leaving the metal 3/8 inch tick. The speaker unit was inserted from the front, attached to a collar, so that the air could go through the center to the speaker unit as in the Dorsey type. The front was then closed with a phosphor bronze diaphragm 0.028 inch thick, white lead being used on the edge and the diaphragm clamped in place with a large circular nut. The designers stated that two days were required to make the magnetophone and that the material cost about $15.00. (Figures 4 and 5).

Several of this type were made up and used, primarily on the Ship HYDROGRAPHER, until displaced by the Dorsey type after the latter were made of rolled brass and free from leakage troubles.

It is not easy to get comparative tests of different types of hydrophones without the expenditure of considerable time, and as rivalry continues between the commanding officers of the different ships to increase the miles of hydrography per season, it becomes more and more difficult to beg time for experimental work in the field. Comparative tests were made at the laboratory, however, on four different magnetophones in March, 1936. The hydrophones were tested, one at a time, in a tank of water in a court of the Commerce Building, each in turn being placed at the same distance from an aperiodic magnetophone used as a sound producer. This was excited at the different frequencies from a beat frequency oscillator through a microvolter so that a constant in-put voltage could be maintained for all frequencies. Preliminary work was done in the daytime to make sure of the method, but because of interference from building noises the final measurements were made at night. These curves are plotted with frequencies as abscissas and decibel losses in amplifier as ordinates. This means that a high voltage amplifier, flat from 30 cycles to 50,000 cycles, was connected to the output of the magnetophone with a meter across the output of the amplifier and the amplifier gain control varied until a constant value was obtained on the output meter. A precalibration curve of this amplifier then made it possible to plot the curves in decibels, thus making a true comparative test of all four magnetophones.

A Vincent type magnetophone, shown in Figure 6, had been sent to the office from the Ship GUIDE and its curve is shown in Figure 7. The Davis type, whose curve is shown in Figure 8, had been used on the HYDROGRAPHER. Two of the Dorsey type are shown in Fig. 9 ; the full line curve shows the results of the test from one constructed in the laboratory, and the dashed line curve from one used on the LYDONIA.

It will be noticed that the West Coast type shows greater sensitivity up to 100 cycles than the East Coast type. This is considered a great advantage by the writer who belives that the really effective part of the bomb signal is just a compressional wave and that any so-called bomb frequencies are produced by reflections from surface and bottom and such frequencies as may be introduced by the receiving apparatus. It is a well known fact in acoustics that a single sound, such as a hand clap or pistol shot, made in front of a flight of steps will be reflected as a musical note of definite frequency depending upon the vertical distance between steps. Near Earnshaws Shipyard at Manila, P.I., the impulses from a gasoline engine were reflected from corrugated sheet iron buildings as distinct whistling notes. It is easy to imagine, by analogy, that reflections from surface water waves in subaqueous acoustics might produce different pitched notes with different lengths of swell. Evidence that the lower frequencies are more effective than the higher ones, is shown by putting a capacitance of one to four microfarads across the input of the amplifier which will cut out frequencies above about 300 and also considerable water noise, but will still give as good bomb returns as without the capacitance. For the same reason it is quite probable that the high sensitivity of the Vincent type at 1250 cycles is useless in this magnetophone.

There are two probable reasons for the high sensitivity of the West Coast type at low frequencies; first, the low natural frequency of the air cavity inside the drum of the magnetophone case and, second, the low natural frequency of the speaker unit when held by its stem.

It will be noticed that the three curves in Figures 8 and 9 have three humps of high sensitivity coming somewhere near the frequencies of 200, 800 and 1500 cycles per second. Since the same type of speaker unit is used in each, it seems probable that these humps are due to the unit itself. The much thinner diaphragm of the Davis type does not add to the sensitivity, for the Dorsey type has a thicker diaphragm but larger area which probably produces the greater sensitivity. Since sounds readily go through the steel hull of a ship, the writer believes that the thickness of the diaphragm has little to do with the sensitivity.

In the case of all radio acoustic ranging apparatus, as well as in echo sounding, experimental work is being continued in an effort to achieve still better results. Captain F.H. Hardy, Commanding Officer of the Ship GUIDE, on which Senior Chief Radio Operator Vincent is serving, describes, in a letter dated August 2, 1938, the latest types of Vincent magnetophones. They are illustrated in Figure 10, and described as follows :

— A —

A bakelite container, cylindrical in form, has the following outside measurements :

Diameter	3"
Length	4"
Thickness of cylinder	3/16"
Thickness of end	1/4"
Thickness of cap.................	1/4"

This container accommodates both the Alnico (aluminium-nickel-cobalt) speaker and the small telephone sound powered units. The seal consists of 5/8" rubber compressed by four 1/4" - 20 machine screws.

— B —

The standard type of aluminum magnetophone container developed by this vessel in 1927 is shown at B. This type is being used with good results for shore station installation. It has sufficient buoyancy to remain suspended in the water without the use of supplemental buoys. Its dimensions are as follows :

Diameter	8-1/4"
Length	5"
Thickness of cylinder	3/16"
Thickness of diaphragm	1/4"
Thickness of end	1/4"
Diameter of opening	4"
Length of collar	1-1/4"

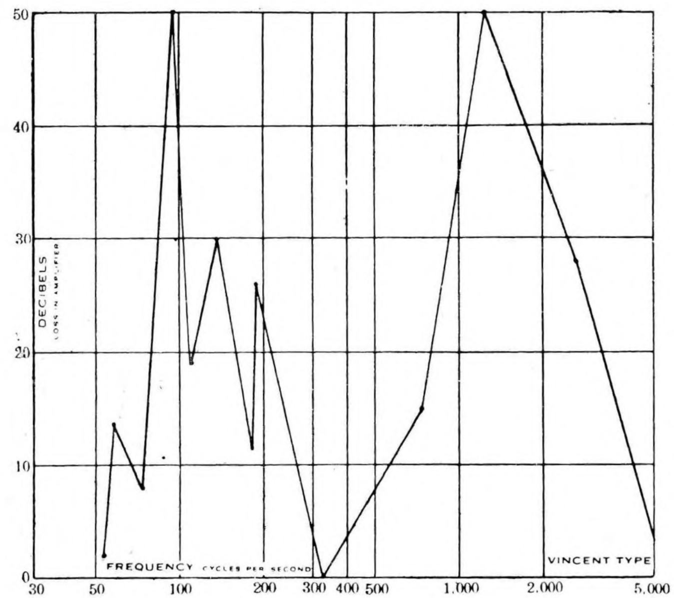

DECIBELS
LOSS IN AMPLIFIER
FREQUENCY CYCLES PER SECOND
VINCENT TYPE

Fig. 7

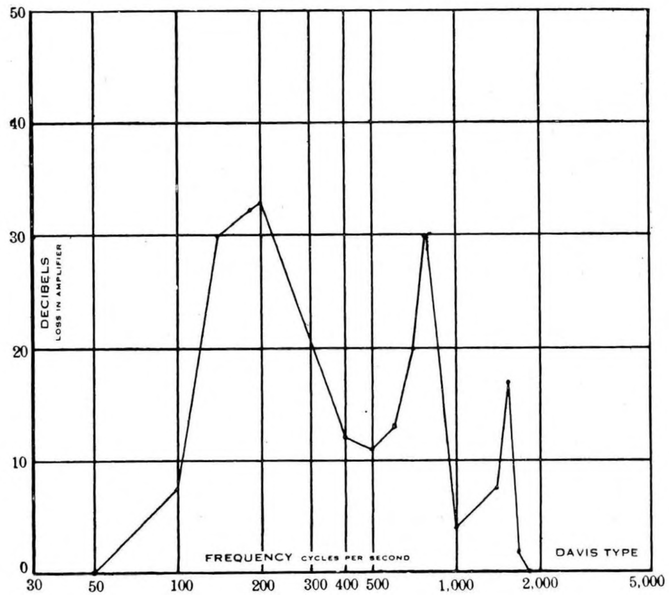
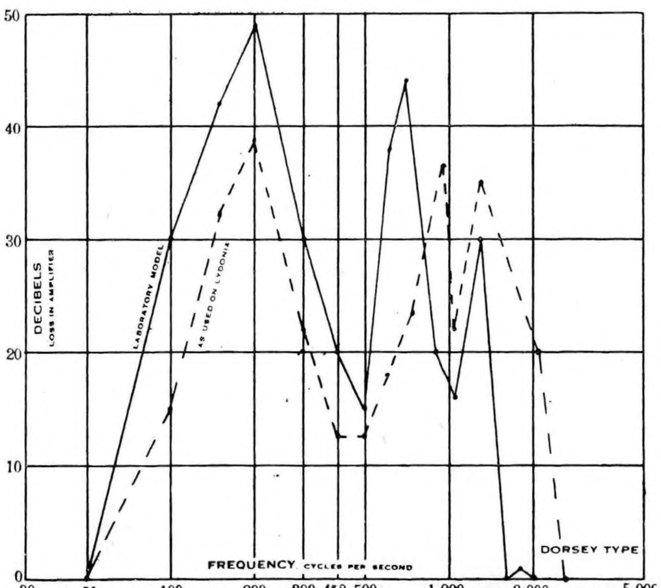

DECIBELS
LOSS IN AMPLIFIER
FREQUENCY CYCLES PER SECOND
DAVIS TYPE

Fig. 8


DECIBELS
LOSS IN AMPLIFIER
LABORATORY MODEL
AS USED ON LYDONIA
FREQUENCY CYCLES PER SECOND
DORSEY TYPE

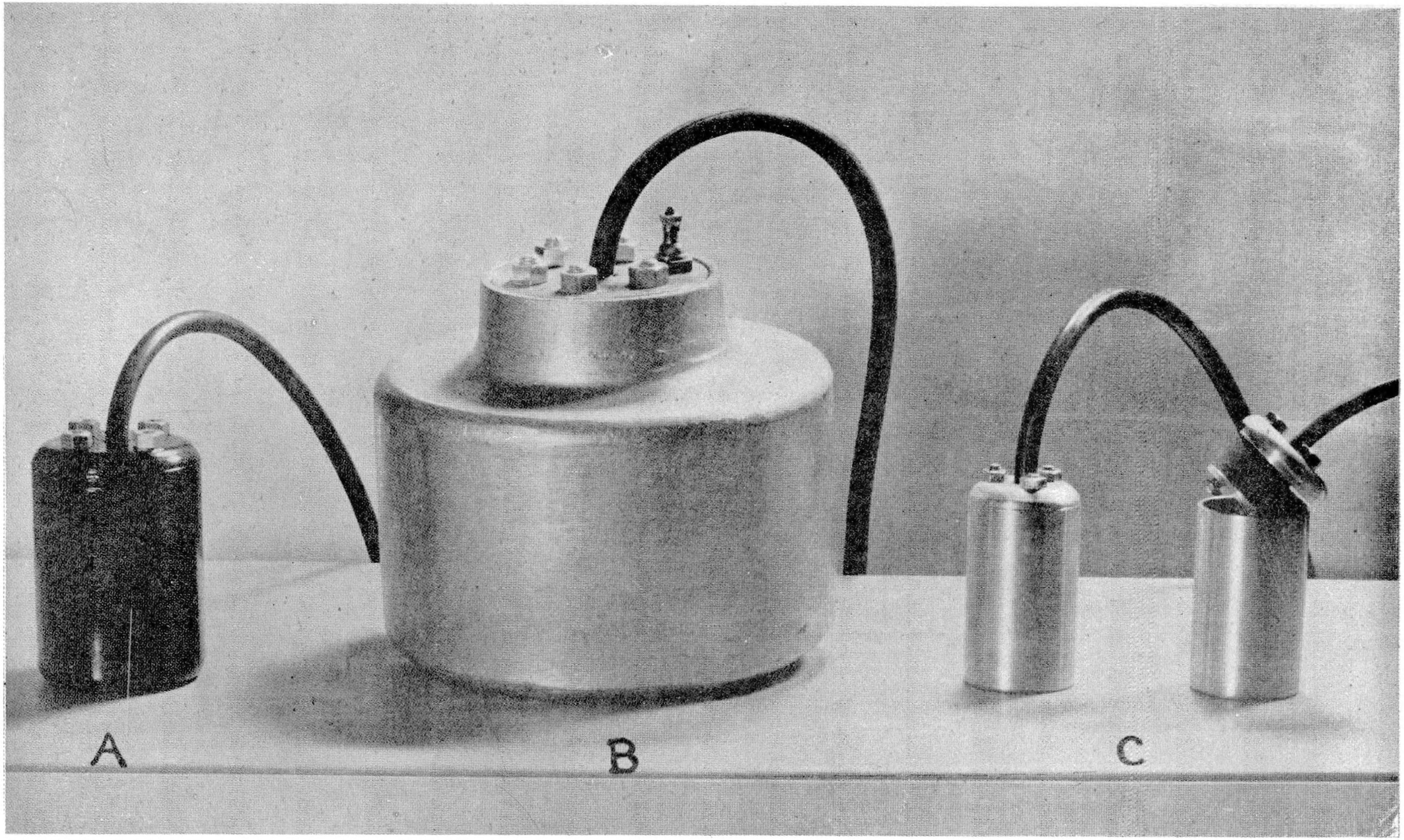


Fig. 10

The inside of the cover is grooved with deep threads to give additional friction to the rubber seal. This container will accommodate all types of magnetic as well as Rochelle salt units. A tire valve is provided for the purpose of introducing air pressure to equalize the water pressure outside the container. This is necessary because of the light construction of the container.

— C —

Open and closed views of a small container being used in connection with sono-radio buoys are shown. Its dimensions are as follows:

Diameter	1-7/8'
Length	3-1/2'
Thickness of cylinder	1/8"
Thickness of cap and end	1/4"

This container accommodates only the small telephone sound powered units and the small crystal vibration pickups. It has been made up in steel, bakelite and aluminum, and bored out of solid rod rather than made from tubing. This makes a much stronger construction. The aluminum containers have been submerged to 150 fathoms without collapsing, while the steel ones are practically unbreakable. The latter have been subjected to 6,600 pounds per square inch external pressure without failure.

Attention is particularly directed to the improved type of seal cap used on the containers in A and C. It will be noted that the cap is provided with a flange which prevents the seal from being forced inward by water pressure. This type of cap permits the use of soft gum rubber for a seal. This improvement is of most value for hydrophone installation in deep water.

The average sensitivity of the small hydrophones is greater than the large ones, B, except at the diaphragm resonance frequency which is above the bomb frequency range and is of little value. The compactness of the former is such that it permits a simplified installation for sono-radio buoy work and allows a wide depth range.

Commander O.W. Swainson, former Commanding Officer of the Ship *Pioneer,* has suggested that "B" could be much easier handled and secured for operation if it had a handle or lug attached to the side or cylindrical part. Many different hydrophones were built on the *Pioneer,* under his command, one type being built of boiler plate, 1/4 inch thick, and about 2 feet in diameter, the cylinder being 8 or 10 inches long. The same type of speaker unit was used and the sensitivity seemed about the same as the Vincent type. I believe careful comparative measurements might show a greater sensitivity for the larger area of diaphragm.

The Dorsey and Davis types of magnetophones were developed on East Coast vessels and continue in use on this and the Gulf Coasts. Those of the Vincent type are preferred on the West Coast. When the latter types have been used on the East Coast the feeling seems to be that bomb signal has been unduly prolonged. One disadvantage is that if roughly handled, while the unit is in place, the unit may be broken loose while the East Coast type has no such disadvantage.

Taken altogether, all of these magnetophones have given excellent results and will continue to do so and operators on each coast will probably use the type with which they believe they can get the best results.

THE BASTIEN POSITION CALCULATOR

(*Reproduced from the « Revue Scientifique » N° 11, November* 1939)
(Translated from the French)

The Bastien Position Calculator, of which the most recent and perfected design has been constructed by the firm of H. Morin in Paris, is essentially an apparatus designed to solve without calculation the spherical triangle in the cases usually encountered in navigation.

All classical systems of spherical coordinates define the position of a point by the angles which its radius makes with two well defined diametral planes. If