THE SONO-RADIO BUOY

by

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Foreword by Commanding Officer of Ship *Hydrographer :*

Radio Acoustic Ranging as a method of determining the position of a surveying vessel was first used successfully by the U.S. Coast and Geodetic Survey on the Pacific Coast of the United States in 1924. R.A.R. stations on the west coast have always been shore stations. When its use was attempted on the east coast difficulties were encountered in obtaining results with shore stations and in order to overcome these difficulties mobile offshore stations were used by having the R.A.R. equipment on surveying vessels or large launches anchored well offshore. This method brought satisfactory results but, of course, at an increased cost.

The advantage of automatic radio buoys to replace the station ships became apparent in 1931 during the first season's survey on Georges Bank when Radio Acoustic Ranging with floating hydrophone stations was successfully accomplished, as had been predicted from results of experiments made by the *Lydonia* and Launch *Echo* in September, 1929. Actual work on the circuits for the buoy was started in the winter of 1932 and 33 during which it was demonstrated that dry batteries could be used to furnish the power. An experimental unit operated for 57 days without change of batteries. This work was stopped for the development of the Dorsey Fathometer but resumed again in July, 1935 and continued intensively during the fall and winter, culminating in the first official report of operation at sea from the *Lydonia* on June 13, 1936.

Several automatic buoys were made available to the party on the *Hydrographer* during the 1936 field season. These were tested thoroughly and used successfully on the Louisiana Coast Project. The development proceeded so satisfactorily that by the latter part of the season it was possible to dispense with one of the station launches. Only one launch will be needed during the 1937 season. While there are a few minor difficulties to be overcome I believe that after next season station launches can be replaced entirely by Sono-Radio Buoys for the off-shore surveys on the Gulf Coast. The advantages, in decreasing the risk to personnel on the launches and in reducing the cost of off-shore surveys are apparent.

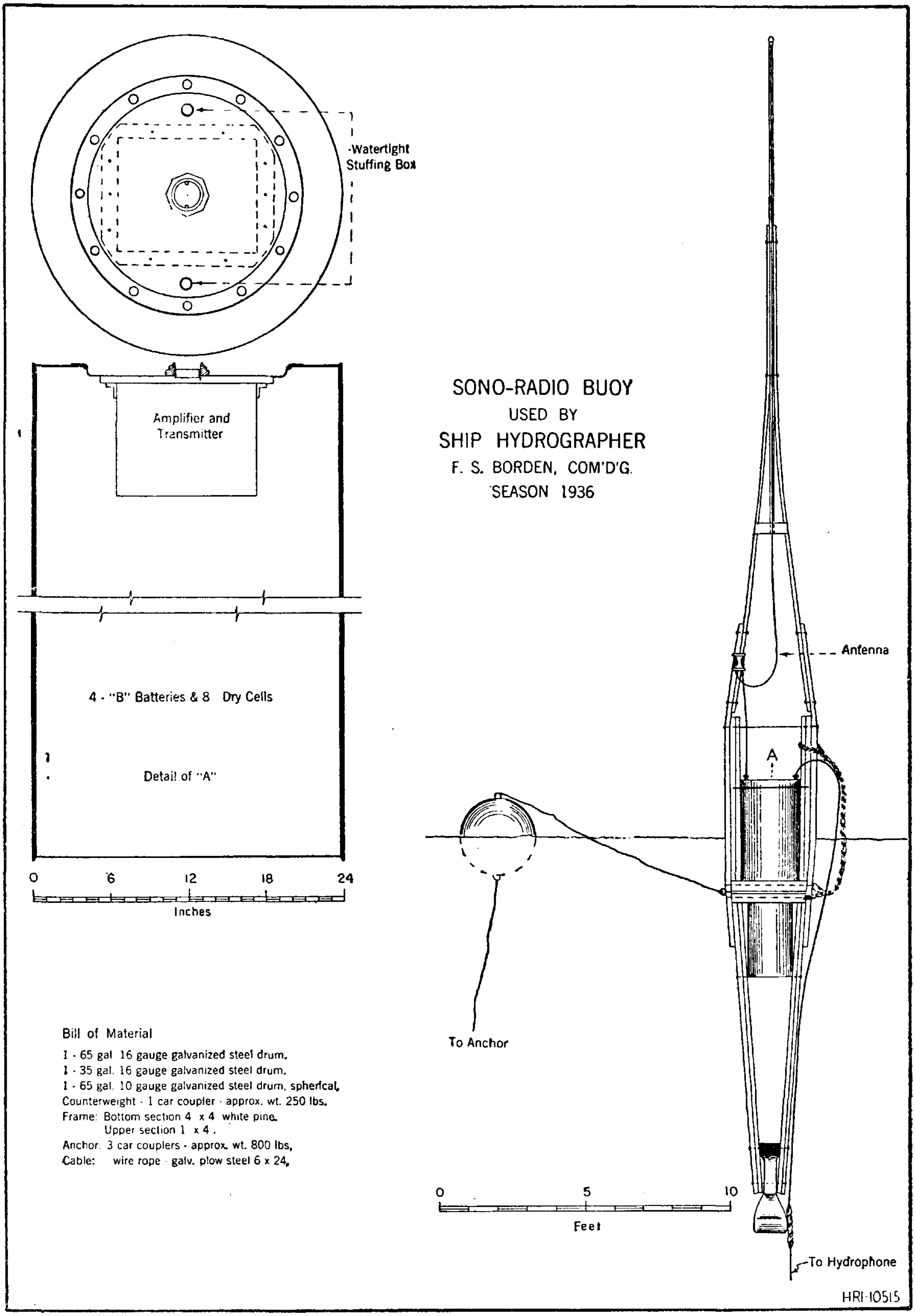
The development of the Sono-Radio Buoy was in charge of Dr. Herbert GROVE DORSEY assisted by Mr. Thomas J. HICKLEY, Assistant Electrical Engineer, and Dr. C. G. Mc ILWRAITH, Senior Electrical Engineer. The results of one of the tests made on the accuracy of Sono-Radio Buoys are given at the end of the article by Dr. McILWRAITH.

F.S. BORDEN, Commanding Ship *Hydrographer.*

A Sono-Radio Buoy (abbreviated " SRB ") consists of a floating structure which supports the RAR equipment. The buoy itself is similar to the ordinary hydrographic buoy except that it is somewhat larger and of heavier construction. The electrical gear designed and built in the Washington Office, is contained in a 65 gallon steel drum with a removable head. This drum is a standard type used for shipping semi-fluid substances, and costs only $ 5.00 complete. The head, pressed from the same material as the drum, is secured with 12 1/4 inch cap screws and is made water-tight by a tubular rubber gasket. A 35 gallon drum is secured in the frame below the larger drum to provide additional buoyancy. The frame is made of 2" × 4" lumber, doubled, and extends 14 feet below the water line. A superstructure of 1" × 4" lumber is carried to a height of 23 feet above the water line. A large car coupler is bolted to the bottom of the frame as a counter weight.

The R.A.R. equipment of the buoy consists of a hydrophone, amplifier, radio transmitter, antenna, and the necessary batteries.

The hydrophone is one designed and built in the office. It uses a small Baldwin unit and the outer diaphragm is sufficiently heavy to obviate the use of internal air pressure.


Watertight
Stuffing Box
Amplifier and
Transmitter
4 - "B" Batteries & 8 Dry Cells
Detail of "A"
0 6 12 18 24
Inches
SONO-RADIO BUOY
USED BY
SHIP HYDROGRAPHER
F. S. BORDEN, COM'D'G.
SEASON 1936
Antenna
A
To Anchor
0 5 10
Feet
To Hydrophone
Bill of Material
1 - 65 gal 16 gauge galvanized steel drum.
1 - 35 gal. 16 gauge galvanized steel drum.
1 - 65 gal. 10 gauge galvanized steel drum, spherical.
Counterweight - 1 car coupler - approx. wt. 250 lbs.
Frame: Bottom section 4 x 4 white pine.
Upper section 1 x 4 .
Anchor: 3 car couplers - approx. wt. 800 lbs.
Cable: wire rope galv. plow steel 6 x 24.
HRI-10515

It is suspended at a depth of 10 fathoms and is connected to the amplifier by Tyrex cable.

The amplifier uses two type 32 and one type 30 tubes. Its voltage gain is between 95 and 100 decibels and it is tuned so that the gain is a maximum at a frequency of 100 cycles per second and falls off rapidly with increasing frequency, being only 47 decibels at 500 cycles per second. This is quite different from the R.A.R. amplifier ordinarily used, which has rather uniform gain from 200 to 1500 cycles per second.

The transmitter consists of a type 33 tube in a crystal controlled circuit. A type 30 tube, used as a keying tube, controls the operation of the transmitter by varying the voltage applied to the screen grid of the 33 tube. The type 30 keying tube takes the place of the thyratron or relay generally used. It permits the type 33 tube to oscillate only so long as the output of the voltage amplifier is above a definite level, determined by the bias on the keying tube. Hence, the SRB gives a return as long as the sound of the bomb at the hydrophone. This is rather a nuisance when two SRB's are at about the same distance. A change in the keying circuit can be made which will make the return uniformly short for any duration of sound, and such a change may be desirable in the future.

The antenna is a 19 foot piece of 3/8" copper tube, supported on the superstructure by small stand-off insulators. Its lower end is 3 feet above the water line, and connects to a tuning unit enclosed in a shield of pipe fittings. The antenna is fed by a low impedance transmission line (Tyrex cable) from the transmitter. This arrangement is necessary because waves, washing over the top of the drum, would detune an antenna fed directly from the transmitter.

The amplifier and transmitter are enclosed in a bakelite box 11" × 9" × 8" which is bolted to the under side of the head of the drum. An opening, about 2" in diameter, closed by a screw plug, gives access to the controls, which permits the apparatus to be turned on or off, or tuned, without removing the head of the drum.

The batteries used include a special 3 volt dry battery for filaments, four 45 volt heavy duty B batteries, four dry cells, and two 22-1/2 volt C batteries. The C batteries are contained in the bakelite box, the others are packed in the bottom of the drum. A can of calcium chloride is used to absorb excess moisture.

The complete buoy weighs about 500 pounds, and while its great length makes it rather clumsy, it has been handled with the ship's gear without difficulty.

The hydrophone is suspended by Manila line directly under the SRB. No difficulty, while setting out the SRB, has been encountered keeping the hydrophone from fouling the moorings, and in no case has a hydrophone ever fouled after the SRB was planted.

The anchor used was made of four car couplers secured together. (Note : Scrap car couplers are used for anchor and counterweight, the average weight of a coupler being about 200 pounds). The anchor line was made from both chain and wire rope. The weight of the moorings was carried by a relieving buoy and the SRB floated at the end of a four fathom bridle. Some ingenuity was required to make the connection to the relieving buoy quiet since in the rattling of the moorings was discovered a fertile source of stray returns. No attempt was made to use more than one anchor.

Two SRB's were anchored in depths of 60 fathoms, one with 120 and the other with 140 fathoms of chain and wire rope. In these cases two relieving buoys were used with each. The second buoy was not necessary, however, for the support of any of the weight of the moorings, but was only added as a safety precaution. The two SRB's in 60 fathoms were picked up without difficulty during moderately rough weather.

Four Sono-Radio Buoys, numbers 7 to 10 inclusive, were used during the 1936 season. One of these, number 8, was lost in a storm after but four days use. The others have survived and have given very satisfactory service. The three were used for a total of 108 buoy-days, number 7 leading with 53 days. One set of batteries was in use a total of 45 days, the others about 30 days each. In no case did the B batteries show serious loss of voltage, but in the buoys that were in use 45 days it was evident that the filament batteries were approaching the end of their useful life.

In general, it appears that at the same time and place, an SRB will give satisfactory returns from a distance about 75% of that which may be expected from a manned RAR station. This difference is not surprising, since the SRB is on all the time, and must have its sensitivity low enough that it will not be actuated by the average water noises; while the operator of an RAR station can adjust the sensitivity to the noise conditions of the moment. The longest distance from which returns were received from an SRB was 41.18 seconds (equal to about 34.2 nautical miles) with a quart bomb.

As for reliability, during this season at least, the launch RAR stations had more technical troubles than did the SRB's. Most of the difficulties with the SRB's were due to noisy tubes or imperfectly soldered connections. It must be admitted, however, that a launch RAR station which is having trouble is silent, while the commonest ailment of an SRB is the emission of a steady series of chirps, which can interfere very seriously with returns from other stations. If that occurs, the offending SRB can only be silenced by pesronal attention from the survey ship.

Measurements made in the office show that with the keying circuit used on these SRB's there is a constant lag of 0.01 second in the return. With other keying circuits the lag may be appreciable.

It is occasionally necessary to moor an SRB in a position where there is danger of its being struck by passing ships. It is suspected that such an accident may have happened to the one which was lost. To diminish that risk, experiments were made with a light on the superstructure. A small 6 volt light in a Fresnel lens was mounted on the top of the antenna frame and lighted from dry cells within the drum. A relay was arranged so as to turn on the light whenever the transmitter was actuated. Since the noise of the propellor of any ship within about a mile will actuate the SRB, an almost steady light will be shown from the buoy which should prevent the ship's collision with it. Two SRB's were equipped with such lights. It was necessary to install choke coils in the wires to the light to avoid detuning the antenna. Type Bl telephone relays were used and they worked reasonably well.

It is difficult to estimate the money saving resulting from the use of SRB's. With no real data on the cost of the units, it is estimated that the value of material and labor in each buoy would not exceed $ 150. A set of batteries costs about $ 15.00 and will probably last all season.

Against these low costs must be set the fact that an SRB can not be ordered from station to station as can a launch but must be carried to its station by an otherwise unproductive trip made by the survey ship.

Before the present season and the development of the automatic SRB, station launches have been used as R. A. R. stations and since these launches must be large enough to be anchored on exposed offshore stations, it seems reasonably certain that statistics will show that the use of SRB's substantially reduces the cost of R. A. R. operations with no sacrifice in accuracy of control.

SONO-RADIO BUOY

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This new type of buoy was first tested in actual field work in 1936 on the Atlantic and Gulf Coasts. It was hoped that their performance would be so successful that sono-radio buoys could replace station ships for R. A. R. work at a considerable saving in cost of operation, and would eliminate the necessity of such dangerous assignments for the smaller vessels of the service.

The buoy as now constructed on the Ship *Lydonia* is similar to a two drum survey buoy, minus the target. The purpose of the lower drum is to furnish buoyancy only, the upper one containing the radio parts. An antenna coupler in a capped water-tight pipe is located on the buoy frame just above the drum and this is connected to an eighteen foot copper tube antenna mounted on insulators on the buoy upright. The same type of hydrophone used on the Atlantic Coast station ships was used with the buoy. It was mounted, however, on a triangular frame with rubber suspension and secured to the buoy anchor cable about 30 feet down from the buoy itself.

A counter weight of two car-couplers was necessary to keep the buoy upright. This increased the weight of the sono-radio buoy to approximately 750 pounds, about all that the *Lydonia's* boom could safely handle. The buoy was anchored with the usual survey-buoy ground tackle.