UNCLASSIFIED CONFIDENTIAL SECRET UNCLASSIFIED - per ltr. from 1240-474:GLB:lm dtd. 14 Dec 78

UNCLASSIFIED

NRL Report 5075
Copy No. 60

# A TOWABLE ELECTRONIC COMMUNICATIONS BUOY

[UNCLASSIFIED TITLE]

K. L. Leidy and H. D. Cubbage

Communications Branch
Radio Division

UNCLASSIFIED CONFIDENTIAL

January 24, 1958

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

Further distribution of this report, or of an abstract, or reproduction thereof may be made only with the approval of the Director, Naval Research Laboratory, Washington 25, D. C., or of the activity sponsoring the research reported therein, as appropriate.

UNCLASSIFIED CONFIDENTIAL

NAVAL RESEARCH LABORATORY
Washington, D.C.

UNCLASSIFIED CONFIDENTIAL

SECRET
DOWNGRADED AT 12-YEAR INTERVALS
NOT AUTOMATICALLY DECLASSIFIED
DOD DIR 5200.10

SECURITY

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794. The transmission or revelation of its contents in any manner to an unauthorized person is prohibited by law.

Reproduction of this document in whole or in part is prohibited except with permission of the issuing office.

ABSTRACT
[Confidential]

An experimental towable electronic communications buoy is described which provides a means for a submerged submarine to communicate with surface craft, aircraft, and other submerged submarines. A size No. 5 OROPESA type minesweeping float is used as a basic vehicle and modified to mount various antennas and their associated equipment. The buoy has been installed and tested on the USS BLENNY using HF, UHF, and IFF antennas. Satisfactory communications were established from sea to sea and sea to air, and the buoy displayed desirable hydrodynamic properties.

PROBLEM STATUS

This is an interim report; work is continuing.

AUTHORIZATION

NRL Problem R01-15
Project NE 021-500
BuShips No. S-1812

Manuscript submitted November 25, 1957

# A TOWABLE ELECTRONIC COMMUNICATIONS BUOY
[Unclassified Title]

## INTRODUCTION

There has been a long-standing requirement for a means of communication between a deeply submerged submarine (e.g., on sonar patrol) and surface vessels or aircraft. As a solution to this problem, an experimental towable buoy was devised by NRL which enables a submarine to utilize a variety of equipments and to transmit and receive on several bands of frequencies while submerged.

## DESCRIPTION OF EQUIPMENT

The system consists of the buoy with its associated antennas and other equipment, and a length of RG-18/U cable as shown in Figs. 1 and 2. The RG-18/U is an armored coaxial cable which has high tensile strength (8000 lb) and low rf losses, and which serves the dual purpose of towing and feeding electrical energy to the buoy. The RG-18/U is secured to the buoy and to the submarine with Kellem's grips, one of which can be seen in Figs. 1 and 3. The submarine end of the cable is secured with a Kellem's grip to the rear of the sail (Fig. 4) and the cable enters the submarine through a UG-640/U or similar pressure hull fitting. Inside the submarine, it may be connected directly to a transmitter-receiver combination or to a system of multicouplers if more than one frequency is to be used simultaneously.

### Buoy

The design approach thus far has been to keep the added weight and complications of the buoy to a minimum, and as far as possible, to keep the circuitry inside the submarine, leaving the buoy to act as a hydrodynamically stable platform for the antennas. The buoy is a size No. 5 OROPESA type minesweeping float modified to mount an antenna mast on top of the buoy and a UG-640/U hull fitting on the bottom. The buoy is 5-1/2 feet long, 16 inches in diameter, and weighs about 75 lb. The relatively light weight makes it easy to handle and its streamlined shape is advantageous for bracing to withstand the water pressures at great depths.

Both the UG-640/U and the antenna mast are pressure sealed with O-rings. The buoy used during the BLENNY tests was not capable of withstanding great pressures. However, with appropriate modifications, it is expected that the existing buoy can be made serviceable at operating depths. Preliminary efforts based on earlier pressure tests indicate that by adding steel internal bracing rings of 3/8 by 1/2 in. cross section, spaced 4 to 5 in. apart, pressure capability can be increased to something in excess of 200 pounds per square inch, which corresponds to approximately 400 ft in depth.

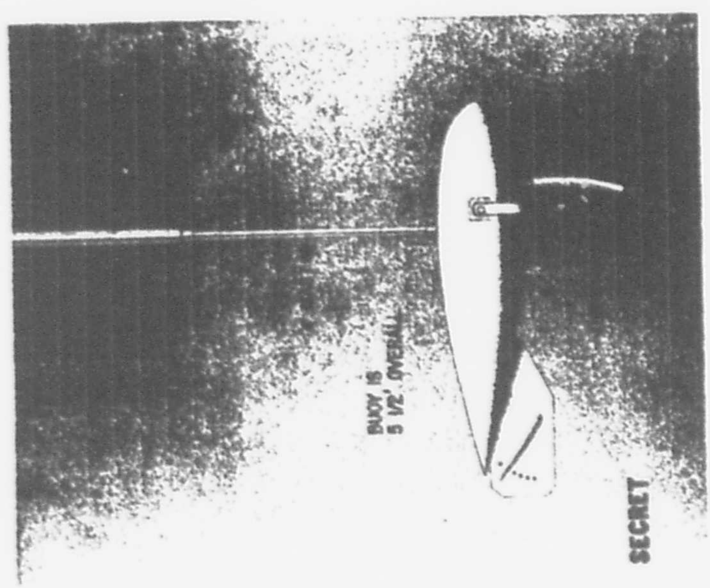


Fig. 1 - Buoy, antenna, and cable connections

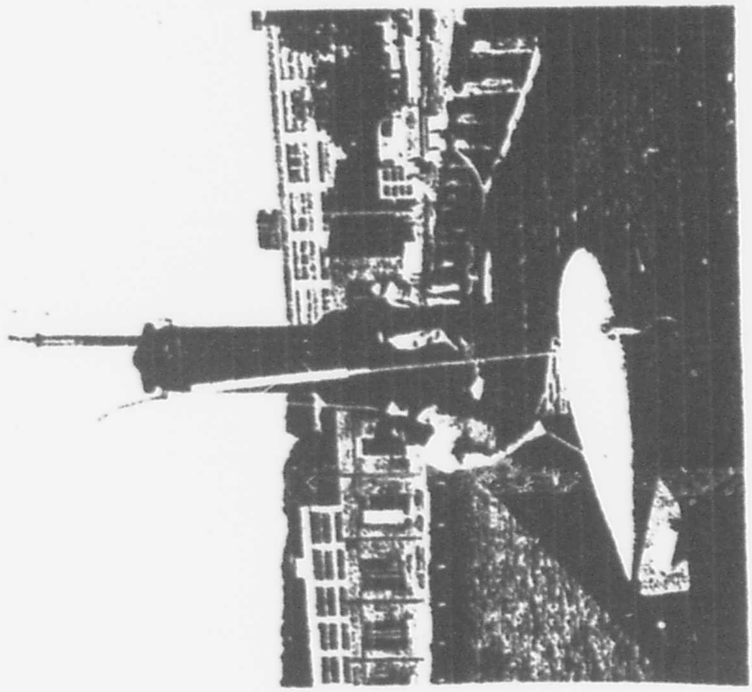

Fig. 2 - Assembled buoy with UHF-IFF antenna mounted

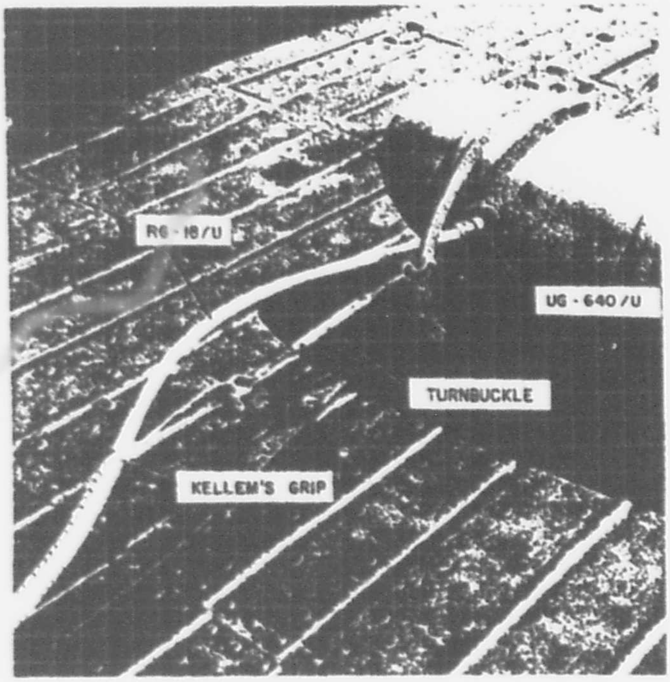


Fig. 3 - Buoy on deck of submarine, showing UG-640/U, RG-18/U, turnbuckle, and Kellem's grip

The buoy was subjected to dynamic towing tests at the David Taylor Model Basin. From the data obtained in these tests, Fig. 5 was plotted, giving the depth of towpoint necessary for a given length of cable at a given speed. In operational use, it is envisioned that a reel would be provided to release and retrieve the buoy and cable. A family of similar curves could be prepared which would allow the submarine's commander to determine the correct cable length for a given depth and speed. The proper amount of cable could then be released from the reel. The curves are intended as a lower boundary, and are taken with the buoy just under the surface of the water. The depth and speed are not critical. If the speed or depth decreases, the buoy will simply ride higher in the water. The maximum tension in the cable at 6 knots was 250 lb, according to the David Taylor Model Basin tests. This allows a safety factor of over 30 for the towing cable. It is felt that this is sufficient to allow for any ordinary conditions of use.

Antennas

Two types of antennas have been used, a high-frequency whip and a combination UHF-IFF antenna.* The whip (Figs. 6 and 7) is inductance-loaded and can be used with existing HF transmitters over a wide band of frequencies

---

*UHF band — 220 to 400 Mc
IFF band — 1000 to 1100 Mc

 

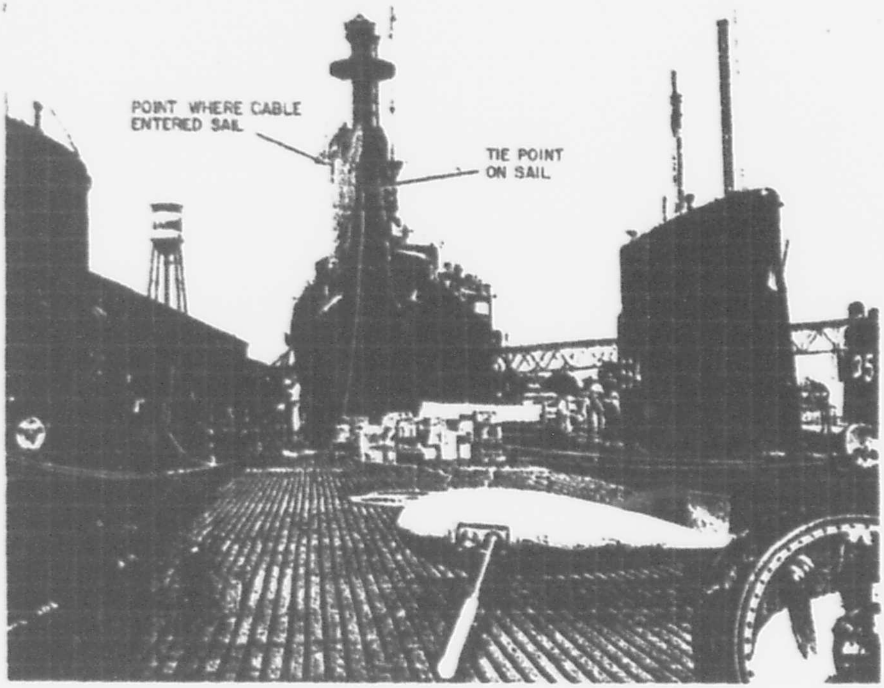


Fig. 4 - Buoy on deck, showing tie point on sail and point of entry on sail

(about 3 to 30 Mc). If maximum efficiency is desired, the whip should be used in its design range. It can be designed to be tunable over any 1-Mc band from approximately 6 to 15 Mc. It should be noted that an extra benefit derived is the fact that either the whip or the UHF-IFF antenna can be used as a receiving antenna on any frequency and with any receiver. Either antenna has certain bands of frequencies on which it is more efficient. However, when the antenna is used for receiving, impedance matching is not as critical as when it is used for transmitting. For example, loran fixes could be obtained in strong-signal areas.

The UHF-IFF antenna (Figs. 2, 4, and 8) is essentially two isolated dipoles which may be used simultaneously with proper multicouplers provided in the submarine. The IFF antenna is a center-fed dipole, 5-3/4 in. long, resonant at 1030 Mc, the IFF transmitter frequency. It has less than 1.5 to 1 SWR* relative to 50 ohms from 1000 to 1100 Mc. It is isolated from the UHF dipole by the quarter-wave sections shown in Fig. 8, which are resonant at 1030 Mc and consequently appear as an open circuit at that frequency. Due to the small L/D ratio of the dipole (approximately 12), its resistance is not the theoretical 72 ohms of a dipole, but is actually very close to 50 ohms. Consequently, 50-ohm coaxial line is used to feed the antenna.

---

* Standing-wave ratio

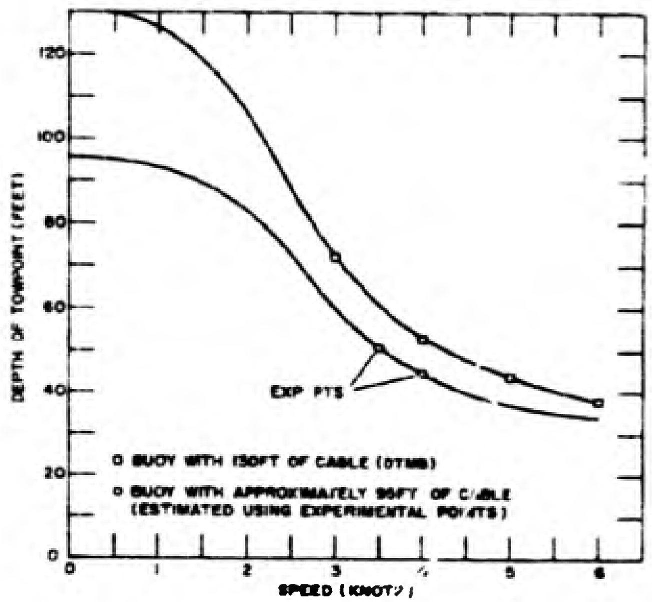


Fig. 5 - Maximum allowable depth of towpoint vs speed required to maintain the NRL electronic buoy at the water surface

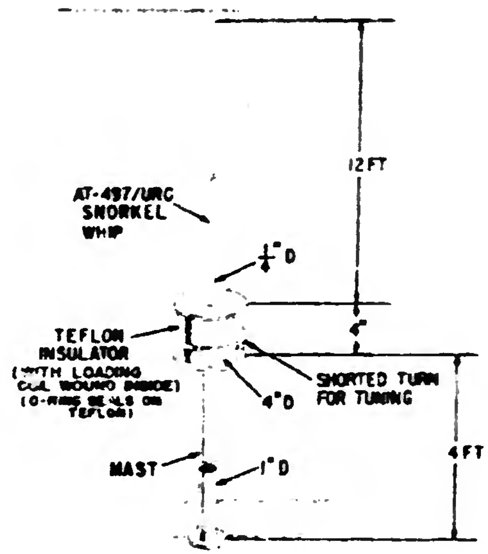


Fig. 6 - HF whip antenna

SECRET

UNCLASSIFIED

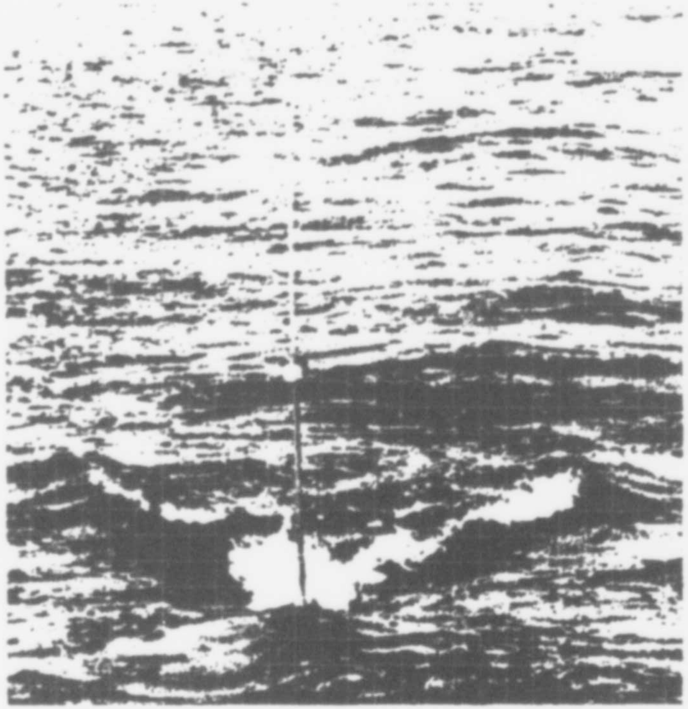

Fig. 7 - Buoy with HF whip mounted, being towed at 6 knots

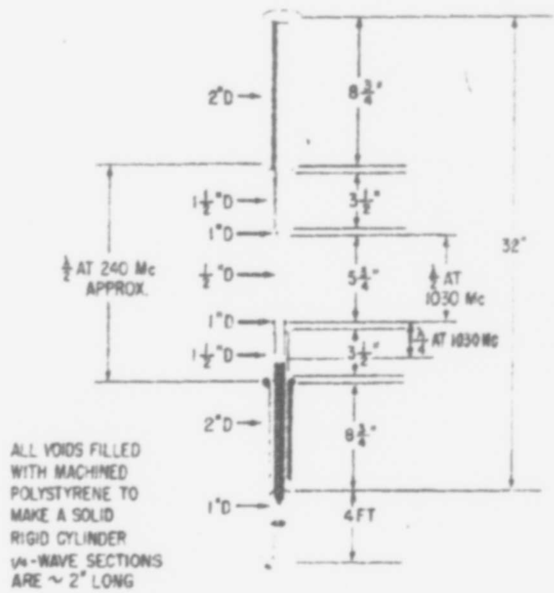




Fig. 8 - UHF-IFF antenna

At UHF, the IFF quarter-wave sections appear as added inductance and shorten the length of conductor necessary for resonance. The 2-in.-diameter end sections act as quarter-wave sections to the UHF at approximately 240 Mc. The 1-1/2-in. sections on the UHF dipole decrease its length/diameter ratio and effectively lengthen the dipole. By balancing the two factors of the length of the 1-1/2-in. sections and the length of the 2-in. end sections, the UHF SWR can be made 3 to 1 or better over the band of 220 to 400 Mc.

The coaxial cable feeding the two dipoles is brought up through the lower section of the antenna, the lower half being grounded and the upper half connected to the inner conductor. A transforming section of 95-ohm line (approximately 8 in. in length - not shown in Fig. 8) is inserted between the feed point and the 50-ohm line. This section is equal to one wave length at 1030 Mc and does not affect the IFF performance

The UHF-IFF antenna has machined polystyrene inserted in all voids and an outer section of 2-in. diameter which bridges the gap between the top and bottom sections of the dipole. The plastic is then glued together, using Polyweld thinner, which actually welds the separate pieces together, making a strong solid antenna which is effectively encased in plastic. This enables it to withstand great water pressures without crushing. Two layers of Teflon tape (15-mil thickness) are then wrapped on the antenna to decrease the danger of water seepage and to add further strength. If extreme conditions of pressure must be met, the antenna may be coated with an outer layer of fiberglass or similar material. On the basis of previous earlier tests, an antenna treated in this manner may be expected to withstand greater than 600 psi.

Figure 9 is a plot of relative field strength of the UHF antenna at 302 Mc and a range of 35 miles, calculated by the method given in NRL Report 4321.* As can be seen from the graph, the buoy antenna gives good coverage over all angles from about 0 to 80 deg, with the critical null occurring at about 0 deg. This effectively limits the possible range for low-flying aircraft and surface vessels using present equipments and available power.

Figure 10 is a plot of the estimated extremes of communication ranges with the buoy antenna, using the TED transmitter, with about 25-watt output on voice at 302 Mc. This plot includes the two experimental points taken during the BLENNY tests, 1000 ft at 28 miles, and 2000 ft at 35 miles. The radio line-of-sight distances are plotted for purposes of comparison.

## FIELD TESTS

During the initial phases of the submarine communication problem, a cylindrical buoy was used as a platform to mount a whip antenna. This buoy and antenna were tested aboard the USS SEA LION using a TBL-12 transmitter and a frequency of 8190 kc. The aircraft taking part in the test was an R4D using an ART-13 transmitter. Both the TBL-12 and the ART-13 have approximately 50-watt output on voice. During the test, the submarine's depth varied from 100 to 132 ft. With the plane's altitude varying between 500 and 1000 ft, reliable

---

*E. Toth, "Theoretical Range Capability of an Amplitude-Modulated UHF Radio-Telephone System," NRL Report 4321 (Confidential), March 1954

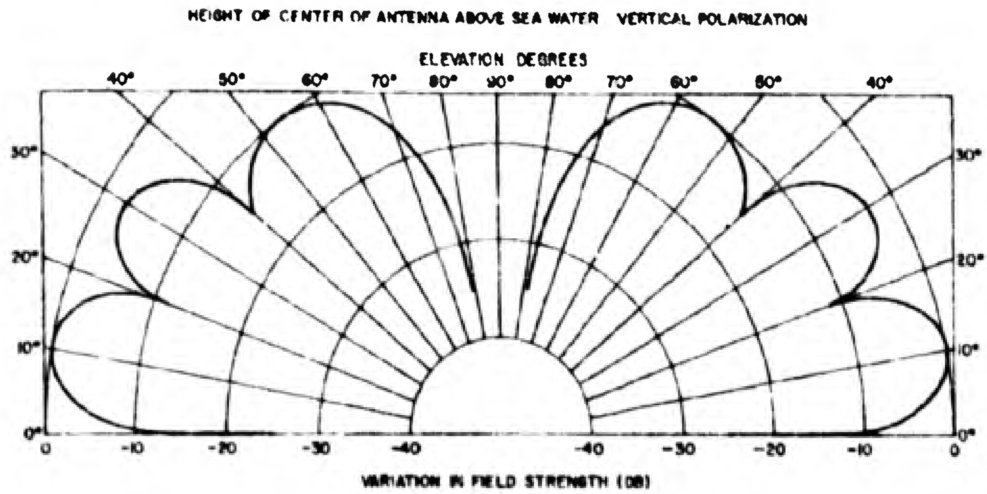


Fig. 9 - Relative field strength at 35 miles with 25-watt output at 302.06 Mc (assuming a 25-db average curve as given in NRL Report 4321)

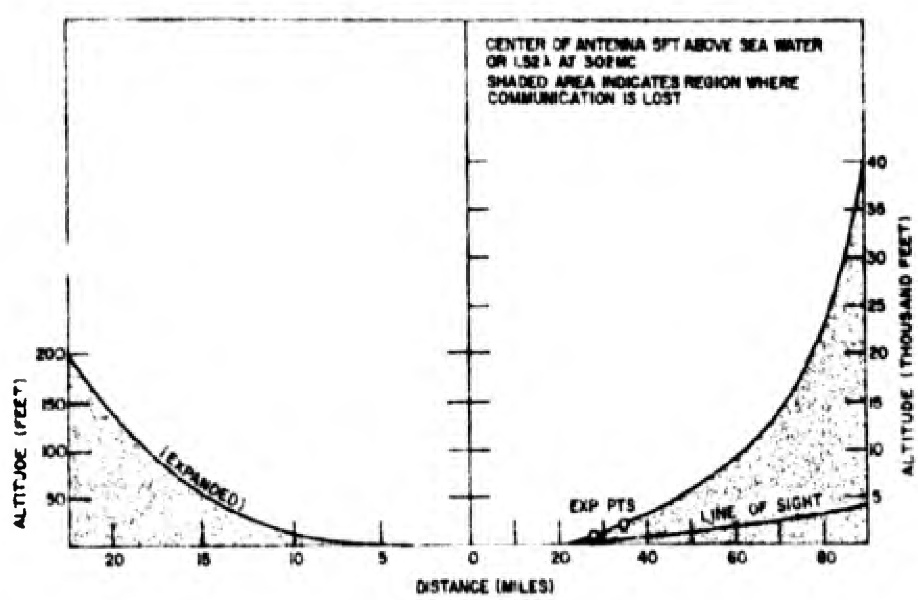


Fig. 10 - Estimated extremes of range with buoy UHF antenna, using TED transmitter of approximately 25-watt output. (A 25-db average curve is assumed as given in NRL Report 4321.)

communications were established out to approximately 100 miles. While performance was satisfactory from a communications point of view, the fact that the buoy could not be towed was a great handicap. Accordingly, a size No. 5 OROPESA type minesweeping float was obtained and the antenna and its matching network mounted on it. Unfortunately, the modifications were so extensive that the buoy became hydrodynamically unstable. A redesign of the antenna and matching network was then undertaken to minimize the modifications necessary to the buoy. Another buoy was modified using the new design. After this buoy was tested at the Model Basin and found satisfactory, it was installed on the USS BLENNY at New London, Conn.

For this installation, the RG-18/U cable tie point was approximately 4 ft below the top of the sail and the cable was then fed through the side of the sail near the port whip of the submarine (Fig. 4). Several feet of slack were left between the tie point and the point where the cable entered the sail to allow for motion of the cable when the submarine submerged and actually towed the buoy. The cable was then fed down through the sail (taking care to maintain clearance for the masts, periscopes, etc.) and inserted through the hull fitting of the emergency antenna (which was not used during the test) into the radio room. It was then connected to the submarine's quick disconnect board. By having three cables with the proper fittings and quick disconnects, it was possible to change quickly from one equipment to another.

Tests were then run at sea with speeds up to 8 knots and depths to 110 feet. During the tests, while the BLENNY was at operating depth, the USS BARRACUDA followed a parallel course approximately 200 yards distant and observed the buoy's stability of operation in the water. Only the mast could be seen when operating at the proper depth and speed, and very little pitch and roll were noticed. The sea state varied from 1 to 2. A slight rake aft of the mast of about 10 deg was observed while under way. If necessary, this could be eliminated by canting the mast forward 10 deg with respect to the buoy. However, this small amount of rake has very little effect on the communication range of the buoy.

Regarding the visibility of the buoy from the air, the observers on the BARRACUDA were of the opinion that the amount of wake left by the mast was comparable to that of an attack periscope.

By using the TBL-12 transmitter and HF whip on a frequency of 12.723 Mc, contact was made with a P2V aircraft which was assisting in the exercise. The plane was directed to head east toward Block Island. After it flew approximately 40 miles with no apparent weakening of signal strength, a decision was made to recall the plane in the interests of time.

While the plane was returning, the submarine surfaced, the buoy was hauled on board, and the HF whip was replaced with the UHF-IFF antenna. This operation took about fifteen minutes. The submarine again submerged and contact was made with the plane using the buoy antenna. The plane then headed approximately south, keeping open water between it and the submarine. An attempt was made to make IFF contact. However the plane's IFF was not operating and there were no other contacts in the vicinity. The plane then proceeded out, checking contact every two minutes. At 27 miles and 1000-ft altitude the plane orbited. The submarine's received signal had some fading, but was readable. The aircraft's received signal was loud and clear. The fading noticed by the submarine may have been due to the plane's antenna pattern. The plane's altitude was then increased to 2000 ft and sent out until the signal was barely readable. At 33 miles, the signal was still loud and clear, and at 35 miles, the plane still received loud and clear signals while the submarine's received signal was very weak, but readable. This may be partially attributed to differences between the respective transmitters and receivers.

The plane was then recalled. It was decided to submerge the antenna to test its strength and ability to withstand the strain of being towed under water. The submarine went to 110 ft keel depth at 6 knots, at which depth the buoy was completely submerged with no sign of it on the surface. The submarine then came up to 90 ft, at which time contact was again made with the plane. The plane was then directed to come in at its lowest safe altitude to try to detect the buoy from the air. There was a relatively small area in which to search since the aircraft knew the position of the BARRACUDA. The plane was flying at approximately 300 knots. The buoy was not detected on the first pass, but was found on the second. Considering this, it is expected that with proper camouflage and with no point of reference to narrow the area of search, the buoy would be very difficult to spot visually from the air. With the buoy just under the surface of the water (normal operation) and only the mast above the surface, it should be a very poor radar target as well. Therefore it is not expected that the detection problem would be too critical.

## CONCLUSIONS AND SUGGESTIONS

These tests indicate the practicability of using a towable buoy as a mobile platform for submarine communications antennas. The buoy permits a submarine to communicate on UHF, IFF, and HF while submerged at great depths. Work is now progressing on an antenna which will combine UHF, IFF, and HF antennas on a single mast. This antenna should be ready for testing in the very near future and will likely then be tested aboard a submarine to determine its operating characteristics and feasibility.

In an envisioned operational system, a reel and some type of nest or cradle would be provided on the submarine, perhaps in the sail area. This would permit the releasing and retrieving of the buoy without the necessity of surfacing. Other services which might be incorporated in the buoy are closed-circuit TV, ECM gear, Radux, and VLF antennas.

Another consideration is the use of a plastic buoy. It appears that a spun fiberglass float will be stronger for a given weight than a steel float. It also has the advantage of being nonmagnetic which would allow a VLF loop, for example, to be inserted in the walls of the buoy.

* * *

# REPRODUCTION QUALITY NOTICE

We use state-of-the-art high speed document scanning and reproduction equipment. In addition, we employ stringent quality control techniques at each stage of the scanning and reproduction process to ensure that our document reproduction is as true to the original as current scanning and reproduction technology allows. However, the following original document conditions may adversely affect Computer Output Microfiche (COM) and/or print reproduction:

- Pages smaller or larger than 8.5 inches x 11 inches.
- Pages with background color or light colored printing.
- Pages with smaller than 8 point type or poor printing.
- Pages with continuous tone material or color photographs.
- Very old material printed on poor quality or deteriorating paper.

If you are dissatisfied with the reproduction quality of any document that we provide, particularly those not exhibiting any of the above conditions, please feel free to contact our Directorate of User Services at (703) 767-9066/9068 or DSN 427-9066/9068 for refund or replacement.

# END SCANNED DOCUMENT