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BRASS II – BOTTOM REFLECTION ACTIVE SONAR SYSTEM MODEL II

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CONTENTS

THE PROBLEM There is a need for the development of a reliable submarine echo-ranging system capable of actively locating targets at ranges in excess of 20,000 yards. The BRASS II system represents the second, or full-scale, phase of the experimental program aimed at fulfilling this requirement.

FINDINGS The results of the tests conducted in the latter part of 1959 reveal that bottom-bounce echo ranging in the deep ocean can indeed be accomplished at ranges out to and greater than 20,000 yards. Over certain areas of high bottom loss a greater figure of merit than that of the BRASS II system is required. Conversely, over areas of low bottom loss, a very high probability of detection is possible. Bottom-bounce echo ranging yields results under poor thermal conditions and on below-the-layer targets, when conventional echo ranging is impossible. A bottom-bounce echo-ranging system can have the definite capability of determining the target depth.

FUTURE PLANS Further tests will be made with the system.

ABSTRACT BRASS II utilizes a horizontally trained, vertically steered transducer which operates at 4300 cycles per second and is capable of placing in excess of 70,000 watts of acoustical power into the water. This power is equivalent to a source index level of 145 db//(1 μbar)^2 at 1 yard, on the axis of the main lobe. The transducer is driven by a transmitter which uses a hydrogen thyratron inverter as the power stage and is capable of delivering more than 100,000 watts of pulsed electrical power. The complete BRASS II system, with the exception of the motor generators, was installed on the USS BLENNY (SS 324) in April 1959.

The results of tests conducted in the latter part of 1959 are presented. These tests include echo ranging against submarine targets, measured values of bottom reflection loss for various ocean areas, and the limitations imposed by reverberation. The results reveal that bottom-bounce echo ranging represents a real break-through in the field of sonar.

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BRASS II - BOTTOM REFLECTION ACTIVE SONAR SYSTEM MODEL II

offers a long-range (20,000 yards) detection capability to completely submerged submarines.

BACKGROUND The BRASS II development program has the following objectives:

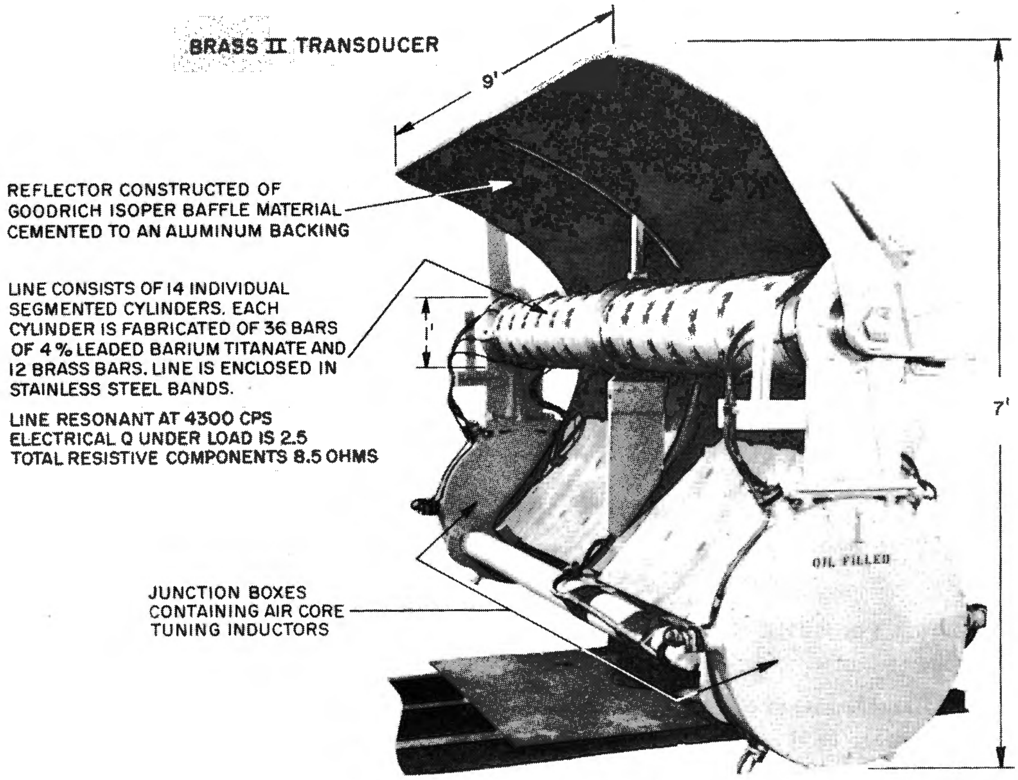
Development program has wide range objectives

- Establishment of feasibility of bottom-bounce echo ranging in the deep ocean and at ranges of 20,000 yards and beyond.
- Establishment of the particular effects of thermal conditions, sea states, and ocean-bottom characteristics on bottom-bounce echo ranging.
- Establishment of the target depth determining capability of a bottom-bounce system.
- Establishment of the effects of reverberation interference.
- Establishment of the effects of target aspect and grazing angle on target strength.
- Procurement of information and experience on the operational and tactical use of bottom-bounce echo ranging.

The system design is based on the following parameters:

Parameters

- Range: 20,000 yards
- Water Depth: Up to 3000 fathoms
- Noise Limit: Sea State 2
- Optimum Frequency: 4300 cps
- Required Source Index Level: 145 db// (1 μbar)^2 at 1 yard.



The transducer can be trained continuously in azimuth and steered vertically from 20 degrees above the horizontal to 45 degrees below the horizontal. It has a horizontal beamwidth of 6.4 degrees, a vertical beamwidth of 10.8 degrees, and a total directivity index of 25 db.

AMOS doctrine was followed in computing propagation loss.

Evolved from BRASS I

In order to gather information on the factors relating to bottom-bounce echo ranging, the experimental program was divided into two phases. In order to obtain quick but limited results, the first phase utilized existing equipments where possible and resulted in a scaled-down system known as BRASS I. This system was successful in obtaining bottom reflection data in coastal waters of 1000-fathom depth and shallower. As a result of these tests,[1] it was decided to proceed with the second, or full-scale phase, utilizing a specially designed system designated as BRASS II.

DESCRIPTION

The BRASS II system consists basically of a transducer, a transmitter, and a receiver and display system.

Early transducer problem

The line transducer, together with two spare cylinders, was delivered to the Underwater Sound Laboratory in March 1959. Preliminary tests of the two spare cylinders at the Dodge Pond Calibration Facility showed that the complete transducer could not deliver the specified 64 kilowatts of acoustical power at the specified 100-foot depth without fracturing. Inspection of the broken cylinders showed that cracks occurred mainly along the cemented joints, although some fractures extended into the titanate.

[1] John B. Drew, Charles I. Matthews, Hugo J. Wilms, Jr., *Bottom-Bounce Echo-Ranging Tests*, USL Report No. 386, 12 May 1958 (CONFIDENTIAL

As a remedy, the line transducer was almost completely enclosed in stainless steel bands maintained under tension, much like hoops on a barrel. The individual bands are of 1/32-inch stock and are one inch wide. Band tension is adjustable. The full-rated acoustical power of 64,000 watts corresponds to a power density of 2.8 watts per square centimeter of active transducer area. The spare transducer cylinders have, under high static pressure, been driven to a power density of over 12 watts per square centimeter. Electroacoustical efficiency is approximately 80 percent, if special cavitation effects are avoided. The complete transducer was installed on the USS BLENNY (SS 324) in the fairing immediately forward of the bridge.

Steel bands prevent transducer damage

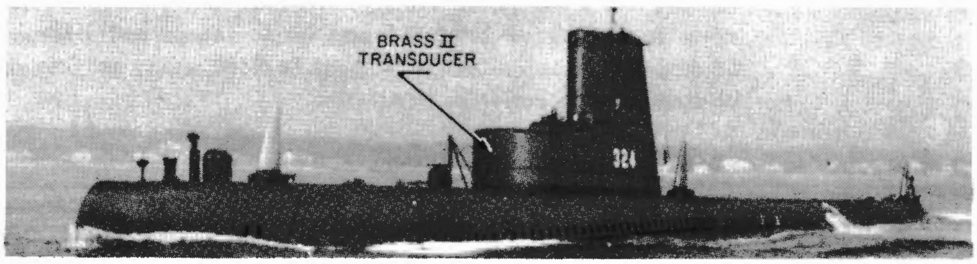
Efficiency 80 percent

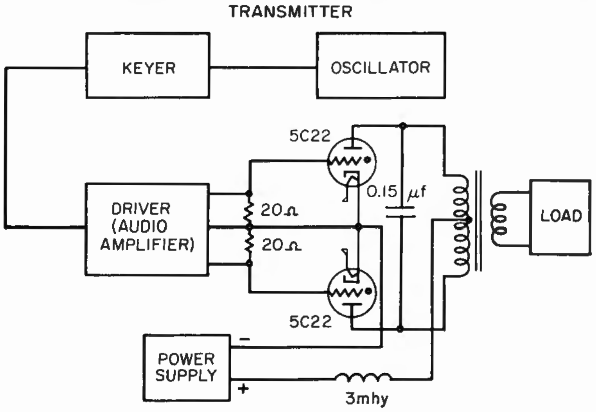
All work to date at high power levels has been done with relatively short pulses—less than 40 milliseconds—due to power supply limitations. It remains to be seen what the *thyratron* limitations will be when long pulses are used. Hydrogen thyratrons capable of much higher powers are currently available and may be used if necessary.

Uses hydrogen thyratron

The present power supply uses capacitive energy storage and is capable of storing 6000 joules (or watt-seconds) of energy. The Laboratory has acquired two DC motor generator sets utilizing flywheel rotational energy storage and plans to incorporate them into the BRASS II system. These motor generators are designed to operate

Each motor generator will deliver over 200,000 watts





Features

Power output stage uses a pair of hydrogen thyratrons.

Over-all transmitter efficiency (including grid-driving and filament power) is better than 90 percent.

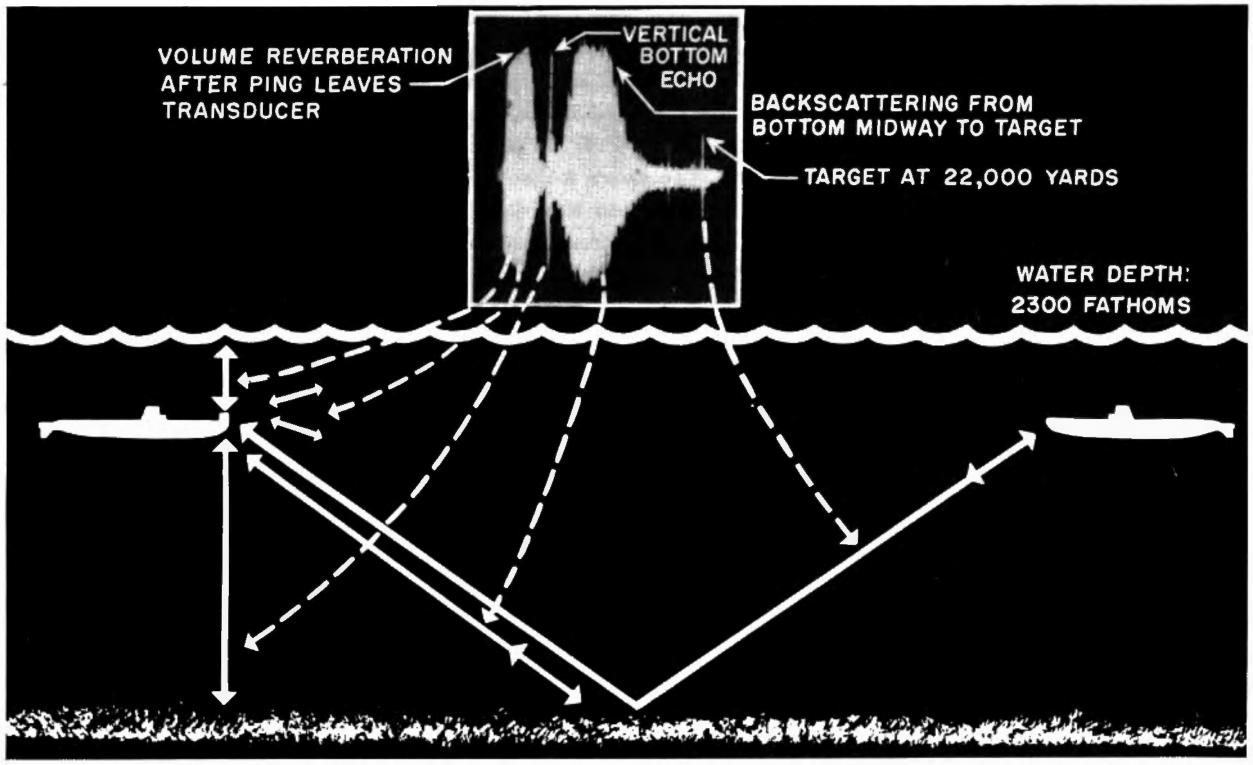
No screen or bias supplies are required.

Grid-driving requirements are relatively modest since a 200-watt audio amplifier is more than adequate.

Since the inverter impedance is quite low (much less than 10 ohms), *the function of the transformer is to supply the proper voltage to the transducer or load, rather than impedance matching.*

It should be noted that the BRASS II transmitter is a departure from traditional sonar transmitters since the power output stage uses a pair of hydrogen thyratrons in an almost standard inverter circuit.

Pulse powers up to 200 kilowatts have been obtained at frequencies from 1 to 10 kilocycles by using this circuit and two 5C22 tubes which require no special cooling.



directly off a submarine battery, and each one is capable of delivering in excess of 200,000 watts for a one-second period, every 15 seconds. Nominal output voltage is 2500 volts, and outputs can be connected in series or in parallel.

The same transducer used for pulse transmission is also used for reception. An echo-ranging receiver with both an output at the echo-ranging frequency and a heterodyned output at 1000 cps is used. The transducer output is also fed to an AN/BQR-3A receiver and provides excellent passive capabilities, at times out-performing the AN/BQR-2B installed on the BLENNY. This is especially true when a vertical angle other than horizontal yields best signal reception.

RESULTS The complete BRASS II system, with the exception of the motor generators, was installed on the BLENNY in April 1959; but because of other commitments very little test time was available until October. From 12 through 23 October, controlled bottom-bounce echo-ranging experiments were conducted between the East Coast of the United States and Bermuda. The USS ODAX (SS 484) served as the target.

Installed and tested

Bottom-bounce method performs when conventional method impossible

Preliminary results of these tests show that long-range bottom-bounce echo ranging can indeed be performed under conditions when conventional echo ranging is impossible. During most of the tests the thermal structure consisted of isothermal water down to 200 feet, followed by a negative gradient below. With either the target submarine or the BLENNY below the layer, conventional or horizontal echo ranging proved impossible at ranges in excess of 5000 yards. However, under the same conditions bottom-bounce echoes were received at ranges out to 20,000 yards and beyond.

Bottom variations influence reflection loss

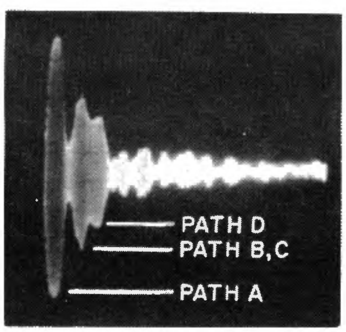
The values of bottom reflection loss obtained in the deep ocean between the East Coast and Bermuda show definite signs of variations with variations in bottom topography and structure. The abyssal plain region located approximately halfway between Cape Hatteras and Bermuda shows a bottom reflection loss of 25 db per bounce, or 9 db greater than the nominal value of 16 used in performance predictions.

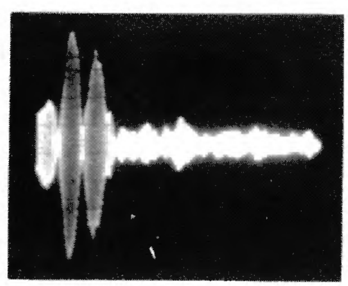
Sea mounts a limiting factor

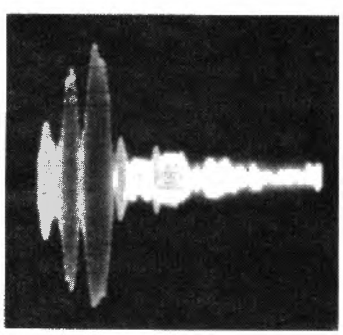
Thermal bending takes over when shallow grazing angle used

This same bottom exhibits a very low backscattering coefficient when compared to most other types of bottoms. No bottom-bounce echoes were received over this or other similar types of high loss bottoms. On the other hand, bottom areas with a reflection loss as low as 4 db per reflection were encountered as over the moderately rough bottoms just north of Bermuda. Reliable bottom-bounce echo ranging was found to be impossible in the very mountainous region surrounding Muir Sea Mount. As with the BRASS I system, when grazing angles as shallow as 5 or 10 degrees are required, thermal bending takes over and results become very unpredictable.

EXPANDED TARGET ECHOES WITH TARGET AT 100-FOOT DEPTH

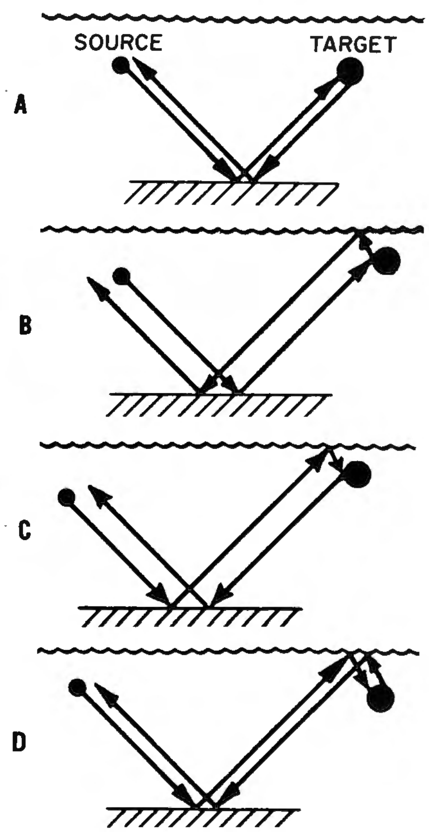






The expanded target echo reveals the different echoes received via discrete bottom and bottom-surface reflected paths.

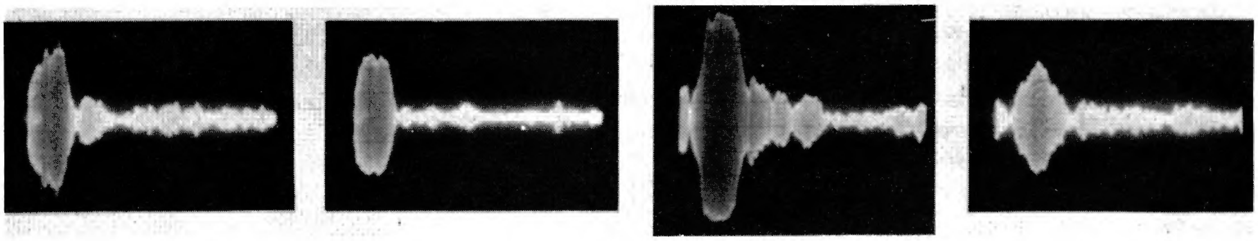
Note the variation in transmission loss over the various paths on three successive pings.



Paths of echoes received via discrete bottom and bottom-surface reflection.

EXPANDED TARGET ECHOES WITH TARGET AT PERISCOPE DEPTH

The three echoes merge as target approaches the surface.



The individual echoes can still be faintly identified in several of these traces. Other echoes from the target are also present, but these have not as yet been identified. It is obvious that target depth influences echo structure, and therefore echo structure may be used to determine target depth.

Bottom reverberation no problem at this time

Based on the best available information, it was felt that reverberation might be the limiting interference in a high-power echo-ranging system such as BRASS II. Therefore, at every opportunity, particular attention has been directed toward observation of any reverberation effects. Bottom reverberation or backscattering from the region where the sonar beam strikes the bottom has always been observed to a greater or lesser degree, but since this interference is always received well before any anticipated target echoes, it presents no problem at this time.

No reverberation limitation with a 10-ms pulse

On the basis of a limited number of special tests conducted during the spring, summer, and autumn, it is believed that reverberation limitations should occur from the volume immediately below the surface. A rather wide spread was found in the observed values of reverberation strength, but relatively little dependence on sea state was observed. On the basis of these tests, the BRASS II system should not be reverberation-limited when it is used with a 10-millisecond pulse on a submarine target at 20,000 yards; the system should begin to see signs of reverberation with a 100-millisecond pulse; and definite reverberation interference should occur with a one-second pulse.

SUMMARY

The results of the BRASS II tests to date can be summarized as follows:

Bottom bounce a real break-through

Bottom-bounce echo ranging in the deep ocean can indeed be accomplished at ranges out to and greater than 20,000 yards.

Over certain areas of high bottom loss a greater figure of merit than that of the BRASS II system is required. Conversely, over areas of low bottom loss, a very high probability of detection is possible.

Bottom-bounce echo ranging yields results under poor thermal conditions and on below-the-layer targets, when conventional echo ranging is impossible.

A bottom-bounce echo-ranging system can have the definite capability of determining the target depth

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