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NR-238-001
Contract Nonr-609(02)

Edwards Street Laboratory
Yale University
New Haven, Connecticut

ESL Technical Memorandum No. 32
(ESL:521:Ser 011)
23 March 1954

This document has been reviewed in accordance with
OPNAVI . The security
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Date: 4/19/54
By direction of
Chief of Naval Research (Code F-2)

Preliminary Tests of a Portable
Search Unit

R. W. Jackson

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The suggestion was made by Prof. L.W. McKeehan that an idea for a portable mine search unit, to be used in conjunction with a leader-cable system of long parallel electrodes, might be worth trying. The unit would consist essentially of a symmetrical pair of coils, connected in series opposing, to be moved about under water in the magnetic field set up by the electrodes. In a perfectly homogeneous field the net output from the coils should be almost zero. In a region of inhomogeneity, such as might be expected around some conducting object on the bottom, one should expect an increased output.

A pair of coils was constructed, each coil 200 turns of No. 28 Cotenamel copper wire wound on a circular form one square foot in area, both mounted on a frame to be carried by a diver. The differential output was spliced to a two-conductor MCOS-2 shielded cable about 150 feet in length to run to an amplifier and pen recorder on a boat. A painted yellow mine (the paint in good condition) type Mk 25, inert loaded to service weight (1852 lbs., about 700 lbs. immersed) was dropped in the central region between the electrodes. Attached to the mine was a guide-rope stretched along the bottom, with knots on it every 10 feet. The diver was to follow the rope along, carrying the coil device with as smooth a motion as possible, signalling as he came to the

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knots and as he passed near the mine. Three attempts were made to obtain an indication:

(1) 8 Sept. 1953. Signals from the diver as he passed the knots were sent up by the same rope used for normal communication between the diver and his tender. It was soon found that this gave rise to too much confusion of meaning. In addition, the diver had to jerk quite hard on the rope to transmit a message successfully, and in doing so could not help moving the coil device sufficiently to generate large transient signals. It was not possible to tell from examining the chart record which peaks might have been caused by electrical inhomogeneities and which by motion of the diver.

(2) 10 Sept. 1953. This time the diver was provided with a push-button with which he could operate directly a second pen in the margin of the pen recorder chart. Still there appeared to be too much motional noise on the chart for any meaningful interpretation. The diver remarked that he had to lean well into the current and sometimes had difficulty keeping his balance against the drag of the cable and signalling rope. Too, he had his hands full of things to do, viz. carry the coil device, with one hand on the push-button, maintain contact with the diving rope in case of

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trouble, and follow along the guide-rope feeling for the knots.

(3) 18 Sept. 1953. It was decided to make one more try with somewhat more refined apparatus. This time two amplifiers and two chart recorders were carried on the boat. An extra coil was mounted on the diver's unit. The diver's unit was connected to the apparatus on the boat by a length of MCOS-6 cable, which contains two separately shielded pairs, and an unshielded pair. (The diver's unit with attached cable is shown in the photograph, Figure 1.) The unshielded pair of conductors was used to carry the marker signals from the push-button. One shielded pair carried the differential output from the symmetrical pair of coils as before. The other shielded pair carried the signal from the extra coil to the second amplifier on the boat where, after amplification, the signal served as reference-phase driving voltage for a phase-sensitive rectifier circuit (Figure 2). For description of the amplifier see ESL Technical Report No. 26.* The phase-sensitive rectifier took the place of the simple rectifier circuit used for the previous attempts. Theoretically the phase-sensitive rectifier circuit should greatly have improved discrimination between the desired signals and the motional noise, since only the desired signals (at 30 c/s)

* Jackson, R.W. "Experiments Toward an Underwater Electromagnetic Detection Scheme". ESL Tech. Report No. 26
Dated 22 March 1954.

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should have been phase-coherent with the primary field.

In practice the improvement was not as great as hoped for, probably because the circuit was not adequately designed to handle large transient signals. However, the main fault of the experiment as it turned out was that the diver's push-button communication broke down so that only a poor correlation of the diver's position with the chart record was obtained. The diver's push-button was rendered water-proof by a thin rubber diaphragm over the button. This had worked satisfactorily the time before, but in the week between experiments the diaphragm appeared to have deteriorated and was replaced by a new piece of rubber. The most reasonable explanation is that the new piece was just enough stiffer that it increased the effective area on which the water pressure acted to the point where the water pressure could actuate the switch. However, the records that were taken still showed no indication that could positively be identified as due to the mine rather than noise from motion of the coil and other sources. The experiments had to terminate at this point, since this was the last day that the divers were available to the project.

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FIG. 1

DIVER'S COIL UNIT

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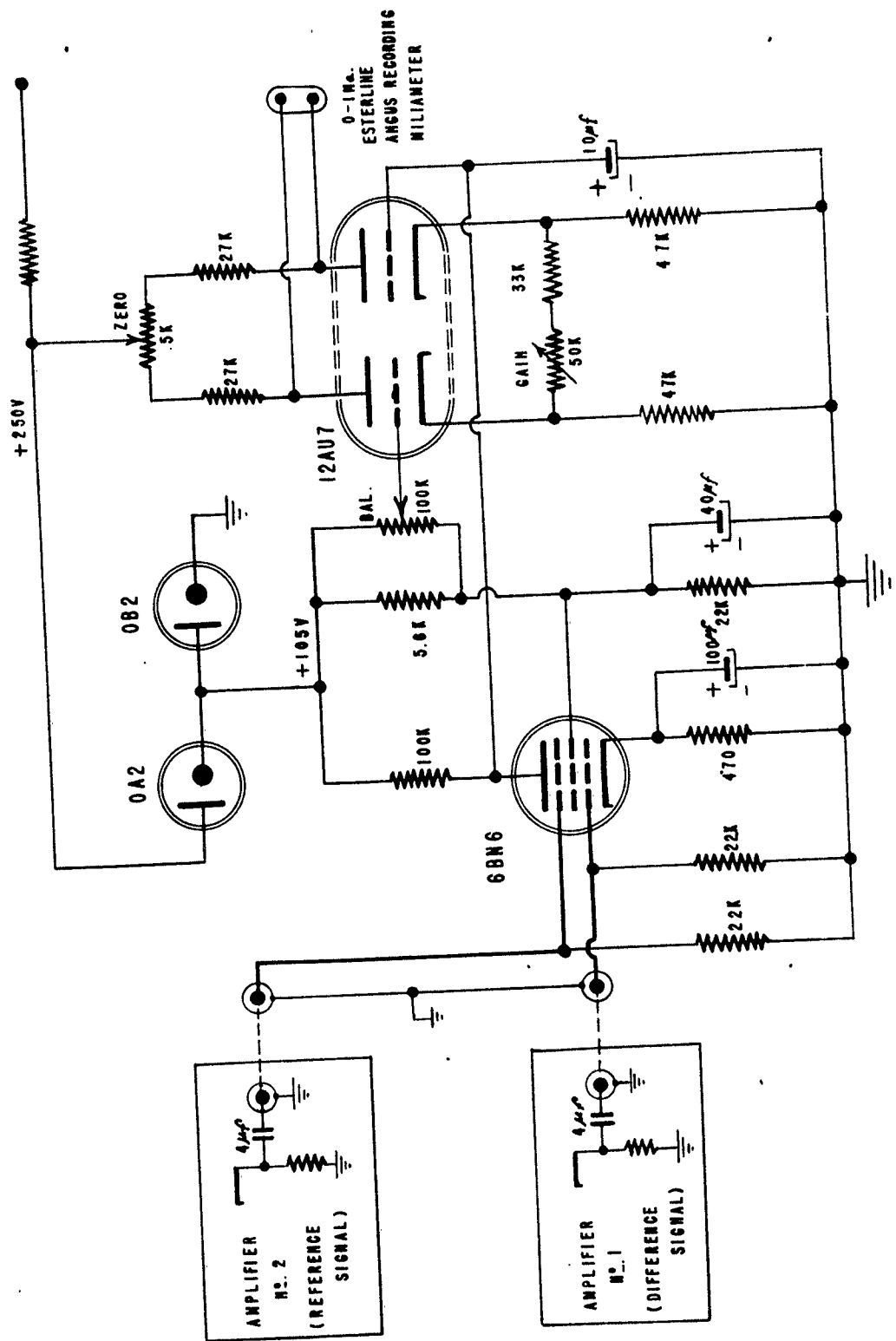


FIG. 2 PHASE-SENSITIVE RECTIFIER AND OUTPUT CIRCUIT
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