AD-758 085

ENGINEERING EVALUATION OF DEPTH-SOUND SPEED MEASURING SET AN/BQH-1 MANUFACTURED BY DYNA-EMPIRE CORPORATION, GARDEN CITY, NEW YORK. CONTRACT NOBSR-75772

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Details of illustrations in this document may be better studied on microfiche.

ADMINISTRATIVE INFORMATION

Reference: (a) BuShips ltr C-S67/13 (689E) Ser 689E-073 dated 1 Oct 1959
(b) BuShips specification MIL-M-21620(SHIPS) dated 1 Oct 1958
(c) Journal of Research of the NBS, Vol. 59 (1957)
(d) National Bureau of Standards Report 6200, "Deep Sea Velocimeter Model TR-2 No. 1," Instruction Manual by C. E. Tschiegg dated 19 Nov 1958

LIST OF ILLUSTRATIONS

REPORT OF INVESTIGATION

I. INTRODUCTION

The AN/BQH-1 measuring set is manufactured by Dyna-Empire Corporation under contract NObsr-75772. It is designed for use in submarines to measure the velocity of sound in water, this information being displayed on a chart as a function of depth.

The equipment consists of the following units:

RO-142/BQH-1 depth-sound speed recorder
RO-143/BQH-1 remote depth-sound speed recorder
OC-11/BHQ-1 depth element
TR-167/BQH-1 sound head (two per equipment)

Illustrations of these units may be seen in Figs. 1, 2, and 3.

The problem of conducting an engineering evaluation was assigned by reference (a), under the provisions of references (b) and (c). Because of the short period of time available for the necessary tests, only partial climatic, shock, and vibration tests were conducted.

II.. EQUIPMENT OPERATION

The AN/BQH-1 represents a departure from the regenerative pulse principle ("sing around") as developed by the National Bureau of Standards, and described in reference (d). In the AN/BQH-1, sound velocity in water is obtained by measuring the travel time of an acoustic pulse over a path of fixed length. The unit is completely transistorized and operates from the 115V, 400-cps power line.

The heart of the system is the sound head, the operation of which is as follows: the output of a crystal-controlled oscillator is shaped into a train of pulses by a Schmitt Trigger circuit and a differentiating network. The negative half of this pulse train performs two functions: (1) it is amplified and transmitted into the water as a train of 1 μsec pulses, and (2) it is used to trigger a bistable multivibrator "ON." The time taken by the transmitted pulse to traverse the water path is dependent on the velocity of sound in water. The path of the signal in the water is shown in Fig. 4. This pulse is received by another hydrophone, amplified, and used to trigger another Schmitt Trigger circuit, the output of which is differentiated and then used to turn the multivibrator to the "OFF" state. The pulsed DC output of this multivibrator has an average value proportional to the sound velocity. This DC signal is then used to position a 400-cycle servo system driving the chart drum.

The depth element connects to the submarine pressure line, and its output is used to position the pen-drive servo system. On the recording chart, the sound velocity is presented on the horizontal axis and the depth on the vertical axis. A remote recorder is included as a unit of this equipment.

III. TEST EQUIPMENT AND DATA

A. Test Equipment

Because of the unique requirements of this evaluation, it was found necessary to acquire a precise temperature measuring device. A Leeds and Northrup system was used, consisting of the following units:

8163-C Platinum Resistance Thermometer
8067 Mueller Temperature Bridge
8068 Commutator
2284-d Galvanometer

For reading absolute temperature, the over-all limit of error of the combination of the bridge and resistance thermometer is ±0.06° C.

B. Test Data

Reference data for values of sound velocity in water were taken from Table 2, Journal of Research of the NBS, vol. 59, page 249 (1957), (reference (c)). The data presented are values of sound velocity in distilled water. The NBS also made measurements on several samples of tap water; these sound velocity readings did not differ appreciably from the values obtained from distilled water. Measurements at USL were conducted using distilled water, but no effort was made to maintain a high level of purity.

The data as presented gave sound velocity at every centigrade degree; linear interpolation was used to get sound velocities at temperatures between these points. The combination of the error in the NBS data and the temperature measurement leads to an over-all error of ±0.4 ft/sec in the known sound velocity.

IV. EQUIPMENT PERFORMANCE

A. Information Presentation

The sound velocity is presented on pressure-sensitive graph paper as a function of the depth of the submarine (see Fig. 5). The sound velocity axis is calibrated in 10 ft/sec intervals from 4600 to 5100 ft/sec; the depth scale is calibrated in 20-foot intervals from 0 to 1500 feet. Also included on the charts are two sets of isoballast curves--one set for the isothermal condition and the other set for the iso-saline condition. Each set of these isoballast curves is computed for a specific class of submarine.

The chart is required to have scale divisions of 10 ft/sec, and a slope change of 1 ft/sec in the sound velocity should be readable. By exercising caution in the reading of the chart, it is possible to read the sound velocity to the nearest 2 ft/sec, but reading to 1 ft/sec would not produce consistent results. The ability to read within 2 ft/sec is considered sufficient.

The chart is not provided with red illumination as required by the equipment specification. The charts are illuminated by clear bulbs, with amber-colored glass being used in the cover of the equipment. The intensity of the lamps is variable, and at maximum intensity the light was judged to be excessively bright. The contractor maintains that if red-tinted bulbs were to be used, it would not be possible to see the chart trace because of the large area that must be covered. Final approval is contingent upon the contractor's providing an illumination system suitable to the Bureau.

B. <u>Sound Velocity Measurement and Calibration</u>

The sound head of the AN/BQH-1 was immersed in a temperature-controlled bath of distilled water, and the bath temperature and the reading of the stylus on the chart were recorded. Figure 6 shows the relationship between the sound velocity as recorded by the AN/BQH and the data obtained from the NBS report. The recorded sound velocity was within 10 ft/sec of the NBS values over the temperature range of 0° C. to 30° C. No tolerance for the sound velocity measurement was spelled out in the equipment specification, but this amount of error is considered to be acceptable.

It is required that means be provided to determine if the sea unit (sound head) has remained in calibration. This is done by depressing a switch on the front panel of the equipment causing the recorder to indicate 4800 ft/sec. Depression of the switch actuates a relay which shorts out the first three stages in the sound head receive-amplifier and injects into the fourth stage a portion of the output from the Schmitt Trigger circuit and differentiating network. This signal causes the receive Schmitt Trigger to turn the output multivibrator "OFF." If the sound head is immersed in water of approximately 20° C., the "cal" indication is 4800 ft/sec. With the sound head immersed in water colder or warmer than this, the "cal" reading departs from 4800 ft/sec, as shown in Table 1. This deviation is caused by changes in the operating points of the sound head transistors with temperature, which changes, however, do not affect the measurement of sound velocity. The error is potentially disastrous, for it is possible to adjust the chart drum with respect to its drive mechanism, resulting in an incorrect position of the chart if it is set at 4800 ft/sec when the "cal" reading is actually something different. The contractor reports that a development to correct this deficiency is under way, but until such time as this correction is brought about, the "cal" reading should be used only to indicate whether or not the equipment is operating and not as an absolute value by which to position the chart. It is recommended that when this deficiency is corrected the AN/BQH-1 be resubmitted to determine if the calibration system is sufficiently accurate to warrant its use as an absolute indication.

Table I

VARIATION OF "CAL" READING WITH TEMPERATURE

Temperature of Sound Head (° C.)	"Cal" Reading* (ft/sec)
2.8	4790
6.9	4791
14.1	4797
19.9	4801
26.7	4805
33.2	4798

*Normal 4800 ft/sec

It is possible to calibrate sound heads for use with different recorder units. This is accomplished by means of three potentiometers in the recorder. One adjusts the low end (4600 ft/sec) of the scale for both sound heads; the other two adjust the high end of the scale for each sound head individually. Since adjustment of these potentiometers requires extremely accurate information as to the temperature of the water in which the sound heads are immersed, the calibration should normally be undertaken only under laboratory conditions. Any effort by ship's personnel to undertake it will only lead to inaccuracies of unknown magnitude in the recorded values of sound velocity. Two avenues of approach are open: first, to replace the potentiometers with fixed resistors, and second, to maintain the settings of the potentiometer with locking devices. The first remedy takes away the ability for easy interchange of recorder units; the second method, while far from being tamperproof, is probably preferable since it does retain the interchangeability feature.

C. Depth Element

The depth element is required to satisfy the following: output linear within ±0.5% of full-scale depth; hysteresis not to exceed ±5.0% of full-scale depth; temperature coefficient not to exceed 0.02% per °F.; and zero shift not to exceed 0.01% per °F. The output of the depth element was not measured directly, the position of the stylus on the chart being deemed sufficiently accurate for the required purposes.

Pressure applied to the depth element was measured by means of a U. S. Gauge Company master gauge, which was in turn checked at different points on its scale by a Crosby Steam Gauge tester accurate to ±1 pound/inch^2.

1. Output Linearity - Figure 7 illustrates the depth as indicated by the AN/BQH-1 versus the pressure applied to the depth element. The depth indication exceeds the linearity requirement only at the extreme upper and lower ends of the scale. The linearity requirement is satisfied completely for depths of 40 to 1470 feet, and is considered to be acceptable.

2. Hysteresis - The amount of hysteresis present in the depth circuit is defined as the difference in indicated depth when the same pressure is applied to the depth element, first when the pressure is increasing and then when it is decreasing.

Figure 7 also indicates the hysteresis present in the depth indicating system. The amount of hysteresis present is twenty feet, well within the limit of ±5% of full-scale depth (±75 feet).

3. Temperature Coefficient and Zero Shift - During the limited climatic tests conducted on the equipment, no temperature-dependent change was observable in the depth indicator, for both constant applied pressure and zero pressure (zero shift).

4. Calibration and Zero Set - Calibration of the depth scale is provided by means of three potentiometers--two for the zero-depth calibration of each sound-head, and one for maximum-depth calibration of both units. The ability to individually calibrate the zero setting no matter which sound-head is in use, fulfills the requirement of being able to adjust for a 25-to-50-foot difference in mounting location of the sound-heads.

V. ENVIRONMENTAL TESTS

A. Pressure Test

The sound-head, including its cable packing, was subjected to the following hydrostatic pressure test: 15 minutes at 950 psig; 14 hours at 600 psig; and 9 hours at 950 psig. Resistance readings were made at the end of the cable, with no difference from the readings obtained at zero pressure being detected during the course of the test.

A test (950 psig for one minute) was also conducted with the sound head connected to the recorder unit. When the pressure was removed, the sound velocity indication returned to within 2 ft/sec of the original indication.

B. Climatic Tests

Climatic testing consisted of two periods of approximately eight hours each. Conditions for the first period were +122° F, and less than 50% R. H.; for the second period they were +122° F. and 95% R. H. No deterioration in performance was noted during this test.

C. Vibration Test

The following vibration test was conducted on the main recorder unit: exploratory run, 5–33 cps, in the front-back and side-side planes; and a variable frequency test (5–33 cps, with five minutes at each discrete frequency) in the front-back plane. The remote recorder received the exploratory and variable frequency tests in the vertical plane. The depth element and the sound heads were not vibrated. No mechanical or electrical failures occurred as a result of these tests. Owing to the short time available for evaluation, only these limited vibration tests were conducted. They are, however, considered sufficient to indicate that no trouble will be experienced with the recorder units under conditions of environmental vibration.

D. Shock Test

The main recorder unit was subjected to the complete, light-weight shock test. Two power-supply filter capacitors, C206 and C220, repeatedly popped from their sockets, despite the use of restraining clamps. The clamps prevented the capacitors from flying around inside the equipment, but were not sufficient to hold them in their sockets. These clamps should be replaced with others that will hold the capacitors in place. The leads of two tubular .47 μf capacitors (C224 and C209) broke during the test. This can be prevented by clipping these capacitors to the chassis.

VI. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The equipment is considered satisfactory for Navy use. Provision of proper chart illumination and an accurate calibration system will serve to correct the only serious deficiencies.

B. Recommendations

The following recommendations will serve to correct the few deficiencies found in the equipment:

1. Modify sound head circuits so that calibration reading is not temperature dependent.
2. Provide proper red illumination for the chart.
3. Mount electrolytic and tubular capacitors so that they will stay in place and not break leads.

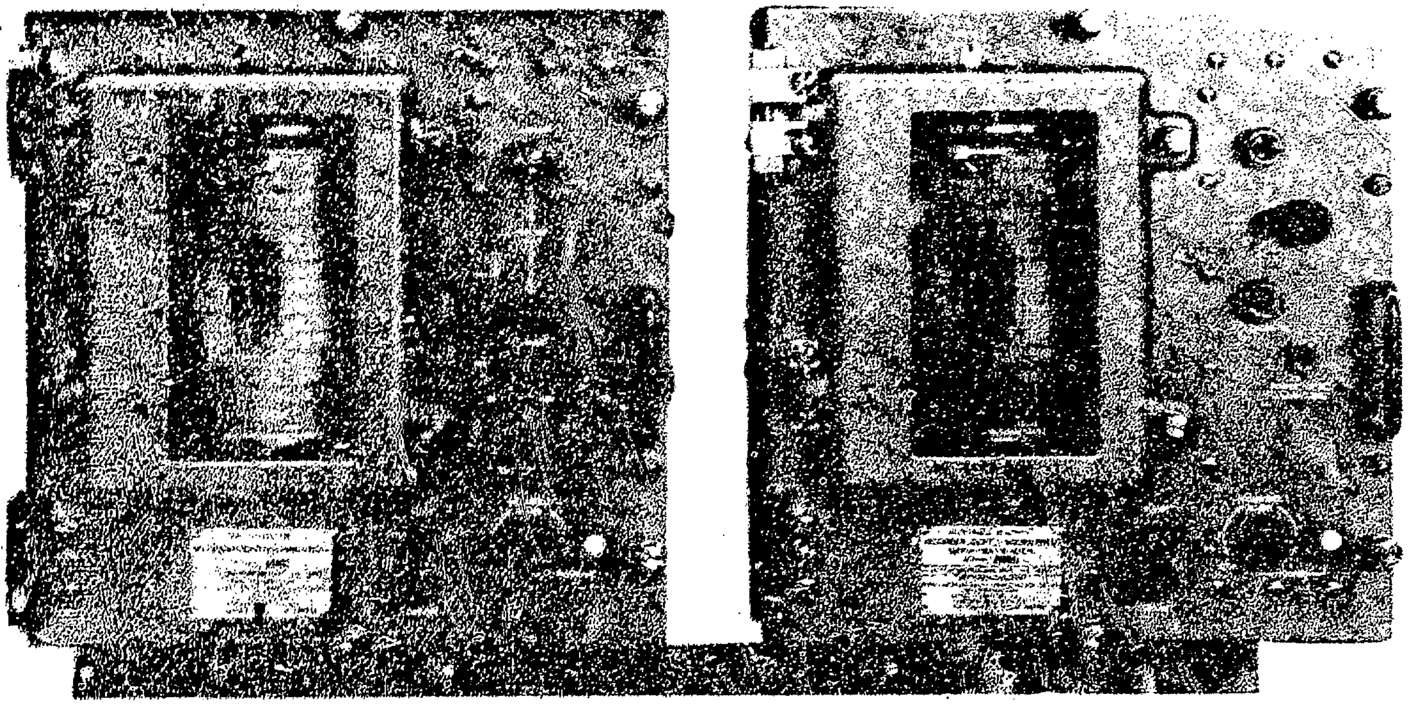

Fig. 1 - Left: The RO-[illegible]/BQH-1 Remote Depth-Sound Speed Recorder
Right: The RO-[illegible]/BQH-1 Depth-Sound Speed Recorder

U. S. Navy Underwater Sound Laboratory — Official Photograph

NDM - 19756 - 2 - 61

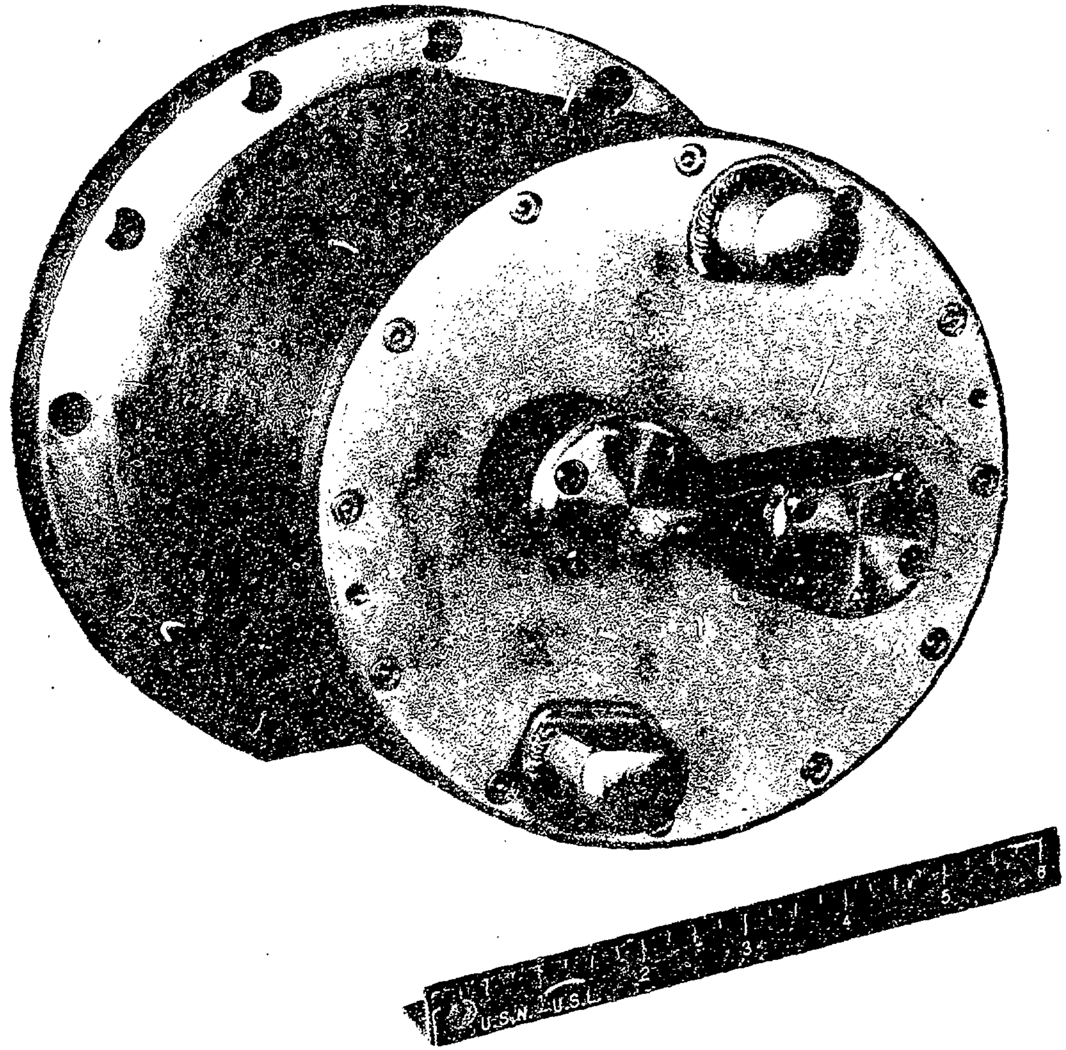

Fig. 2 - The TR-167/BQH-1 Sound Head

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Official Photograph

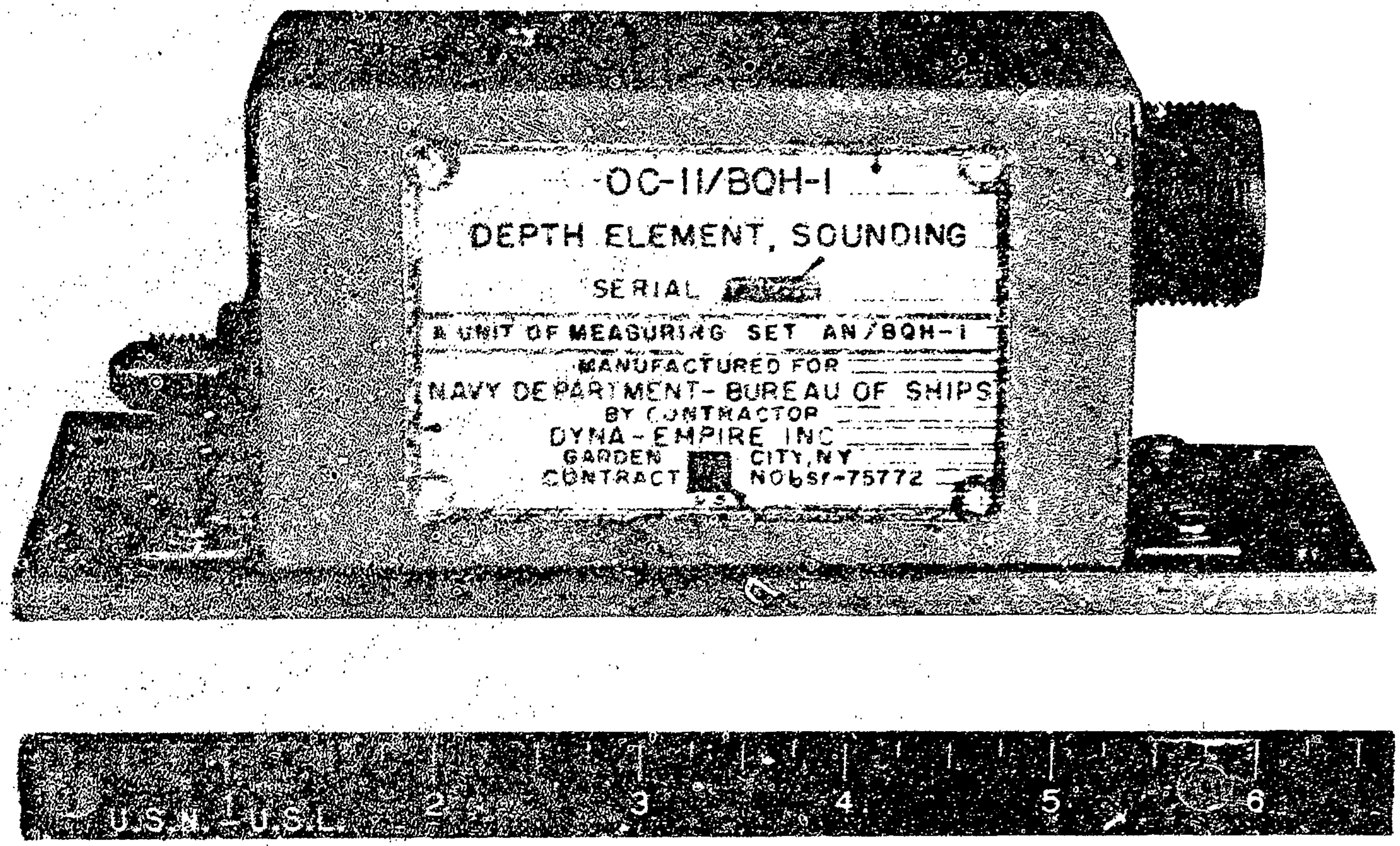

Fig. 3 - The OC-11/BHQ-1 Depth Element

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Official Photograph

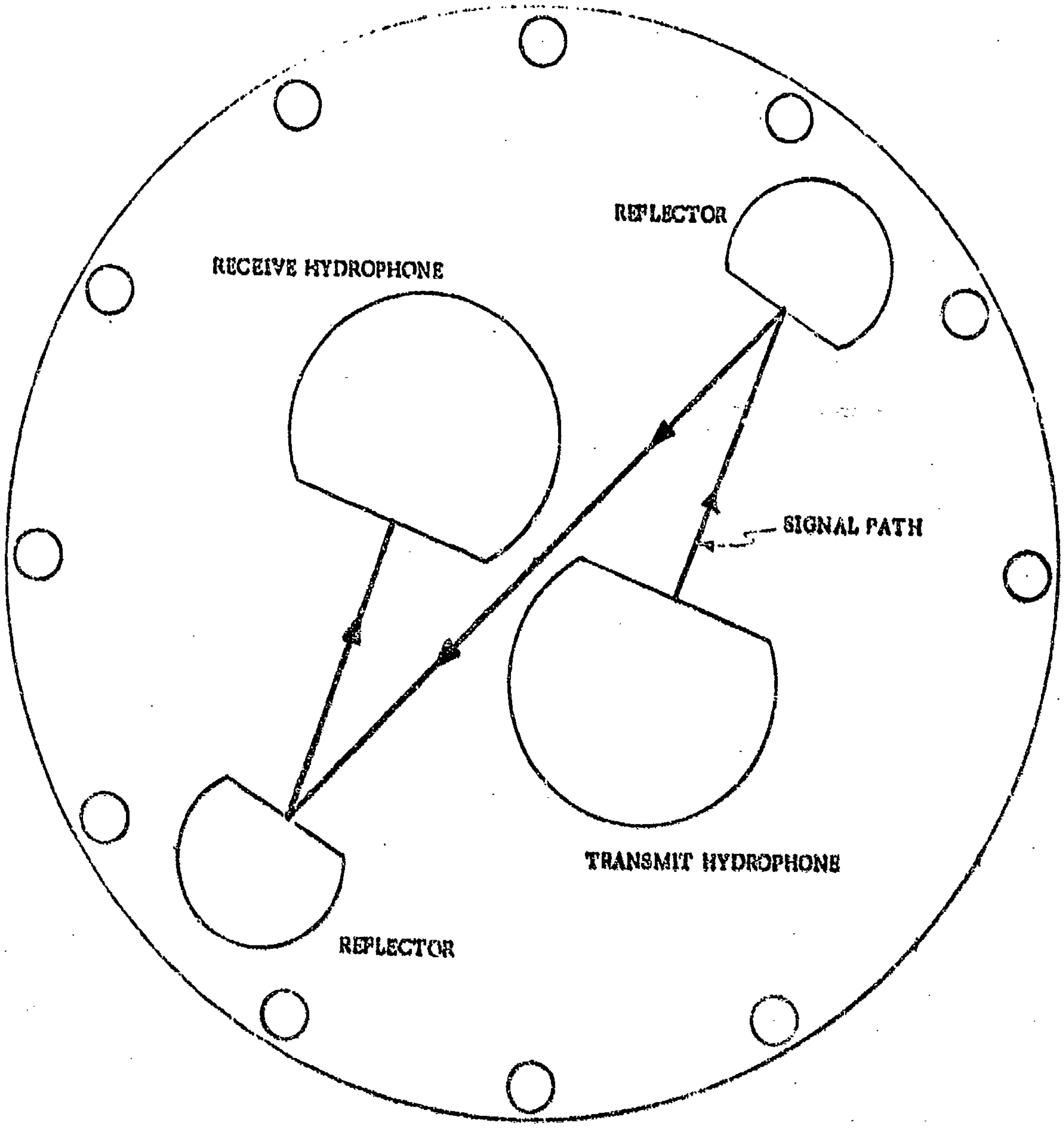

Fig. 4 - Path of Signal Through Water

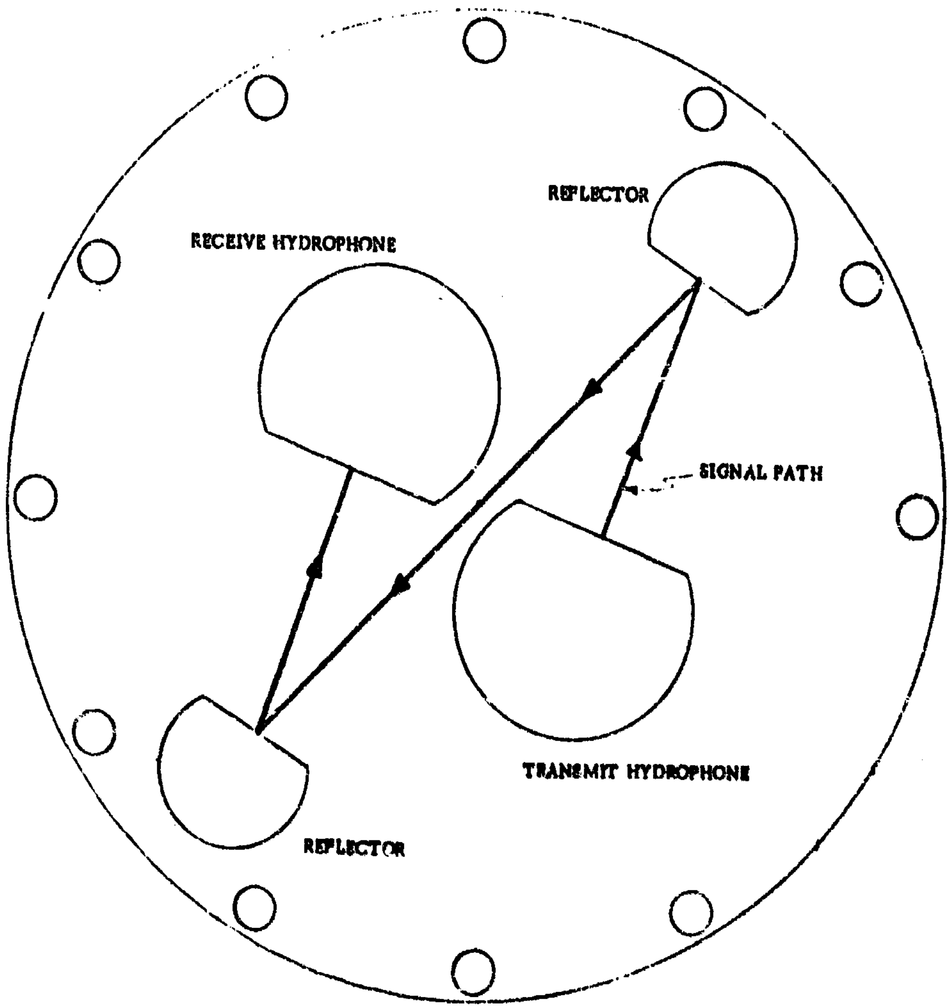

Fig. 4 - Path of Signal Through Water

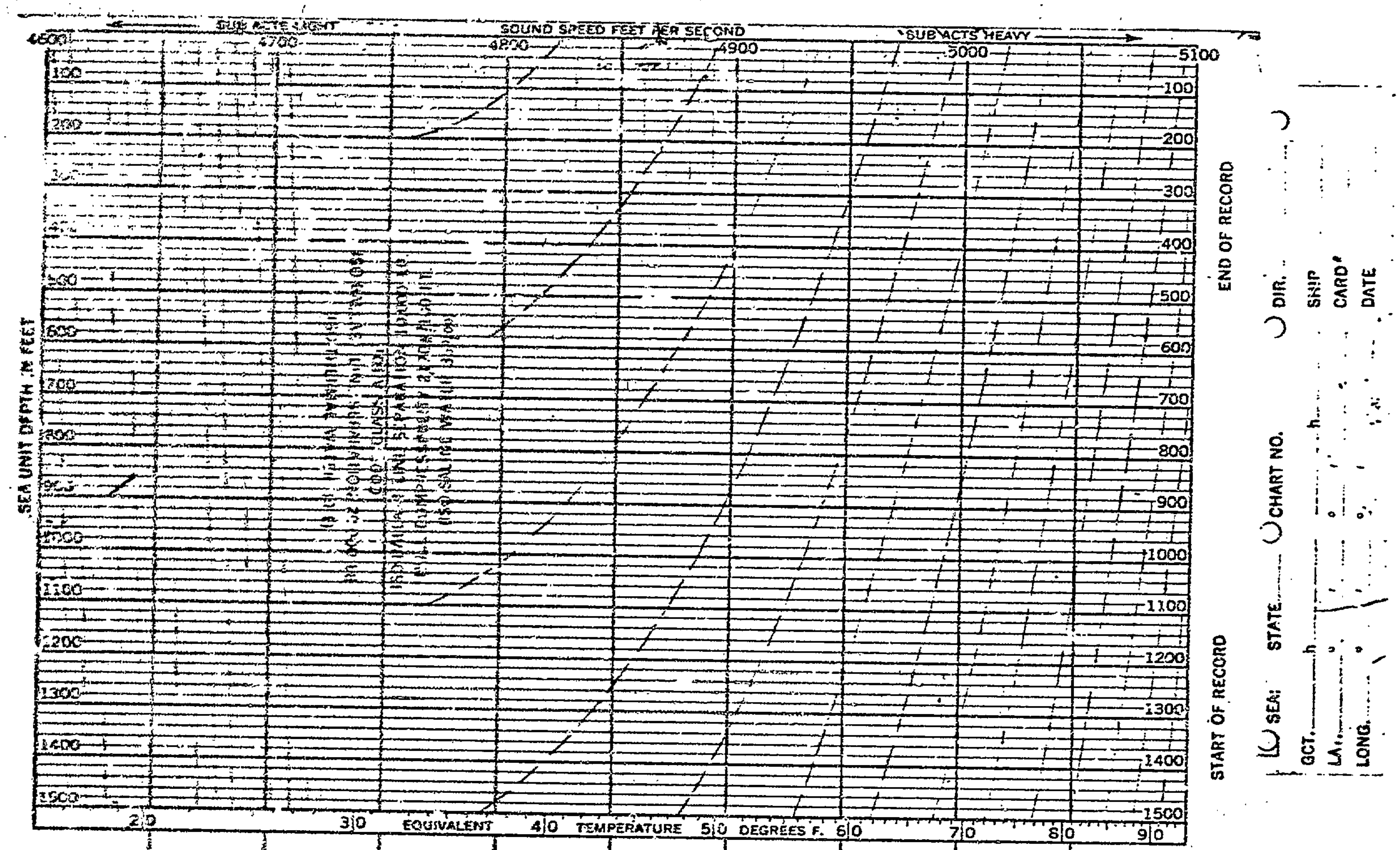

Fig. 5 - Chart Paper Used in AN/BQH-1 Depth-Sound Speed Measuring Set

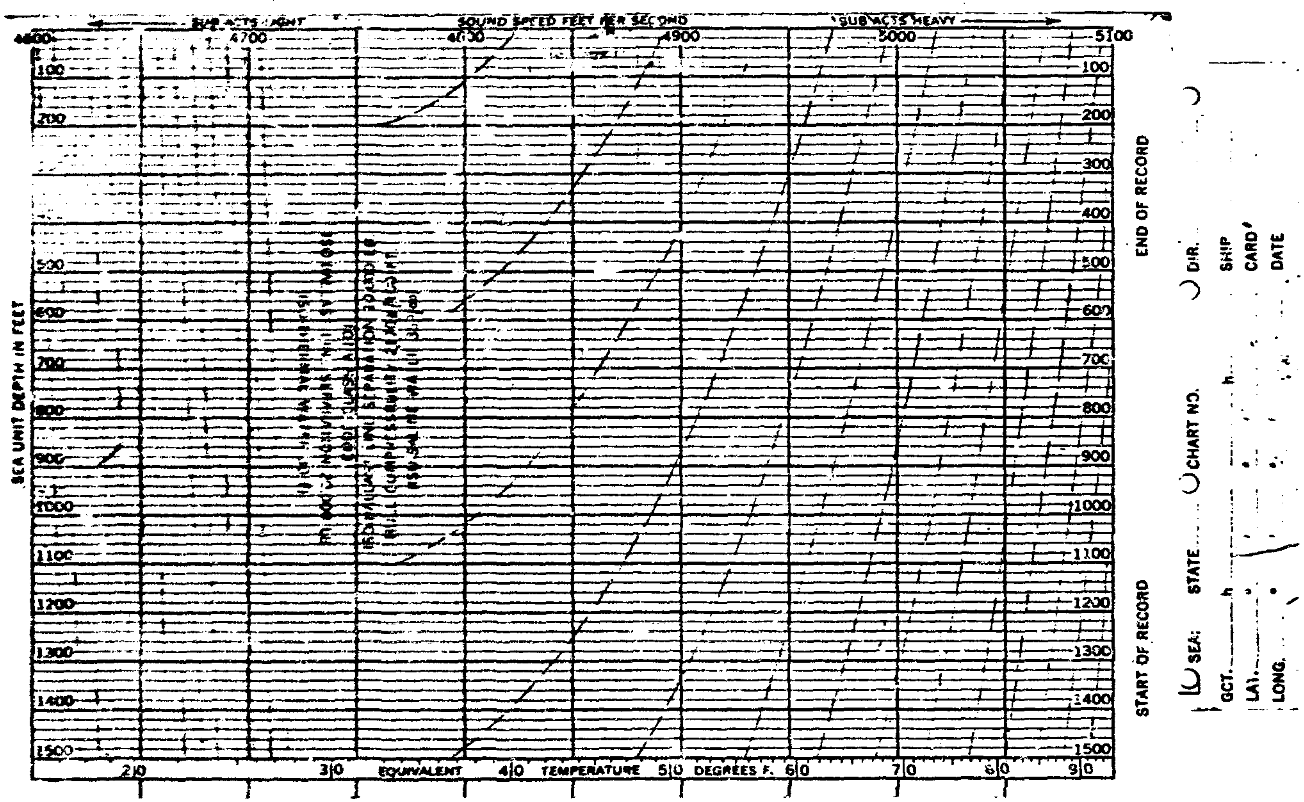

Fig. 5 - Chart Paper Used in AN/BQH-1 Depth-Sound Speed Measuring Set

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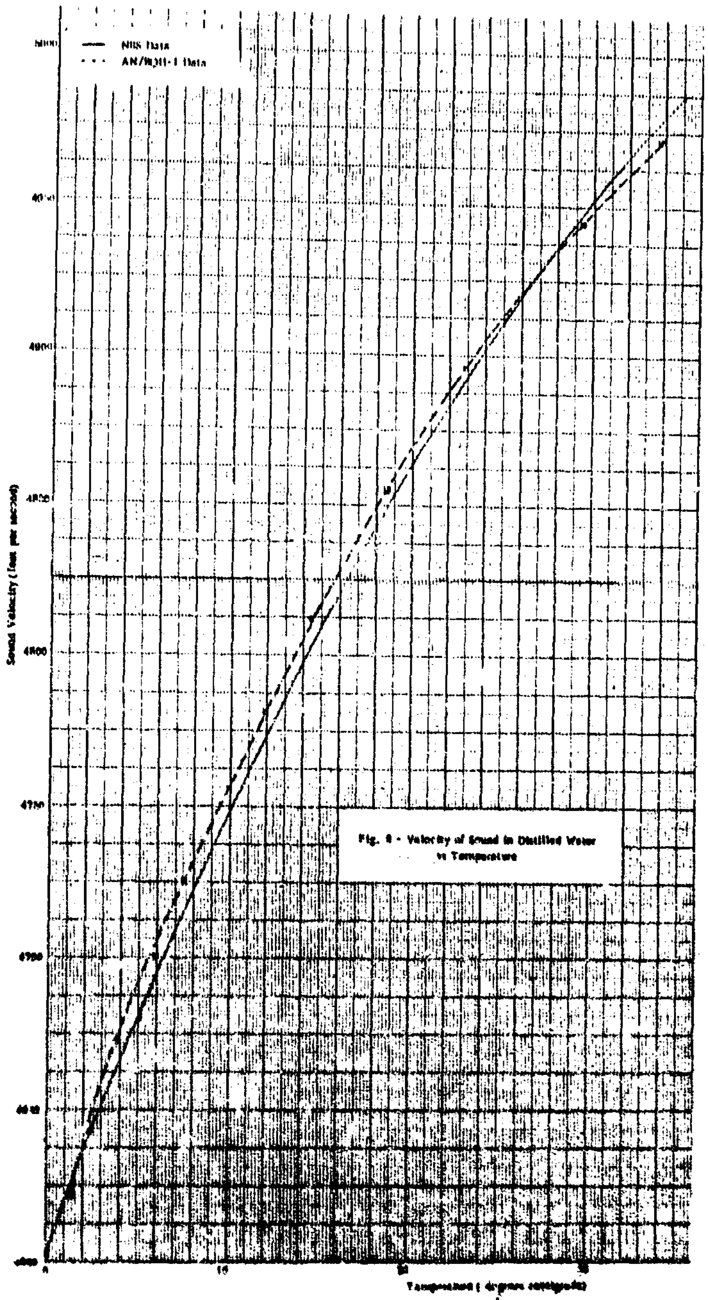

Fig. 8 - Velocity of Sound in Distilled Water vs Temperature

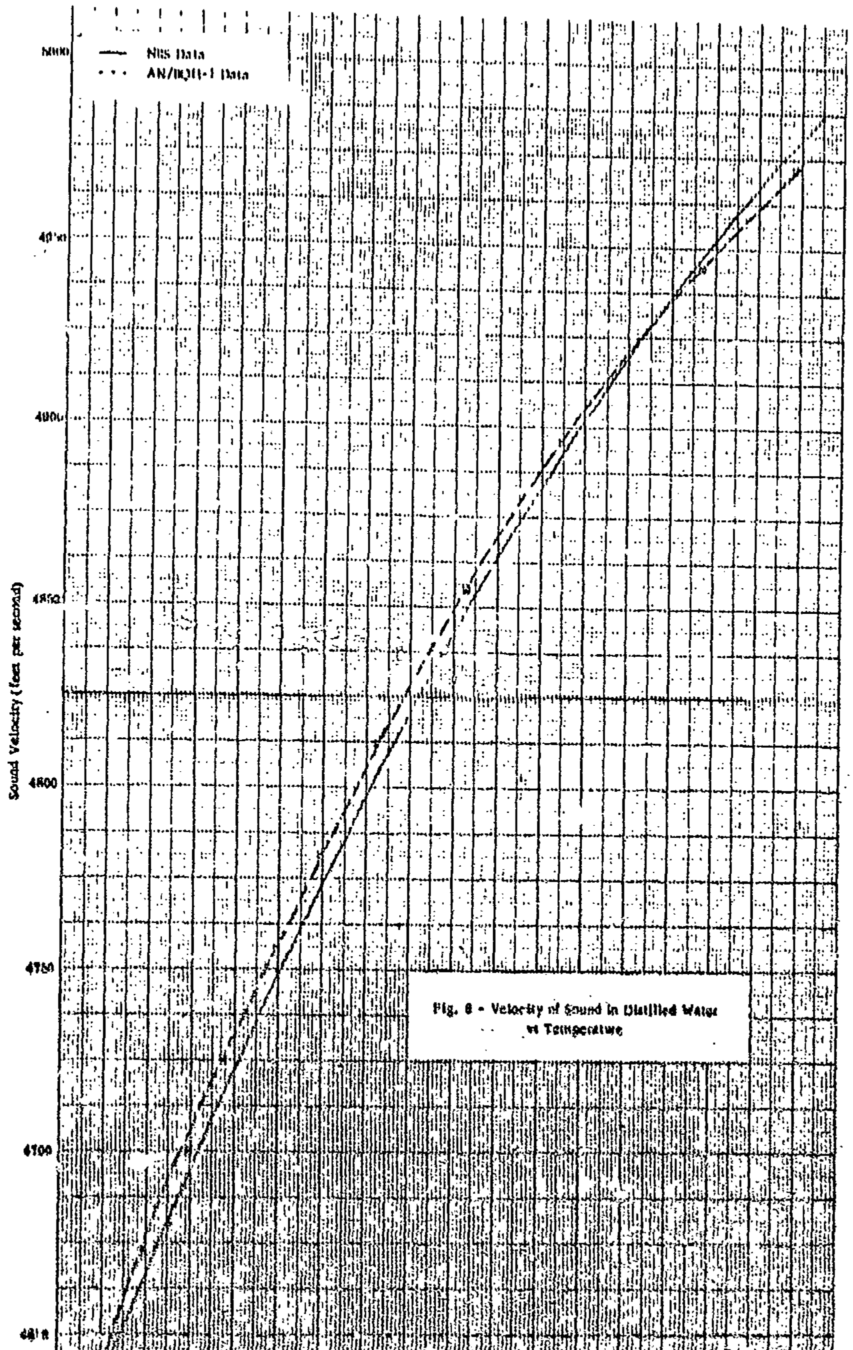

Fig. 8 - Velocity of Sound in Distilled Water vs Temperature

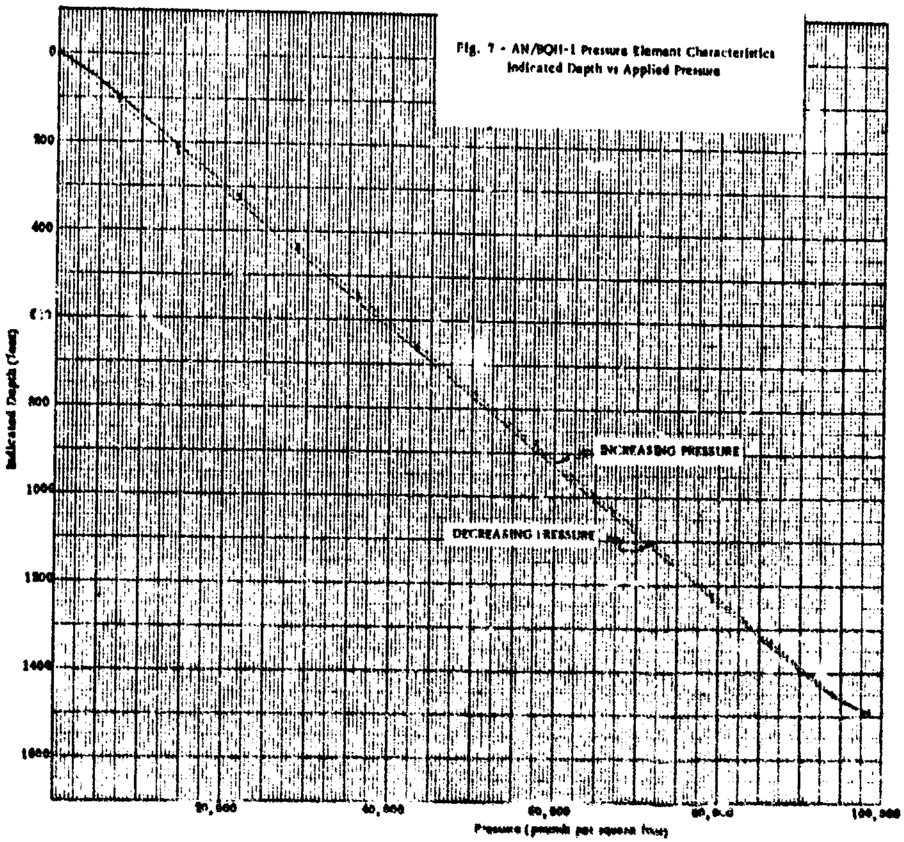

Fig. 7 - AN/BQH-1 Pressure Element Characteristics
Indicated Depth vs Applied Pressure

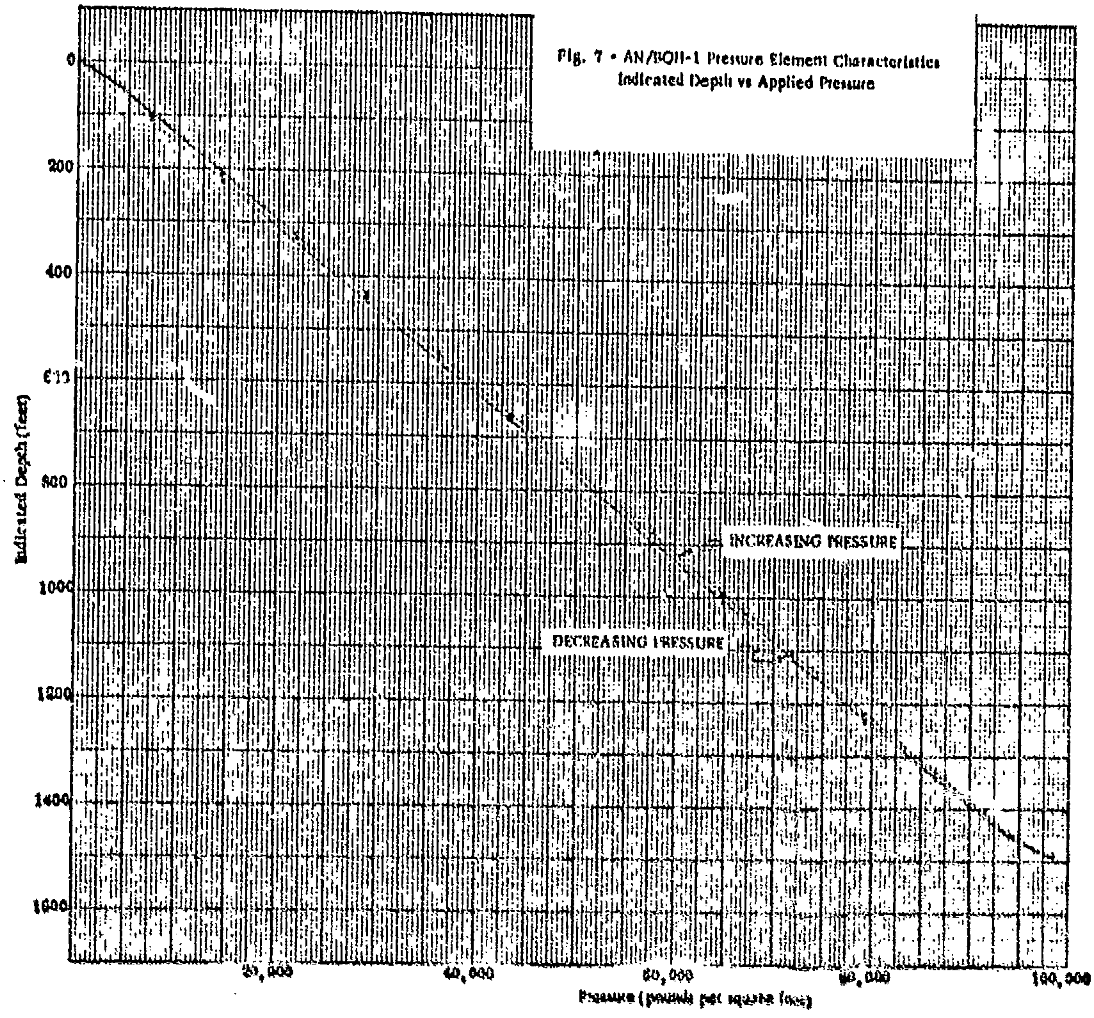

Fig. 7 - AN/BQH-1 Pressure Element Characteristics
Indicated Depth vs Applied Pressure

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