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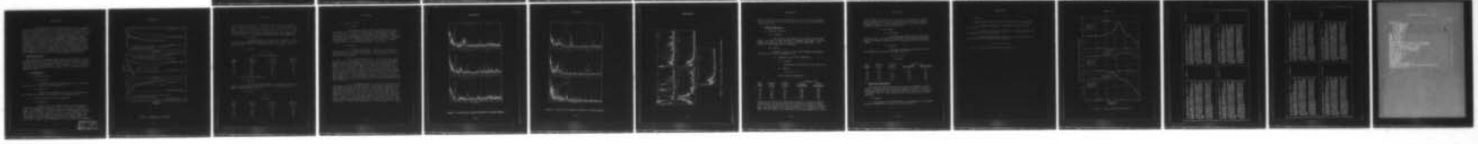

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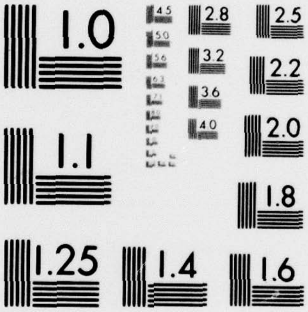

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U. S. NAVAL AIR DEVELOPMENT CENTER

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Anti-Submarine Warfare Laboratory

REPORT NO. NADC-AW-6227 11 SEP 1962

AN/SSQ-28 SONOBUOY LABORATORY EVALUATION

WEPTASK NO. RUDO2B000/2021/F001-13-07
Problem No. 519

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11 September 1962

This is a report on the results of an investigation on the performance of the AN/SSQ-28 sonobuoy under laboratory and simulated environmental conditions. The investigation was conducted to evaluate new measuring techniques and to determine if the equipment operated in conformance with Specification MIL-S-22485(WEP).

The sonobuoys were made available from each of the present manufacturers of the AN/SSQ-28; the contractors are the Magnavox Co., the Hazeltine Corp., and the Sparton Corp. This report covers the areas in which these sonobuoys did not meet the required limits of the specification.

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SUMMARY

INTRODUCTION

The AN/SSQ-28 sonobuoy is an expendable ASW equipment designed to be dropped into the sea from an aircraft. The AN/SSQ-28 detects and amplifies underwater sounds to modulate a self-contained f-m transmitter. The f-m signals from the sonobuoy are transmitted to the associated sonobuoy receiver in the aircraft. When the demodulated signal from the receiver is connected to the proper analysis equipment, underwater sound sources can be located and identified.

The NAVAIRDEVCEN, under the authority of the BUWEPS, reference (a), conducted an investigation on the performance of the AN/SSQ-28 sonobuoy under laboratory and simulated environmental conditions. The investigation evaluated new measuring techniques and determined if the equipment operated in conformance with Specification MIL-S-22485(WEP) dated 20 May 1960.

One sonobuoy was selected from each of the present AN/SSQ-28 contractors: the Magnavox Company, contract NOw 60-0234r; the Hazeltine Corporation, contract NOw 62-0288f; and the Sparton Corporation, contract NOw 61-0697f. This was a necessity because at the time that these tests were made production type AN/SSQ-28 sonobuoys were available from only one contractor. The sonobuoy manufactured by the Magnavox Company was a production type, while the Sparton and Hazeltine Corporation sonobuoys were engineering samples. The Motorola Company, contract NOw 62-0287f, did not have any sample available at the time.

SUMMARY OF RESULTS

This investigation, although conducted on a small sample of three sonobuoys, indicated that the AN/SSQ-28 sonobuoys had certain questionable performance characteristics. These characteristics differed in each manufacturer's sonobuoy. This report covers the areas in which these three sonobuoys did not meet the required limits of the specification. The sonobuoys tested failed to meet the low-frequency noise limits, r-f carrier frequency stability, and frequency response requirements.

RECOMMENDATIONS

It is recommended that:

1. The AN/SSQ-28 sonobuoy program be reviewed with emphasis on the questionable areas to determine whether the basic design or the manufacturing process is at fault. The NAVAIRDEVCEN is continuing to investigate these matters and will assist the BUWEPS in such a review.

2. The existing phase measuring technique be retained until the phase requirements of the JEZEBEL system can be fully evaluated and a new technique be devised that would be more compatible with the present and future JEZEBEL type sonobuoys. The emphasis is to be on a standard sonobuoy test technique to be established and used by all sonobuoy contractors.

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FIGURES

TEST PROCEDURES

The following tests were conducted in accordance with Specification MIL-S-22485(WEP).

The outer case of the sonobuoy was left intact with the hydrophone cable in place within the sonobuoy. The bottom plate was removed to allow the battery to drop into its normal operating position with the hydrophone termination mass, preamplifier, and hydrophone suspended a few inches below the sonobuoy.

A. Electrical Tests

The hydrophones were removed from each of the three sonobuoys under test and replaced with a "dummy hydrophone" (electrical circuit equivalent of the hydrophone) provided by each sonobuoy contractor. The antenna was replaced with an equivalent resistive load. Power was supplied by an external source.

1. Frequency Response

a. Procedure

An audio signal was fed into the hydrophone amplifier through the dummy hydrophone. The output of the sonobuoy was held constant at 75 kc deviation.

b. Results

Figure 1 shows curves of the hydrophone amplifier frequency response. The sonobuoy, manufactured by the Sparton Corporation, had the gain of the hydrophone amplifier set 3.4 db above the specified level. The other two sonobuoys tested met the requirements.

2. Modulation Distortion

a. Procedure

The total harmonic distortion was measured at frequency deviation ranges of 40 and 105 kc.

b. Results

See table I.

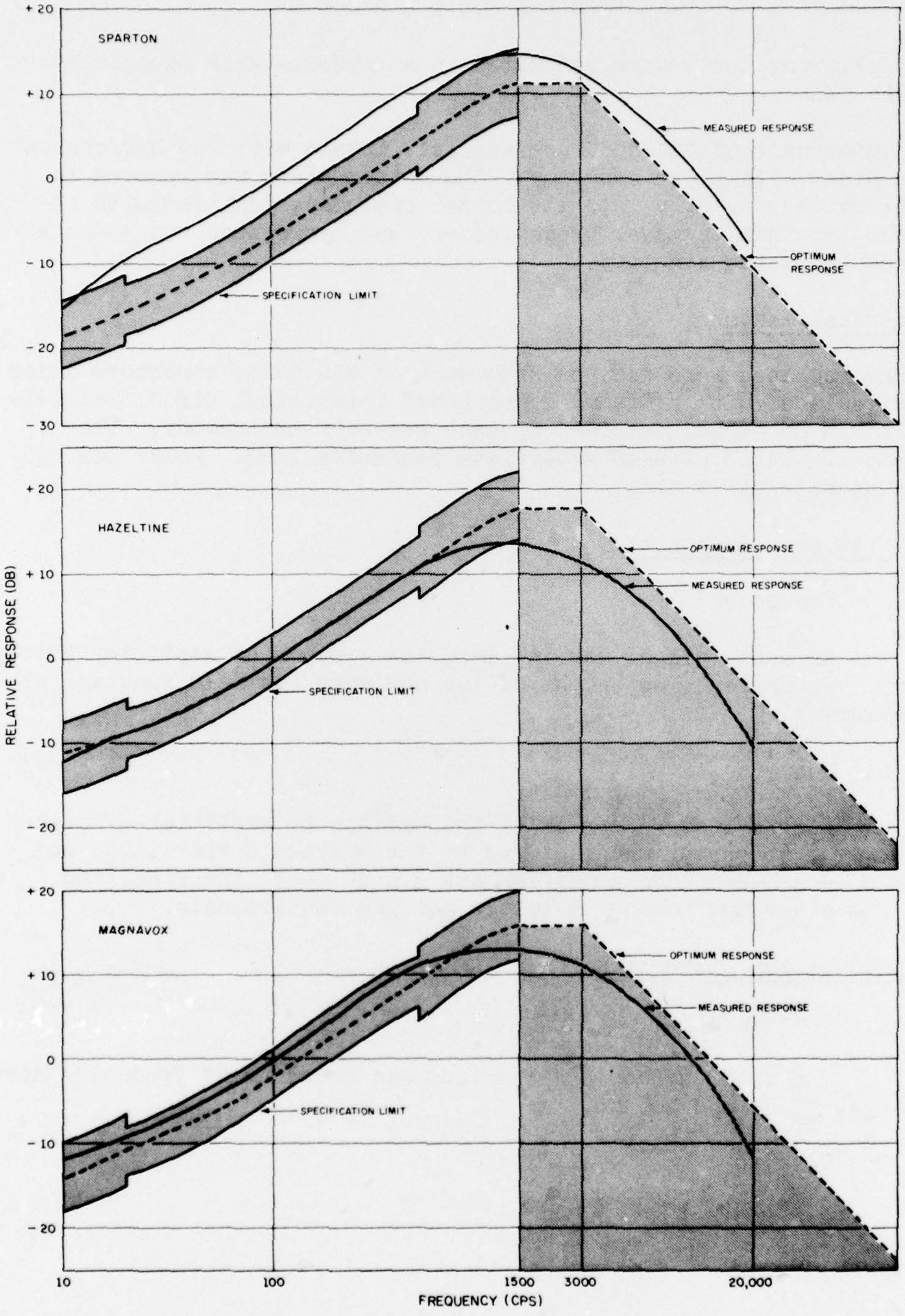


FIGURE 1 - Hydrophone Amplifier Frequency Response

TABLE I

MODULATION DISTORTION

Manufacturer	40 KC DEVIATION (PERCENT) 50 cps	100 cps	1 kcps	3 kcps	105 KC DEVIATION (PERCENT) 50 cps	100 cps	1 kcps	3 kcps
Sparton	2.6	2.6	3.0	2.8	1.2	1.5	2.0	2.2
Hazeltine	3.0	3.2	3.4	3.0	1.9	2.1	3.0	2.6
Magnavox	*	*	*	*	*	*	*	*

* Excessive d-c converter noise increased distortion to greater than 20 percent.

3. Harmonic Content and Spurious Oscillations

a. Procedure

The r-f carrier was analyzed for its frequency content and spurious oscillations.

b. Results

There were many spurious oscillations observed; only those frequencies that were less than 60 db below the sonobuoy channel frequencies were recorded. Figure 2 is an illustration of bar charts showing the harmonic content. It is noted that all of the sonobuoys tested met the specified 1-watt power requirement at the channel frequency.

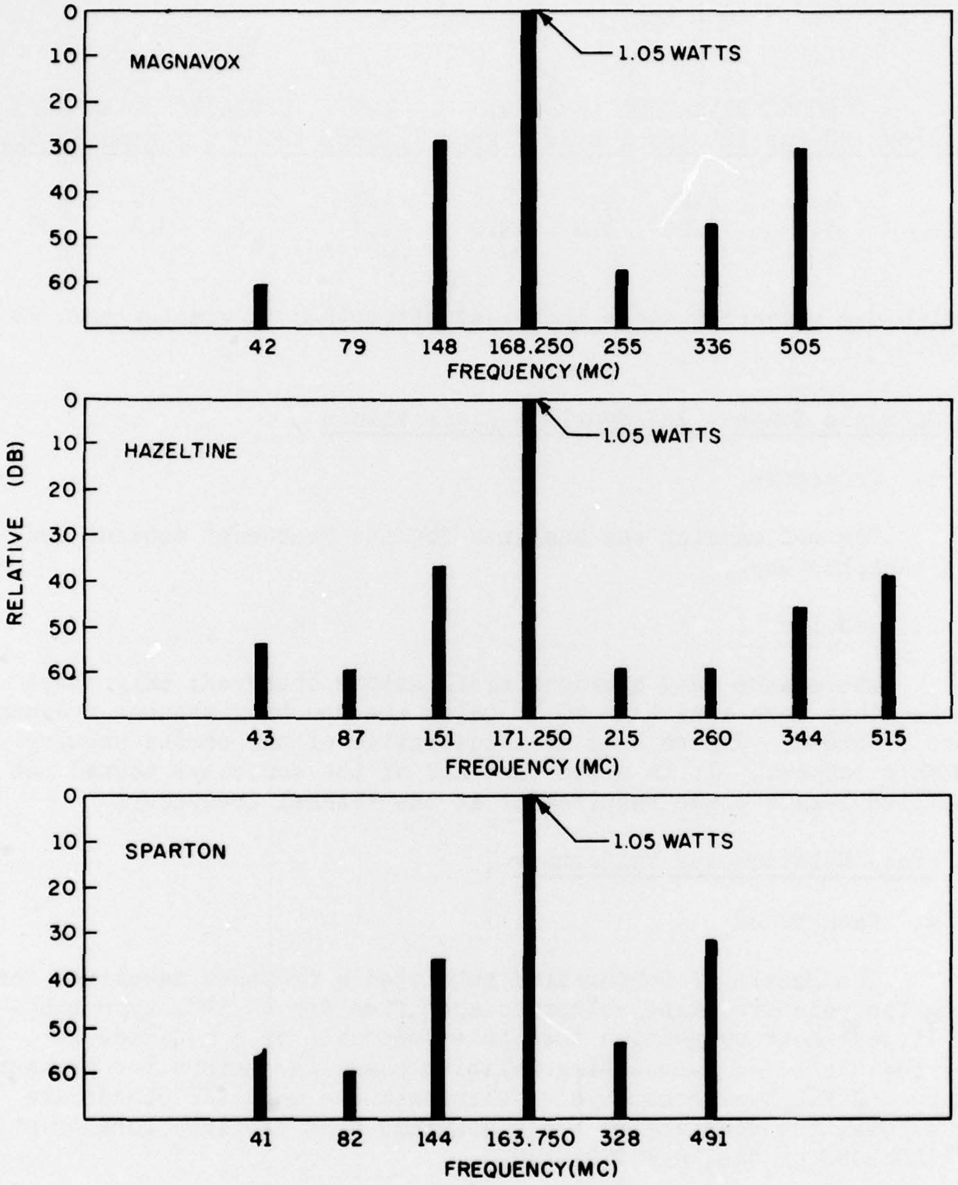
4. Phase Relation and Uniformity

a. Background

The Hazeltine Corporation submitted a proposed technique for measuring the relative phase relations specified for JEZEBEL type sonobuoys. It was their suggestion that this proposal, or a modified version, be the basis for formulating relative phase parameters for present and future JEZEBEL type sonobuoys to eliminate the need for coordinate testing between the contractors and a standard test facility located at the NAVAIRDEVCEN or the NAVAVIONICFAC.

The existing technique, established at the NAVAIRDEVCEN, was not planned to formulate design parameters but to measure the relative phase difference between two sonobuoys on the production line.

The NAVAIRDEVCEN technique, figure 3, involves measuring the phase difference between the input signal of the hydrophone amplifier and the demodulated output of the sonobuoy. The effect of the hydrophone



NOTE:
ALL FREQUENCIES MEASURED BELOW 60 DB ARE NOT RECORDED

FIGURE 2 - Harmonic Spectrum

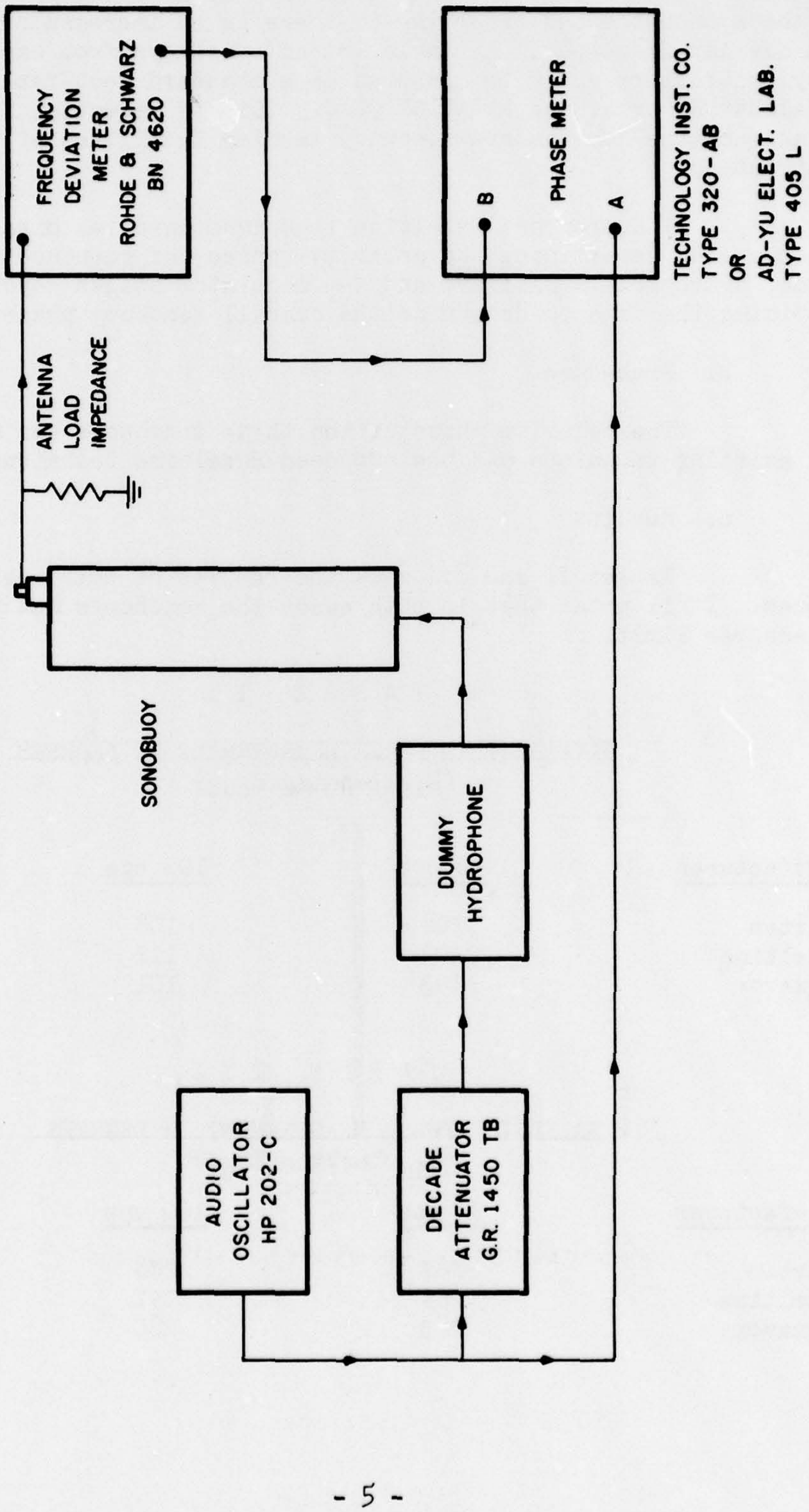


FIGURE 3 - NAVAIRDEVCEN Relative Phase Shift Measurement Method

polarity on the r-f carrier is determined by applying positive pressure on the hydrophone and observing if there is an increase or decrease of the carrier frequency. A sample lot of sonobuoys from each of the sonobuoy contractors would be measured on a standard test facility at the NAVAIRDEVCEN or at the NAVAVIONICFAC. This is essential for correlation because of the nonstandard sonobuoy testing facilities of the sonobuoy contractors.

The proposed Hazeltine technique involves disassembling the sonobuoy and determining the polarity (phase) of response for the hydrophone, hydrophone amplifier, and f-m modulator stages separately, then combining the data to determine the overall sonobuoy phase shift.

b. Procedure

The relative phase of the three sonobuoys was measured using the existing technique and the proposed Hazeltine technique.

c. Results

Tables II and III show the results of both measurement techniques. It is noted that in both cases the sonobuoys met the specified ±11-degree limit.

TABLE II

NAVAIRDEVCEN PHASE MEASUREMENT IN DEGREES
(E_{in} leading E_{out})

Manufacturer	50 cps	100 cps	500 cps
Sparton	102	108	141
Hazeltine	109	112	140
Magnavox	103	101	136

TABLE III

HAZELTINE PHASE MEASUREMENT IN DEGREES
(E_{in} leading E_{out})

Manufacturer	50 cps	100 cps	500 cps
Sparton	282	288	321
Hazeltine	289	291	320
Magnavox	283	280	316

There were some difficulties encountered when using the Hazeltine technique; primarily due to the mechanical design of the AN/SSQ-28 sonobuoy. The AN/SSQ-28 sonobuoy utilizes a hydrophone preamplifier, and two of the present AN/SSQ-28 sonobuoy contractors have combined the hydrophone and preamplifier in one unit. The disassembly of this unit, in order to measure the hydrophone and preamplifier separately, was both difficult and time consuming. The measurement of the transistorized amplifier and the reactance modulator (vari-cap) was difficult because of the amount of noise injected into these circuits when the sonobuoy was disassembled. The Hazeltine technique would be extremely difficult to use on a sonobuoy production line because of the time required to disassemble, measure, and then reassemble the sonobuoy. The Hazeltine Corporation technique proved to be inadequate for production line testing of the AN/SSQ-28 sonobuoy because of the time required with its use.

B. Environmental Tests

The sonobuoys were evaluated under simulated environmental conditions. The small sample of sonobuoys available at the time of the test, with no materials for refurbishing, made it mandatory that only the low temperature tests be conducted using the sonobuoy batteries. The sonobuoys were tested at ambient temperature with external power to simulate the high temperature tests.

1. Low Temperature

a. Frequency Stability

(1) Procedure

The three sonobuoys were stabilized at -20° C and then operated in 1-1/2 percent salinity water at 0° C.

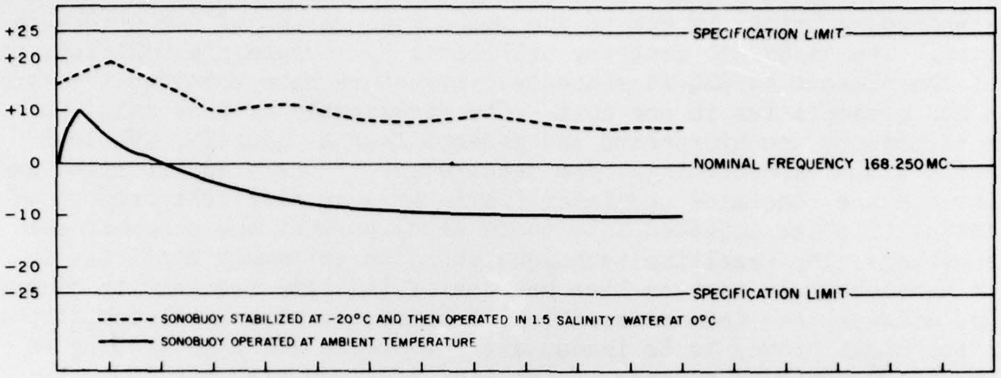
(2) Results

Figure 4 shows frequency drift curves indicating that all sonobuoys tested met the specified ±25 kc deviation limits.

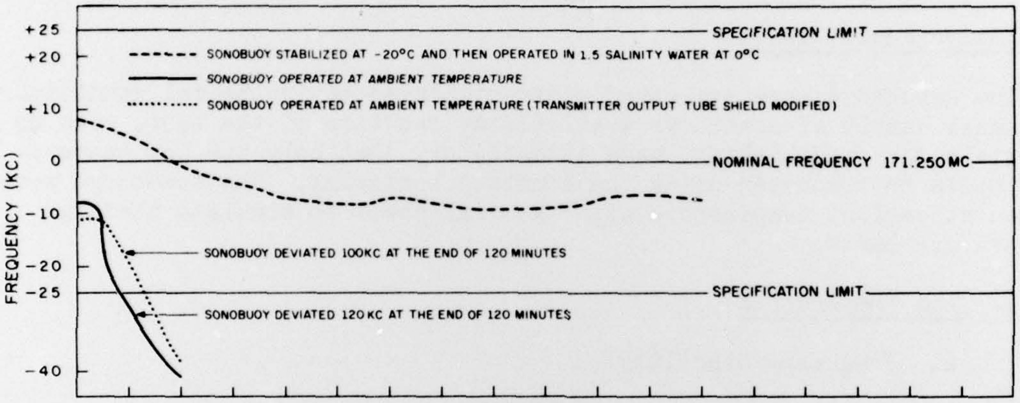
b. Transmitter Output Tube Bulb Temperature

(1) Background

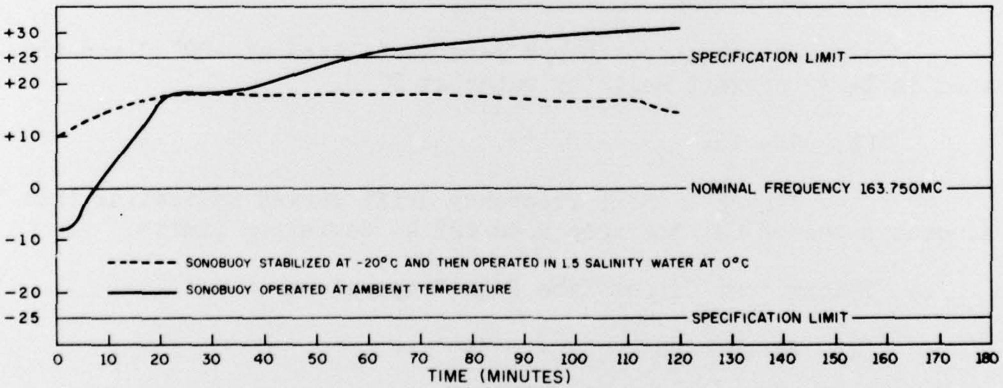
In the past it was believed that the power sag experienced by some AN/SSQ-28 sonobuoys might be caused by the transmitter output tube temperature increasing. High bulb temperature can seriously hamper tube reliability since this condition: (1) accelerates the evolution of gas; (2) causes "runaway" if the grid circuit resistance is too high; (3) promotes sublimation, which causes interelement leakage; and (4) increases interface resistance, which causes a "slump-off" in tube performance. During a visual examination of the three AN/SSQ-28 sonobuoys,



(A) MAGNAVOX



(B) HAZELTINE



(C) SPARTON

FIGURE 4 - Frequency Drift Curves

it was noted that the values of the drive resistors in the transmitter output stage were different. This would cause the output temperature to vary. It was also noted that the tube shield of the Hazeltine sonobuoy was not black as were the shields used in the other two sonobuoys. The black tube shields absorb the heat generated by the tube and provide a good thermal path to the chassis, thus reducing the bulb temperature.

(2) Procedure

A thermocouple was attached to the transmitter output tube which has a maximum allowable bulb temperature of 155° C. The sonobuoy was stabilized at -20° C and operated in 1-1/2 percent salinity water at 0° C.

(3) Results

TABLE IV

OUTPUT TUBE BULB TEMPERATURE

Time (min)	Sparton (°C)	Hazeltine (°C)	Magnavox (°C)
10	57	103	--
20	69	107	--
30	77	112	87
60	85	114	90
90	86	111	91
120	84	101	90

c. R-F Power Measurements

(1) Procedure

The antenna was replaced with an equivalent resistive load. The sonobuoy was stabilized at -20° C and then operated in 1-1/2 percent salinity water at 0° C.

(2) Results

TABLE V

R-F POWER

Time (min)	Sparton (w)	Hazeltine (w)	Magnavox (w)
10	---	2.0	2.0
30	2.2	1.7	2.2
60	2.2	1.7	2.2
90	2.0	1.4	2.2
120	1.6	1.1	2.0

d. Electrical Noise

(1) Procedure

The complete sonobuoy (with the hydrophone cable in place within the sonobuoy), the bottom plate removed with the battery in its normal operation position, the hydrophone replaced with a dummy hydrophone, and the hydrophone and hydrophone mass suspended a few inches out of the case, was stabilized at -20° C and operated in 1-1/2 percent salinity water at 0° C. The noise between the 0 and 500 cps band was analyzed using a 3-cycle bandwidth setting on the analyzer.

(2) Results

(a) Sparton Corporation - There was a 15-db rise of noise below 50 cps, although the increase of noise was still below the specified limits. Figure 5 is the record of the noise taken at 15-, 30-, and 120-minute intervals.

(b) Hazeltine Corporation - The sonobuoy came on the air with loud "crackling" and "frying" sounds. The crackling stopped when the hydrophone preamplifier, still activated, was removed from the water. The crackling returned when the hydrophone preamplifier was placed back into the water. Figure 6 is a record of the noise made at 15-, 60-, and 120-minute intervals. These records show an 8- to 12-db rise of noise below 50 cps. The records were made with the preamplifier out of the water but still activated. This was necessary to make a useable noise record. The preamplifier was left out of the water during the complete test. After 90 minutes of operation there were sharp clicks heard coming from the sonobuoy under test; the clicks continued until the end of the test.

(c) The Magnavox Company - The sonobuoy came on the air with sharp clicks and crackling sounds. The hydrophone preamplifier was removed from the water and the crackling noise ceased. After the sonobuoy had been operating for 20 minutes, the hydrophone preamplifier was returned to the water; figure 7(a) is a record of this noise. The preamplifier was again removed from the water to reduce the high noise level. Figure 7(b) is a record of the noise showing an increase of noise below 50 cps. Figure 7(c) indicates that the noise increased 26 db at 20 cps. This increase exceeds the specified limits. After the sonobuoy had been operating for 60 minutes the preamplifier was again placed into the water.

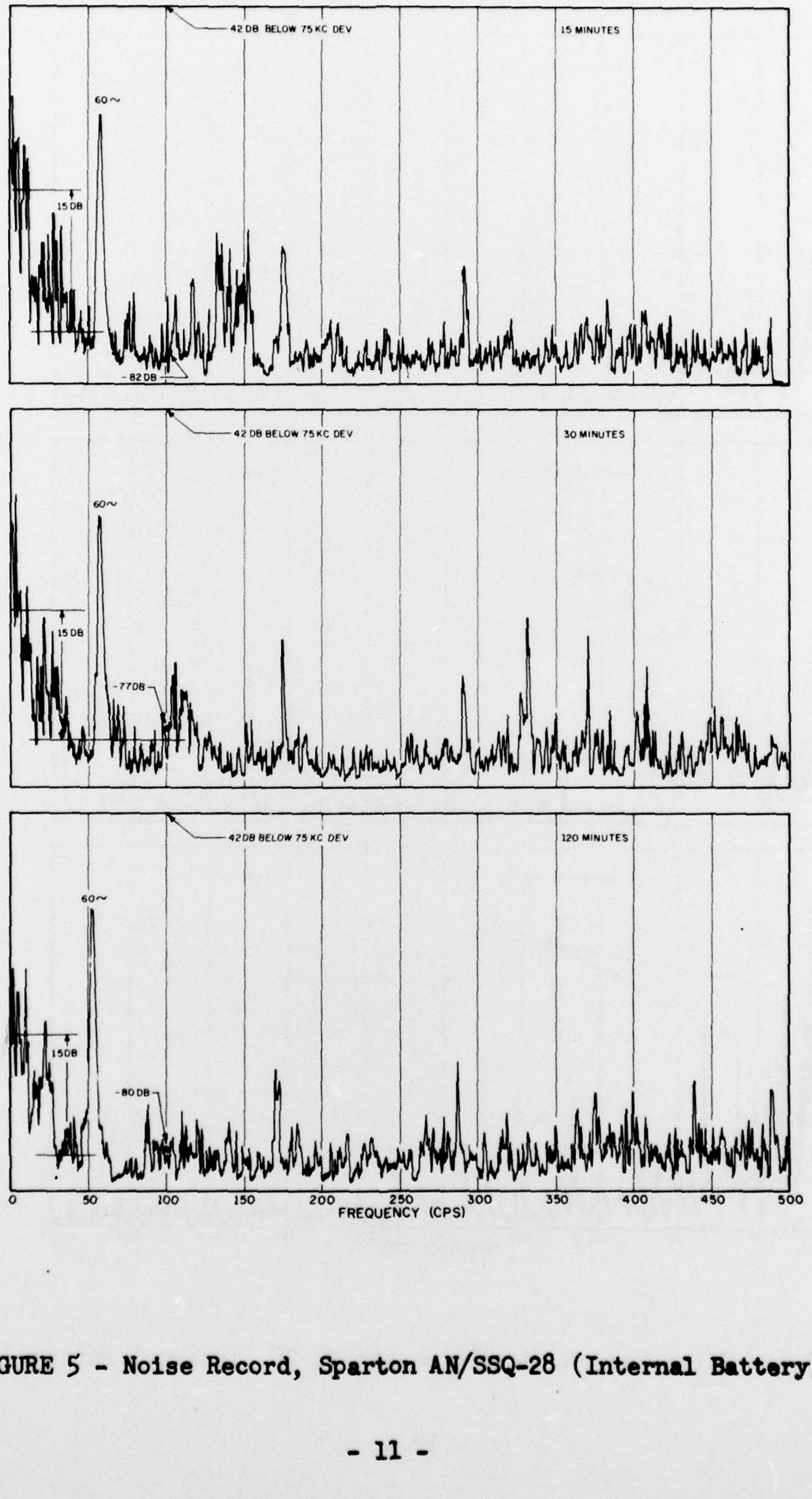


FIGURE 5 - Noise Record, Sparton AN/SSQ-28 (Internal Battery)

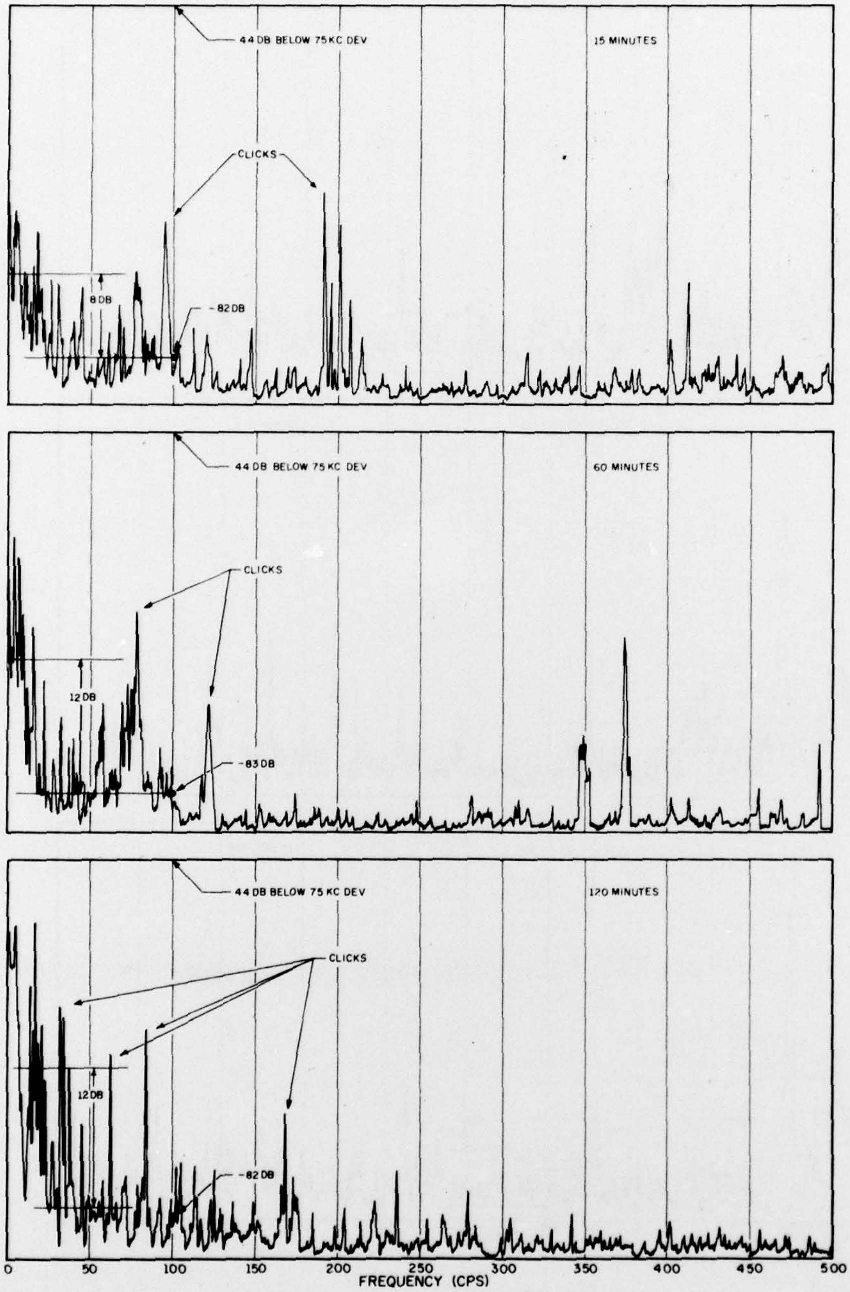


FIGURE 6 - Noise Record, Hazeltine AN/SSQ-28 (Internal Battery)

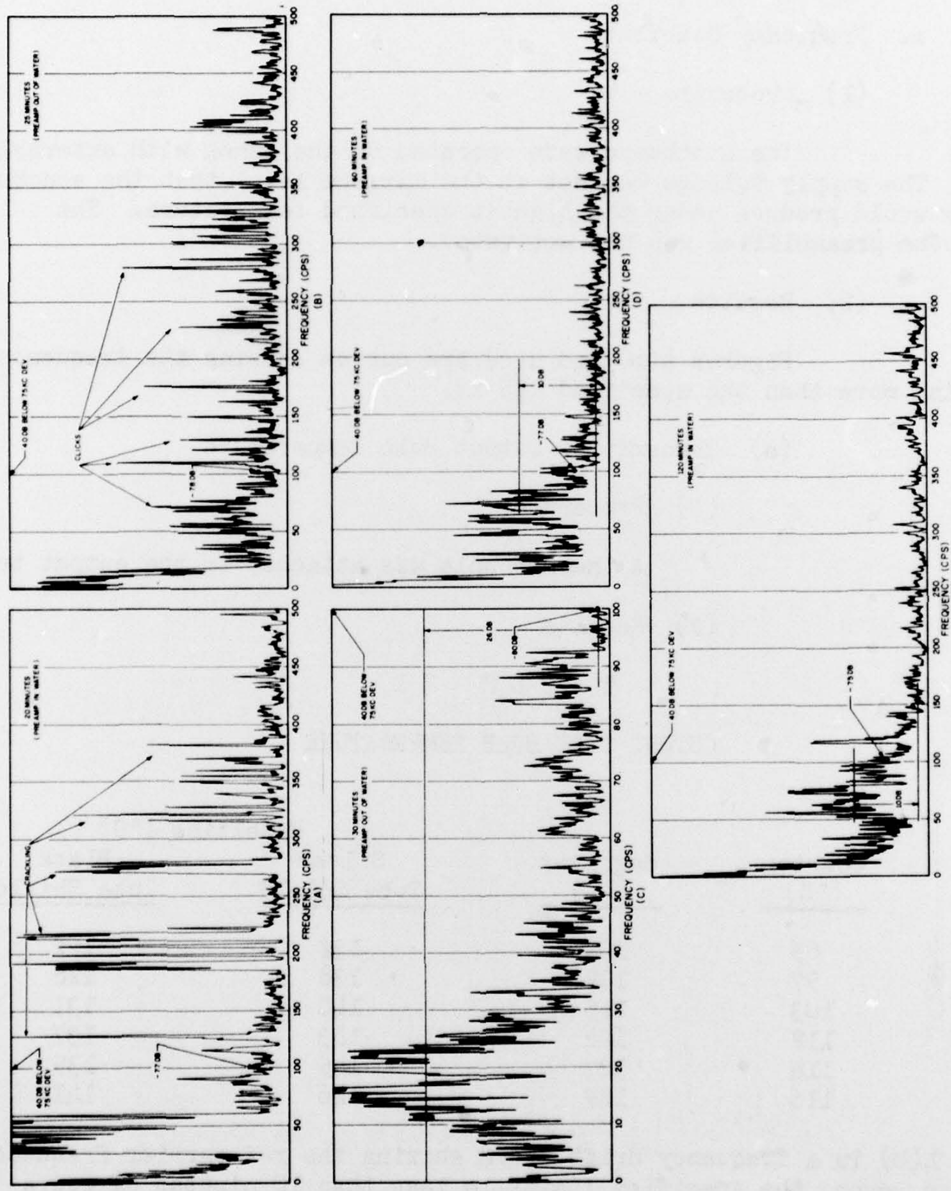


FIGURE 7 - Noise Record, Magnavox AN/SSQ-28 (Internal Battery)

Figures 7(d) and 7(e) are records taken at 60- and 120-minute intervals. These records show a 10-db rise of noise at 70 cps and the 26-db rise of noise below 50 cps.

2. Ambient Temperature

a. Frequency Stability

(1) Procedure

The sonobuoys were operated on the bench with external power. The supply voltage was set at the maximum level that the sonobuoy battery would produce under the highest specified temperature. The hydrophone preamplifier was not activated.

(2) Results

Figures 4(b) and 4(c) are curves showing the frequency deviating more than the specified ±25 kc.

(a) Transmitter Output Bulb Temperature

(1) Procedure

A thermocouple was attached to the output tube.

(2) Results

TABLE VI

OUTPUT TUBE BULB TEMPERATURE

Time (min)	Sparton (°C)	Magnavox (°C)	Hazeltine (°C) Silver Tube Shield	Hazeltine (°C) Black Tube Shield
10	85	105	132	122
20	97	109	138	128
30	103	115	140	131
60	112	124	143	137
90	114	127	145	139
120	116	129	146	141

Figure 4(b) is a frequency drift curve showing the r-f carrier frequency deviated beyond the specified limits in less than 10 minutes of operation. It was believed that this large deviation of the carrier frequency might have been caused by the high temperature of the transmitter output tube. The tube shield of the Hazeltine sonobuoy was changed from a silver colored shield to a black shield to reduce this temperature. Table VI shows a comparison of the bulb temperatures of the sonobuoys tested. The small reduction of heat caused by the black tube shield caused no significant change in the carrier deviation.

(b) R-F Power

(1) Procedure

The antenna was replaced with an equivalent resistive load. The sonobuoy was operated on the bench with external power. The supply voltage was set at the maximum level of the sonobuoy battery.

(2) Results

The voltage drop across the resistive load was measured and the power calculated (table VII).

TABLE VII

R-F POWER

Time (min)	Sparton (w)	Magnavox (w)	Hazeltine (w) Silver Shield	Hazeltine (w) Black Shield
10	1.9	2	1.8	1.7
20	1.9	2	1.6	1.6
30	1.8	1.8	1.6	1.6
60	1.7	1.8	1.4	1.5
90	1.6	1.8	1.3	1.6
120	1.4	1.6	1.3	1.6

C. Hydrophone Measurements

There were two types of hydrophones used in the AN/SSQ-28 sonobuoys tested. The Magnavox Company and the Hazeltine Corporation used the Bender-Dics type with the preamplifier combined in one unit. The Sparton Corporation used the "ball" hydrophone which was separate from the preamplifier.

1. Procedure

One hydrophone from each manufacturer was measured at the NAVAIRDEVCEN for capacitance, dissipation, and sensitivity.

2. Results

Figure 8 shows curves of the audio response of the hydrophones.

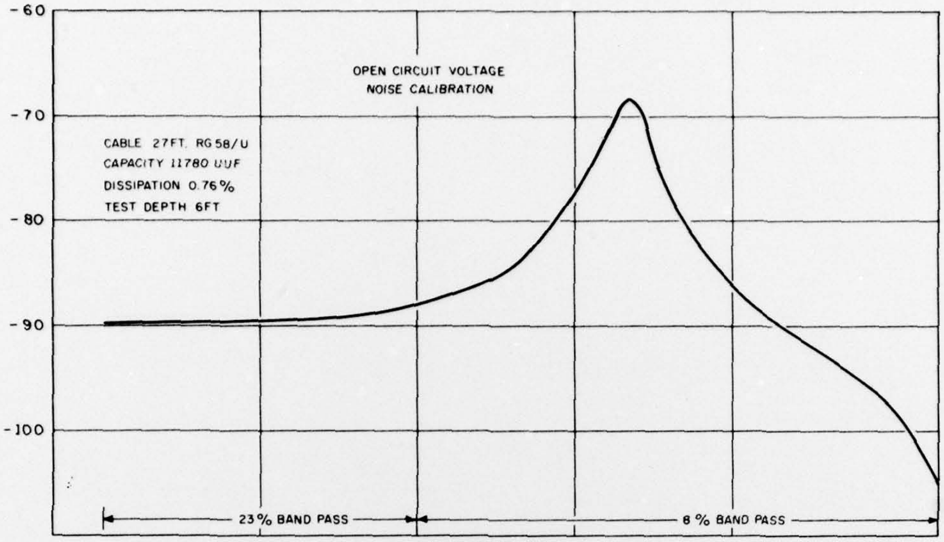
a. The Magnavox hydrophone, figure 8(a), shows a 22-db rise at 2500 cps.

b. The Sparton hydrophone, figure 8(b), is relatively flat with a maximum rise of 4 db at 4000 cps.

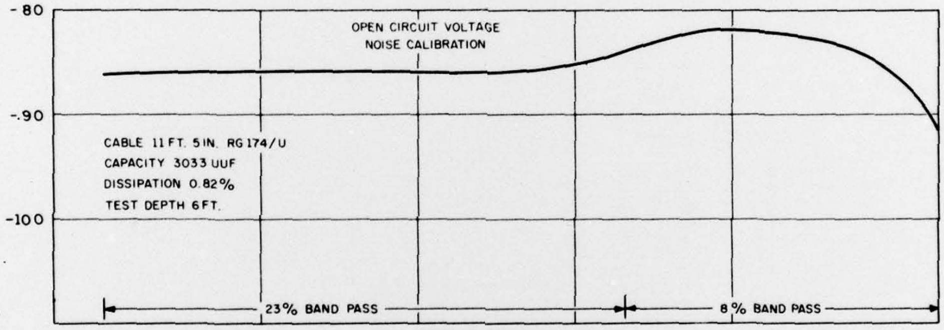
c. The Hazeltine hydrophone, figure 8(c), shows a 6-db rise at 2000 cps and falls off rapidly after this rise.

REFERENCES

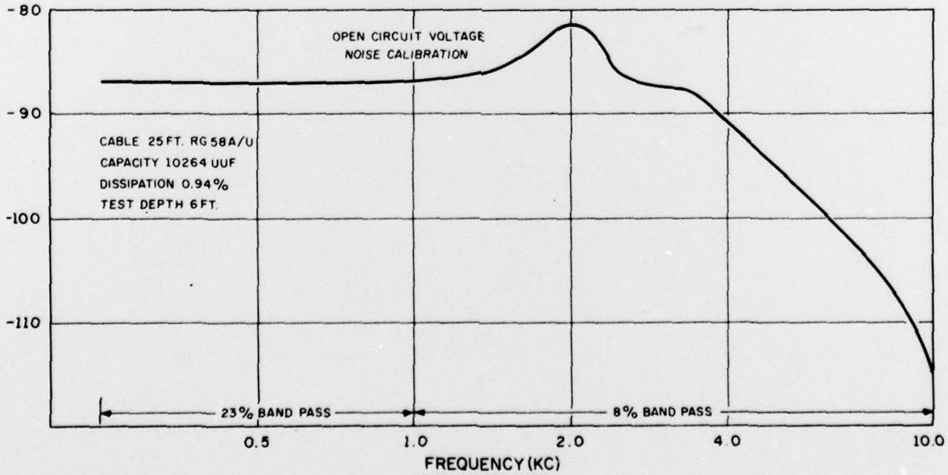
(a) WEPTASK RUDC2B000/2021/F001-13-07, Problem No. 519



(A) MAGNAVOX



(B) SPARTON



(C) HAZELTINE

FIGURE 8 - Hydrophone Receiving Response

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AN/SSQ-28 SONOBUOY, LABORATORY EVALUATION; by W. Leupold; 11 Sep 1962; 20 p; Report No. NADC-AW-6227; WEPTASK RUDC2B000/2021/F001-13-07, Problem No. 519.

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The sonobuoys were made available from each of the present manufacturers of the AN/SSQ-28; the contractors are the Magnavox Co., the Hazeltine Corp., and the Sparton Corp. This report covers the areas in which these sonobuoys did not meet the required limits of the specification.

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