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SOUND LEVEL TESTING OF THE STANDARD USN MK V AIR AND HELIUM-OXGEN DIVING HELMETS

Stephen D. Reimers, et al

Navy Experimental Diving Unit
Washington, D. C.

8 June 1973

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NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

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13. ABSTRACT

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Nine standard USN Mark V Air Diving Helmets and two standard USN Mark V Helium-Oxygen Diving Helmets were subjected to sound level testing on two specially built acoustical manikins at the Navy Experimental Diving Unit. The sound levels existing in the helmets were found to be into the hearing damage risk levels under nearly all the conditions tested. Wide variability in the measured sound levels was found to exist from helmet to helmet. The relationship of the test results to other similar work is discussed. Several possible ways of reducing the measured sound levels are presented.

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I. INTRODUCTION

Hardhat (helmet) divers have for years routinely reduced their air supply whenever they wished to communicate. Usually this has been blamed on poor communications. Another contributing factor, helmet noise, is now recognized.

High environmental noise levels have long been a recognized hazard in many military and industrial applications. However, their recognition as a hazard in diving applications has been a relatively recent event.

The Navy Experimental Diving Unit was the first to call attention to the problem in 1970 with the publication by Summitt and Reimers of their paper entitled "Noise, a Hazard to Divers and Hyperbaric Chamber Personnel"(1). There was a small amount of unpublished work done prior to that time, and there has been a considerable amount done since.

Summitt and Reimers reported the published literature bearing on the problem and treated the general occurrence and considerations of noise in diving applications. It is the purpose of this report to report in detail all the work that has been done to date at the Navy Experimental Unit on the Standard USN Mark V air and Mark V Helium-Oxygen Diving Helmets, and to tie it in with work done elsewhere.

II. TEST PROCEDURES

A. General Comments

The testing of the MK V Air Diving Helmet was done on three separate occasions. The equipment, techniques and procedures used were somewhat different each time as they were being constantly improved. The initial testing of 7 air helmets and 2 helium-oxygen helmets was done in NAVXDIVINGU's #5 recompression chamber in April, 1970. Two more air helmets were subsequently tested: one in a wet testing box in NAVXDIVINGU's #5 recompression chamber in August, 1972 and one in NAVXDIVINGU's #6 wet pot in March, 1973. The April, 1970 batch of testing work still constitutes the bulk of the sound level testing work that has been done to date on the MK V air helmet. It constitutes all of the sound level testing work known to have been done on the MK V helium-oxygen helmet.

B. Initial Testing, April, 1970

1. Apparatus

A test manikin consisting of a soft rubber head and a fiberglass torso was modified to accommodate a Bruel and Kjaer 1-inch condenser microphone and preamplifier at either the right or left ear position. The microphone head was recessed 1/4 inch from the surface of the manikin ear and was connected through appropriate wiring to a B&K sound level meter outside the chamber. Figure 1 shows a simplified schematic diagram of the complete experimental apparatus.

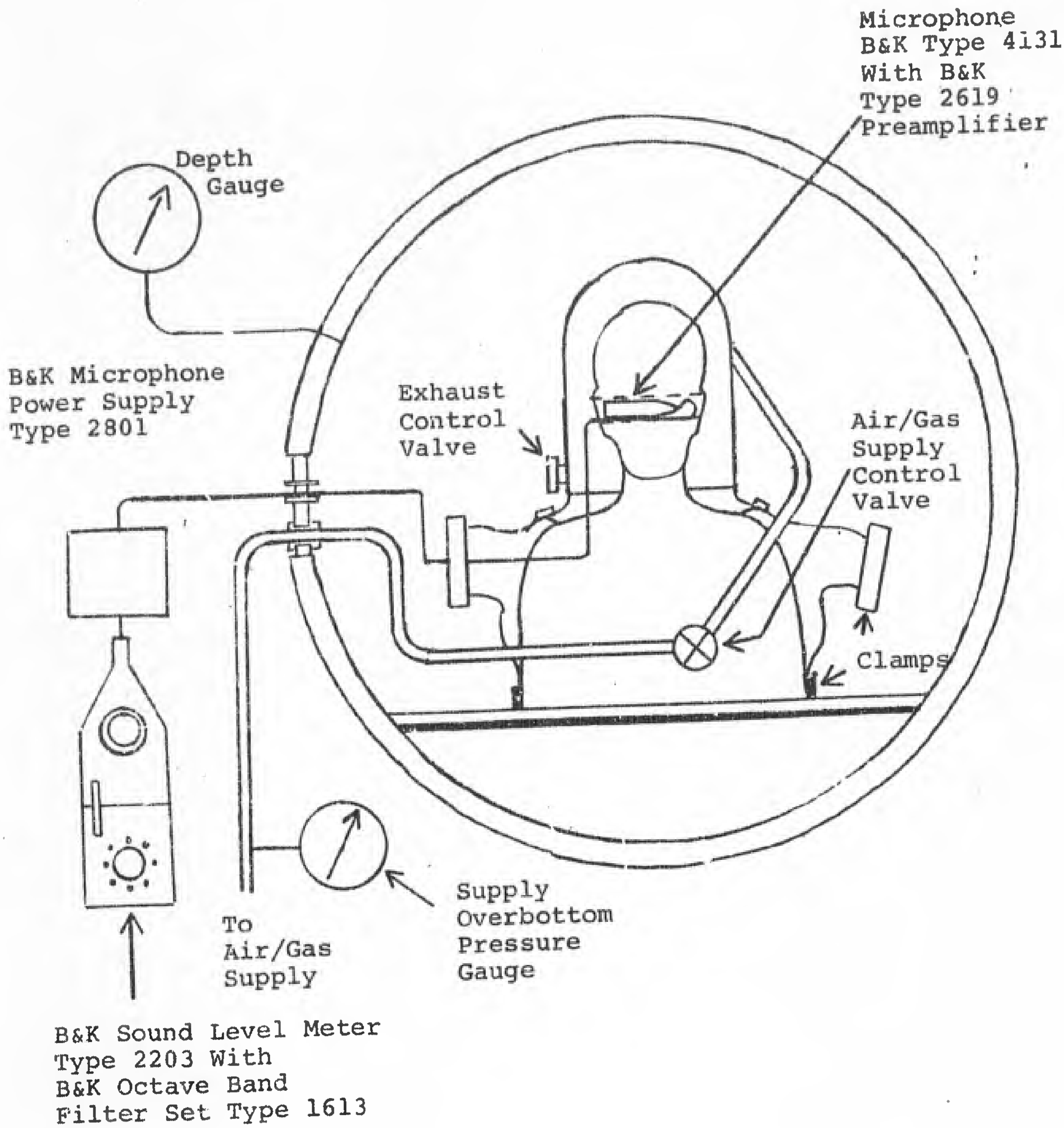

FIGURE 1

Test Set-Up for Measuring
Helmet Noise, April, 1970

The Mark V helmets are designed to be used only with a breastplate and standard deep sea diving dress. This necessitated placing the entire manikin inside the dress. To prevent over inflation of the dress, it was clamped tightly against the manikin torso just above its base. This level corresponds roughly to the hip joint level in a normal man. The excess dress was rolled up and tied off. The sleeves of the dress were clamped closed at the elbows with flat clamps, and the wires from the microphone were brought out through one of the clamps.

The entire apparatus was carefully watched and checked for leaks as these tended to increase the measured sound levels. None were observed to occur.

2. Procedure

a. Air Helmets

Supply air was provided to the helmet air control valve at a pressure nominally 100 psi over chamber pressure. The control valve was then positioned at a number of different settings and the octave band sound pressure levels inside the helmet were recorded at chamber pressures equivalent to 0, 50, 100, 150 and 200 feet of seawater. The helmet exhaust valve was positioned at full open in most cases with limited tests run with it set at 1/2 open. Both ear positions were tested.

b. Helium-Oxygen Helmets

Venturi mode sound levels were measured using a mixture of 16% helium and 84% oxygen at 100 psi over bottom pressure at depths of 0, 50, 100, 150 and 200 fsw. They were also measured using 100% oxygen at 50 psi over bottom pressure at depths of 0 and 50 fsw. Open circuit sound levels were measured under all the conditions described above, with the exception that air was substituted for oxygen. Air is much safer to use, and its acoustical properties are nearly identical to those of oxygen. Both ear positions were tested.

c. General

The helmets were tested dry in all cases, and there were no extraneous noise sources in the test chamber. After the helmet tests were completed, chamber background sound pressure levels were checked at all test depths and found to be insignificant.

The microphone calibration was checked before and after each test using a standard B&K Sound Level Calibrater Type 4230. No changes in microphone calibration were found.

3. Data Handling

The descriptive sound measurement most frequently used to determine noise risk in industry and in the Navy is the A-weighted sound level, dBA. This term also relates closely to the various noise-rating numbers used to describe interference with communications, annoyance and noise fatigue (4)(5)(6). Unfortunately, calibration curves for the A-weighted sound level measurement at increased ambient pressures as read directly from the sound level meter are not available. It was necessary to first correct the octave band sound pressure levels for increased pressure (9)(10)(11) and then determine an equivalent A-weighted sound level (dBA) from the equivalent sound level contours shown in Figure 2.

The pressure correction factors published by Thomas, Preslar and Farmer for B&K condenser microphones when used in an He-O_2 environment cover only certain specific He-O_2 mixtures (9). However, the procedures used to obtain the published correction factors and other unpublished work (10) provide nearly conclusive evidence that the correction factors contained in reference 9 are accurate for nearly all helium-oxygen mixtures of less than 50% oxygen.

The chamber ascent technique used was straight pressure bleed-off. Thus the helium percentage <u>on ascent only</u> was almost a constant 98.6% instead of the reported variable percentage. Yet there was no change in the microphone calibration from the descent tests where the percentage helium was considerably less. Unpublished tests by Thomas at 1 atmosphere have also indicated no significant difference in the calibration of B&K Type 4132 1" condenser microphones when used on mixtures of 80/20 (80% helium, 20% oxygen) 85/15; 90/10 ; 95/5 or 100% helium (10,.

Sound levels below 90 dBA could not be handled in the above manner. For surface tests the A-weighted recordings from the sound level meter were used directly. Under pressure the method described below was used to obtain an approximation of the dBA level.

The contour penetration method of determining the equivalent A-weighted sound levels described above, works well in cases where the dBA levels are controlled by noise in the 1000 to 4000 Hz center frequency octave bands. This was the case in all of the open circuit air helmet tests. In these cases, very close agreement was obtained between dBA levels calculated by this method and the dBA levels calculated by mathematically exact methods. These are accomplished by adjusting the measured octave band sound pressure levels by the appropriate A-weighting factor and then combining the results by the time-consuming, mathematically exact rules for addition of decibel expressed quantities(4)(12)(13)(14).

The contour penetration method, however, breaks down when the dBA levels are controlled by energy in the 125, 250, and 500 Hz center frequency octave bands. It gives dBA levels that are much too low. Here, the mathematically exact method or equivalent must be used. Under these conditions and when using 1" B&K condenser microphones, very close agreement with the mathematically exact method can be obtained by simply adding to [illegible] dBA reading

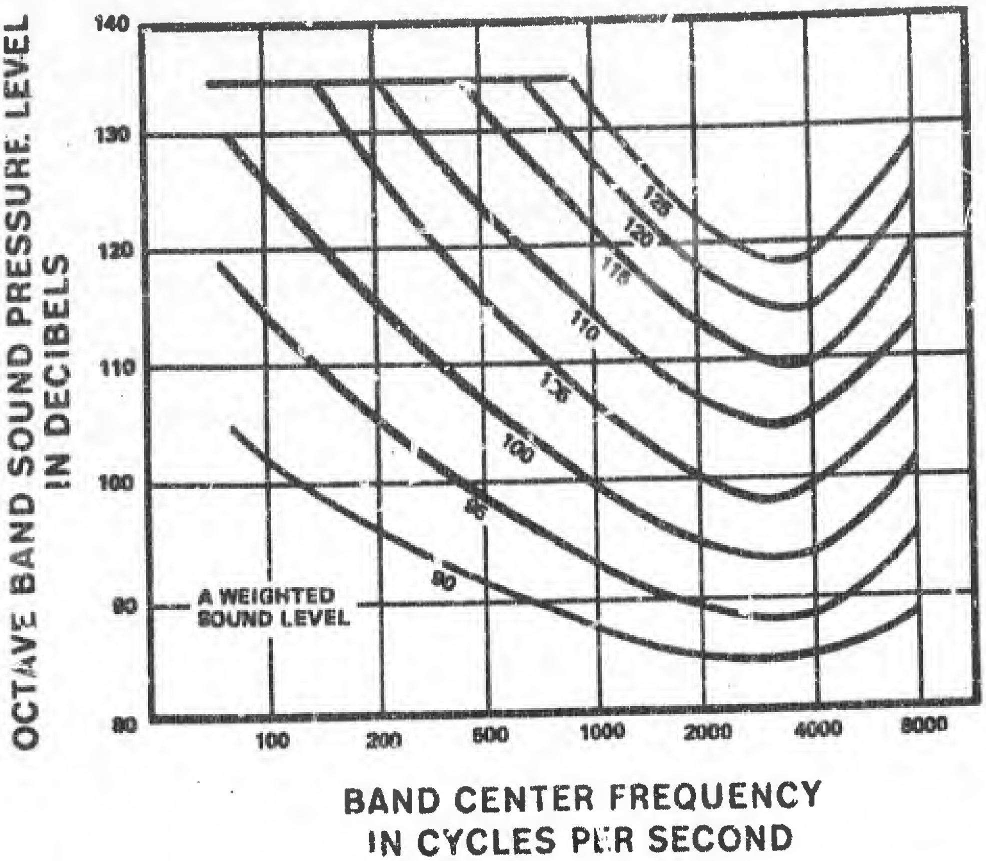

Fig. 2. Equivalent A-Weighted Sound Level Contours. Octave Band Sound Pressure Levels May Be Converted to the Equivalent A-Weighted Sound Level by Plotting Them on This Graph and Noting the A-Weighted Sound Level Corresponding to the Point of Highest Penetration into the Sound Level Contours (2).

from the sound level meter the microphone pressure correction factor for low frequencies. This occurs because for the B&K 1" condenser microphones, the pressure correction factors are essentially equal (to within [illegible] dB or less) for all octave bands with center frequencies up to and including 2000 Hz on air and up to and including 4000 Hz on helium-oxygen mixtures (9)(11). This was the method used to arrive at the equivalent dBA levels for the helium-oxygen helmets when used in the open circuit mode.

The point where one must use one of the latter methods occurs when the measured sound pressure levels in the octave bands with center frequencies at 125, 250, and 500 Hz exceed the measured sound pressure levels in the octave bands with center frequencies at 1000, 2000 and 4000 Hz by their A-weighted correction factors These are 3.3 dB for the 500 Hz, 8.7 dB for the 250 Hz, and 16.2 dB for the 125 Hz center frequency octave bands (4).

4. Discussion of Procedure

During these tests, and as is standard practice in fleet diving, the 100 psi over bottom pressure was maintained at the outlet of the pressure regulator controlling the pressure of the gas entering the diver's air manifold at the topside diving station. Subsequent experience (Section II.C) has demonstrated that for all but very small valve openings, there is very little resistance to flow in the gas control valve and the helmet plumbing downstream from it. Most of the resistance to flow in a standard MK V system is in the air hose and piping between the topside pressure regulation point and the gas control valve.

In a flowing gas line the incremental pressure drops are proportional to the incremental flow resistances. The incremental pressure drops must always add up to the total pressure drop. In the case of the Mark V helmet systems there is normally a 100 psi total pressure drop between the topside pressure regulation point and the point where the gas actually enters the helmet interior. The intermediate location over bottom pressures will vary between 0 and full over bottom pressure depending on how much of the total flow line resistance is downstream from them. For all but the smallest valve openings, there is very little flow line resistance in the gas control valve and its downstream plumbing. Consequently, the over bottom pressure existing at the gas control valve inlet under most situations is very low, usually no more than 5-10 psi. Of course, if the valve is closed or if anything happens to restrict the flow downstream from the valve, the over bottom pressure at the valve inlet will quickly rise to nearly the full, normally 100 psi, over bottom pressure.

The open circuit flow rates that existed under this section, although not monitored, are considered to have been approximately equal to those in Section II.C.

During semi-closed circuit (venturi) operation, the flow rates and supply pressures to the venturi during these tests are known. Since during venturi operation the flow rates are low, the helmet supply pressure is nearly equal to the topside controlled over bottom pressure. The primary flow resistance is the venturi nozzle itself. Other flow losses are negligible. Also, the flow rates through the venturi and recirculating through the CO_2 absorbant canisters are known for the depth ranges tested to be approximately .5 cfm and 6.0 cfm, respectively (15). See reference 15 for additional details.

The results obtained from these tests are still considered valid even though subsequent experience has demonstrated the high desirability of monitoring the helmet flow rate and the pressure actually reaching the control valve.

C. Subsequent Testing, August, 1972 and March, 1973

1. Apparatus

For these tests a CBS Acoustical Manikin, Model 1037-1, was borrowed from the Navy Electronics Laboratory Center at San Diego. A block diagram of the test set-up and the instrumentation used in the data collection is shown in Figure 3. The helmet under test was placed over the head of the CBS Acoustical Manikin. The manikin head was detached from its usual place on the manikin torso and mounted on a special waterproof base as shown in Figure 4. The helmet was held in place by a large 4-bolt plate clamp. The pressure from the clamp allowed a watertight seal to be maintained between the bottom of the helmet neck ring and the foamed neoprene glued to the top of the base.

For the tests conducted in August, 1972, the helmet and manikin head were placed in a plastic hexagonal box 2.5 feet in width and 4 feet deep. The box was located inside NAVXDIVINGU #5 recompression chamber (Figure 5). For the tests conducted in March, 1973, the helmet and acoustical manikin head were suspended approximately 1 foot off the bottom of NAVXDIVINGU's #6 wetpot. Water depth over the helmet was approximately four feet.

The CBS acoustical manikin normally includes a carefully designed human-like head, an upper torso, and an electronics box located under the torso. Bruel and Kjaer 1" condenser microphones, type 4132, are located at the ends of human-like ear canals in the head. The manikin's ears have been designed to have acoustical response patterns very close to those of human ears. Also contained in the head are the preamplifiers for the ear microphones and a calibrated speaker that serves as an artificial voice. Power supplies and signal conditioning circuits are located in the electronics box. There are no electronics

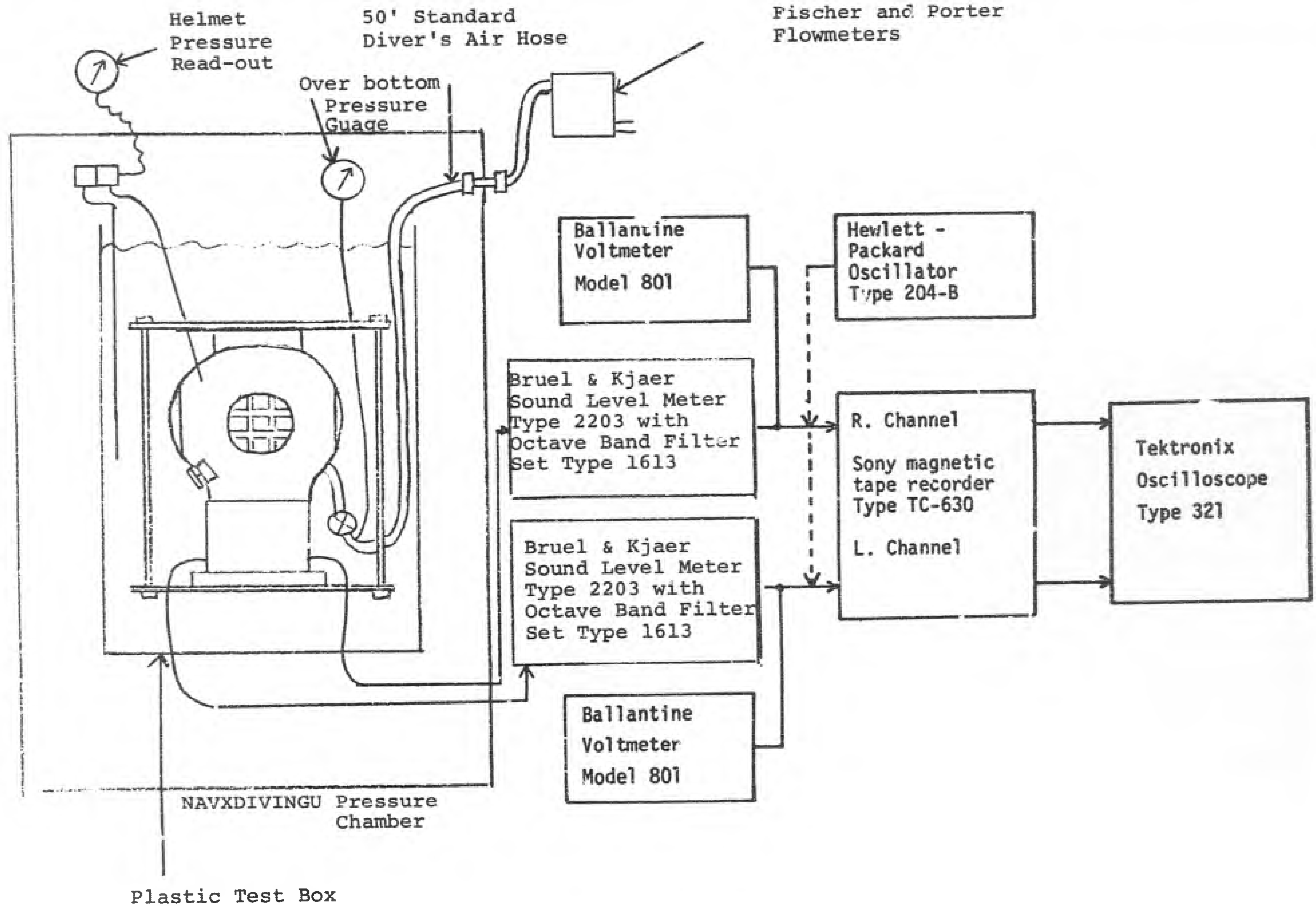

Figure 3 Test Set-up for Measuring Helmet Noise, August, 1972

Figure 4

CBS Acoustical Manikin Head on Waterproof Base.

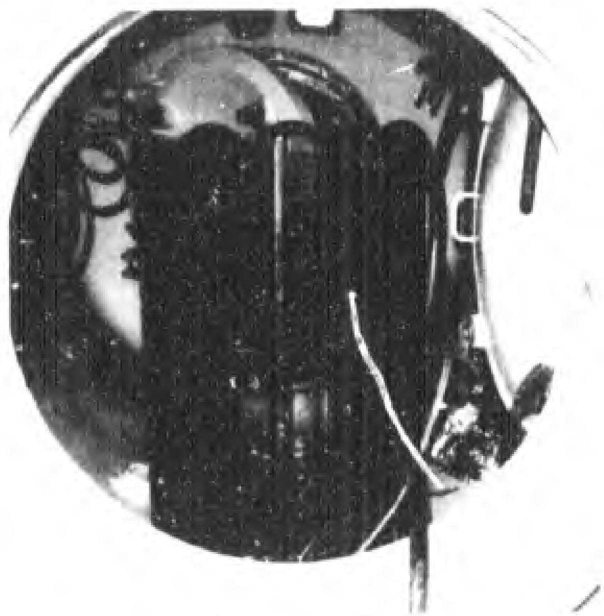

Figure 5

CBS Acoustical Manikin in Plastic Test Box in #5 Recompression Chamber during an Acoustic Test of the USN Prototype MK XII Diving Helmet. MK V Helmet Test Arrangement was Identical in the torso. For these tests the upper torso and electronics box remained outside the pressure chamber. (Further information about the manikin, if desired, may be found in reference 17. The acoustical manikin described therein is identical to the one used in these tests, with the exception that it has some additional signal conditioning capabilities shown in Figures 7 and 9, reference 17, which were not built into the manikin used for this work).

The outputs from the right and left manikin electronics were fed to B&K Type 2203 Sound Level Meters and B&K Type 1613 Octave Band filter sets plus recording equipment (Figure 3).

2. Procedure

Acoustic measurements were made at 50 foot increments from 0 to 250 feet sea water. The helmet air control valve was normally set at a pre-selected position, usually 1/2 or full open, and the flow rate through the helmet controlled by varying the topside supply pressure. Due to geometric considerations, the reach rods normally used to control helmet air control valves from outside the chamber could not be used. The exhaust valves were set at the fully closed position for all these tests to minimize the chances of flooding the helmet and manikin head.

The excess of pressure in the helmet interior over the outside water pressure was constantly monitored. This gave an indication of exhaust valve performance. Also, as long as it remained sufficiently positive it assured that the no flooding was occuring inside the helmet.

Several appropriate helmet air flow rates were tested at each depth.

The manikin ear microphones and supporting electronics were calibrated before and after each major test. No changes in calibration were found. Calibration sound signals were generated using a General Radio Type 1562-A Sound Level Calibrator with special coupler in the August, 1972 tests and a B&K Type 4230 Sound Level Calibrator in the March 1973 tests. The G.R. calibrator emits sound at known intensities at each of 5 selectable frequencies- 125, 250, 500, 1000, and 2000 Hz. The B&K calibrator is factory set at 1000 Hz.

3. Data Handling

Both octave band and 1/3 octave band analyses were performed. The octave band measurements were made on-line using the B&K Sound Level Meters and Octave Band Filter sets. From these octave band levels equivalent dBA levels were determined by the methods described in Section II, B.3.

The 1/3 octave band analysis was performed at the Naval Coastal Systems Laboratory using magnetic tape recordings taken from the amplifier output of the B&K Sound Level Meters. In this case the B&K Sound Level Meters were used as calibrated amplifiers to maintain the signal level going to the recorder within the dynamic range of the recorder. Reference 3 contains the detailed procedures used to maintain the recorder signal calibration and to analyze the taped data at NCSL. For ease of reference the 1/3 octave band analysis results are repeated in Appendix C.

Due to a flooded connector in the August, 1972 tests, the left ear channel was rendered inoperative. This also imposed a ground loop hum on the right ear that resulted in considerable background noise levels at the frequencies of 120, 180 and 240 Hz (the first 3 harmonics of power line frequency). The signal levels in the analysis bands containing these frequencies were often lower than the background noise. These cases are indicated in the data (Appendix C) by <xy where xy is the background level.

During the March, 1973 tests the preamplifier in the manikin head for the right ear malfunctioned causing the right ear microphone to exhibit an abnormal calibration. Consequently, data from that ear was not used.

III. RESULTS AND DISCUSSION

A. MK V Air Helmet

Table 1 gives the equivalent A-weighted sound levels obtained for the 7 air helmets that were tested in the dry mode (April, 1970). The helmets exhibited a wide variability in the sound levels they produced. Helmet A1, the oldest one (Circa 1912), and Helmet #7, the newest one (Circa 1967), exhibited the highest levels while the helmets of intermediate age exhibited the lowest levels. Figure 6 shows the mean and standard deviation for the sound levels measured at the right ear position for the condition of supply valve 1/4 open in helmets A1 through A6. The standard deviations are quite large, but the mean is reasonably steady at about 100 dBA for most depths.

It is worth noting here that there was little difference in the sound levels measured at the two different ear positions (see TAble 1). Exhaust valve position also had little effect on the measured sound levels (Appendix B).

Table 2 gives the equivalent A-weighted sound levels obtained for the 2 air helmets tested in the submerged condition.

The dBA values reported in Table 2 are generally about 7 dB higher than those in Table 1. Helmet A8 was the first helmet to be tested wet. The increased sound levels apparently resulting from submergence were first thought to be due to acoustic effects of the plastic test box. Much of the acoustic energy increase was in the 1000 and 2000 Hz center frequency octave bands, and the box dimensions were close to the wavelength of 2000 Hz sound in water.

Also, previous work done on the Aquadyne and Swindell Air Diving Helmets at NCSL (18) had indicated for those helmets that the sound level increase upon submergence occurred only in the lower frequencies (below 500 Hz). Work done by DiMattia and Panella on the USN Mark V helmet at the Naval Explosive Ordance Disposal Facility (7) (Appendix D) had indicated the same thing for the MK V. Their work, however, also reported equivalent dBA levels significantly higher than those measured at NAVXDIVINGU. The data from their General Radio P-5 Microphone indicates an equivalent dBA level of about 112 to 116. Data from their one reported test with the CBS Acoustical Manikin indicates an equivalent dBA level on somewhere around 125. This concern was what led to the testing of helmet A9 in NAVXDIVINGU's #6 wetpot, a much larger test cavity. The wetpot is 9 ft. 7½ inches in diameter and normally holds approximately 8000 gallons of water. The test results (see TAble 2) were not significantly different from the results for helmet A8, thus discounting the resonance argument. Also, helmet A9 itself exhibited a marked (about 10 dB) increase in most of its submerged condition sound levels over a dry condition reference test (Table 2, top line).

The apparent difference in the equivalent dBA levels reported in Tables 1 and 2 at this time has still not been adequately explained. It may be due simply to the wide acoustic variability from helmet to helmet. It may also be due to differing response characteristics between the "NAVXDIVINGU manikin" used for Section II.C. The calibration techniques and reference levels used for the two manikins were similar. However, no careful, direct

DEPTH FSW	SUPPLY VALVE SETTING	HELMET A1		HELMET A2		HELMET A3		HELMET A4		HELMET A5		HELMET A6		HELMET A7	
		R EAR POS.	L EAR POS.	R EAR POS.	L EAR POS.	R EAR POS.	L EAR POS.	R EAR POS.	L EAR POS.	R EAR POS.	L EAR POS.	R EAR POS.	L EAR POS.	R EAR POS.	L EAR POS.
SURFACE	1/8 OPEN	104	106		94		90		88		96		88	104	104
	1/4 OPEN	104	106		92		90		88		94		90	105	105
	1/2 OPEN	104	106											105	105
	3/4 OPEN	104	106											106	105
	FULL OPEN	104	106		92		107*		90		112*		88	106	
50 FEET	1/8 OPEN	106	107		101		96		94		101		97	101	
	1/4 OPEN	108	107		99		96		95		101		97	102	
	FULL OPEN	108	107		100		98		94		102		97	102	
100 FEET	1/8 OPEN	106	107		99		97		96		102		98	100	
	1/4 OPEN	107	106		99		96		96		102		98	100	
	FULL OPEN	106	106		100		97		96		103		98	101	
150 FEET	1/8 OPEN	106	106		99		94		96		100		98	99	
	1/4 OPEN	106	106		99		95		96		100		98	100	
	FULL OPEN	106	106		99		96		96		101		98	100	
200 FEET	1/8 OPEN	106	106		100		95		97		100		98	100	
	1/4 OPEN	106	106		101		95		96		100		100	101	
	FULL OPEN	106	106		101		97		96		100		98	101	

Table 1. Equivalent A-Weighted Sound Levels Obtained from Octave Band Sound Pressure Levels in MK V Air Helmets Tested Dry. Asterisk indicates non-return valve chatter.

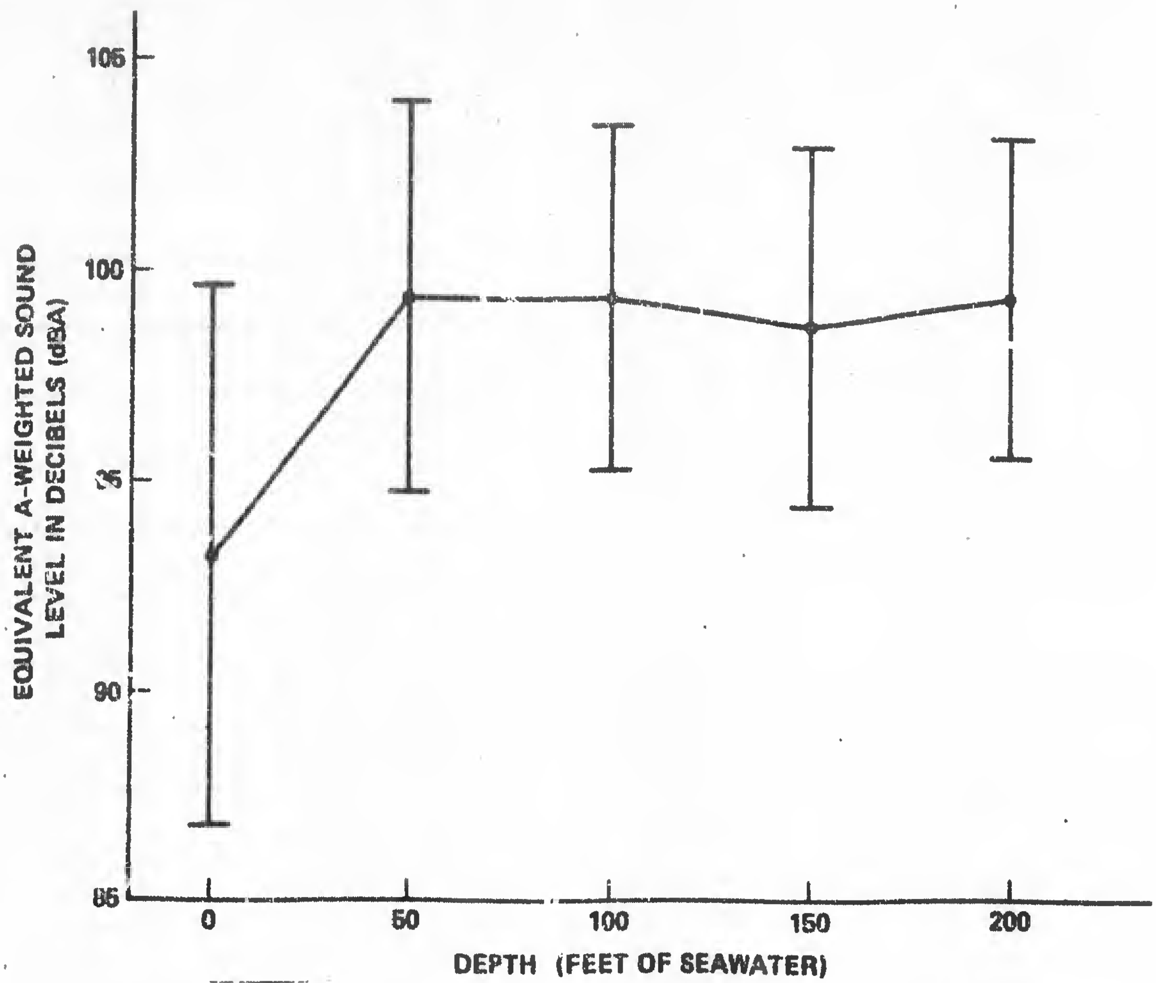

Figure 6.

Relationship Between Depth and the Equivalent A-Weighted Sound Levels Obtained from Measurements at the Right Ear Position of Helmets A1 Through A6 With the Supply Valve Set at 1/4 Open. The Horizontal Line Represents the Mean. The Vertical Lines Represent One Standard Deviation About the Mean.

				Helmet A8		Helmet A9	
Depth FSW	Supply Valve Position	Over Bottom Press. PSI	Flow Rate CFM	Left Ear Position	Right Ear Position	Left Ear Position	Right Ear Position
0 (dry)	1/4 OPEN	50	6.0			98	
2	FULL OPEN	~0	7.1		104		
4	1/2 OPEN	~0	9.0			104	
	1/2 OPEN	~0	4.5			96	
50	FULL OPEN	~0	3.6		101		
	1/2 OPEN	~0	3.1			99	
	1/2 OPEN	~0	5.1			105	
100	FULL OPEN	~10	5.0	This ear channel lost due to a flooded connector.	108		This ear channel lost due to a malfunctioning microphone.
	1/2 OPEN	~0	5.0			107	
	1/2 OPEN	~0	3.3			105	
	1/2 OPEN	~0	6.4			108	
150	FULL OPEN	~10	4.0		108		
	1/2 OPEN	~0	3.9			109	
	1/2 OPEN	~0	5.2			110	
200	FULL OPEN	~10	3.1		106		
	1/2 OPEN	~0	3.5			109	
	1/2 OPEN	~0	4.5			111	
250	FULL OPEN	N.A.	2.8		105		
	1/2 OPEN	~0	3.1			109	
	1/2 OPEN	~0	3.9			109	

Table 2

Equivalent A-Weighted Sound Levels Obtained From the Octave Band Sound Pressure Levels in the Two USN Mk V Air Diving Helmets Tested While Submerged Using the CBS Accoustical Manikin.

comparison of their response characteristics has been made, and this should be done. Such a comparison was planned for the March, 1973 tests, but it was scuttled due to a microphone preamplifier failure in the NAVXDIVINGU manikin.

The difference in the equivalent dBA levels obtained from the different tests is, however, in reality a matter of little importance. The salient point is that through all the known testing and regardless of the measurement techniques used, the sound levels measured for the Mark V Air Helmet have nearly always been well into the accepted damage risk levels. Figure 7 shows the currently accepted limits for safe daily (once each 24-hour period) exposure to high ambient noise levels (2)(4). The maximum and minimum levels obtained for halmets A1 through A9 are shown for ease of reference.

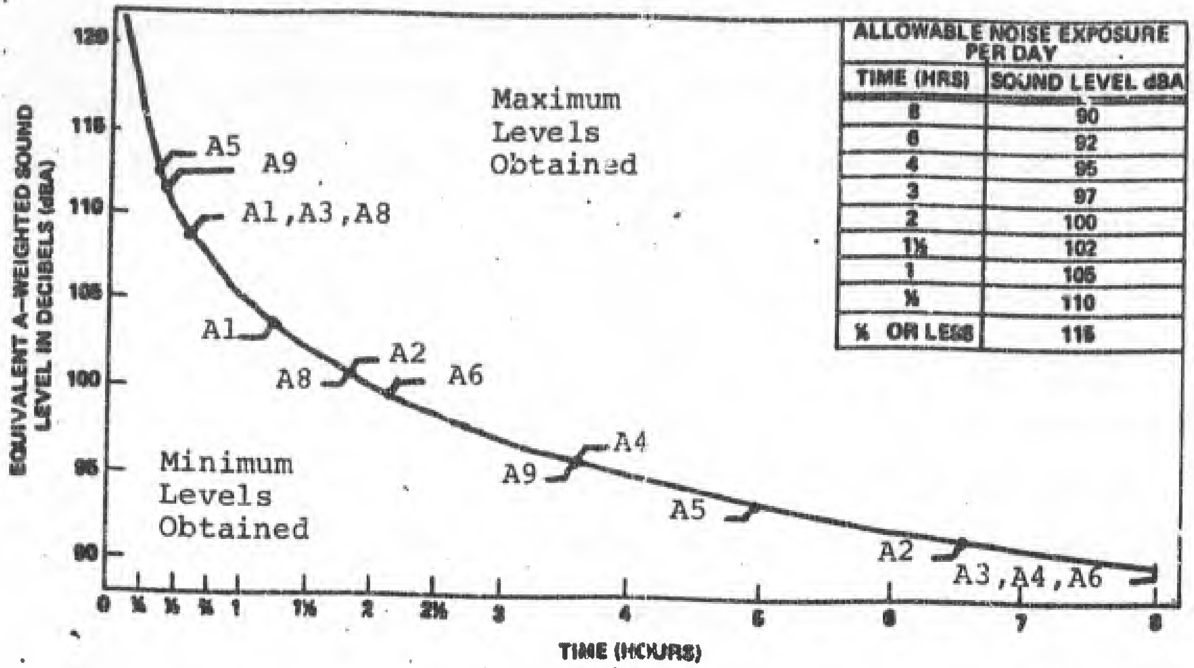

Figure 7.

Relationship Between the Currently Accepted Noise Exposure Limits (2)(4) and the Noise Levels Recorded in the Individual Diving Helmets A1 Through A9.

B. MK V Helium-Oxygen Helmet

Table 3 presents the equivalent dBA levels obtained for the two MK V Helium-Oxygen helmets tested dry while in the semi-closed-circuit mode. Table 4 presents the equivalent dBA levels obtained for the same helmets when used in the open circuit mode. The open circuit mode is used when changing gases, during an emergency air decompression, etc.

The sound levels evident in Table 3 are often into the damage risk levels, but generally not far enough to be a serious hazard. The maximum safe exposure times for most of them are long enough to allow completion of most dive profiles.

The indicated open circuit levels are dangerous. The octave band analysis (Appendix E) however, indicates that most of the noise is low frequency. This suggests the possibility that non-return valve chatter is the source. Non-return chatter in the air helmets (Tables A-3 and A-5, Appendix A) produced similar noise spectrums. The one open circuit test where this high low frequency noise was absent produced dBA equivalent levels similar to the air helmets. This was the test run 0 to 200 fsw with supply valve 1/8 open for helmet H2. The high low frequency noise was absent except at the surface (Table E-6). A diver will, if possible, adjust his supply valve so that he does not get non-return chatter. Consequently, it is felt that the MK V helium-oxygen helmet on open circuit is probably no more hazardous than the MK V air helmet. The divers should, however, be warned about the hazardous effects of non-return chatter, or high low

				Helmet H1		Helmet H2	
Depth FSW	Gas	Over Bottom Press. PSI	Exhaust Valve Position	Left Ear Position	Right Ear Position	Left Ear Position	Right Ear Position
0	O_2	50	1/2 OPEN		89		
50	O_2	50	1/2 OPEN		90		
0	16% HeO_2	100	1/2 OPEN	88	87		86
50	16% HeO_2	100	1/2 OPEN	94	92		93
100	16% HeO_2	100	1/2 OPEN	94	94		96
150	16% HeO_2	100	1/2 OPEN	98	94		97
200	16% HeO_2	100	1/2 OPEN	100	95		96

Table 3

Equivalent A-Weighted Sound Levels Obtained from the Octave Band Sound Pressure Levels in Two USN MK V Helium Oxygen Helmets Tested During Semi-Closed (Venturi) Operation.

				Helmet H1		Helmet H2	
Depth FSW	Gas	Supply Valve Position	Exhaust Valve Position	Left Ear Position	Right Ear Position	Left Ear Position	Right Ear Position
0	Air, O_2	1/4 OPEN	FULL OPEN		103		110
50	Air, O_2	1/4 OPEN	FULL OPEN		111		119
0	16% HeO_2	1/8 OPEN	1/2 OPEN	103	112		106
	16% HeO_2	1/4 OPEN	1/2 OPEN	103	106		108
50	16% HeO_2	1/8 OPEN	1/2 OPEN	110	112		99*
	16% HeO_2	1/4 OPEN	1/2 OPEN	109	115		116
100	16% HeO_2	1/8 OPEN	1/2 OPEN	111	112		99*
	16% HeO_2	1/4 OPEN	1/2 OPEN	111	116		116
150	16% HeO_2	1/8 OPEN	1/2 OPEN	112	113		100*
	16% HeO_2	1/4 OPEN	1/2 OPEN	113	114		118
200	16% HeO_2	1/8 OPEN	1/2 OPEN	114	115		96*
	16% HeO_2	1/4 OPEN	1/2 OPEN	115	116		119

* The extremely high sound pressure levels in the 125, 250 and 500 Hz center frequency octave bands, a characteristic of non-return valve chatter, were not observed in these test conditions. They were present in all other open circuit tests using the Mk V HeO_2 Helmet.

Table 4

Equivalent A-Weighted Sound Levels Obtained from the Octave Band Sound Pressure Levels in Two USN MK V Helium Oxygen Helmets Tested During Open Circuit Operation.

frequency noise coming from some other source in the HeO_2 helmet.

Further testing to clarify this question should be undertaken at the earliest practicable time.

C. Reducing the Equivalent dBA Levels

Divers generally like a certain amount of noise associated with their air supply. It gives them a feeling of security knowing that they can hear the air coming in. This is probably a major reason why one rarely hears a diver complain about a noisy helmet.

They do, however, complain about poor communications and often reduce their air supply when they wish to communicate. Examination of the dBA levels makes this very understandable. Noise levels in excess of 90 dBA generally make voice communication difficult to impossible even at point blank range (4)(5)(6). A trade-off in helmet design is necessary between good communications and the diver's desire to have some audio assurance that their air supply is still intact.

Experience to date indicates that reducing helmet noise levels while staying with the traditional designs is difficult. Several things have been tried with varying degrees of success.

NAVXDIVINGU tried simply adding a 1/2" thick layer of foamed neoprene to the inside of a MK V Air Helmet (Appendix F). It helped reduce the very low and very high frequency noise levels, but did nothing in the mid-frequency range near 1000 Hz. Consequently, it did little for the equivalent dBA levels (see Appendix F).

The Navy Prototype MK 12 Hardhat uses a specially designed air control valve. It is of the "velocity stack" type and helps keep down the noise level by avoiding high localized flow velocities in the control valve. Experience with it has so far been encouraging, but the dBA equivalent levels are still higher than desired (3). Also, there are some indications that noise from the exhaust valve may also be significant (8)(19).

The Naval Electronics Laboratory Center built a silencer system for the MK V Air Helmet in 1968. It was developed as part of an improved communication system and it appears to have some promise (16)(Appendix G). It uses standard acoustic mufflers which do cause a significant pressure drop. Table 2, however, indicates that in the MK V Air Helmet this pressure may be available since the pressure drop across the control valve is very low. It is recommended that this system be investigated further. It is inexpensive and could be easily installed by fleet personnel. If it proves to be as effective as claimed, it would be a significant benefit to the divers.

One thing that can and should be done with respect to the MK V helmets is to encourage the replacement of the original non-return valves as quickly as possible with the newer ones using the Kepner Products insert. The Kepner non-return insert is much less prone to chattering than are the older non-return valves(18)(20).

The possibility of using lower overbottom pressures should not be discarded, especially for the MK V helmet. For the MK V, high overbottom pressures are not necessary at the helmet. Experience with other helmets has indicated that dropping the supply pressure from 100 psi overbottom to 50 psi overbottom, usually drops the equivalent dBA levels 5 to 10 dB (3)(19). With lower overbottom supply pressures, flowmeters in the diver's topside air manifold would be necessary for diver confidence and safety. These are, however, available in rugged models.

It is worth noting here for future helmet designers, that having an air control valve physically detached from the helmet as in the case of the MK V may be very advantageous from a noise point of view. It allows the use of acoustic silencing techniques not possible with a valve located on the helmet, and it makes it possible to avoid a rigid mechanical connection between the valve and the helmet shell.

IV. CONCLUSIONS

1. The sound levels existing inside the MK V Air Helmet are well into the damage risk levels under almost all conditions of normal use.
2. The sound levels existing inside the MK V Helium-Oxygen Helmet when in the semi-closed circuit mode are often into the damage risk levels.
3. The sound levels existing inside the MK V Helium-Oxygen Helmet when in the open circuit mode are well into the damage risk levels under almost all conditions.
4. The sound levels in both helmets are high enough to make voice communication difficult regardless of the quality of the communication system.
5. The method for arriving at equivalent dBA levels from octave band sound pressure levels described in BUMED INSTRUCTION 6260.6B, 1970 does not work when the acoustic energy is heavily concentrated in the frequency range below 500 Hz.

V. RECOMMENDATIONS

A completely new deep sea diving system, the MK XII Prototype Deep Sea Diving Outfit, is undergoing sea trials at this time. The MK XII Outfit may be used for either air or helium-oxygen diving. Considerable attention is being paid to the acoustic characteristics of the MK XII helmet, and it is expected to have sound levels that are safe for all exposure times.

Consequently, an extensive, expensive program to reduce the sound levels in the MK V air and helium-oxygen helmet is not considered to be warranted at this time, particularly when their limited use is taken into account. It will, however, be some time, probably 3 to 4 years, before the MK XII Diving Outfits reach the fleet in significant numbers. Limited efforts to achieve at least some reduction in the sound levels existing in the MK V air and helium-oxygen helmets are therefore considered desirable and waranted. It is in this light that the following recommendations are made.

1. Investigate the sound level reduction capabilities of the NELC muffler system.
2. Parallel with recommendation 1, look into other inexpensive ways of reducing the sound levels in the MK V helmets.
3. Encourage the speedy replacement of old type non-return valves with the newer ones using the Kepner Products Insert.
4. Require careful inspection of the audiogram history for 1st and 2nd class divers each time they have their annual physical.

5. Procure a CBS Acoustical Manikin or equivalent for NAVXDIVINGU.

6. Retest the MK V Helium-Oxygen Helmet as soon as practicable to determine if non-return chatter or other causes were the source of the very high open circuit sound levels measured.

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APPENDIX A

OCTAVE BAND SOUND PRESSURE LEVELS AND CALCULATED EQUIVALENT dBA LEVELS IN 7 STANDARD USN MK V AIR DIVING HELMETS

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	77	84	84	79	90	92	98	98	96	84	104
	1/4 OPEN	76	84	84	78	90	92	98	98	96	84	104
	1/2 OPEN	76	84	84	78	91	92	98	98	97	84	104
	3/4 OPEN	77	84	84	79	92	93	98	98	96	84	104
	FULL OPEN	77	84	84	79	92	94	98	98	96	84	104
50 FEET	1/8 OPEN	77	84	85	80	92	96	102	98	92	83	106
	1/4 OPEN	79	84	86	80	93	96	104	99	90	82	108
	FULL OPEN	79	82	85	82	96	98	104	97	90	82	108
100 FEET	1/8 OPEN	76	86	86	80	94	96	102	96	92	80	106
	1/4 OPEN	80	86	86	82	94	96	103	98	88	79	107
	FULL OPEN	78	84	86	83	96	99	103	98	90	79	107
150 FEET	1/8 OPEN	78	90	88	82	95	95	101	96	90	76	106
	1/4 OPEN	78	90	88	83	96	96	102	98	86	76	106
	FULL OPEN	78	86	86	84	98	100	102	98	88	76	106
200 FEET	1/8 OPEN	78	88	88	83	96	96	102	96	104	84	106
	1/4 OPEN	79	87	89	84	98	96	102	98	100	80	106
	FULL OPEN	79	86	89	86	101	101	102	99	98	78	106

Table A-1L Sound Levels in USN Mk V Air Diving Helmet A1 (Very Old) April 16, 1970
Serial Number Unknown, Left Ear Position, Exhaust Valve Fully Open

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DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	79	84	84	76	87	91	100	100	95	87	106
	1/4 OPEN	79	85	83	76	87	91	100	100	96	87	106
	1/2 OPEN	80	84	82	76	88	91	100	100	96	87	106
	3/4 OPEN	80	84	83	76	89	92	100	100	96	87	106
	FULL OPEN	81	85	83	76	90	92	100	100	96	87	106
50 FEET	1/8 OPEN	81	86	86	78	90	93	103	98	90	84	107
	1/4 OPEN	81	86	86	78	90	94	103	98	91	84	107
	FULL OPEN	81	86	86	79	93	94	103	99	91	84	107
100 FEET	1/8 OPEN	78	88	88	78	92	94	103	98	89	80	107
	1/4 OPEN	78	88	88	78	92	94	102	98	90	81	106
	FULL OPEN	79	88	88	80	94	96	102	99	90	81	106
150 FEET	1/8 OPEN	80	90	88	80	92	94	102	99	86	76	106
	1/4 OPEN	79	91	88	80	93	94	101	99	86	77	106
	FULL OPEN	78	90	90	81	96	96	102	99	88	78	106
200 FEET	1/8 OPEN	80	88	88	80	93	94	102	98	96	76	106
	1/4 OPEN	79	88	89	81	94	94	102	98	88	74	106
	FULL OPEN	79	89	89	82	98	97	102	99	90	76	106

Table A-1R Sound Levels in USN Mk V Air Diving Helmet A1 (Very Old) April 16, 1970
Serial Number Unknown, Right Ear Position, Exhaust Valve Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	66	68	71	77	87	87	84	87	88	86	94
	1/4 OPEN	66	68	72	78	88	87	84	86	88	88	92
	FULL OPEN	67	68	72	79	88	88	83	86	88	86	92
50 FEET	1/8 OPEN	73	72	79	86	92	93	90	94	93	90	101
	1/4 OPEN	71	72	78	87	92	93	90	92	92	90	99
	FULL OPEN	72	72	79	88	94	94	90	93	92	91	100
100 FEET	1/8 OPEN	72	72	82	86	92	94	90	92	90	90	99
	1/4 OPEN	72	72	82	88	94	94	90	92	90	88	99
	FULL OPEN	72	72	85	89	96	96	91	93	90	88	100
150 FEET	1/8 OPEN	72	74	84	88	94	96	92	92	88	86	99
	1/4 OPEN	72	74	85	90	94	96	91	92	87	84	99
	FULL OPEN	74	74	88	92	97	98	92	92	87	86	99
200 FEET	1/8 OPEN	72	74	92	91	95	96	93	93	86	84	100
	1/4 OPEN	72	75	89	92	96	97	92	94	87	82	101
	FULL OPEN	74	75	92	92	98	99	94	94	86	84	101

April 23, 1970

Table A-2 Sound Levels in USN Mk V Air Diving Helmet A2, Serial Number 07, Right Ear Position, Exhaust Value Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	59	64	67	76	83	84	84	84	85	84	90
	1/4 OPEN	63	64	69	78	84	84	84	84	88	84	90
	FULL* OPEN	112	113	112	112	118	92	84	84	84	83	107
50 FEET	1/8 OPEN	66	68	77	84	89	90	89	89	88	88	96
	1/4 OPEN	76	72	78	82	91	90	90	89	93	90	96
	FULL OPEN	78	72	79	88	94	93	92	91	92	90	98
100 FEET	1/8 OPEN	66	70	81	86	92	92	90	90	88	87	97
	1/4 OPEN	78	72	81	84	92	92	90	86	91	86	96
	FULL OPEN	80	73	82	90	94	94	91	89	92	86	97
150 FEET	1/8 OPEN	68	71	82	84	92	92	88	88	85	82	94
	1/4 OPEN	82	76	84	88	94	93	88	86	87	84	95
	FULL OPEN	82	76	84	90	94	94	88	87	86	81	96
200 FEET	1/8 OPEN	68	62	85	87	93	93	88	88	84	80	95
	1/4 OPEN	71	73	87	89	94	84	88	88	86	81	95
	FULL OPEN	71	76	86	92	96	96	89	89	86	80	97

* Non-Return Valve Chattering

April 22, 1973

Table A-3 Sound Levels in USN Mk V Air Diving Helmet A3
Serial Number 8, Right Ear Position, Exhaust Valve Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	67	69	70	71	84	80	81	82	79	75	88
	1/4 OPEN	67	68	69	71	84	80	81	82	78	75	88
	FULL OPEN	68	67	70	73	87	82	83	84	80	77	90
50 FEET	1/8 OPEN	71	71	79	78	92	87	89	87	85	80	94
	1/4 OPEN	71	71	80	80	93	88	89	88	86	83	95
	FULL OPEN	69	71	79	77	91	87	88	86	86	80	94
100 FEET	1/8 OPEN	70	73	82	78	88	90	90	83	88	77	96
	1/4 OPEN	72	70	80	78	92	89	90	88	86	80	96
	FULL OPEN	72	72	80	78	93	89	90	87	88	79	96
150 FEET	1/8 OPEN	72	74	84	80	93	90	90	87	83	78	96
	1/4 OPEN	72	72	84	80	93	90	90	86	81	78	96
	FULL OPEN	70	73	86	80	94	90	90	86	80	78	96
200 FEET	1/8 OPEN	72	76	86	80	94	91	91	88	81	78	97
	1/4 OPEN	72	73	86	81	94	92	90	88	80	78	96
	FULL OPEN	73	74	87	81	95	92	90	86	80	78	96

April 23, 1970

Table A-4 Sound Levels in USN Mk V Air Diving Helmet A4
Serial Number 630, Right Ear Position, Exhaust Valve Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	66	68	72	77	79	85	90	87	90	84	96
	1/4 OPEN	63	67	71	77	78	82	88	84	88	82	94
	FULL* OPEN	110	115	112	106	94	86	85	84	86	81	112
50 FEET	1/8 OPEN	68	72	77	80	82	90	95	92	94	86	101
	1/4 OPEN	68	73	78	81	81	90	95	92	93	86	101
	FULL OPEN	68	73	79	82	86	90	96	93	93	86	102
100 FEET	1/8 OPEN	68	72	79	82	82	90	96	92	90	84	102
	1/4 OPEN	68	73	80	84	82	90	96	91	92	84	102
	FULL OPEN	68	74	82	84	84	92	98	93	94	84	103
150 FEET	1/8 OPEN	68	72	82	84	84	92	94	91	87	81	100
	1/4 OPEN	68	76	88	76	75	93	94	90	87	81	100
	FULL OPEN	68	74	85	86	86	94	95	91	88	80	101
200 FEET	1/8 OPEN	70	73	84	86	86	93	94	92	85	79	100
	1/4 OPEN	69	77	86	86	86	93	94	91	85	79	100
	FULL OPEN	69	77	89	90	88	94	94	92	86	79	100

April 23, 1970

* Non-Return Valve Chattering

Table A-5 Sound Levels in USN Mk V Air Diving Helmet A5
Serial Number H-203, Right Ear Position, Exhaust Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	66	69	70	71	88	82	82	92	78	75	88
	1/4 OPEN	71	72	72	74	92	85	84	84	78	76	90
	FULL OPEN	68	72	72	72	88	83	82	80	78	76	88
50 FEET	1/8 OPEN	71	74	79	78	95	90	91	86	84	84	97
	1/4 OPEN	72	75	80	79	96	91	91	88	86	85	97
	FULL OPEN	74	75	79	78	96	92	91	86	84	80	97
100 FEET	1/8 OPEN	70	72	80	78	94	90	92	86	86	81	98
	1/4 OPEN	70	74	82	79	94	90	92	86	87	82	98
	FULL OPEN	70	72	82	78	96	92	92	86	86	79	98
150 FEET	1/8 OPEN	70	74	84	80	95	92	92	86	86	80	98
	1/4 OPEN	70	72	84	80	95	92	92	86	86	80	98
	FULL OPEN	70	72	85	81	97	94	92	86	85	79	98
200 FEET	1/8 OPEN	70	74	92	85	96	92	92	88	87	78	98
	1/4 OPEN	71	74	87	82	96	93	94	88	92	82	100
	FULL OPEN	72	76	96	90	100	95	92	88	90	81	98

April 23, 1970

Table A-6 Sound Levels in USN Mk V Air Diving Helmet A6
Serial Number 834, Right Ear Position, Exhaust Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN	78	82.5	83	84	93	92	95	98	94	89	104
	1/4 OPEN	79	81	80	84	94	93	96	99	92	90	105
	1/2 OPEN	79	81	81	85	95	93	96	100	94	90	105
	3/4 OPEN	78	82	82	85	96	94	96	100	94	90	106
	FULL OPEN	79	82	82	85	96	94	96	101	93	90	106
50 FEET	1/8 OPEN	80	93	88	85	91	91	95	94	90	86	101
	1/4 OPEN	80	93	87	87	93	92	96	96	91	86	102
	FULL OPEN	79	91	87	88	94	94	95	95	90	86	102
100 FEET	1/8 OPEN	82	94	87	87	90	93	94	92	89	84	100
	1/4 OPEN	81	94	92	89	92	93	94	92	89	93	100
	FULL OPEN	81	93	88	90	95	96	95	93	89	83	101
150 FEET	1/8 OPEN	84	94	89	89	92	94	93	91	87	81	99
	1/4 OPEN	89	93	89	91	94	95	94	91	87	91	100
	FULL OPEN	84	93	91	92	96	98	94	91	87	81	100
200 FEET	1/8 OPEN	87	93	90	89	93	94	94	91	86	80	100
	1/4 OPEN	88	93	90	92	96	96	95	90	86	79	101
	FULL OPEN	87	92	90	92	98	98	95	91	87	79	101

Table A-7L Sound Levels in USN MkV Air Diving Helmet A7 (New) April 15, 1970
Serial Number 2956, Left Ear Position, Exhaust Valve Fully Open

DEPTH FSW	SUPPLY VALVE SETTING	OCTAVE BAND SOUND PRESSURE LEVELS DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
		31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
SURFACE	1/8 OPEN											
	1/4 OPEN	78	83	81	84	93	93	94	98	93	90	104
	1/2 OPEN	79	82	81	84	94	93	95	99	95	89	105
	3/4 OPEN	79	82	81	85	94	94	94	99	94	90	105
	FULL OPEN	78	83	82	85	94	94	94	99	94	90	105
50 FEET	1/8 OPEN											
	1/4 OPEN											
	FULL OPEN											
100 FEET	1/8 OPEN											
	1/4 OPEN											
	FULL OPEN											
150 FEET	1/8 OPEN											
	1/4 OPEN											
	FULL OPEN											
200 FEET	1/8 OPEN											
	1/4 OPEN											
	FULL OPEN											

April 15, 1970

Table A-7R Sound Levels in USN Mk V Air Diving Helmet A7 (New) Serial Number 2956, Right Ear Position, Exhaust Valve Fully Open

APPENDIX B

EFFECT OF EXHAUST VALVE SETTING ON THE MEASURED SOUND PRESSURE LEVELS IN 5 STANDARD USN Mk V AIR DIVING HELMETS

HELMET SERIAL NUMBER	DEPTH FSW	SUPPLY VALVE POSITION	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
				31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
H-203	0	¼ OPEN	½ OPEN	65	68	71	78	79	84	86	85	88	82	92
			FULL OPEN	63	67	71	77	78	82	88	84	88	82	94
	200	¼ OPEN	½ OPEN	69	74	90	90	87	94	94	91	86	80	100
			FULL OPEN	69	77	86	86	86	93	94	91	85	79	100
834	0	¼ OPEN	½ OPEN	64	66	68	69	85	80	81	78	76	73	87
			FULL OPEN	71	72	72	74	92	85	84	84	78	76	93
	200	¼ OPEN	½ OPEN	70	75	89	83	96	93	93	88	87	78	99
			FULL OPEN	71	74	87	82	96	93	94	88	92	82	100
	0	¼ OPEN	½ OPEN											
			FULL OPEN											
	200	¼ OPEN	½ OPEN											
			FULL OPEN											

APPENDIX B Effect of Exhaust Valve Setting on Measured Sound Pressure Levels in 5 Standard USN Mk V Air Helmets. Helmet tested dry.

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HELMET SERIAL NUMBER	DEPTH FSW	SUPPLY VALVE POSITION	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
				31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
7	0	¼ OPEN	½ OPEN	64	68	72	78	87	86	84	87	88	86	94
			FULL OPEN	66	68	72	78	88	87	84	86	88	88	92
	200	¼ OPEN	½ OPEN	74	76	89	92	96	97	93	94	88	82	101
			FULL OPEN	72	75	89	92	96	97	92	94	87	82	101
8	0	¼ OPEN	½ OPEN	58	60	67	75	82	79	81	81	83	83	88
			FULL OPEN	63	64	69	78	84	84	84	84	88	94	90
	200	¼ OPEN	½ OPEN	71	73	76	90	94	93	89	90	85	80	97
			FULL OPEN	71	73	87	89	94	84	88	88	86	81	95
630	0	¼ OPEN	½ OPEN	67	70	71	70	83	78	80	82	79	76	88
			FULL OPEN	67	68	69	71	84	80	81	82	78	75	88
	200	¼ OPEN	½ OPEN	72	73	87	81	95	92	91	89	81	78	96
			FULL OPEN	72	73	86	81	94	92	90	88	80	78	96

APPENDIX B Effect of Exhaust Valve Setting on Measured Sound Pressure Levels in 5 Standard USN Mk V Air Helmets. Helmet tested dry.

APPENDIX C

MEASURED SOUND LEVELS IN THE USN MK V AIR DIVING HELMET DURING IN THE SUBMERGED CONDITION

The enclosed test data came from two different tests. In both tests the MK V air diving helmet was tested submerged and under pressure using the CBS acoustical manikin as the sound measuring device. The data indicated as right ear was taken in NEDU's plastic testing box in #5 recompression chamber in August, 1972. The data indicated as left ear was taken in NEDU's #6 wetpot in March, 1973. The acoustical manikin has two independent ear channels. However, in each test one channel was suspect and its readings were not used. Previous experience (Tables A-1 and A-2) have indicated that there is little difference in the sound pressure levels existing at the right and left ear posicions in the MK V air helmet.

	Supply Valve Setting	Exhaust Valve Setting	Over-Bottom Press, PSI	Flow, CFM	Ear & Depths, FSW	Broad-Band, SPL DB	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE .0002 MICROBAR AT INDICATED CENTER FREQUENCIES IN HZ										dBA
							31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
**	1/4 Op	Cl	50	6.0	L 0'	94	64	65	60	66	81	85	93	85	82	69	98
*	Op	Cl	~0	7.1	R 2'	102	107	100	90	88	99	100	99	96	91	74	104
	1/2 Op	Cl	~0	9.0	L 4'	101	100	93	84	76	88	91	99	93	91	75	104
	1/2 Op	Cl	~0	4.5	L 4'	94	100	90	83	77	85	85	90	85	81	67	96
*	Op	Cl	~0	3.6	R 50'	99	103	101	91	89	97	92	95	89	82	—	101
	1/2 Op	Cl	~0	3.1	L 50'	96	101	91	80	80	85	89	93	66	79	—	99
	1/2 Op	Cl	~0	5.1	L 50'	100	100	94	84	81	89	94	100	93	89	—	105
*	Op	Cl	~10	5.0	R 100'	108	105	103	92	91	101	102	105	95	90	—	108
	1/2 Op	Cl	~0	5.0	L 100'	106	102	93	82	80	90	98	103.5	93	90	—	107

* August, 1972 tests
** Helmet not submerged, note decrease in low frequency noise levels

Table C-1
Octave Band Sound Pressure Levels and calculated dbA levels for 2 submerged USN MK V Air Diving Helmets

	SUPPLY VALVE SETTING	EXHAUST VALVE SETTING	OVER-BOTTOM PRESS, PSI	FLOW, CFM	EAR & DEPTHS, FSW	BROAD-BAND, SPL DB	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE .0002 MICROBAR AT INDICATED CENTER FREQUENCIES IN HZ										dBA
							31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv.
	1/2 Op	C1	~0	3.3	L 100'	102	102	93	82	78	87	94	100.5	90	85	—	105
	1/2 Op	C1	~0	6.4	L 100'	107	99	93	83	81	93	99	105.5	94	91	—	108
*	Op	C1	~10	4.0	R 150'	107	106	104	95	93	100	100	105	93	90	—	108
	1/2 Op	C1	~0	3.9	L 150'	107	101	94	82	80	90	98	105.5	93	89.5	—	109
	1/2 Op	C1	~0	5.2	L 150'	108	100	93	83	81	92	99	106.5	93	90.5		110
*	Op	C1	~10	3.1	R 200'	104	105	105	95	93	97	97	102	91	87	—	106
	1/2 Op	C1	~0	3.5	L 200'	107	100	92	82	79	89	97	105.5	94	88	—	109
	1/2 Op	C1	~0	4.5	L 200'	109	100	93	82	81	90	98	107.5	93	91	—	111
*	Op	C1	N.A.	2.8	R 250'	103.5	104	105	96	94	97	95	100	90	83	—	105
	1/2 Op	C1	~0	3.1	L 250'	107	98	92	82	79	88	97	106	93	87	—	109
	1/2 Op	C1	~0	3.9	L 250'	109	98	92	82	79	88	97	106	93	87	—	109

Table C-1 (Continued)

SUPPLY VALVE SETTING	EXHAUST VALVE SETTING	OVER-BOTTOM PRES., PSI	FLOW, CFM	EAR & DEPTH	BROAD-BAND SPL DB	ONE-THIRD OCTAVE BAND LEVELS IN DB REF .0002 MICROBAR AT INDICATED CENTER FREQUENCIES IN HZ.																					
** 1/4 Op	Cl	50	4.3	L 0'	84	72	77	79	68	60	62	61	62	63	71	69	76	76	72	73	75	77	69	67	71	63	61
* Op	Cl	~0	7.1	R 2'	102	89	88	87.5	84.5	77.5	74.5	<76	<78	80.5	97	87	87	95	92	97	90	89	91.5	90	91.5	91.5	81.5
1/2 Op	Cl	~0	9.0	L 4'	101	87	87	85	81	76	73	70	70	74	88	76	84	84	89	93	96	92	90	91	90	92	87
1/2 Op	Cl	~0	4.5	L 4'	94	83	82	83	79	76	73	71	70	72	83	75	75	76	81	86	88	83	81	82	80	79	77
* Op	Cl	~0	3.6	R 50'	99	86.5	86.5	84.5	<85	<71	<70	<73	<76	<80	96	87.5	82.5	89	88	92	91.5	88	84	85	87	83	75
1/2 Op	Cl	~0	3.1	L 50'	96	84	80	80	75	73	74	73	74	74	85	77	80	[illegible]	86	91	90	86	85	84	81	81	78
1/2 Op	Cl	~0	5.1	L 50'	100	86	81	82	76	75	74	71	71	75	87	78	84	86	91	96	95	89	89	90	88	88	86
* Op	Cl	~10	5.0	R 100'	108	90	89	88.5	89.5	79	77.5	<82	79	87	100	94	91.5	97	99	104	103	94.5	89	89	93.5	90	79.5
1/2 Op	Cl	~0	5.0	L 100'	106	86	84	81	79	74	75	75	75	79	90	81	89	92	95	103	102	92	89	90	89	87	90

** Helmet tested dry, note decrease in low frequency noise levels

* August 1972 tests

Table C-2
One Third Octave Band Sound Pressure Levels for 2 Submerged USN MK V Air Diving Helmets

SUPPLY VALVE SETTING	EXHAUST VALVE SETTING	OVER-BOTTOM PRES., PSI	FLOW, CFM	EAR & DEPTH	BROAD BAND SPL DB	ONE-THIRD OCTAVE BAND LEVELS IN DB REF .0002 MICROBAR AT INDICATED CENTER FREQUENCIES IN HZ.																					
1/2 Op	Cl	~0	3.3	L 100'	102	87	84	80	78	73	73	75	75	76	88	79	86	87	92	99	99	95	93	92	84	81	84
1/2 Op	Cl	~0	6.4	L 100'	107	86	83	81	79	75	76	75	76	81	93	83	90	91	96	104	104	93	90	91	90	88	91
* Op	Cl	~10	4.0	L 150'	107	90.5	89	88.5	<93	81	79	<83	80	88	99	94	90.5	96.5	97	102	102.5	93	87	87	90	86	76.5
1/2 Op	Cl	~0	3.9	L 150'	107	8.8	83	82	79	75	74	75	76	79	89	81	90	93	95	103	104	92	88	90	85	84	88
1/2 Op	Cl	~0	5.2	L 150'	108	87	84	81	78	75	74	75	77	81	92	83	90	93	96	105	105	92	89	89	86	85	89
* Op	Cl	~10	3.1	R 200'	104	89.5	86	87.5	<94	79	<75	<84	74.5	84.5	96.5	92	87	93.5	93.5	99	99.5	91	86	83	87	83	78.5
1/2 Op	Cl	~0	3.5	L 200'	107	86	83	82	77	74	74	73	75	78	89	80	90	93	94	102	105	93	92	89	84	83	92
1/2 Op	Cl	~0	4.5	L 200'	109	86	83	81	77	74	74	74	77	80	90	82	91	94	95	104	106	92	90	89	85	86	95
* Op	Cl	N.A.	2.8	R 250'	103.5	89.5	87	88.5	<95	79	<78	<85	75	84	95	91.5	85	92	98.5	98.5	89	83.5	82	86.5	82	82.5	79.5
1/2 Op	Cl	~0	3.1	L 250'	107	87	82	82	77	74	73	74	74	77	88	80	90	92	92	101	105	92	90	87	82	84	90
1/2 Op	Cl	~0	3.9	L 250'	109	85	82	82	77	74	74	74	76	80	89	81	91	93	94	103	106	91	90	88	84	88	94

Table C-2 (Continued)

APPENDIX D

"NOISE AND MEASUREMENT PROBLEMS ASSOCIATED WITH HARD HAT DIVING HELMETS"

A. L. DiMATTIA

J. J. Panella

Presented to the Acoustical Society of America, Spring Meeting, 1972, Buffalo, N.Y. This paper does not appear in the published literature.

NOISE AND MEASUREMENT PROBLEMS ASSOCIATED WITH HARD HAT DIVING HELMETS

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The hard hat diver descends into the depths of the ocean wearing a rigid metal helmet, a rubberized suit and leaded shoes. Unlike the SCUBA diver, his life-sustaining air is supplied from the surface through a sturdy hose, and the flow rates are greatly in excess of his actual oxygen needs in order to flush off carbon dioxide expelled from the diver's breath. This copius flow which is funneled through small valves and other openings and which reaches velocities approaching Mach one, results in turbulence and its attendant noise. Thus, the diver, in addition to the many perils of a hostile environment, is subjected to intense noise, well into the damage risk levels. It is the purpose of this paper to explore special problems encountered in the measurement of such noise, to present some noise level data and perhaps to generate further interest in this problem.

Figure #1 will help us get acquainted with the deep. Here we see a cross section of the ocean. The draftsman has attempted to depict the vastness of these operations by keeping things in proportion and showing a diver working on the bottom at a depth of 132 feet. A scale along the left hand side is marked in feet of depth, and is divided into blocks of 33 feet each, or one atmosphere increase in pressure. A companion scale shows the pressure in atmospheres absolute as a function of depth. Absolute bottom pressure P_b, in atmospheres, is equal to the depth in feet plus 33, divided by 33, which if multiplied by 14.7 will give the pressure in PSIA. Back on the surface, we find the tender supplying compressed air at "100 PSI overbottom", to use a diver's expression, signifying that the tender is ready to furnish air at 100 pounds per square inch in excess of the absolute bottom pressure.

This air, being supplied to the diver through his safety air hose, passes through a number of valves and other openings. One of these, the divers air-control valve, is used by the diver to control the flow of air into his helmet. Another pneumatic control device, called the non-return valve, is attached to the helmet and serves to prevent loss of air if the diver's hose should suddenly break. Finally, the diver may use his exhaust valve to regulate the inflation of his suit and, consequently, his buoyancy. In addition to this control function, however, the exhaust valve has an automatic control feature which insures that the pressure inside the helmet always exceeds the pressure outside the helmet by a range of .5 to 2 psi.

Thus we find that the pressure inside the diver's helmet P_h, is equal to P_b plus delta P, the small differential over pressure. This causes the rather copious flows that cause noise, as well as a huge stream of bubbles depicted in the sketch.

The diver's air needs are in accordance with the Diver's Air Formula shown in Figure #2. S equals 4.5 times the fraction D plus 33, over 33; where S is the free air flow at surface conditions, in cubic feet per minute; and D is the depth in feet. The chart shows some free air flow rates at some typical depths (4.5 cu. ft. on the surface, 11.3 at 50 feet, 18.2 at 100 feet, etc.). (800 liter/min = 13 liters/sec)

With the high turbulence that is known to exist, there is concern over where a measurement microphone should be placed and what will be the obstacle effect of the microphone in creating additional turbulence due to its presence in the jet stream. The measurements to be reported were done with two systems -- first, a General Radio P-5 ceramic microphone with foam windshield, and used in a wide frequency range circuit, and secondly, the CBS Laboratories' designed Acoustical Manikin. The latter has microphones recessed in a simulated ear canal and incorporates fleshy pinnae; it was felt that both of these features should result in a close replication of the human hearing anatomy.

Figure #3 shows the helmet arrangement used for the simulated manikin dives. For the P-5 measurements a rubber manikin was fastened to a wooden base inside a ring of laminated plywood also fastened to the base. The P-5 microphone and its preamplifier is shown mounted next to one of the dummy's ears. A rubber gasket on top of the laminated ring provided a seal for the helmet which in turn was forced down by a formed wooden cap, an aluminum plate, and four tension rods. Microphone leads were brought out through a watertight gland, so the whole assembly weighted down with some lead weights could be lowered to the bottom of a pressure water tank.

For the second series of tests, the Acoustical Manikin replaced the rubber dummy and the P-5 microphone was removed from the assembly. Figure #4 shows a photograph of the P-5 system. Figure #5 is a view of the Acoustical Manikin. Figure #6 shows the system closed and ready for diving.

Figure 7 shows a block diagram of the test setup, arranged to work in the special high-pressure water tank at the Naval EOD Facility. The helmet assembly was normally placed on the bottom of the tank, and connected to the measurement apparatus as shown.

Figure #8 displays some 1/3 octave band noise levels taken with the P-5 system and furnishes an interesting comparison of helmet noise with the helmet in air and in water. The solid curve is in ten feet of water while the dashed curve is in air, but with the air pressure increased to simulate the pressure at ten feet of water. The large increase in low frequency noise in water is attributable to bubble noise extending well into the infrasonic region, and probably enhanced by being in a steel tank. Third octave bank levels reach as high as 116 dB SPL, and the overall level was 126 dB.

Figure #9 shows helmet third octave noise levels in water at three values of simulated depth, the solid curve at ten feet, dashed curve at 50 feet, and dotted curve at 100 feet. The noise spectrum extends well into the high frequency region and third octave levels exceed 110 dB SPL. In another measurement, (not shown here), taken at 50 feet and with wider control valve opening, third octave levels reached 120 dB at around 2,500 Hz.

Figure #10 shows one of a series of measurements made with the Acoustical Manikin. Band levels reached 124 dB, but here it is felt that actual sound pressure levels are not so significant as the simulated sensation levels, since the Acoustical Manikin contains the Weiner-Ross ear canal enhancement characteristic as part of its hearing process. Certain of the data shown should be corrected for change in calibration of the measurement microphone with increased pressure. The nature of these corrections is to raise the levels shown here by about

2 dB for 50 feet and about 4 dB for 100 feet of depth. It should be realized, however, that these measurements were made without coupling to a diver's suit cavity, where the sound pressure would drop by a variable amount depending on suit inflation.

In conclusion, it may be said that these measurements, made under difficult conditions, may be in error by 5 or 6 dB. What certainly transpires, however, is that noise levels are extremely high; they exceed minimum damage risk levels and effectively serve to annihilate communications. The authors hope to continue work in this area, and they wish to publicly thank Mr. Eugene Sopchick of the Naval EOD Facility and his assistants for their diving expertise and their willingness to get wet.

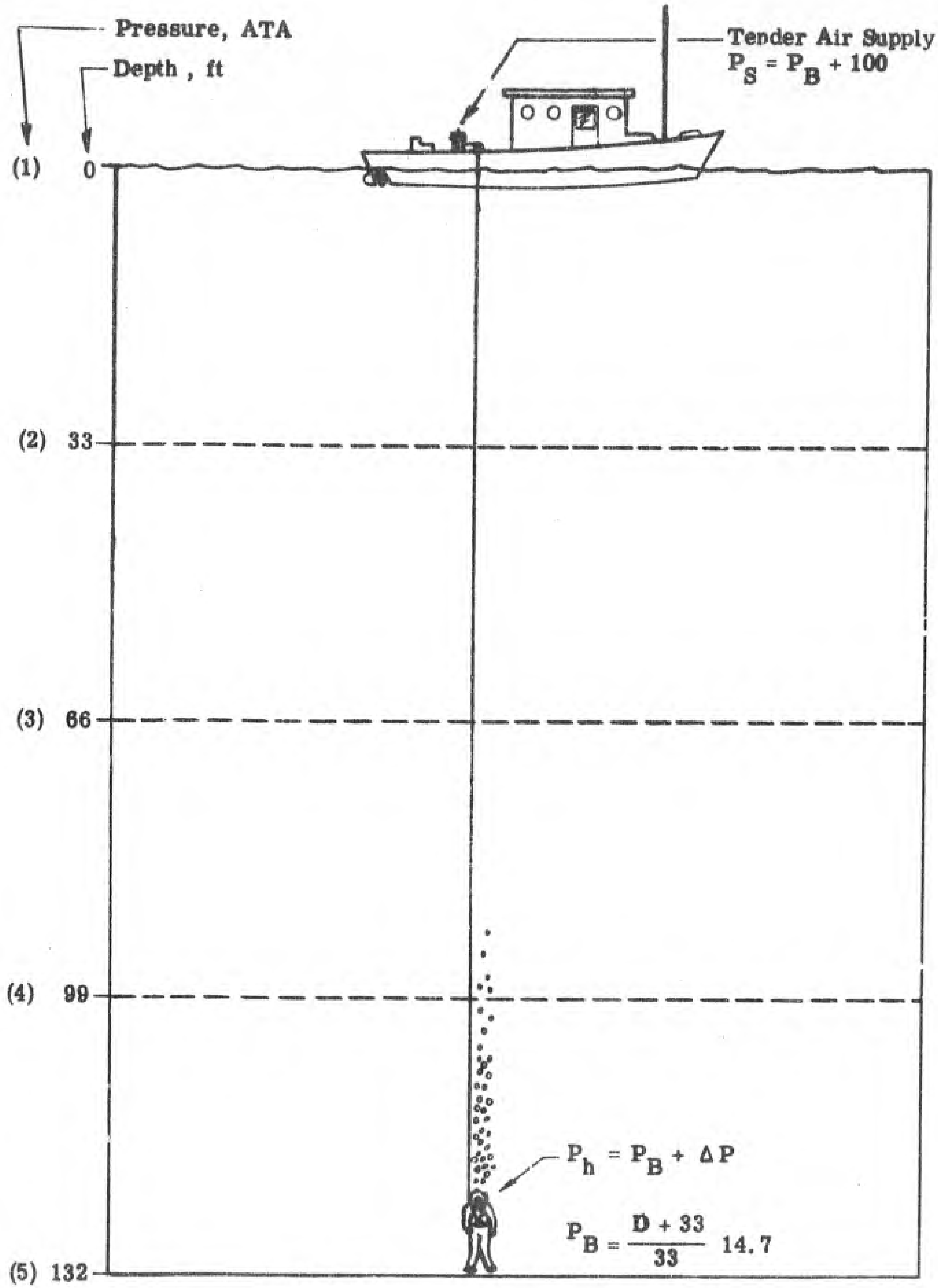

Figure 1. Drawing Depicting Hard Hat Diver Operation

$$S = 4.5 \frac{D + 33}{33}$$

where: S = Free air flow, cu ft per minute

D = Depth in feet

Depth, ft	cu ft/min
0	4.5
50	11.3
100	18.2
200	31.9
400	59.1

Figure 2. Diver's Air Formula

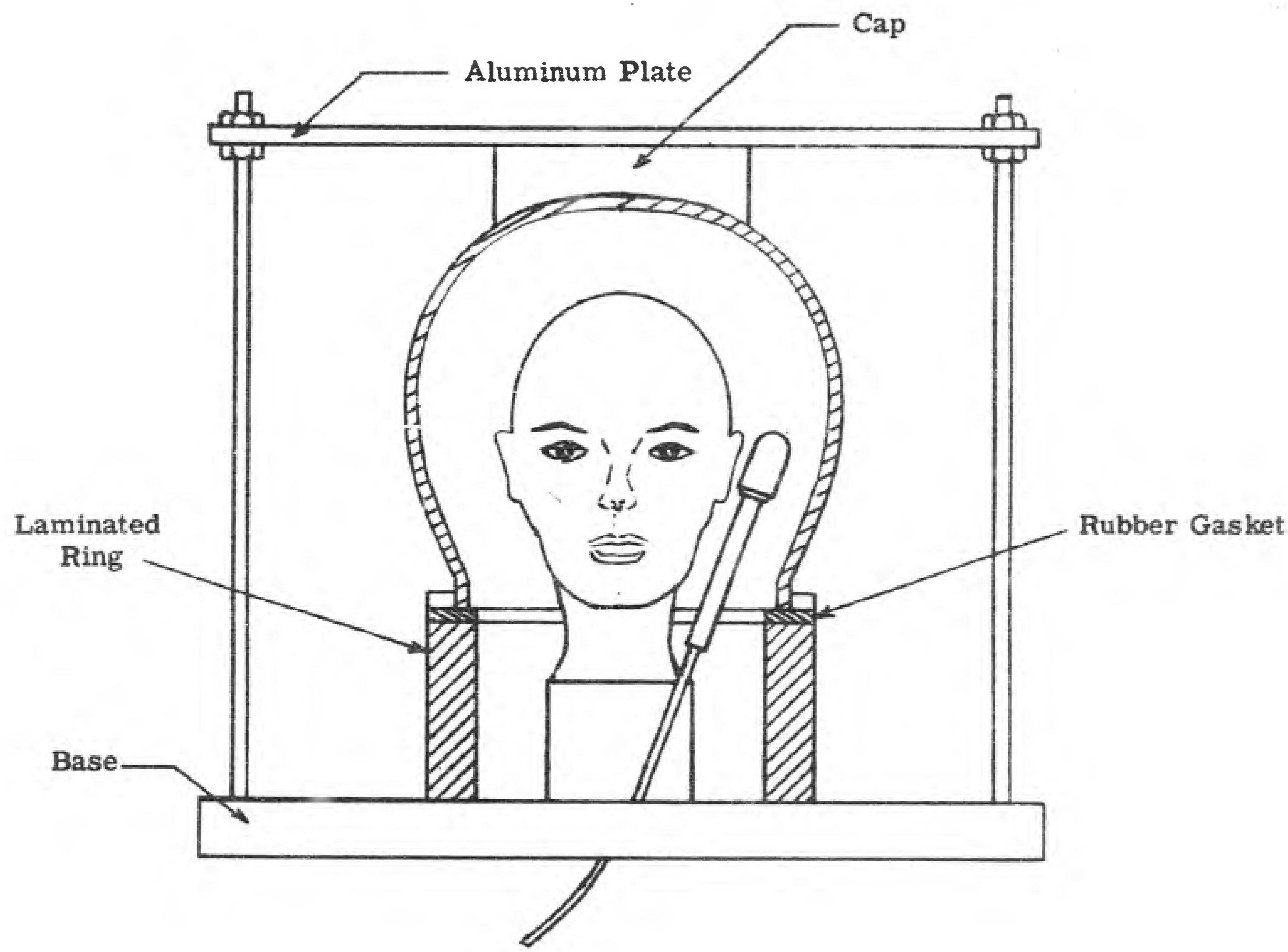

Figure 3. Helmet Arrangement Used for Diver Noise Tests

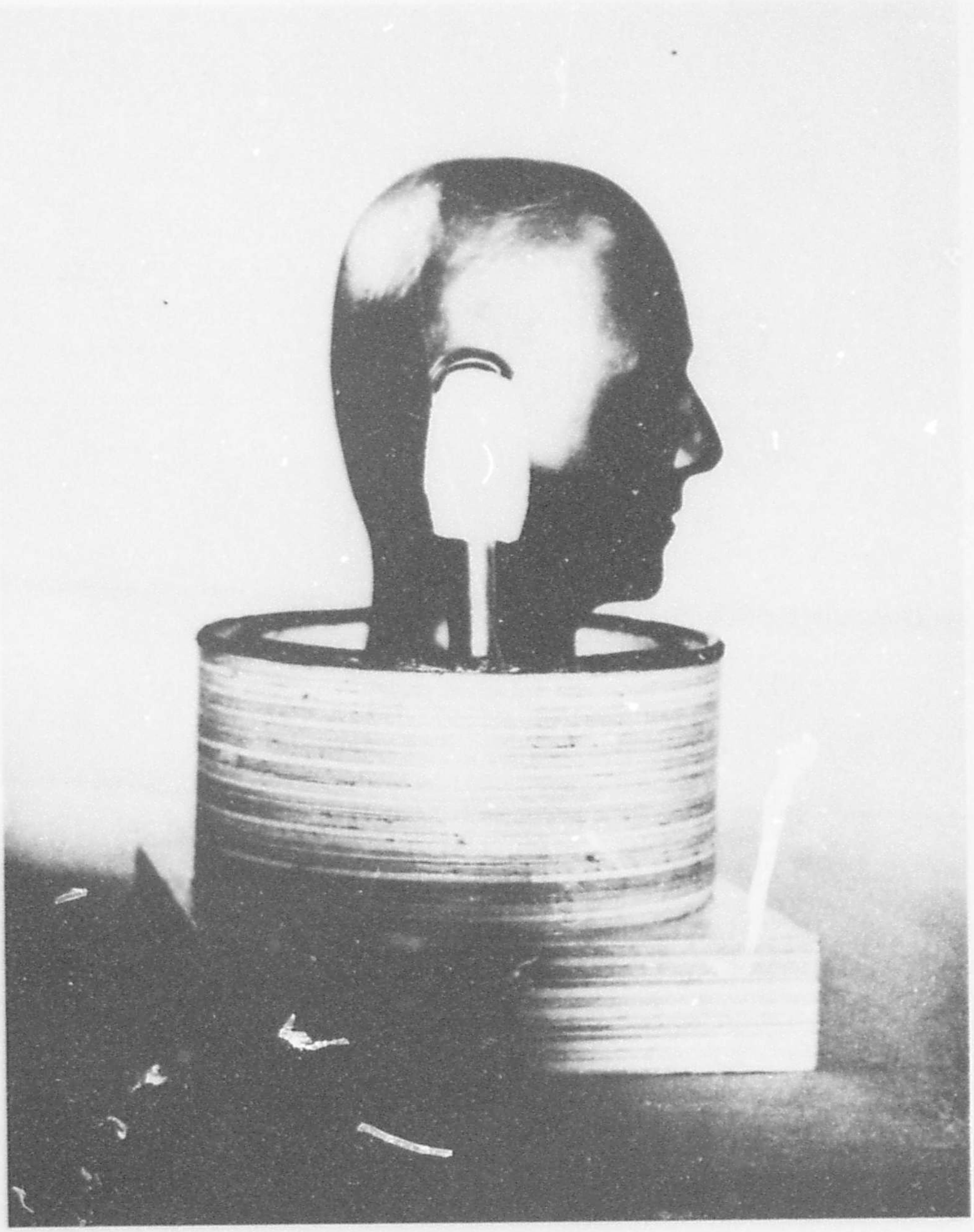

Figure 4. G.R. P-5 Microphone System and Rubber Dummy

Figure 5. Test Set-Up Using the Acoustical Manikin

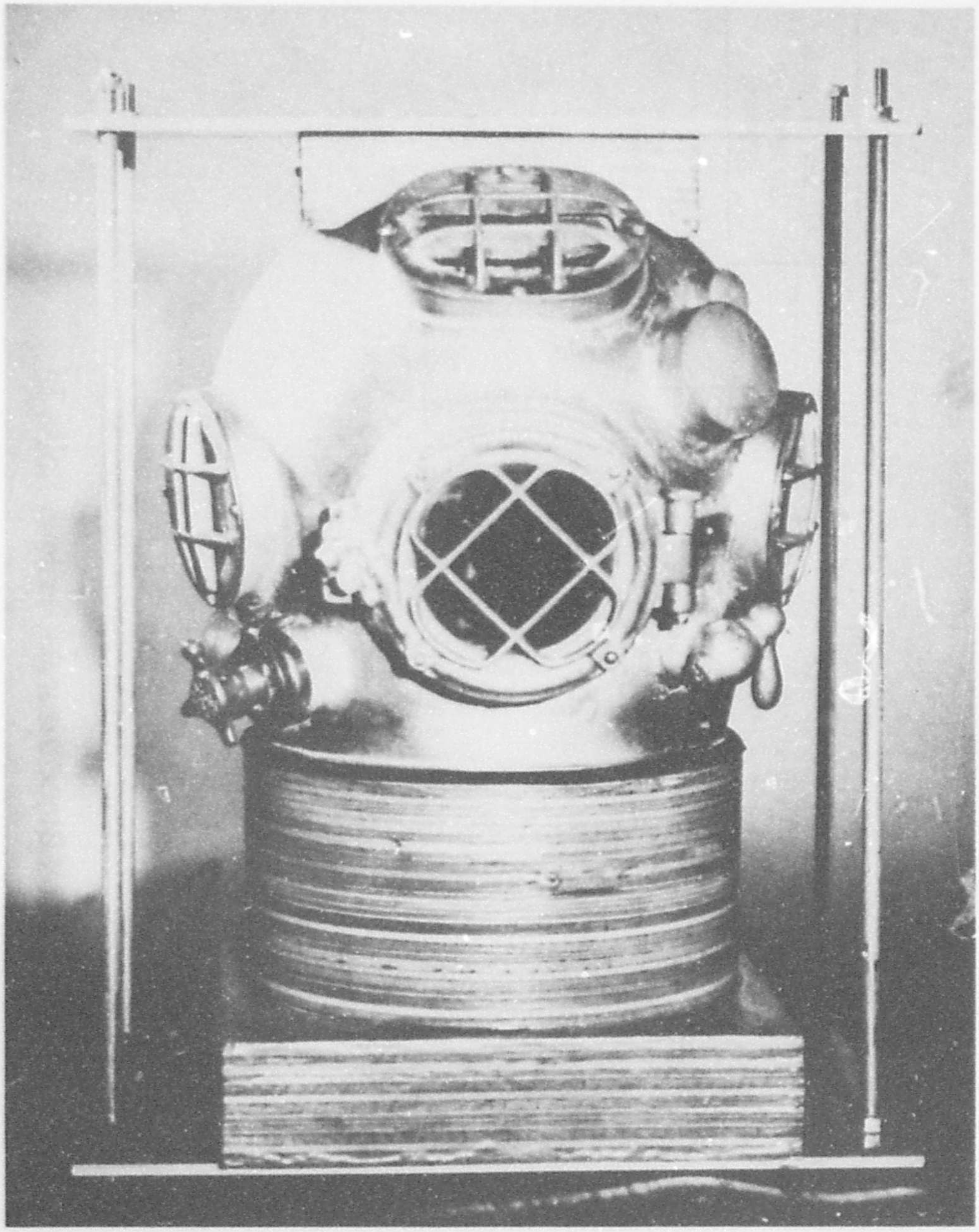

Figure 6. Mark V Model 1 Helmet System Closed and Ready for Immersion

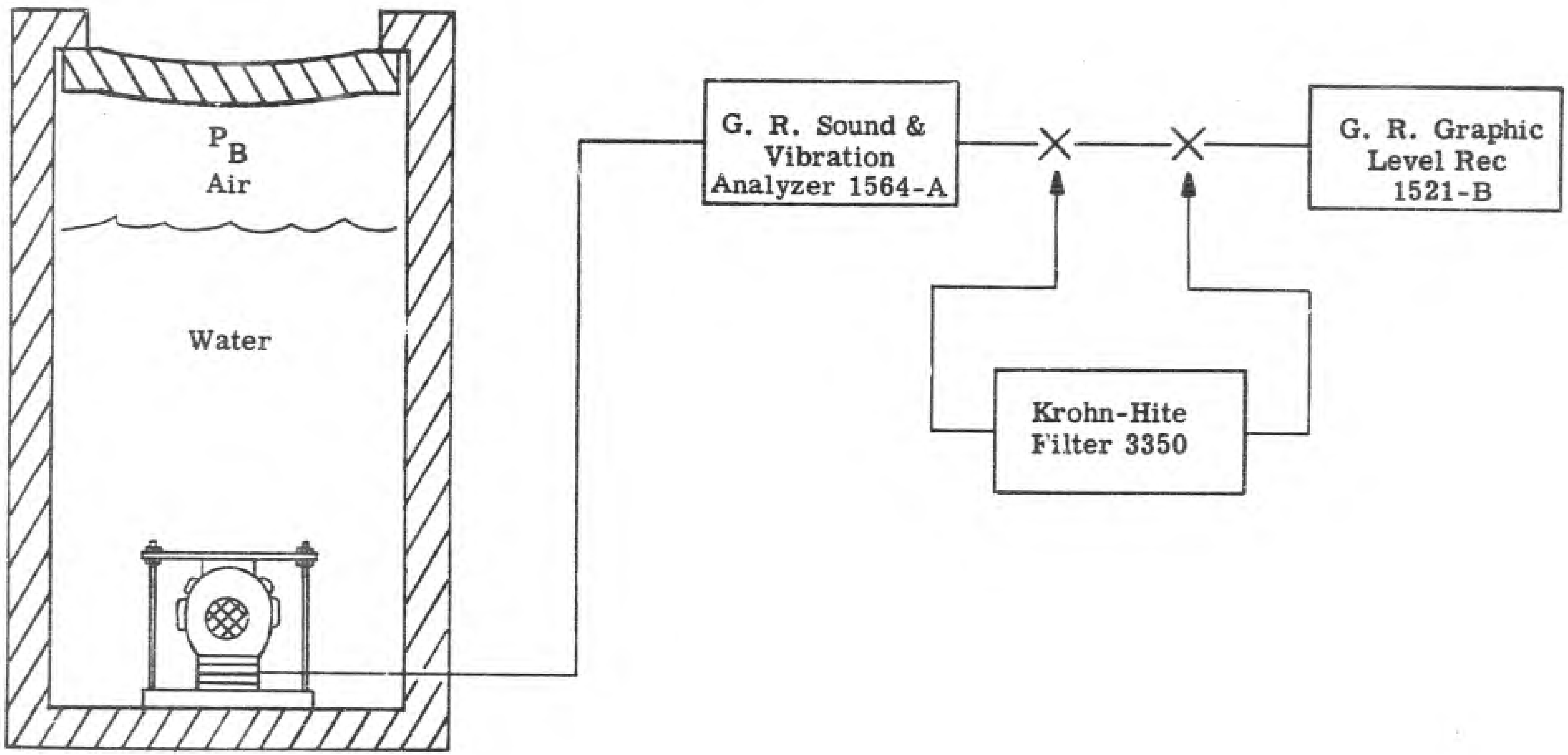

Figure 7. Apparatus Block Diagram, Helmet Noise Test

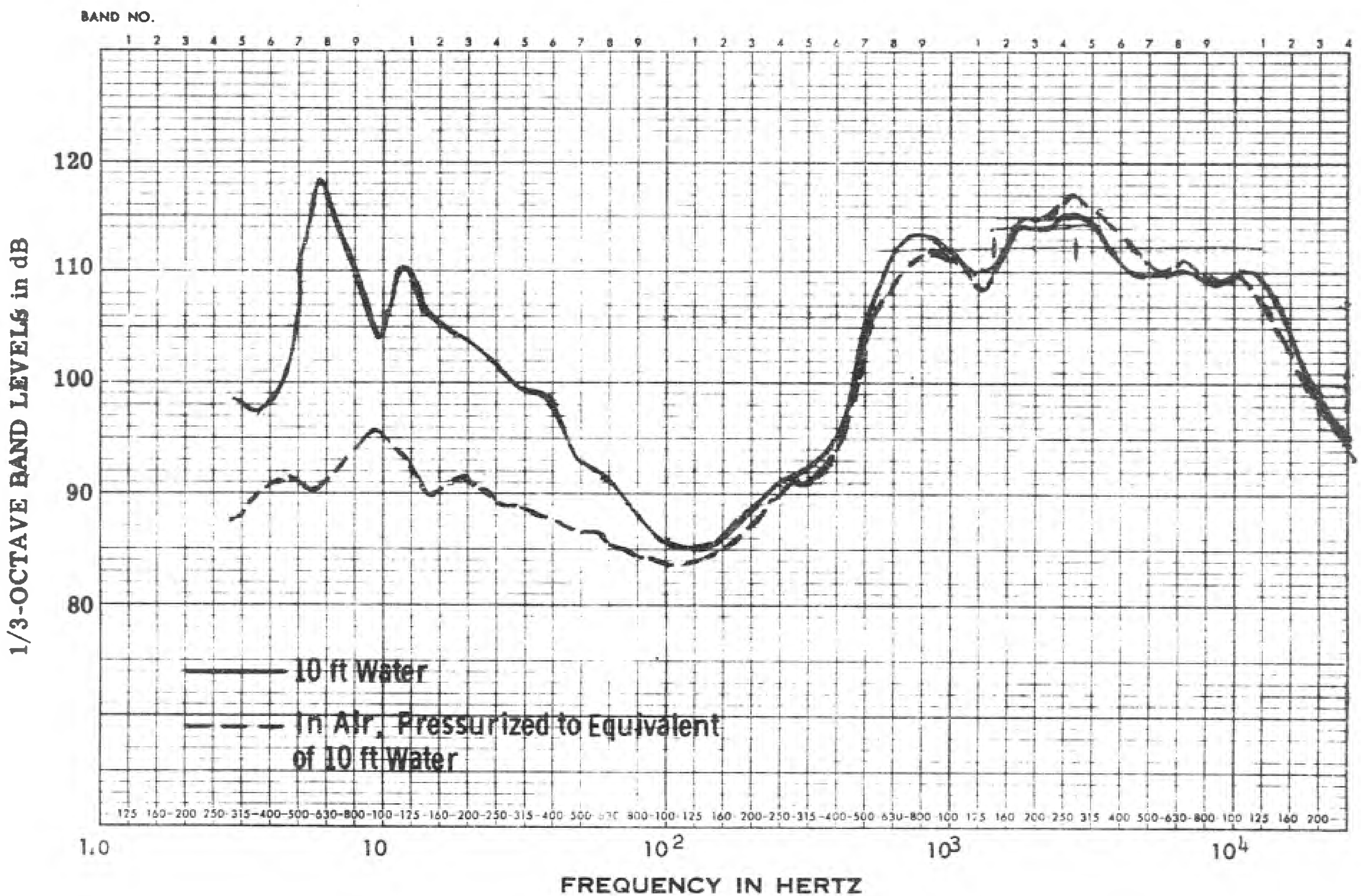

Figure 8. Comparison of Noise Levels with Helmet in Air and Water

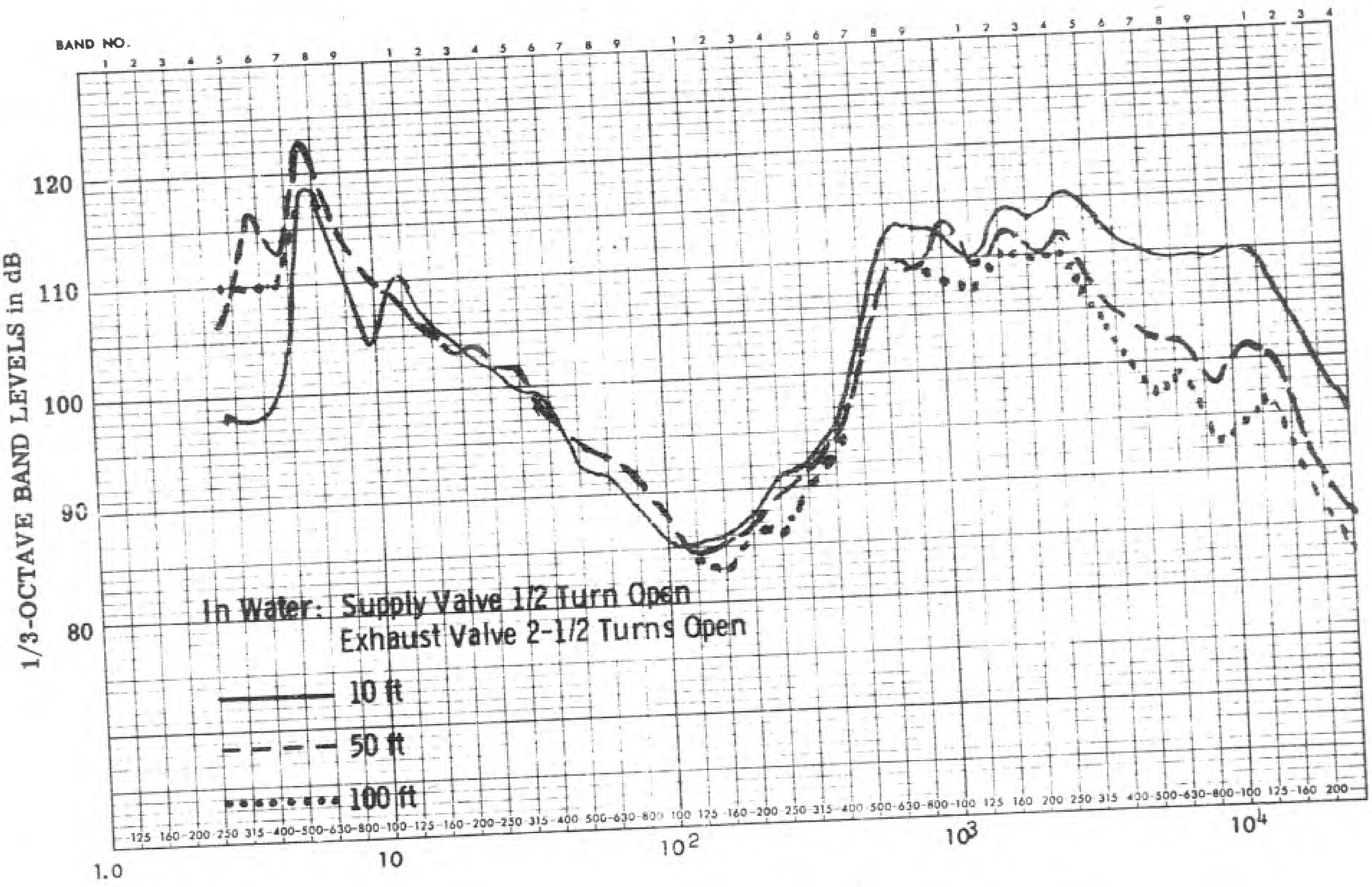

Figure 9. Helmet Noise Levels in Three Values of Simulated Water Depths

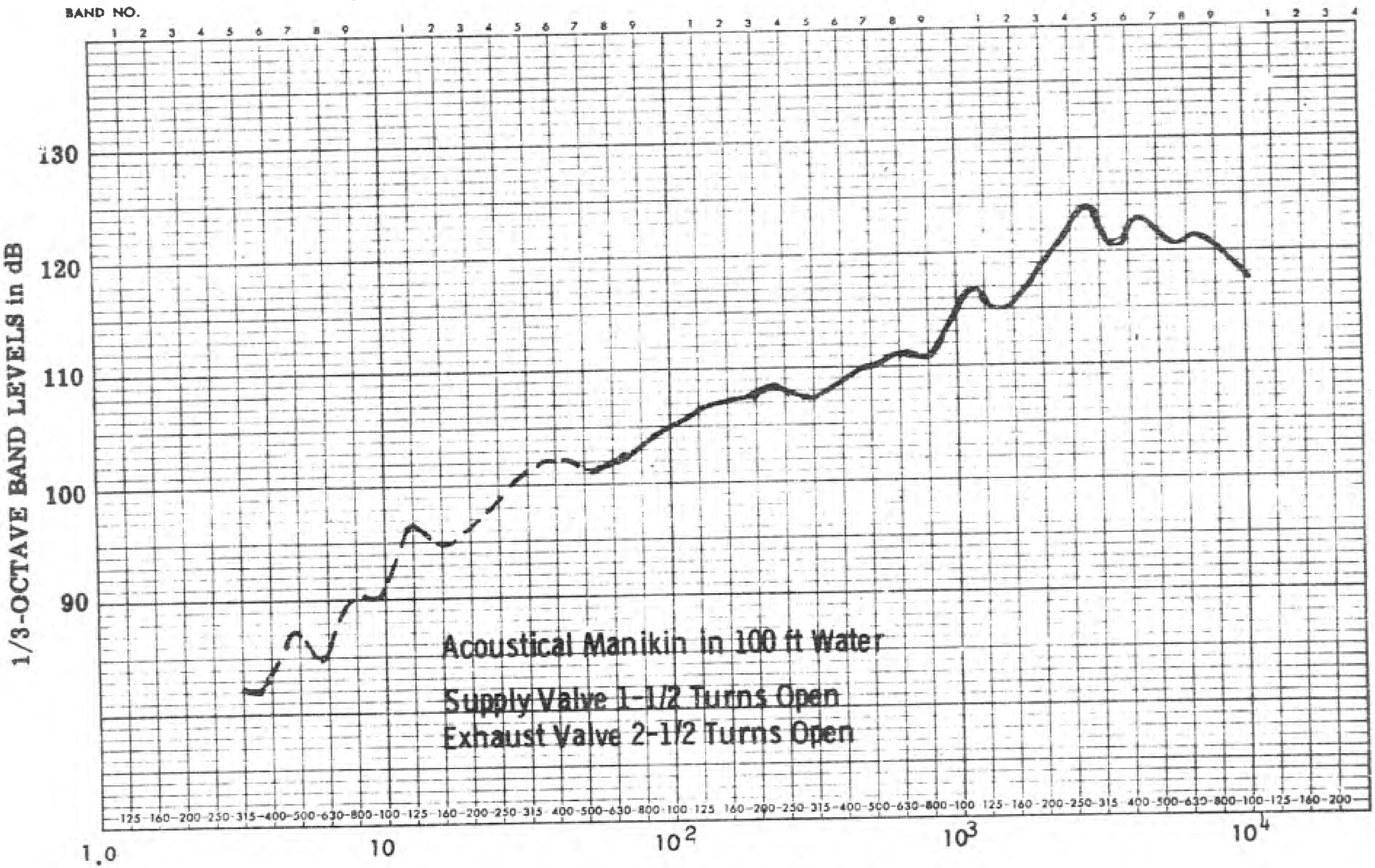

Figure 10. Helmet Noise Measurements Made with The Acoustical Manikin

APPENDIX E

OCTAVE BAND SOUND PRESSURE LEVELS AND CALCULATED EQUIVALENT dBA SOUND LEVELS IN TWO STANDARD USN MK V HELIUM-OXYGEN DIVING HELMETS. SOUND LEVELS ARE GIVEN FOR BOTH SEMI-CLOSED CIRCUIT (VENTURI) AND OPEN CIRCUIT OPERATION.

DEPTH FSW	GAS	OVER POT. PRESSURE PSI	HOKE VALVE POS	SUPPLY VALVE POS	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA EQUIVA-LENT
						31.5	63	125	250	500	1000	2000	4000	8000	16000	
0	100% O_2	50	OP	Cl	Cl	76	86	88	79	80	82	79	84	83	80	89
50	100% O_2	50	OP	Cl	Cl	75	93	93	79	77	79	82	84	83	—	90
0	16%	100	OP	Cl	Cl	65	78	85	86	78	76	79	80	83	75	87
50	16%	100	OP	Cl	Cl	77	81	94	93	83	78	82	86	88	—	92
100	16%	100	OP	Cl	Cl	72	81	97	95	85	80	84	88	89	—	94
150	16%	100	OP	Cl	Cl	75	82	98	98	85	79	83	88	89	—	94
200	16%	100	OP	Cl	Cl	74	82	99	100	84	89	83	88	89	—	95

DATE 20 APRIL 1970

Table E-15

Sound Levels in a Standard USN MK V Helium Oxygen Diving Helmet, H1 During Semi-Closed Circuit Operation, Right Ear Position, Helmet Tested Dr

DEPTH FSW	GAS	OVER BOT. PRESSURE PSI	HOKE VALVE POS.	SUPPLY VALVE POS.	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA EQUIVA-LENT
						31.5	63	125	250	500	1000	2000	4000	8000	16000	
0	16%	100	OP	C1	C1	70	78	86	91	82	79	80	82	80	75	88
50	16%	100	OP	C1	C1	70	79	90	89	84	83	84	88	86	—	94
100	16%	100	OP	C1	C1	88	79	90	92	83	80	82	87	65	—	94
150	16%	100	OP	C1	C1	75	82	98	99	86	83	85	91	[illegible]		98
200	16%	100	OP	C1	C1	77	85	103	103	92	87	89	94	91		100

DATE 20 APRIL 1970

Table E-2

Sound Levels in a Standard USN MK V Helium Oxygen Diving Helmet, H1 During Semi-Closed Circuit Operation, Left Ear Position, Helmet Tested Dry

DEPTH FSW	GAS	OVER BOT. PRESSURE PSI*	FOKE VALVE POS.	SUPPLY VALVE POS	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA EQUIVALENT
						31.5	63	125	250	500	1000	2000	4000	8000	16000	
0	O_2	∿0	C1	1/4 OP	FULL OPEN	115	114	114	118	96	88	86	87	83	78	103
50	O_2	∿0	C1	1/4 OP	FULL OPEN	123	118	120	119	109	104	34	92	87	—	111
0	16%	∿0	C1	1/8 OP	1/2 OPEN	114	118	118	117	112	103	93	84	86	80	112
0	16%	∿0	C1	1/4 OP	1/2 OPEN	112	114	117	114	98	94	84	77	80	73	106
50	16%	∿0	C1	1/8 OP	1/2 OPEN	107	117	122	121	115	107	97	86	88	—	112
50	16%	∿0	C1	1/4 OP	1/2 OPEN	109	116	122	120	114	105	98	86	85	—	115
100	16%	∿0	C1	1/8 OP	1/2 OPEN	106	117	124	122	108	106	97	86	88	—	112
100	16%	∿0	C1	1/4 OP	1/2 OPEN	108	114	123	121	110	106	101	85	86	—	116
150	16%	∿0	C1	1/8 OP	1/2 OPEN	106	117	125	123	111	102	99	87	88	—	113
150	16%	∿0	C1	1/4 OP	1/2 OPEN	109	115	124	122	111	107	91	86	87	—	114
200	16%	∿0	C1	1/8 OP	1/2 OPEN	107	118	126	123	112	103	99	88	88	—	115
200	16%	∿0	C1	1/4 OP	1/2 OPEN	110	117	125	123	112	104	92	87	88	—	116

Date 21 April 1970

Table E-3

* estimate

Sound Levels in Standard USN MK V Helium-Oxygen Diving Helmet Open Circuit Operation, Right Ear Position, Helmet Tested Dry.

DEPTH FSW	GAS	OVER BOT. PRESSURE PSI*	HOKE VALVE POS.	SUPPLY VALVE POS	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA
						31.5	63	125	250	500	1000	2000	4000	8000	16000	EQUIVALENT
0	O_2	~0	C1	1/4 OP	FULL OPEN											
50	O_2	~0	C1	1/4 OP	FULL OPEN											
0	16%	~0	C1	1/8 OP	1/2 OPEN	116	114	117	112	94	87	81	80	81	75	103
0	16%	~0	C1	1/4 OP	1/2 OPEN	114	113	117	111	97	87	81	79	81	76	103
50	16%	~0	C1	1/8 OP	1/2 OPEN	107	116	122	120	107	99	89	84	84	—	110
50	16%	~0	C1	1/4 OP	1/2 OPEN	106	112	121	119	108	97	89	85	84	—	109
100	16%	~0	C1	1/8 OP	1/2 OPEN	107	116	123	120	108	97	88	83	83	—	111
100	16%	~0	C1	1/4 OP	1/2 OPEN	106	113	123	120	109	98	89	83	83	—	111
150	16%	~0	C1	1/8 OP	1/2 OPEN	109	117	124	122	110	99	89	84	83	—	112
150	16%	~0	C1	1/4 OP	1/2 OPEN	108	115	124	122	112	101	91	85	84	—	113
200	16%	~0	C1	1/8 OP	1/2 OPEN	109	118	125	123	112	102	91	86	84	—	114
200	16%	~0	C1	1/4 OP	1/2 OPEN	109	117	125	123	113	104	93	87	85	—	115

Date 21 April 1970

* estimate

Table E-4

Sound Levels in Standard USN MK V Helium-Oxygen Diving Helmet, H1 Open Circuit Operation, Left Ear Position, Helmet Tested Dry.

DEPTH FSW	GAS	OVER BOT. PRESSURE PSI	HOKE VALVE POS.	SUPPLY VALVE POS.	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA EQUIVALENT
						31.5	63	125	250	500	1000	2000	4000	8000	16000	
0	16%	100	OP	Cl	Cl	68	79	89	90	80	78	74	78	79	68	86
50	16%	100	OP	Cl	Cl	77	89	101	100	86	82	80	84	84	—	93
100	16%	100	OF	Cl	Cl	81	92	105	103	89	81	80	86	84	—	96
150	16%	10C	OP	Cl	Cl	81	90	104	103	87	81	82	88	85	—	97
200	16%	100	OP	Cl	Cl	78	92	105	102	86	80	81	87	84	—	96

DATE 22 APRIL 1970

Table E-5

Sound Levels in a Standard USN MK V Helium Oxygen Diving Helmet, H2
During Semi-Closed Circuit Operation Right Ear Position, Helmet Tested Dry

DEPTH FSW	GAS	OVER BOT. PRESSURE PSI*	HOKE VALVE POS.	SUPPLY VALVE POS	EXHAUST VALVE POSITION	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.0002 MICROBAR AT THE INDICATED CENTER FREQUENCIES IN HERTZ										dBA EQUIVALENT
						31.5	63	125	250	500	1000	2000	4000	8000	16000	
0	AIR	~0	C1	1/4 OP	1/2 OPEN	100	109	114	115	109	103	92	87	85	67	110
50	AIR	~0	C1	1/4 OP	1/2 OPEN	112	111	125	123	118	112	102	93	93	67	119
0	16%	~0	C1	1/8 OP	1/2 OPEN	70	66	93	115	92	95	85	76	71	68	106
0	16%	~0	C1	1/4 OP	1/2 OPEN	104	108	106	107	102	97	93	80	78	74	108
50	16%	~0	C1	1/8 OP	1/2 OPEN	71	73	84	95	85	94	93	86	92		99
50	16%	~0	C1	1/4 OP	1/2 OPEN	88	106	119	120	116	109	105	87	86	—	116
100	16%	~0	C1	1/8 OP	1/2 OPEN	71	73	85	91	83	92	93	85	94	—	99
100	16%	~0	C1	1/4 OP	1/2 OPEN	101	111	121	121	116	109	105	86	85	—	116
150	16%	~0	C1	1/8 OP	1/2 OPEN	70	74	87	92	84	94	94	87	95	—	100
150	16%	~0	C1	1/4 OP	1/2 OPEN	104	113	123	123	117	110	106	87	85	—	118
200	16%	~0	C1	1/8 OP	1/2 OPEN	70	75	85	92	83	93	90	88	94	—	96
200	16%	~0	C1	1/4 OP	1/2 OPEN	106	115	124	124	118	111	100	88	84	—	119

Date 22 April 1970

* estimate

Table E-6

Sound Levels in Standard USN MK V Helium-Oxygen Diving Helmet, H2 Open Circuit Operation, Right Ear Position, Helmet Tested Dry.

APPENDIX F

EFFECT OF LINING THE INTERIOR OF HELMET A7 WITH A LAYER OF 3/16" FOAMED NEOPRENE WETSUIT MATERIAL.

SUPPLY VALVE SETTING	EXHAUST VALVE SETTING	OVER-BOTTOM PRESS, PSI	FLOW, CFM	EAR & DEPTHS, FSW	BROAD-BAND, SPL, DB	OCTAVE BAND SOUND PRESSURE LEVELS IN DB RE 0.2 MICROBAR AT INDICATED CENTER FREQUENCIES IN HZ										dbA
						31.5	63	125	250	500	1000	2000	4000	8000	16000	Equiv-alent
FULL OPEN	FULL OPEN		YES	R 0'		78	77	75	79	88	88	89	86	76	74	95
FULL OPEN	FULL OPEN		NO	R 0'		78	83	82	85	94	94	94	99	94	90	105
FULL OPEN	FULL OPEN		YES	R' 100'		74	73	87	83	88	96	93	83	78	73	99
FULL OPEN	FULL OPEN		NO	L 100'		81	93	88	90	95	96	95	93	89	83	101
FULL OPEN	FULL OPEN		YES	R 200'		72	74	88	86	91	98	93	82	74	71	99
FULL OPEN	FULL OPEN		NO	L 200'		87	92	90	92	98	98	95	91	87	79	101

APPENDIX F   Effect of lining the inside of Helmet A7 with a layer of 3/16" foamed neoprene wet suit material.

APPENDIX G

MUFFLER SYSTEM DEVELOPED BY THE NAVAL ELECTRONICS LABORATORY CENTER* FOR THE USN MARK V AIR DIVING HELMET.

* Formerly the Navy Undersea Warfare Center.

DEPARTMENT OF THE NAVY
NAVAL UNDERSEA WARFARE CENTER
SAN DIEGO, CALIFORNIA 92132

IN REPLY REFER TO:
NUWC 605C
25 Oct 1968

AIRMAIL

From: Roy G. Klumpp, Code 605C, Naval Undersea Warfare Center
To: Commander W. Milwee, U. S. Navy Experimental Diving Unit, Washington Navy Yard, Bldg. 214, Washington, D. C. 20390

Subj: Modification of the Mark V, Mod. 1 helmet for improved voice communication

To improve communication with a diver in a deep sea suit, modifications were made to the Mark V, model 1 helmet.

Items removed from the helmet included:

(1) The small intercom loudspeaker.
(2) The two-wire communications connector.
(3) The three shallow ducts carrying input air .

Items added to the helmet included:

(1) A four-wire EO connector.
(2) A noise-cancelling MJ01 microphone and preamplifier.
(3) A cloth helmet with H-143 earphones.
(4) Three air ducts (pipes), each terminating in a silencer with sintered metal elements.

These changes were made to improve the speech-to-noise ratio and the fidelity of transmission to and from the diver. The changes also permit the helmet to be used with the NUWC model 2 diver communication amplifier.

The pair of photographs enclosed show the air silencing arrangement before it was installed in the helmet.

Preliminary results indicate:

(1) The silencer arrangement reduces air input noise in the speech band between 20 and 30 dB depending upon air flow rate.
(2) Restriction produced by the silencer arrangement at a flow of 30 cubic feet per minute (maximum available at time of test) was no greater than that of the standard Mark V ducts.
(3) Preliminary dives to 20 feet indicate no interference with normal suit operation. Communication was good to excellent.

Roy G. Klumpp
ROY G. KLUMPP

Copy to:
NAVSHIPS Code 00C, CAPT W.F. Searle