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MEMORANDUM REPORT NO. 68-1

**IMPROVING THE INTELLIGIBILITY OF HELIUM-SPEECH PRODUCED  
IN 13.18 TIMES NORMAL ATMOSPHERIC PRESSURES**

by

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**Bureau of Medicine and Surgery, Navy Department  
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NAVAL SUBMARINE MEDICAL CENTER  
NAVAL SUBMARINE BASE NEW LONDON  
GROTON, CONNECTICUT

MEMORANDUM REPORT 68-1

IMPROVING THE INTELLIGIBILITY OF HELIUM-SPEECH PRODUCED  
IN 13.13 TIMES NORMAL ATMOSPHERIC PRESSURES

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## SUMMARY PAGE

### THE PROBLEM

To obtain a high-fidelity recording of helium-speech at 13.13 atmospheres (simulating a depth underwater of 400 ft), and to note improvement to the intelligibility of that speech when two frequency-shifting techniques are employed.

### FINDINGS

Higher intelligibility than usually reported in the literature was obtained by employing a high-fidelity microphone and recording system. The intelligibility of that high-fidelity recording was greatly increased by tape playback at one-half speed. A significant increase also resulted when frequencies were shifted downward by a factor of two made possible by techniques inherent in the "Varivox" equipment.

### APPLICATION

Information contained in this report is useful to the design of a communications system which will improve reception of divers' speech during deep-submergence.

## ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Work Unit MF022.01.04-9005 - Procedures for Improving Vision, Auditory Communication, and Orientation Underwater. The present report is No. 3 on this Work Unit and has been designated as Memorandum Report No. 68-1. It was approved for publication on 8 January 1968.

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# IMPROVING THE INTELLIGIBILITY OF HELIUM-SPEECH PRODUCED IN 13.13 TIMES NORMAL ATMOSPHERIC PRESSURES

## INTRODUCTION

The principal distortions of the speech signal in underwater voice communications are those from breathing helium-rich mixtures, from increases in ambient pressure, and from a number of special environmental demands made upon communications equipment.

Acoustic analysis of helium-speech reveals an upward shift in the frequency spectrum; appropriate electronic components might therefore be designed to reduce frequencies to the normal range, and thereby improve intelligibility.

The intelligibility of helium-speech has been improved in a number of different ways: (a) one may simply incorporate higher-fidelity communication components, (b) some workers improved intelligibility by using one-half-speed tape playback, (c) some have "unscrambled" helium speech, usually by lowering frequency components, using tape splicing, heterodyning, vocoder and other speech synthesizers, and (d) the reconstruction of a more normal acoustic spectrum through computer technology. Most of these reports are qualitative in nature.

## PURPOSE

This study documents the intelligibility of a high-fidelity recording of helium-speech for monosyllables spoken at 13.13 atmospheres, and the improvement when the taped speech was: (a) played to listeners at half speed, and (b) passed through a system ("Varivox", see Ref. 1) which shifted frequencies downward by a factor of two while preserving real time.

## PROCEDURE

An adult male diver, experienced in dives which require helium-rich breathing mixtures, spoke while inside a pressure chamber pressurized to an ambient pressure equivalent to 400 feet submersion underwater, or 13.13 ata. The chamber was filled with an HeN<sub>2</sub>O<sub>2</sub> mixture consisting of 88% He, 6% N<sub>2</sub>, and 6% O<sub>2</sub>. A list from the Modified Rhyme Test (2) was read aloud and picked up with a Beyer M-130 low-impedance ribbon microphone inside the chamber and fed to an Ampex 602 half-track tape recorder outside the chamber. The recording had an excellent mean speech-to-noise ratio of +32 dB. A second recording of another comparable list was made with the diver breathing air at normal atmospheric pressure.

Three panels of young men were used, who had normal hearing by standard audiometry; none was familiar with helium-speech. The speech was presented monaurally in a group testing room containing 50 matched Telephonics TDH-39 earphones imbedded in supra-aural muffs. The tapes were

played on an Ampex 300-2 tape recorder. Each listening panel heard the normal speech with white noise added to produce a speech-to-noise ratio of -1 dB.

Fourteen men comprising Panel 1 heard the untreated HeNO<sub>2</sub> speech; 15 men of Panel 2 heard the same HeNO<sub>2</sub> recording played at one-half speed; 10 men of Panel 3 heard the HeNO<sub>2</sub> recording after frequencies had been reduced to .50 times the original, with the Varivox (this signal was band-pass filtered at 350-3600 Hertz to eliminate some of the noise introduced by the operation of the Varivox).

## RESULTS AND DISCUSSION

1. Untreated high-fidelity recordings of helium-speech at 1 ata.  
Previous work from this laboratory has shown that such recordings can yield 98+% intelligibility.

2. Untreated high-fidelity recordings of helium-speech under pressure.  
Table 1 shows mean intelligibility scores for the normal speech (at S/N = -1 dB) between 56.2% and 58.0%; the three panels were similar in their responses to normal speech-in-noise. Intelligibility was 78% for the high-fidelity recording of helium-speech at high pressure. When compared with the 98% scores of (1) above, the effect of pressure is seen to amount to a decrement of 20 words per hundred. However, the score of 78% is high compared to reports by other investigators. For example, Hollien and Thompson (3) state that "The combined effects of HeO<sub>2</sub> mixtures and high ambient pressures were extremely detrimental to speech intelligibility (scores of less than 20% were common at 450 feet.)". The fidelity of the equipment used in the present study must be emphasized. In an evaluation of military and commercial communicators, Hollien, et al (4) report very poor speech intelligibility; speech, produced by divers submerged to 35 feet in water, was recorded

TABLE I.

Intelligibility Scores Obtained for Normal Speech in Noise and for Different Treatments to HeNO<sub>2</sub> Speech Spoken under 13.13 Atmospheres

Panel	N	Treatment	Speech in Air		HeNO <sub>2</sub> Speech	
			in Noise %	1 ata S.D.	at 13.13 ata %	S.D.
1	14	Normal Playback	58.0	2.8	78.0	3.6
2	15	One-half Speed	57.2	3.5	96.8	1.1
3	10	Varivox Treated	56.2	1.8	85.6	1.7

through different swimmer communication systems and later played to 12 listeners in a sound-treated room. In their investigation, "scores varied from levels close to zero to slightly over 50%". Undoubtedly the communications components studied represented the usual field compromises with laboratory standards.

3. Effect of lowering frequencies while proportionately stretching time.

Note in Table I that a mean intelligibility score of 96.8% was obtained when helium-speech was played back at one-half normal speed. This is a striking improvement over the 78.0% obtained for the same recording played at normal speed. Although the "quality" of the voice is noticeably changed from that of Helium-speech, other distortions introduced by this technique make recognition of an individual's voice poor.

4. Effect of lowering frequencies while preserving real time.

When frequencies of the HeNO<sub>2</sub> recording were reduced to a more normal range with the Varivox, a mean intelligibility score of 85.6% was obtained, representing a significant improvement to the original recording. In addition, the quality seemed very near normal to the panel of listeners.

5. Comparison of methods of shifting frequencies downward.

Under the conditions of this study, the tape-speed translation yielded significantly (11.2 intelligibility points) better reception than the Varivox, but has the disadvantage of losing real time: after a diver speaks, communications must cease, until the taped recording is played back at twice the message time; obviously more than three times the original time is required for message reception. The Varivox, however, is capable of on-line playback while maintaining real-time, with perhaps a supportable drop in reception and with a noticeable change in "quality" toward a more normal sounding voice.

## SUMMARY AND CONCLUSIONS

An experienced diver produced speech in a helium-rich atmosphere at 13.13 atmospheres. It was found that higher intelligibility than usually reported in the literature was obtained by employing a high-fidelity microphone and recording system. The intelligibility of that high-fidelity recording was greatly increased, at the expense of losing real time, by tape playback at one-half speed. A significant increase to intelligibility resulted when frequencies were shifted downward by a factor of two by techniques inherent in the "Varivox", and furthermore, near-real time was preserved.

## REFERENCES

1. Instruction Manual: Vari-Vox, Issue A., Kay Electric Company, Pine Brook, N.J., 1959.
2. House, A. S., Williams, Hecker, M.H.L. and Kryter, K. D. Psychoacoustic speech tests: A modified rhyme test. Tech. Doc. Rept. ESD-TDR-63-403, Electronic Systems Div., Air Force Systems Command, Hanscom Field, June 1963.
3. Hollien, H. and Thompson, C. L. Speech intelligibility as a function of helium-oxygen breathing mixture and ambient pressure. Abstract BB7, 74th Meeting, Acoust. Soc. of Amer., November 1967, Miami Beach, Fla.
4. Hollien, H., Coleman, R. F. and Thompson, C. L. Evaluation of underwater speech communicators. Abstract BB10, 74th Meeting, Acoust. Soc. of Amer., November 1967, Miami Beach, Fla.

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13. ABSTRACT This study reports the results of efforts to improve the intelligibility of helium- speech when spoken at a simulated depth of 400 feet. These efforts included the taping of helium-speech and playing it back to listeners at half speed, also passing it through an equipment system ("Varivox") which shifted frequencies downward by a factor of two while preserving real time. Higher intelligibility was obtained by employing a high-fidelity microphone and recording system. The intelligibility of this recording was greatly increased when the playback was slowed to one half speed. And a significant further increase in intelligibility was found when frequencies were shifted downward by the techniques inherent in the special equipment described.			

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