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May 15, 1957

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Subject: Contract RD-94
Task Order No. 2

[redacted]

In accordance with Article 2 of the basic contract, there are forwarded herewith two (2) copies of the Monthly Progress Report for April, 1957 on Task Order No. 2 of RD-94. The report is dated April, 1957. This report is UNCLASSIFIED. An additional copy is being held [redacted] by the project engineer for the use of your personnel while at this location.

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In connection with this monthly progress report, the following information is submitted:

Total expenditures to 3-31-57	$26,152
Outstanding commitments as of 3-31-57	135
Funds remaining as of 3-31-57	$34,029

Very truly yours,

[redacted] 25X1

Assistant Manager
Government Contract Administration

THR:mr
f-14608
Enclosures

cc: [redacted] n [redacted]

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Monthly Progress Report

April 1957

Task Order No. 2

Contract No. RD-94

Audio Noise Reduction Circuits

The object of this project is to develop a noise reduction circuit suitable for use in separating speech intelligence from a signal containing speech and noise when the speech intelligence is masked by the noise. The proposed method involves a principle which has been used successfully to improve the signal-to-noise ratio in music reproducing or transmission systems.[1] The system used for music contains bandpass filters which pass frequencies over a range of an octave or less. These filters are used at the input and output of a non-linear element. The output of the non-linear elements contain the fundamental, and also harmonics and subharmonics of the fundamental. However, since the pass band of the input and output bandpass filters is no greater than an octave, the harmonics and subharmonics are not transmitted by the system. The function of the non-linear element is to reject all noise signals below a given amplitude or threshold level. The threshold levels of the non-linear devices in each channel can be adjusted so that, in the absence of desired signal, the noise is rejected. When the desired signal is greater than the threshold level, the non-linear elements allow the composite signal to pass. Thus, for passages of recorded music, when the music signal is below the noise level in a given frequency channel, the channel is inoperative, and its output is eliminated from the total output. Since the contribution of this channel to the total output would have been only noise, the overall noise level is reduced. When the music

1. H.F. Olson, "Electronics," Dec. 1947.

signal in a given channel is greater than the noise, the channel conducts and allows the composite signal to pass. Thus, a channel conducts only when the desired signal is greater than the noise, and rejects when noise alone is present.

In order to apply this method of noise reduction to speech, when the wide band speech signal-to-noise ratio is very low, it is necessary to find frequency regions in which there are times when the speech amplitude is greater than the noise. Although the long time average spectrum of speech is continuous, and similar in shape to the spectrum of room noise,[2] the short time spectrum of various speech sounds contains regions of maximum energy called speech formants.[3] The assumption that this method of noise reduction could be utilized for speech was based upon the belief that it would be possible to find frequency regions in which the amplitude of the speech formants would be greater than the noise a substantial part of the time.

A study has been made to determine what bandwidths are required in order to obtain speech formant amplitudes above the noise when a wide band speech sample is just intelligible in noise. It is known that for noises with a continuous spectrum it is the noise components in the immediate frequency region of the masked tone which contribute to the masking.[4] When a very narrow band of noise is used to mask a pure tone, the masking increases as the bandwidth is increased until a certain bandwidth is reached. After this, as the bandwidth is increased, the amount of masking remains constant. This bandwidth at which the masking reaches a fixed value is termed the critical bandwidth. **Measurements have been**

2. H. Fletcher, "Speech and Hearing on Communication," Van Nostrand Co., Inc., New York, 1953 (see Figures 61 and 70).

3. Op.cit. chap. 1.

4. L.L. Beranek, "The Design of Speech Communication Systems," Proc. IRE, Vol. 35, pp. 882, Sept. 1947.

5. N.R. French and J.C. Steinberg, "Factors Governing the Intelligibility of Speech Sounds," Jour.Acoust.Soc.Amer., Vol. 19, Jan. 1947 (see Figure 7).

made using filters which were both narrower and wider than the critical bandwidth. Both pure tones and speech mixed with continuous spectrum type noises have been studied. The results of this study show that, for the narrowest permissible bands which can be used to pass speech formants, the number of times the speech formant amplitude in a given band exceeds the noise is small. Also, in these bands, the speech amplitude is never considerably greater than the noise. Since very narrow bandwidths are required to reduce the noise below the signal, the number of bands required to cover the speech spectrum is quite large. There is no satisfactory way of evaluating the effect upon speech intelligence of small contributions from many narrow bands without building a many channeled circuit and evaluating it. From the information available from studying a few channels throughout the speech spectrum, it seems possible that some improvement in intelligibility can be effected, but this improvement may prove to be small.

In view of the fact that there is no convenient way to evaluate the contributions of a few narrow band channels to speech intelligibility, a complete multi-channel system is being developed in order to determine the effectiveness of this method of improving speech intelligibility in noise.

During April the wiring and model shop work on the eighty channel noise reducer was completed. The chassis have all been checked and perform satisfactory. The individual channels are now being aligned. The frequency of each channel is adjusted to within ± 2 cycles per second of the design frequency. The frequency is measured with an electronic counter to insure accuracy. The bandwidth of each channel is adjusted to within ± 2 cycles per second of the desired bandwidth; that is, 3 db less than the critical bandwidth at each frequency. The power supply has been installed in the rack and the associated wiring is completed. As soon as all of the chassis are aligned the complete noise reducer can be evaluated using speech.

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