United States Patent

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[54] **APPARATUS FOR RECONSTRUCTING SPEECH GENERATED IN AN ABNORMAL GAS ATMOSPHERE**
6 Claims, 2 Drawing Figs.

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[50] **Field of Search** 179/1 SA; 324/77 E

[56] **References Cited**

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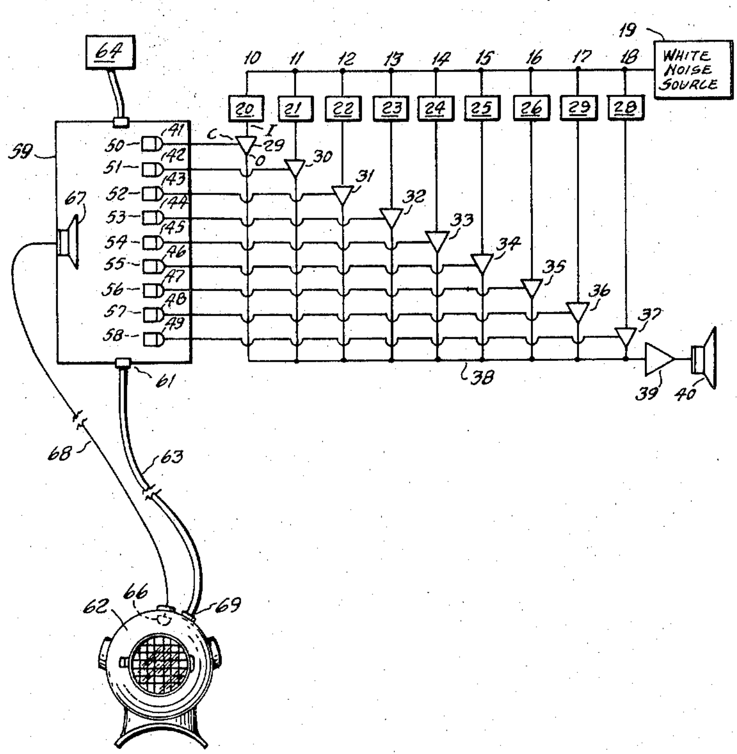
ABSTRACT: The reconstruction of distorted speech due to an abnormal breathing atmosphere is accomplished by providing a series of separate channels each supplied with a white noise signal and having therein a narrow band filter and an amplitude controllable amplifier. The control input of each amplifier is connected to a microphone disposed within a Helmholtz resonator whose resonant frequency in air is equal to that of the filter associated with that particular amplifier. The resonators are disposed in an atmosphere identical to that of the person whose speech is to be reconstructed or proximate the speaker and are subjected to the distorted acoustic speech. The outputs of the amplifiers are simultaneously applied to an output amplifier which in turn drives a transducer such as a loudspeaker to provide a corrected speech pattern.



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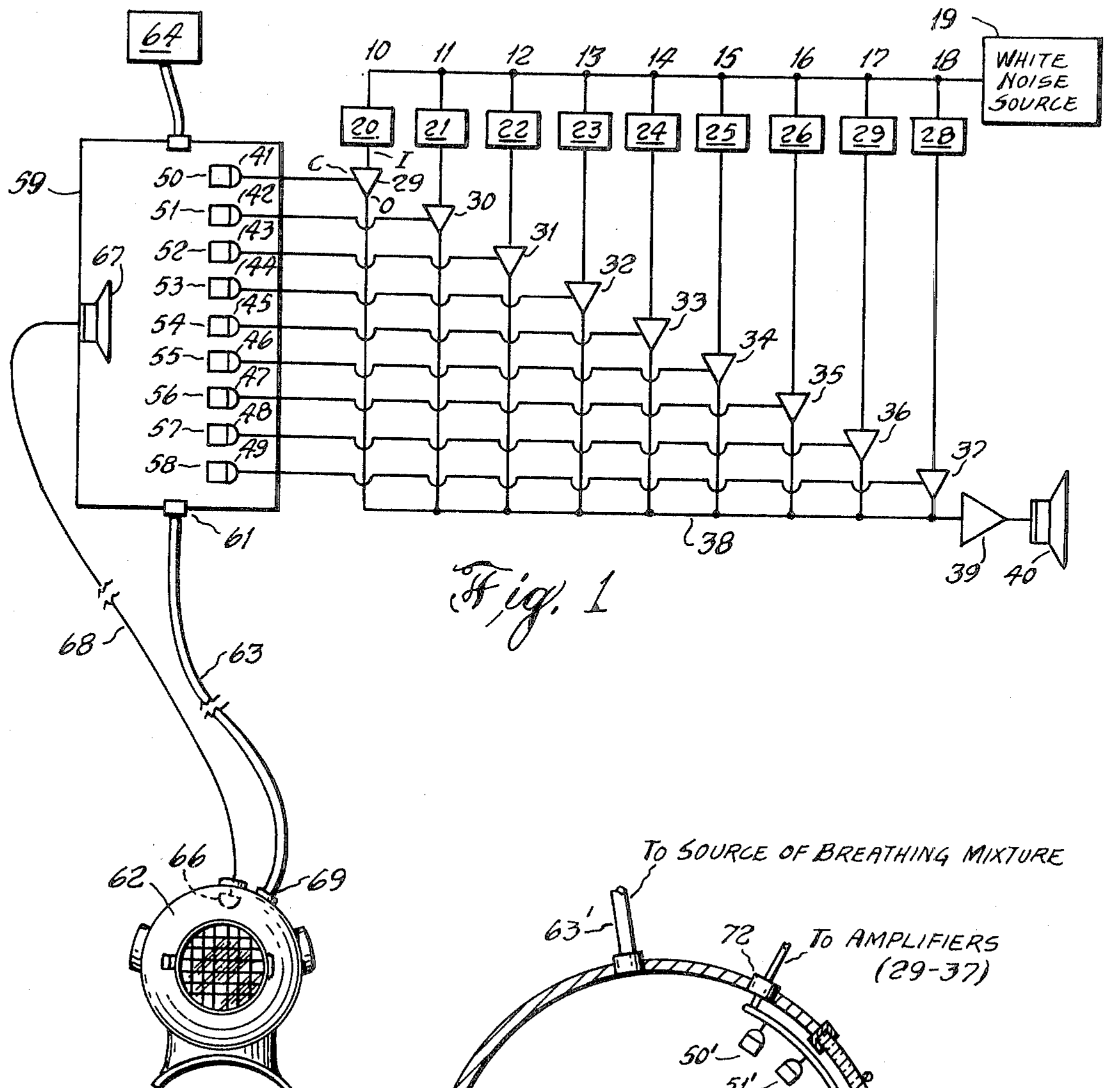

Fig. 1

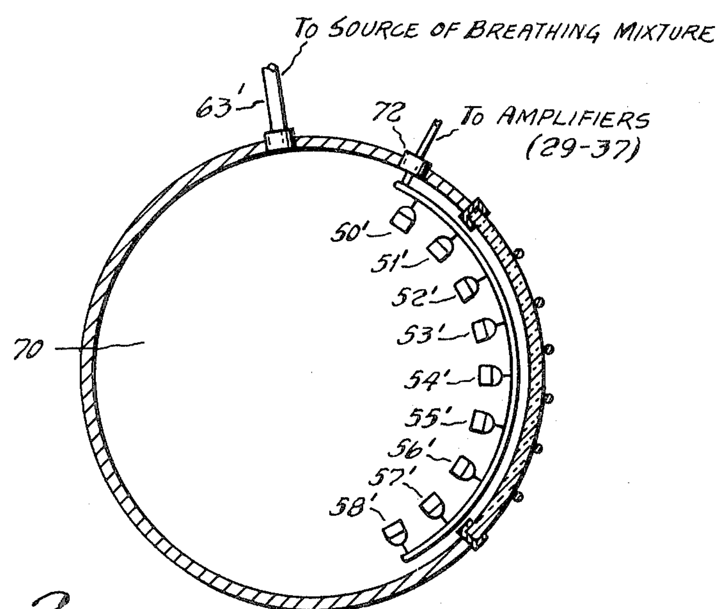

Fig. 2

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APPARATUS FOR RECONSTRUCTING SPEECH GENERATED IN AN ABNORMAL GAS ATMOSPHERE

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to speech reconstruction and more particularly pertains to the correction or synthesis of voice distortion resulting from speaking in an abnormal gaseous environment.

2. Description of the Prior Art

In the field of voice reconstruction, it has been the general practice to employ complex electronic equipment wherein the acoustic voice signal is first converted into its electrical analog which is then processed by frequency separation. Each separate frequency channel is independently shifted by a specific amount and the channel outputs reassembled to provide the undistorted speech pattern. Such devices have been unsatisfactory in that, where attempts have been made to employ them for correcting speech distorted by an abnormal gaseous environment, either prior complex calculations or trial and error methods are necessary to determine proper processing values for each channel.

SUMMARY OF THE INVENTION

The general purpose of this invention is to provide a voice distortion correction apparatus that has all the advantages of similarly employed prior art devices and has none of the above-described disadvantages. To attain this, the present invention provides a unique speech reconstruction system wherein a microphone disposed within the chamber of a Helmholtz resonator, tuned to a specific frequency, controls the amplitude of an amplifier which is receiving white noise in the same frequency spectrum. A plurality of channels are employed to cover the voice spectrum and their outputs combined to provide undistorted speech. The Helmholtz resonators are located in the environment of the speaker or in an identical gaseous environment whereby automatic frequency shifting is attained.

An object of the present invention is to provide a simple, direct, inexpensive and reliable apparatus for correcting distorted speech induced by the speaker's presence in an abnormal gaseous environment.

Another object is to provide an apparatus for automatic reconstruction of speech having been distorted so as to be unintelligible by an abnormal gaseous atmosphere and to improve intelligibility.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of an embodiment made in accordance with the principle of this invention; and

FIG. 2 illustrates a modification of the embodiment of FIG. 1 wherein sensing transducers are located proximate the speaker's face.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The generation of human speech is a relatively complicated process in that it involves the coordinated use of lungs, vocal cords and the resonating cavities and passages in the throat, mouth, and nose. A plurality of muscles are coordinated in the vocalizeing act and constantly alter the resonant characteristics of the voice through positioning of the tongue, palate, cheeks, lips and teeth. The use and dexterity of the muscles to shape sounds and to form them into words is learned early in life and thereafter becomes an automatic process necessitating little or no conscious effort. It is clear, however, that the use of these resonant cavities to form intelligible speech is adapted to an air environment. When a speaker attempts to talk in "other than normal air" atmosphere, he makes use of his muscles to shape the resonant cavities that would produce normal speech in air. Since the characteristic frequency of a resonant cavity depends not only on the physical dimensions of the cavity but also on the velocity of the acoustic wave in the medium which fills the cavity, the resultant voice sounds unnatural.

The velocity of sound in an atmosphere is a function of the particular gas which comprises the atmosphere, its temperature and pressure. The effect or correction for pressure is relatively negligible, while the velocity is approximately proportional to the square root of the absolute temperature. This also has very little effect on any frequency shift. The factor most responsible for changes in voice characteristics, resulting in distorted speech, is the gas chosen as the breathing mixture. In deep diving operations, a helium-oxygen mixture is most often employed. The speed of sound in pure helium at 0° C. at 1 atmosphere pressure, is 3,182 ft./sec., compared to 1,087.5 ft./sec. for air under identical conditions. Since the characteristic acoustic resonance of a cavity is directly proportional to the speed of sound, the replacement of the normal atmosphere by a helium-oxygen breathing mixture causes the voice formants to shift upward in frequency. This upward shift is accomplished by a spreading in the formants caused by each resonant frequency shifting by a different amount.

As an example, consider a typical voice formant which encompasses a frequency range of 300 to 1,000 Hertz in a normal atmosphere. The substitution of a new breathing mixture which caused the acoustic velocity to double would result in the formant shifting to cover the frequency range of 600 to 2,000 Hertz. This fact has been confirmed by voice prints made in both normal and helium-oxygen atmospheres.

In view of the foregoing, in order to restore the distortion caused by a new breathing mixture, it would be necessary to shift down and compress the formants by an amount equal to the up shift and spreading due to the mixture. An apparatus to accomplish this is illustrated in FIG. **1**, where a plurality of channels **10—18** are connected to each receive the output of a white or random noise source **19**. Each channel has connected therein in series or tandem a narrow band filter **20—28** and an amplitude or gain controllable amplifier **29—37**. The filters preferably are of the electrical type, and each covers a different narrow band of the voice intelligence spectrum, so that in total they cover the entire spectrum, or at least those bands contributing to overall intelligence. One such spectrum of voice formants would be 300 to 1,000 Hertz where, for example, the first filter **20** in channel **10** would cover the narrow range of 300 to 350 Hertz and the last filter **28** would cover 902—1,000 Hertz. Each of these amplifiers (**29—37**) is provided with an input terminal I, an output terminal **0** and intermediate thereof a control input C which controls the gain or output amplitude of its amplifier dependent on the voltage applied. The amplifier outputs O are all joined to a common output **38** and feed a broadband output amplifier **39**, which in turn drives a transducer or loudspeaker **40**.

Each of the control terminals C is directly tied to a sound pressure sensing transducer such as microphones **41—49** which is relatively omnidirectional and broadband. The microphones are each located within the cavity of a Helmholtz resonator **50—58**. (Essentially, a Helmholtz resonator is a cavity provided with a small aperture. The ratio of the enclosed volume to the aperture diameter (or area) determines the frequency resonance thereof. Since the ratio of the acoustic pressure developed inside the resonator to that of free space varies inversely with the volume of the resonator cavity, by providing a small volume, the resonator will exhibit a sharp pressure peak over a narrow frequency band. Thus each resonator can be made resonant in air over the narrow band-pass of the respective filter with which its microphone is associate.

The Helmholtz resonators 50—58 and the microphones 41—49 are all disposed and supported within a gas sealed tank or chamber 59, which is provided with an inlet port 60 and an outlet port 61. This chamber, for best results, should be acoustically deadened.

Where this apparatus is to be employed with a deep driving hard-hat diver using a helium-oxygen mixture, or some "other than air" breathing mixture, helmet 62 is connected by hose 63 to the chamber 59, outlet port 61, while inlet port 60 is connected to the source of breathing mixture 64 via hose 65. This insures that the Helmholtz resonators will be exposed to a gaseous environment identical to that of the diver and one into which he speaks. Microphone 66 in helmet 62 is electrically connected to a loudspeaker 67 disposed in the chamber opposite the resonators via cable 68 and, where necessary, broadband amplifier 69. With this arrangement the diver's voice, which is distorted, is reproduced withing the chamber. Since the effect of an other than normal atmosphere is minimal for a loudspeaker, no additional voice distortion is introduced by the loudspeaker 67.

Consider now the embodiment of FIG. 2. Here, the diver's helmet 70 is provided with a plurality of Helmholtz resonators 50′—58′ supported on the inner wall of the helmet opposite or proximate the mouth of the diver. The breathing mixture is supplied to the helmet by hose 63′ from the source, which is generally located on the ship. The microphones 41′—49′ are located within the cavities of the resonators and connected by multiple wire cable 72 to their respective controllable amplifiers on the ship. This arrangement obviates the necessity of employing a separate chamber aboard the ship and an additional microphone and loudspeaker to reproduce the diver's voice therein.

Summarizing the operation a series of Helmholtz resonators are placed into an acoustically deadened chamber. The diver's speech is supplied to the chamber and the diver's breathing mixture comprises the atmosphere of the chamber. A microphone is placed into the Helmholtz resonator to measure the sound pressure developed in the cavity.

By inserting a microphone into the cavity and placing the Helmholtz resonator into an acoustic field, the output of the microphone will give us an output which varies directly with the amplitude of the narrow band of frequencies at which the cavity is resonant. This output can be used to control the gain of an amplifier.

The input of the amplifier is a narrow band of frequencies which is the narrow band at which the Helmholtz resonator is resonant in air. As the Helmholtz resonator responds to an acoustic field in air, it will control the gain of an amplifier supplying the same narrow band of frequencies to a loudspeaker.

By using a series of resonators throughout the audio spectrum to control amplifiers whose inputs correspond to the frequencies of the resonators in air the output at the loudspeaker will correspond to the acoustical input in air.

The inputs to the controlled amplifiers can be obtained by a series of narrow band filters at the output of a white noise source. The output of each narrow band filter will supply the input to a controlled amplifier. A Helmholtz resonator microphone combination will supply the control signal. The output of each controlled amplifier will always be the same narrow band of frequencies, and it will be the narrow band of frequencies at which the Helmholtz resonator which supplies its controlling signal is resonant in air.

When the atmosphere in the chamber which contains the series of Helmholtz resonators is changed to a different gas the narrow frequency band at which the Helmholtz cavity resonates will shift. The small band of frequencies which the cavity-microphone signal controls, does not shift. If the atmosphere in the chamber is the same as what is breathed by the speaker, the system will compensate the shift and spread of the voice characteristics and provide an output similar to the voice characteristics of the speaker in air.

For example, taking a typical voice formant of 300 to 1,000 Hertz in air, we know that if the speakers breathing atmosphere were changed to one in which the speed of sound doubled the formant would now occupy 600 to 2,000 Hertz. If we introduce the new atmosphere to the chamber containing the series of Helmholtz resonators, the resonators covering the spectrum of 300 to 1,000 Hertz in air will cover the spectrum 600 to 1,000 Hertz in the new atmosphere. However, these resonators will supply controlling signals to amplifiers whose output covers the 300 to 1,000 Hertz spectrum.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. An apparatus for correcting the acoustic distortion of the reproduced voice of a diver breathing an other than normal atmosphere which comprises;
- a plurality of audio channels each having connected, in tandem therein,
- a narrow band filter,
- a gain controllable amplifier having input and output terminals and a control terminal,
- said channels each having its filter tuned to a different center frequency to cover a portion of the audio spectrum,
- a source of random noise having its output connected simultaneously to each of said filters,
- a closed chamber having therein an atmosphere identical to that of said diver and having disposed therein
- a plurality of Helmholtz resonators each tuned in air to a frequency identical to one of said filters,
- an acoustic transducer for each of said resonators disposed to sense the acoustic pressure in each of said resonators,
- mean connecting each of said transducers with said control terminal of said gain controllable amplifier which is in tandem with said filter tuned to the same frequency as said resonator associated with that transducer,
- acoustic output means connected simultaneously to said output of said amplifiers, and
- reproducing means disposed in said chamber and connected to reproduce the distorted speech of said diver therein,
- whereby the output from said acoustic means will convert said diver's voice into intelligible speech.

2. The apparatus according to claim 1 wherein said transducers are microphones.

3. The apparatus according to claim 2 wherein said acoustic output means is a loudspeaker.

4. The apparatus according to claim 3 wherein said reproducing means is in part, external to said chamber and includes:
- a speaker's microphone disposed proximate said diver's face,
- a second loudspeaker disposed within said chamber, and
- an electrical connection between said second loudspeaker and said speaker's microphone.

5. An apparatus for correcting the acoustic distortion of a diver using a diving helmet and breathing an other than normal atmosphere, which comprises:
- a plurality of audio channels each having connected in tandem therein:
- a narrow band filter,
- a gain controllable amplifier having input and output terminals and a control terminal,
- said channels each having its filter tuned to a different center frequency to cover a portion of the audio spectrum,
- a source of random noise having its output connected simultaneously to each of said filters
- said helmet having disposed therein;
- a plurality of Helmholtz resonators each tuned in air to a frequency identical to one of said filters,

an acoustic transducer for each of said resonators disposed to sense the acoustic pressure in each of said resonators,

means connecting each of said transducers with said control terminal of said gain controllable amplifier which is in tandem with said filter tuned to the same frequency as said resonator associated with that transducer, and

acoustic output means connected simultaneously to said output of said amplifiers,

6. The apparatus according to claim **5** wherein said transducers are microphone and said acoustic output means is a loudspeaker.