United States Patent [19]

Acks

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[54] **HYDROSONIC DIVING COMMUNICATION AMPLIFIER SYSTEM**

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[52] **U.S. Cl.** ..... **179/1 D,** 179/1 UW

[51] **Int. Cl.** **H04m 9/00**

[58] **Field of Search**.. 179/1 P, 1 D, 1 UW, 100.2 K; 333/76, 81 B, 28 T; 325/477

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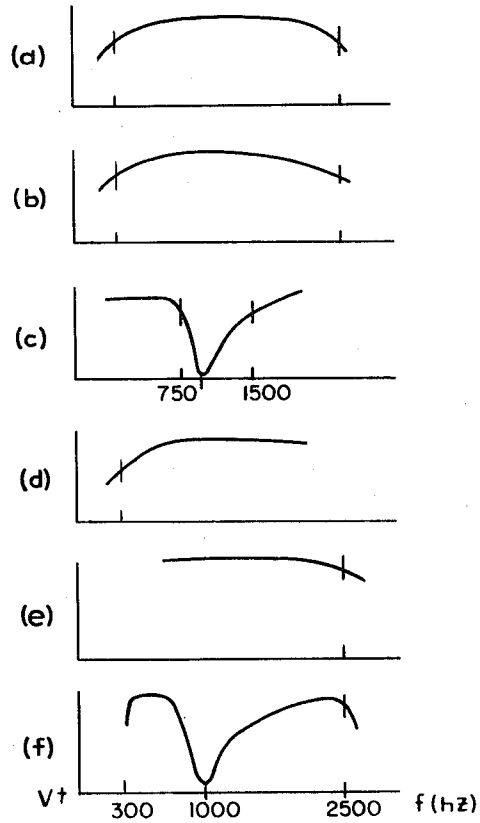
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[57] **ABSTRACT**

Intelligible audio communications between a diver and a surface boat, or from the occupant of a recompression chamber to the outside, are ensured by interposing an electronic system between a microphone and a speaker to block major portions of gas-flow noise generated as the gas is transferred. A preamplifier stage is electrically connected to the microphone, and a preamplifier filter defines the passband of composite signals composed of gas-flow noise and audio communications. An attenuation stage receives the composite signals and further excludes signals lying outside the composite signals' passband, and notches out high intensity gas-flow noise concentrated at a particular noise frequency predetermined by spectral analysis of the composite signal. Necessarily, a portion of the audio communications, centered about the noise frequency, is also blocked; however, the remainder is sufficient to enable reconstruction of intelligible speech at an interconnected speaker.

3 Claims, 9 Drawing Figures



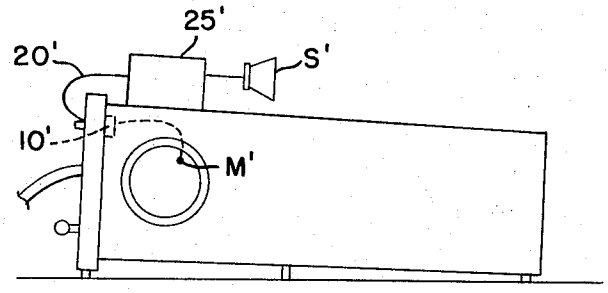


FIG. 4

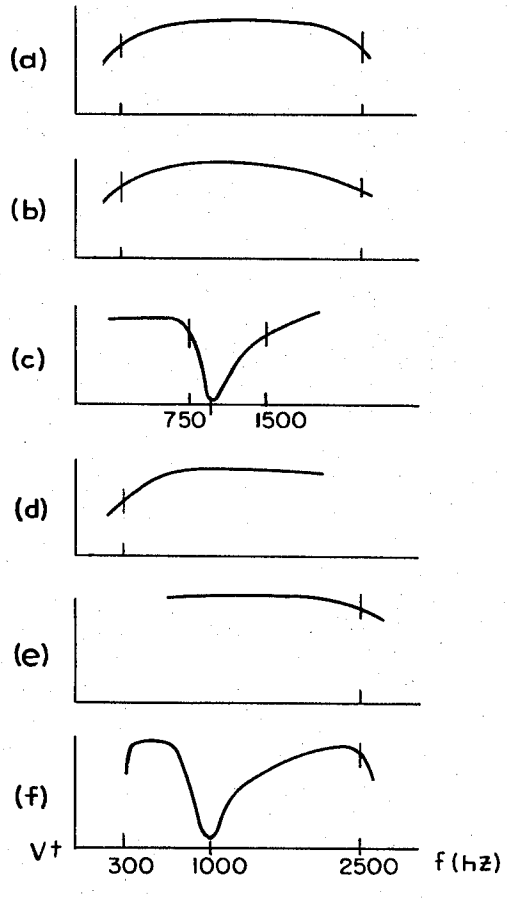


FIG. 3

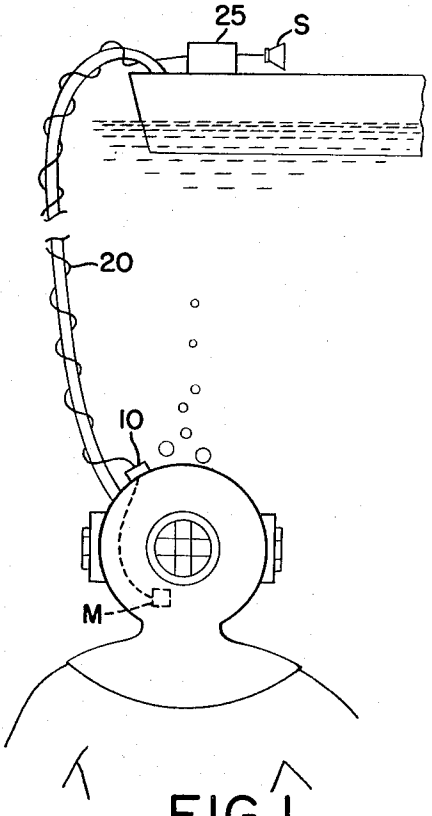


FIG. 1

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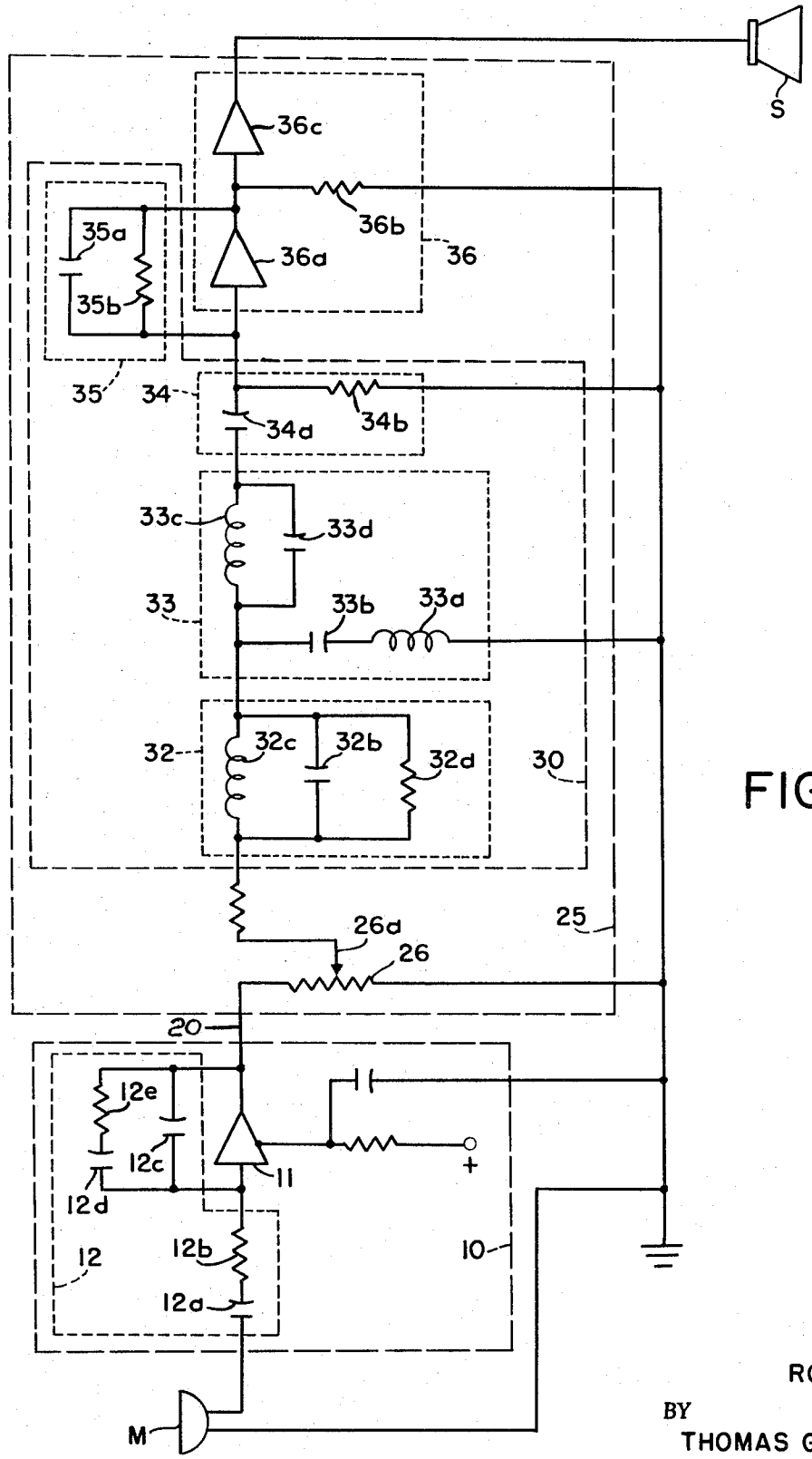


FIG. 2

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HYDROSONIC DIVING COMMUNICATION AMPLIFIER SYSTEM

STATEMENT OF GOVERNMENT INTEREST

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

Life support systems passing relatively high volumes of gas, e.g., air or helium-oxygen mixtures, are all burdened with relatively high levels of gas-flow noise generated within the systems. A hard hat diver, relying on a surface-supplied source of air, receives up to 10 cubic feet of air per minute, at depth pressure, while working under strenuous conditions. As this volume of gas is vented from the life-support hose to the helmet's interior, a nearly deafening level of gas-flow noise is created at this interface and the diver has difficulty in making himself understood over the intercom linking him to his supporting ship due to the high gas-flow noise. One well-known method of reducing this noise uses a mechanical, sponge-like, or sintered metal, filter arrangement to diffuse the gas-flow and meets with some degree of success. However, since a diver's gas demands increase with depth and increased physical activity, the mechanical filters are incapable of attenuating the deafening noise attendant the greatly increased flow rates. Usually, under these conditions, reliable communications are urgently needed, but they are blocked by the noise. Scuba users also find communications impossible due to regulator and bubble noise. Similarly, victims of a decompression sickness, when placed in a recompression chamber, are unable to communicate with chamber attendants because the noise, generated as the recompressing gas is exchanged in the chamber, masks speech. The basic problem, which explains the ineffectiveness of contemporary noise suppression systems, resides in the fact that the bandwidth of gas-flow generated noise embraces, substantially, the same audio spectrum as does the bandwidth of the intelligible speech. Attempts at electronically filtering this noise, heretofore, seriously degraded the intelligibility of the audio communications and have largely proven to be unsatisfactory.

SUMMARY OF THE INVENTION

The present invention is directed to providing an improvement in gas transfer systems having gas-flow noise interfering with the audio communication between a microphone to a remotely located speaker. A preamplifying stage coupled to the microphone defines the bandwidth of composite signals composed of gas-flow noise and audio communications. Appropriate circuitry attenuates selective bands of the composite signals where gas-flow noise is greatest while passing intelligible audio communications to an amplifier stage and to a following speaker.

A prime object of the invention is to provide an electronic circuit for improving audio communications in an environment having high gas-flow noise.

Still another object is to provide a system ensuring more reliable audio communications between a diver and a supporting vessel.

Still another object is to provide a gas transfer system having electronic circuitry for notching out highly objectionable concentrations of gas-flow noise to permit the transfer of intelligible speech.

Yet another object is to provide a gas transfer system having an electronic noise rejection capability far superior to contemporary, mechanical noise rejection systems.

A further object is to provide a method for ensuring reliable communications between a diver and a surface vessel.

These and other objects of the invention will become more readily apparent from the ensuing description when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric depiction of the invention operationally deployed.

FIG. **2** is a schematic diagram of the invention.

FIGS. **3** (*a*)–(*f*) are gain-bandwidth representations of signals being fed through the invention.

FIG. **4** is an isometric depiction of another application of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention primarily is designed to enable more reliable communications between a diver and his surface tender by masking out certain high noise-energy bands within the audio spectrum. In FIG. **1**, a diver working on the bottom is fitted with any one of several differently configured, commercial diving helmets which have an internal microphone M carried adjacent the diver's mouth. A hose reaches up to a surface supporting vessel and provides a passageway for life-sustaining air or mixed gas. The air is vented to the helmet's interior, at a location usually behind the diver's head, and at this interface, all the conventional diving helmets produce deafening levels of gas flow noise.

Each helmet passes its own gas-flow noise spectrum depending upon its configuration, the rate of gas flow, etc. All the noise spectrums totally, or partially, occupy the audio spectrum in which intelligible speech is found. The gas-flow noise spectrums of the many different diving helmets are determined by monitoring their noise distributions with an audio spectrometer.

By way of specific example, the gas-flow noise generated in the United States Navy's standard diving helmet, the Mk V, Mod 1, under moderate working conditions, was found to be concentrated at a narrow frequency range centered at 1,000 Hz, while flow noise at a greatly reduced level was uniformly distributed throughout the audio spectrum. By blocking out the concentrated 1,000 Hz noise, the uniformly distributed, reduced level of noise was tolerable, particularly if the lower frequencies and the audio frequencies above the speech range were attenuated.

A preamplifier stage **10**, schematically shown in FIG. **1** carried on the top of the helmet, receives the composite signals made up of the diver's audio communication and the gas-flow noise. Looking to FIG. **2**, the preamplifier stage includes a temperature compensated amplifier **11** performing the basic function of all preamplifiers, that being to raise the output of a low-level source to enable its further processing without an appreciable degradation of the signal-to-noise ratio. The temperature compensated amplifier chosen for this

particular application is an RCA CA3035. A passband limiting filter **12** includes a 1μfd capacitor **12***a* serially joined to a 470Ω resistor **12***b* to form a high pass portion for cutting out the very low frequency portions of the composite signal, and, a low pass portion consisting of 0.01μfd capacitor **12***c* blocks the passage of composite signals lying above the intelligible speech range. The very low frequency portions lying in the range from 0 to 300 Hz are excludable from the composite signals since this range of frequency does not contribute significantly to speech intelligibility, and often embraces a range of exceptionally high-energy gas-flow noise. Similarly, those frequency components of the composite signal, lying above the range of intelligible speech, are excluded by the passband limiting filter at approximately 2,500 Hz to lower the audio communication-to-gas-flow noise ratio. The closed loop gain of the preamplifier stage is set by a 4.7μfd capacitor **12***d* and a 10KΩ resistor **12***e* which electronically cooperate with the previously described elements to provide a gain-bandwidth curve shown in FIG. **3***a* having a half power points at 300 and 2,500 Hz.

The passband limited composite signals are fed from the preamplifier stage on an insulated conductor **20** reaching to the surface vessel. Further signal processing circuitry **25** appropriately processes the signals to deliver intelligible speech to a speaker S.

On the input side of the signal processing circuitry, a volume limiting control **26,** or potentiometer, receives the composite signal and its selectively adjustable wiper **26***a* provides a signal having a desired magnitude.

The passband limited composite signals are fed from the wiper to an attenuation stage **30** for further signal processing. A resonant circuit or bandpass filter section **32** includes a 10 kilohm resistor **32***a*, a 0.02 microfarad capacitor **32***b*, and a 0.2 henry inductor **32***c* connected in parallel to define a gain-bandwidth characteristic curve, see FIG. **3***b*, which is substantially identical to the gain bandwidth characteristic of the preamplifier **10.** The additive effect of having both gain bandwidth product characteristic curves being substantially identical is to increase the rate of "roll-off" at the low and high ends to more precisely define the passband of audio communications between 300 and 2,500 Hz. Resistor **32***a* is included to lower the Q of the circuit and to increase the bandpass over a wider frequency range, in the present case, that being between 300 and 2,500 Hz.

As mentioned above, from an audio spectrometer analysis, the Mark V, Mod 1 diving helmet was found to possess a highly undesirable concentration of gas-flow noise around the 1,000 Hz frequency. A band elimination filter section **33,** or notch filter, consists of a 0.2 henry inductor **33***a* serially joined to a 0.15 microfarad capacitor **33***b*, and a 0.2 henry inductor **33***c* parallelly connected with a 0.15 microfarad capacitor **33***d* which receives the passband, limited, composite signals from section **32** to selectively attenuate the high concentration of gas-flow noise centering about 1,000 Hz. The gain-bandwidth characteristic, in this case the band rejection characteristic, is shown schematically in FIG. **3***c*, and has half-power points on the side of the rejection band at 750 and 1,500 Hz. Notching this concentration of gas-flow noise out of the composite signal lying between the 300 and 2,500 Hz limits, does not appreciably degrade the intelligibility of speech found within this passband irrespective of the fact that the audio communications also were "notched out" between 750 and 1,500 Hz.

The rate of "roll-off" at the lower limit of the composite signal passband is further increased by including a high pass filter section **34** including a 0.15 microfarad capacitor **34***a* and a 1.2 kilohm resistor **34***b* to provide the gain-bandwidth characteristic set out in FIG. **3***d*. Similarly, the upper limit "roll-off" rate is increased by a low pass filter section **35** formed of a 0.015 microfarad capacitor **35***a* and a 47 kilohm resistor **35***b*, electronically cooperating to define the gain-bandwidth characteristic set out in FIG. **3***e*. Together, the high pass filter section and the low pass filter section, having substantially the same half-power points on their respective ends as does the gain-bandwidth curve defined by bandpass filter section **32,** additively sharpen the lower and upper limits of the attenuated composite signals.

The attenuated composite signals, possessing the gain-bandwith waveform of FIG. **3***f*, are fed to an amplifying stage **36.** The stage includes a commercially available **107**B analog device **36***a* that is self-biased and temperature-compensated to amplify and feed the attenuated composite signals across a load resistor **36***b*. A following audio power amplifier **36***c*, for example a Bendix BHA–0004, further amplifies the signals to recreate intelligible speech at the speaker.

Inclusion of attenuation stage **30,** having the particular parameters described, eliminated the concentration of gas-flow noise signals at 1,000 Hz as well as below and above the speech range. Other helmets, or, for that matter, any gas transfer systems, when subjected to an audio spectrometer analysis, are found to have highly objectionable concentrations at one or more levels within the speech range. The present circuit is easily modified to attenuate concentrations of a gas-flow noise at different frequencies by merely choosing different components.

FIG. **4** depicts the adoption of the invention in another system having a prohibitively high level of gas flow noise. A recompression chamber, housing a diver suffering from a decompression sickness, is provided with a substantially identical electronic noise suppression system, a preamplifier section **10′**, an interconnecting conductor **20′**, and signal processing circuitry **25′**, feeding intelligible speech between a microphone M′ and a speaker S′. After proper circuit components are selected, noise is suppressed and responsive treatment of the diver proceeds since the diver is able to communicate freely with attending personnel.

It is apparent that scuba systems are adaptable to including the invention to overcome the communication limitations imposed by regulator and bubble noise. Locating the concentrations by spectral analysis permits a synthesis of the electronic system according to the foregoing teachings to ensure more reliable communication between scuba divers.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a diving system having gas-flow noise as gas is fed to a diver, an improvement is provided for reducing

the electronically communicated level of said gas-flow noise from a microphone to a remote speaker comprising:

means for preamplifying the composite signals composed of gas-flow noise and audio communications coupled to said microphone;

means for filtering the preamplified composite signals coupled to the preamplifying means to define a passband between 300 and 2,500 Hz;

a long conductor reaching from the filtering means tending to distort the composite signal passband;

means for selectively varying the magnitude of said composite signals coupled to said long conductor;

a bandpass filter section connected to the selectively varying means and having the same lower and upper limits as the filtering means for enhancing the lower and upper roll-off rates and to reduce the transfer of distortion attributed to said long conductor;

a band elimination notch filter section coupled to receive said composite signals within said passband, being formed of discrete components for attenuating a narrow-band concentration of said gas-flow noise centered on a predetermined noise frequency along with a narrow band portion of said audio communication while passing signals representative of intelligible audio communications to said speaker; and

means for amplifying the attenuated composite signal to pass the signals representative of intelligible audio communications to said speaker, the amplifying means being coupled between the notch filter section and the speaker.

2. A system according to claim **1** further including:

means coupled to said amplifying means for reattenuating the composite signal having substantially the same lower and upper limits as said filtering means and the bandpass filter for further enhancing the lower and upper roll-off rates.

3. A method of ensuring the transfer of signals representative of intelligible speech from a diver's microphone to a remote speaker as composite signals formed of vocal communications and gas-flow noise impinge on the diver's microphone comprising:

preamplifying said composite signals at the diver's microphone,

filtering the preamplified composite signals to attenuate the low frequency components below 300 Hz and to attenuate the higher frequency components above 2,500 Hz,

transmitting the attenuated composite signals from the diver to the remove speaker,

shaping the transmitted composite signals at the remote speaker to reattenuate the low frequency components below 300 Hz and to reattenuate the higher frequency components above 2,500 Hz to sharpen the cut-off of the bandwidth of the attenuated composite signals and to filter out distortion caused by transmission from the diver to the remote speaker,

notching out the concentrated gas-flow noise and a narrow band of the vocal communications from the reattenuated composite signals leaving signals representative of intelligible speech,

refiltering the intelligible speech passband to provide a notched passband between 300 and 2,500 Hz,

amplifying the notched passband, and

feeding the amplified notched passband to the speaker for the projection of signals representative of intelligible speech.

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