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ROTARY MAGNETIC HEAD RECORD AND PLAYBACK SYSTEM FOR
RENDERING UNINTELLIGIBLE SPEECH INTELLIGIBLE
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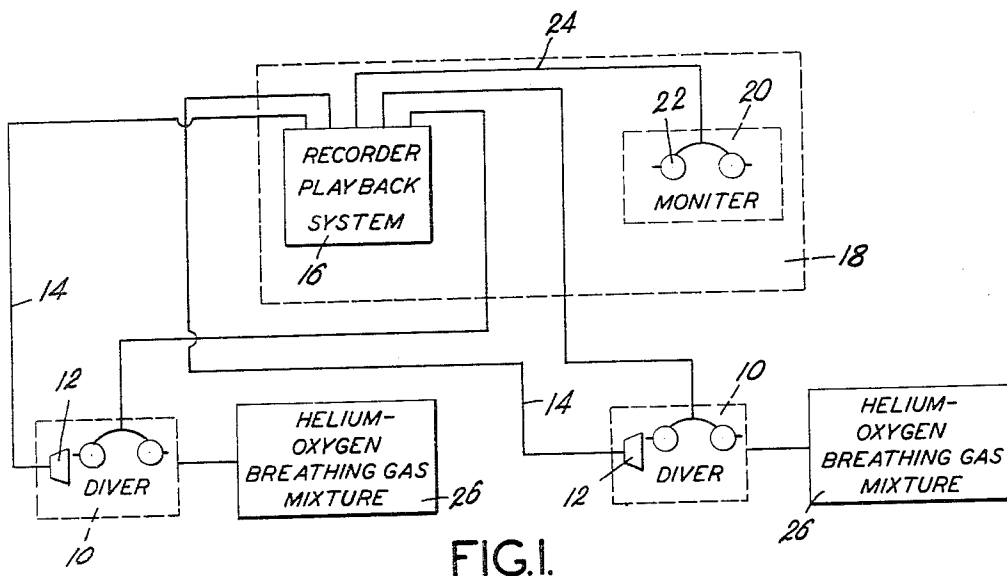


FIG. 1.

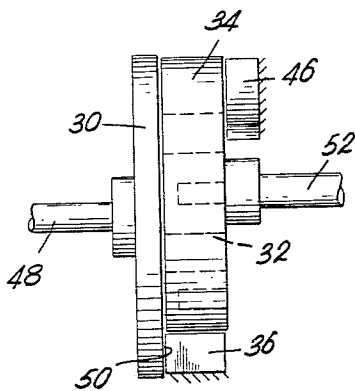


FIG. 2.

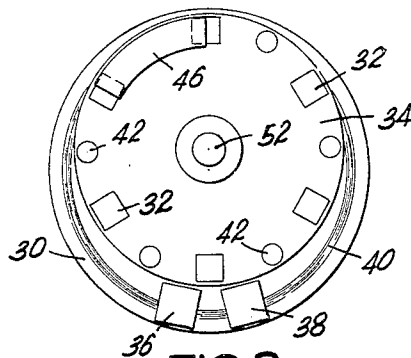


FIG. 3.

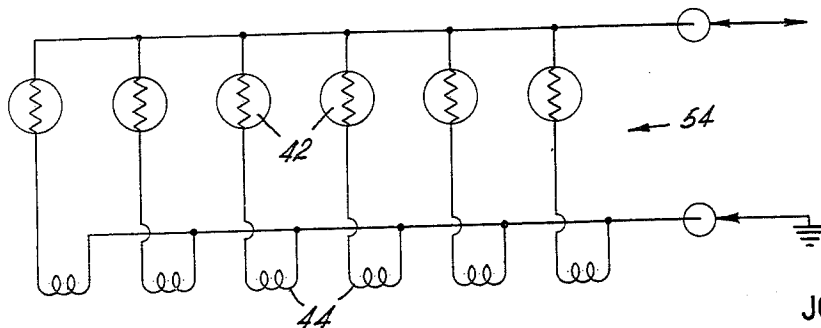


FIG. 4.

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3,485,960 ROTARY MAGNETIC HEAD RECORD AND PLAYBACK SYSTEM FOR RENDERING UNINTELLIGIBLE SPEECH INTELLIGIBLE

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5 Claims

ABSTRACT OF THE DISCLOSURE

A voice communication system having a transducer circuit for converting unintelligible speech into electrical signals, means for recording such signals on a circular magnetic track, and means for rotating the track at a predetermined constant speed. An audio output circuit comprising a read head assembly including a rotary support member is positioned eccentrically with respect to the axis of rotation of the track. A plurality of read heads are mounted on the support in substantially equally spaced relationship to each other. The read head support member is rotated at a slower speed than that of the track such that each head traverses only a predetermined segment of the track while moving in an orbit that passes adjacent the orbit of said track in an arc spaced from the recording means.

This invention relates to systems for correcting unintelligible human speech, such as that which originates in an atmosphere which alters such speech, so as to make it intelligible, and more particularly to underwater helium-oxygen voice communications systems.

The invention provides a transducer circuit for converting unintelligible speech into electrical signals, means for recording such signals on a circular magnetic track at a recording station, and means for rotating such track at a predetermined relatively constant speed. An audio output circuit comprising a read head assembly including a rotary support member is positioned eccentrically with respect to the axis of rotation of said track. A plurality of read heads are mounted on said support in substantially equally spaced relationship to each other. Said read head support member is rotated at a predetermined speed which is different from that of said track so that said heads move in an orbit that passes adjacent the orbit of said track in an arc spaced from such station at such different speed. Thus, the unintelligible speech recorded on said track is reproduced at different frequency without alteration of the real time duration thereof, rendering such speech intelligible.

A common but serious affliction of divers is known as the "bends." It is caused by the release of nitrogen from solution in the blood upon decompression during ascent, the nitrogen having been absorbed from the air in the lungs under the high-pressure condition. Nitrogen is also the cause of deep-water euphoria. A highly successful technique to prevent euphoria is to replace the air's nitrogen with helium, the optimum ratio of helium to oxygen being determined by the working depth.

This substitution, however, causes a difficulty in the speech communication of the diver with the surface and with his fellow divers. Word sounds are produced by shaping the wide-band spectral energy generated in the larynx, by the cavities of the throat, mouth and nose, into combinations of relatively narrow frequency bands (referred to as "formants" in the science of speech analysis).

The resonant frequency of a given cavity is proportional to the velocity of sound in the medium which fills it, and since this is greater for helium than for nitrogen the primary effect is a general multiplication of all the frequencies constituting any speech sound by a roughly constant factor for any given depth. This factor varies in practice between the approximate limits of 1.5 and 2.6 and the resulting sounds bear little resemblance to the intended syllables. It becomes very desirable to have a simple device capable of receiving these sounds and producing therefrom, immediately, the intended intelligible speech.

A great deal of improvement may be obtained by simple "slow-motion" playback—recording the sounds on tape and playing it at reduced speed. Conversation is hampered by the increased time required, however, and the stretch-out of syllable duration considerably impairs intelligibility. Very good results are obtained if the speed of such a tape is brought back to normal by cutting in into short pieces and sticking it back together with alternate pieces omitted. A voice processing device, then, should be able to achieve a similar effect but with very little delay.

The requirement is to record the input and then play back short pieces of it, each piece being stretched out in time so as to give a continuous output. The input recorded in time t_1 is played back so as to fill the longer time t_2 , thus reducing the frequency in the ratio of t_1/t_2 . The input during the residual time t_2-t_1 must be discarded, but speech analysis indicates that little useful content is lost if each discarded segment is less than ten milliseconds duration. The random re-phasing of the output wave at the start of each interval will cause a slight broadening of spectral components, especially the lower frequencies.

This effect is increased with sampling frequency. A 75 c.p.s. rate would seem to be a satisfactory compromise. Thus t_2 is 13.3 ms. and t_1 must be adjustable from 9 ms. (shallow) down to 5 ms. (deep).

Various record-play-erase configurations can be concocted to yield the required result, generally involving relative motion between the record and playback heads. The tape is driven at an adjustable rate by a drive wheel turning at speeds s_1 . Two play heads are mounted 180° apart in a wheel turning in the same direction but at a slower rate, s_2 , which is constant at 37.5 r.p.s. (for a 75 c.p.s. sampling rate). Assuming equal-size wheels s_1 is adjustable from 60 r.p.s. for deep water up to 115 for shallow. Thus, in the latter case, a point on the tape which is at position A when head A starts playing (and B leaves off) will move 3.1 times as far as head A while the latter is moving down to the bottom, this being the ratio of t_2 to t_2-t_1 . At the end of this time, head B is at the top and takes over from A at a distance behind A equal to half the circumference, thus leaving this much recorded tape unused, corresponding to t_2-t_1 . Recording speed is proportional to s_1 , since the record head is stationary, while the playback relative speed between tape and head is proportional to s_1-s_2 . The frequency reduction ratio is therefore $(s_1-s_2)/s_1$.

Problems of high speed and excessive wear are present in such configuration. These are reduced by employing three or four or more heads around the playback wheel, and reducing the contact angle accordingly.

In the drawings:

FIGURE 1 is a diagram of the invention for intelligently monitoring a diver's conversation;

FIGURE 2 is a fragmentary view in side elevation of a preferred recorder-playback system embodying the invention;

FIGURE 3 is a top plan view of such system; and
FIGURE 4 is a circuit diagram.

As shown in FIG. 1, each underwater diver 10 is provided with a microphone 12 that is connected by cable 14 to a recorder-playback system 16 of the invention located at a remote station as for example, in a ship 18. A monitor 20 in the ship is provided with a set 22 of ear-

phones, or a loudspeaker, connected to the system 16 by a cable 24. Each diver 10 is supplied with a breathing gas mixture of helium and oxygen from a suitable supply source 26.

The breathing gas mixture contains a large percentage of helium which so greatly distorts the speech that, under prior art systems, it was virtually impossible for a diver to communicate by voice with the monitor or other divers. The invention provides a communication system which renders such conversations intelligible, and also avoids adverse wear of heads and recording material.

As shown in FIGS. 2 and 3, the tape is replaced by a coated disc 30 and the play heads 32 are carried by a disc 34 which is eccentric thereto, to allow room for a stationary record head 36 and erase head 38. The magnetic material 40 is confined to a narrow circular strip on its disc to minimize the effect of skewing, due to the eccentricity, of the play heads relative to the recorded "image." The eccentricity also causes some spurious frequency modulation, but with four or more heads and a resulting play sector of 90 degrees or less, this is negligible.

With six play heads 32 as shown, the constant play-head disc speed s_2 is 12.5 r.p.s. (750 r.p.m.), and the magnetic-film disc speed s_1 , is variable from 20 r.p.s. for deep water to 39 for shallow. As in the case of FIG. 2, the ratio of frequency out to frequency in is $(s_1-s_2)/s_1$ so

$$s_1 = \frac{f_1 s_2}{f_1 - f_0}$$

While it has proven satisfactory to rely on the geometry for correct commutation of the play heads, where they are turned on and off at the right times by the proximity of the tape, nevertheless in some applications where the fade-in and fade-out times may be excessive a more positive commutation method may be utilized. Six photoconductors 42 are spaced around the play-head disc and connected in series with the respective output coils 44, so that only the head whose photoconductor is illuminated is effectively connected to the output. A light source 46 is arranged to illuminate 60 degrees of the disc periphery, causing the heads to be employed in sequence while they occupy the "play sector."

Fade-in and fade-out will thus be rapid but not abrupt, and the light sector width can be adjusted to yield constant total power gain during the transitions. Photo-duodiods, as made by Texas Instruments, are found to have the appropriate low-level electrical characteristics as well as very high speed of operation.

In operation, a diver 10, FIG. 1, talks into microphone 12 in a helium-oxygen atmosphere which alters his speech so as to render it unintelligible under prior art conditions. The present system converts such unintelligible speech into electrical signals and records them through record head 36, FIG. 2, on the circular magnetic track 40 at the recording station 50. The track is rotated at a relatively constant speed by shaft 48. A shaft 52, at the same time, rotates support member 34 eccentrically with respect to the axis of rotation of the track 40, at a speed which is different from that of the track. Thus, the play heads 32 move in an orbit that passes adjacent the orbit of the track 40 in an arc spaced from record station 50 of record head 36 at such different speed. As a result, the

unintelligible speech recorded on the track 40 is reproduced in playback circuit 54 at a different frequency without alteration of the real time duration thereof so as to render such speech intelligible as it is transmitted to the monitor 20 and the other diver.

What is claimed is:

1. In a system for rendering unintelligible speech intelligible, which comprises a transducer circuit for converting unintelligible speech into electrical signals, means for recording such signals on a circular magnetic disk within a relatively narrow zone, and means for rotating such disk at a predetermined relatively constant speed; an audio output circuit comprising a read head assembly including a circular rotary support member aligned in parallel relationship to said recording disk and eccentrically positioned with respect to the axis of rotation of said disk, a plurality of read heads mounted on said support in substantially equally spaced relationship to each other, and means for rotating said read head support member in the same direction as said disk but at a predetermined speed which is lower than said disk speed such that each of said heads traverse only a predetermined segment of the recording zone on said disk at said lower speed while moving in an orbit that passes adjacent the orbit of said disk causing selected portions of the unintelligible recorded speech on said disk to be reproduced at a frequency which is the reciprocal of the summed durations of the selected portions whereby the real time duration of the recorded speech is maintained substantially constant so as to render such speech intelligible.

2. A system as defined by claim 1, which includes means for erasing signals from said track prior to recording and subsequent readout.

3. A system as defined by claim 1, which includes at least four read heads.

4. A system as defined in claim 1, including commutating means for providing an output from respective ones of said read heads only during the time a respective read head occupies said predetermined segment on said track.

5. A system as defined in claim 4, in which said commutating means includes a plurality of photoconductors, respective ones of which are positioned adjacent respective ones of said read heads, and illuminating means for rendering said photoconductors selectively conductive.

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