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[54] **HELIUM VOICE TRANSLATOR UTILIZING EITHER A GLOTTAL SYNCHRONOUS OR A MEMORY FULL RESET SIGNAL**
3 Claims, 6 Drawing Figs.

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ABSTRACT: The voiced sounds produced by a diver breathing a helium oxygen mixture are stored as incremental charges on individual ones of a bank of condensers. The condensers are sequentially, and for discrete intervals of time, connected to the input by a series of switches sequentially closed by operation of a storage counter. A first oscillator, which may be variable, controls the rate of operation of the storage control counter. A series of output switches are successively closed to connect successive condensers to an output circuit. The output switches are successively closed by the operation of a readout counter which is in turn controlled by the output of a second oscillator operated at a fixed frequency which is less than the frequency of the first oscillator. In the free-running mode, i.e., in the absence of a glottal wave, both storage and readout counters are reset by the last count of the readout counter. The imposition of a glottal wave on the input, however, operates to reset both storage and readout counters regardless of how far a count has progressed. Formant frequencies are thus reduced in proportion to the ratio of the oscillator frequencies while glottal frequencies are unchanged.

OSC
18 TO 37 KHz
12
STORAGE
COUNTER
13
33
36
GLOTTAL
SYNC
32
INPUT
11
16
17
18
19
20
21
26
27
28
31
34
29
OUTPUT
23
OSC
16 KHz
READ-OUT
COUNTER
22

FIG. 1

+
53
48
54
66
74
51
46
47
52
59
58
64
71
73
RESET
PULSE
67
61
INPUT
41
42
57
68
63
62
72
56
−

FIG. 4

FIG. 2A

FIG. 2B

FIG. 3A

FIG. 3B

HELIUM VOICE TRANSLATOR UTILIZING EITHER A GLOTTAL SYNCHRONOUS OR A MEMORY FULL RESET SIGNAL

The invention herein described was made in the course of or under a contract with the Department of the Navy.

The present invention relates to an electronic translator system for rendering the speech of deep-sea divers more intelligible.

Deep-sea divers breath a mixture of helium and oxygen to avoid the adverse effects produced by the nitrogen in ordinary air mixtures at high pressures. The use of helium as a substitute for nitrogen, however, causes difficulty in speech communication between the diver and the surface or his fellow divers. In general it may be stated that word sounds are produced by shaping a wide-band spectrum of energy generated in the larynx as a glottal wave into relative narrow frequency bands, referred to as formants, by the cavities of the throat, mouth and nose. The resonant frequency of a given cavity such as the mouth is proportional to the velocity of the sound in the medium which fills it, and since this velocity is greater for helium than nitrogen, the effect is that the formant frequencies are increased while the glottal frequencies being mechanically produced remain the same. The result is that the helium voice sounds bear little resemblance to the intended syllables.

It has been suggested that the helium voice sounds may be recorded and then played back at a slower speed omitting portions of each syllable so that although the playback is stretched out at a lower frequency the playback occupies no more time than the initial speech. This greatly improves intelligibility, but has the disadvantage that the glottal frequencies unaffected by the helium atmosphere are also reduced, producing unnatural voice sounds.

The translator of present invention avoids the disadvantage of the prior approaches by retaining the fundamental glottal frequencies and at the same time reducing the frequencies of the formant voice sounds. More particularly the sounds voiced by a diver are stored incrementally and sequentially at one storage rate and are read out from storage also incrementally and sequentially at a lower rate. If no glottal wave is present, that is, if no signal is present or during an unvoiced sound such as *f* or *s*, the translator is placed in a free-running mode. In this mode the readout apparatus completes its cycle and produces a reset signal which simultaneously resets both storage and readout devices to start a new cycle of incremental storage and slower readout. If, however, a glottal wave is imposed on the input, the then existing cycle of storage and readout is terminated immediately and both storage and readout begin a new cycle.

Since the glottal fundamental, if present, acts to initiate successive cycles of storage and readout, the fundamental glottal frequency is retained. On the other hand, since the readout is at a slower rate than the storage, the formant sounds are stretched out and hence reduced in frequency. Portions of the formant sounds are of course omitted, since only the initial portion of the sounds can be stored during the time required for readout. This it has been found, however, does not affect intelligibility.

An object of the invention is to provide an apparatus for improving the intelligibility of helium speech.

Another object of the invention is provide an apparatus for lowering the frequencies of the formant sounds in helium speech while at the same time retaining the fundamental glottal frequencies.

The invention will be more fully understood from the following detailed description taken together with the accompanying drawings, in which:

FIG. 1 is a diagram partly schematic and partly in block form illustrating an embodiment of the invention.

FIGS. 2A, 2B, 3A and 3B are waveforms illustrating the mode of operation of the invention.

FIG. 4 is a schematic diagram of the glottal synchronizer used in the circuit of FIG. 1.

Turning now to FIG. 1 an electrical wave corresponding to the distorted helium speech sound is applied as an input signal on conductor 11.

An oscillator 12 which may be variable so as to have an output frequency of say between 18 kHz. to 37 kHz. operates a storage counter 13 so that successive impulses are applied to the gate electrodes of field effect transistors 16, 17 and 18. When an impulse is applied to a respective gate electrode the associated source-drain path is rendered conductive and a charge is applied to one of the condensers 19, 20 or 21 connected between the drain electrodes and ground. The charge stored in any individual condenser will be representative of the magnitude of the signal wave impressed of the conductor 11 at the time its associated transistor switched is rendered conductive so that a complex voice wave may be stored as increments of charge on a series of condensers represented by condenser 19–21 successively connected to the input by the action of the storage counter 13 and transistor 16–18.

In order to read out and reconstitute the stored wave at a lower frequency, a readout counter 22 is operated by a fixed frequency oscillator 23 operated at a lower frequency, say 16 kHz., this frequency being lower, than the lowest frequency of the oscillator 12. The commutating signals successively generated by the readout counter 22 under control of the oscillator 23 successively render field effect transistor 26, 27 and 28 conductive so that the charges stored in condensers 19, 20 and 21 are successively applied to the output conductor 29.

The storage and readout may be operated in either one of two modes depending on whether a glottal wave is present or not. Consider first the free-running mode in the absence of a signal or during an unvoiced sound such as *f* or *s*. The translator operates at its lowest reset rate of say 62.5 Hz. and both counters 13 and 22 are not reset until the readout counter has completed its count. At that time a reset pulse is applied to the conductor 31 and through the "OR" gate 32 to each of conductors 33 and 34 to reset both storage counter 13 and readout counter 22.

It will be appreciated that with a free-running frequency of 62.5 Hz. and an output sampling frequency of 16 kHz., 256 units of storage are required, i.e., 256 condensers represented by condensers 19–21; however, since some at least of the condensers are discharged before the end of cycle the number may be reduced by use of appropriate logic circuits in the counters as will be understood by one skilled in the art.

FIGS. 2A and 2B illustrate the operation of the translator during its free-running mode in the absence of a glottal wave. FIG. 2A illustrates the input wave which may represent a formant sound unaccompanied by a glottal wave. At time t_o the input wave begins to be stored as successive increments of charge on successive ones of the commutator condensers represented by 19, 20 and 21. At the same time t_o, since counter 22 also begins its operation the wave form of FIG. 2B, begins to be applied to the output 29. At time t_1 the counter 13 having been operated at the faster rate by the high-frequency oscillator 12, say at 32 kHz., has completed its count and the waveform extending between times t_o and t_1 is completely stored in the commutating condensers and storage counter 13 ceases to count until it is reset. This reset does not occur in this mode until readout counter 22 completes its count at the later time t_2, since its counting operation is under control of the lower frequency oscillator 23. Thus the readout in effect stretches the input wave of FIG. 2A occuring between times t_o and t_1 to the lower frequency wave of FIG. 2B which occupies the time from t_o to t_2. Of course that portion of the waveform of FIG. 2A occuring between times t_1 and t_2 is rejected since the storage counter 13 has completed its count and hence its storage condenser switching operation. The loss of bits of voice waveform has been found, however not to appreciably affect the intelligibility of the voice of sounds. What is important is that the formant frequencies are reduced by an amount equal to the ratio of the frequencies of the oscillators 12 and 23 or 50 percent in the example given. This greatly increases helium voice intelligibility but is not the whole answer since it

is also of importance that the glottal frequencies be retained unchanged.

In order to accomplish this a glottal synchronizer is inserted between the input conductor **11** and a second input of the OR gate **32**. When a glottal wave is present and impressed on the glottal synchronizer **36** a reset pulse is produced which through the OR gate resets both the storage counter and the readout counter even though the readout counter has not completed its count which will generally be the case since the glottal fundamental in voiced speech is greater than 62.5 Hz. the fundamental reset frequency.

The waveforms of FIG. 3A and FIG. 3B are illustrations of the operation of the translator in its glottal synchronization mode. FIG. 3A is a waveform of voiced sound containing a glottal fundamental. It will be observed that a characteristic of glottal speech is that each wave train is marked by abrupt change in signal level as at **37**, **38** and **39** occuring at time t_o, t_2 and t_4. It is these abrupt changes in level which in a manner to be described later, generate the reset pulse in the glottal synchronizing circuit **36** which in turn reset both storage counter **13** and readout counter **22** to start a new cycle of rapid incremental storage and slower incremental readout.

For example at time t_1, FIG. 3A the storage counter **13** has completed so much of its counting operation that the wave signal occuring between times t_o and t_1 is fully stored in the commutating condensers. At the same time at time t_o the readout counter begins its operation although at a lower counting rate and the readout wave is expanded, that is, played back in real time at a lower frequency. At time t_2 it is assumed that a second glottal waveform begins. The abrupt increase in signal level indicated at **38** acting through glottal synchronizer **36** produces a reset pulse which resets both storage counter **13** and readout counter **22** even though readout counter **22** has not completed its count. Thus a new cycle of storage and slower playback is initiated. As was the case with respect to the waveforms of FIG. 2A and FIG. 2B the signal occuring between time t_1 and t_2 and again between time t_3 and t_4 is discarded but this is of no great concern as far as intelligibility is concerned.

It will be apparent therefore, that the fundamental glottal frequencies as indicated by the abrupt signal changes occuring at times t_o, t_2 and t_4 are retained unchanged in the output waveform whereas at the same time the formant frequencies are lowered to a level where the speech is rendered intelligible.

Turning now to FIG. 4 there is therein disclosed in schematic form a circuit for the glottal synchronizer **36** which acts to convert the first abrupt amplitude change in a wave train following a period of relatively low amplitude, into a reset pulse.

The input wave such as illustrated of FIG. 3A is applied to the base of a transistor **41** which together with transistor **42** constitutes a single-ended input differential output amplifier. The differential output appearing at junctions **43** and **44** are respectively applied to the bases of a pair of transistors **46** and **47** connected in parallel. A resistor **48** is connected between the emitters **51**, **52** and a source of positive potential indicated by the conductor **53**. The resistor **48** is shunted by a condenser **54** so that when an abrupt negative change in signal level is applied to the base of transistor **46** or **47** a pulse of current is drawn through condenser **54** producing a pulse **56** in the resistor **57** connected between the junction of the collectors **58** and **59** and ground. Thus a peak detector is formed in which an initial abrupt peak of potential produces a sharp output pulse current, but which by action of the slower decay of the charge in condenser **54** through resistor **48** isolates the initial peak output and prevents the production of pulse outputs from abrupt changes in signal level immediately following the first abrupt signal level change. Thus it is only the initial level changes **37**, **38** and **39** of the waveform of FIG. 3A that produce the output pulses **56**.

Voltage pulses **56** are applied to the base **61** of transistor **62** which together with transistor **63** constitutes a single-shot multivibrator whose time constant is determined by the positive feedback circuit consisting of condenser **64**, resistor **66**, rectifier **67** and transistor **68**. The square wave pulse whose duration is determined by the time constant of the positive feedback circuit is then differentiated by the circuit consisting of condenser **71** and resistor **72** to produce the reset pulse by the positive-going edge of the square wave output **74**. Since the square wave output lasts several milliseconds premature reset is prevented by peaks of input signal immediately following the initial peak of the glottal wave train.

Thus the storage and readout cycles are each initiated in synchronism with the initiation of a glottal wave train but the incremental readout is at a slower rate, i.e., lower frequency than that of incremental storage so that glottal frequencies are retained while formant frequencies are lowered.

What is claimed is:

1. A helium voice translator for translating the voiced sounds of a diver breathing a helium oxygen mixture, comprising:

an input circuit for receiving a voice input wave corresponding to the aforesaid voice sounds;

means coupled to said input circuit for successively storing increments of the voice input wave received thereby cyclically at a first selected rate of storage, and including a storage counter, first switch means and a bank of condensers, said voice input wave being stored as incremental charges on individual ones of said bank of condensers and said bank of condensers being sequentially and for discrete intervals of time connected to the input circuit by said first switch means, said first switch means comprising a series of switches connected to and successively actuated by the operation of successive stages of said storage counter;

an output circuit;

means for cyclically reading out said incremental charges on said bank of condensers at a selected rate lower than said first selected rate, said last-named means including a readout counter, and second switch means comprising a series of switches respectively connected to successive stages of said readout counter and successively actuated by the operation of such stages, said second switch means successively connecting the condensers of said bank of condensers to the output circuit;

first circuit means having an input connected to said input circuit and including a glottal synchronizer network for producing a reset pulse in the presence of glottal sounds appearing on said voice input wave received by said input circuit, and said first circuit means having an output connected to said storage counter and to said readout counter to introduce said reset pulse to the counters so as to terminate a storage and readout cycle and to initiate a new storage and readout cycle; and

second circuit means having an input connected to the output of said readout counter and operative in the absence of a glottal sound on said voice input wave received by said input circuit to produce a reset pulse at the termination of a readout cycle, said second circuit means having an output connected to said storage counter and to said readout counter to introduce said last-named reset pulse to the counters so as to terminate a storage and readout cycle and to initiate a new storage and readout cycle.

2. A helium voice translator as set forth in claim **1**, and which includes a first oscillator operating at a first selected frequency, and a second oscillator operating at a second selected frequency, and in which said storage counter is connected to said first oscillator and said readout counter is connected to said second oscillator.

3. A helium voice translator as set forth in claim **1**, in which said first and second switch means are composed of field effect transistor circuits.

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