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[54] **TISSUE CONDUCTION MICROPHONE UTILIZED TO ACTIVATE A VOICE OPERATED SWITCH**

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[51] **Int. Cl.** **G10l 1/04**
[58] **Field of Search** ..... 179/1 VC, 1 SW, 1 SA, 179/121 C, 167, 168, 164, 187, 188, 1 P, 1 VW, 157, 1 ST; 340/8 R, 5 R, 5 T

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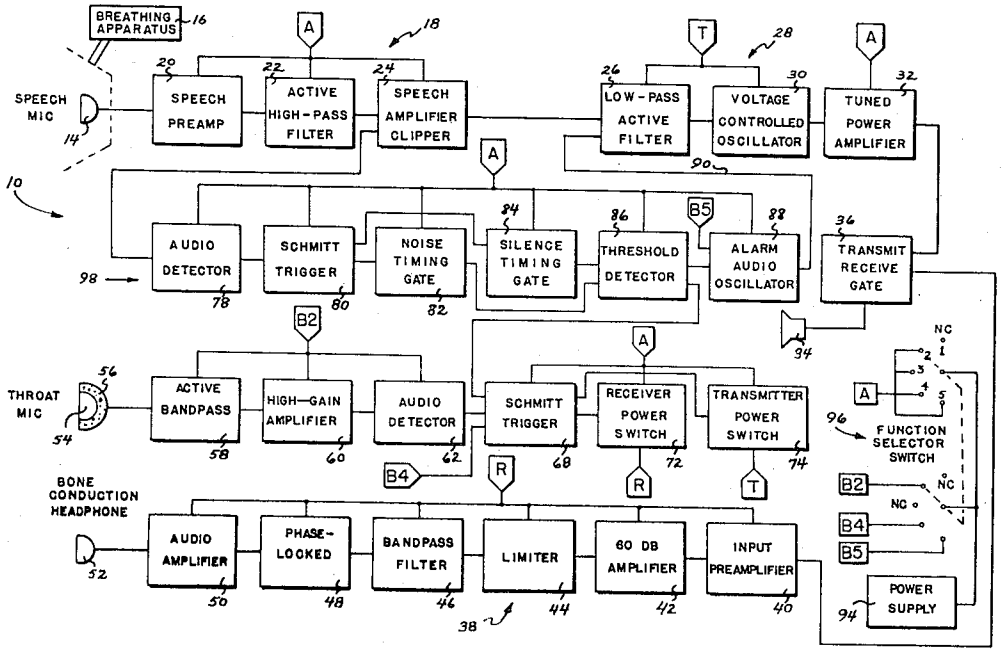
[57] **ABSTRACT**

A voice-activated transmit switch (VOX) for high noise environment voice communication systems which employ a speech microphone, a transmitter and a receiver. A separate tissue-conduction microphone is employed to generate a signal which activates a transmitter enabling and receiver disabling circuit. The tissue-conduction microphone is positioned in contact with the user's neck tissue in the vicinity of the larynx. A bandpass filter eliminates the unwanted signal from the tissue-conduction microphone output and passes the desired speech signals to an amplifier. The amplifier output actuates a Schmitt trigger which in turn operates a transmitter enable-receiver disable switching circuit. Delay means are provided so that the transmitter does not turn off during brief intersyllabic pauses.

13 Claims, 2 Drawing Figures



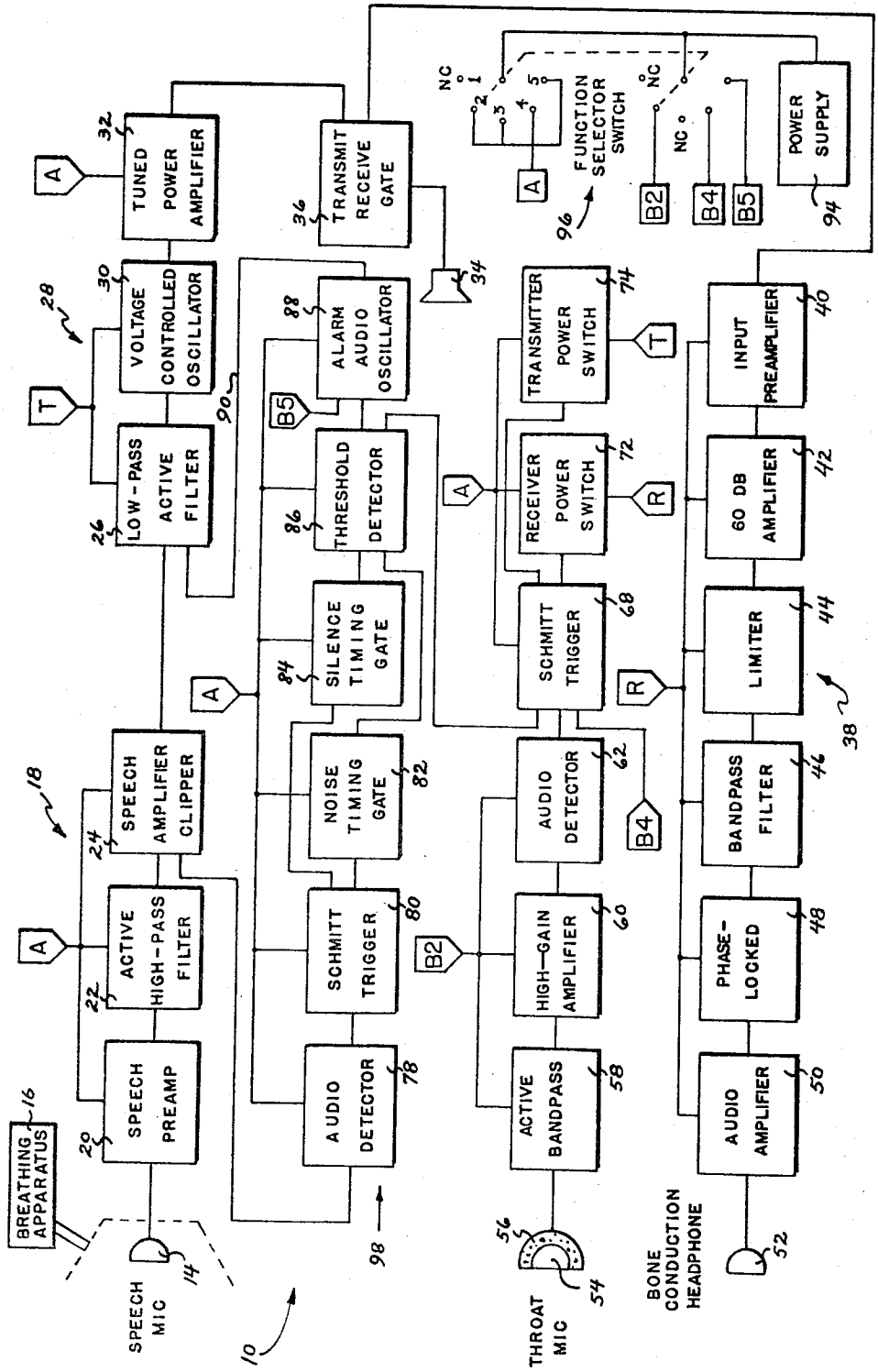

BREATHING APPARATUS
16
SPEECH MIC
14
10
SPEECH PREAMP
20
ACTIVE HIGH-PASS FILTER
22
SPEECH AMPLIFIER CLIPPER
24
18
LOW-PASS ACTIVE FILTER
26
VOLTAGE CONTROLLED OSCILLATOR
30
28
TUNED POWER AMPLIFIER
32
A
T
TRANSMIT RECEIVE GATE
36
34
ALARM AUDIO OSCILLATOR
88
90
B5
THRESHOLD DETECTOR
86
SILENCE TIMING GATE
84
NOISE TIMING GATE
82
SCHMITT TRIGGER
80
AUDIO DETECTOR
78
98
ACTIVE BANDPASS
58
56
THROAT MIC
54
HIGH-GAIN AMPLIFIER
60
B2
AUDIO DETECTOR
62
B4
SCHMITT TRIGGER
68
RECEIVER POWER SWITCH
72
R
TRANSMITTER POWER SWITCH
74
FUNCTION SELECTOR SWITCH
96
NC
1
2
3
4
5
B2
B4
B5
POWER SUPPLY
94
AUDIO AMPLIFIER
50
PHASE-LOCKED
48
BANDPASS FILTER
46
LIMITER
44
60 DB AMPLIFIER
42
INPUT PREAMPLIFIER
40
38
BONE CONDUCTION HEADPHONE
52

FIG. 1

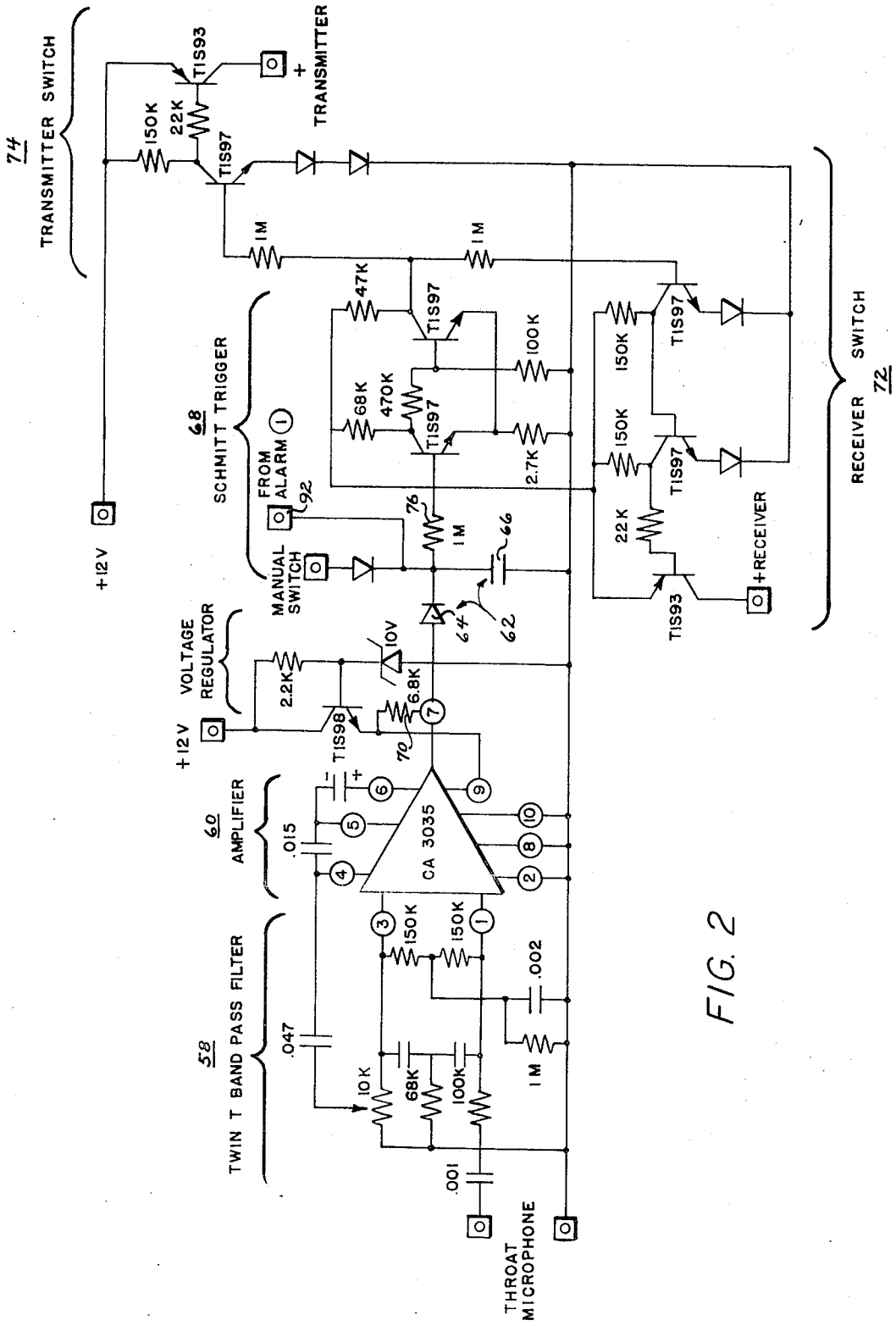

74
TRANSMITTER SWITCH
150K
22K
T1S93
T1S97
+
TRANSMITTER
+12V
1M
1M
68
SCHMITT TRIGGER
FROM ALARM
92
MANUAL SWITCH
47K
68K
470K
T1S97
T1S97
100K
2.7K
76
1M
66
64
62
VOLTAGE REGULATOR
2.2K
10V
6.8K
T1S98
70
+12V
60
AMPLIFIER
.015
CA 3035
58
TWIN T BAND PASS FILTER
.047
10K
68K
100K
150K
150K
.002
1M
.001
THROAT MICROPHONE
150K
150K
22K
T1S97
T1S97
T1S93
+RECEIVER
RECEIVER SWITCH
72

FIG. 2

TISSUE CONDUCTION MICROPHONE UTILIZED TO ACTIVATE A VOICE OPERATED SWITCH

BACKGROUND OF THE INVENTION

The present invention relates to communication systems in general and, more particularly, to a voice-activated transmit switch for high noise environment voice communication systems.

The use of voice activated transmit switches (VOX) in communication systems is well known. In such systems, the output from a speech microphone is used to actuate a circuit which enables the transmitter while at the same disabling the receiver. However, this type of system is highly susceptible to false keying of the transmitter by non-speech noises. The problem of false keying of the transmitter is particularly acute in underwater communications systems where the diver's breathing noises and gas flow noises may actuate a standard VOX circuit. Similar problems also occur in other high noise environments.

It is, therefore, a general object of the present invention to provide a voice actuated transmitter switch or VOX that is substantially insensitive to non-speech generated sounds.

It is a specific object of the present invention to provide a voice actuated transmit switch for use in a high noise environment voice communication system.

It is another object of the invention to provide a voice actuated transmit switch which is especially suited for underwater communication systems.

It is still another object of the invention to provide a voice actuated transmit switching circuit which is insensitive to breathing noise.

It is a feature of the invention that the circuitry thereof can be easily incorporated in existing communication systems.

It is still another feature of the invention that optimum speech intelligibility is maintained while at the same time providing for voice actuation of the communication system transmitter in a high noise environment.

These objects and other objects and features of the invention will best be understood from a detailed description of a preferred embodiment thereof, selected for purposes of illustration, and shown in the accompanying drawings, in which:

FIG. 1 is a block diagram of a communication system utilizing the voice actuated transmit switch of the present invention; and,

FIG. 2 is a schematic diagram of the VOX circuit.

Turning now to the drawings, the voice actuated switch or VOX of the present invention will be described in connection with an underwater communications system shown in block diagram form in FIG. 1 and indicated generally by the reference numeral **10.** It should be understood that the description of the invention in connection with the underwater communications system is by way of illustration only and that the voice-activated transmit switch can be used in other communication systems and that it is particularly suited for high noise environment communication systems.

Looking at FIG. 1 which depicts the illustrative underwater communications system, the diver interface comprises a speech cavity **12** and a speech microphone **14.** Preferably, the speech microphone **12** is a high-impedance, piezo electric unit which is suitable for the underwater use. The microphone is enclosed in the

speech cavity **12** which surrounds at least the diver's mouth in order to provide a gas space into which the diver can articulate speech in a more or less normal fashion. The speech cavity is also connected to the diver's breathing apparatus **16** so that the acoustic input to the cavity is a mixture of speech occurring at random intervals and gas flow and breathing noises occurring at more or less regular intervals.

The speech cavity **12** has sharp, well-defined resonances typically below 1000 hz, which cause the acoustic output of the diver's vocal track to rise at a rate of roughly **12** decibals per octave below that frequency. This abnormal frequency response in the speech signal seriously impairs intelligibility. A speech processor, indicated generally by the reference numeral **18,** is employed to electrically modify the speech signal from the speech microphone **14** in such a way that resonances are removed, the power content of the signal is increased and the intelligibility in noise is improved. The speech processor **18** comprises a speech pre-amplifier **20,** a highpass filter **22,** and a speech amplifier/clipper **24.**

The implementation of the circuitry of the speech pre-amp, highpass filter and speech amplifier/clipper are well-known in the art and need not be described in detail. However, preferably the speech pre-amplifier **20** comprises a junction field-effect transistor connected as a common-source amplifier having a gain of approximately 20 decibels from 500 to 10,000 hz., with an input impedance of **1** megohm. The function of the speech preamplifier **20** is to boost the output of the speech microphone **14** to approximately 500 mV peak-to-peak for further processing.

The active highpass filter **22** comprises a fourth-order filter having a Butterworth response with a corner frequency of 1100 hz. It comprises two second-order sections in series, synthesized by means of RC elements and unity-gain source-follower JFET amplifier. Since the speech information below 1000 hz are emphasized by the speech cavity **12** at a rate of 12 decibels per octave, the output of the highpass filter is a speech signal in which components below the corner frequency roll off at a rate of −12 decibels per octave. This type of frequency response results in virtually complete elimination of the first formant of the speech signal, which is not essential to good intelligibility, and of low-frequency noises arising either in the water or in the speech cavity.

The speech amplifier/clipper **24** preferably comprises a bipolar transistor connected as a common-emitter amplifier having a gain of approximately 40 decibels. Two silicon diodes in parallel, but in opposite directions, are capacitively coupled between the base and collective terminals of the transistor. The resulting non-linear negative feedback allows signals below approximately **10**mv peak-to-peak to be amplified with little distortion. Signals above this level are heavily clipped. The maximum output from this stage is approximately 1.2 V p-p, regardless of input level.

The net effect of filtering the speech signal as described above and clipping it is to increase its average power content and its intelligibility in noise by reinforcing essential portions of the frequency spectrum. The process of clipping generates harmonics which are removed by an active low-pass filter **26** which is a second-order Butterworth filter having a corner frequency of 3.5 khz. This filter is also synthesized with RC elements

and a unity-gain JFET source-follower. The corner frequency of 3500 hz is high enough to preserve frequencies which are essential to good intelligibility.

The transmitter portion of the underwater communications system indicated generally by the reference numeral **28**, comprises a voltage controlled oscillator **30** and a tuned power amplifier **32**. The linear VCO **30** is set to operate a center frequency of approximately 40 khz. The function of the VCO is to provide a frequency-modulated carrier. Its transfer characteristic is such that changes in control voltage of plus or minus 1000 mV cause the center frequency to change by plus or minus 3.5 khz. Thus, if the maximum speech frequency to be transmitted is 3.5 khz the modulation index is 1.0 and the speech signal can be transmitted using a total bandwidth of 7 khz.

The tune power amplifier **32** preferably comprises a single-transistor class-C tuned power amplifier. The amplifier delivers 500 mW of electrical power into a 1000-ohm resistive load. Since the output of the voltage controlled oscillator **30** is a square wave the input of the tuned amplifier contains a series resonant circuit to eliminate harmonics of the desired carrier frequency. A tuned transformer matches the collector of the transistor to a transducer **34**. The secondary of the transformer is designed to resonate at the carrier frequency of 40-khz with a 3-db bandwidth 7 khz, corresponding to an effective Q of 5.72. The output of the tuned power amplifier **32** is connected through a transmit receive gate **36** to the previously mentioned transducer **34**. The transducer is a resonant, air-filled tubular ceramic transducer whose dimensions and material are chosen to resonate at the carrier frequency in the radial mode of vibration. The length-to-diameter ratio is approximately 1, so as to provide some directionality in planes parellel to the longitudinal axis of the transducer. The transducer is capped to increase its receiving sensitivity and it is encapsulated in a thin sheet of sound-transparent material so as to render it waterproof and capable of operating in at least 250 feet of sea water. The static capacitance of the transducer **34** is used as part of the capacitance necessary to tune the secondary winding of the tuned power amplifier output transformer so that a separate tuning coil is unnecessary.

Since the power amplifier operates in the class-C mode, it is unnecessary to disconnect it from the tuned transformer during reception, because the reverse-biased transistor becomes a resistor having a resistance which is several orders of magnitude larger than the resonant resistance of the transducer **34**.

The transducer **34** is also used for the detection of acoustic signals for reasons of economy and simplicity. The receiver input, therefore, must be effectively disconnected from the transducer during transmission. This is accomplished by the previously mentioned transmit/receive gate **36** which comprises a carrier-activated series/shut analog gate having an inductor, two pairs of switching diodes, a series tuning compacitor and a parallel tuning capacitor connected so as to block the signal from the input of the receiver during transmission.

The receiver section of the underwater communications system, indicated generally by the reference numeral **38**, comprises an input pre-amplifier **40**, an amplifier **42**, a limiter **44**, a band-pass filter **46** a phase-locked loop **48**, an audio amplifier **50** and a bone conduction headphone **52**. The input pre-amplifier **40** preferably is a low-noise JFET connected as a common-source amplifier with a gain of approximately 20 db at the carrier frequency. The amplifier **42** provides 60 db of linear gain and the limiter **44** provides approximately 40 db of the gain before limiting. The gain and limiting have been chosen to provide a useful limited signal of at least 100 mv rms with a minimum input of 1 microvolt rms from the transducer **34**.

The bandpass filter **46** is a simple parallel-tuned LC resonant circuit placed at the output of the limiter **44** in order to restore the sinusoidal character of the signal. The output from the bandpass filter **46** is applied to the phase-locked loop **48** which is used as a frequency demodulator. The VCO of the phase-locked loop is set to operate at approximately 40 khz, and its low-pass filter elements are chosen to provide a capture range of at least plus or minus 4 khz. This allows the demodulator to lock onto any signal whose frequency is within 10 percent of the nominal carrier frequency. This relatively large capture range makes it possible to utilize simple RC oscillators in the transmitter, since frequency stability is unimportant.

The output of the phase-locked loop **48** drives an audio amplifier **50** having a maximum power output of **150** mW and a sensitivity of 45 mV rms for pull-power output. The audio amplifier is transformer coupled to a high-impedance piezo-electric bone -conduction headphone **52** which couples the audio signal into the diver's ear.

Having briefly described the speech microphone, transmitter, and receiver portions of the underwater communications system **10**, I will now describe in detail the voice-activated transmit switch circuitry. It is impractical to maintain the transmitter portion of a communication system continuously activated since it consumes much more power than any other portion of the system. On the other hand, manual activation of a switch for transmission would require a working diver to maintain one hand available for this purpose. This may not be possible at all times and thus may prevent the diver from being able to communicate during a critical situation.

A voice-operated transmit switch (VOX) is desirable in such a communications system. However, it is not possible to use the output of the speech microphone **14** for VOX purposes, since it contains breathing noises which would activate the transmitter **28** every time the diver inhales or exhales. Furthermore, it is not possible to discriminate against these noises on the basis of acoustic levels alone, since these noises are of at least the same level as speech signals. If a VOX system is set so that it will not be activated by these noises, a diver would have to shout into the microphone to make the system operate. It is not possible to discriminate against these breathing noises on the basis of frequency alone either since their frequency spectrum is rather wide and erratic.

Various solutions have been proposed to this problem. Some form of frequency analysis is usually employed to distinguish noise from speech, but the complexity required to make this solution rather unenomical for use in a self-contained miniature communications system of the type shown in FIG. **1**.

The present invention utilizes a separate tissue-conduction microphone **54** to generate a transmitter keying signal. Preferably, the tissue conduction micro-

phone 54 is a throat microphone which is located in the vicinity of the larynx of the diver, in such a position that the tissue vibrations due to modulation of the vocal chords (speech) have a much higher amplitude than those due to gas flow or breathing and swallowing noises. However, the tissue conduction microphone also can be placed against the chest cavity to detect the speech sounds. The detection of the speech sounds at very favorable signal-to-noise ratios makes it possible to discriminate against unwanted noises on the basis of amplitude alone, without having to resort to more elaborate signal processing techniques. At the same time, optimum speech intelligibility is assured by the use of the separate speech microphone 14 positioned directly in front of the mouth of the diver.

The tissue-conduction throat microphone 54 should be in good contact with the diver's neck tissue. The optimum location varies from individual to individual and it must be determined by each individual by trial and error. This is usually a one-time operation which is easily performed in the water. The throat microphone 54 is isolated from waterborne noises by a layer of sound absorbing material 56. Preferably the sound absorbing material 56 comprises a layer of 3/16 inch mark cellular rubber or neoprene of the type normally used to construct wet diving suits. If the diver wears a diving hood of this material, the best location for the throat microphone is under the neck portion of the hood. Otherwise, a simple holder (not shown) is used to maintain the microphone in place and to provide acoustical isolation from the water.

The output from the throat microphone 54 is applied to a bandpass filter 58 having a center frequency slightly below 1 khz and a passband of 40 to 100 hz. The purpose of the bandpass filter 58 is to eliminate high or low-frequency noises, either waterborne or generated by the diver which may accidentally trigger the VOX system. This filter is particularly important when the diver is using a single-hose demand regulator having an exhaust port only a few inches away from the throat microphone, since the noise generated by the exhaust bubbles would otherwise cause the VOX system to operate every time the diver exhaled.

The output from bandpass filter 58 is applied to a high gain amplifier 60 which provides sufficient gain to amplify the signal from the bandpass filter to a level sufficient to drive an audio detector 62. The output from the amplifier 60 is rectified by the combination of diode 64 and capacitor 66 (FIG. 2) to produce a DC level at the input of Schmitt trigger 68. The value for resistor 70 and the smoothing capacitor 66 are chosen so that the resulting time constant is less than 500 microseconds, to assure fast actuation of the VOX system.

Looking at FIG. 2, the Schmitt trigger circuit 68 has a high input impedance, an upper trip point of approximately 1.2 V, and a hysteresis of approximately 0.2 V. The function of the Schmitt trigger is to provide sharply defined ON/OFF levels and some degree of immunity to low-level random noise inputs. The output of the Schmitt trigger 68 is used to activate a receiver power switch 72 and a transmitter power switch 74. These switches comprise PNP transistors which are connected to the positive power supply and are activated by the combination of inverters shown in FIG. 2 so that the receiver power is OFF when transmitter power is ON and vice versa.

A resistor 76 is used to couple the output of the audio detector 62 to the input of the Schmitt trigger 68. The value of this resistor is chosen to provide a delay of approximately 0.2 seconds after the rectified audio signal is removed, so that the transmitter does not turn off during brief intersyllabic pauses. The total time elapsed between the start of the word and full activation of the transmitter is approximately 1 millisecond given the circuitry shown in FIG. 2. Since the average syllabic length is approximately 24 milliseconds, there will be no loss of syllables during normal conversation.

The primary advantage of using an underwater speech communication system is the enhancement of diver safety, resulting from the capability of the diver to inform others of his own situation, and of others to recognize potential dangerous situations from information supplied by the diver. In a case of portable communication devices, however, it is not practical to maintain the diver's transmitter activated continuously. Certain types of diving accidents may take place during diver silence periods. A specific example is the loss of consciousness due to low oxygen concentration in the breathing medium which takes place in a very gradual manner and usually goes unnoticed by the victim. If an unconscious diver is not within visual range and immediate reach of the other divers, his problem may go entirely unnoticed until it is too late for rescue.

One solution to this problem is to use telemetry techniques for monitoring diver physiological functions by sensing cardiac rhythm, blood pressure, and body temperature or environmental conditions, such as breathing medium pressure or partial pressure of critical gases. The technology for accomplishing this type of monitoring exists at the present time, but the equipment required is usually so expensive as to be justifiable only when the objective of monitoring is the acquisition of bio-medical data.

In my co-pending application, filed of even data herewith, and entitled PHYSIOLOGICAL ALARM SYSTEM, there is described an alarm system which is especially suited for an underwater communication system. The alarm system monitors the diver by means of facilities already present in the underwater communications system and evaluates the data within the system itself and triggers the transmission of the alarm signal only when anomalous conditions are detected. The alarm system is shown in block diagram form in FIG. 1 and will be briefly described in order to show its interrelationship with the VOX system of the present invention.

The speech microphone 14 is exposed to speech signals which are generated at random intervals, and to breathing and gas flow noises which take place at regular intervals. The time distribution of diver-generated signals which are conveniently present at any point in the speech processor 18, can be used as a means of detecting anomalous respiratory conditions.

It is obvious that the diver must breathe at least once during a certain period of time from which a definite upper bound T_s exists regardless of exertion level and individual breathing habits. If a signal is not produced within this period of time, the diver may be assumed at best to be breathing too slowly, or at worst, to have stopped breathing altogether.

Similarly, the diver or his breathing equipment must be silent at least once during the breathing cycle or at the end of sentences during the generation of speech. Thus, another upper bound T_n exists for the maximum

duration of a diver-generated signal. If this upper band is exceeded, the diver may be assumed to be breathing abnormally. This condition may come about, for example, if a demand regulator fails and delivers a continual stream of gas into the diver's speech cavity **12** or if the speech cavity is accidentally removed from the diver's face and gas flow into the water generates a continuous noise.

The detection of these abnormal conditions is performed by the circuitry shown in block form in FIG. **1.** Specifically, an audio input signal is obtained from the output of the speech amplifier/clipper **24.** The audio signal is detected by audio detector **78** which provides a DC voltage to another Schmitt trigger **80** whenever a signal appears at the input of the audio detector. The output from Schmitt trigger **80** is applied to a noise timing gate **82** and a silence timing gate **84.** Both timing gates are outputted to a threshhold detector **86** which produces an output signal if the output from either of the timing gates exceed a predetermined level which represents an abnormal condition. The output of threshhold detector **86** is used to actuate an alarm audio oscillator **88** which is coupled to the transmitter **28** through lead **90.** The output of the threshold detector is also applied to the input of the VOX Schmitt trigger **68** through input terminal **92** (See FIG. **2**).

The overall result of the circuitry just described is that whenever a signal is present at the input of the audio detector **78** for a time longer than T_n or a signal is absent from the input to the audio detector for a period longer than T_s, the audio alarm oscillator **88** is activated, the VOX system is triggered through input terminal **92,** the transmitter **28** is activated, and a signal containing the audio alarm note is transmitted through the water.

The alarm circuit is deactivated if the diver resumes normal breathing. If the abnormal condition persists, the radiated alarm signal can be used in conjunction with underwater homing devices to locate the victim.

Although the alarm circuit just described is specifically designed for evaluating speech and breathing noises, it will be appreciated that it is also suitable for evaluating cardiac rhythm. In that situation, the noise timing gate **82** is omitted and the time constant of the silence timing gate **84** is greatly reduced to accommodate a normal human heart rhythm.

Power for operating the underwater communication system **10** is obtained from a conventional power supply **94** and distributed to the appropriate circuits through a function selector switch **96.** Looking at both figures of the drawings, the function selector switch **96** comprises a two-pole, five position switch which can be operated by the diver by means of an external knob (not shown). The speech processor **18,** the alarm system **98,** the tuned power amplifier **32** and the Schmitt trigger, receiver power switch, and transmitter power switch portions **68,72,** and **74,** respectively, of the VOX system are connected to the power supply **94** whenever the function selector switch is in any position other than Position No. **1.** The tuned power amplifier **32** does not draw any current unless the VCO **30** is activated, since it operates in the class-C mode.

When the function selector switch is in Position No. **2,** the receiver power switch **72** is ON and delivers current to the receiver circuits identified in the block diagram by the reference numerals **40** through **50,** the transmitter power switch **74** is OFF, and the transmitter **26** and **30** is deactivated while the input section of the VOX system comprising bandpass filter **58,** amplifier **60** and audio detector **62** are activated. Thus, when the diver speaks, the throat microphone **54** detects the speech signal which after amplification and detection turns OFF the receiver power switch **72** and then turns ON the transmitter power switch **74.** This activates the low pass filter **26** and the voltage controlled oscillator **30,** which causes a modulated carrier to be delivered to the tuned power amplifier **32** which begins to draw current. The output of the power amplifier causes the transmit/receive gate **36** to block the signal from the input of the receiver as soon as the transmitter output voltage reaches a predetermined level. The transmitter is turned OFF and the receiver is turned ON again as soon as the diver stops speaking.

When the function selector switch **96** in in Position No. **3,** the input section of the VOX system (reference numerals **58–62**) is deactivated, so that the transmitter does not operate when the diver speaks. This "listen only" position is useful when the diver is under great exertion and is generating so much noise (gasping, for example) that the throat microphone **54** receives a sufficiently strong signal to activate the VOX system or in situations in which the diver is forced to observe communications silence. However, the alarm system **98** and the switching portion of the VOX system are fully operationable so that an abnormal condition can still be detected.

When the function selector switch is in Position No. **4,** the input section of the VOX is deactivated but a control voltage B4 is applied to the VOX Schmitt trigger **68** so that the receiver power switch **72** is in the OFF mode and the transmitter power switch **74** is continuously ON. This mode of operation is useful when the diver's speech and/or breathing must be monitored continuously. An alarm condition causes no change in the system other than the application of the audio alarm signal to the input of the transmitter **28.**

Finally, when the function selector switch **96** is in Position No. **5,** the underwater communication system is in the full "Alarm" mode continuously. This mode of operation is useful when the diver wishes to inform others of an extremely dangerous situation, or wishes to be located by means of his radiated signal.

It will be appreciated from the preceding description of the VOX system of my invention that numerous modifications can be made without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In a voice communication system having a transmitter, a receiver, and a speech microphone acoustically coupled through a gaseous medium to a speech source signal for generating a modulation signal for said transmitter, a voice actuated transmit switch comprising:

1. a separate tissue-conduction microphone; and,
2. means responsive to an output signal from said microphone for enabling said transmitter.

2. The transmit switch of claim **1** wherein said tissue-conduction microphone is a throat microphone.

3. The transmit switch of claim **1** wherein said tissue-conduction microphone is a chest microphone.

4. The transmit switch of claim **1** further characterized by means for disabling said receiver.

5. In a voice communication system having a transmitter, a receiver, and a speech microphone acoustically coupled through a gaseous medium to a speech source for generating a modulation signal for said transmitter, a voice-activated transmit switch comprising:

1. a separate tissue-conduction microphone;
2. bandpass filter means coupled to said throat microphone;
3. amplifier means coupled to the output of said bandpass filter means;
4. trigger means responsive to an output signal from said amplifier means for generating a trigger signal; and,
5. means responsive to said trigger signal for enabling said transmitter.

6. The voice-activated transmit switch of claim 5 wherein said bandpass filter means has a center frequency slightly below 1 khz and a passband of 40 to 100 hz.

7. The voice-activated transmit switch of claim 5 wherein said trigger means includes delay means for maintaining said trigger signal for a predetermined length of time after the termination of the amplified vocal sound output from said amplifier means.

8. The voice-activated transmit switch of claim 7 wherein said predetermined length of time is approximately 0.2 seconds.

9. The voice-activated transmit switch of claim 5 wherein said means responsive to the trigger signal for enabling the transmitter is actuated within approximately 1 millisecond after reception of a vocal sound by said tissue-conduction microphone.

10. The transmit switch of claim 5 further characterized by means for disabling said receiver.

11. In an underwater voice communication system having a transmitter, a receiver, and a speech microphone for generating a modulation signal for the transmitter, said speech microphone being positioned in an acoustic cavity in front of the user's mouth and acoustically coupled thereto through a gaseous medium, a voice-actuated transmit switch comprising:

1. a separate tissue-conduction microphone;
2. means for acoustically isolating said microphone from waterborne noises;
3. bandpass filter means coupled to said microphone;
4. amplifier means coupled to the output of said bandpass filter means;
5. trigger means responsive to an output signal from said amplifier means for generating a trigger signal; and,
6. means responsive to said trigger signal for enabling said transmitter.

12. The transmit switch of claim 11 wherein said tissue-conduction microphone is a throat microphone.

13. The transmit switch of claim 11 further characterized by means for disabling said receiver.

* * * * *