

United States Patent

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- [50] Field of Search

179/1 (ST),
107; 330/10; 128/2.05 (S)
- [56]

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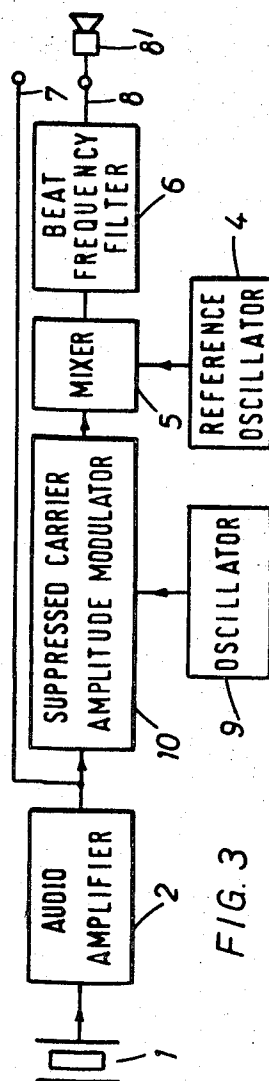
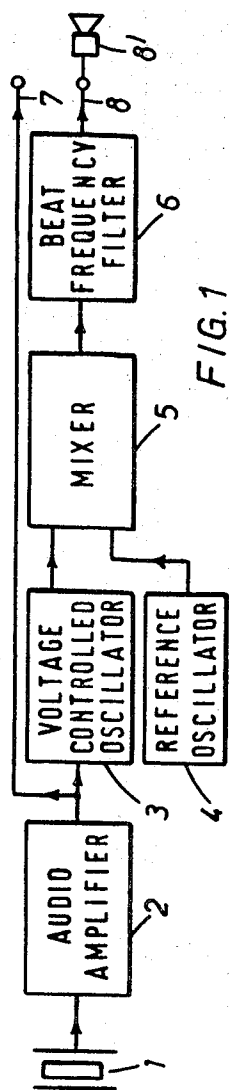
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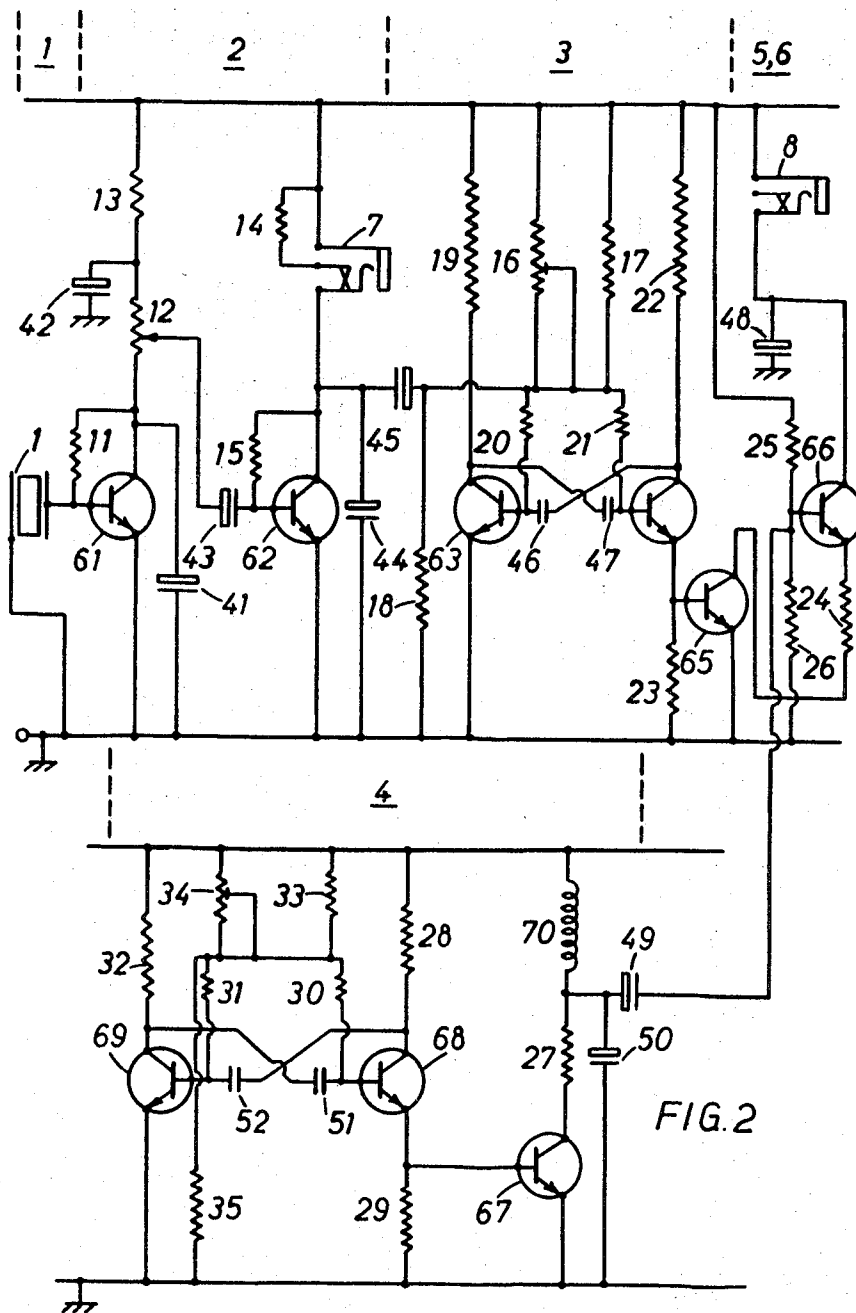
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- [54] ARRANGEMENTS FOR USE IN THE
EXAMINATION OF SOUND WAVE PATTERNS
1 Claim, 3 Drawing Figs.
- [52] U.S. Cl..... 179/1
- ABSTRACT: A transducer circuit for use in a stethoscope. Signals which are in an inaudible or difficult to hear frequency range are converted to signal variations in an easily heard frequency range by using modulating and mixing techniques.
- The diagram illustrates a block diagram of a transducer circuit. It begins with an input terminal (1) connected to an AUDIO AMPLIFIER (2). The output of the audio amplifier (3) is fed into a MIXER (5). A VOLTAGE CONTROLLED OSCILLATOR (3) and a REFERENCE OSCILLATOR (4) are connected to the MIXER (5). The output of the mixer (5) is then passed through a BEAT FREQUENCY FILTER (6). The final output is taken from terminal (7) and (8), which are connected to a speaker or earphone (8').





ARRANGEMENTS FOR USE IN THE EXAMINATION OF SOUND WAVE PATTERNS

This invention relates to stethoscopes.

In spite of the progress of electrocardiography, the stethoscope still offers for a medical diagnostic instrument the advantage of simplicity, light weight, low cost and relative ease of interpretation. However, the shortcomings of this instrument are also considerable. Low signal levels and the fact that significant portions of the phenomena investigated (heart pulsations, etc.) lie in the very low frequency region, where the sensitivity of the human ear is poor, result in a serious loss of the information potential of the stethoscope.

The problem of low signal levels can be relied, to some extent, by the use of microphones and signal amplifiers such devices being known as "electronic" stethoscopes. In this respect, however, the improvements achieved by some commercially available electronic stethoscopes are of limited significance. The inherent insensitivity of the ear — as well as the earphones used in this application — to the very low frequencies involved still prohibits full use of the signal information. Carrier modulation may be employed to translate such low frequency signals into a frequency region lying in a more easily audible range. However the presence of an audible carrier tone which itself bears no information physiologically impairs the sign processing capacity of the ear.

It is an object of the invention to provide an improved electronic stethoscope in which one or more of the above mentioned difficulties is overcome or reduced. It is to be understood that in this specification, and in the claims, the term "stethoscope" is not intended to be restricted to the type of instrument used in medicine, but is intended to cover any like instrument for the examination of acoustic wave patterns. For example such an instrument can be used in the examination of sounds emitted by internal combustion engines.

According to the invention there is provided a stethoscope comprising:

- a. a first transducer for converting an incident acoustic wave pattern to an electrical input signal;
- b. an oscillator for generating oscillations at a carrier frequency;
- c. modulator means and mixing means for modulating said oscillations by said input signal and for deriving components related to said input signal, but in a higher region of the audible frequency range than said input signal, one of said modulating and mixing means removing the carrier frequency;
- d. a second transducer for converting said modulated oscillation to an acoustic wave pattern;
- e. means for applying said modulated oscillation to said second transducer to produce an audible acoustic output wave pattern related to said incident acoustic wave pattern, with an inaudible carrier.

In order that the invention may be clearly understood and readily carried into effect it will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a block diagram of a circuit arrangement for use in one embodiment of the invention,

FIG. 2 is the circuit diagram of the arrangement shown in FIG. 1, and

FIG. 3 is a block diagram of a circuit arrangement for use in another embodiment of the invention.

Referring to FIG. 1, a ceramic transducer 1 is used to convert the sound wave pattern to an electrical input signal which is amplified by the amplifier 2. An output from said amplifier is taken to an output point 7 where a transducer (not shown) can be connected for the direct monitoring of the input wave pattern. Another output from amplifier 2 controls the oscillation frequency of an oscillator 3, the output from said oscillator thus being a carrier oscillation frequency modulated by the electrical signal from amplifier 2. The output from oscillator 3 is mixed with oscillations at the carrier oscillation frequency provided by a reference oscillator 4 in the mixer 5 to obtain a

translated frequency oscillation, frequency modulated by the input signal in which the translated carrier frequency is zero. The translated frequency modulated oscillation is selected by the filter 6, and the output taken to the point 8 where a transducer 8' can be connected for converting the electrical signal to an acoustic signal. Whilst the transducer can be an earphone, it can also be constituted for example by the record and replay parts of a tape recorder, and the term "transducer" in the specification and claims is intended to cover such an arrangement.

In the circuit diagram shown in FIG. 2 the parts which serve as the blocks shown in FIG. 1 are given the same reference numerals. The circuit portions are conventional and will not be described in detail. The amplifier 2 comprises a two stage transistor amplifier and the monitor output point 7 is a jack arranged in such a way that when a transducer is connected the transducer serves as the load for transistor 62 in place of resistor 14. The oscillator 3 comprises an astable multivibrator including transistor 63 and 64 the frequency of which is controlled by the output of amplifier 2 applied via capacitor 45, and the center frequency of which may be adjusted by the variable resistor 16. The output from the oscillator 3 is fed via a switch transistor 65 and a resistor 24 to the emitter of mixer transistor 66. The transistor 65 is driven alternately to conditions of high conductivity and low conductivity so that the emitter load of transistor 66 alternates between a value approximately equal to that of resistor 24 and a very high value approximately equal to the collector emitter resistance of transistor 65 when it is in its "off" condition. The reference oscillator 4 includes a further astable multivibrator the frequency of which is adjusted by the variable resistor 34, to equal the frequency of unmodulated oscillation of oscillator 3, and the transistor 67 which converts the output of said multivibrator to a sinusoidal wave at the same frequency with the aid of the inductor 70 and the capacitor 50. The output is fed to the base of mixer transistor 66. Thus the reference oscillation from 4 is modulated by the frequency modulated square wave switching signal from oscillator 3. The fundamental beat frequency component is filtered out at the collector of transistor 66 by the simple RC filter formed by the capacitor 48 and by an earphone, inserted in the jack 8. This provides a frequency modulated output with a carrier frequency equal to zero. Thus, the carrier is inaudible and the depth of modulation of oscillator 3 is adjusted so that the output frequency modulated oscillation extends into the audible frequency range. The difference between the center frequency of oscillator 3 and the frequency of oscillator 4.

In practice it has been found preferable to set the resistor 34 so that oscillator 4 oscillates with a frequency equal to the resonance frequency of inductor 70 and capacitor 50 and then to adjust resistor 16 to give a zero difference frequency, that is FM carrier frequency. In one embodiment of the invention the frequency of said oscillator 4 was 30 kc/s and the frequency deviation of oscillator 3 produced by the input signal was of the order of 8 kc/s, maximum.

Frequency modulation exploits the ability of the human ear to detect comparatively small changes of tone. Signals whose rates of change are slow, compared to the time-constant of hearing, are tracked by the ear rather than give an averaged sense of pitch. From the point of view of recognition and interpretation, this mechanism makes frequency modulation very useful for detecting such low frequency signals. A large portion of the produced FM spectrum can be made to coincide with the sensitive audio sensory bandwidth.

In another embodiment of the invention instead of utilizing the amplified signal from the input to frequency modulate an oscillator it is used to amplitude modulate an oscillator. This has the effect of translating the entire range of significant frequencies to an audible band, facilitating detection by ear. Preferably the modulation is by suppressed carrier methods because the presence of the carrier tone which itself bears no information physiologically impairs the signal processing capacity of the ear.

An example of such an embodiment of the invention is illustrated in FIG. 3. Points which are similar to corresponding parts in FIG. 1 are denoted by the same reference numeral. As before there is provided a ceramic transducer 1 the output of which is amplified by the amplifier 2. The output of the amplifier is used to amplitude modulate in suppressed carrier fashion in the modulator 10 oscillations generated by the oscillator 9. The modulated oscillations are mixed with oscillations provided by the reference oscillator 4 in the mixer 5 to obtain a difference frequency oscillation which is amplitude modulated with suppressed carrier by the input wave pattern and which lies in the audible frequency range. As before the difference frequency is selected by the filter 6 and the output taken to the point 8 where a transducer 8' is connected for converting the electrical signal to an acoustic signal.

Interpretation of the audio output of the present stethoscope (as is the case for any stethoscope, in fact,) is, for the main part, subjective in nature and must be properly acquired through experience and learning. In particular, because the modulated signals are necessarily different, to some degree, from the original signals adaptation to the different sounds is required.

Auxiliary features and techniques may be incorporated to enhance the usefulness of the instrument. These may include selective input and/or output filtering, to discriminate different types of signal; amplitude compression, to emphasize low level signals; and automatic gain control, to compensate for variations of signal level from one patient to another. The incorporation of the direct audio amplifier output in addition to the modulated output will help in the process of learning new sounds, by comparison with the conventional stethoscope sounds.

The frequency band of the output signals lends itself to recording on disc or magnetic tape. Typical responses, corresponding to various conditions of health or disease, may be

catalogued by recording. As such they would be permanently available for reference and consultation. The records would also provide a convenient means of rapidly acquiring the experience needed for proper use of the instrument as a diagnostic tool.

It will be appreciated that the stethoscope described above differs from conventional types in that it is not merely a signal amplifier, but also a frequency translator. It uses modulation techniques which make it capable of presenting normally inaudible or poorly audible signal information in a manner suitable for auditory detection, by shifting the modulation band into the audible frequency range.

We claim:

1. a. first transducer for converting an incident acoustic wave pattern, including components which because of their frequency are inaudible or difficult to hear, to an electrical input signal;
- b. a first oscillator for generating oscillations at a carrier frequency;
- c. means for frequency modulating said oscillations by said input signal to produce a frequency variation with components signal in a more easily audible frequency region;
- d. a second oscillator for generating oscillations at said carrier frequency;
- e. means for deriving a difference frequency signal relating to the frequency difference between the modulated oscillations and the oscillations generated by said second oscillator,
- f. a second transducer for converting an electrical signal to an acoustic wave pattern; and
- g. means for applying said difference frequency signal to said second transducer to produce an audible acoustic output wave pattern related to said incident acoustic wave pattern and with the carrier removed.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,562,428 Dated February 9, 1971

Inventor(s) Bertrand Julian Starkey & Robert John Felix Edwards

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page, at "[32] Priority", cancel "Nov. 16, 1966" and insert -- Nov. 10, 1966 --.

Signed and sealed this 10th day of August 1971.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents