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ELECTRONIC STETHOSCOPE

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2 Sheets-Sheet 2

Fig. 3.

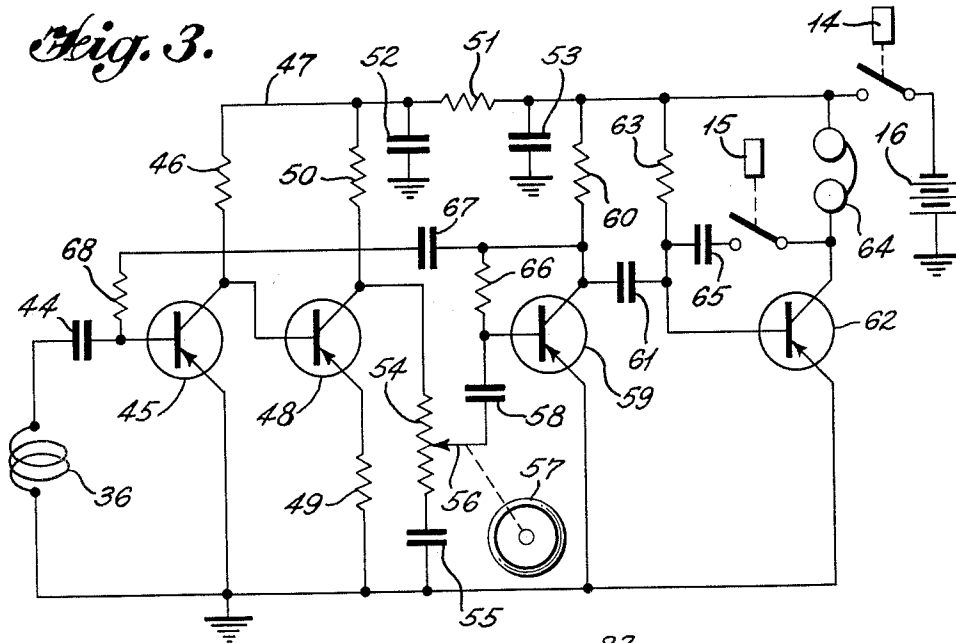
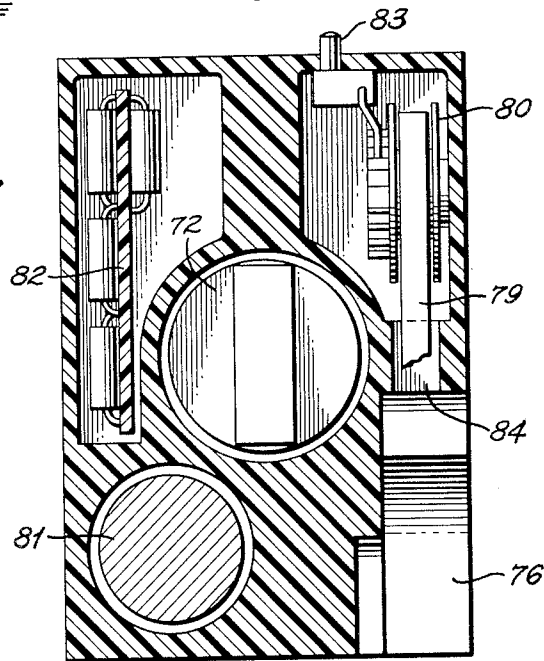


Fig. 5.



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ELECTRONIC STETHOSCOPE

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This invention relates to sound-detecting apparatus and more particularly to an electrical stethoscope adapted for diagnostic uses and effective to reproduce heart sounds in a manner substantially approximating the conventional acoustical stethoscope.

Heretofore, various attempts have been made to construct a stethoscope incorporating an electrical amplifier so that either acoustical or electrical output can be provided which reproduces the heart sounds in an amplified manner. However, the prior devices have been found to be unacceptable by practicing physicians who have become accustomed to the conventional acoustical stethoscope. The prior electrical stethoscopes have been faulty in that it has been attempted to utilize a contact microphone for pickup, whereas the acoustical stethoscope utilizes an open-ended conical bell as a pickup which permits the skin of the patient being examined, being stretched across the bell, to act as a diaphragm. In practice, the pressure applied to the bell by the examining physician varies the degree to which the skin is stretched over the bell, and so varies the character of the sound transmitted to the ear plugs. Moreover, it has been found that merely positioning a microphone at the base of a bell-shaped pickup does not provide the conventional quality of sound output, but instead introduces undesirable acoustical distortion.

It is therefore the principal object of this invention to provide a stethoscope incorporating electrical amplification which is adapted to acoustically or electrically reproduce heart sounds in a manner closely approximating and enhancing the sound reproduction characteristics of the conventional acoustical stethoscope.

In accordance with this invention, an electrical stethoscope is provided which uses a pickup housing including an open-ended, cone-shaped bell. The inner end of the bell opens into a substantially closed acoustical chamber within the pickup housing, and a thin flexible diaphragm having a diameter approximating that of the wide end of the bell is mounted near one end of the chamber closely adjacent the opening of the inner end of the bell. A coil is mounted on the diaphragm in a magnetic field and so provides the electrical output. Small passageways connect the chamber on both sides of the diaphragm with the atmosphere. A transistor amplifier is also enclosed in the pickup housing along with a battery and has an input connected to the coil. The output of the amplifier is connected to a transducer in a headset which incorporates conventional ear plugs. The output, of course, could also be connected to a recording arrangement for providing a permanent visual indication of heart sounds. In a further embodiment of the invention, a single ear plug is provided which may be carried in the pickup housing and pulled out when used, the connecting wire being wound on a reel in the pickup. This latter embodiment provides a compact, easily portable unit.

The novel features believed characteristic of this invention are set forth in the appended claims. The invention itself, as well as further objects and advantages thereof, will best be understood from the following description of particular embodiments thereof, when read in conjunction with the accompanying drawing, in which:

FIGURE 1 is a pictorial representation of a stethoscope

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assembly incorporating the principal features of this invention;

FIGURE 2 is a cross section of the pickup housing of FIGURE 1 taken along the line 2—2;

FIGURE 3 is a schematic diagram of the transistor amplifier utilized in this invention;

FIGURE 4 is a pictorial representation of a pickup housing of another embodiment of a stethoscope according to this invention; and

FIGURE 5 is a cross section of the pickup housing of FIGURE 4 taken along the line 5—5.

With reference to FIGURE 1, there is shown a pictorial representation of an electronic stethoscope assembly incorporating the principal features of this invention. The assembly includes a pickup head enclosed in a housing 10 and having a cone-shaped bell 11 positioned therein. A microphone 12 is positioned at the base of the cone and is connected to a transistor amplifier 13 which will be subsequently described and which is mounted on the interior of the housing 10. A pushbutton 14 for an on-off switch projects through the housing in such a position as to be easily operated by a person using the device. Likewise, a volume control knob (not shown) projects through the back of the housing 10 and lever 15 for a tone control switch extends through the top. A battery 16 is disposed within the housing to power the device. The output terminals of the amplifier 13 are engaged by a plug 17 which is connected by a pair of leads 18 to a headset 20. The headset includes a central joint 21 to which a plug 22 on the end of the leads 18 is connected. The joint 21 is seen to be generally cylindrically shaped and includes two separate portions 23 and 24 which are axially rotatable with respect to one another. A curved hollow tube 25 is joined at one end to one portion 23 of the joint 21 while a second hollow tube 26 is joined at one end to the other portion 24. A pair of ear plugs 27 and 28 are positioned on the other ends of the curved hollow tubes 25 and 26. With this arrangement, the tubes 25 and 26 may be rotated with respect to one another so that the ear plugs 27 and 28 may be inserted into the ears of the user with ease and will remain there while the pickup housing 10 is manipulated. The portion 24 of course includes a transducer, which may be of the clip-in type. The output device or headset 20 may well be of the type described in the U.S. Patent No. 2,498,960, issued to C. D. Mullin on February 28, 1950.

With reference to FIGURE 2, the housing 10 is shown in cross section. The housing 10 is composed of a suitable material such as plexiglass or a thermosetting plastic. The cone-shaped bell 11 is seen to be integrally formed in the front wall of the housing, and the hole at the base of the bell communicates with a cylindrical chamber 30 integrally formed by the housing. The microphone 12 is secured to the interior of the housing at the base of the cone-shaped bell 11 by means such as a suitable fastener, clip, or adhesive. A ring-shaped gasket 31 renders the uppermost portion of the chamber 30 airtight with respect to the remainder of the chamber. The microphone 12 may be of the type commercially available as an Electro-Voice 82111, 150 ohms, and includes a permanent magnet 32 having its upper end projecting through a hole in a disc-shaped pole piece 33 which is connected at its outer edges to a U-shaped magnetic member 34 to complete the magnetic circuit. A thin plastic diaphragm 35 is mounted over the disc-shaped member 33 and includes a small bulge in its center to receive the end of the magnet 32. A coil 36 of very fine wire is secured to the diaphragm 35 so that it is in the area of the air gap between the magnet 32 and the pole piece 33, and moves with the diaphragm which is free to flex in an axial direction.

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It is thus seen that the microphone is suspended between the bell and the cylindrical chamber 30. It should be noted that the outer end of the bell 11 is open just as in the conventional acoustical stethoscope so that as the bell is forced against the skin of the patient under examination, the skin is stretched across the bell to form a diaphragm. The amount of pressure applied by the user to hold the bell against the patient will determine the tautness of the diaphragm formed by the skin, and so will determine to some extent the acoustical characteristics of the device. That is, when the skin is stretched taut across the mouth of the bell 11, the high frequency sounds will be favored and the lower frequencies attenuated. When the skin is relatively loose, on the other hand, the low frequency heart sounds will be enhanced. A thin, flat chamber is seen to exist between the diaphragm 35 and the housing 10, and this chamber is vented by a small passage 37, so that pressure cannot build up within the chamber during wide excursions of diaphragm caused by high amplitude, low frequency sounds. The chamber 30 is likewise vented by a small hole 38 in a back cover 39, since the chamber is otherwise sealed by the diaphragm 35 and the gasket 31. In a preferred embodiment, the diameter of the outer end of the bell 11 is about one inch, the diameter of the chamber 30 about 7/8 inch, the diameter of the diaphragm 35 about 3/4 inch, and the vent holes 37 and 38 about 1/32 inch. The housing 10 also includes a chamber 40 in which a printed circuit board assembly 41 having the necessary transistor amplifier components may be positioned. Further, the housing 10 includes a chamber (not shown) in which a power supply in the form of the battery 16 is inserted.

With reference to FIGURE 3, a schematic diagram of the transistor amplifier which is enclosed in the housing 10 is shown. The coil 36 of the microphone 12 is connected by a capacitor 44 to the base of a PNP transistor 45. The emitter of the transistor 45 is grounded while the collector is connected through a load resistor 46 to a supply line 47. The collector of the transistor 45 is further connected to the base of a second transistor 48. The emitter of the transistor 48 is connected through a resistor 49 to ground, while the collector is connected through a load resistor 50 to the supply line 47. It is thus seen that two stages of amplification are first provided. The line 47 is connected through a decoupling arrangement including a resistor 51 and a pair of like capacitors 52 and 53 to the negative terminal of the battery 16 through an on-off switch operated by the pushbutton 14. The collector of the transistor 48 is directly connected to one end of a potentiometer 54 which has its other end connected through a capacitor 55 to ground. A movable tap 56 on the potentiometer 54 is operated by a volume control knob 57 which projects through the back of the housing 10, and this tap 56 is electrically connected through a capacitor 58 to the base of a third transistor 59. The emitter of this transistor is grounded while the collector is connected through a load resistor 60 to the negative supply 16. The collector is further coupled through a capacitor 61 to the base of a final transistor 62. This base is also connected through a biasing resistor 63 to the negative supply, while the emitter of this transistor is grounded. The collector of the transistor 62 is connected through the earphones or output device 64 to the negative supply 16. This collector is further connected through a switch operated by the small button or lever 15 and a capacitor 65 to the base of the transistor 62 to provide negative feedback at high frequencies when it is desired to simulate the diaphragm characteristics of some acoustical stethoscopes. Feedback is also used in the third transistor stage, a resistor 66 being connected between the collector of the transistor 59 and the base thereof to provide linear gain. Further, negative feedback is provided between the collector of the transistor 59 and the base of the transistor 45 at frequencies determined by a capacitor 67 and a resistor 68.

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While the actual values of the components utilized in this transistor amplifier will depend upon the particular application, the following table specifies the types and magnitudes of the circuit components by way of example only.

Table

Transistors 45, 48, and 49	2N185.
Transistor 62	2N368.
Microphone coil 36	150 ohms.
Resistors 46 and 63	15K ohms.
Resistor 49	82 ohms.
Resistors 50 and 60	1K ohm.
Resistor 51	47 ohms.
Resistor 54	30K ohms.
Resistor 66	200K ohms.
Resistor 68	10K ohms.
Capacitors 44, 55, 58, and 61	8 μ fd.
Capacitors 52 and 53	47 μ fd.
Capacitor 65	0.5 μ fd.
Capacitor 67	1 μ fd.
Battery 16	4 volts.

Another embodiment of the stethoscope of this invention is illustrated in FIGURES 4 and 5, and includes a single earpiece which may be housed within the pickup assembly rather than a binaural headset as shown above. As seen in FIGURE 4, a pickup housing 70 is provided having a cone-shaped bell 71 with a microphone 72 at its base. A pushbutton on-off switch 74 projects through the housing, and a transistor amplifier and battery (not shown) are suitably mounted within the housing. A recess 76 is formed in the side of the housing 70 to receive a transducer 77 for converting the amplified electrical signals corresponding to the heart sounds into audible signals. The transducer 77, when reeled out of the housing 70, clips into an earpiece 78 which is moulded to fit the ear lobe of the physician using the device. Alternatively, the transducer 77 could be clipped into a binaural headset similar to the headset 20 of FIGURE 1. The transducer 77 is connected to the output of the amplifier in the housing 70 by a pair of thin flat conductors in a flat tape 79 which is wound upon a reel 80. As seen in the cross-sectional view of FIGURE 5, the housing 70 includes suitably shaped interior chambers for a battery 81, an amplifier circuit board 82, the microphone 72, and the reel 80 with its pawl and ratchet wind-up mechanism. A pushbutton 83 projects through the housing 70 and is operative to lift the pawl away from the ratchet and allow the spring-biased reel 80 rewind the tape 79. The tape 79 is seen to pass through a channel 84 into the recess 76 for engagement with the transducer 77. One of the conductors in the tape 79 is connected to the bearing of the reel 80, while the other conductor is electrically connected to the ratchet. The bearing and ratchet are insulated from one another, and the output of the transistor amplifier is connected between the pawl and bearing, so that no slip ring arrangement is necessary.

While this invention has been described with reference to specific illustrative embodiments, this description is not meant to be construed in a limiting sense. It is, of course, understood that various modifications may be made by persons skilled in the art, and it is therefore contemplated that the appended claims will cover any such modifications as fall within the true scope of the invention.

What is claimed is:

1. Sound-detecting apparatus comprising a cone-shaped bell being open at the wide end, a hollow chamber positioned adjacent to and axially aligned with said bell, said chamber having an opening communicating with the small end of said bell, a thin flexible diaphragm having a diameter approximating that of said wide end of said bell and positioned within said chamber closely adjacent said opening, said diaphragm separating a small portion of said chamber from the remainder thereof, a first narrow air

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passage connecting said small portion to atmosphere, a second narrow air passage connecting said remaining portion of said chamber to atmosphere, a coil secured to said flexible diaphragm and positioned in a magnetic field, and amplifying means having an input connected to said coil.

2. An electronic stethoscope comprising a pickup housing, a cone-shaped bell integrally formed in said housing and being open at the wide end, a hollow cylindrical chamber having a diameter approximating that of said wide end formed within said housing and axially aligned with said bell, said chamber having an opening communicating with the small end of said bell, a thin flexible diaphragm having a diameter approximating that of said wide end of said bell and positioned within said chamber closely adjacent said opening, said diaphragm separating a small portion of said chamber from the remainder thereof, first and second narrow air passages connecting said small portion and said remainder respectively to atmosphere, a coil secured to said flexible diaphragm and positioned in a magnetic field, a transistorized amplifier having an input connected to said coil and being positioned within said housing, and a transducer having an input connected to the output of said amplifier.

3. An electronic stethoscope comprising a pickup housing, a cone-shaped bell integrally formed in said housing and being open at the wide end, a hollow cylindrical chamber having a diameter approximating that of said wide end formed within said housing and axially

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aligned with said bell, said chamber having an opening communicating with the small end of said bell, a thin flexible diaphragm having a diameter approximating that of said wide end of said bell and positioned within said chamber closely adjacent said opening, said diaphragm separating a small portion of said chamber from the remainder thereof, first and second narrow air passages connecting said small portion and said remainder respectively to atmosphere, a coil secured to said flexible diaphragm and positioned in a magnetic field, a transistorized amplifier having an input connected to said coil and being positioned within said housing, and a transducer having an input coupled to the output of said amplifier by a twin-conductor lead, said transducer being received within a recess in said housing, said lead being wound on a spring-biased reel within said housing, and an earpiece external of said housing having at least one earplug and adapted to receive said transducer.

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