

Nov. 27, 1945.

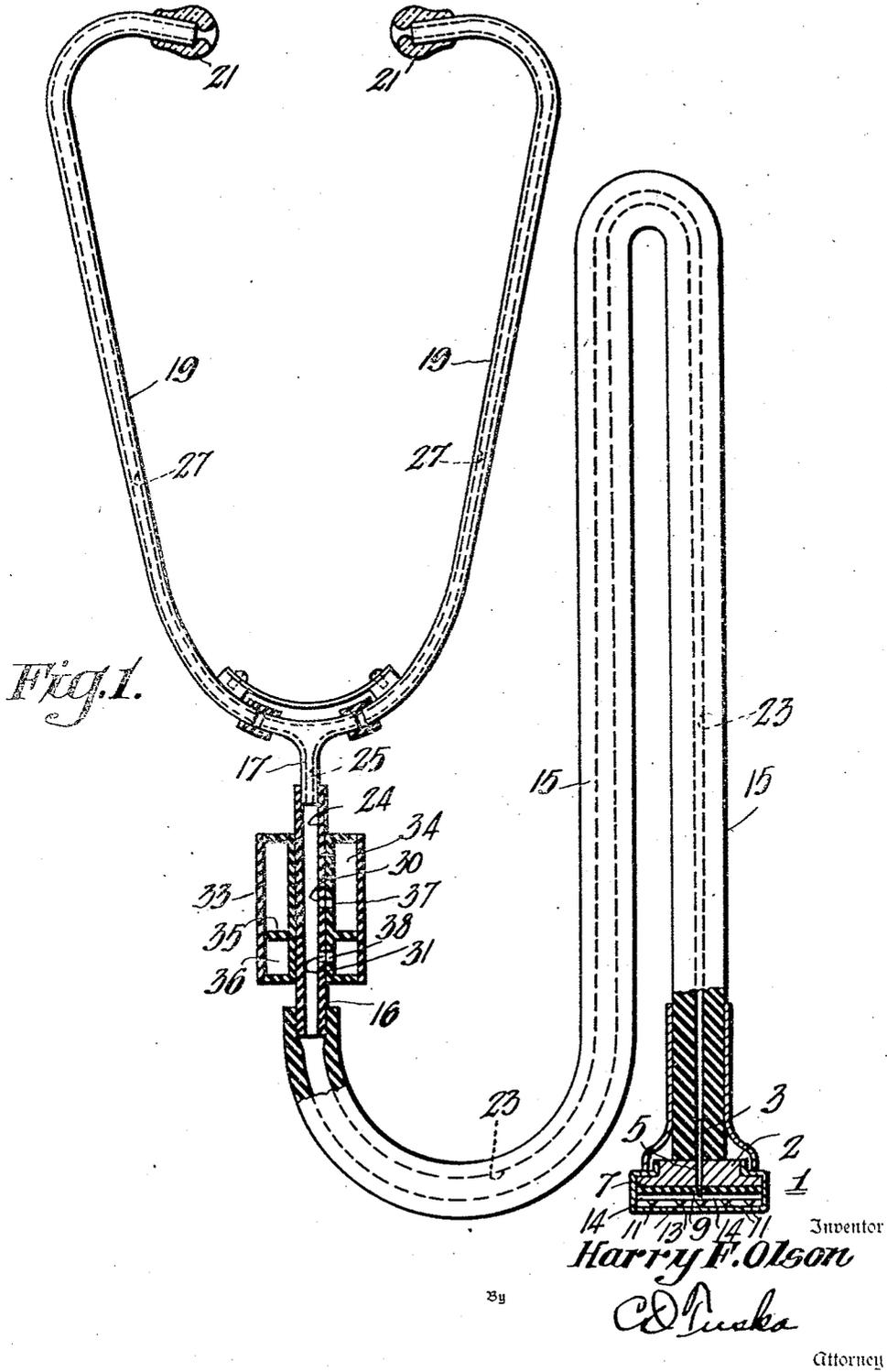
H. F. OLSON

2,389,868

ACOUSTIC STETHOSCOPE

Filed Oct. 29, 1943

3 Sheets-Sheet 1



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Fig. 2.

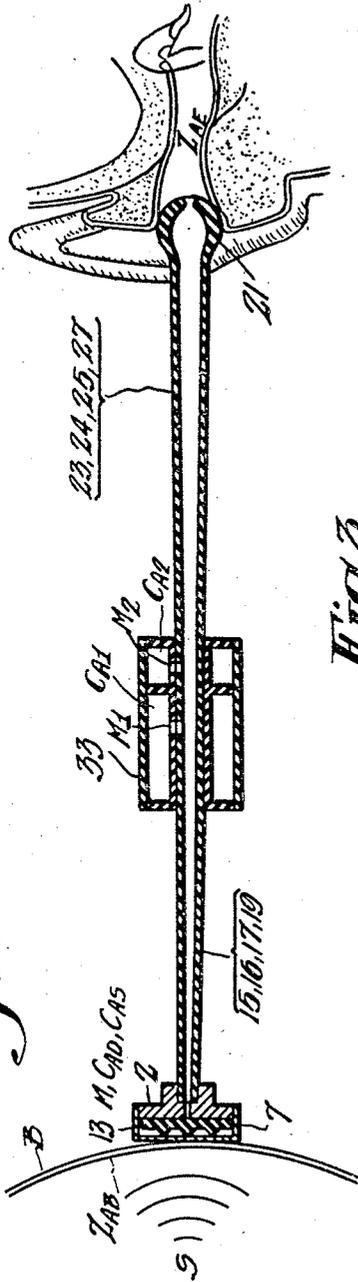
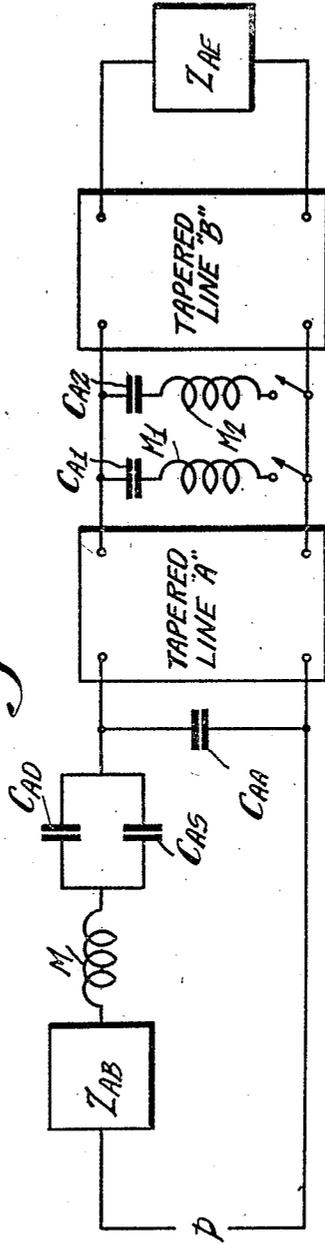


Fig. 3.



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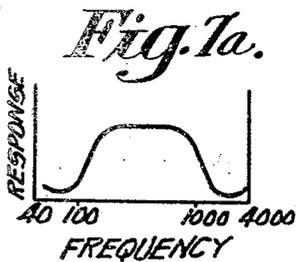
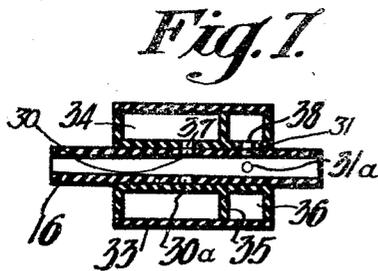
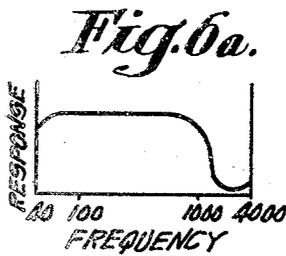
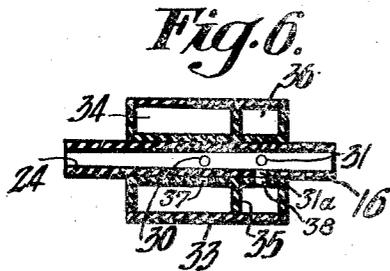
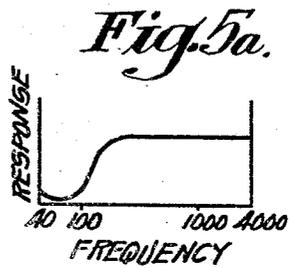
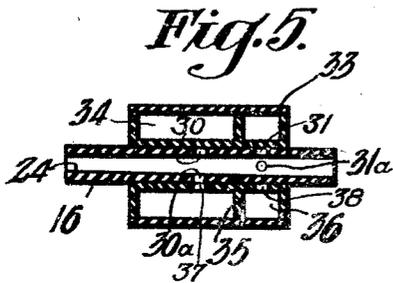
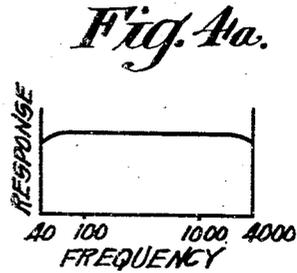
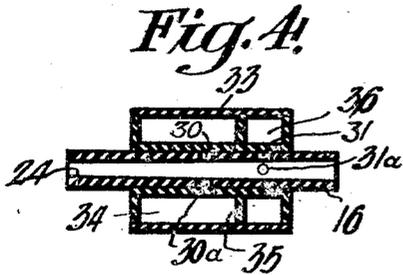
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,389,868

ACOUSTIC STETHOSCOPE

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Application October 29, 1943, Serial No. 508,215

3 Claims. (Cl. 181—24)

This invention relates to an acoustic pickup device, and more particularly to an acoustic stethoscope, the present invention being an improvement over that disclosed and claimed in my copending application, Serial No. 437,139, filed April 1, 1942, now Patent No. 2,363,686, granted November 28, 1944.

In the aforesaid application, I have disclosed an acoustic stethoscope which is effective over a much wider range than stethoscopes of the prior art and by means of which sound can be picked up over a localized area of the subject being examined. The stethoscope comprises, briefly, a pickup device of relatively small area adapted to cooperate with a portion of the subject having a relatively high impedance, the pickup device being coupled to a suitable detector, such as the ears of the user, by a tapered acoustical line which matches the relatively high impedance at the receiver to the relatively low impedance of the ears, thereby being capable of transmitting acoustical energy without substantial loss or attenuation.

While the wider frequency range afforded by the stethoscope disclosed in my aforesaid copending application is a very desirable feature, there are some cases in which this wider range causes some confusion because the added low and high frequency sounds occasionally mask certain desired sounds upon which the user wishes to concentrate. The primary object of my present invention, therefore, is to provide an improved stethoscope of this type which will not be subject to the aforementioned limitation.

More particularly, it is an object of my present invention to provide an improved, wide range stethoscope by means of which sounds of various frequencies can be readily differentiated.

Another object of my present invention is to provide, in a stethoscope of the type set forth above, a corrective acoustic network by means of which undesired portions of the frequency range to which the stethoscope is responsive may be eliminated without impairing the desired portion of this range.

It is also an object of my present invention to provide an improved acoustic stethoscope and network as above set forth which is simple in construction, inexpensive in cost, and highly efficient in use.

In accordance with my present invention, I form in the tubular member constituting the acoustic coupling device between the pickup and the receiver a plurality of openings which are spaced from each other and rotatably mount on

this tubular member a second tubular member formed with a plurality of discrete acoustic chambers. The second tubular member is arranged to communicate with the passage in the tapered line through one or more of the aforesaid openings whereby one or more of the aforesaid chambers may be brought into communication with the passage in the tapered line. Each of the chambers and the air in the associated openings constitutes a Helmholtz resonator which operates in known manner to reject or attenuate certain frequencies or bands of frequencies transmitted by the tapered line, and the second named tubular member may be selectively rotated on the tubular member of the tapered line to any desired position for either attenuating the low frequencies, the high frequencies, both the low frequencies and the high frequencies, certain intermediate frequencies, or any combination thereof as may be desired.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description of one embodiment thereof, when read in connection with the accompanying drawings, in which

Figure 1 is an elevational view, partly in section, of an acoustic stethoscope constructed in accordance with my present invention,

Figure 2 is a schematic, cross-sectional view of the acoustic system of the improved stethoscope of my present invention shown applied to the body and the ear,

Figure 3 is a wiring diagram of the equivalent electrical circuit of the acoustic system shown in Figure 2,

Figures 4 to 7, inclusive, are sectional views of the acoustical network of my present invention shown applied to a portion of the tubular member constituting the tapered line, and arranged in each figure to be effective over different frequency ranges, and

Figures 4a to 7a, inclusive, are response curves showing, respectively, the responses of the arrangements of Figures 4 to 7.

Referring more particularly to the drawings, wherein similar reference characters designate corresponding parts throughout, Fig. 1 shows a pickup device 1 adapted to be placed against the human body or other subject to be studied and comprising a supporting plate 2 having a hollow stem 3 extending from its back face, a bore or

opening 5 being formed in the supporting plate 2 in communication with the hollow stem 3. Secured to the front face of the plate 2 is a backing member 7 having an opening 9 in communication with the opening 5 and also having a plurality of forwardly extending projections 11 thereon. The backing member 7 may be of any suitable material, but it is preferably made of an elastic material, such as rubber, in accordance with the teachings of my above identified patent. The projections 11 may be conical, pyramidal, or the like. A membranous diaphragm 13 of thin, sheet rubber or the like is carried by the supporting plate 2 with its rear or inner surface in engagement with the apices of the projections 11. The projections 11 are spaced from each other on the backing member 7 and are distributed over the entire area of the diaphragm 13, the spacing of the projections being such as to provide a plurality of intersecting and intercommunicating passageways 14 which communicate with the openings 9 and 5 and the hollow stem 3, all as more fully described and claimed in my above identified patent.

Fitted onto the stem 3 is a flexible tube 15 of rubber or the like which connects the pickup device 1 to a tube 16, the latter, in turn, being connected to a Y connector 17. The connector 17 connects the tube 16 to a pair of ear tubes 19 terminating in a pair of ear pieces 21. The tubular members 15 and 16 are provided with a continuously tapered passage 23, 24 which expands gradually and uniformly from the stem 3 to the connector 17. The connector 17 and the ear tubes 19 are formed with similarly expanding passages 25 and 27 so that, from the stem 3 to the ear pieces 21, a continuously expanding passage is provided. Except for the addition of the tube 16, the construction thus far described is precisely like that disclosed in my above identified patent, the tube 15 of the latter being connected directly to the Y connector 17 instead of through the tube 16.

The diaphragm 13 is of the order of 1" in diameter and the relatively high impedance of the area of the human body covered thereby when in contact therewith matches the surge acoustic impedance of the air in the stem of passageway 23 at its smaller or receiver end. Since, however, this does not match the impedance of the ear canals, the passages 23, 24, 25, and 27 are tapered as above described, the rate of taper being such that the relatively high impedance at the pickup end of the tube 15 will be matched to the relatively low impedance of the ear canals at the ear pieces 21.

A stethoscope such as that described thus far has a frequency range of from about 40 cycles per second to about 4000 cycles per second. This range permits hearing sounds generated in the human body which cannot be heard with other stethoscopes. In some cases, the additional sounds which are heard cause confusion by masking the sounds to which it is desired to listen particularly. To avoid this difficulty, there may be formed in the wall of the tubular member 16 one or more openings which afford communication between the portion 24 of the tapered passage and the exterior thereof. Two such openings 30 and 31, spaced from each other longitudinally along the tube 16, a third opening 30a aligned with but spaced 180° from the opening 30, and a fourth opening 31a aligned with but spaced only 90° from the opening 31, are shown by way of illustration. Another tubular member

33 which is closed at each end and has a partition 35 therein dividing it into two chambers 34 and 36 is rotatably mounted on the tube 16 about the openings 30, 30a, 31 and 31a. The inner wall of the member 33, which acts as a filter device, is provided with a pair of openings 37 and 38 spaced from each other in a longitudinal direction the same distance as the openings 30 and 31, the opening 37 being arranged to cooperate with the openings 30 and 30a, and the opening 38 being arranged to cooperate with the openings 31 and 31a.

The filter tube 33 may be manually rotated 90° on the tube 16 from one position wherein its inner wall closes off all of openings 30, 30a, 31 and 31a, as shown in Fig. 4, to a second position wherein the opening 37 is brought into registration with the opening 30a, thereby establishing communication of the passage portion 24 with the larger chamber 34, the openings 30, 31 and 31a remaining closed off, as shown in Fig. 5. In the position of Fig. 4, the filter is entirely ineffective and the tapered line transmits the full range of frequencies, as shown by the response curve of Fig. 4a. In the position of Fig. 5, however, the mass M_1 of the air in the aligned openings 30a and 37 resonates with the capacitance C_{A1} of the volume of air in the chamber 34 in the well known manner of a Helmholtz resonator, and if the size of the openings 30a and 37 and the volume of the chamber 34 are properly chosen, the resonator will filter out the low frequency sounds, as shown by the curve of Fig. 5a, thereby preventing them from reaching the ears.

The filter tube 33 may also be rotated manually 90° more to a third position, as shown in Fig. 6. In this position, the openings 30, 30a and 31 are closed off and the opening 38 is brought into registration with the opening 31a to thereby establish communication between the passage portion 24 and the smaller chamber 36. The mass M_2 of the air in the aligned openings 31a and 38 will then be free to resonate with the capacitance C_{A2} of the air in the chamber 36 to trap the high frequency sounds when properly dimensioned, and the resulting response will be of the type shown by the curve of Fig. 6a.

In a fourth position to which the filter tube 33 may be rotated an additional 90°, the openings 37 and 38 are both brought into registration with their respectively associated openings 30 and 31, as shown in Fig. 7, the openings 30a and 31a then being closed off. This will bring both of the chambers 34 and 36 into communication with the tapered passage portion 24, and the two Helmholtz resonators will then be effective to attenuate or filter out both the low frequency sounds and the high frequency sounds to provide a response such as shown by the curve of Fig. 7a. Thus, by a simple, manual manipulation, any one of the responses represented by the curves of Figs. 4a to 7a, inclusive, may be obtained. The filter tube 33 may be releasably locked in any one of the adjusted positions shown in Figs. 4 to 7, inclusive, by suitable means (not shown).

Fig. 2 shows a simplified, acoustic system employing the filter device of my present invention in a stethoscope as above described, and Fig. 3 shows a wiring diagram of the analogous electrical system or circuit. In these figures,

B represents the body under examination and in which a sound source S generates acoustic vibrations with a pressure p ,

Z_{AB} represents the impedance of the body B,

M represents the mass of the diaphragm 13,
 C_{AD} represents the capacitance of the diaphragm,
 C_{AS} represents the capacitance of the resilient
 projections 11,

C_{AA} represents the capacitance of the air chamber between the diaphragm 13 and the projections 11,

Z_{AE} represents the impedance of the ear canals,
 C_{A1} represents the capacitance of the air chamber 34,

M_1 represents the mass of the air in the openings 30 or 30a, as the case may be, and the opening 37 when aligned,

C_{A2} represents the capacitance of the air in the chamber 36, and

M_2 represents the mass of the air in the openings 31 or 31a, as the case may be, and the opening 38 when aligned.

When the filter tube 33 is placed in the position of Fig. 4, this is equivalent to opening the shunt circuits C_{A1} , M_1 and C_{A2} , M_2 of Fig. 3. When the filter tube 33 is rotated to the position of Fig. 5, this is equivalent to closing the switch of the circuit C_{A1} and M_1 . Turning the filter tube 33 next to the position of Fig. 6 will be equivalent to opening the switch of the circuit C_{A1} , M_1 and closing the switch of the circuit C_{A2} , M_2 . Finally, when the filter tube 33 is turned to the position of Fig. 7, this is equivalent to closing the switches of both of the shunt circuits C_{A1} , M_1 and C_{A2} , M_2 .

From the foregoing description, it will be apparent to those skilled in the art that I have provided a simple and effective means for excluding undesired sounds in a wide range stethoscope without interfering in the slightest with the transmission of sounds in the desired range. Obviously, the filter tube 33 may be provided with as many chambers as may be found suitable or desirable, two chambers having been illustrated merely for the purpose of illustration. Moreover, it will undoubtedly be apparent to those skilled in the art that many variations of the present invention, as well as other changes in the particular one described, are possible. I therefore desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In an acoustic stethoscope, a pick-up device having a relatively high impedance equal substantially to that of a given area of a subject to be examined, an acoustic coupling line connected at one end to said pick-up device and adapted to be connected at its other end to a detector having a relatively low impedance, said line including a tubular member and having a tapered passage between its ends which expands gradually from said pick-up device to its detector end, the ends of said passage having impedances which match said high and low impedances, re-

spectively, whereby said coupling line is adapted to transmit acoustical energy from said subject to said detector without substantial attenuation, said tubular member having a plurality of openings in the wall thereof which are spaced from each other and each of which affords communication between said passage and the exterior, and means associated with said line for rejecting acoustical energy of certain frequencies within the range transmitted by said line whereby to prevent energy of said certain frequencies from reaching said detector, said rejecting means comprising a plurality of acoustical resonators of the Helmholtz type equal in number to the number of said openings and each associated with a separate one of said openings whereby to afford communication between each of said resonators and said passage, said resonators each being effective over a different frequency range.

2. The invention set forth in claim 1 characterized by the inclusion of means for selectively establishing communication between any one or more of said resonators and said passage at will.

3. In an acoustic stethoscope, a pick-up device having a relatively high impedance equal substantially to that of a given area of a subject to be examined, an acoustic coupling line connected at one end to said pick-up device and adapted to be connected at its other end to a detector having a relatively low impedance, said line including a tubular member and having a tapered passage between its ends which expands gradually from said pick-up device to its detector end, the ends of said passage having impedances which match said high and low impedances, respectively, whereby said coupling line is adapted to transmit acoustical energy from said subject to said detector without substantial attenuation, said tubular member having a plurality of openings in the wall thereof which are spaced from each other and each of which affords communication between said passage and the exterior, and means associated with said line for rejecting acoustical energy of certain frequencies within the range transmitted by said line whereby to prevent energy of said certain frequencies from reaching said detector, said rejecting means comprising a second tubular member rotatably mounted on said first-named tubular member about said openings, said second-named tubular member having a plurality of discrete chambers therein each associated with a separate one of said openings and forming therewith a resonator of the Helmholtz type, said resonators each being effective over a different frequency range, and said second tubular member being rotatable on said first-named tubular member to any one of a plurality of predetermined positions wherein communication between any one or more of said resonators and said passage may be established at will.

HARRY F. OLSON.