Feb. 7, 1928. 1,658,327

H. F. DODGE

STETHOSCOPIC APPARATUS

Filed May 29, 1924

Fig. 1

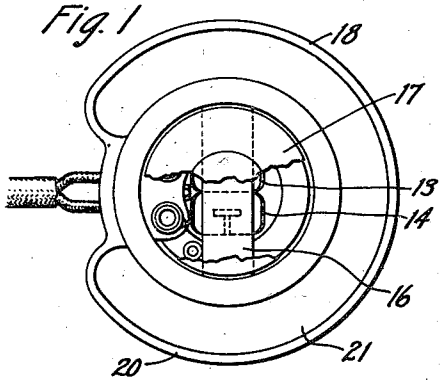


Fig. 2

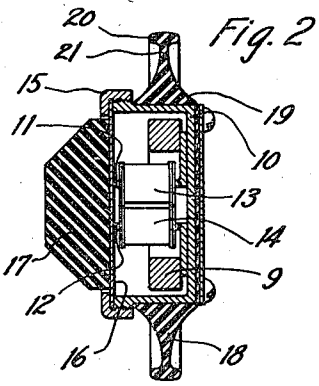


Fig. 3

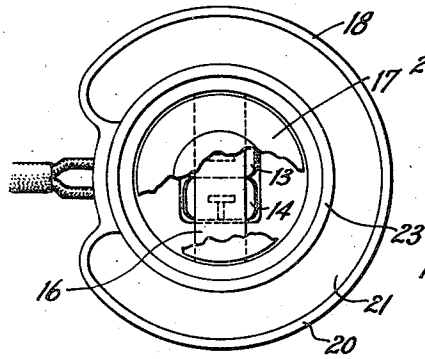


Fig. 4

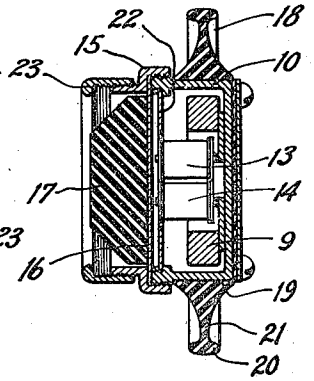


Fig. 5

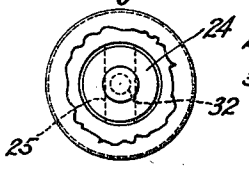


Fig. 6

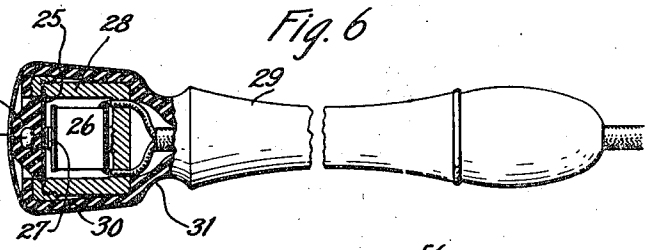
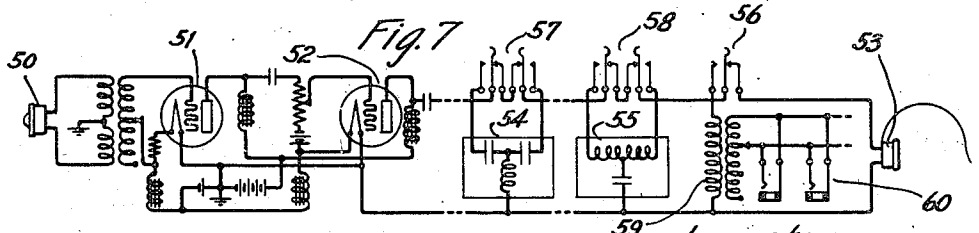


Fig. 7



Inventor:
Harold F. Dodge,
by E. W. Adams Atty

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UNITED STATES PATENT OFFICE.

HAROLD F. DODGE, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

STETHOSCOPIC APPARATUS.

Application filed May 29, 1924. Serial No. 716,640.

This invention relates to stethoscopes and has for its object to provide a stethoscope or pick-up device of high quality which is particularly sensitive to vibrations produced within the body while substantially unresponsive to extraneous sounds.

Heretofore, the vibratory system of stethoscopes was commonly coupled to the body acoustically by means of an air chamber between the flesh and the vibratory member. The usual air chamber, formed by the instrument itself holding the vibrating member out of contact with the body provides very inefficient coupling between the flesh and the vibrating member, but a fairly efficient coupling with the surrounding air, with the result that extraneous noises are readily picked up in spite of the fact that sometimes the air chamber is surrounded by heavy walls. There is also a multiple reflection of the sound waves in such air chambers which interferes with the sounds of interest. With this form of coupling the ratio of useful sound energy to noise energy is low, hence it is difficult for a physician to detect or focus his attention on the faint chest sounds. It has been found by providing a suitable coupler or mechanical transformer between the flesh and the vibratory member of the stethoscopic device that the energy transferred to the latter may be increased 20 to 100 times depending upon the nature of the area of auscultation. With a suitable form of flexible vibratory member the device may at the same time be made very inefficient for picking up extraneous sound.

Preferably the coupler or mechanical transformer, should have a characteristic mechanical impedance to sound vibrations between the characteristic impedance of flesh and the impedance of the vibratory member.

A feature of the invention provides an electrical stethoscopic apparatus having a vibratory system of such material and proportions that the impedance looking into said system is substantially the same as the impedance looking into the flesh with which it makes contact, i. e., the impedances in both directions from the point of contact are matched and substantially equal, thereby providing close mechanical coupling with the flesh but loose coupling with the air.

In its preferred form, the invention provides an electromagnetic stethoscopic pick-up device having a narrow vibratory member or armature which carries a mass of soft elastic material such as gum rubber, providing a tapered mechanical impedance from the flesh to the armature. The case of the instrument may also be provided with a holder or handle of very elastic material to absorb extraneous vibrations caused by relative motions of the ausculator's hand and body of the patient.

Referring to the drawings, Fig. 1 is a plan view of the stethoscopic device embodying the invention;

Fig. 2 is a cross-sectional view of the device shown in Fig. 1;

Fig. 3 is a plan view of another embodiment of the invention;

Fig. 4 is a cross-sectional view of the device shown in Fig. 3;

Figs. 5 and 6 show a miniature stethoscopic device embodying the invention; and

Fig. 7 shows a system in which the device may be used.

In a case 10 is provided a permanent magnet 9 on which are mounted pole pieces 11 and 12 carrying coils 13 and 14 respectively, The magnetic structure is preferably the same as that described in Patent No. 1,273,351 of July 23, 1918 to H. A. Frederick. Screwed to the case 10 is a ring 15 to which is attached by welding, or other suitable means, an armature or reed 16 in operative relation to the pole pieces 11 and 12. The armature 16 is shown as a narrow reed secured at both ends. Although a diaphragm of the usual type may be used, the narrow armature is preferable as it does not pick up sound vibrations from the air so readily. Attached to the armature 16 by cement or other suitable means is a coupler or mechanical transformer 17, consisting of a mass of soft elastic material such as gum rubber for making direct contact with the body. As shown, the coupler 17 is in the form of a truncated cone about $\frac{5}{8}$ inches high with bases about $\frac{3}{4}$ inches and $1\frac{1}{2}$ inches in diameter. The larger base is attached to the armature 16 and is smaller in diameter than the opening in the ring 15 leaving a small annular opening therebetween. Preferably, the coupler 17 is in contact with the entire outer surface of the armature 16, thereby contributing high damp-

ing to the small vibrations of the latter. The natural period of the member 17 and the armature 16 thus coupled together is quite low being less than 300 cycles per second and when placed against the flesh the whole vibratory system is substantially aperiodic. A vibratory system of this type will therefore readily detect both the high pitched systolic and diastolic sounds made up of frequencies between 120 and 700 cycles per second, very high pitched components of certain murmurs and of ratio sounds up to 1500 cycles per seecond and the normal heart sounds, fetal heart sounds, or presystolic murmer sounds which are composed primarily of energy of relatively low frequencies.

In order to prevent the transmission of hand tremors of the auscultator and to preclude friction noises which would otherwise be caused by the rubbing of the fingers on the case 10, the device may be provided with a flexible handle or holder 18. This holder may be made of any suitable yielding material and a variety of shapes may be used depending upon the flexibility of the material employed. As shown it is composed of soft rubber in the form of an annulus which may be slipped over the case of the instrument. The inner edge 19 and the outer edge 20 which are comparatively thick are connected by a thin web 21. At the point where the usual telephone conductors enter the case, the annulus is cut away to prevent rubbing contact with the conductors which would introduce objectionable friction noises.

The device shown in Figs. 3 and 4 is substantially the same as that shown in Figs. 1 and 2 except a plate 22 is disposed at the back of the reed 16 to close the case and the ring 15 is provided with an adjustable cylindrical flange 23 which permits compression of the flesh without freezing the armature when it is necessary to apply pressure to the detector to get closer to the source of sound, as in fetal heart auscultation. It is also useful in strapping the detector on the patient when making phonograph records or cardiograms.

Figs. 5 and 6 show another form of the detector which, on account of its small size, is especially suitable for the internal explorations, such as the early detention of fetal heart sounds. The coupling means 24 and the armature 25 may be the same as the members 17 and 16 respectively, for the device hereinbefore described, except for size. The relative sizes are substantially as shown in the drawing. The magnetic system is the well-known electromagnetic type. The coil 26 is mounted on a pole 27 secured to a case 28 which forms part of the magnetic circuit. The detector is held in a soft rubber cup 30 the wall of which is sufficiently thin near the bottom to preclude the transmission of longitudinal vibrations from the handle 29 of hard rubber or other suitable material, attached thereto. A longitudinal opening for the leads or conductors from the detector is provided in the handle 29. A casing 31 of dental dam rubber is provided for the completed device. For special observations, it is sometimes of advantage to provide a vibratory member which is most efficient at the frequency of the vibrations to be observed. This may be readily accomplished by loading the rubber coupler 24 with lead pellets 32, or other suitable material, as shown in Fig. 6. Obviously the same method of loading the vibratory system may also be used in the detectors shown in Figs. 1 and 2 and 3 and 4. Although the detector 26 is shown as having its axis coincident with that of the handle 29 in most cases it will be set at a slight angle to permit the survey of a large area by turning the handle 29.

In the system shown in Fig. 7 the sound vibrations are picked up by the detector 50 of any of the forms herein described and translated into electrical vibrations. The electrical vibrations are then amplified by means of amplifying vacuum tubes 51 and 52 connected in any well known manner. Any number of vacuum tubes may be used depending upon the amount of amplification desired. Between the output of the last stage of amplification and the translating device 53 there may be connected by means of suitable switches 57 and 58 a series of low and high pass filters 54 and 55. While only two filters are shown there should be a sufficient number having different characteristics to give a suitable variety of frequency bands for permitting observation of the different classes of sounds of interest in auscultation and suppressing all extraneous sounds outside of these bands. Any suitable form of wave filters may be used, such as those described in Patent No. 1,227,113 of May 22, 1917, to G. A. Campbell.

As shown the translating device 53 is the usual head telephone receiver connected directly through the switches 57, 58 and 56 to the output of the amplifier 52 for general observation of all body sounds.

By manipulating the filter switches any desired combination of filters may be obtained. It is therefore possible to subdue to any desired degree extraneous noises and such of the body vibrations as are not of immediate interest.

It is obvious that any suitable translating device such as a recording device or a loud speaker may be employed.

It is also often desirable to permit a large number of persons to listen to the vibrations at the same time, especially for teaching and consulation. A loud speaking re-

ceiver may be used for that purpose or each observer may be provided with an individual receiver. When a plurality of instruments are used it is preferable to connect them through a transformer 59 which may be connected in circuit by means of a switch 56. Preferably the secondary of the transformer is tapped so as to compensate for variation in the number of instruments connected to the jacks 60. The examining physician may transmit remarks to other observers by talking directly against the flesh of the patient while the detector is resting against it. It is preferable to disconnect the filters while transmitting speech sounds.

This apparatus may also be connected to an ordinary telephone or other communication system permitting diagnosis by an absent physician or consultation by a number of absent physicians thus expediting matters in serious or unusual cases.

By connecting a plurality of recording devices and associated filters in multiple, it is possible to record simultaneously any number of frequency components of the vibrations originating in the body.

Although the invention is illustrated with soft rubber any other material having the proper characteristics may also be used and microphones and other types of detectors may be used in place of the magnetic type. The magnetic detector is, however, preferable on account of its inherently higher quality, and the absence of annoying carbon noises which tend to mask the faint sounds of pathological interest.

The arrangement of the parts comprising the detector may also be reversed by making the body-contact vibratory system consist of the magnetic system supported in the case by means of a suitable spring, with the pole pieces of said magnetic system in operative relation with a non-flexible member attached to the case.

What is claimed is:

1. In a stethoscopic device a casing, a flexible member supported therein, and a relatively heavy mass of material having the mechanical properties of soft rubber secured to said flexible member and adapted to make contact with the body for detecting sound vibrations originating therein.

2. In a stethoscopic device, a casing, a narrow vibratory reed supported at both ends in said casing, and a mass of soft rubber secured to said reed and adapted to make contact with the body, whereby sounds originating therein may be detected.

3. In a stethoscopic device, means for converting sound vibrations into electrical vibrations including a flexible member and yielding means having a characteristic impedance to sound vibrations slightly greater than that of the flesh.

4. In a stethoscopic device, a vibratory member, and a mass of yielding sound conducting material having a mechanical impedance slightly less than that of the vibratory member.

5. In a stethoscopic device a flexible member, a mass of soft elastic material for making contact with the body supported on said flexible member and substantially covering its free area.

6. In a stethoscopic device a casing having a circular opening therein, a narrow vibratory member supported across said opening, a mass of soft elastic material supported on one side of said vibratory member out of contact with said case, and adapted to make contact with the body.

7. In a stethoscopic device a casing having an opening therein, an electromagnet in said casing, a vibratory armature in operative relation to said electromagnet, a truncated conical mass of soft rubber supported on said armature and substantially closing the opening in said casing, said mass of soft rubber being adapted to make contact with the body.

8. The combination of an electrical stethoscopic device with a soft rubber support surrounding said device thereby substantially insulating it from vibrations due to relative motions between the patient and the auscultator's hand.

9. In an electrical stethoscopic device the combination of an electromagnetic detector for converting mechanical vibrations into electrical vibrations, the vibratory system of said detector having an impedance to sound vibrations substantially the same as that of flesh, an amplifier for amplifying said electrical vibrations, and adjustable electrical filters for passing only the vibrations to be observed, and means for converting the passed vibrations into observable effects.

10. In a stethoscopic device, a vibratory system having a low natural period, said system comprising a vibratory member, a mass of soft elastic material secured thereto, and a material of greater density embedded in said elastic material.

11. In a stethoscopic device a vibratory system comprising a vibratory member, a mass of soft elastic material secured to the face thereof, a casing for said vibratory system, a cylindrical extension therefrom adapted to compress the flesh while said elastic material is in contact therewith.

12. An electrical stethoscopic device comprising a vibratory element and a contacting element of soft elastic material adapted to make contact with the body said elements having sufficiently large values of mass and stiffness to give them a natural period below 300 cycles per second frequency.

13. An electrical stethoscopic device having a vibratory system for making direct

contact with the body said system comprising a flexible member and a mass mounted thereon, the impedance looking into said system being substantially the same as the impedance looking into the flesh with which it makes contact.

14. In a stethoscopic device, a vibratory member adapted to be vibrated in response to sound vibrations within a patient's body, and means comprising a soft elastic medium for directly transferring vibrations from the body to said member, said medium being substantially unaffected by incident air vibrations.

15. In a stethoscopic device a flexible member, a mass of elastic material for making contact with the human body secured to said flexible member and covering at least one-half of the surface thereof.

In witness whereof, I hereunto subscribe my name this 28th day of May A. D. 1924.

HAROLD F. DODGE.