Oct. 30, 1951 J. L. HATHAWAY ET AL 2,573,438

ELECTROACOUSTIC TRANSDUCER SET

Filed Sept. 18, 1946 2 SHEETS—SHEET 1

Fig. 1.

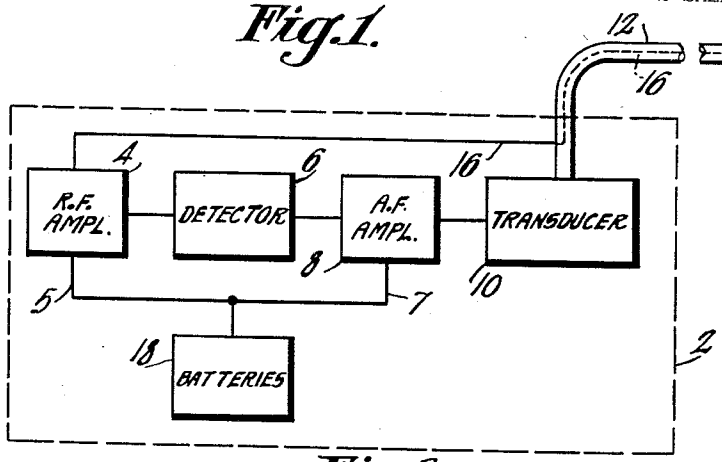


Fig. 2.

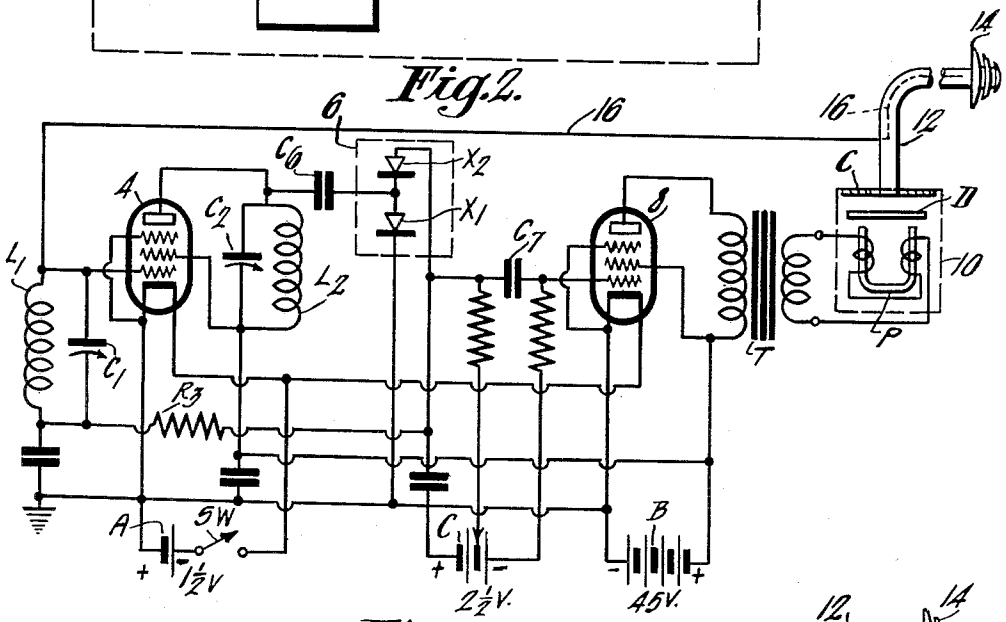
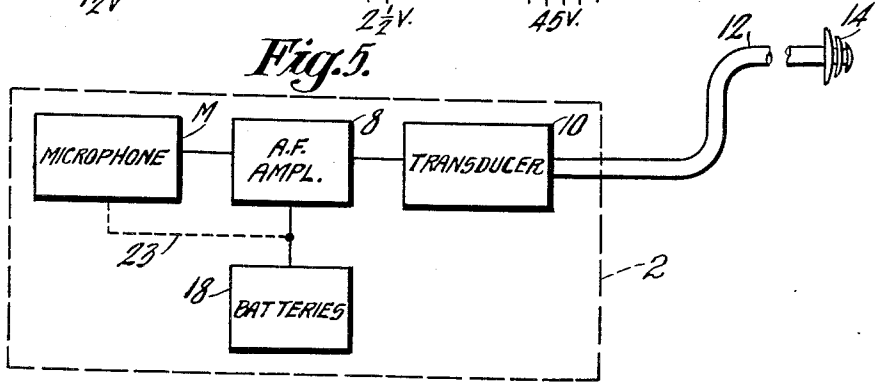


Fig. 5.



INVENTORS
JARRETT L. HATHAWAY
& WILLIAM HOTINE
H. S. Grover
ATTORNEY

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Fig. 3a.

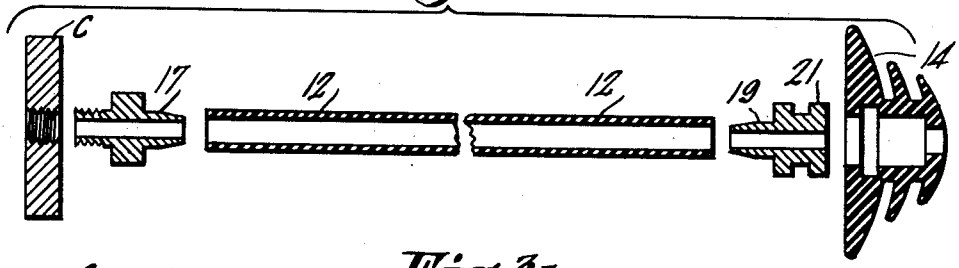


Fig. 3b.

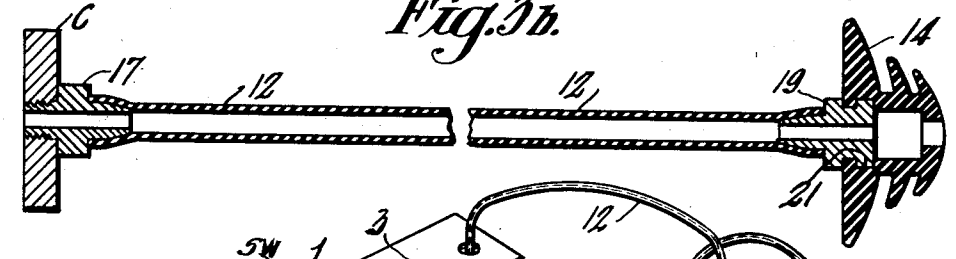


Fig. 4.

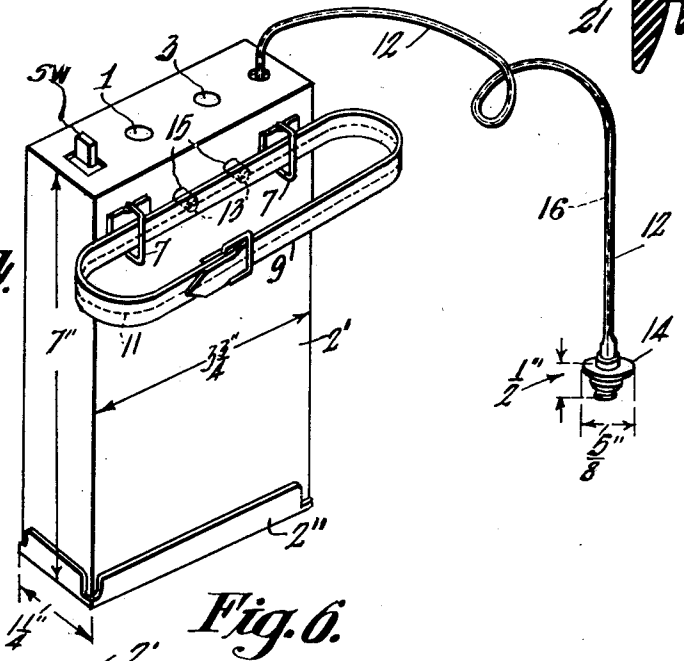
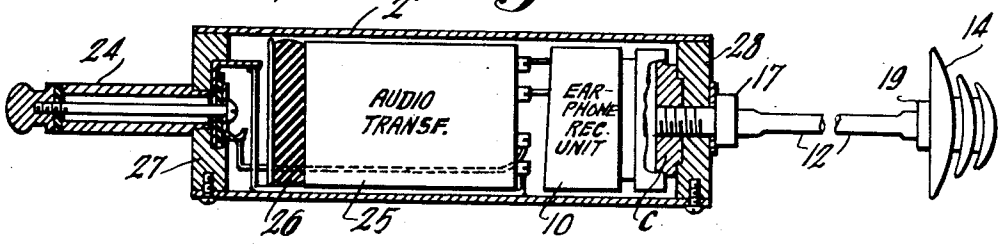


Fig. 6.



INVENTORS
JARRETT L. HATHAWAY
& WILLIAM HOTINE
BY H. S. Grover
ATTORNEY

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ELECTROACOUSTIC TRANSDUCER SET

Jarrett L. Hathaway, Manhasset, and William Hotine, Bayville, N. Y., assignors to Radio Corporation of America, a corporation of Delaware

Application September 18, 1946, Serial No. 697,666

6 Claims. (Cl. 250—14)

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This invention relates to extremely small, compact and lightweight electro-acoustic transducer sets capable of being worn on the person.

A specific application of this invention is in the field of vest pocket type radio receivers, although features of the invention are applicable to apparatus for aiding persons who have difficulty in hearing. When the invention is used in connection with a radio receiver, the receiving unit may either be carried in a pocket of the wearer or strapped about the waist or suspended from the shoulder of the wearer.

Hitherto, the small portable radio receiving sets designed for carriage on the person have suffered from one or more of the following disadvantages: Bulkiness, excessive weight, lack of stability, and insufficient battery life for the required sensitivity.

The present invention overcomes these difficulties and provides an extremely small and lightweight radio receiver set capable of being worn on the person and one which possesses sufficient sensitivity for satisfactory reception for many hours of continuous operation.

An important feature of the invention is the extremely lightweight and very thin flexible tubing and associated ear attachment for transferring sound from the transducer located in the housing carried on the person to the ear of the wearer. Where this feature is employed in a radio receiver, the flexible tubing may serve the additional purpose of an enclosure for a thin antenna wire.

Another feature of the invention is the use of a metallic housing or casing for the radio receiving apparatus in conjunction with a carrying belt of such character as to increase the overall effective length of the antenna.

One embodiment of the invention is a radio receiver of the vest pocket type, which is contained in a housing, and comprises a battery type built-in power supply, a signal rectifying and amplifying system, and an electro-acoustic transducer. Extending from this housing and coupled to the transducer is a thin-walled flexible tube conducting sound waves from the transducer to a small ear plug which may be fitted into the ear. A radio antenna wire is inserted within the thin-walled flexible sound conveying tube. By way of example only, we have found that a small

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diameter Vinylite hollow tube can be used with very satisfactory results.

This entire unit is extremely small, compact and of lightweight and can easily fit into a pocket of the wearer. If desired, the housing may be provided with loops for enabling a carrying strap to be inserted through the loops, thus permitting the set to be carried by the wearer. If a strap is employed, it is preferred that this strap include a wire or some conducting material extending for the length of the strap and which, by coupling to the housing of the radio receiver, will effectively increase the overall length of the antenna.

Another embodiment of the radio receiver is a hearing aid having a compact, small and lightweight housing containing therein a suitable microphone, an audio amplifier and a transducer. Here again, as in a radio receiver embodiment, there is employed a thin-walled flexible tube for conducting sound waves from the transducer to a small ear plug which may be fitted into the ear.

A more detailed description of the invention follows in conjunction with a drawing, wherein:

Fig. 1 diagrammatically shows, in box form, a radio receiver of the present invention;

Fig. 2 is a detailed circuit diagram of the receiver of Fig. 1;

Fig. 3*a* and 3*b* respectively show exploded and assembled views of the flexible sound conveying tube in association with an ear plug at one end and the telephone electro-acoustic receiver at the other end;

Fig. 4 is a perspective view of the complete vest pocket type of radio receiver of the invention;

Fig. 5 diagrammatically shows, in box form, the invention as applied to a hearing aid type of apparatus;

Fig. 6 shows the flexible sound conveying tube feature of the invention in association with a standard telephone plug at one end and a small ear plug at the other end.

Throughout the figures of the drawing the same parts are represented by the same reference numerals.

Referring to Fig. 1 of the drawing in more detail, the radio receiver of the invention comprises a casing represented here by a dashed rectangle 2 containing therein a radio frequency vacuum tube amplifier 4, a detector 6 coupled to the output of the radio receiver amplifier, an audio fre-

quency vacuum tube amplifier 8 following the detector 6, and an electro-acoustic transducer 10 coupled to the output of the audio amplifier 8. A, B and C batteries, represented diagrammatically by the box 18, supply polarized potentials via leads 5 and 7 to the amplifiers 4 and 8, respectively. Casing 2 is preferably made of metal although, if desired, a suitable molded plastic material can be used. An input antenna 16 in the form of a wire is connected at one end to the input of the radio frequency amplifier 4, and extends for the major portion of its length through the interior of a flexible plastic thin-walled small diameter tube 12. The tube 12 has the appearance of a thin piece of spaghetti and is coupled at one end to the transducer 10 and coupled at its other end to an ear plug 14. The manner in which the tube 12 may be joined to the transducer 10 and the ear plug 14 will be described in more detail later in connection with the description of Figs. 3*a* and 3*b*.

By reference to the schematic circuit diagram of Fig. 2, it will be seen that the radio frequency amplifier comprises a pentode vacuum tube 4 having a parallel tuned input circuit L1, C1, and a parallel tuned output circuit L2, C2. A condenser C6 couples the output of the radio frequency amplifier 4 to a detector circuit 6 comprising a pair of dry rectifiers X1 and X2 arranged as a voltage doubler. These rectifiers may be crystal detectors, or germanium rectifier units, silicon rectifiers, or any suitable type. Although they have been shown as dry rectifiers, it will be obvious that, if desired, they may be replaced by a vacuum tube type of rectifier, in a manner well known to those skilled in the art. The output of the rectifier 6 is utilized to supply the AGC voltage to the grid of tube 4 by way of a resistor R3. Rectifier 6 also furnishes an audio voltage via condenser C7 to the audio amplifier 8, which is approximately double that of a single rectifier. The output of the audio amplifier 8 is coupled to a suitable audio transformer T whose secondary winding is coupled to an electro-acoustic transducer 10.

Transducer unit 10 is shown as a telephone receiver having a pair of coils wound around the poles of a permanent magnet P and connected in series to the secondary winding of the audio transformer. The diaphragm is located immediately above the coils of the telephone receiver and responds to variations in current through the coils of the transducer. A cap C having a suitable aperture centrally located therein closes the transducer unit. This central aperture in the cap C communicates with the interior of the thin spaghetti-like plastic tube 12. The opening at the other end of the tube 12 communicates with the interior of the ear plug 14, thus conveying sound waves from the transducer unit 10 through the interior of the plastic tube 12, to the ear of the wearer in which the ear plug 14 is inserted.

The antenna of the radio frequency receiver is a thin wire 16 which extends for the major portion of its length within the plastic tube 12. Although in Figs. 1 and 2 the wire 16 appears as though the major portion of its length were outside the plastic tube 12, it should be understood that these showings are merely diagrammatic and that a more accurate showing appears in Fig. 4, which shows the perspective view of a radio receiver actually constructed in accordance with the invention, and tested with highly satisfactory results.

In one embodiment of the invention, successfully tried out and practiced, the radio frequency amplifier 4, was an RCA 1L4 miniature tube, amplifier 8 was an RCA 3Q4 miniature tube, while rectifiers X1 and X2 were germanium rectifier units. The A battery for the filaments of the two tubes was 1½ volts and connected to an on-off switch SW. The C battery was 2½ volts, while the B battery was 45 volts. The A battery was a small cylindrical flash-light type, while the B and C battery was a dry battery type of rectangular configuration. The plastic spaghetti type of tube was a vinyl plastic tubing about three feet long and having an inside diameter of .060 inch. The thickness of the vinyl tubing was .02 inch. The dimensions of the receiver casing and the locations of the elements viewable from the outside of the housing are generally shown in Fig. 4. For tuning the input and output circuits of the radio frequency amplifier, there are provided holes 1 and 3 on the top of the housing for enabling a screw driver to be inserted for changing the values of the variable condensers C1 and C2. The antenna wire 16 had a diameter of .003 inch and was especially small to prevent any undue antenuation of the sound waves passing through the tube 12 from the transducer to the ear plug. It will thus be seen that although the tube 12 had an inside diameter of approximately 1/16 of an inch, the diameter of the antenna wire was considerably smaller in size so that it occupied relatively little space within the tubing.

The casing 2 was made of metal and had a rectangular shape adapted to fit into the pocket of a wearer. The on-and-off SW switch was located at the top, as well as the plastic tube 12, and the control holes 1 and 3. The casing 2′ had a cover 2″ at the bottom which could be removed quickly and easily for the replacement of batteries. The batteries were slid into the bottom of the casing 2′ and required no wire connections, inasmuch as reliance was had on contact springs within the case which engaged the battery terminals.

The metallic casing 2′ was also provided with metallic belt loops 7 through which a belt 9 could be inserted for supporting the receiver, either from the shoulder or from the waist of the wearer. The belt 9 is shown as having embodied therein a wire 11 for association with metallic snap fastener elements 13 and 15. Elements 15 are mounted on the metallic casing 2′. The metallic wire 11 in the belt 9 serves to increase the overall effective length of the antenna. If desired, the snap fastening elements 13 and 15 may be eliminated entirely, and the same result obtained by virtue of capacity coupling between wire 11 and the metallic casing 2′ when the belt is inserted through the loops 7, 7 and worn on the wearer. The ear plug 14 was made of soft rubber and had an overall length of slightly less than ½ inch and a maximum width of about 5/8 of an inch. These extremely small dimensions enable the ear plug to be almost completely hidden from view when inserted into the ear.

The weight of the entire receiving unit of Fig. 4, without the carrying strap 9, was 24 oz. The weight of the carrying strap was 1½ oz. The weight of the soft rubber ear plug 14 was about .012 oz.

An embodiment of Fig. 4 was actually tried out in practice in a television studio for receiving instructions from a small radio transmitter operating at a frequency of 27.32 megacycles. The maximum output from the audio transformer T was of the order of 50 milliwatts. It will be understood, of course, that the invention is not

limited to this particular frequency, or to this order of output since other frequencies may be used and other outputs obtained, depending upon the types of tubes and circuits employed.

The manner in which the spaghetti-like plastic sound conveying tubing 12 is connected to its terminal fittings is shown in detail in Figs. 3a and 3b. One end of the tube 12, for example the left hand end, is pushed (by stretching it) over the tapered end, is pushed (by stretching it) over the tapered end of a sleeve 17 whose other end is threaded into the interior of the cap C of the telephone receiver 10. Once the end of tube 12 is pushed on the tapered end of the sleeve 17, it will remain firmly joined to this end by friction. The other end of tube 12, the right hand end, is similarly pushed (by stretching it) over the tapered end of sleeve 19 and remains fixed and is held on the sleeve by friction. If desired, a suitable cement may be used to insure a tight and permanent fit between the ends of the plastic tubing and the sleeves 17 and 19. The other end of sleeve 19 is provided with a flange 21 which is pushed into the bore of the rubber ear plug 14 and is retained therein. It will thus be seen that the ear plug is readily replaceable quickly and easily, which is an important feature for sanitary reasons especially when the unit is to be used by different persons. While Fig. 3a shows an exploded view of the cap C, sleeve 17, tube 12, sleeve 19, and ear plug 14, Fig. 3b shows how these fit together. In the embodiment actually constructed and satisfactorily tried out in practice, the sleeves 17 and 19 were made of brass, although it should be understood that, if desired, a suitable molded plastic material may also be used.

Fig. 5 shows diagrammatically how the invention may be used in connection with a hearing aid type of apparatus to be carried on the person. In Fig. 5 the hearing aid is shown as a suitable housing represented by the rectangle 2 containing a microphone M, an audio amplifier 8, an electro-acoustic transducer 10 and suitable batteries 18. If the microphone M is of the carbon type it will require a connection to the batteries 18 in which case there will be provided a connection shown by the dashed line 23 suitably coupled to the elements in a manner well known to those skilled in the art. The output of the electro-acoustic transducer 10 which will be a telephone receiver, is conveyed by a thin walled flexible plastic tube 12 to the ear plug 14.

Fig. 6 is a mechanical assemblage which shows how the plastic tubing 12 and its terminal fittings can be carried as a complete plug-in type unit. One end of the plastic tube 12 is connected to the soft rubber ear plug 14, while the other end of the plastic tubing is connected via sleeve 17 and suitable apparatus within a housing 2' to a telephone plug 24. This plug 24 is adapted to be inserted into the audio output jack of any suitable audio circuit. This audio circuit, may, for example, be the audio output circuit of a radio receiver, or a telephone line, or a stationary or portable hearing aid. The housing 2' contains in its interior a suitable audio transformer 25, whose terminals are connected to the tip and sleeve of plug 24 and to the electro-acoustic transducer unit 10. The audio transformer 25 is a stepdown transformer and provides a suitable change in impedance between the telephone plug end of the circuit and the earphone transducer unit 10. The sponge rubber insert 26 serves the dual purpose of insulating the metallic casing of the audio transformer from the telephone plug terminals and mechanically stabilizing the audio

transformer. The telephone receiver 10 is provided with the usual cap C having a centrally threaded aperture which communicates with the interior of the sleeve 17 associated with one end of the plastic tube 12. Suitable end plugs 27 and 28 serve to hold the elements within the housing 2'.

What is claimed is:

1. In a radio receiver, an electro-acoustic transducer for producing sound waves, and means for conveying said sound waves to the ear of a person, said means including a flexible hollow tube having one hollow end communicating with said transducer, and a small hollow ear plug communicating with the other end of said flexible hollow tube, and an antenna wire within said flexible hollow tube and coupled to said receiver.

2. A receiver having a length of spaghetti-like flexible tubing having one hollow end in sound transfer relation to an earphone, an ear plug in sound transfer relation to the other end of said flexible tubing, and a thin antenna wire located in the interior of said tubing and coupled to said receiver.

3. In combination, a radio receiver comprising an electro-acoustic transducer, a lightweight flexible hollow tube having one hollow end in sound transfer relation with said transducer, an ear plug in sound transfer relation with the other hollow end of said flexible hollow tube, an antenna wire located within said flexible hollow tube and coupled to the input of said radio receiver.

4. Means for conveying sound waves from an earphone having a closure provided with a threaded aperture, comprising a relatively long hollow flexible lightweight spaghetti-like thin-walled tubing, a rigid hollow sleeve substantially entirely concealed by said tubing and having a threaded end for association with said threaded aperture and a tapered end for accommodating one end of said tubing, another rigid hollow sleeve substantially entirely concealed by said tubing and having a tapered end for accommodating the other end of said tubing, a soft lightweight rubber-like ear plug sufficiently small to be concealed within the ear of a person and having a bore therein and a wider diameter hole along one portion of said bore, said last rigid sleeve also having a flange for accommodation in said wider diameter hole of said ear plug for holding said ear plug in position on said last sleeve.

5. For use with the audio output of a communication system, a telephone plug having tip and sleeve terminals, an audio transformer coupled to said terminals, an earphone type of electro-acoustic transducer coupled to the output of said transformer, a thin-walled lightweight hollow flexible spaghetti-like tubing, inconspicuously small rigid hollow sleeve substantially concealed by the ends of said tubing, a lightweight ear plug sufficiently small to be concealed within the ear of a person and having a bore therein for association with one of said sleeves, and means for linking the other sleeve to said transducer in sound transfer relation.

6. Means for conveying sound waves from an earphone having a closure provided with a threaded aperture, comprising a relatively long hollow flexible lightweight spaghetti-like thin-walled tubing, a rigid hollow sleeve having a threaded end for association with said threaded aperture and a tapered end for accommodating one end of said tubing, another rigid hollow sleeve

having a tapered end for accommodating the other end of said tubing, a soft lightweight rubber-like ear plug sufficiently small to be concealed within the ear of a person and having a bore therein and a wider diameter hole along one portion of said bore, said last rigid sleeve also having a flange for accommodation in said wider diameter hole of said ear plug for holding said ear plug in position on said last sleeve.

JARRETT L. HATHAWAY.
WILLIAM HOTINE.

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