Aug. 7, 1951 R. T. BOZAK 2,563,452

LOUDSPEAKER UNIT

Filed Sept. 9, 1949 2 Sheets-Sheet 1

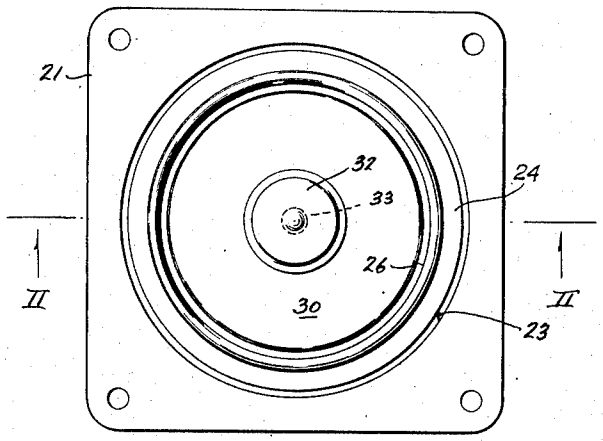


Fig. 1.

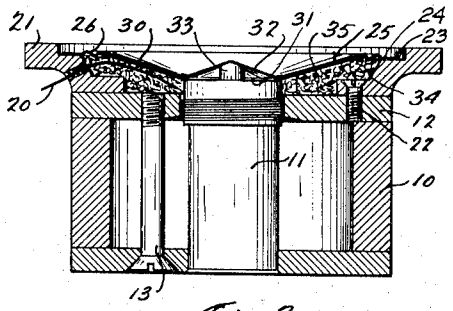


Fig. 2.

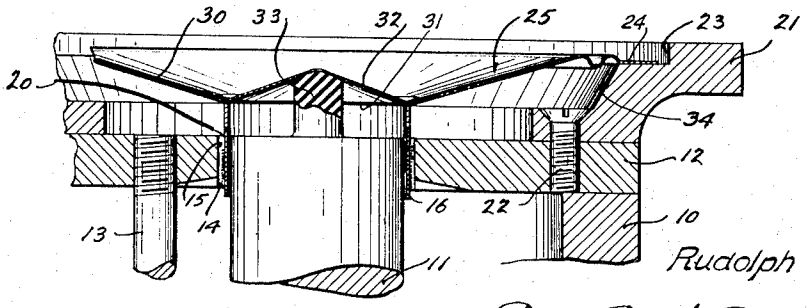


Fig. 3.

INVENTOR.
Rudolph T. Bozak
BY Bean, Brooks, Buckley & Bean.
ATTORNEYS.

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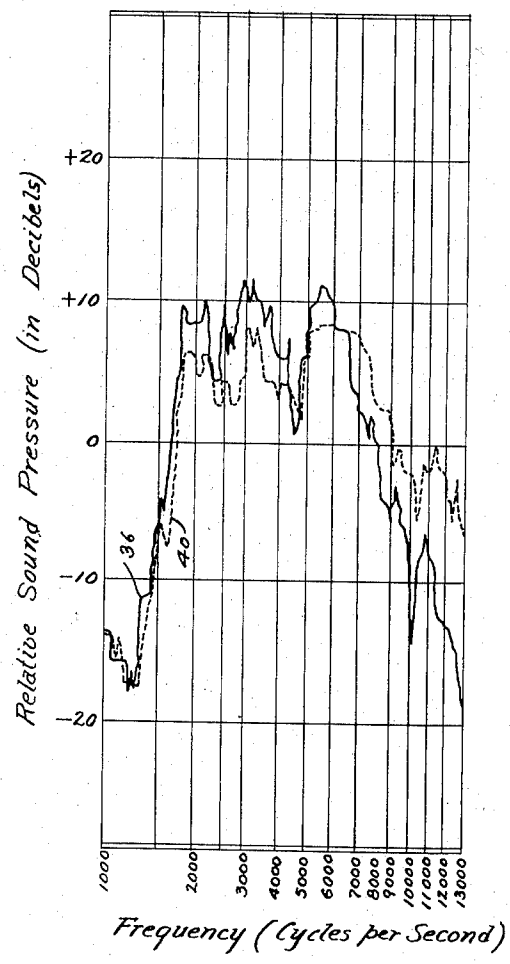


Fig. 4.

INVENTOR.
Rudolph T. Bozak

BY Bean, Brooks, Buckley & Bean.
ATTORNEYS.

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UNITED STATES PATENT OFFICE

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LOUD-SPEAKER UNIT

Rudolph T. Bozak, Buffalo, N. Y.

Application September 9, 1949, Serial No. 114,815

7 Claims. (Cl. 179—115.5)

1

My invention relates in general to loudspeaker units for use in connection with sound reproducing devices, such as public address systems, radio receivers, and record players, and specifically to a unit of the direct radiator type having a movable coil.

The principal object of my invention is to provide a loudspeaker unit for reproducing sound in the form of voice and/or music with all the overtones in a manner having high fidelity and realism.

Another object is to provide a loudspeaker unit by which the frequency response or pressure in the high frequency region shall be lifted or increased and the frequency response or sound pressure in the lower frequency region shall be reduced thereby producing a leveling effect.

Moreover, by the use of a paper cone having a duraluminum apex and a resilient supporting abutment, I am able to provide a loudspeaker unit which has a very decided smoothing effect on the reproduced sound, thereby minimizing sharp peaks of frequency response or pressure.

The above objects and advantages have been accomplished by the device shown in the accompanying drawings, of which:

Fig. 1 is a face view of one of my loudspeaker units;

Fig. 2 is a sectional elevation of my loudspeaker unit taken on line II—II of Fig. 1;

Fig. 3 is an enlarged fragmentary sectional view of the loudspeaker and is taken on line II—II of Fig. 1; and,

Fig. 4 is a graph showing the improved performance of my speaker over that of the ordinary speaker of the present day art.

My unit comprises the usual shell 10 which is magnetized and a centrally arranged core 11. An iron disc 12 is secured by means of screws 13 to the top surface of the shell 10. The usual space 14 is provided between the disc 12 and the core 11 which projects up through an aperture 15 formed in the disc, and in this space is mounted the voice cylinder and coil 16. Only one of the leads 20 from the coil is shown, but it is obvious that two such leads are employed and are connected in the usual radio circuit in a manner well known to those skilled in the art.

Mounted upon the top of the iron disc 12 is a flange member 21 which is secured to the disc by means of screws 22. The upper surface of this flange member is provided with a recess 23 in which is mounted the flange 24 of the cone-shaped diaphragm 25. This diaphragm is provided with the usual corrugated ring 26 and its wall 30 con-

2

verges inwardly toward the disc 12. The diaphragm 25 does not extend to the center of the loudspeaker, as is customary, but is formed with a central opening 31 which is closed by means of a diaphragm apex member 32. This apex member is made of very light-weight, thin material, such as duraluminum, and is cone-shaped in form, the walls thereof converging outwardly in a direction opposite to the cone-shaped wall 30 of the diaphragm 25. The voice coil and cylinder are secured either to the rim of the wall 30 bounding the opening 31 of the diaphragm, or to the apex member 32 by any suitable and well known means.

In order to improve the performance of the loudspeaker unit, I provide an abutment member 33 made of resilient material such as sponge rubber or the like and which is preferably in the form of a cylinder of pencil-like formation having a diameter equal to substantially one-fourth to one-half of the diameter of the core. This abutment is mounted between the core 11 and the apex member 32, and it is secured to the core at its lower end by means of suitable adhesive. The upper end of the abutment conforms substantially to the shape of the cone-shaped central portion of the apex member 32 to which it is also secured by a suitable adhesive. Under relatively low frequency response, this resilient abutment member will vibrate with the vibration of the diaphragm and serve to more faithfully reproduce sound vibrations because of its damping action. The abutment also serves to reduce the response or pressure at the lower frequencies. However, when the loudspeaker responds to high frequencies, this small pencil-like abutment member will become relatively rigid because of the rapidity of reciprocation or vibration of the voice coil, and has the effect of lifting or increasing the response or pressure at such high frequencies. Because of the small diameter of the abutment in relation to the diameter of the core and the apex member, a substantial portion of said member is left unsupported by the abutment, whereby the apex member will be responsive to vibrations of the higher frequencies. Thus, this abutment has the effect of leveling off and smoothing any sharp peaks of frequency response. Suitable acoustic material 35 is disposed in the space 34 between the diaphragm 25 and the disc 12 in order to damp out the low frequency resonance and to prevent the formation of any sound waves which might produce harmful reactions on the sound output from the diaphragm. For clearness of illustration, this

acoustic material has been omitted from the showing in Fig. 3.

The performance of my loudspeaker unit of high frequency type is clearly shown in Fig. 4 where a graph made upon a curve recorder is illustrated. In this graph the vertical lines represent the frequency of the input in cycles per second, and the horizontal lines represent the relative sound pressure or frequency response of the input. The full line **36** represents the curve plotted by a loud speaker of the present day art and the dotted line **40** represents the curve of my improved loudspeaker of similar capacity. As clearly shown by the dotted lines in this diagram, the amplitude of the peak in the lower frequencies is materially reduced and the sharpness thereof rounded off, as compared with the sharp peaks of the ordinary loudspeaker at substantially the same frequency. This effect continues in my device substantially through a range from 2,000 cycles to approximately 6,000 cycles. However, in the higher frequency from approximately 6,000 cycles up to 13,000 cycles and beyond, the frequency response of my loudspeaker is lifted or increased over that of the conventional loudspeaker. As will thus be clearly seen from the diagram, when my device is in use on sound waves having frequency from the substantially 2,000 to 6,000 cycles, the response peaks are leveled off and a much smoother response is obtained. The reduction of the response in these lower frequencies is attributed to the damping action of the abutment member which is resilient at such frequencies. However, the rise or increase of frequency response above approximately 6,000 cycles reduces the resiliency of the abutment and causes it to become stiff at frequencies from between approximately 6,000 cycles and 13,000 cycles, or above, when it will function as a substantially rigid post. Thus, whereas at low frequencies, the diaphragm edge suspension is the dominating stiffness, at high frequencies the rubber abutment introduces an additional stiffness factor. This may be mathematically shown in the following formula where a system may be considered as a three element band pass filter where f_1 is the low frequency cut-off and f_2 is the upper frequency cut-off. Where m is the mass of the moving system, S_1 the edge stiffness of the diaphragm, and S_2 the stiffness of the abutment at high frequency. The formula is as follows:

$$f_1=\frac{1}{2\pi}\left(\frac{S_1}{m}\right)^{\frac{1}{2}}$$

$$f_2=\frac{1}{2\pi}\left(\frac{S_1+S_2}{m}\right)^{\frac{1}{2}}$$

I claim:

1. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, a diaphragm composed of material responsive to lower frequencies supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm and mounted in the magnetic field, and an apex member of relatively thin light-weight sheet material responsive to high frequencies secured to said diaphragm over and closing the opening therein to form therewith a sound reproducing member having two portions of differential frequency response, and a resilient abutment disposed between and secured to the core and to the apex member having vibration-dampening physical contact with the apex member only at its center for low frequency functioning while being incapable of dampening high frequency vibrations.

2. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, a flaring cone-shaped diaphragm of paper supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm and mounted in the magnetic field, a cone-shaped apex member of relatively thin light-weight sheet material secured at its periphery to the opening-defining margin of the diaphragm to close the opening therein and to form a composite sound-reproducing member of differential frequency response, and a sponge rubber abutment disposed between and secured to the core and to the apex member and supporting the apex member at its center while leaving its outer portion free and unsupported thereby.

3. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, and inwardly flaring cone-shaped diaphragm supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm and mounted in the magnetic field, an apex member of relatively lightweight sheet material secured at its periphery to the opening-defining margin of the diaphragm, and formed with a convex center portion, said apex member serving to close the opening in the diaphragm, and a resilient abutment having its lower end stationarily supported by said core and its upper end disposed within and secured to the convex central portion of said apex member while leaving the outer margin of the apex member free and unsupported except where it is connected to the diaphragm, and the voice coil being connected to the otherwise unsupported and surrounding portion of the apex member.

4. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, and inwardly flaring cone-shaped diaphragm supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm and mounted in the magnetic field, an apex member of relatively lightweight sheet material secured at its periphery to the opening-defining margin of the diaphragm, and formed with a convex center portion, said apex member serving to close the opening in the diaphragm, and a resilient abutment having its lower end stationarily supported by said core and its upper end disposed within and secured to the convex central portion of said apex member while leaving the outer margin of the apex member free and unsupported except where it is connected to the diaphragm, and the voice coil being connected to the otherwise unsupported and surrounding portion of the apex member, said resilient abutment being of a material to become rigid above a predetermined frequency thereby to reduce the immediate area of the apex member subject to vibration for receiving the high frequencies.

5. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, a diaphragm composed of material responsive to the lower frequencies supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm mounted in the magnetic field, and an apex member of relatively thin light-weight sheet material responsive to the

higher frequencies secured to said diaphragm over and closing the opening therein to form therewith a sound reproducing member having two portions of differential frequency response, and a resilient abutment disposed between and secured to the core and the apex member and having vibration-dampening physical contact with the apex member only at its center for low frequency functioning while being incapable of dampening at high frequency, said abutment having a diameter less than one-half the diameter of said apex member.

6. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, a diaphragm composed of material responsive to the lower frequencies supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm mounted in the magnetic field, and an apex member of relatively thin light-weight sheet material responsive to the higher frequencies secured to said diaphragm over and closing the opening therein to form therewith a sound reproducing member having two portions of differential frequency response, and a resilient abutment disposed between and secured to the core and the apex member and having vibration-dampening physical contact with the apex member only at its center for low frequency function while being incapable of dampening at high frequency, said abutment having a diameter equal to substantially one-fourth to one-half of the diameter of said apex member, whereby the surrounding exposed portion of the apex member will be free to vibrate at higher frequencies.

7. A loudspeaker unit, comprising a magnetized shell, a core carried by said shell and forming therewith a magnetic field, a diaphragm composed of material responsive to lower frequencies supported at its outer edge by said shell and having a centrally arranged opening, a voice coil carried by said diaphragm mounted in the magnetic field, and an apex member of relatively thin light-weight sheet material responsive to high frequencies secured to said diaphragm over and closing the opening therein to form therewith a sound reproducing member having two portions of differential frequency response, and a resilient abutment disposed between and secured to the core and the apex member and having vibration-dampening physical contact with the apex member only at its center for low frequency functioning while being incapable of dampening high frequency vibrations, said abutment being so proportioned that it will dampen the vibrations of said cone at frequencies from substantially 2,000 cycles to substantially 6,000 cycles and become relatively rigid at frequencies from 6,000 cycles up to 13,000 cycles, thereby to transmit the higher frequency vibrations of the coil to said apex member.

RUDOLPH T. BOZAK.

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