March 22, 1932. A. A. THOMAS 1,850,855

ELECTROSTATIC LOUD SPEAKER

Filed Feb. 16, 1929

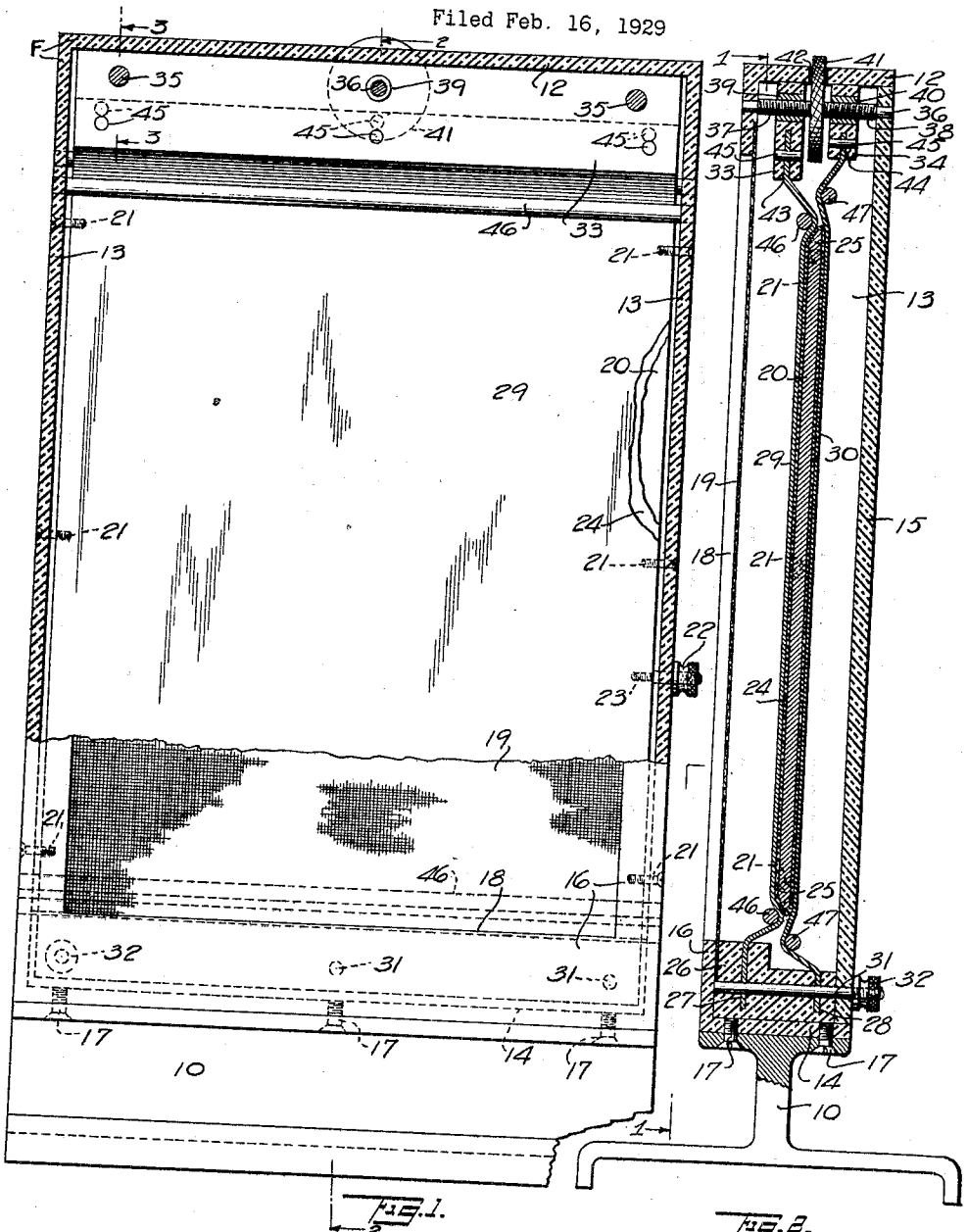


FIG. 1.

FIG. 2.

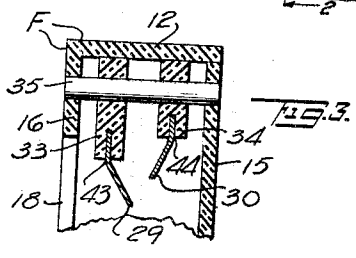


FIG. 3.

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ELECTROSTATIC LOUD SPEAKER

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This invention is for a new loudspeaker of the condenser type characterized by novel features of construction which produce an instrument of high efficiency and improved operation. A preferred form of my invention comprises a pair of vibratory sheets held under tension in close electrostatic relation to a fixed plate on opposite sides thereof. An elastic dielectric made as thin as possible separates the two vibratory sheets from the fixed plate. The tensioned sheets are supported at two ends only, and they constitute a pair of free-edged loudspeaking diaphragms adapted to vibrate with substantially equal amplitude over their entire acoustic area. Another feature of my invention comprises means for readily adjusting the normal tension of the diaphragms to control the quality of reproduction. The condenser parts are housed in a suitable casing open for the passage of sound from both diaphragms.

The back of the casing may be closed by a sounding board which is set in vibration by the rear diaphragm to amplify the tones. In a simplified embodiment of my invention, I may use only one diaphragm.

The various novel features and practical advantages of my invention will be understood from a description of the accompanying drawings, in which—

Fig. 1 shows one form of my new electrostatic loudspeaker, this view being partly broken away and sectioned on line 1—1 of Fig. 2 for clearness;

Fig. 2 is a vertical section on line 2—2 of Fig. 1; and

Fig. 3 represents a fragmentary section on line 3—3 of Fig. 1.

A suitable base 10 supports an upright frame indicated as a whole by F, which in this instance is in the form of a shallow casing comprising a top 12, sides 13, a bottom 14, a back wall 15, and a front 16. Screws 17 or other suitable fastening means secure the frame or casing F rigidly to the supporting base 10. The casing F is preferably of insulating material, such as wood, hard rubber, bakelite, and others of a similar nature, but it may also be made of metal. The top 12, sides 13 and bottom 14 may be cast or molded as a single piece, if desired. The front 16 has an opening 18 large enough for the free passage of sound. A sheet of gauze or screen 19 may cover the opening 18 to protect the parts in the casing, as well as to improve the appearance of the instrument. The back wall 15 is secured to the body of the frame or casing F in any practical way, as by screws, bolts and the like. In some instances, the member 15 may be constructed as a sounding board to amplify the volume of reproduction, as will presently be understood.

A rigid metal plate 20 is fixed in casing F by means of screws 21, or otherwise. It is convenient to insert the screws through the sides 13 of the frame into the edges of plate 20, which constitutes a fixed condenser plate adapted to be connected to one side of a suitable output circuit. A binding post 22 attached to the side of frame F has a screw 23 engaging the plate 20, whereby the latter is readily connected to a circuit lead. The condenser plate 20 can be made of any suitable metal having good electric conductivity, such as aluminum and its alloys, brass, tin, iron, and various other metals and alloys with which the electrician is familiar. The opposite faces of plate 20 are covered with elastic dielectric material 24, which may be a thin layer of rubber cement, a stretched sheet of india rubber, loosely woven fabric like netting, cheese-cloth and the like, or any other material acting as an electric insulator and sufficiently elastic to yield under pressure. A single sheet of dielectric material may be wound taut over the metal plate 20 to cover both faces and the opposite ends 25. The outer end of the sheet is then cemented or otherwise fixed in place to hold the sheet in permanently stretched condition.

An insulating block 26 is mounted in the lower portion of casing F, being secured by screws (not shown) or in any other practical way. In some instances the block 26 may be cast or molded integral with the body of the casing. The block 26 is provided with two parallel longitudinal slots 27 and 28 for receiving the lower ends of a pair of flexible metal sheets or thin plates 29 and 30 arranged on opposite sides of the fixed plate

20 and held in pressure contact with the dielectric 24. These sheets are mounted for vibratory movement and function as loudspeaking diaphragms. Cross-pins 31 passing through the block 26 hold the lower ends of the metal sheets 29 and 30 anchored in place. One of the pins 31 may project through the casing to receive a binding post 32 for connecting the sheets 29 and 30 in circuit. If these diaphragm sheets are intended to be connected to opposite sides of a circuit, they are insulated from each other and a binding post is provided for each. In the upper portion of casing F are mounted two cross-bars 33 and 34, which are supported on fixed pins 35 and a rotary shaft 36 for lateral movement. The shaft 36 has oppositely screwthreaded sections 37 and 38 passing through correspondingly screwthreaded bushings 39 and 40 in cross-bars 33 and 34. The ends of screw shaft 36 are journalled in the front and rear walls of casing F. A wheel 41 fixed on the center of shaft 36 projects out of the casing through a slot 42 for manual operation. The cross-bars 33 and 34 have slots 43 and 44 in which the upper ends of the vibratory metal sheets 29 and 30 are inserted and secured by cross-pins 45 or otherwise. The front sheet 29 is kept in tensioned condition by means of a pair of transverse rods 46 mounted in the side walls of casing F, and similar rods 47 engage the rear sheet 30 to hold it constantly under tension.

It is clear from Fig. 2 that the tensioning rods 46 and 47 maintain the elastic metal sheets 29 and 30 in firm pressure contact with the dielectric sheet 24, which is therefore always under slight compression. The practical advantage of this arrangement is that the sheets 29 and 30 are held as closely as possible to the fixed condenser plate 20 without actually touching it. The sheets 29 and 30 constitute free-edged loudspeaking diaphragms which vibrate when subjected to potential variations with respect to the fixed plate 20. It will not be necessary to show or describe an operative circuit for the condenser plates, because such circuits are well understood by those skilled in the art and they form no part of this invention. It is enough to say that the fixed condenser plate 20 is connected to one side of an output circuit of proper voltage while the two vibratory sheets 29 and 30 are connected to the other side of the circuit. If a constant polarizing potential is used in addition to the signal voltage, the vibratory electrodes may be connected to opposite sides of the signal circuit, and the fixed electrode 20 is connected to one side of the polarizing circuit. This will be clear to those familiar with radio circuits. The dielectric material 24 has sufficient elasticity to permit free and full vibration of diaphragms 29 and 30. The fact that these diaphragms are always in pressure contact with the dielectric increases the sensitiveness of the instrument. The vibratory diaphragm sheets 29 and 30 may consist of any suitable metal or alloy, such as aluminum, duralumin, brass, steel, and others along the same line. If desired, the outer surface of each diaphragm may be covered with a thin sheet of paper, cloth or leather to soften the sound. The dielectric 24 may be attached to the inner faces of the diahpragm sheets instead of being mounted on the fixed plate 20, but I prefer the latter arrangement as being simpler.

The quality and volume of reproduction may be controlled to a certain extent by varying the normal tension of the elastic diaphragm sheets 29 and 30. This is done by simply turning the hand wheel 41 in the proper direction. Looking at Fig. 2, it is evident that when the wheel 41 is turned to separate the cross-bars 33 and 34, the tension on the diaphragms is increased, while a reverse rotation of the wheel correspondingly lessens the tension. During this transverse movement of the cross-bars 33 and 34, the fixed pins 35 and the rotary screw-shaft 36 act as guides. Instead of adjusting the tension of both diaphragms simultaneously, a separate wheel 41 and screw-shaft 36 may be provided for each diaphragm. In a simpler form of my invention the tension-adjusting arrangement may be dispensed with and the cross-bars 33 and 34 mounted in fixed position.

As previously mentioned, the back wall 15 of casing F may be in the form of an elastic sounding board for amplifying the reproduction. The vibrations of the rear diaphragm 30 will create sound waves impinging against the sounding board and setting it in vibration. The space back of diaphragm 30 may be open to the outer air through an opening in back wall 15 or through sound passages at the sides of plate 20 leading to the front opening 18. In this way the acoustic output of both diaphragms comes through the open front of the casing. It is possible to use only one diaphragm, leaving out the rear diaphragm 30, but that would mean reduced volume of reproduction. Although the frame F is so mounted that the diaphragm sheets are supported along horizontal lines and free along their vertical edges, it is obvious that the supporting frame F may be held at any other angle.

Attention is called to the fact that the rectangular tensioned sheets 29 and 30 constitute edge-free diaphragms adapted to vibrate with substantially equal amplitude over their entire acoustic area. Consequently, these diaphragms respond with practically uniform efficiency at all frequencies within practical limits. The vibratory areas of the diaphragms lie between the pairs of tensioning

rods 46 and 47, respectively. Although the tensioned diaphragm sheets 29 and 30 are very thin and therefore flexible, they vibrate like stiff plates without nodal regions and are thus capable of giving a faithful reproduction. If desired, one diaphragm may be of different material or dimensions and under a different degree of tension from the other diaphragm, so as to respond most efficiently over a different band of frequencies. For example, if the front diaphragm 29 is made thinner and held under greater tension than the rear diaphragm 30, the front diaphragm will emphasize the higher tones, while the other diaphragm will emphasize the lower tones. The particular size and dimensions of the diaphragms are a matter that can only be determined by experiment well within the skill of the trained artisan to give the best results in any particular design of instrument.

Although I have shown and described a specific construction, I want it understood that my invention is not limited to the details set forth. It is to be expected that changes and modifications will occur to others without departing from the scope of the invention as defined in the following claims. It is hardly necessary to add that the drawings do not show the parts in their correct relative proportions, which have been purposely exaggerated for clearness, particularly the thickness of the dielectric and the vibratory diaphragms.

I claim as my invention:

1. An electrostatic loudspeaker comprising a fixed condenser plate, a pair of vibratory metal sheets constituting diaphragms arranged on opposite sides of said plate, elastic dielectric material separating said sheets from said plate, said sheets and plate being substantially flat over their operated areas, and means for supporting said sheets under tension and pressing them against said dielectric material.

2. An electrostatic loudspeaker comprising a casing, a plurality of substantially flat condenser plates in said casing, at least one of said plates consisting of a rectangular vibratory sheet supported at two opposite ends only and held under tension, and manually operable means projecting out of said casing for adjusting the normal tension of said sheet.

3. An electrostatic loudspeaker comprising a casing, a plurality of substantially flat condenser plates in said casing, at least one of said plates consisting of a rectangular vibratory sheet supported at two opposite ends only and held under tension, and a rotary member projecting out of said casing for adjusting the normal tension of said sheet, said member being manually operable in either direction to increase and decrease said tension.

4. An electrostatic loudspeaker comprising a fixed condenser plate, a pair of vibratory condenser sheets supported at opposite ends under tension on either side of said fixed plate and insulated therefrom, said tensioned sheets constituting loudspeaking diaphragms adapted to vibrate with substantially equal amplitude over their whole acoustic area, and means for adjusting the normal tension of both diaphragms.

5. An electrostatic loudspeaker comprising a fixed condenser plate, a pair of vibratory metal sheets situated on opposite sides of said plate in electrostatic relation thereto, said plate and said sheets being substantially rectangular, supporting means at opposite ends of each sheet to hold the same stretched, each of said sheets consisting of a diaphragm, and means for adjusting at least one of the supporting means for each diaphragm to regulate the normal tension thereof.

6. An electrostatic loudspeaker comprising a fixed condenser plate, a pair of vibratory condenser sheets supported at opposite ends under tension on either side of said fixed plate and insulated therefrom, said tensioned sheets constituting loudspeaking diaphragms adapted to vibrate with substantially equal amplitude over their whole acoustic area, and a casing in which said diaphragms are housed, the front of said casing being open and the back being closed by a sounding board.

7. An electrostatic loudspeaker comprising a fixed condenser plate, a vibratory metal sheet arranged adjacent said fixed plate and constituting a diaphragm, said plate and sheet being substantially rectangular, elastic dielectric material between said plate and sheet, supports at opposite ends of said sheet to hold the same under tension, and a pair of cross-rods engaging said sheet and so arranged as to press the same against the dielectric material.

8. An electrostatic loudspeaker comprising a fixed condenser plate, a vibratory metal sheet arranged adjacent said fixed plate and constituting a diaphragm, said plate and sheet being substantially rectangular, elastic dielectric material between said plate and sheet, supports at opposite ends of said sheet to hold the same under tension, a pair of cross-rods engaging said sheet so that the same is pressed against the dielectric material, and means for adjusting the normal tension of said sheet.

9. An electrostatic loudspeaker comprising a fixed condenser plate, a vibratory metal sheet arranged adjacent said fixed plate and constituting a diaphragm, said plate and sheet being substantially rectangular, elastic dielectric material between said plate and sheet, supports at opposite ends of said sheet to hold the same under tension, a pair of cross-rods engaging said sheet so that the same is pressed against the dielectric material, and rotary means for adjusting at least one of said supports laterally of said cross-bars

to regulate the normal tension of said sheet.

10. An electrostatic loudspeaker comprising a casing, at least two electrodes operatively mounted in said casing, one of said electrodes comprising a flat tensioned sheet constituting a diaphragm, and means for adjusting the normal tension of said diaphragm from outside said casing, said adjusting means including a slidable member.

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