Oct. 15, 1929. A. A. THOMAS 1,731,799

LOUD SPEAKER

Filed March 12, 1927 2 Sheets-Sheet 1

FIG. 1.

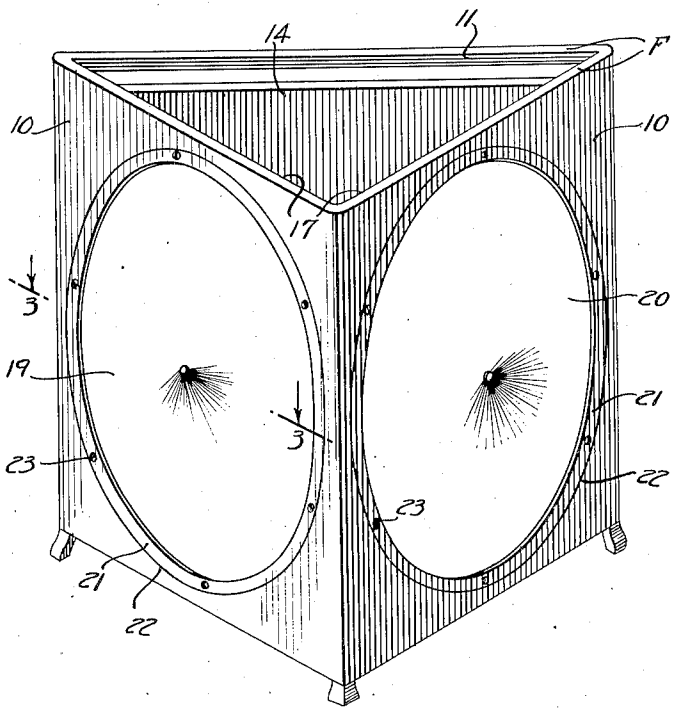


FIG. 2.

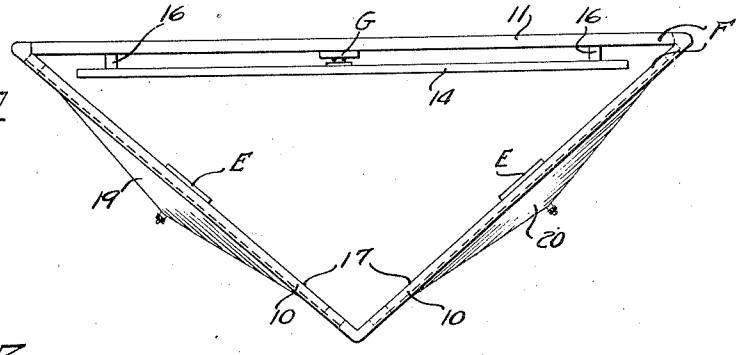
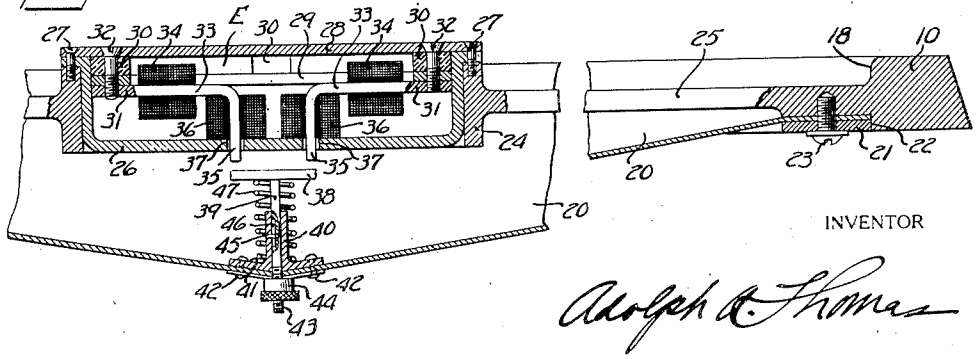


FIG. 3.



INVENTOR

Adolph A. Thomas

Oct. 15, 1929. A. A. THOMAS 1,731,799

LOUD SPEAKER

Filed March 12, 1927 2 Sheets-Sheet 2

FIG. 4.

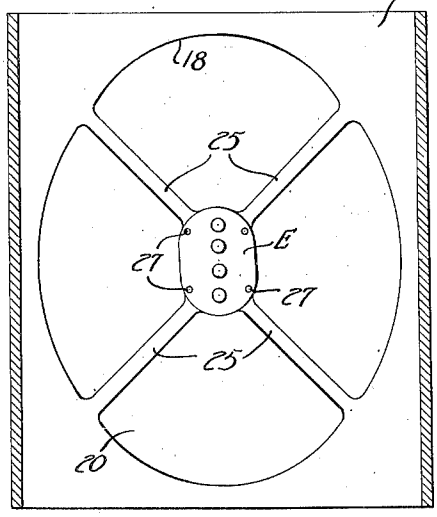


FIG. 5.

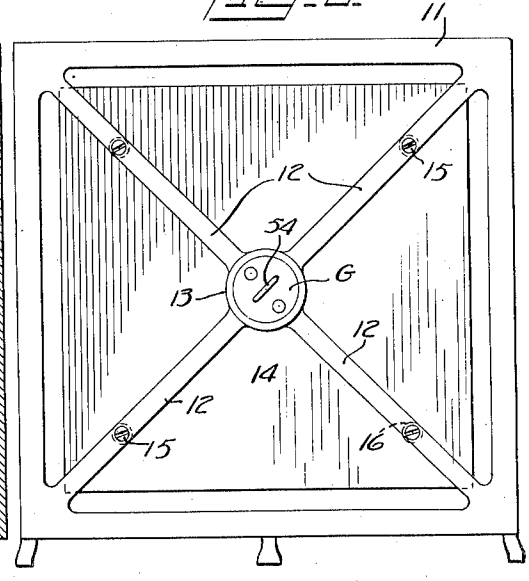


FIG. 6.

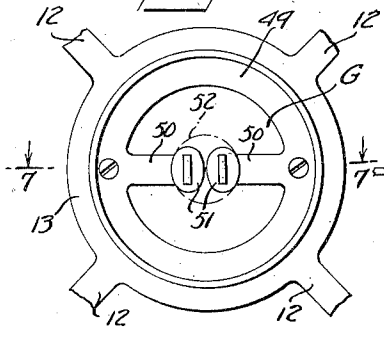


FIG. 7.

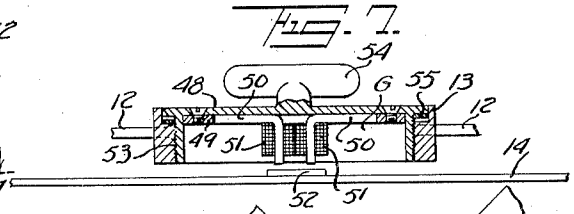


FIG. 8.

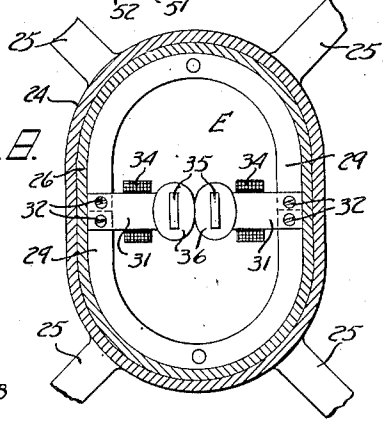
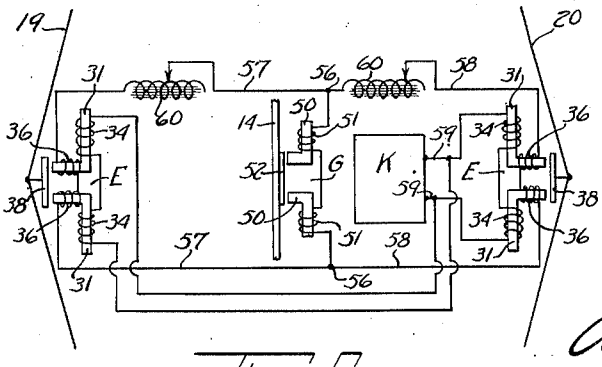


FIG. 9.



INVENTOR

Adolph A. Thomas

Patented Oct. 15, 1929 1,731,799

UNITED STATES PATENT OFFICE

ADOLPH A. THOMAS, OF NEW YORK, N. Y.

LOUD-SPEAKER

Application filed March 12, 1927. Serial No. 174,724.

The present invention relates to electric sound-reproducing devices, usually called loudspeakers, such as are used in radio reception, phonographic reproduction and telephone receiving systems. The object of my invention is to provide a hornless loudspeaker of compact construction and capable of giving a reproduction of great volume and fidelity over the entire musical scale.

In a preferred embodiment I employ a plurality of loudspeaking diaphragms having different natural frequencies. As a general rule, two diaphragms are sufficient, one for accentuating the higher frequencies and the other for accentuating the lower frequencies, and these diaphragms are supported in a frame of novel construction. This frame is of trihedral shape, and the diaphragms are mounted on the two front faces or panels. The third or rear face of the frame preferably consists of (or is otherwise provided with) a sounding board. The faces of the trihedral frame form an open sound chamber for confining a column of air. The diaphragms are so mounted that on the front side they are directly open to the outer air, and on the reverse side they are exposed to the column of air in the sound chamber. Consequently, when the diaphragms are vibrated by means of electromagnetic driving units, the inner column of air and the sounding board are set in vibration to amplify the reproduction. The movements of the sounding board may be utilized to generate electric impulses for augmenting the electromagnetic action of the driving units, whereby the final reproduction is greatly amplified.

The foregoing and other features and advantages of my invention will be clear to those skilled in the art from a detailed description of the accompanying drawings, in which—

Fig. 1 shows a perspective view of a preferred form of loudspeaker constructed in accordance with my invention;

Fig. 2 is a plan view of Fig. 1;

Fig. 3 represents an enlarged transverse section approximately on line 3—3 of Fig. 1, certain portions being broken away for lack of space;

Fig. 4 shows a rear view of a front panel of the trihedral supporting frame;

Fig. 5 is a rear view of Fig. 1, showing the mounting of the sounding board on the back wall of the frame;

Fig. 6 is a detached view of the current-generating unit controlled by the sounding board;

Fig. 7 is a cross-section on line 7—7 of Fig. 6;

Fig. 8 is an inside view of the electromagnetic driving unit for the diaphragms; and

Fig. 9 is a diagram of the circuit connections for controlling the operation of the driving units.

The trihedral frame F consists of a pair of front panels or faces 10 and a rear panel 11. In the present instance the rear panel is not solid, as well it may be, but is in skeleton or spider form to provide rigid arms 12, which terminate in a cylindrical head 13. The arms 12 support a sounding board 14, which is secured in position by screws 15 or in any other practical way. Insulating sleeves or pegs 16 hold the sounding board spaced from the wall 11, so that it may vibrate as freely as possible in the sound chamber 17 formed within the hollow supporting frame F.

The front walls 10 of frame F are provided with openings 18 in which are mounted a pair of loud-speaking diaphragms 19 and 20, which may conveniently be of the so-called cone type, either circular or elliptical. In the present construction the diaphragms are of elliptical shape, so that the maximum acoustic surface may be accommodated within the rectangular area of the supporting panels 10. The diaphragms are mounted on the supporting frame in any practical way, as by means of clamping rings 21, which fit into correspondingly shaped recesses 22 on panels 10. Screws 23 or other fastening devices hold the rings 21 in clamping position.

The diaphragms 19 and 20 are preferably constructed to accentuate different bands of frequencies for the proper reproduction of the entire musical scale. For this purpose the diaphragms may be either of different size or of different materials, so as to have different natural frequencies. It may be assumed

that diaphragm 19 is intended to operate most efficiently on the higher bands of frequencies, and that diaphragm 20 accentuates the lower frequencies, there being sufficient overlapping between these frequencies to reproduce the middle register with the same degree of efficiency. Cone diaphragms are usually made of paper, but other materials may be used, such as sheet metal, celluloid, parchment, stiffened fabric, and the like. The high diaphragm 19 may be constructed of a very thin sheet of duralumin, so dimensioned as to have a high natural frequency. The vibrations of diaphragms 19 and 20 cause the column of air in chamber 17 to vibrate correspondingly, the vibrations of the air column representing the combined movements of the diaphragms. As the sound waves produced by the vibrating air column reach the outer air, they augment the sound waves generated by the outer faces of the diaphragms, thus increasing the volume of reproduction. The sound chamber 17 is so designed that sound waves produced by diaphragms 19 and 20 cause vibration of the sounding board 14, as previously explained.

The diaphragms 19 and 20 are operated by electromagnetic driving units indicated as a whole by E. These units are rigidly supported in a head 24 which may be integral with arms 25 formed on panel 10. The construction of the electromagnetic units E is clearly shown in Figs. 3 and 8. As these units are alike, a description of one will be sufficient. The operative parts of the unit are housed in a casing 26 adapted to fit snugly in the supporting head 24, to which it is secured by screws 27 or otherwise. On the base plate 28 of the unit is mounted a permanent steel magnet 29, which may be stamped out of sheet steel as a single member, or it may be composed of two U-shaped magnets secured in contact with each other at their like poles. By making the magnet structure elongated, somewhat in the shape of an ellipse, an increased length of magnetic path is obtained, thereby adding to the life and efficiency of the magnet. Insulating pads or blocks 30 may be used to hold the magnet spaced from the base. To the polar ends of magnet 29 are secured L-shaped pole pieces 31. In the present instance, the pole pieces are attached to the magnet by screws 32, which also hold the magnet on the base 28. The diametric limbs 33 of the pole pieces carry a pair of coils 34, which are connected in series and operate as a single coil. On the axial limbs 35 of the pole pieces are mounted coils 36. The coils 34 are adapted to be connected in a talking circuit, by which I mean any circuit of variable electric impulses that represent transmitted sound waves to be reproduced. The parallel limbs 35 of the pole pieces extend through holes 37 in housing 26 into operative relation to an armature disk or bar 38 mounted on the apex of the diaphragm. As shown in Fig. 3, the armature is fixed to a rod 39 slidably mounted in a sleeve or hub 40, which may be integral with a disk 41 secured to the diaphragm by screws or rivets 42. The outer portion of rod 39 is screw-threaded, as indicated at 43, and a nut 44 is mounted on the screw-threaded end to permit adjustment of the armature 38 toward and away from the polar limbs 35. A fixed pin 45 in sleeve 40 engages in an axial slot 46 of rod 39 to prevent turning of the latter when the nut 44 is adjusted. A tensioned coil spring 47 is arranged between armature 38 and disk 41 to hold the rod 39 pushed toward the electromagnetic unit, whereby the armature 38 remains firmly in adjusted position.

It will be understood that variable current impulses in the circuit of coil or coils 34 produce a correspondingly variable magnetic effect on the armature 38 to cause vibration of the connected diaphragm. In the broad aspect of my invention, the electromagnetic unit E may be regarded as representing any practical driving device for the diaphragm.

In the supporting head 13 of the rear panel 11 is mounted an electric generating unit indicated as a whole by G. In the casing 48 of unit G is fixed a permanent magnet 49 having pole pieces 50 on which are mounted a pair of coils 51, as best shown in Fig. 7. The sounding board 14 carries an armature plate or disk 52 in operative relation to pole pieces 50. The cylindrical casing 48 is adjustable in the fixed support 13 by a screw-threaded engagement 53. A suitable finger-piece 54 projecting from the rear of the casing permits ready adjustment of the normal airgap between pole pieces 50 and armature 52. If desired, a corrugated annular spring 55 may be inserted to hold the unit G firmly in adjusted position without the possibility of rattling or working loose. It will be clear from Fig. 7 that the vibrations of sounding board 14 cause the armature 52 to vary the magnetic field through the coil or coils 51, whereby electric impulses are generated in the circuit of these coils in accordance with the vibrations of the sounding board.

The impulses of generating unit G may be utilized in any practical way, but I prefer to feed them into the driving units E for the purpose of re-enforcing their action on the diaphragms. This will be understood from the circuit diagram of Fig. 9. From the points 56 in the circuit of the generating coils 51 lead two parallel circuits 57 and 58. The circuit 57 includes the coils 36 of the driving unit for one of the diaphragms (in this instance diaphragm 19), while the circuit 58 includes the coils 36 of the other driving unit. The main controlling coils 34 of the two driving units are connected in parallel to the leads 59 of an acoustic device K, which may be a radio receiving set, an electric pho-

nograph, or any other piece of apparatus intended for the reproduction of sound. The current impulses generated in the circuit of coil or coils 51 by the vibratory movements of the sounding board 14 are sent through the parallel circuits 57 and 58 into the auxiliary coils 36 of the driving units E, thereby re-enforcing or amplifying the electromagnetic effect of the main operating coils 34 on the armatures 38 of the diaphragms. It will be understood, of course, that the coils 34 and 36 are so connected and arranged that their electromagnetic effect is cumulative. A variable inductance device 60 may be included in one or both of the generating circuits 57 and 58, so as to adjust the impedance value of each circuit for the most efficient reproduction. That is to say, if we assume the diaphragms 19 and 20 to operate with greatest efficiency at high notes and low notes respectively, then the impedance of circuit 57 is so adjusted as to transmit the higher frequencies more readily than the lower frequencies, while the impedance of circuit 58 is adjusted to transmit the lower frequencies most efficiently.

It will be seen from the preceding description that the sounding board 14 amplifies the reproduction in two ways: mechanically, by setting sound waves in motion; electrically, by generating current impulses that augment the electro-magnetic action of the driving units for the diaphragms. The armature 52 is so light that it adds no appreciable weight to the sounding board.

Although I have shown and described a specific construction, I want it understood that I have done so for the purpose of explaining the various features of my invention and not with the intent of imposing any restriction or limitation that is not included in the claims. It is to be expected that changes and modifications will occur to those skilled in the art without departing from the scope of the invention as defined in the following claims.

I claim as my invention:

1. A loudspeaker comprising a trihedral frame provided with openings in two of its walls, said frame being hollow to confine an open column of air within its walls, a pair of loudspeaking diaphragms carried by said frame at said openings, whereby said diaphragms are directly exposed on one side to the outer air and on the reverse side to the open air column within said frame, and separate electric means mounted on each of said walls for operating said diaphragms, which cause vibration of said air column to reinforce the reproduction.

2. A loudspeaker comprising a trihedral frame provided with openings in two of its faces, a sounding board mounted on the third side of said frame, a pair of loudspeaking diaphragms carried by said frame at said openings, whereby said diaphragms are directly exposed on one side to the outer air and on the other side to the open air column within said frame, so that the sounding board is set in vibration by said diaphragms to amplify the reproduction, and electric means mounted on said frame for operating said diaphragms.

3. A loudspeaker comprising an upright hollow frame having walls that form a vertical sound chamber for confining a column of air, said chamber being open at the top, a loudspeaking diaphragm mounted in a wall of said frame so as to be directly exposed on one side to the outer air and on the reverse side to said chamber, whereby said diaphragm vibrates the air column in said chamber to reinforce the reproduction, and electric means mounted on said wall for operating said diaphragm.

4. A loudspeaker comprising a hollow frame having walls that form a sound chamber for confining a column of air, said chamber being open at one end, one of said walls constituting a sounding board, a loudspeaking diaphragm mounted in a wall of said frame so as to be directly exposed on one side to the outer air and on the reverse side to said chamber and sounding board, whereby said diaphragm causes vibration of said sounding board to amplify the reproduction, and an electric unit carried by said frame for operating said diaphragm.

5. A loudspeaker comprising a trihedral frame consisting of a unitary casing, a pair of loudspeaking diaphragms mounted over openings in the front faces of said frame, integral arms on said frame extending across said openings, and electromagnetic driving units for said diaphragms supported by said arms.

6. A loudspeaker comprising a hollow supporting frame constructed to provide a sound chamber open to the outer air, a sounding board in said chamber, a loudspeaking diaphragm mounted on said frame so that the front of the diaphragm is directly exposed to the outer air and the rear of the diaphragm is exposed to said chamber and sounding board, and an electric driving unit carried by said frame for operating said diaphragm.

7. A loudspeaker comprising a direct-acting diaphragm, an electric driving unit for said diaphragm, said unit including an electromagnetic coil, means mechanically operated by sound waves produced by said diaphragm for generating current impulses in a circuit independent of the circuit of said coil, and means for causing said current impulses to reinforce the action of said coil.

8. A loud speaker comprising the combination of a direct-acting diaphragm freely exposed to the outer air, an electric driving unit for said diaphragm, a sounding board set in vibration by sound waves produced by

said diaphragm, electromagnetic means operated by the movements of said sounding board to generate current impulses, and connections whereby said current impulses reinforce the action of said driving unit on the diaphragm.

9. In an acoustic device, an electromagnetic driving unit comprising a substantially annular magnet structure provided centrally with a pair of L-shaped pole pieces in diametric alignment, each pole piece having a radial limb and an axial limb, the axial limbs terminating in polar faces, a pair of coils on said radial limbs, a separate pair of coils on said axial limbs, means associated with each pair of coils for generating electric impulses therein in accordance with transmitted sound, and a diaphragm controlled by the combined action of said pairs of coils.

10. In an acoustic device, the combination of a diaphragm, an electromagnetic driving unit for said diaphragm, said unit comprising a magnet structure having a pair of pole pieces, two pairs of coils mounted on said pole pieces, one pair of said coils being adapted to be connected in a reproducing circuit, a vibratory acoustic member set in operation by sound waves produced by said diaphragm, a current-generating device controlled by the movements of said member, and means for connecting the other pair of said coils with said device to augment the electromagnetic effect of said driving unit.

11. In sound-reproducing apparatus, the combination of a pair of diaphragms having different natural frequencies for proper reproduction of high and low tones, an electromagnetic driving unit for each diaphragm, means for simultaneously operating said driving units, a sounding board set in vibration by the combined action of the sound waves produced by said diaphragms, electric means operated by the movements of said sounding board to generate current impulses, and a pair of parallel circuits between said electric means and said driving units for causing the impulses of said generating means to augment the electromagnetic action of said driving units.

12. A loudspeaker comprising a frame or casing constructed to form a sound chamber for confining a column of air, said chamber being open at one end, a plurality of loudspeaking diaphragms mounted on said frame so as to be directly exposed on one side to the outer air and on the reverse side to said chamber, said diaphragms having different natural frequencies for the proper reproduction of high and low tones, and electric means carried by said frame for simultaneously operating said diaphragms, which cause the air column in said chamber to vibrate in accordance with the combined vibrations of the diaphragms, whereby the reproduction is amplified.

13. A loudspeaker comprising a hollow frame having walls that form a sound chamber for confining a column of air, said chamber being open at one end, one of said walls constituting a sounding board, a loudspeaking diaphragm mounted in a wall of said frame so as to be directly exposed on one side to the outer air and on the reverse side to said chamber and sounding board, whereby said diaphragm causes vibration of said sounding board to amplify the reproduction, an electric unit carried by said frame for operating said diaphragm, electric means operated by the movements of said sounding board to generate current impulses, and connections whereby said current impulses reinforce the action of said driving unit on the diaphragm.

14. A loudspeaker comprising a trihedral frame provided with openings in two of its faces, a sounding board mounted on the third side of said frame, a pair of loudspeaking diaphragms carried by said frame at said openings, whereby said diaphragms are directly exposed on one side to the outer air and on the other side to the open air column within said frame, so that said sounding board is set in vibration by said diaphragms to amplify the reproduction, electric driving units mounted on said frame for operating said diaphragms, electric means operated by the movements of said sounding board to generate current impulses, and connections whereby said current impulses reinforce the action of said driving units on the diaphragms.

15. In sound-reproducing apparatus, the combination of a pair of diaphragms having different natural frequencies for proper reproduction of high and low tones, an electromagnetic driving unit for each diaphragm, means for simultaneously operating said driving units, a sounding board set in vibration by the combined action of the sound waves produced by said diaphragms, electric means operated by the movements of said sounding board to generate current impulses, a pair of parallel circuits between said electric means and said driving units for causing the impulses of said generating means to augment the electromagnetic action of said driving units, and a variable electric device in each parallel circuit to regulate its impedance value for the most efficient operation of the connected diaphragm.

16. A loudspeaker comprising a trihedral frame constructed to be self-supporting, a pair of loudspeaking diaphragms mounted on two walls of said frame, and electric driving means mounted on each of said walls for operating said diaphragms.

17. A loudspeaker comprising a hollow framework having walls adapted to confine an open column of air, a cone diaphragm mounted on a wall of said frame so as to be exposed on one side to the free air and on the reverse side to said confined column of air, whereby said diaphragm vibrates the air col-

umn to reinforce the reproduction, and an electric driving unit mounted on said framework for operating said diaphragm.

18. A loudspeaker comprising a hollow frame having a wall adapted to act as a sounding board, a cone diaphragm mounted on each of the other walls, and electric means mounted on said frame for simultaneously operating said diaphragms, which cause said sounding board to vibrate and thereby augment the reproduction.

19. A loudspeaker comprising a trihedral frame having a wall adapted to act as a sounding board, a pair of loudspeaking diaphragms mounted on the other two walls of said frame, the vibrations of said diaphragms setting said sounding board in operation to reinforce the reproduction, and electric driving means for simultaneously operating said diaphragms.

20. A loudspeaker comprising a supporting frame, a pair of direct-acting diaphragms mounted on said frame, said diaphragms having different natural frequencies so as to reproduce the higher and lower musical registers, electric driving means for simultaneously operating said diaphragms, and a sounding board mounted on said frame so as to be set in vibration by the joint action of said diaphragms to reinforce the reproduction.

21. A loudspeaker comprising a hollow frame constructed to provide an open column of air, a cone diaphragm mounted on said frame and exposed to said column of air to vibrate the same, a sounding board carried by said frame and set in operation by said column of air to reinforce the reproduction, and electric driving means mounted on said frame for operating said diaphragm.

22. A loudspeaker comprising a hollow frame constructed to provide an open column of air, a cone diaphragm mounted on said frame and exposed to said column of air to vibrate the same, a sounding board carried by said frame and set in operation by said column of air to reinforce the reproduction, electric driving means mounted on said frame for operating said diaphragm, and electromagnetic means operated by said sounding board to generate current impulses for reinforcing the electromagnetic action of said driving means.

23. A loudspeaker comprising a pair of direct-acting diaphragms having different natural frequencies so as to reproduce the higher and lower musical registers, a sounding board set in operation by the sound waves produced by the combined action of said diaphragms, electromagnetic mechanism for simultaneously operating said diaphragms, and electromagnetic means operated by said sounding board to generate current impulses for reinforcing said driving mechanism.

24. Acoustic apparatus comprising a loud speaking diaphragm, electromagnetic means including a coil for operating said diaphragm, a second diaphragm vibrated by sound waves produced by said first diaphragm for generating current impulses in a circuit independent of the circuit of said coil, and means for utilizing said current impulses.

25. In acoustic apparatus, the combination of a frame, a loud speaking diaphragm mounted on said frame, electric means for operating said diaphragm, a second diaphragm carried by said frame and arranged to be vibrated by sound waves produced by said first diaphragm, and electromagnetic means for generating current impulses by the vibration of the second diaphragm, said frame providing a sound chamber of which said diaphragms constitute vibratory walls.

ADOLPH A. THOMAS.