July 2, 1935. H. C. HARRISON 2,006,453

ACOUSTIC DEVICE

Filed Nov. 21, 1933 3 Sheets-Sheet 1

FIG. 1

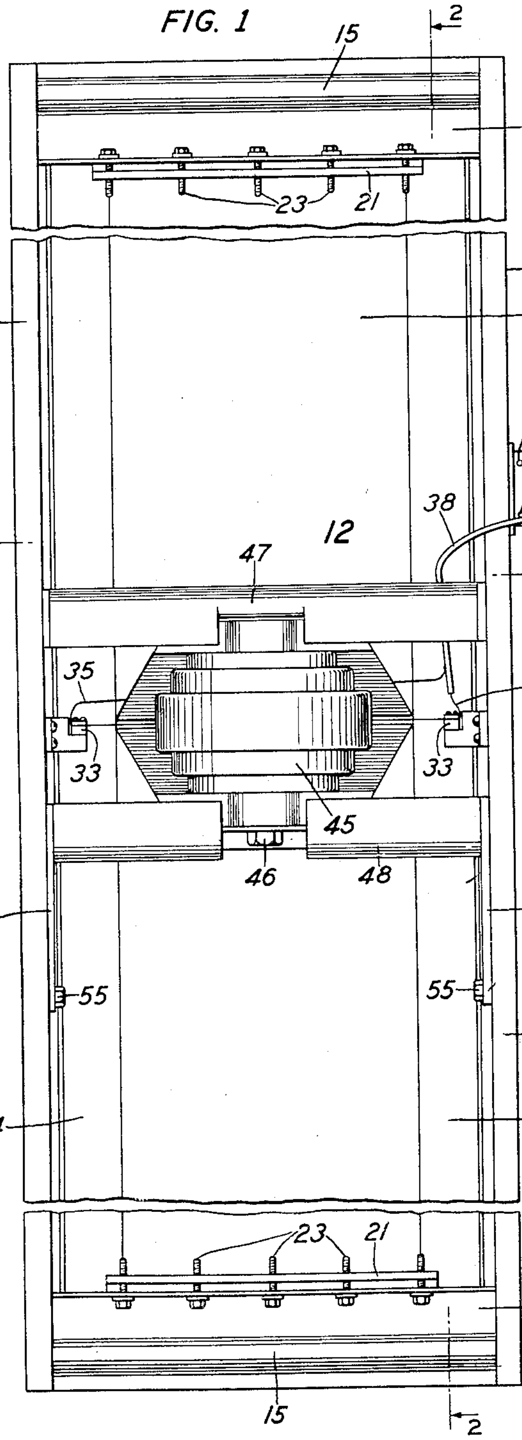
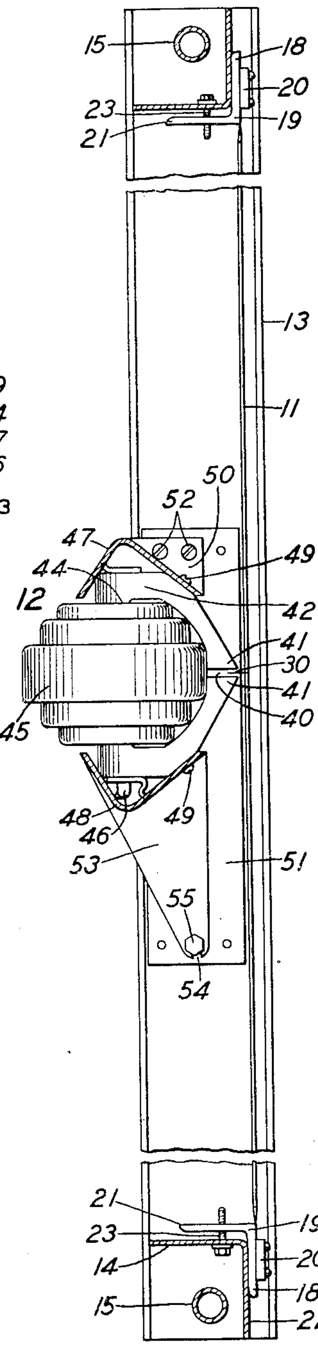



FIG. 2

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ACOUSTIC DEVICE

Filed Nov. 21, 1933 3 Sheets-Sheet 2

FIG. 3

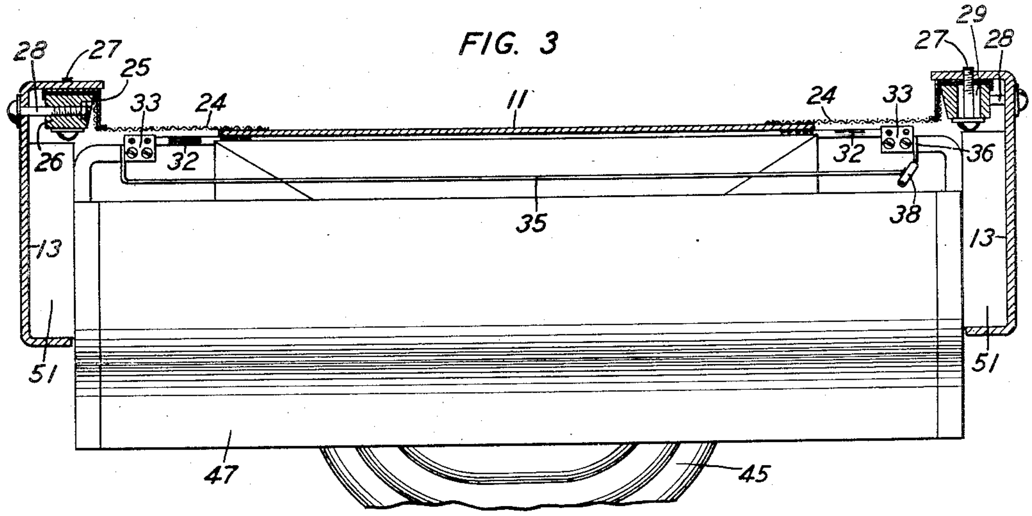



FIG. 4

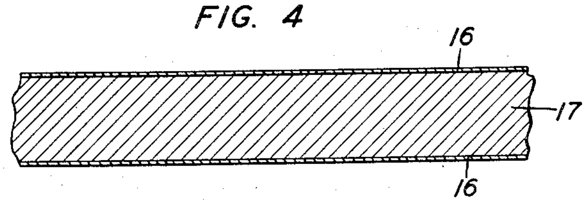



FIG. 5

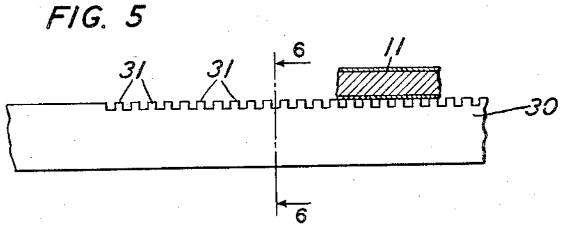
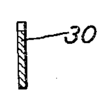



FIG. 6

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Filed Nov. 21, 1933 3 Sheets-Sheet 3

FIG. 10

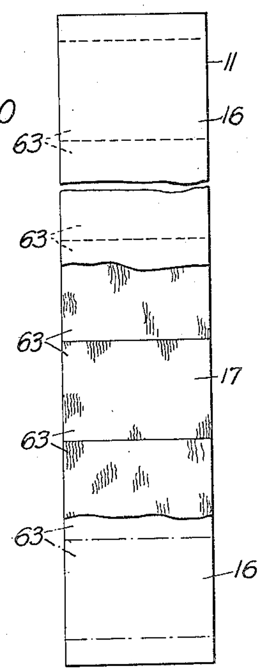



FIG. 7

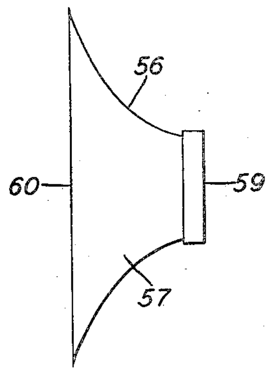



FIG. 8

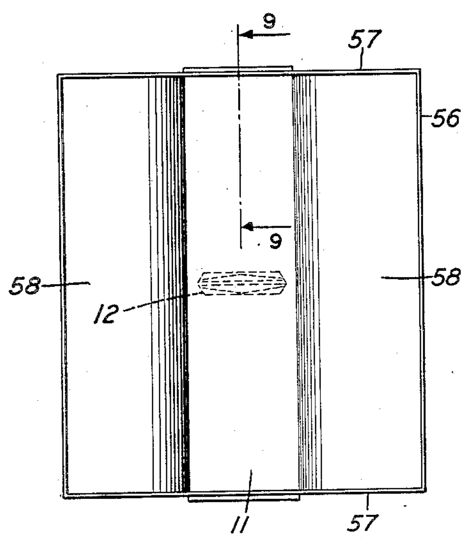
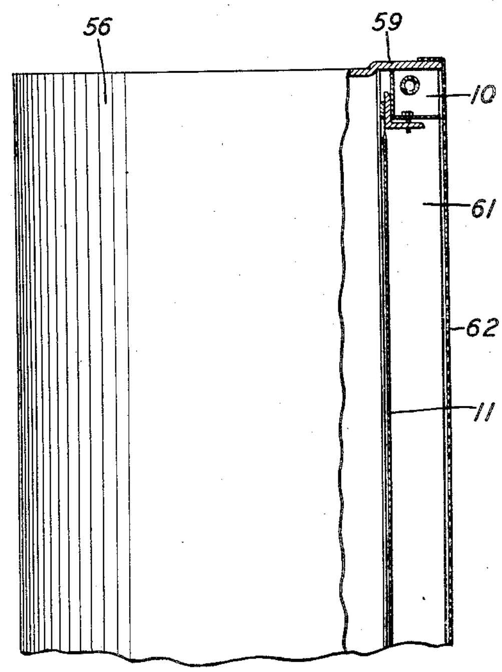



FIG. 9

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2,006,453

# UNITED STATES PATENT OFFICE

2,006,453

## ACOUSTIC DEVICE

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Application November 21, 1933, Serial No. 698,965

26 Claims. (Cl. 181—31)

This invention relates to acoustic devices and, more particularly, to a sound wave reproducer comprising a diaphragm of large area.

An object of this invention is to translate sound waves, efficiently and with fidelity to the original over the greater portion of the frequency range.

A feature of this invention comprises a composite diaphragm having outer metallic layers and an intermediate layer of fibrous material, the various layers being cemented together.

A further feature comprises a diaphragm having a pair of sheets, of a lightweight, high strength material, such as duralumin, spaced apart by but secured to a layer of a lightweight fibrous material, such as balsa wood.

Still another feature comprises a stretched diaphragm having outer metallic layers and a fibrous internal layer.

A further feature comprises the method of making the diaphragm of this invention.

Still another feature comprises a loudspeaker comprising a horn and a direct-acting diaphragm positioned in the throat of the horn, a wall of acoustic dampening material being spaced from the rear side of the diaphragm.

Other and further features not hereinabove specifically enumerated will be evident from the detailed description which follows hereinafter.

In one embodiment, this invention comprises a loudspeaker having an elongated, rectangular shaped diaphragm, comprising a pair of strips, sheets or layers of a lightweight, high strength material, such as duralumin, spaced apart by but secured to an intermediate layer of a lightweight, fibrous material, such as balsa wood, the elements of the diaphragm being secured together preferably by a thermoplastic cement. The diaphragm is supported on a suitable frame and a stretching force of great magnitude is applied at its short edges, and a stretching force of comparatively small magnitude is applied at its long edges. The short edges of the diaphragm are secured directly to the frame, the long edges by elongated strips of flexible material, preferably rubberized fabric. The diaphragm is actuated preferably by a straight line drive of the electrodynamic type, may be loaded on one side by a horn, which flares outwardly from the long edges of the diaphragm, and may be provided with dampening material on its other side and in spaced relation thereto.

A more complete understanding of this invention will be obtained from the detailed description which follows, read with reference to the appended drawings, wherein:

Fig. 1 is an elevational view, partly broken away, of an acoustic device embodying this invention;

Fig. 2 is a sectional view of the device of Fig. 1 along the line 2—2 thereof;

Fig. 3 is a plan view of a section of the device of Fig. 1 along the line 3—3 thereof;

Fig. 4 is an enlarged sectional view of a fragment of the diaphragm constituting a feature of this invention;

Fig. 5 is an enlarged plan view of a fragment of the line drive for the device of Fig. 1;

Fig. 6 is a sectional view of the line drive of Fig. 5 along the line 6—6 thereof;

Fig. 7 is a plan view of another embodiment of this invention;

Fig. 8 is a front elevational view of the device of Fig. 7;

Fig. 9 is an enlarged side elevational view of a fragment of the device of Fig. 7 partly broken away and partly in section; and

Fig. 10 is a front elevational view of the diaphragm of this invention partly broken away to show the details of its construction.

The device of Figs. 1 to 6 comprises a frame, generally designated **10**, supporting a diaphragm **11**, and means, designated generally **12**, for actuating the diaphragm. The frame is rectangular in shape and comprises lateral or side, channel shaped members or pieces **13**, cross or end angle members or pieces **14**, and bracing members or pipes **15**.

The diaphragm, preferably quadrilateral and more specifically rectangular in shape comprises a pair of metallic sheets **16**, preferably planar, rectangular in shape, and of duralumin, spaced apart by and secured to an intermediate layer **17** of a fibrous material, such as balsa wood. A preferred method of securing diaphragm layers together comprises coating the duralumin sheet on one surface with a thermoplastic cement, drying this coating, placing the layer of fibrous material against the coated surface, and thereafter applying heat to the outside of the metallic sheet, for instance, with an iron, thereby causing the layers to adhere and to be bound securely together. The diaphragm is attached at each of its short edges to a flanged portion or angular extension **18** of a plate or angle member **19**, being fastened thereto by the clamping strips **20**. The plate members **19** have their horizontal portions **21** spaced from and parallel to one portion of the frame members **14** and have their flanged portions **18** resting against the vertical portions **22** of the members **14**. The frame members **14** and the plate members 19 are secured together by the bolts 23 or other suitable means. Adjustment of these bolts varies the relative positions of the frame end members and the plates 19, and the tension in the diaphragm along its long dimension may be thus adjusted to the desired degree. Preferably, the diaphragm is highly tensioned and to a degree such that the velocity of propagation of sound waves along the length of the diaphragm is comparable to that of sound waves in air, the tensioning force in one device constructed in accordance with this invention being approximately sixty thousand pounds per square inch. The long edges of the diaphragm are connected with the lateral frame members by strips 24 of flexible material, such as rubberized fabric. The diaphragm is tensioned, preferably, to a slight degree in the direction of its short dimension, the stretching force being, for instance, of the order of one hundred pounds per square inch. This cross tensioning of the diaphragm aids in maintaining the velocity of propagation in the diaphragm by canceling the air mass effect on the diaphragm in the region of the lower frequencies. The outer edge of each flexible strip is secured between a pair of elongated members 25, 26 which are secured to the frame side members by suitable fastening means, such as screws 27, 28. The screws 27 pass through oversized holes 29 in the members 25, 26, the position of which may be varied, therefore, by adjustment of the screws 28 to permit cross-tensioning of the diaphragm and variation in the degree of such tension. The diaphragm described translates sound waves efficiently and with fidelity to the original sounds and, although highly tensioned, is subject to substantially no lateral bending while vibrating. In a device constructed in accordance with this invention, the diaphragm consisted of rectangular sheets of duralumin approximately nine inches by ten feet and .003 inch in thickness, separated by an intermediate layer of balsa wood approximately .065 inch in thickness and consisting of a large number of strips 63 of balsa wood assembled one adjacent the other, the grain of the balsa wood being arranged in the direction of the long dimension of the diaphragm.

The diaphragm is driven preferably at its midportion along a line parallel to its short edges by a moving strip member or conductor 30, for instance, of aluminum. The conductor is provided with a multiplicity of projections or feet portions 31 which are fastened to the diaphragm by a suitable cement. The end portions of the conductor are made flexible by shredding them, as at 32, and are terminated at the terminal members 33. A transformer 34 having input leads 39 is supported on one of the frame lateral members. Conductors 35, 36 connect the terminals 33 with the output terminals 37 of the transformer, and for a portion of their lengh, as at 38, may be concentrically disposed although suitably insulated from one another. The driving strip is disposed in an air gap 40 defined by the spaced pole pieces 41 of the magnet structure 42, the core 44 of which is surrounded by an energizing winding 45. The magnet structure 42 comprises two similarly shaped portions held together by a bolt 46. The magnet structure is secured between trough-like sheet metal members 47, 48 by the bolt 46 and screws 49. The member 47 is provided at its ends with inwardly extending flange portions 50 adapted to be secured to the frame member 51 by suitable fastening means, such as the screws 52. The member 48 is provided with depending triangularly shaped extensions 53 at its ends. Each extension 53 is provided with a slot 54 at its apex portion adapted to engage with the shank of the pins or bolts 55. By removing the fastening members 52, the magnet structure and trough-like supports may be removed as a unit from the frame 10, or may be swung away from the diaphragm about the members 55 as an axis. This permits easy access to the driving strip and to the magnet air gap for adjustment, repair or cleaning.

Figs. 7 to 9 disclose a sound wave reproducer comprising a baffle member 56 in the form of a horn having parallel end walls 57, and flaring side walls 58 which taper such that the cross-sectional area of the sound path from the throat portion 59 to the mouth portion 60 of the horn varies exponentially with the distance from the throat of the horn. The device described with reference to Figs. 1 to 6 is mounted in the throat portion of the horn, one surface of the diaphragm 11 radiating sound waves out through the horn, and the other surface radiating sound waves into a chamber 61 defined by the diaphragm and a wall or sheet 62 of acoustic dampening material, which is supported by the horn, or, if desired, by the frame 10.

While the features of this invention have been disclosed with reference to a specific embodiment, it is to be understood that various modifications thereof may be made without departing from the spirit of the invention, the scope of which is to be considered as limited by the appended claims, only.

What is claimed is:

1. A diaphragm comprising a pair of spaced metallic members and a layer of a fibrous material between said members and secured thereto, the thickness of each metallic member and of the fibrous layer being in the approximate ratio of one to twenty.

2. A diaphragm comprising a metallic sheet approximately .003 inch in thickness, a layer of fibrous material approximately .065 inch in thickness, and a second metallic sheet approximately .003 inch in thickness, said fibrous layer being positioned intermediate said metallic sheets and secured thereto.

3. A diaphragm comprising a sheet of balsa wood approximately .065 inch in thickness between a pair of duralumin sheets approximately .003 inch in thickness.

4. A diaphragm comprising a pair of elongated, rectangular strips of duralumin spaced apart by an intermediate layer comprising a plurality of strips of balsa wood.

5. A stretched composite diaphragm comprising outer metallic layers and an intermediate fibrous layer, the diaphragm being stretched unequally in different directions.

6. An acoustic device comprising a diaphragm, rectangular in shape and comprising a pair of metallic sheet members separated by and secured to a layer of a fibrous material, a supporting frame, one pair of opposite edges of the diaphragm being secured directly to said frame, and strips of flexible material connecting the other pair of diaphragm edges to the frame, said diaphragm being tensioned through said strips in a direction parallel to the edges secured directly to the frame, and being tensioned to a greater degree in another direction.

7. A composite diaphragm comprising outer metallic layers and an intermediate fibrous layer cemented together, said diaphragm being

stretched to different degrees in different directions.

8. The method of making a diaphragm of a metallic layer and a fibrous layer which comprises coating a surface of the metallic layer with a thermo-plastic cement, drying the coating, placing the fibrous material against the coated surface of the metallic layer, and heating the metal whereby the metallic and fibrous layers are cemented together.

9. The method of making a diaphragm comprising a layer of sheet duralumin and a layer of balsa wood which comprises coating a surface of the duralumin sheet with a thermo-plastic cement, drying the coating, placing the balsa wood layer against the coated surface of the duralumin sheet, and heating the duralumin sheet whereby the duralumin sheet and balsa wood layer are cemented together.

10. An acoustic device comprising a composite diaphragm adapted to radiate sound waves directly into the air, a horn, said diaphragm being mounted in the throat of said horn, said horn increasing in sectional area away from said diaphragm in accordance with an exponential law, and damping means on the other side of said diaphragm and spaced therefrom.

11. An acoustic device comprising a frame, a stretched diaphragm mounted on said frame, means for actuating said diaphragm, a magnet structure carried by said frame, a horn, said frame being mounted in the throat of said horn so that said horn loads one side of the diaphragm, and damping means on the other side of the diaphragm and spaced therefrom to form an air chamber therewith.

12. An acoustic device comprising an elongated diaphragm having a pair of opposite parallel edges, means for securing one of said edges, and means for applying a tensioning force to said diaphragm along the other of said edges, said means comprising a stationary frame member, and a movable plate member having a flanged portion, said other diaphragm edge being secured to said flange portion, and means engaging said plate member and said frame member for drawing them together to stretch said diaphragm.

13. An acoustic device comprising a diaphragm having outer layers of metal and an intermediate layer of a fibrous material, said diaphragm being rectangular in shape and of greater length than width, a rectangular frame of greater width than said diaphragm and having lateral members of greater length than its cross members, means for securing the short edges of the diaphragm to the cross members of said frame, and a strip of rubberized fabric connecting each long edge of said diaphragm and the lateral members of said frame.

14. An acoustic device comprising a rectangular frame, a rectangular diaphragm, means for securing one pair of opposite edges of the diaphragm to said frame and for exerting a tensioning force at right angles to said edges, and flexible fabric strips for securing each of the other pair of opposite edges of the diaphragm to said frame and for exerting a comparatively smaller tensioning force at right angles to the latter mentioned edges of the diaphragm.

15. An acoustic device comprising a rectangular frame, a rectangular diaphragm having one pair of parallel edges rigidly secured to the frame and the other pair of parallel edges flexibly secured to the frame, a baffle member in the shape of a horn at whose throat portion the frame is mounted, said baffle member flaring outwardly from the frame on one side of said diaphragm, and damping means on the other side of said diaphragm, substantially coextensive with said diaphragm and in spaced relation thereto.

16. An acoustic device comprising a frame having parallel, spaced, side members and parallel, spaced, end members, and a diaphragm having a plurality of pairs of oppositely positioned parallel edge portions, each edge portion of one of said pairs of edge portions being secured to a plate member having right angle extensions, one of said extensions resting against a frame end member and the other extension being disposed parallel to and movable relatively to another portion of the frame end member for varying the tension in the diaphragm.

17. A diaphragm comprising a pair of metallic sheets spaced apart by an intermediate layer of fibrous material, said fibrous layer comprising a plurality of strips of fibrous material.

18. A diaphragm comprising a pair of metallic sheets spaced apart by an intermediate layer of fibrous material, said fibrous layer comprising a plurality of strips of fibrous material, said fibrous material being of balsa wood.

19. A diaphragm comprising elongated strips of metal spaced apart by and secured to an intermediate layer of balsa wood, the grain of the balsa wood being arranged in the direction of the long dimension of said diaphragm.

20. A diaphragm comprising a sheet of balsa wood between a pair of duralumin sheets, said balsa wood sheets comprising a plurality of adjacent strips of balsa wood.

21. A diaphragm comprising a pair of metallic sheets spaced apart by an intermediate layer of fibrous material, said fibrous layer comprising a plurality of strips of fibrous material, said metal sheets and fibrous layer being secured together by a thermo-plastic cement.

22. An acoustic device comprising a composite diaphragm having outer layers of metallic material and an intermediate layer of fibrous material, means for tensioning the diaphragm in one direction, and means for tensioning the diaphragm to a lesser degree in a direction substantially at right angles to said first mentioned direction, said layer of fibrous material comprising a plurality of strips assembled one adjacent the other.

23. The method of making a diaphragm of a metallic layer and a fibrous layer which comprises coating a surface of the metallic layer with a thermo-plastic cement, drying the coating, placing the fibrous material in the form of a plurality of strips against the coated surface of the metallic layer and assembled one adjacent the other, and heating the metal, thereby cementing the metallic and fibrous layers together.

24. An acoustic device comprising a diaphragm, said diaphragm being tensioned in one direction by a tensioning force of approximately 60,000 pounds per square inch and in a direction at right angles thereto by a tensioning force of the order of one hundred pounds per square inch.

25. An acoustic device comprising an elongated, rectangular diaphragm, said diaphragm being tensioned in the direction of its longer side by a tensioning force of approximately sixty thousand pounds per square inch and in the direction of its shorter side by a tensioning force of the order of one hundred pounds per square inch.

26. An acoustic device comprising an elongated, rectangular diaphragm, comprising external sheets of metal and an internal layer of fibrous material tensioned in its long dimension to such a degree that the velocity of propagation of sound waves therealong is comparable to that of sound waves in air and tensioned in the direction of its short dimension to the extent of maintaining the velocity of propagation in the diaphragm by cancelling the air mass effect on the diaphragm in the region of the lower frequencies.

HENRY C. HARRISON.