Oct. 21, 1930. E. H. SMYTHE 1,778,871

ACOUSTIC DEVICE

Filed Nov. 2, 1927 2 Sheets-Sheet 1

FIG. 1.

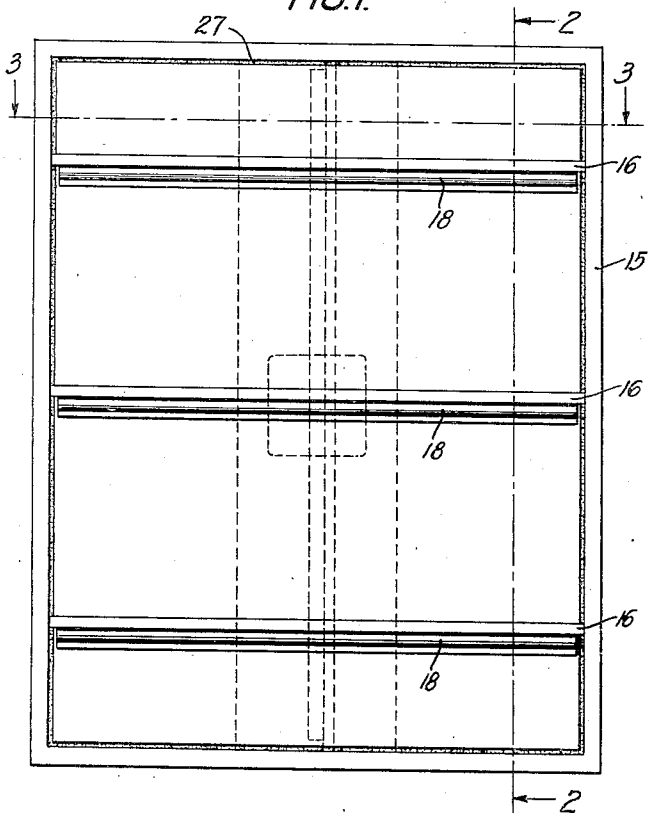


FIG. 2.

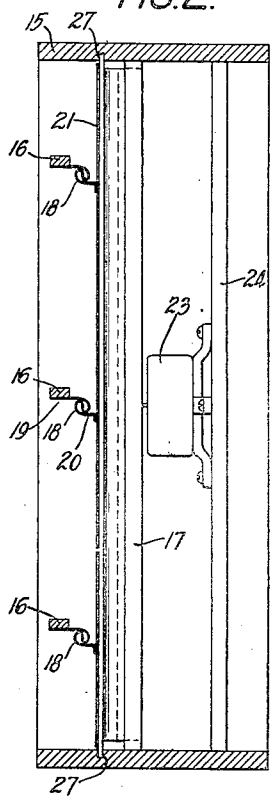


FIG. 3.

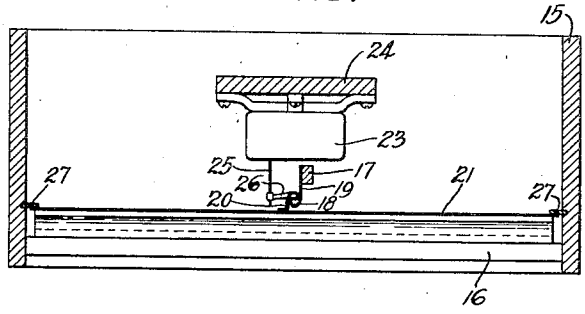
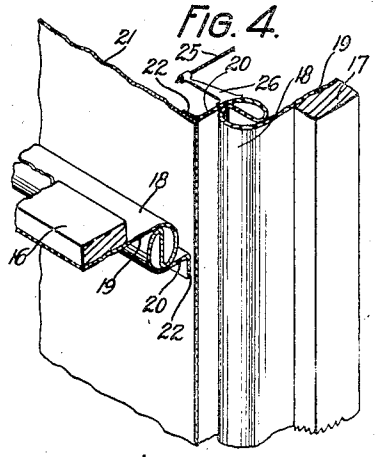


FIG. 4.



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FIG. 5.

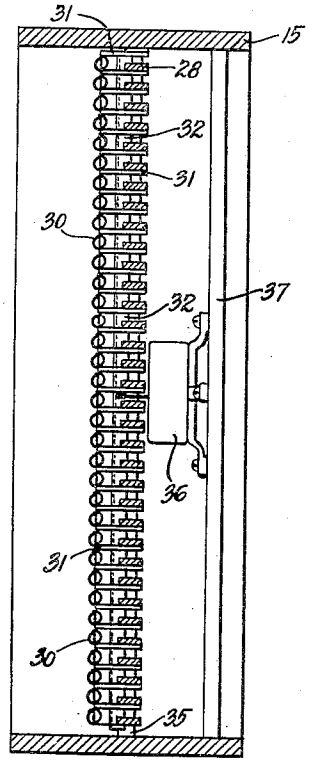


FIG. 9.

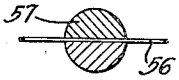


FIG. 10.

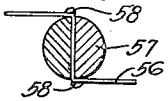


FIG. 11.

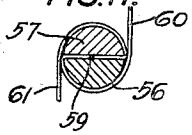


FIG. 12.

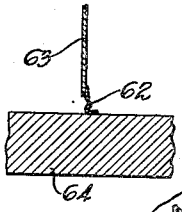


FIG. 7.

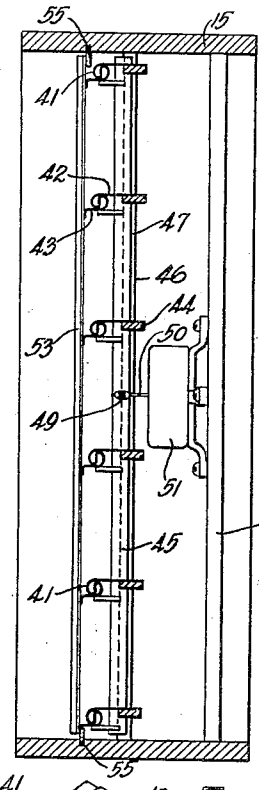


FIG. 6.

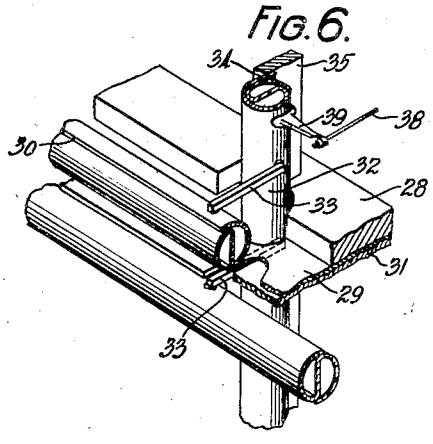
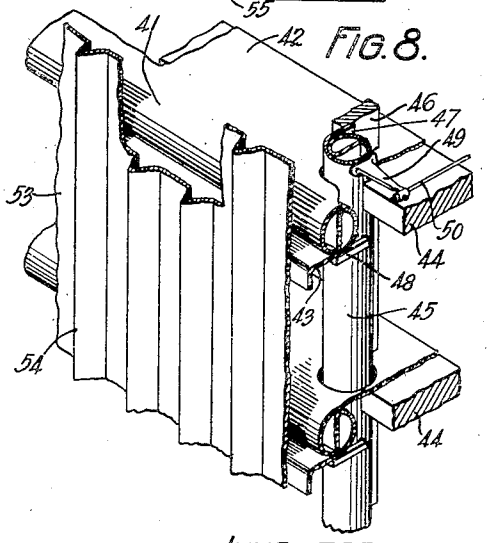


FIG. 8.



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UNITED STATES PATENT OFFICE

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ACOUSTIC DEVICE

Application filed November 2, 1927. Serial No. 230,571.

This invention relates to acoustic devices and more particularly to large direct-acting sound radiators.

An object of the invention is to impart vibrational energy to substantially all portions of a large sound radiating area as nearly simultaneously as possible.

Another object of the invention is to support a large radiating surface by an extended distributing system which imparts vibrational energy to the surface.

In accordance with a broad aspect of the invention a large radiating surface, having such a degree of flexural rigidity as may readily be attained with small material weight, is coupled to a driving element through a multiple torsional distributing system of relatively high torsional rigidity, so that energy is communicated to substantially all parts of the entire area of the radiating surface at a velocity that is high as compared with the flexural velocity of propagation in the material of the radiating surface.

In accordance with one embodiment of the invention, the sound radiator comprises a large plane diaphragm of relatively light material to one surface of which a plurality of parallel torsional members or tubes are attached along their length by means of webs. The torsional tubes are attached to supporting members on a frame surrounding the edges of the sound radiator. A transverse torsional tube or member attached to the opposite surface of the diaphragm and supported in a manner similar to the parallel members, is connected to a driving element which transmits energy to it, and through it distributes the energy to the system of parallel torsional tubes and the diaphragm. The multiple torsional system of this invention forms a highly efficient means of distributing the energy from the driving element to all portions of the area of the diaphragm substantially simultaneously, and at a velocity high as compared with the velocity of flexural propagation in the diaphragm.

Other embodiments of the invention comprise a large number of parallel torsional members spaced close together so that the members themselves provide the sound radiating surface; or a thin sheet of material may be affixed to the torsional members to act as the radiating surface. These members are driven by one or more transverse torsional members which are coupled to the driving element.

A feature of the invention relates to the use of a sound radiator in which the transverse or flexural rigidity of the radiating surface may vary inversely with the number of parallel torsional members employed in the distributing system. For instance, if the width of the radiating surface between adjacent torsional members is small, very little flexural rigidity is necessary in the material of the radiating surface; if the width is greater, the radiating surface is given a greater degree of flexural rigidity.

Another feature of the invention relates to the radiating surface or diaphragm being supported substantially solely by the torsional distributing system. In this arrangement the diaphragm is entirely or substantially free at the edges and is supported by the webs extending from the torsional tubes of the distributing drive.

The invention is not limited to a plane surface diaphragm since the same fundamental principles may be applied to other types of sound radiators. Nor is the invention limited to the particular form of torsional distributing system disclosed as a number of variations operating on the same principle are possible.

These and other features of the invention will be clearly understood from the following detail description in connection with the accompanying drawings in which—

Fig. 1 shows in elevation one embodiment of the invention with the parallel and transverse torsional members supporting the sound radiator therebetween.

Fig. 2 is a cross-sectional side view of Fig. 1 taken on the line 2—2.

Fig. 3 is a top view in cross-section on the line 3—3 of Fig. 1.

Fig. 4 illustrates in perspective the detailed assembly of the torsional members and the diaphragm.

Fig. 5 illustrates in cross-section a modi-

fied arrangement of the invention in which the closely spaced torsional members act as a vibrating sound radiator.

Fig. 6 shows in perspective portions of the parallel members connected to the torsional driving member.

Fig. 7 is a modification of Fig. 5 wherein a sound radiator having a definite degree of flexural rigidity is attached to the parallel torsional members.

Fig. 8 shows in perspective the detailed construction of the arrangement shown in Fig. 7.

Figs. 9, 10 and 11 illustrate the various steps in forming a type of light torsional member employed in this invention; and

Fig. 12 shows in cross-section a portion of the radiating surface within the casing and a closure between the edge of the radiating surface and the casing.

The sound radiator shown in Figs. 1, 2 and 3 comprises a box-like casing or frame 15, which may be made of wood or other suitable material, and which has an opening at the front and rear. A plurality of parallel supporting members 16 are located within and close to one edge of the casing 15 and are attached to the side walls thereof. These supporting members may be of wood and may be equally spaced apart in the casing. A similar supporting member 17 is located near the center of the casing or frame and is attached to the upper and lower walls of the frame in a position transverse to the parallel supporting members 16. Attached to each supporting member is a long narrow driving or torsional member 18 which may be constructed in a variety of shapes and materials but is preferably made of light stiff material, such as paper, and formed into a tube provided with opposite tangential webs 19 and 20. The webs 19 of the parallel driving members 18, which are horizontally disposed in the form illustrated, are attached or glued to the lower flat surfaces of the supporting members as shown more clearly in Fig. 4, while the web 19 of the transverse driving tubular member 18 is glued to the flat surface of the transverse supporting member 17. The tubular driving members 18 form light rigid levers or torsional members which are fulcrumed along one edge by the webs 19 and are connected to a driven vibratory surface 21, such as a large plane diaphragm or sound radiating surface, by the opposite webs 20 of the torsional members. The edge 22 of these webs is bent at right angles to the plane of the web and attached to the surface of the diaphragm 21 along the whole length of the driving members 18.

The connection of the driving members or torsional tubes 18 both with the diaphragm and with the casing or frame along the horizontal and vertical webs of the torsional distributing system which they constitute forms an efficient means of supporting the radiating surface substantially solely by the distributing system. When the number of tubular members distributed over the large plane surface of the diaphragm is small the surface should have a proportionately higher degree of flexural rigidity. By increasing the number of driving tubes 18 connected to the diaphragm a lesser degree of flexural rigidity is necessary in the diaphragm surface and it is possible to impart vibratory movement to a large radiating surface of small flexural rigidity simply by arranging the driving tubes or members close together and supporting the radiating surface by means of the webs projecting from the torsional driving members.

The large radiating surface or diaphragm 21, as shown in the drawing, is out of contact with the walls of the casing 15 and while the surface may be arranged within the casing so slightly separated therefrom that the air displacement through the space between the edge of the radiating surface and the casing causes very little detrimental effect, it may be desirable to close the space between the edge of the diaphragm and the casing. This may be accomplished by means of strips of flexible material 27, such as felt.

A driving motor element, such as an electromagnetic unit 23, is centrally positioned in the casing 15 and supported on a base 24 extending between the upper and lower walls of the casing. The driving rod 25 projecting from the unit 23 is coupled to the mid-point of the transverse torsional driving member 18 by the rigid link member 26 in such a manner that the driving member is turned or twisted about a longitudinal axis. Through the medium of the transverse driving member 18, the energy supplied by the motor element 23 is applied to the other driving tubes 18 and torsionally transmitted by them to substantially all portions of the area of the radiating surface 21 at a velocity that is high as compared with the flexural velocity of propagation in the material of the radiating surface. This is accomplished by the reaction upon the diaphragm of the torsional forces set up in the driving tubes with reference to their fulcrum upon the frame, the forces being exerted through the continuous webs through which the tubes have connection with the diaphragm and casing.

In Fig. 5 is shown a modification of the invention in which no continuous plane radiating surface is employed for imparting sound waves to the air. Instead, the torsional distributing system acts as a sound radiator and comprises a structure in which a large number of parallel supporting members 28 are arranged in the center of the casing 15. The torsional members 30 are similar to those employd in the structure described in the preceding figures but have single webs 29 which

are fastened to the lower surfaces of the supporting members 28. The torsional tubes are arranged as close together as possible, and a thin tongue of felt 31, or other suitable material, also attached to the supporting strips 28 has its free end in the plane of the axes of the torsional tubes 30 and substantially fills the air space between the tubes. The close relation of the horizontal torsional tubes 30 causes them to act as a substantially continuous radiating surface. Vibratory motion is imparted to the closely spaced parallel members 30 by a single transverse torsional member 32 which lies to the rear of the horizontal member and extends through cut-out portions in the supporting members 28, webs 29 and tongues 31 as shown in Fig. 6. The transverse torsional member 32 is connected to the members 30 by short, light, rigid rods 33 which extend tangentially from the torsional member 32 and are attached to the members 30 at a point diametrically opposite the point of contact of the tangential web 29. A continuous tangential web 34 on the transverse tubular member 32 is attached to a supporting member 35 which extends from the upper to the lower wall of the casing 15 and may be attached to the supporting members 28 by a notched joint. The transverse torsional member 32 is therefore fulcrumed along one edge by the web 34 and is connected on the opposite edge to the driven system of torsional members 30 by the connecting rods 33. A driving element 36 supported on a vertical baseboard 37 has its driving rod 38 connected to the free end of an arm 39 rigidly attached to the torsional member 32 intermediate the ends thereof.

Figs. 7 and 8 show a further modification in which a light but relatively rigid radiating surface is driven by the torsional distributing system of this invention. The parallel torsional members 41 are provided with oppositely disposed tangential webs 42 and 43. The members 41 are arranged in the casing 15 and are equally spaced and supported by the strips 44 extending from the side walls of the casing 15. A driving torsional member 45 is arranged transversely to the rear of the parallel torsional members 41 and located equi-distant between the ends of the members 41. The transverse torsional member 45 is supported by its continuous web 46 extending toward the rear of the casing 15 and attached to the associated supporting member 47 in a manner similar to the construction described in connection with Fig. 5. The coupling of the driving member 45 to the parallel members 41 consists of light rigid rods 48 attached to the members at points opposite the tangential supporting webs. An arm 49 extends from the driving member 45 and is attached to the rod 50 of the electromagnetic unit 51 supported on the base 52 attached to the casing. The ends of the parallel webs 43 of the driven torsional members 41 are bent downwardly to form connecting surfaces for the sound radiating surface 53 which is made of relatively light material, such as paper. The radiating surface is made comparatively rigid by the corrugations 54 which extend along the surface of the sound radiator in a direction transverse to that of the torsional members 41. A suitable border of light felt strips 55 surrounds the edge of the radiator 53, to close the air space between the casing and the radiating surface.

A simple method of forming the light rigid tubular torsional members employed in the distributing drive of this invention is shown in Figs. 9, 10 and 11 in which long strips of material 56, such as paper, are placed between two halves of a cylindrical form 57, made of wood. The wooden form 57 is rotated 90° while the ends of the paper strip 56 are held in a horizontal plane as shown in Fig. 10, and a plastic substance, such as glue or paste, is applied to the surface of the paper strip along a line shown at 58. The form 57 is then rotated 180° while pressing the extending ends of the paper toward the cylindrical form sufficiently to bind the adjacent surfaces of the rolled paper strip as shown clearly in Fig. 11. When the glue or paste has dried the semi-cylindrical halves of the form may be removed, being made collapsible for that purpose if desired, and a light rigid tubular member is produced in which the central portion 59 forms a strengthening means for the tube and the ends 60 and 61 project tangentially from the opposite surfaces of the tube to act as webs.

In Fig. 12 is shown other means for closing the air space around the edge of the radiating surface. This arrangement consists in attaching a strip 62 of light material, such as tissue or silk, to the edge of the diaphragm 63 and the casing 64.

The use of "torsional member" or equivalent term in the specification and claims is intended to include both solid and hollow members of variously shaped cross-sections, and of various materials. For example, hollow tubular torsion members such as those specifically disclosed may conveniently be formed of light, thin, elastic sheet metal, such as duralumin.

What is claimed is:

1. An acoustic device comprising a radiating surface having small flexural rigidity, a driving element, and a multiple distributing drive system connecting said driving element with substantially all portions of the area of said radiating surface and adapted to communicate energy from said driving element to substantially the entire area of said radiating surface at a velocity high compared with the velocity of flexural propagation through the material of said radiating surface.

2. An acoustic radiator comprising a diaphragm, a driving element, and a torsional system distributing driving force from said element to substantially all portions of the area of said diaphragm simultaneously.

3. An acoustic radiator comprising a diaphragm, a driving element, a torsional system distributing driving force from said element to substantially all portions of the area of said diaphragm simultaneously, and means for supporting said diaphragm solely by said torsional system.

4. An acoustic radiator comprising a diaphragm, a driving element, and a torsional system distributing driving force from said element to continuous parallel paths of said diaphragm substantially simultaneously.

5. An acoustic radiator comprising a diaphragm, a driving element, and a multiple torsional system arranged to support said diaphragm and distribute driving force from said element thereto.

6. An acoustic radiator comprising a sound radiating surface, a driving element, and a multiple torsional power distributing system arranged to support said surface and connect said surface with said driving element.

7. An acoustic radiator comprising a sound radiating surface, a multiple torsional driving support for said surface, and means for imparting vibratory motion to said driving support.

8. An acoustic radiator comprising a driving element, a multiple torsional distributing system driven thereby, and a radiating surface supported by said system and receiving vibratory movement therefrom.

9. An acoustic radiator comprising a radiating surface, a driving element, and a distributing system connecting said driving element with said radiating surface, said distributing system comprising a plurality of parallel members extending across one face of said surface and adapted to distribute energy from said driving element to said radiating surface at a velocity high as compared with the flexural velocity of propagation in the material of the radiating surface.

10. An acoustic radiator comprising a radiating surface, a driving element, and a distributing system connecting said driving element with said radiating surface, said distributing system affording a plurality of torsional energy communicating paths between any part of said radiating surface and said driving element.

11. An acoustic radiator comprising a radiating surface having small flexural rigidity, a driving element, and a torsional distributing system connecting said driving element with said radiating surface and adapted to impart substantially bodily movement to said radiating surface at low frequencies.

12. An acoustic radiator comprising a radiating surface having small flexural rigidity, a driving element, and a distributing system connecting said driving element with said radiating surface and adapted to communicate energy from said driving element to substantially all portions of the area of said radiating surface at a velocity high as compared with the flexural velocity of propagation in the material of the radiating surface.

13. An acoustic radiator comprising a driving element, a plurality of parallel driven torsional members, and a transverse driving member connecting said driving element to said parallel members to impart vibratory motion to said members substantially simultaneously.

14. An acoustic radiator comprising a driving element, a plurality of parallel driven torsional members, a transverse driving member connecting said driving element to said parallel members, and a radiating surface connected to and moving with said parallel members.

15. An acoustic radiator comprising a driving element, a plurality of parallel members, a transverse member, means for connecting said transverse member to said parallel members, and means for connecting said driving element to said transverse member to impart torsional movement to all of said members substantially simultaneously.

16. An acoustic radiator comprising a driving element, a plurality of parallel torsional members, a transverse torsional member, means for connecting said transverse member to said parallel members, means for connecting said driving element to said transverse member, and a large radiating surface actuated by said members.

17. An acoustic radiator comprising a driving element, a plurality of parallel torsional members, a transverse torsional member, means for connecting said transverse member to said parallel members, means for connecting said driving element to said transverse member, and a large radiating surface actuated by said members, said radiating surface being supported solely by said parallel torsional members.

18. An acoustic device comprising a casing, a driving element, a plurality of parallel torsional members having continuous webs, means for supporting said webbed members from said casing, a transverse torsional member coupled to said parallel members, and means for connecting said transverse member to said driving element.

19. An acoustic device comprising a casing, a driving element, a plurality of parallel torsional members having continuous webs, means for supporting said webbed members from said casing, a transverse torsional member coupled to said parallel members, said

transverse member being connected to said driving element, and a sound radiating surface supported by said parallel members.

20. A tubular drive member for an acoustic device having a strengthening portion within the member and a tangential web projecting therefrom.

21. A distributing device for sound radiators comprising a tubular member having an integral strengthening portion within the member and an integral extension projecting therefrom.

22. The method of forming a rigid member of light flexible material for an acoustic device on a collapsible die which comprises, placing said material centrally between two halves of said die, bending the projecting ends of said material at opposite right angles with respect to the portion of material between said die, applying adhesive material to each projecting end on a line defined by the right angle bend, rotating said die one half revolution while pressing said projecting ends against said die and adhesive material, and removing said die.

In witness whereof, I hereunto subscribe my name this 27th day of October, A. D. 1927.

EDWIN H. SMYTHE.