Feb. 22, 1966 A. B. COHEN 3,236,958

LOUDSPEAKER SYSTEM

Filed April 25, 1961 4 Sheets-Sheet 1

Fig. 1

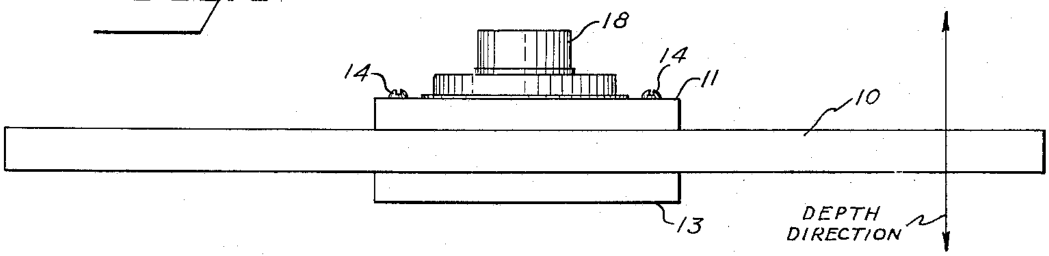


Fig. 2

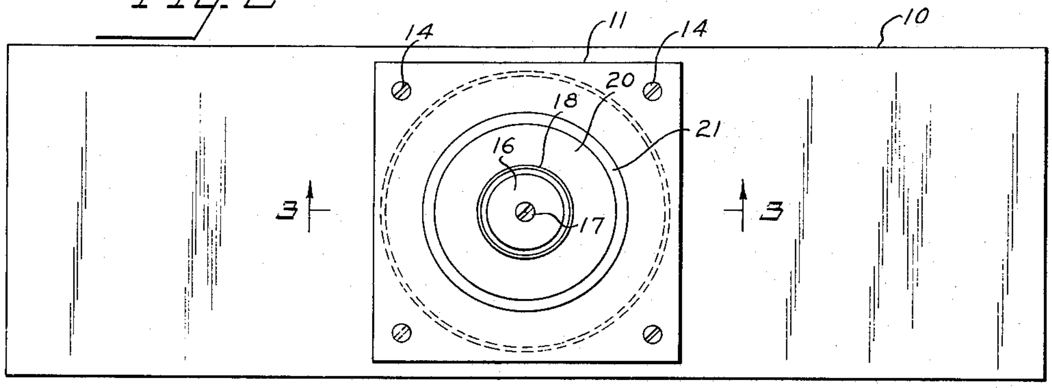
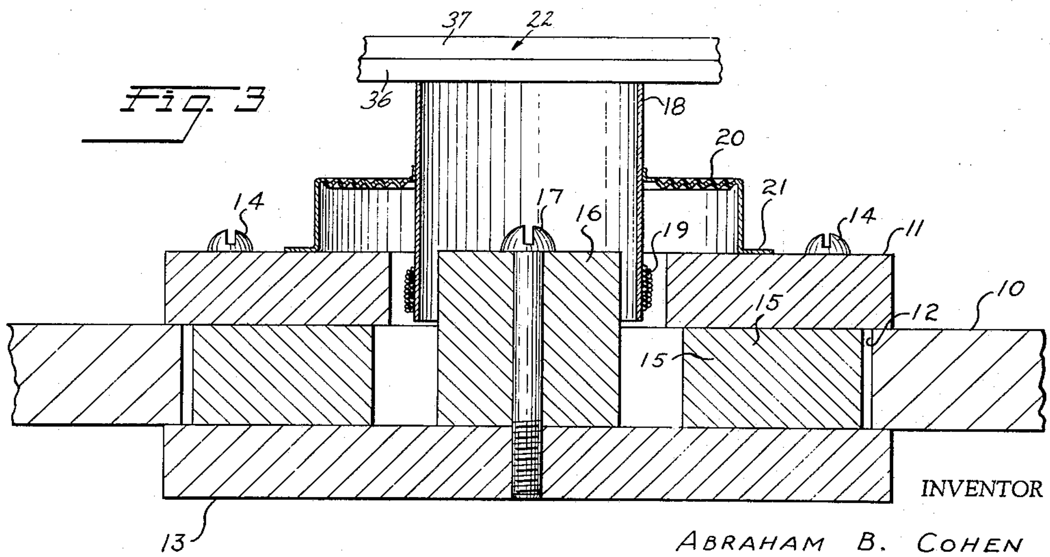


Fig. 3



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LOUDSPEAKER SYSTEM

Filed April 25, 1961

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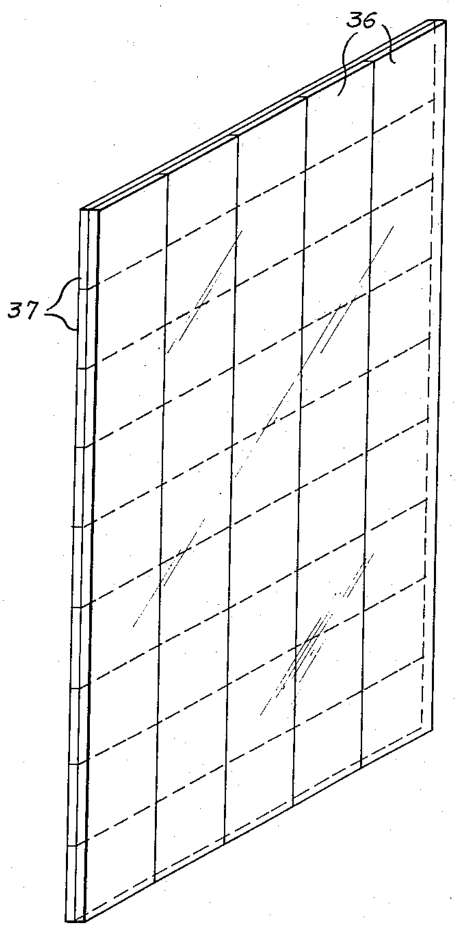
Fig. 4



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LOUDSPEAKER SYSTEM

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FIG. 8

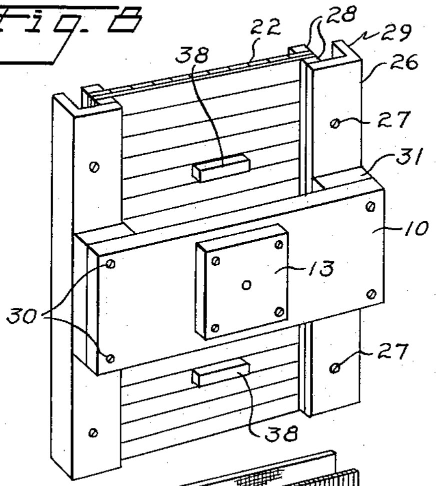


FIG. 11

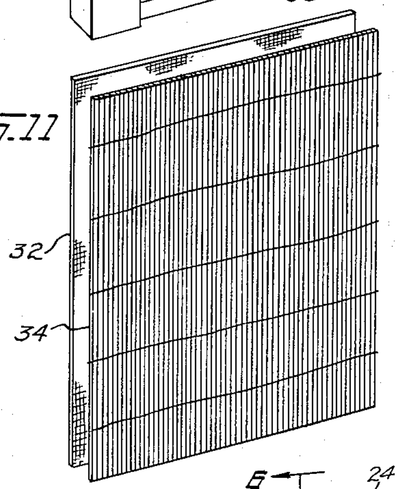


FIG. 5

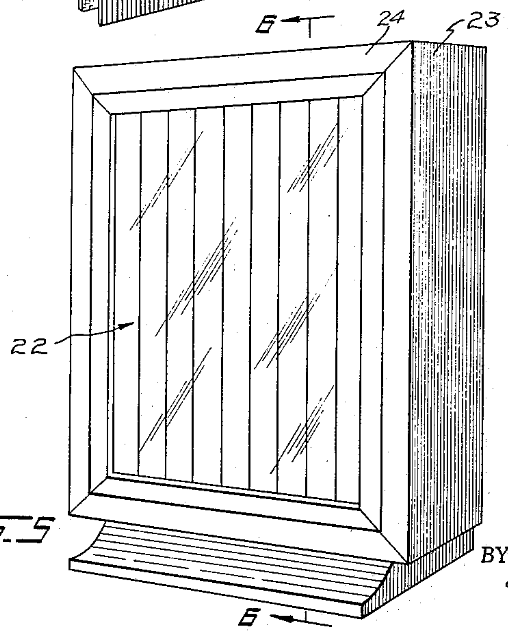


FIG. 7

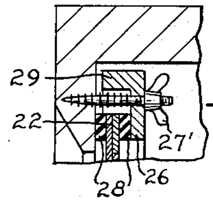
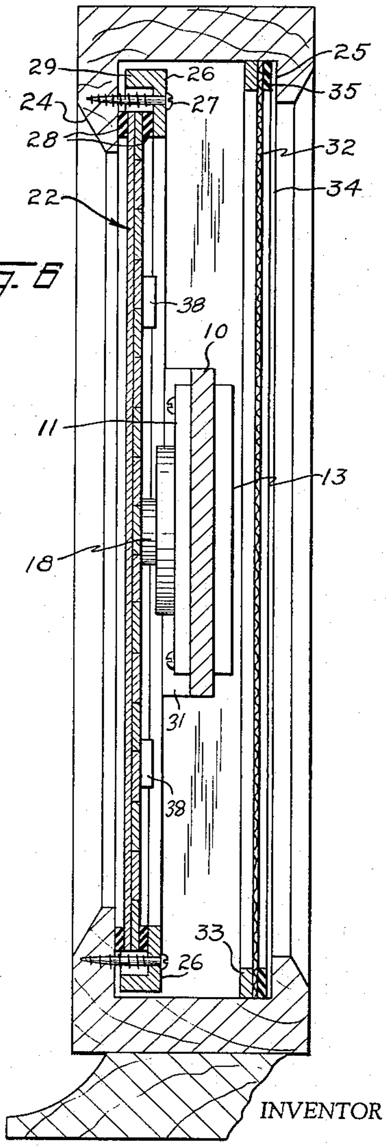


FIG. 6



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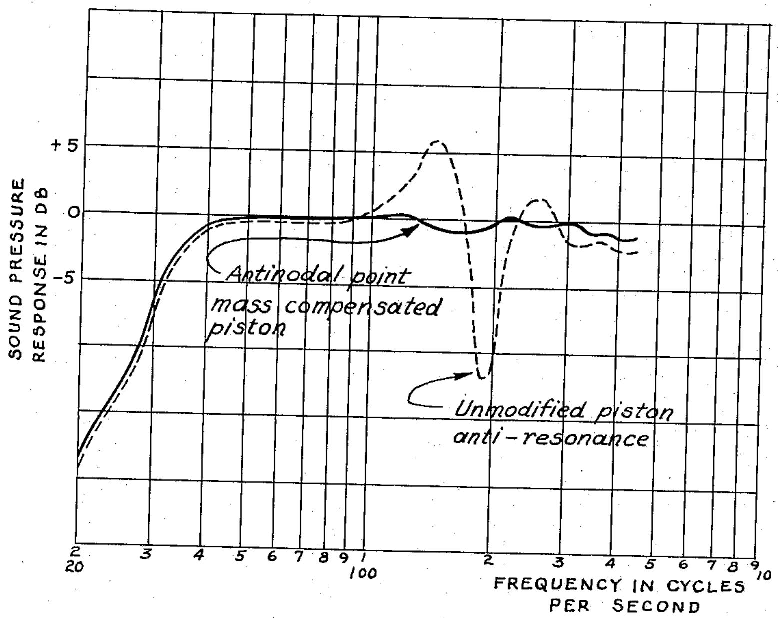


Fig. 9

Fig. 10A

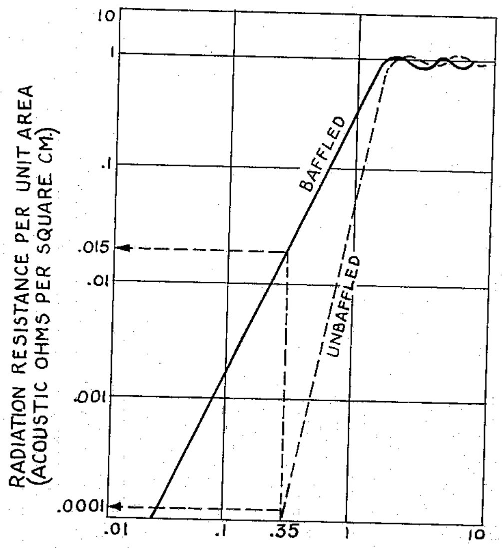
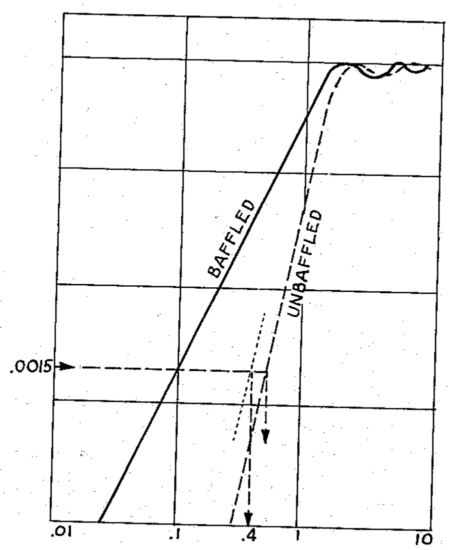


Fig. 10B



CIRCUMFERENCE / WAVELENGTH c/λ RATIO

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United States Patent Office

3,236,958

Patented Feb. 22, 1966

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3,236,958
LOUDSPEAKER SYSTEM

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Filed Apr. 25, 1961, Ser. No. 105,315
5 Claims. (Cl. 179—115.5)

This invention relates to a loudspeaker system and more particularly to an improved loudspeaker system of a type employing a flat extended, rigid vibratile piston driven by an electric voice coil situated in a magnetic flux gap, which flat vibratile structure is particularly adapted for faithfully reproducing the lower frequencies of the acoustical spectrum from a structure which is exceptionally flat in depth, employs no front to back interceptive baffling system, and which provides effective double sided radiation.

It is well known in the sound reproducing art to employ loudspeakers having conical diaphragms formed from paper pulp and the like. Such conical diaphragm configuration is necessitated by reasons of physical rigidity to prevent diaphragm buckling under conditions of wide excursions. To reproduce the lower acoustical register it is common practice to increase the depth of the cone and the diameter of its base in order to further increase both the rigidity of the piston and its acoustic coupling area. Because of the necessity of making the cone deeper, the usual bass reproducing speaker is very often as great in depth as it is in diameter. This necessitates deep enclosures to accommodate the deep speaker units, and the complete assembly is accordingly large and clumsy. However, the present invention employs a completely flat and rigid vibratile piston and a correspondingly flat driving system which does not require a deep housing to contain it, and which is, therefore, of considerable advantage in space requirement.

In conventional enclosures, the design of the internal volume and its relative size and shape will determine the degree to which the speaker which is mounted in the enclosure will reproduce the low bass notes. These enclosures may be either closed boxes, tuned boxes (bass reflex) or horn loaded systems, and their primary purpose is to prevent destructive interference between the acoustically radiated wave from the front of the piston and the acoustically radiated wave from the back of the piston. Sound is, therefore, radiated into the room from only one face of the reproducing system. This invention provides a system whereby such back to front wave cancellation from the vibrating flat piston is eliminated within the range of audible reproduction of the piston without the use of wave restrictive enclosures, thus permitting front and back radiation simultaneously with increased liveliness of sound reproduction resulting from direct sound rays from the speaker system reaching the listener's ears, reinforced by room reflected rays from the back of the speaker system.

Conventional speaker systems which use enclosure devices have a radiation pattern which is essentially a hemisphere at low frequencies causing widespread and random distribution of low frequencies throughout the listening area with contingent ambiguity of the direction from which the low frequency sounds originate. Consequently the directivity of low frequency sound emanations from boxed enclosures is obscured and is largely ineffective as far as stereo reproduction is concerned. In fact, many stereo loudspeaker systems of the low price group actually combine the low frequencies from both channels in one reproducer—"blended lows"—on the basis that low frequency directivity is not important for stereo reproduction. This is of course actually a compromise for where price is not the governing factor, and space is available, then stereo systems invariably use two complete spectrum systems, one for each channel—to produce the full stereo effect. Notwithstanding this latter system however, low frequency directivity is still nondescript from closed box sources because of their hemispherical pattern as compared to the sharper narrower beams for the high frequency sounds which pinpoint them in space quite easily. The reproduction of all the sound from the flat piston diaphragm of this invention is generally of a figure eight beam pattern so that increased directivity of sound emanations from the system will be enhanced over the entire reproduced spectrum.

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In general, low frequency performance of a loudspeaker is dependent upon the resonant frequency of the vibratile system. This resonant frequency is determined by the mass of the moving system, and the stiffness (or compliance) with which it is suspended and free to move. Once the component parts have been assembled there is no arrangement presently known in the art by which the natural resonant frequency of the vibratile member may be altered to meet controlled performance specifications. This invention employs a vibratile structure whereby in the assembly of the reproducing unit it is possible to vary the resonant frequency of the assembly at will within wide limits.

To a great extent loudspeakers using paper cones are used for the reproduction of music. However, no standard musical instrument utilizes any similar paper cone diaphragm for the original production of the sound. In order to provide a reproducing system that more nearly approaches the physical structure of musical instruments such as a bass violin, this invention provides means whereby the vibratile system very closely simulates the vibrating systems of such stringed instruments, the sound boards of pianos, the stretched head of the percussion instruments, and yet at the same time is accurately responsive to the energizing signal for faithfully reproducing the complex tones of the rest of the orchestral family.

In present loudspeaker system practice, it is the usual procedure to mount a complete speaker unit into one of very many types of enclosures where the speaker and the enclosure are completely independent components which are subsequently combined through mechanical fastening means into a compound assembly. This invention provides means whereby a flat vibratile member, its energizing magnetic component and its mounting frame are all intimately and integrally assembled mechanically and electrically as one component which requires no further mounting or baffling in any other enclosure.

In conventional loudspeakers designed for low frequency reproduction it is present practice to provide a vibratile cone structure capable of wide axial excursions in order to produce sufficient air motion to provide adequate sound pressure at low frequencies. To minimize driving distortion in such systems, the signal voice coil which is attached to the apex area of the vibratile cone and which moves axially within the magnetic flux gap, is usually designed so that as much as 50% of the signal receptive coil does not intimately link the magnetic flux circuit to the end that as the structure vibrates axially, the excess portions of the coil that symmetrically extend outside the magnetic gap and that cyclically move into and out of the gap, provides a continuous linkage between the flux in the gap and a constant number of turns of wire on the signal coil. While such a system provides a measure of magnetic linearity which gives some insurance of minimized distortion at low frequencies, there are however, attendant disadvantages to such "overhanging coil" systems. Due to the fact that such a large portion of the signal receptive coil does not continuously link the magnetic gap flux, an accordingly proportionate part of the signal power is lost in the overhanging coil portions which results in low efficiency of transduction of electrical power to acoustic power. While this deficiency in transduction efficiency may be compensated by providing a more powerful driving amplifier, a more serious defect of such overhanging coil systems is the corresponding loss of electrical braking—or damping effect—for the signal current in the overhanging coil portions that do not link the magnetic circuit. In other words, these overhanging coil portions neither provide driving traction, nor braking effect. To compensate for this mode of performance, such systems usually provide a very large measure of acoustical resistive damping by filling the back of the sealed enclosure housing the system with acoustically resistive material.

By this invention clean low frequency reproduction with excellent electrical efficiency and high electrical damping are obtained by providing an exceptionally large and heavy vibratile system which greatly reduces the necessary diaphragm motion for producing the required sound pressures. In one form which has been reduced to practice, a flat diaphragm vibratile member is provided which is approximately eight times the area of the conventional 12" loudspeaker of the aforementioned type. Essentially this means that the flat vibratile member of this invention need move only one eighth the axial distance to produce the same sound pressure as the conventional loudspeaker. Furthermore, since the large flat vibratile member is also about eight times as heavy as the conventional cone diaphragm, the stiffness by which it must be suspended to resonate at the correspondingly low frequency is accordingly eight times as great. Therefore, since the large flat vibratile member motion is so greatly reduced and its stiffness resistance to motion is so greatly increased while yet producing the required sound pressure field as the large free excursion type cones, its driving voice coil need not be of the overhanging type. The voice coil is in fact very closely engineered to match the magnetic gap dimensions, so that there is actually full and complete coupling between the signal current and the magnetic flux, and consequently there is comparatively excellent electrical braking—or damping—between the signal current and the magnetic circuit. Accordingly by this invention, due to the high electrical damping, no significant acoustic damping is required which in part permits the use of the previously explained unbaffled system and expansive dipole radiation, and correlatively produces undistorted low frequency radiated power.

In accordance with this invention, then, the disadvantages of previously known loudspeakers and enclosures are eliminated by a system which is very flat in the depth direction, which produces an enlarged sound perspective by its dipolar radiation from both front and back faces of the vibratile member, which eliminates the necessity of enclosures or compensating baffles, and which may be adjusted in assembly to resonate over a wide bank of low frequency limits.

It is accordingly an object of this invention to provide a loudspeaker system which is very compact especially in the depth dimension.

It is a further object of this invention to provide a loudspeaker system wherein a flat vibratile member with its driving coil and magnetic system energizing it together with a supporting frame are intimately integrated in electrical and mechanical relationship.

It is still a further object of this invention to provide a loudspeaker system capable of reproducing the lowest of audible frequencies, which acts as a dipole radiator without low frequency wave cancellation problems and which does not require baffling or a separate enclosure.

It is still a further object of this invention to provide a loudspeaker system which is acoustically adjustable as a complete unit.

Still another object of this invention is to provide a loudspeaker system which is particularly adapted for the undistorted reproduction of the lower frequencies of the acoustical spectrum.

It is still another object of this invention to utilize the principles of sound propagation of musical instruments in a loudspeaker system.

A still further object of this invention is to provide means of control over the modal vibrations of flat pistons to insure uniform vibrations of all parts of the flat plane of the piston.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The organization and manner of operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 illustrates one unit, the magnetic driving system, of the invention.

FIG. 2 is a top view of the structure illustrated in FIG. 1.

FIG. 3 is an enlarged cross-sectional view of the structure shown in FIG. 1, and illustrates the internal structure thereof in detail.

FIG. 4 illustrates in detail a preferred form of diaphragm that can be employed in this invention.

FIG. 5 is a front view of the complete loudspeaker system of this invention.

FIG. 6 is a side view of FIG. 5 taken along section line 6—6 to illustrate the internal structural detail thereof.

FIG. 7 is an enlarged view of a portion of FIG. 6 showing an alternative clamping means.

FIG. 8 illustrates the structure shown in FIGS. 1, 2 and 3 assemblied to another unit, the adjustable pressure plates, of this invention.

FIG. 9 represents the acoustical response as a function of frequency of the loudspeaker system of this invention.

FIGS. 10A and 10B represent radiation resistance curves for baffled and unbaffled loudspeaker systems.

FIG. 11 illustrates in detail the rear panel shown in FIG. 6.

Referring now to FIGS. 1, 2, and 3, the magnetic structure for forming the magnetic flux gap is mounted on a support board or member **10** in such a manner that the support member **10** embraces the central portion of the magnetic circuit structure itself in the depth direction, thus permitting minimization in the depth direction as indicated in FIG. 1. Accordingly a top plate **11** of high permeability material and having a central circular opening is mounted over a circular orifice **12** in support board **10** as shown in FIG. 3. Similarly, a bottom plate **13** of high permeability material is placed on the underneath side of support board **10**. The top plate **11** is provided with corner screw holes and bottom plate **13** has corresponding tapped holes for threadably receiving retaining screws **14**. A ring permanent magnet **15** preferably of ceramic ferrite magnetic composition and having a diameter slightly less than orifice **12** is placed symmetrically in orifice **12** and secured by top plates **11** and **13**.

A cylindrical pole piece **16**, also of high permeability material, is secured to the center of bottom plate **13** by means of screw **17** and extends through the central openings in ring magnet **15** and top plate **11** to approximately the upper surface of the top plate. The annular space between the top plate **11** and pole piece **16** forms a high gauss magnetic flux gap.

The voice coil form **18** carrying turns **19** is accurately positioned symmetrically in the flux gap by an alignment tool and secured in this position by spider **20**. Spider **20** has a flange **21** which is affixed to top plate **11** by a suitable adhesive such as an epoxy base compound. Turns **19**, though almost completely covering the axial length of the magnetic circuit annular gap do not extend to the very ends of the gap, so that in operation, when electrically driven, all the turns of the voice coil remain in the gap under the condition of very small excursions of the piston as previously explained. This complete immersion of the voice coil turns **19** in the magnetic gap annulus thus insures high magnetic linearity, high efficiency and high damping.

FIG. 4 illustrates a preferred embodiment of the flat planar vibratile member **22** as employed in this invention. Member **22** is comprised of a cross laminated system using a plurality of selected wooden strips **36** running in the direction of the major dimension of the piston, and a plurality of like wooden strips **37** arranged in a direction of the minor dimension of the piston. These wooden strips are individually edge bonded to each other at their long dimensions and the two laminar sections are also bonded to each other by means of an adhesive which insures a complete and permanent bond at the interface between the laminar sections. The method of making the vibratile system **22** from a plurality of strips **36** and **37** insures achieving a vibratile system of maximum uniformity over the entire face of piston **22** by choosing the individual strips **36** and **37** to possess the same mass and resilience characteristics. Thus maintaining such unit strip conformity of mass and resilience over the piston surface of **22** maximum uniformity and synchronism of motion to all parts of the piston with consequent uniformity of acoustical output is provided.

FIG. 5 is a front view of the complete speaker system showing the front face of the piston **22** in almost flush mounting to the front frame lip **24** of the overall frame **23** as shown in FIG. 6.

FIG. 6 is a side view of FIG. 5 with one vertical side removed for purposes of showing the internal structure and to illustrate the function of the various parts. The inner surface of the frame front lip **24** has affixed to it on all four sides compressible strips **28**, of rubber, for example. These strips of compliant material **28** are positioned around the inner face of lip **24** so that they will provide a resilient cushion directly mating with the outer front edges of the vibratile piston **22**. Piston **22** is placed upon the peripheral resilient cushion **28**, and a corresponding resilient cushion is affixed to the inner peripheral edges of piston **22** so that in effect the planar peripheral edges of piston **22** are sandwiched between the resilient rear and front cushions **28**. To secure piston **22** and cushions **28** in place, and provide a means of adjusting the compression of cushions **28**, there are shown L-shaped members **26** which are arranged in contact with the free face of the inner cushion **28** and are secured to the inside lip of **24** by either woodscrews **27** or by table leg bolts **27'** as shown in FIG. 7. The compression of the peripheral front and rear cushions **28** under the pressure of L-shaped members **26** will determine the stiffness of the supporting peripheral edge of the vibratile piston **22**, and by adjusting the tightness of screws **27** or wingnut assemblies **27'** the peripheral stiffness of member **22** may be adjusted to provide a very wide range of ratios of stiffness to mass, which ratio determines the free resonance frequency of the vibratile system when driven by an energizing source. In one version of this invention which has been reduced to practice, it has been possible to choose a resonant frequency from as low as 20 cycles per second to as high as 65 cycles per second, which is about an octave and a third in variation encompassing the entire ultra low frequency range which determines the bass response of the loudspeaker system.

To energize the vibratile system, the pot support board **10** assembly is secured to the vertical pressure members **26** and spaced away from them by spacers **31**, and secured by screws **30**, as shown in FIG. 8 which is a partial assembly view extracted out of FIG. 6. Referring back to FIG. 6, when the magnetic pot support is properly positioned, the forward circular edge of the voice coil form **18** must abut to the rear face of the vibratile piston **22** to which it is adhered by proper adhesive applications. To insure that this abutment of voice coil form **18** is properly made to the rear face of panel **22**, spacers **31** of FIG. 8 are proportioned to a depth between the pot support board **10** and pressure strips **26** such as to bring about this abutment to the right degree. When so positioned the voice coil form **18** is adapted to mechanically drive the piston assembly **22** when the voice coil form **18** is energized by the signal current.

When the vibratile system **22** is thus relatively stiffly clamped, and energized at its central point by voice coil form **18**, the vibratile system bows in and out with maximum excursion at the central driven point, and the degree of excursion gradually diminishes towards the peripheral edges. It may be thus generally classified as a "clamped" piston bowed at the center. It is well known in the art of physical vibrations of membranes that when a clamped membrane is thus energized there are set up various nodes of vibrations with trough and peaks determined by the energizing frequency, by the shape of the diaphragm, and by the physical constants of the material of the membrane. Whereas such nodes of vibrations are relatively well known for standard circular and homogenous membranes, the determination of such nodes and anti-nodal points can be determined only by approximate empirical methods for other than symmetrically contoured areas. For the type of flat vibratile systems which has been reduced to practice in this invention where one side of the vibratile system is approximately one and one half times the length of the other, and where the piston overall dimension is approximately 15" × 22", the node of vibration is such that at approximately 200 cycles per second there is a pronounced anti-resonance in the acoustic response of the system as indicated by the dotted curve of FIG. 9. By exploring the vibrations of the panel with a sound probe, it was found that there were anti-nodal points of vibration very nearly equidistant between the furthermost clamped extremities of the panel and the voice coil driving point. To eliminate the anti-nodal vibration areas, it is feasible to load these points with masses of proper weight that will cause the overall modal vibration display to change. The effect of adding these masses **38** (shown in FIG. 8) is to eliminate the pronounced acoustic drop at 200 c.p.s. and to smooth out the overall response curve as a whole as indicated by the solid curve of FIG. 9. This invention thus teaches a method whereby it is possible to improve and make uniform the vibration of irregular piston shapes by probing them acoustically for anti-nodal points, and then mass loading these points to upset their anti-resonance effect.

The acoustic power output of an acoustic radiator is determined by the air load against which the mechanical vibrations of the vibratile system works. It is apparent that the greater the area of the vibratile system, the more air will be engaged and more power will be radiated into the air load. It is also apparent that the more rapid the rate at which the mechanical pulses engage the air, the more power will be transferred to the air. To those skilled in the art, these two factors of vibratile piston size and frequency of vibration determine the "radiation resistance" that the piston "sees," and may be graphically represented as in FIG. 10A. This graphical presentation verifies what has been learned from every day practice, namely that for conventional speaker units, for a given size piston radiating at a given frequency (circumference to wave-length ratio), radiation efficiency will be greater when baffled than when unbaffled. Thus, for instance, if the piston is sealed off and operating at some frequency such that the ratio of piston circumference to wave-length is 0.35, then the radiation resistance will be .015

acoustic ohms per square centimeter. However, for the same piston unbaffled operating at the same frequency, the radiation resistance drops to .0001 acoustic ohms per square centimeter. This effect simply leads to the well known conclusion that when unbaffled, the piston will not produce as much low frequency power as when baffled, and gives rise to the need for baffle elements suitably matched to conventional speaker units to obtain proper bass response. However, for purposes of this invention, wherein one aspect of the invention is to provide a free unbaffled dipole radiating system and to maintain at the same time substantially the same low frequency power as from a baffled system, there is another manner in which this graphically represented radiation resistance function may be interpreted. The present objective in the light of the foregoing is to choose a radiation efficiency level that might be expected from a boxed piston, operating at a given frequency and then determine what size unbaffled piston will produce the same radiation resistance level. Thus for a given desired level of radiation, one simply moves horizontally from the baffled curve (FIG. 10B) to the unbaffled curve and can now determine a different circumference-to-wave-length ratio for the unbaffled piston which will produce the same radiation output as the same baffled ratio of piston circumference to the same wave-length. From FIG. 10B it will be seen that for a radiation resistance of .0015 for a ratio of .1 (small box condition), one can move horizontally to the unbaffled curve and find a value close to .5. Since, however, the wave-length is maintained constant, then the circumference of the unbaffled piston will have to be approximately five times as large as the baffled one to produce the same power output at the given frequency. Thus, by simply choosing the right size radiator, there can theoretically be reproduced, by means of an unbaffled piston, any desired low frequency power equivalent to that of a considerably smaller boxed piston.

However, for purposes of adaptability for home use, a piston size of 15" × 22" was chosen and even this size is not too critical. For example, if the figure of .0015 radiation resistance level for a circumference-to-wave-length ratio of .1 for a baffled piston is used and then moved horizontally to some intermediate value of the ratio of circumference to wave-length such as .4, which for a fixed frequency means a piston four times as large as the baffled one, then it is found that it is almost but not directly on the curve representing an unbaffled piston. At this ratio equal to .4, which represents an almost unbaffled piston condition, it may be expected that the same level of radiation as a baffled piston of one quarter its size will obtain.

Now the expression "almost unbaffled" may seem paradoxical. This is actually only a matter of semantics, for what is meant by a closed box is really a device that prevents the rear wave of the speaker from coming around to the front. Actually, then the phrase "somewhere between a closed box and an unbaffled piston" may be restated as "at some condition of radiation where part of the rear wave is kept from interfering with the front wave." With this interpretation, it becomes fairly easy to provide the necessary control of the radiation from the back side so that the piston will operate on the intermediary characteristic indicated on the graph of FIG. 10B.

Thus, in order to further adjust the acoustic output of the system there is provided a rear wave control to insert a small measure of attenuation into the acoustic power radiated from the rear of the vibratile system, which attenuation being small in nature and allowing the rear of the diaphragm to breath fairly freely through the acoustic attenuator, will not substantially upset the dipole radiation characteristics of the system. In one version of this present system which has been reduced to practice, the acoustic attenuation system consists of a combination of a panel of porous flannel cloth 32 shown in FIG. 11 over which is superimposed another porous yet decorative panel 34 of closely laced together bamboo strips, for example. The combined effect of the fibrous flannel resistance and the bamboo aperture resistance provides to the flow of air the necessary small amount of attenuation to premit bringing the unbaffled vibratile system down to a compact size suitable for home use without sacrificing any low frequency performance. The inner resistance panel 32 and the outer resistance panel 34 may be in contact one with the other and together may be stapled to the inner rear lip 25 of frame 23. Or in another version the decorative and resistive bamboo panel 34 and the inner resistive panel 32 are retained within the rear lip 25 of frame 23 by spacers 35 which press against the inner surface of rear lip 25. In this arrangement there is provided an air space between the two resistive panels which minimizes any tendency of these two resistive panels to flutter against each other under the action of the air pulses passing through them from the rear surface of the vibratile system 22.

From the foregoing description it can be readily understood by those skilled in the art, that a loudspeaker system is provided that is compact in aspect, and specifically in depth, ideally adapted for the faithful reproduction of the lower and middle bands of frequencies of the acoustical spectrum, which forms an integrated system which does not require a separate baffle or enclosure, and which utilizes in part the principles of musical instruments for the production of sound, and which provides for the propagation of a dipolar sound pattern which provides an extra depth perception to the reproduced sound.

While particular embodiments of the invention have ben shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. In a loudspeaker system, a magnetic structure and support therefor comprising a support member having an orifice therein, a ring magnet symmetrically situated in said orifice, top and bottom plates of ferromagnetic material and having major dimensions which exceed the diameter of said orifice, means for securing said plates together on opposite sides of said orifice such that said ring magnet is clamped therebetween, said top plate having an orifice therein, a cylindrical pole piece secured to said bottom plate such that it symmetrically extends through said ring magnet into said top plate orifice, a voice coil retained on a voice coil form, and a spider secured to said voice coil form and to said top plate to symmetrically support said voice coil in the gap formed by the orifice in said top plate and said pole piece.

2. The combination as set forth in claim 1 wherein the axial length of the voice coil is less than the length of the magnetic flux gap and said voice coil is located entirely within said flux gap.

3. In a loudspeaker system, a diaphragm composed of a plurality of layers of material laminated together with each layer of material composed of a plurality of relatively wide, flat, elongated strips of material secured together in parallel relation and along the longitudinal edges of the strips, the strips making up adjacent layers of the diaphragm being disposed at an angle to each other, a supporting frame for said diaphragm extending about the edges of the diaphragm, means fixedly securing the marginal portions of the diaphragm to said frame, a voice coil form, a voice coil mounted on said voice coil form, a magnetic structure embodying elements arranged in spaced relation and cooperating to form a magnetic flux gap of greater length than said voice coil, said voice coil being positioned wholly within said magnetic flux gap, and said voice coil form projecting beyond the end of

the voice coil and engaging said diaphragm near the center of the diaphragm.

4. A loudspeaker assembly comprising a substantially flat diaphragm, a frame extending about the marginal edges of the diaphragm, said diaphragm having its marginal edges fixedly secured to said frame, a substantially cylindrical voice coil form secured to the diaphragm adjacent the central portion of the diaphragm, a voice coil mounted on said voice coil form, a magnet supporting member extending substantially parallel to said diaphragm and spaced therefrom, said magnet supporting member having opposite ends secured to said frame and having a central portion spaced from the diaphragm and provided with a magnet receiving opening, a magnet located in said opening in the supporting member, pole pieces on the magnet presenting substantially parallel cylindrical surfaces surrounding and spaced from said voice coil form and voice coil, the axial length of said cylindrical surfaces of the pole pieces exceeding the axial length of the voice coil on said voice coil form, and means on said supporting member holding said magnet and pole pieces in fixed postions within the opening in said supporting member and with respect to said voice coil.

5. A loudspeaker assembly as defined in claim 4 wherein the diaphragm embodies a plurality of elongated, relatively flat, strips of material having substantially the same mass density and elasticity characteristics throughout, said strips being arranged in parallel relation and secured together in edge to edge relation throughout substantially the entire length thereof and cooperating to provide a flat diaphragm of substantial uniformity throughout the area thereof.

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