ACOUSTIC LOADING SYSTEM

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ABSTRACT

A loudspeaker system comprising an enclosure having at least one active radiator and at least one passive radiator mounted in respective openings in the enclosure. The passive radiator has a diaphragm supported by a highly compliant suspension. A mass is coaxially distributed and attached to the passive diaphragm. The mass is chosen so that the movement of the passive radiator will be substantially in phase with the movement of the active radiator within the frequency range of between approximately 20 Hz – 100 Hz. This mass is sufficient to reduce the natural resonance frequency of the loudspeaker system to a frequency substantially lower than its natural resonance frequency without the added mass attached to the passive diaphragm.

4 Claims, 10 Drawing Figures
ACOUSTIC LOADING SYSTEM
BACKGROUND OF INVENTION

1. Field of the Invention
The present invention relates to passive, radiators and more particularly to a massive passive radiator having an additional predetermined mass to improve the low frequency reproduction capability of an active radiator used in conjunction therewith.

2. Description of Prior Art
Passive radiators heretofore known are utilized to simulate the mechanical characteristics of the low frequency active radiator to smooth out its response. The passive radiators are also constructed with minimum mass. At low frequencies (16 - 50 Hz) within the audible range the output of the passive radiator will shift completely out of phase with the active radiator resulting in distortion and loss of gain.

SUMMARY OF INVENTION
It is a feature of the present invention to provide a loudspeaker system having a massive-passive radiator which will permit the active radiator to reproduce low frequencies of the musical or audible spectrum, reduce low frequency distortion and provide a substantial increase in the transducing at low frequencies, i.e., from 20 Hz to 100 Hz or even 150 Hz.

Further features of the present invention include the provision of a loudspeaker system which will provide a more closely linear response from BASS to MEDIUM by means of radical reduction of resonance peaks; improvement in bass transient response; reduction in unnatural colouration in bass frequencies and a reduction in cabinet resonant output (due to pressure build-up in the cabinet); direct the pressure build-up energy to be spent in useful sound radiation instead of producing spurious "box" resonances; and provide better bass handling power.

Accordingly, from a broad aspect, the present invention provides a loudspeaker system comprising an enclosure having at least one active radiator and at least one passive radiator mounted in respective openings in the enclosure. The passive radiator has a diaphragm supported by a highly compliant suspension. A mass is coaxially distributed and attached to the passive diaphragm. The mass is chosen so that the movement of the passive radiator will be substantially in phase with the movement of the active radiator within the frequency range of between approximately 20 Hz - 100 Hz. This mass is sufficient to reduce the natural resonance frequency of the loudspeaker system to a frequency substantially lower than its natural resonance frequency without the added mass attached to the passive diaphragm. The reduction in the natural resonance frequency is approximately one octave.

BRIEF DESCRIPTION OF DRAWINGS
A preferred embodiment of the present invention will now be described with reference to the accompanying drawings in which:
FIGS. 1A and 1B are front and rear views respectively, of a passive radiator constructed in accordance with the present invention;
FIGS. 1C and 1D are sectional side views of a passive massive diaphragm showing the suspensions;

FIG. 2 is a schematic cross-sectional view of a suggested enclosed loudspeaker system having an active radiator and a passive massive radiator;
FIG. 3A is an actual frequency response curve of a system embodying the present invention;
FIG. 3B is an actual power input curve of a loudspeaker embodying the present invention;
FIGS. 4A and 4B are actual frequency and power input curves of the same loudspeaker system as in FIGS. 3A and 3B but with the passive radiator having no additional mass, and
FIGS. 5 shows response curves representing the phase relation of the displacement values of the active radiator, the pressure values of the enclosure, the velocity values of the massive passive radiator and the displacement values of the massive passive radiator.

DESCRIPTION OF PREFERRED EMBODIMENTS
In the description that follows reference to the expression "massive passive radiator" is intended to mean a diaphragm mounted or suspended in an acoustic enclosure so that it will be as free as possible to move inward or outward in the enclosure port much like the diaphragm of an ordinary loudspeaker, but loaded with a suitable mass. The diaphragm is passive because it contains no motor or motive power source of its own and is actuated only by the pressure impulses generated in the enclosure by the back of an active radiator associated with it, while it is delayed or retarded in its motion by the reaction of its mass which offers resistance to all change in its state either of rest or motion.

Referring to FIGS. 1A to 1D, there is shown a massive passive radiator 10 having a diaphragm 20 supported between an exterior suspension 9 and an interior suspension 8. The diaphragm 20 is supported within a frame 7. A mass herein shown as an element 23 having a predetermined weight is secured to the diaphragm 20 and equally distributed about the center thereof. This mass may be secured to the diaphragm 20 and the suspension 8 by gluing it circumferentially in the diaphragm 20 and suspension 8 as illustrated by the example shown in FIG. 1C, or else could be glued or secured by other suitable means to the back of the diaphragm as illustrated in FIG. 2.

Referring to FIG. 2, there is shown a suggested loudspeaker system incorporating a massive passive radiator 10, according to the present invention. The system comprises preferably an air-tight enclosure 11 having two radiator ports 12 and 13 in the front wall 14 thereof. An active radiator 15, having a motor 17, is mounted within port 12 and the massive passive radiator 10 in port 13.

The diaphragm 20 of the massive passive radiator 10 is supported in port 13 preferably by a suitably flexible high-compliance air-tight suspension as shown schematically by numeral 21. It is possible, however, to obtain good results with a stiffer suspension. The massive passive radiator 10 may have a short or a long throw excursion. The diaphragm of the massive passive radiator 10 can be of any shape, i.e., conic, dome, oval, square or oblong or flat piston type.

The weight of the mass 23 is determined in accordance with the inner volume of the enclosure 11 being utilized for the particular loudspeaker system and calculated to make the fundamental resonant frequency of the passive diaphragm 20 equal to or lower than the
This is best illustrated by the accompanying vector graphs FIG. 5 where the curve 30 plots displacement values of the active diaphragm on the Y axis.

Curve 31 plots the enclosure pressure values on the Y axis. Curve 32 plots the velocity values of the massive passive diaphragm on the Y axis, and curve 33 plots the displacement values of the massive passive diaphragm on the Y axis. On the X axis are plotted the time or angular values of all the above values.

By referring to these vector graphs, it will be observed that the displacement values of the active radiator (curve 30) are 180° out of phase with the enclosure pressure values (curve 31). It is obvious that the pressure in the enclosure is minimum when the active diaphragm is in the extreme OUT displacement and conversely the pressure in the enclosure is maximum when the active diaphragm is in the extreme IN displacement.

Referring to curve 32, the velocity values of the massive passive diaphragm are observed to lag by approximately 90° behind the values of the activating enclosure pressure values, (curve 31).

Referring to curve 33, the displacement values of the massive passive diaphragm are observed to lag by approximately 90° behind its velocity values, (curve 32). This is quite logical: one must move (i.e., have motion, velocity) toward a goal (displacement) before one reaches that goal.

By these two 90° lag intervals (velocity of the massive passive radiator diaphragm, curve 32, behind the enclosure pressure, curve 31, on the one hand and displacement of the massive passive radiator diaphragm, curve 33, behind its velocity, curve 32, on the other hand, it is obvious that the displacement of the massive passive radiator diaphragm is 180° out of phase with the enclosure pressure values, curve 31, and therefore in phase with the displacement values of the active radiator diaphragm, curve 30, which is the result to be achieved whereby the back energy of the active radiator is radiated outwardly by the passive radiator and in phase with the active radiator.

It can be appreciated that the present invention makes use of the out-of-phase energy lost in the back by the active radiator and adds it in phase to the front radiation without loss of waveform. Also a high degree of efficiency is obtained in relatively small enclosures, in proportion to the volume delivered. Still further, the massive passive radiator is non-resonant within its frequency range. A still further important feature of the present invention is that it provides for a system permitting increased power input capabilities within the massive passive radiator frequency range. Further, any type and shape of enclosure can be used and the massive passive radiator can be mounted on any surface of the enclosure. Also, the massive passive radiator has a substantially constant time delay within its frequency range.

I claim:

1. A loudspeaker system comprising an enclosure having at least one active radiator and at least one passive radiator mounted in respective openings in said enclosure, said passive radiator having a diaphragm supported by a highly compliant suspension and a mass coaxially distributed and attached to said passive diaphragm, said mass being chosen so that the movement of the passive radiator will be substantially in phase with the movement of the active radiator within the frequency range.
frequency range of between approximately 20 Hz–100 Hz, said mass being sufficient to reduce the natural resonance frequency of said loudspeaker system to a frequency substantially lower than its natural resonance frequency without said added mass attached to said passive diaphragm, said reduction being approximately one octave.

2. A passive radiator diaphragm as claimed in claim 16 whereby the phase of said passive radiator diaphragm is retarded approximately 180°, relative to the phase of the back pressure of said active radiator, by said additional mass.

3. A passive radiator diaphragm as claimed in claim 16 wherein said additional mass is a weighted element secured substantially at the center of said diaphragm.

4. A passive radiator diaphragm as claimed in claim 1 wherein said loudspeaker enclosure is an air-tight enclosure.