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Fathollahi

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(54) **AUDIO SPEAKER ASSEMBLY**

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(51) **Int. Cl.**
H04R 25/00 (2006.01)

(52) **U.S. Cl.**
USPC **381/182**; 381/152; 381/431

(58) **Field of Classification Search**
USPC 381/152, 182, 190–191, 423–429, 431
See application file for complete search history.

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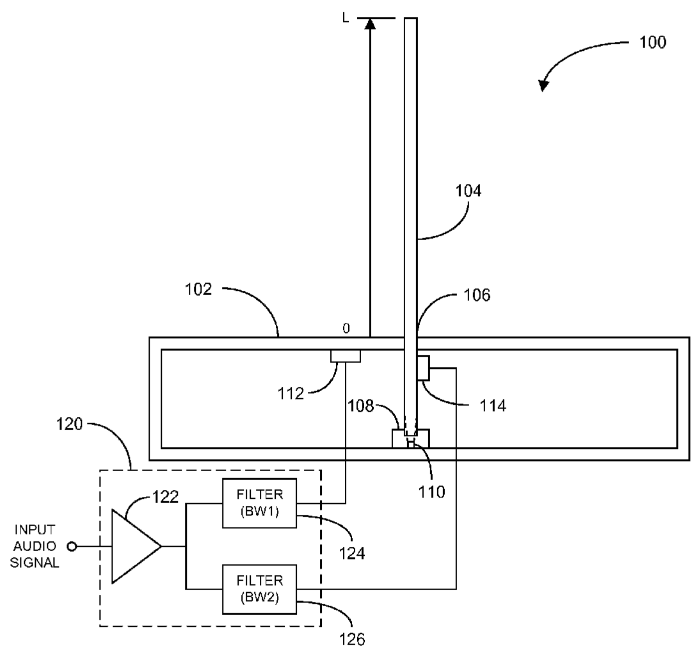
(57) **ABSTRACT**

An audio speaker assembly including a housing defining an internal compartment, and a glass membrane having a first portion supported in the housing and a second portion extending externally from the housing. The second portion having a length greater than its width, the length of the second portion extending orthogonal to the width of the housing, the second portion defining at least one aperture and a curved section formed along an edge of the glass membrane. A driver is mounted to the membrane that is responsive to an electrical signal causing the membrane to vibrate.

20 Claims, 11 Drawing Sheets



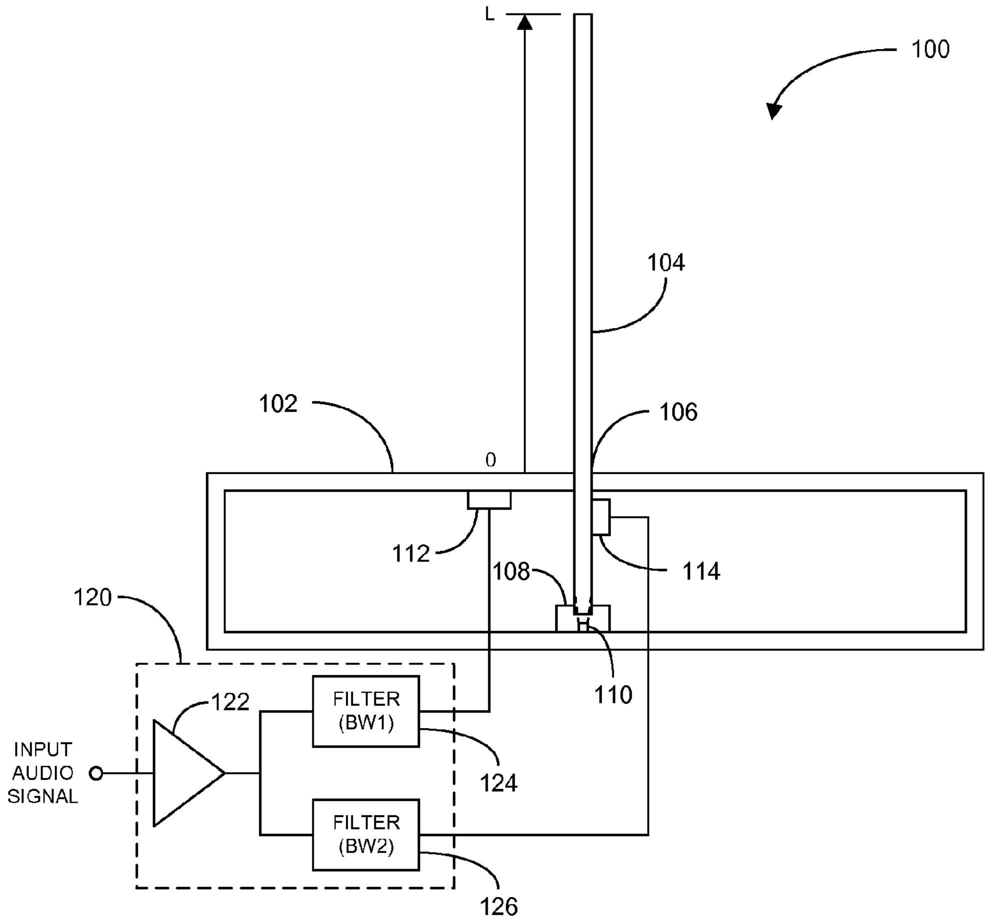

L
100
104
102
106
0
112
108
114
120
110
122
FILTER (BW1)
INPUT AUDIO SIGNAL
124
FILTER (BW2)
126

FIG. 1A

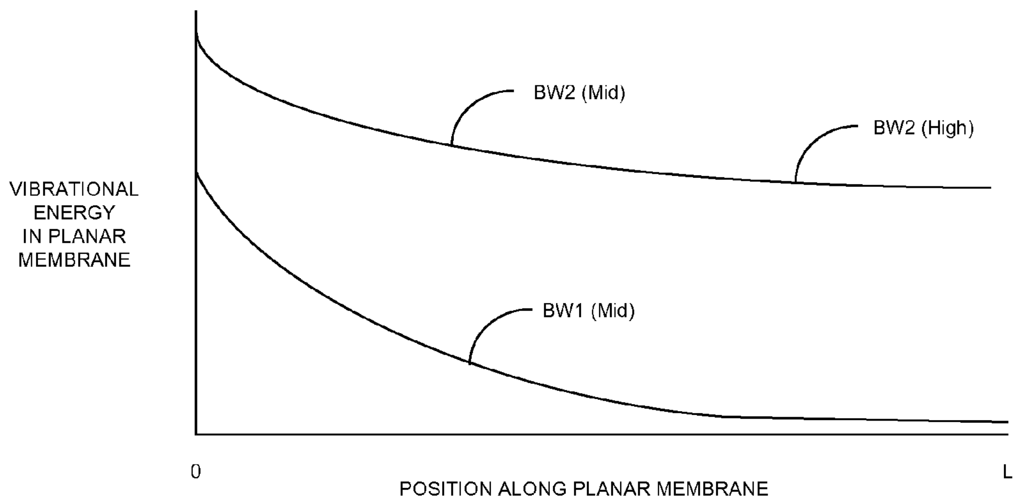

BW2 (Mid)
BW2 (High)
VIBRATIONAL ENERGY IN PLANAR MEMBRANE
BW1 (Mid)
0
L
POSITION ALONG PLANAR MEMBRANE

FIG. 1B

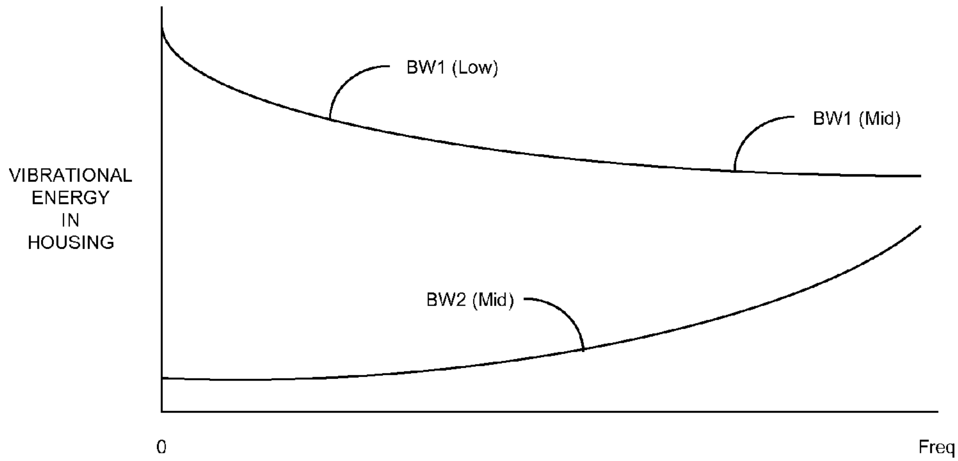

BW1 (Low)
BW1 (Mid)
VIBRATIONAL ENERGY IN HOUSING
BW2 (Mid)
0
Freq

FIG. 1C

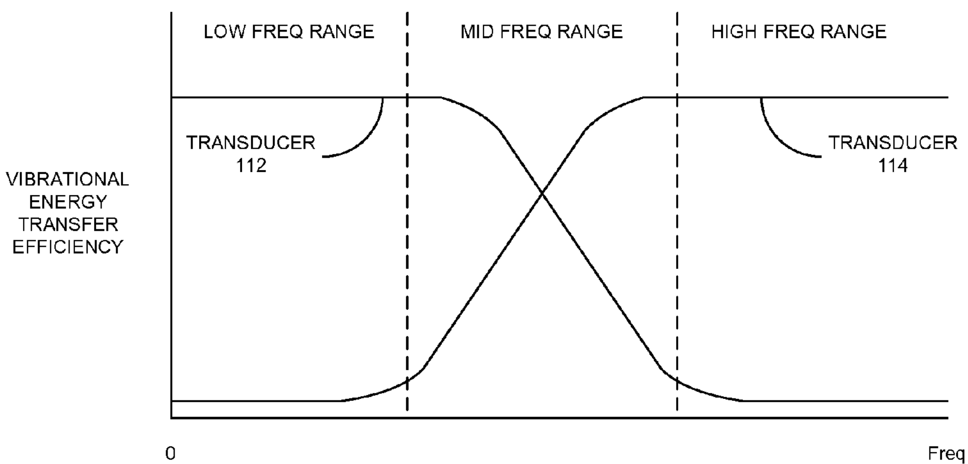

LOW FREQ RANGE
MID FREQ RANGE
HIGH FREQ RANGE
TRANSDUCER 112
TRANSDUCER 114
VIBRATIONAL ENERGY TRANSFER EFFICIENCY
0
Freq

FIG. 1D

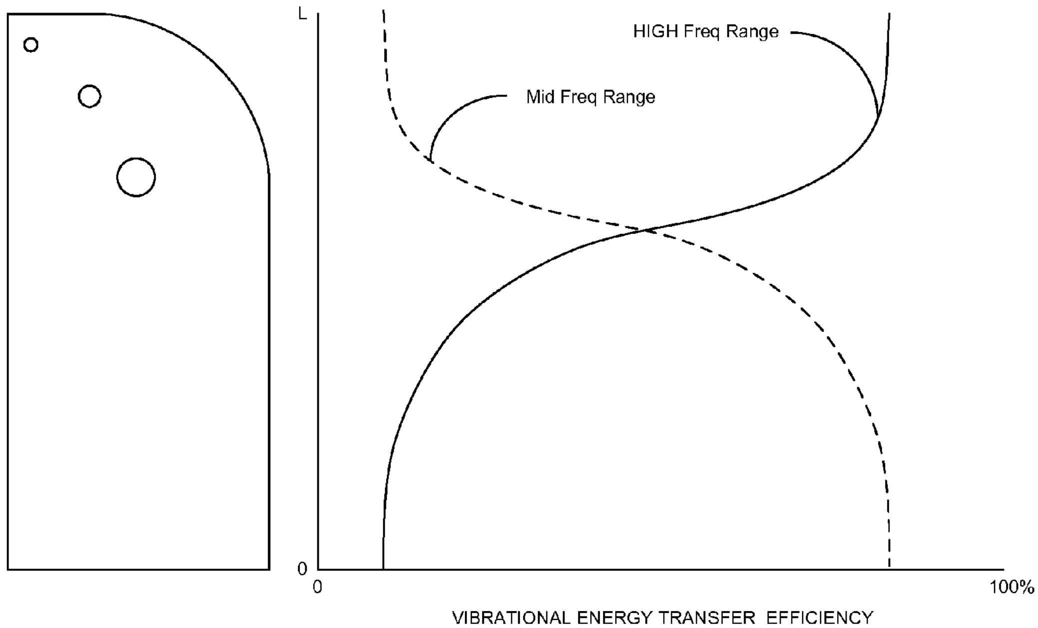

L
HIGH Freq Range
Mid Freq Range
0
0
100%
VIBRATIONAL ENERGY TRANSFER EFFICIENCY

FIG. 1E

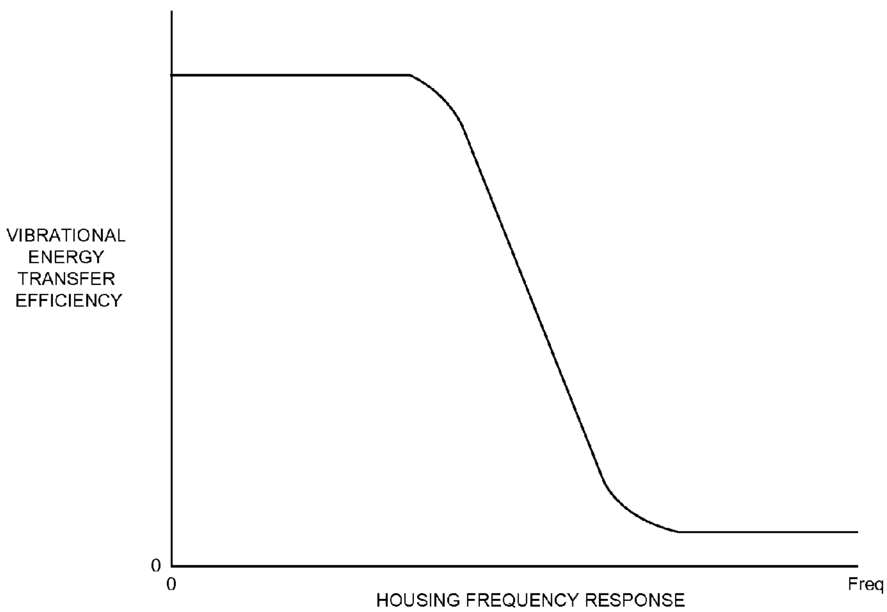

VIBRATIONAL
ENERGY
TRANSFER
EFFICIENCY
0
0
Freq
HOUSING FREQUENCY RESPONSE

FIG. 1F

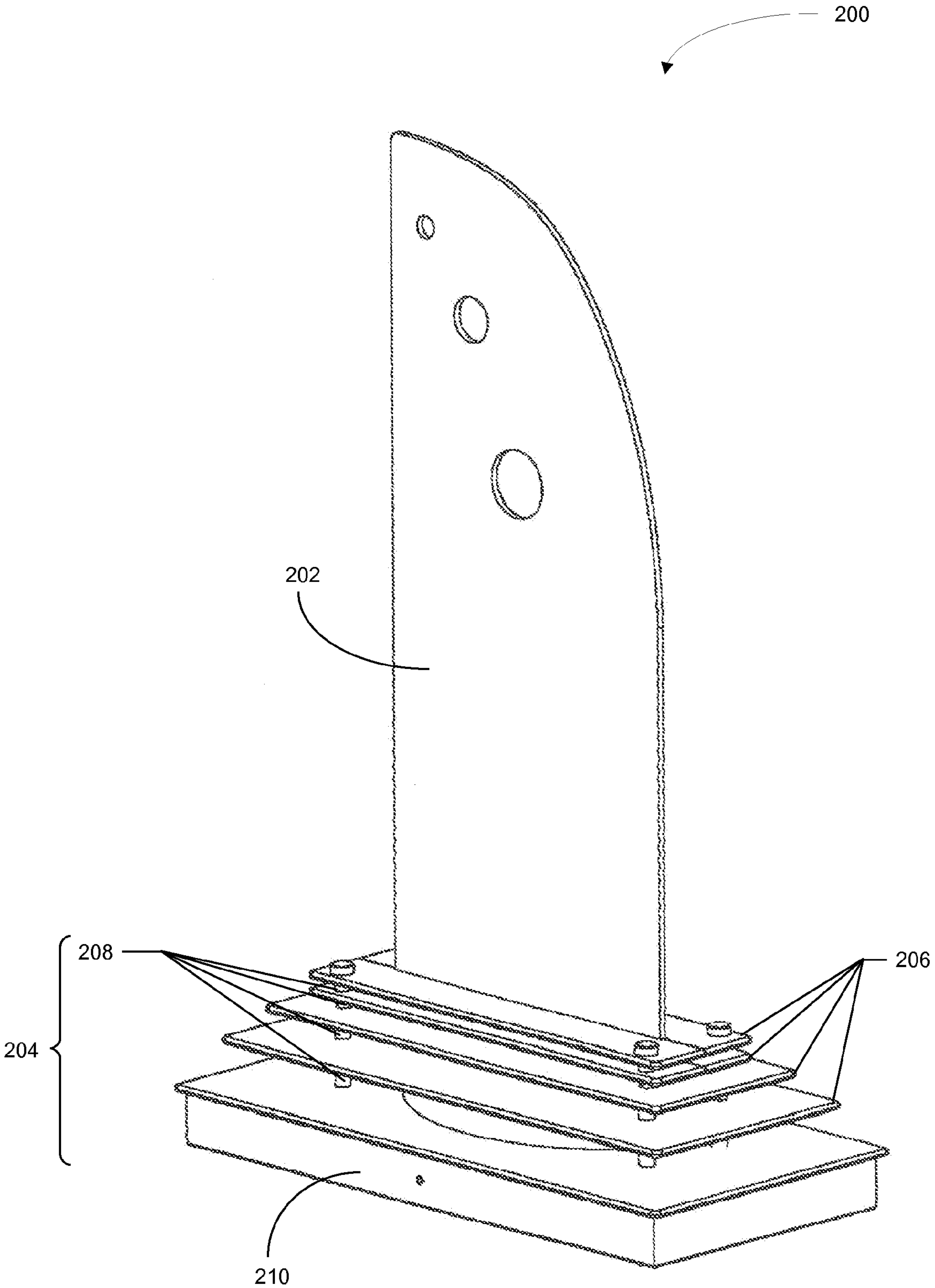
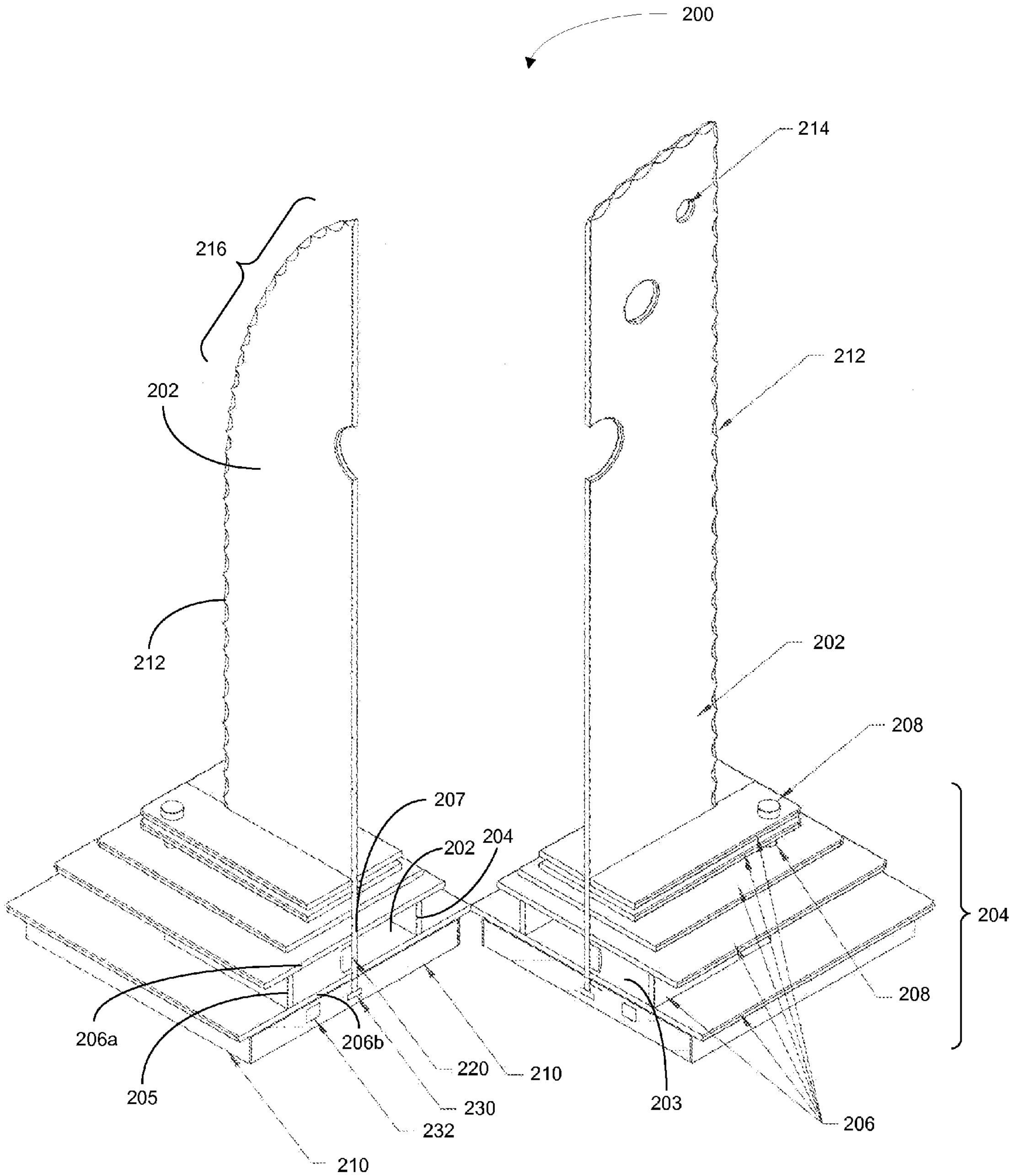


FIG. 2A


200
214
216
202
212
212
202
208
207
202
204
204
206a
206b
205
220
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230
232
210
203
208
206

FIG. 2B

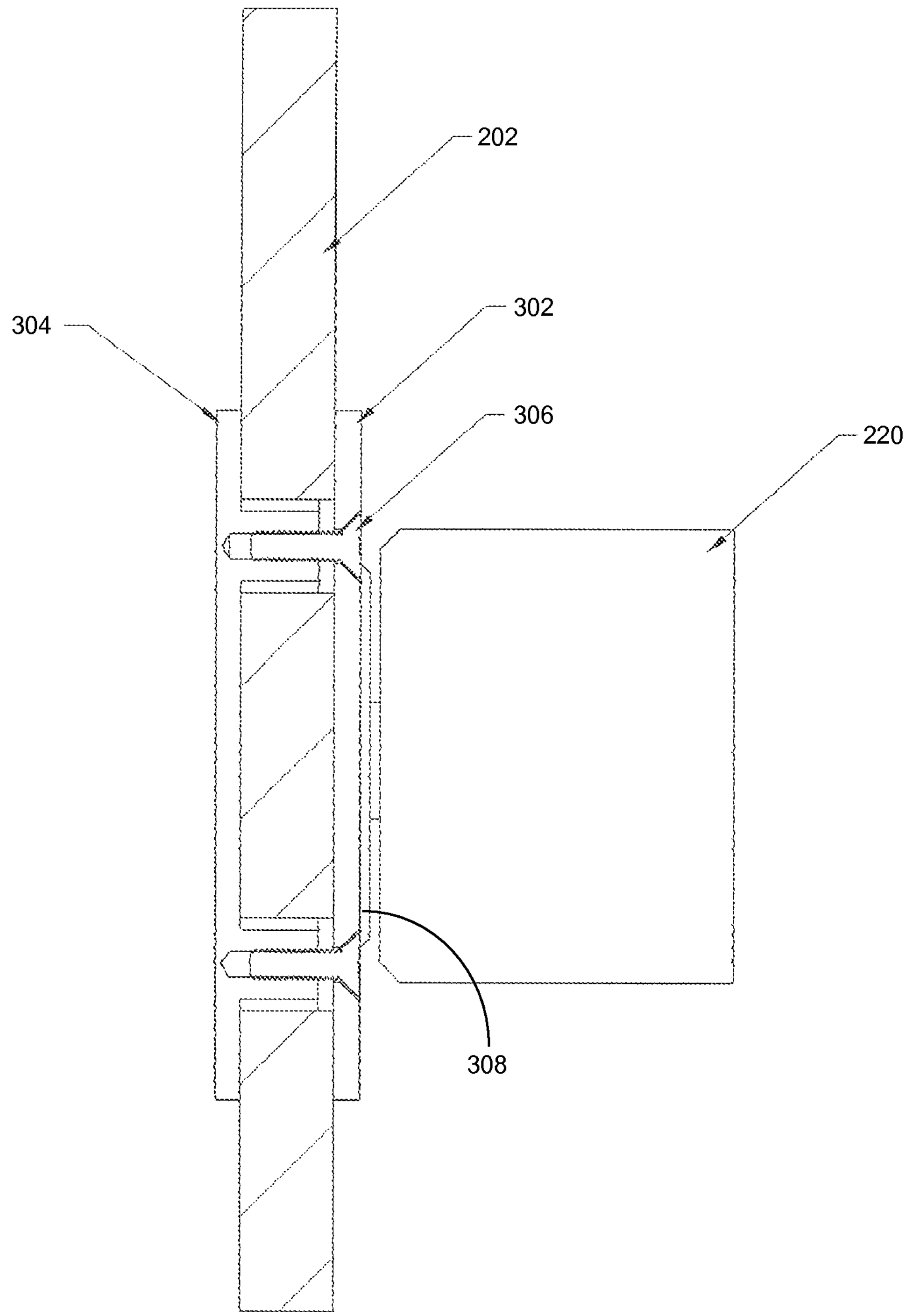

FIG. 3

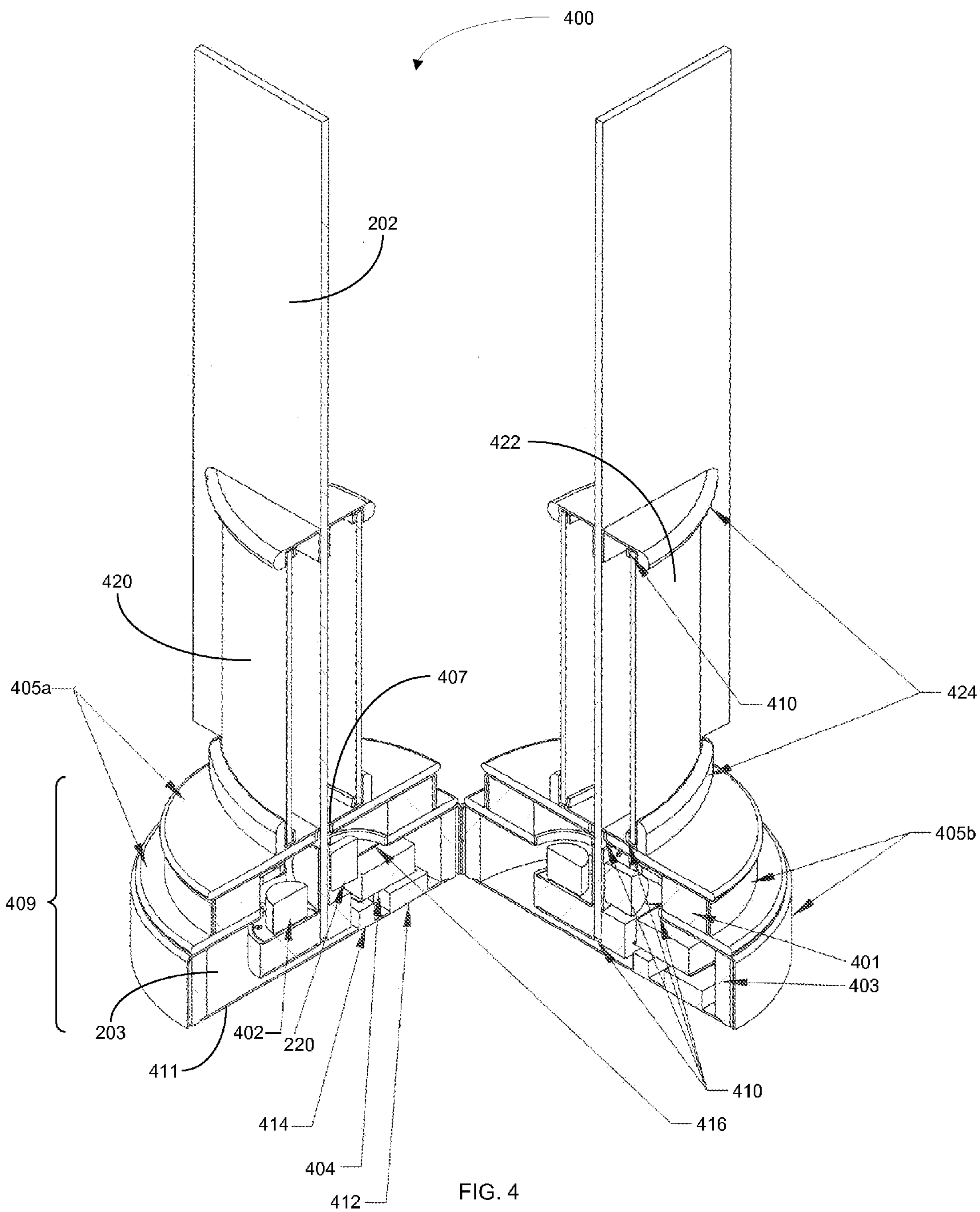
400
202
422
420
407
410
424
405a
405b
409
401
403
203
402
220
411
414
404
412
410
416

FIG. 4

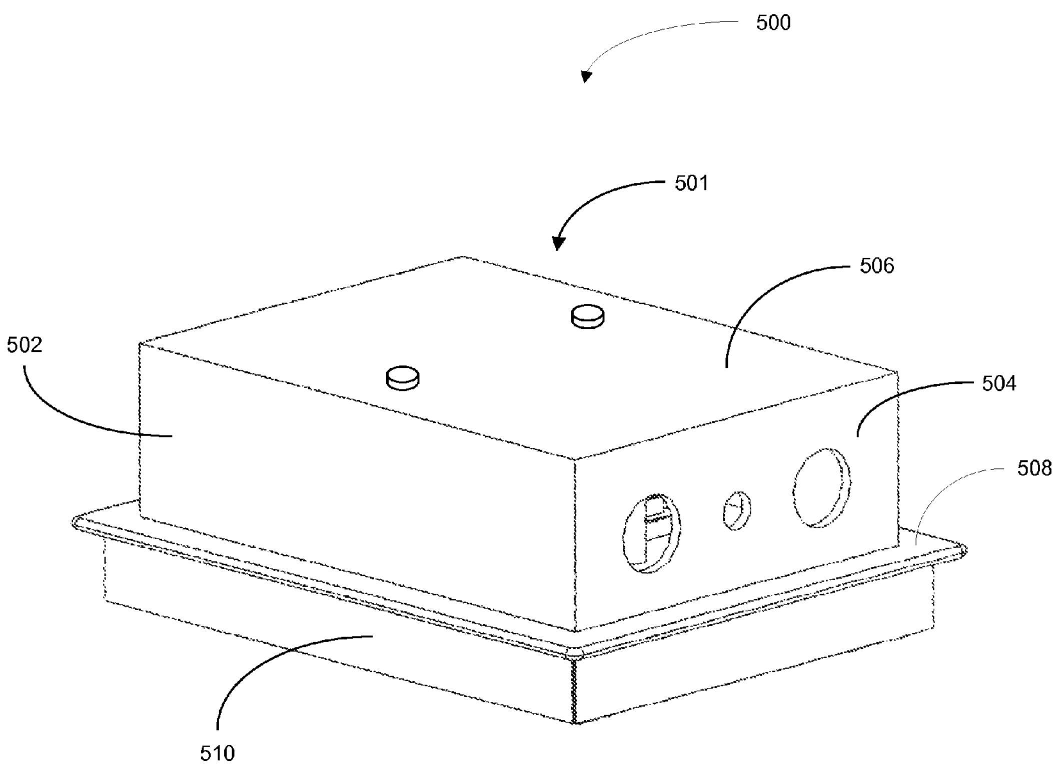

FIG. 5A

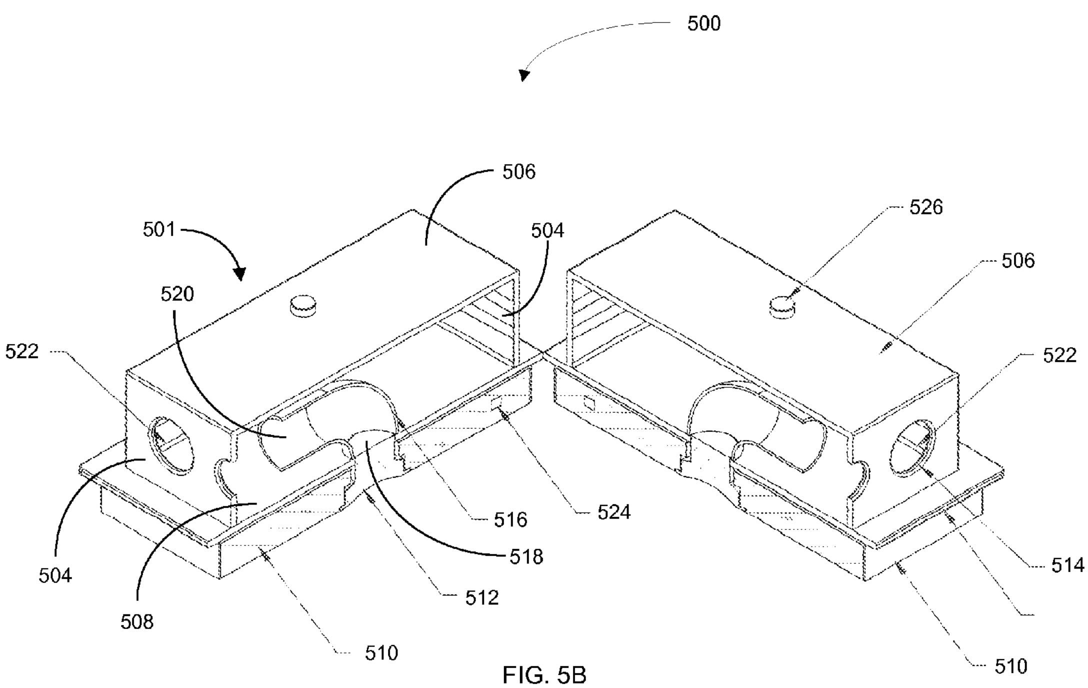
500
506
501
504
526
506
520
522
522
516
524
518
514
504
508
512
510
510

FIG. 5B

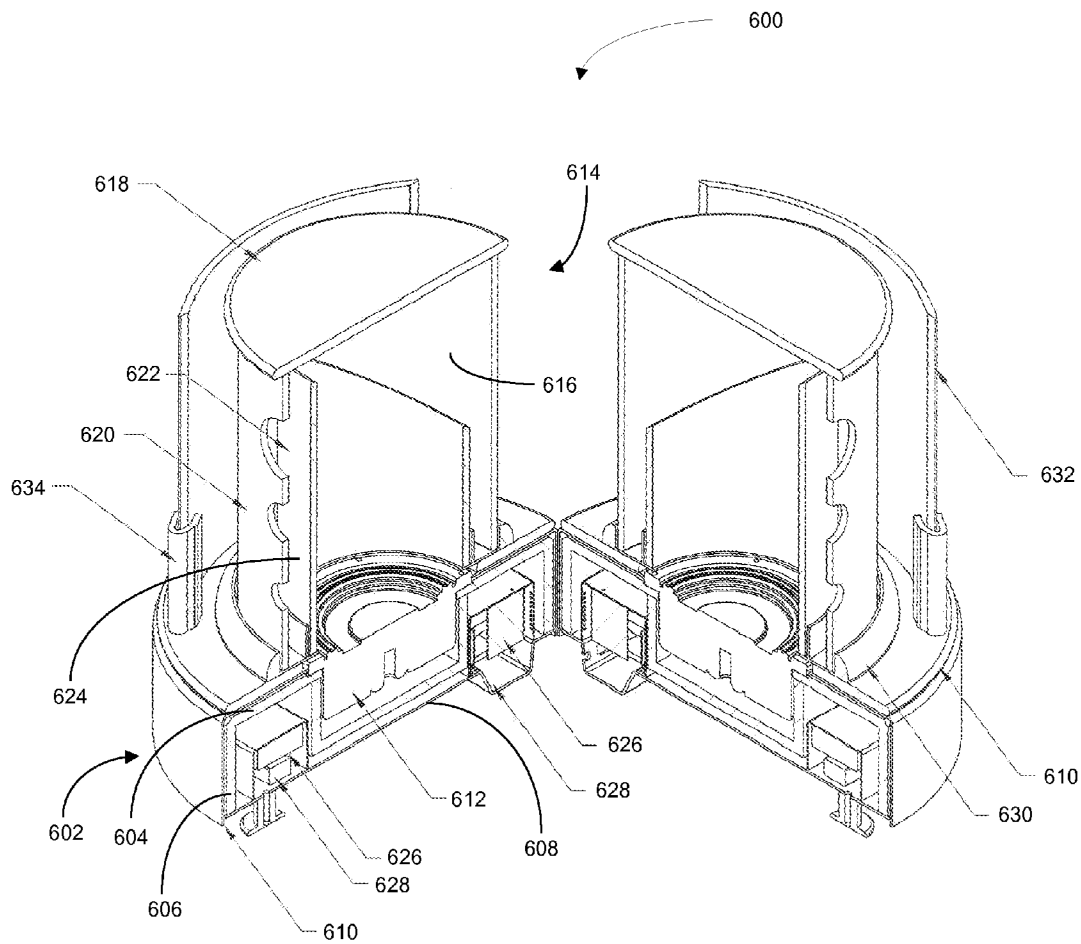
600
614
618
616
622
620
634
632
624
626
610
612
628
630
602
604
608
626
628
606
610

FIG. 6

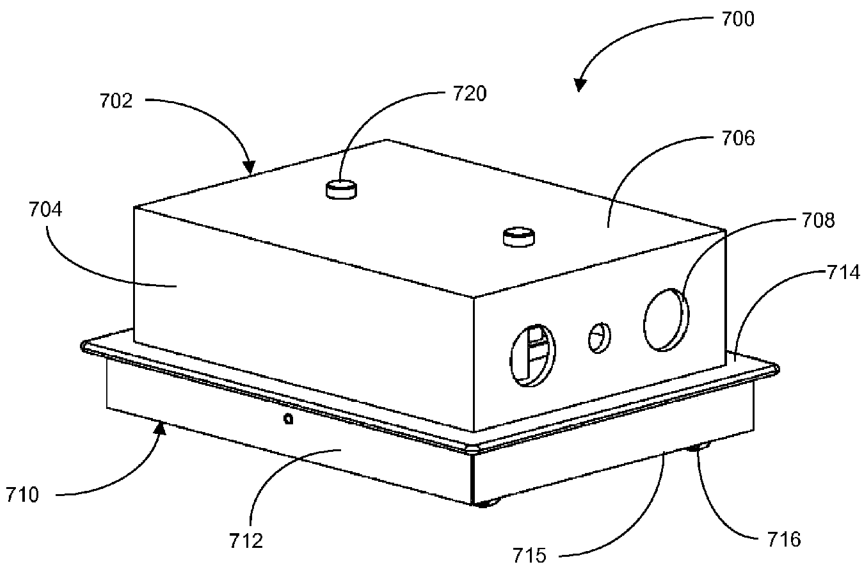
700
702
720
706
704
708
714
710
712
715
716

FIG. 7A

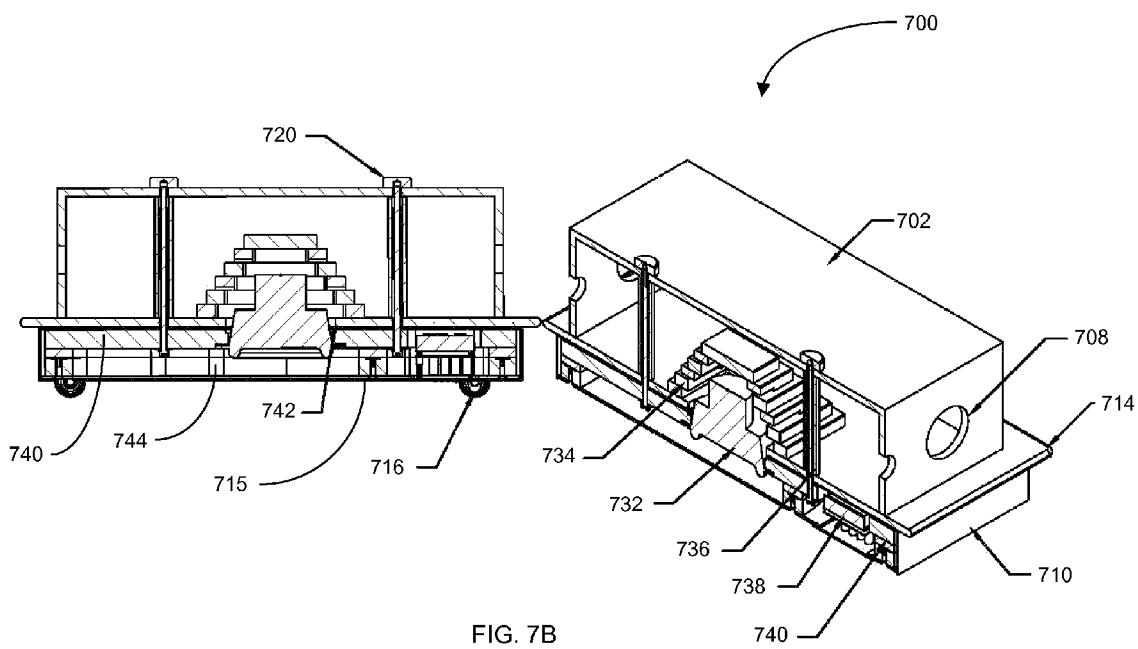
700
720
702
708
714
740
744
742
715
716
734
732
736
738
740
710

FIG. 7B

AUDIO SPEAKER ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of the filing date of patent application, Ser. No. 61/422,058, filed on Dec. 10, 2010, and entitled "Audio Speaker Assembly," which is incorporated herein by reference.

FIELD

This disclosure relates to a speaker assembly, and specifically, to a speaker assembly having a flat, vertically extending glass membrane.

BACKGROUND

Conventional audio speakers use relatively rigid paper or plastic cones, or diaphragms, and require an air enclosure to provide acceptable sound reproduction in the low/mid frequency regions where voices and musical instruments produce most of their sound energy. The air enclosures inherently "resonate" in such a manner as to accentuate some frequencies while diminishing others.

Conventional cone speakers typically require multiple speaker elements, such as woofers, midranges, and tweeters. Each element provides reproduction of a different frequency range of sound. Unfortunately, it is difficult with such multi-element designs to provide smooth transitions between the speaker elements at all listening angles.

The air enclosure and multi-element design result in reduced naturalness and clarity of the reproduced sound. What is needed is an audio speaker without the need for an air enclosure, to remove or reduce altered and unnatural acoustic effects, and with improved sound quality.

SUMMARY

An aspect of the disclosure relates to an audio speaker assembly configured to produce sound with varying frequency from distinct regions of the speaker assembly. The audio speaker assembly comprises an elongated planar membrane adapted to produce sound with a first frequency response that varies along the length of the planar membrane. A housing, configured to support the planar membrane, is configured to have a second frequency response that differs from the first frequency response of the elongated planar membrane.

A first transducer, configured to efficiently apply vibrational energy in accordance with the first frequency response of the elongated planar membrane, is directly coupled to the planar membrane. A second transducer, configured to efficiently apply vibrational energy in accordance with the second frequency response of the housing, is directly coupled to the housing.

A signal processing unit is provided to generate first and second drive signals for the first and second transducers from an input audio signal, respectively. The first drive signal has a frequency content that better matches the first frequency response of the elongated planar membrane. Similarly, the second drive signal has a frequency content that better matches the second frequency response of the housing.

As an example of the above concepts, the housing may serve as a base to support the elongated planar membrane in a generally vertical orientation. The elongated planar membrane may be configured to more efficiently produce sound in a high audio frequency range along an upper region of the membrane, and more efficiently produce sound in an upper mid-frequency range along central and lower regions of the membrane. The housing may be configured to more efficiently produce sound in a low to lower-mid frequency range.

The first transducer, directly coupled to the planar membrane, may be configured to more efficiently generate vibrational energy in the upper mid- and high frequency audio range. Similarly, the second transducer, directly coupled to the housing, may be configured to more efficiently generate vibrational energy in the low and lower mid- frequency audio range.

The first drive signal for the first transducer may include substantially only the upper mid- and high frequency components of the input audio signal. Similarly, the second drive signal for the second transducer may include substantially only the low and lower mid-frequency components of the input audio signal. Such configuration results in lower frequency sound being efficiently produce at a lower region of the speaker assembly with a smooth transition to higher frequency sound being efficiently produce at an upper region of the speaker assembly. This gives the speaker assembly a smooth spatial frequency diversity along the vertical axis of the speaker assembly.

In another aspect, the disclosure provides an audio speaker assembly. The audio speaker assembly includes a housing having a base defining an internal compartment. The audio speaker assembly also includes a membrane having a width, a length and a thickness. A first portion of the membrane is supported in the housing and a second portion of the membrane extends externally from the housing. The length of the membrane external to the housing extends orthogonal to the base of the housing. The audio speaker assembly also includes a driver mounted to the membrane. The driver is responsive to an electrical signal causing the membrane to vibrate.

In another aspect, an audio speaker assembly is provided including a housing defining an internal compartment, having a width and a length, and a glass membrane having a first portion supported in the housing and a second portion extending externally from the housing. The second portion of the membrane having a length greater than its width. The length of the second portion extending orthogonal to the width of the housing. A driver is mounted to the membrane that is responsive to an electrical signal causing the membrane to vibrate.

In yet another aspect, an audio speaker is provided including a housing defining an internal compartment, having a width and a length, and a glass membrane having a first portion supported in the housing and a second portion extending externally from the housing. The second portion has a length greater than its width, and the length of the second portion extends orthogonal to the width of the housing. The second portion defines at least one aperture and a curved section formed along an edge of the glass membrane. A driver is mounted to the membrane. The driver is responsive to an electrical signal that causes the driver and thus the membrane to vibrate. The audio speaker assembly also includes lighting effects positioned along the housing and the glass membrane, and a wireless receiver coupled to the driver and the lighting effects to operate the driver and the lighting effects remotely.

Other aspects, advantages and novel features of the present disclosure will become apparent from the following detailed description when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates a diagram of an exemplary audio speaker assembly in accordance with an aspect of the disclosure.

FIG. 1B illustrates a graph of an exemplary spatial frequency response of an elongated planar membrane in accordance with another aspect of the disclosure.

FIG. 1C illustrates a graph of an exemplary frequency response of a support housing in accordance with another aspect of the disclosure.

FIG. 1D illustrates a graph of exemplary vibrational energy transfer efficiency responses of a pair of associated transducers in accordance with another aspect of the disclosure.

FIG. 1E illustrates a view of an exemplary planar membrane and a juxtaposed graph of an exemplary vibrational energy transfer efficiency to the planar membrane by a pair of transducers in accordance with another aspect of the disclosure.

FIG. 1F illustrates a graph of a frequency response of an exemplary housing in accordance with another aspect of the disclosure.

FIG. 2A illustrates a perspective view of another exemplary audio speaker assembly in accordance with another aspect of the disclosure.

FIG. 2B illustrates a sectional view of the exemplary audio speaker in accordance with another aspect of the disclosure.

FIG. 3 illustrates a side view of an exemplary driver mounted to a planar membrane in accordance with another aspect of the disclosure.

FIG. 4 illustrates a perspective sectional view of another exemplary audio speaker assembly in accordance with another aspect of the disclosure.

FIG. 5A illustrates a perspective view of an exemplary subwoofer assembly in accordance with another aspect of the disclosure.

FIG. 5B illustrates a sectional view of the exemplary subwoofer assembly in accordance with aspect of the disclosure.

FIG. 6 illustrates a perspective sectional view of another exemplary subwoofer assembly in accordance with another aspect of the disclosure.

FIG. 7A illustrates a perspective view of an exemplary speaker assembly in accordance with another aspect of the disclosure.

FIG. 7B illustrates a sectional view of the exemplary speaker assembly in accordance with aspect of the disclosure.

It should be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements are exaggerated relative to each other for clarity. Further, where considered appropriate, reference numerals have been repeated among the figures to indicate corresponding elements.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

FIG. 1A illustrates a diagram of an audio speaker assembly **100** in accordance with an aspect of the disclosure. In summary, the audio speaker assembly **100** is configured to provide spatial diversity as to the origin from which different frequency components of audio sound are generated. That is, the audio speaker assembly **100** is adapted to generate a wide spectrum of audio sounds from different locations along the audio speaker assembly.

Continuing the summary, the audio speaker assembly **100** accomplishes this spatial frequency diversity by first employing a planar membrane (e.g., made out of a tempered glass) having a frequency response that varies along a length of the membrane. As an example, the planar membrane is adapted to generate audio in an upper mid-frequency range along lower and central regions of the membrane, and generate audio in a high-frequency range along an upper region of the membrane. In order to better implement the production of high frequency audio in the upper region of the membrane, the mass of the membrane is reduced at the upper region by incorporating a curved edge to narrow its width at that region, and one or more thru-holes.

Continuing the summary, to further effectuate the spatial frequency diversity, the audio speaker assembly **100** includes a housing that supports the planar membrane in a generally vertical orientation. The housing is adapted to produce audio in the low and lower mid-frequency ranges. The housing may be made out of a wood material.

Continuing the summary, the audio speaker assembly **100** further includes a first transducer directly coupled to the housing. The first transducer is adapted to more efficiently transfer audio to the housing in the low- and lower mid-frequency ranges. Because the housing is mechanically coupled to the planar membrane in order to support it in a vertical orientation, some of the audio in the lower mid-frequency range from the first transducer is transferred to the planar membrane. This lower mid-frequency audio component will be produced as sound at the lower region of the planar membrane.

Continuing the summary, the audio speaker assembly **100** further includes a second transducer directly coupled to the planar membrane. The second transducer is adapted to more efficiently transfer audio to the planar membrane in the upper mid- and high-frequency ranges. Because the housing is mechanically coupled to the planar membrane in order to support it in a vertical orientation, some of the audio in the upper mid-frequency range from the second transducer is transferred to the housing.

Continuing the summary, the audio speaker assembly **100** further includes a first filter (or first preamplifier) configured to amplify and filter an input audio signal in order to output the low and lower mid-frequency components of the audio signal. The output of the first filter is coupled to the first transducer. Similarly, the audio speaker assembly **100** further includes a second filter (or second preamplifier) configured to amplify and filter the input audio signal in order to output the upper mid- and high-frequency components of the audio signal. The output of the second filter is coupled to the second transducer.

With reference to FIG. 1A, the audio speaker assembly **100** comprises a housing **102** and a planar membrane **104**. As previously discussed, the housing **102** may be formed of a wooden or other materials suitable to more efficiently produce sound in the low and lower mid-frequency ranges. The planar membrane **104** may be formed of tempered glass or other materials suitable to efficiently produce sound in the upper mid- and high frequency ranges. The housing **102** includes a slot **106** along its upper wall through which the planar membrane **104** extends in a fitted configuration. A bottom portion of the planar membrane **104** is anchored proximate a bottom wall of the housing **102** by an anchoring device **108**. The anchoring device **108** may include a light source **110** (e.g., a light emitting diode (LED) light strip) adapted to produce ornamental colored light through the planar membrane **104**, such as tempered glass.

A first transducer **112** is directly coupled or attached to the housing **102**, for example, along an inside surface of the upper wall of the housing. As an example, the first transducer **112** may be adapted to more efficiently produce sound vibrations in the housing **102** in a low and lower mid-frequency range of an input audio signal. A second transducer **114** is directly coupled to or attached to the planar membrane **104**, for example, at a lower region of the planar membrane situated within the housing **102**. As an example, the second transducer **114** may be adapted to more efficiently produce sound vibrations in the planar membrane **104** in an upper mid- and high-frequency ranges of an input audio signal. It shall be understood that the term “directly coupled or attached to” means that the transducer makes contact with the corresponding element, or makes contact with the corresponding element via an insignificant material.

The audio speaker assembly **100** further comprises an audio signal processing unit **120** including a pre-amplifier **122**, a first filter **124**, and a second filter **126**. The pre-amplifier **122** is adapted to receive and amplify an input audio signal. The first filter **124** is adapted to filter the amplified audio signal to generate an audio signal with a first defined spectrum. For example, the first filter **124** may be adapted to output the low- and lower mid-frequency components (BW**1**) of the amplified audio signal. Similarly, the second filter **126** is adapted to filter the amplified audio signal to generate an audio signal with a second defined spectrum. For example, the second filter **126** may be adapted to output the upper mid- and high-frequency components (BW**2**) of the amplified audio signal. The output audio signals from the first and second filters **124** and **126** drive the first and second transducers **112** and **114**, respectively. It shall be understood that the audio signal processing unit **120** may include instead two pre-amplifiers tuned to distinct frequency bands (e.g., BW**1** and BW**2**).

In this configuration, the audio speaker assembly **100** is adapted to: (1) efficiently produce sound at the high-frequency range along an upper region of the planar membrane **104**; (2) efficiently produce sound at an upper mid-frequency range along a mid- and lower-portion of the of the planar membrane **104**; and (3) efficiently produce sound at a lower mid- and low frequency range at the housing **102**. This produces a rich spatial frequency diversity sound smoothly along a general vertical axis of the audio speaker assembly **100**. The following exemplary graphs further explains the spatial frequency diversity of the audio speaker assembly **100**.

FIG. **1**B illustrates a graph of an exemplary spatial frequency response of the planar membrane **104** in accordance with another aspect of the disclosure. The vertical axis of the graph represents the vibrational energy in the planar membrane **104**. The horizontal axis of the graph represents the vertical position along the planar membrane **104** from a point proximate the slot **106** to the top of the planar membrane **104**.

The graph depicts a first spatial frequency response BW**1** (mid). The first spatial frequency response BW**1** (mid) represents the contribution of sound energy generated in the planar membrane **104** by the first transducer **112**. As previously discussed, the first transducer **112** produces vibrational energy in the low and lower-mid frequency ranges. Due to the inherent frequency response of the planar membrane **104**, a portion of the lower mid-frequency range of the audio energy produced by the first transducer **112** ends up being produced as sound by the planar membrane **104**. As noted, most of this energy is produced at the lower region of the planar membrane **104** due to: (1) the frequency response of the planar membrane **104** favoring the production of sound in the lower mid-frequency range at the lower region of the membrane; and (2) the fact that the first transducer **112** is indirectly coupled to the planar membrane (e.g., via the housing **102**), the energy of the lower mid-frequency range of the audio sound only propagates a certain distance along the planar membrane **104**.

The graph depicts a second spatial frequency response BW**2** (Mid) and BW**2** (High). The second frequency spatial response BW**2** (Mid) and BW**2** (High) represents the contribution of sound energy generated in the planar membrane **104** by the second transducer **114**. As previously discussed, the second transducer **114** produces vibrational energy in the upper mid- and high-frequency ranges. Due to the inherent frequency response of the planar membrane **104**, a portion of the upper mid-frequency range of the audio energy produced by the second transducer **114** ends up being produced as sound at lower and mid regions of the planar membrane **104**. And, the high frequency range of the audio energy produced by the second transducer ends up being produced as sound at an upper region of the planar membrane **104**. This results in spatial frequency diversity of sound along the length of the planar membrane **104**.

FIG. **1**C illustrates a graph of an exemplary frequency response of the housing **102** in accordance with another aspect of the disclosure. The vertical axis of the graph represents the vibrational energy in the housing **102**. The horizontal axis of the graph represents the frequency of the sound energy produced by the housing **102**.

The graph depicts a first frequency spatial response BW**1** (Low) and BW**1** (Mid). The first frequency spatial response BW**1** (Low) and BW**1** (Mid) represents the contribution of sound energy generated in the housing **102** by the first transducer **112**. As previously discussed, the first transducer **112** produces vibrational energy in the low and lower mid-frequency ranges. The energy of sound generated by the housing **102** due to the first transducer **112** is relatively high due to the direct coupling or attachment of the first transducer to the housing.

The graph depicts a second frequency response BW**2** (Mid). The second frequency response BW**2** (mid) represents the contribution of sound energy generated in the housing **102** by the second transducer **114**. As previously discussed, the second transducer **114** produces vibrational energy in the upper mid- and high-frequency ranges. Due to the inherent frequency response of the housing **102**, a portion of the upper mid-frequency range of the audio energy produced by the second transducer **114** ends up being produced at sound by the housing **102**. Because the second transducer **114** is indirectly coupled to the housing **102** (by way of the planar membrane **104**), the sound energy generated in the housing **102** due to the second transducer **114** is less than the sound energy due to the first transducer **112**. This results in frequency diversity of sound generated by the housing **102**.

FIG. **1**D illustrates a graph of exemplary vibrational energy transfer efficiency responses of the first and second transducers **112** and **114** in accordance with another aspect of the disclosure. The vertical axis of the graph represents the vibrational energy transfer efficiency associated with the transducers **112** and **114**. The horizontal axis of the graph represents the frequency of the vibrational energy produced by the transducers **112** and **114**.

As noted, the first transducer **112** is configured to have a frequency response that has a high vibrational energy transfer efficiency at the low and lower mid-frequency ranges. This results in an efficient transfer of energy to the housing **102** for the production of sound in those frequency ranges. The second transducer **114** is configured to have a frequency response that has a high vibrational energy transfer efficiency at the upper mid- and high-frequency ranges. This results in an efficient transfer of energy to the planar membrane **104** in those frequency ranges. Again, this is done to produce spatial frequency diversity of sound along the audio speaker assembly **100**.

FIG. **1**E illustrates a view of the planar membrane **104** and a juxtaposed graph of an exemplary vibrational energy transfer efficiency to the planar membrane by the transducers **112** and **114** in accordance with another aspect of the disclosure. The vertical axis of the graph represents the position along the length of the planar membrane **104**. The horizontal axis of the graph represents the vibrational energy transfer efficiency. The solid line indicates the transfer efficiency associated with the high-frequency range of the audio energy. The dash line indicates the transfer efficiency associated with the mid-frequency range of the audio energy.

As noted, the vibrational energy transfer efficiency associated with the high-frequency range is relatively high at the upper end of the planar membrane **104**, and relatively low at the lower end of the membrane. This is due to the fact that there is less mass at the upper region of the planar membrane **104**. The less mass at the upper region is due to the narrowing width caused by the curved edge and the one or more thru-holes in that region. In contrast, the vibrational energy transfer efficiency associated with the mid-frequency range is relatively high at the low and mid regions of the planar membrane **104**, and relatively low at the upper end of the membrane. This is due to the fact that there is relatively more mass at the lower and mid regions of the planar membrane **104**. Again, this produces spatial frequency diversity of sound along the audio speaker assembly **100**.

FIG. **1**F illustrates a graph of an exemplary frequency response of the housing **102** in accordance with another aspect of the disclosure. The vertical axis of the graph represents the vibrational energy transfer efficiency associated with the transfer of vibrational energy from the transducers **112** and **114** to the housing **102**. The horizontal axis of the graph represents the frequency of the transferred vibrational energy. As noted, the transfer of vibrational energy from the transducers to the housing **102** is relatively high at the low and lower-mid frequency range of the vibrational energy, and relatively low at the upper frequency range. This results in lower frequency sound being efficiently produced by the housing **102**. Again, this achieves spatial frequency diversity of sound produced by the audio speaker assembly **100**. The following describes how these concepts may be embodied in speaker products.

Audio speakers typically include a relatively stiff diaphragm that is coupled to an electromagnetic driver. The driver generally includes a voice coil and a permanent magnet. The audio speakers are typically mounted so as to occupy an opening in an enclosure or housing. The varying magnetic field of the voice coil that is produced when a changing current is passed through the voice coil and the interaction of the magnetic field of the permanent magnet causes the loudspeaker diaphragm to vibrate. Vibration of the diaphragm causes movement of air, which in turn produces sound.

FIG. **2**A illustrates a perspective view of an exemplary audio speaker assembly **200** in accordance with another aspect of the disclosure. The audio speaker assembly **200** includes a membrane **202** that extends from a base housing **204**. The base housing **104** is particularly designed to facilitate a vertical orientation of the speaker membrane **202** relative to the floor. The base housing **204** may take any particular shape that may define an internal compartment (See e.g., FIG. **2**B) that is suitable for housing components of the speaker assembly **200**. Externally, the base housing **204** may be designed in a plurality of varying decorative embodiments. In one embodiment, shown in FIG. **2**A, the base housing **204** includes a plurality of stacked members **206**. Each stacked member **206** may be made of tempered glass. At least some of the stacked members **206** are arranged to rest on top of the internal compartment. The stacked members **206** are separated by a plurality of spacers **208** arranged strategically between each stacked surface. The stack members **206** are mechanically coupled to the membrane **202**, and thus, also emit sound due to the transfer of vibrational energy from the membrane to the stack members. The internal compartment, described in detail below, is positioned on a base **210** made of, a solid material, such as wood, a hard plastic, a metal and the like.

FIG. **2**B illustrates a sectional view of the audio speaker assembly **200** in accordance with an embodiment showing the internal compartment **203** of the base housing **204**. The internal compartment **203** is defined by a top wall **206***a*, lateral side walls **205**, a front side wall (not shown) and a rear side wall (not shown), each resting on the base **210**. In one embodiment, the top wall **206***a* is provided by one of the plurality of stacked members **206**, and the lateral side walls **205** may be made of tempered glass. In one embodiment, one of the plurality of stacked members **206** may be positioned between the internal compartment **203** and the base **210** to provide a bottom wall **206***b* to the internal compartment **203**.

While preferred materials are disclosed in the formation of the base housing **204** in accordance with embodiments described herein, other materials for the base housing **204** may be used without departing from the spirit of the present disclosure. Regardless of the material used in the construction of the base housing **204**, the chosen material should resonate in a manner transmitting sound from the internal compartment **203**.

The internal compartment **203** is provided with a slot **206***a* defined through the top wall **106***a*. On the opposite side from the top wall **106***a* is a slot **207** provided through the bottom wall **206***b* and into the base **210**. The slot **207** is sized and shaped to receive a portion of the speaker membrane **202** therethrough. In accordance with an embodiment, the speaker membrane **202** is positioned substantially orthogonally relative to the base **210**.

The membrane **202** may be attached to the base housing **204**, through the internal compartment **203**, to stand vertically erect or orthogonal relative to the base **210** using various well known fabrication techniques. One manner of coupling the membrane **202** to the base housing **204** is by sliding the membrane into the slots **207** such that a bottom edge of the membrane **202** comes to rest within the slot **207** in the base **210**. The membrane **202** may be secured in the slots **207** and in the base **210** using, for example, an epoxy or other adhesive. Additionally or alternatively to the adhesive, the membrane **202** can be attached by press or friction fitting the membrane **202** into one or more of the slots **207**.

In one embodiment, the membrane **202**, having edges **212**, is made of a rigid material, such as tempered glass. The membrane **202** is made thick enough and durable enough to endure the vibrational forces of a driver (described below), and yet flexible enough to vibrate in response to the driver. The membrane **202** produces the desired acoustic characteristics of the speaker assembly **200**.

The sound quality of the speaker assembly may be improved by reducing the mass of the membrane **202**. The mass of the membrane may be reduced using many techniques, such as providing small apertures **214** strategically located and positioned on the membrane **202**. The apertures may vary in size from approximately 10 cm in diameter to 100 cm, with a final determination of size depending on the number of apertures **214** provided and the overall dimensions of the membrane **202**.

In one embodiment, the membrane **202** may have a substantially rectangular geometry. However, mass may be removed from the membrane **202** by modifying the geometry of the membrane **202**. In one embodiment, the membrane **202** may be modified such that one edge or a plurality of edges **212** of the membrane is shaped. For example, as shown in FIG. 2B, the edge **212** may be curved and formed into an arc shape **216**. In other embodiments, the membrane **202** may be modified to other geometric shapes each providing the benefit of removing mass from an otherwise rectangular shaped membrane **202**.

The speaker assembly **200** having a flat, vertically extending glass membrane provides a larger radiating area for higher sound pressure level with little displacement as compared to conventional cone type speakers. The membrane **202** is capable of reproducing an extremely wide range of frequencies at all listening angles from a single speaker element. In this way, acoustic blending problems associated with multi-element designs may be eliminated or reduced.

In another example, mass may be removed from the membrane **202** by varying the thicknesses along the height and width of the membrane **202**.

Referring again to FIG. 2B, the speaker assembly **200** includes a driver **220** positioned in the internal compartment **203** and mounted to the membrane **202**. The driver **220** vibrates in response to an electrical signal, which, in turn, vibrates the membrane **202** to produce sound.

The driver **220** may be an electromagnetic driver assembly that is well known in the art. In one embodiment, for example, the driver **220** may include a voice coil wrapped about a pole piece, a permanent magnet partially disposed within one end of the pole piece, and a thin plate attached to the other end of the pole piece. In order to vibrate the driver, a changing current is passed through the voice coil. The interaction of the magnetic field of the permanent magnet and the magnetic field of the voice coil that is produced from the changing current causes the coil and consequently, the attached thin plate **308** (FIG. **3**) to vibrate like a piston with respect to the permanent magnet.

As shown in FIG. **3** the driver **220** is mounted to the membrane **202** using a driver mounting plate **302**. In this embodiment, the driver mounting plate **302** is mounted to the membrane **202** using a mounting bracket **304** that captures the driver mounting plate **302** via holes defined through the membrane **202**. The driver mounting plate **302** and the mounting bracket **304** may be held together using conventional means **306**, such as using screws or similar fasteners. As the thin plate **308** vibrates, the membrane **202** consequently vibrates to produce sound.

Referring back to FIG. **2**B, in one embodiment, the audio speaker assembly **200** may include lighting effects. The lighting effects allow the user to change the appearance of the membrane **202** by using colored light that permeates through the membrane to provide different hues. In one embodiment, the lighting effects may be provided using LED strip lighting **230** that is strategically placed along various portions of the audio speaker assembly **200**. The LED light strips **230** may be coupled together or controlled independently using an LED controller and power supply **232**. The lighting effects may include a variety of colors and hues and may be powered to different intensities to create a range from dim to bright lighting. The color of the lighting may be set to a specific color or it may be allowed to vary and change at different timing intervals.

FIG. **4** illustrates a sectional view of an audio speaker assembly **400** in accordance with an embodiment. The audio speaker assembly **400** includes the features described above with regard to audio speaker assembly **200**, however, the description of this embodiment may provide for some additional features not described above that may be found in each of the speaker assembly embodiments described herein.

In this embodiment, the audio speaker assembly **400** includes a first circular tier **401** and a second tier **403**. The first and second circular tiers **401** and **403** are made of a solid material, such as wood, a hard plastic, a metal and the like. In one embodiment, each tier **401** and **403** is covered with a decorative feature, such as a cover member **405*a*** made of, for example, tempered glass, and side coverings **405*b*** made of, for example, decorative plastic or aluminum. The first and second tiers are stacked concentrically and rest on a base **411**.

The stacked circular tiers **401** and **403** include a hollowed out or open portion that defines the internal compartment **203**. The first circular tier **401** includes a slot **407** defined through the decorative feature resting on top of the first circular tier **401**. The slot **407** is sized and shaped to receive a portion of the speaker membrane **202** therethrough. The speaker membrane **202** extends and is secured within the internal compartment **203** using various well known fabrication techniques. The membrane **202** rests substantially orthogonally oriented relative to the base **411** of the base housing **409**.

The driver **220** is mounted within the internal compartment **203** to the glass membrane **202** using, for example, the mounting plate **302** and the mounting bracket **304** (See e.g., FIG. **3**). In this embodiment, an additional sound device **402** is provided. By securing the driver **220** to an additional sound device, such as a wood membrane and the like, lower sound frequencies can be produced. An amplifier **404** including a power supply are also located in the internal compartment **203** and are used in conjunction with the driver **220**. The amplifier **404** is to provide the driver **220** with the signal voltages appropriate for the functional of the driver.

In one embodiment, the audio speaker assembly **400** includes a wireless receiver **416**. The wireless receiver **416** may be located in the internal compartment **203** and is capable of receiving control signals from which to control the driver **220**, the amplifier **404** and power converter **406** to provide the ability to remotely control the audio speaker assembly **400**.

In one embodiment, the audio speaker assembly **400** may include lighting effects. The lighting effects allow the user to change the appearance of the membrane **202** by using colored light that permeates through the membrane to provide different hues. In one embodiment, the lighting effects may be provided using LED strip lighting **410** that is strategically placed along various portions of the audio speaker assembly **400**. The LED light strips **410** may be coupled together or controlled independently using an LED controller **412** powered by an LED power inverter **414**. The light effects may include a variety of colors and hues and may be powered to different intensities to create a range from dim to bright lighting. The color of the lighting may be set to a specific color or it may be allowed to vary and change at different timing intervals.

In one embodiment, the audio speaker assembly **400** includes a wireless receiver **416**. The wireless receiver **416** may be located in the internal compartment **203** and is capable of receiving control signals from which to control the LED controller **412** to provide the ability to remotely control the lighting effects.

In this embodiment, an optional upper housing **420** may be provided that is mounted upon the first circular tier **401** and extends along a portion of the height of the membrane **202**. The upper housing **420** includes panels **422**. The panels **422** are curved or arced members that are positioned on each side of the membrane **202** to create an enclosed space that surrounds a portion of the membrane **202**. The curved panels **422** are held in position using mounting brackets **424**. In one embodiment, lighting strips **410** may be positioned with in the upper housing **420** to provide additional lighting effects to the speaker assembly **400**.

In one example, with no intent to be limiting, the speaker assemblies may have the following characteristics:
Speaker output: about 50 Watts,
Impedance: about 8 Ohms,
Frequency response: 50 Hz-20 kHz
Dimensions: (L×W×H) 21.5"×43"×65.5"
Decibel: about 90 dB

FIG. **5**A illustrates a perspective view of an exemplary subwoofer assembly **500** in accordance with another aspect of the disclosure. Subwoofer assembly **500** includes a substantially rectangular housing **501** including opposed lateral side walls **502**, opposed end walls **504**, a top wall **506** and a bottom wall **508** (See e.g., FIG. **5**B). The walls rest on a back plate or base **510**. The housing **501** may be made from any materials that resonate in a manner transmitting sound from the interior of the housing. In one embodiment, the housing **501** may be made from ½ to ¼ inch thick tempered glass.

As shown in FIG. **5**B, a centrally mounted sound device **512** is secured to the base **510** of the housing **501**. The sound device **512**, is for example a woofer driver. The base **510** has a recess provided for the sound device **512**. In one embodiment, the recess in the base **510** is centrally located with respect to the housing **501**. The sound device **512** is placed inside the recess such that one end of the sound device is aligned with and preferably attached to the bottom of the base **510**. The bottom of the housing **501** remains open to be ultimately closed off when the subwoofer assembly **500** is placed on the floor.

In one embodiment, a plurality of openings **514** are defined on end walls **504**. The openings **514** are provided to release the air that is trapped between the walls **502**, **504**, **506** and **508** of the housing **501**. The number and size of the openings **514** are design choices that affect the sound quality.

In one embodiment, a port tube **516** is positioned over the bottom of the sound device **512**. The port tube **516** may be made of any suitable material, preferably glass. The port tube **516** has a first opening **518** that is positioned over the sound device **512** and a second opening **520** that is directed toward the openings **514** on the side wall **504**. In this manner, air is directed from the sound device directly to the openings **512**. The port tube **516** allows air to be removed more efficiently from with the housing **501** to improve sound emissions by making a clear path for the movement of air.

In one embodiment, the subwoofer assembly **500** may include lighting effects. The lighting effects allow the user to change the appearance of the housing **501** using colored light that permeates through the walls to provide different lighting hues. In one embodiment, the lighting effects may be provided using LED strip lighting **522** that is strategically placed along various portions of the housing **501**. The LED light strips **522** may be coupled together or controlled independently using an LED controller and LED power inverter **524**.

FIG. **6** illustrates a perspective sectional view of a subwoofer assembly **600** in accordance with another aspect of the disclosure. Subwoofer assembly **600** includes a substantially circular base housing **602**. In one embodiment, the circular base housing **602** includes a top wall **604**, a side wall **606** and a bottom wall or base plate **608**. The walls and bottom plate are configured to create internal recesses and compartments used to position various components of the subwoofer assembly. The top and side wall of the base housing **602** may be made from any suitable material, such as wood, hard plastic and metal. The top wall **604** and side wall **606** may be covered by suitably decorative surface features **610**, such as glass, plastic, aluminum and the like.

A portion of the base housing is recessed from the top wall. A centrally mounted sound device **612**, such as a conventional bass speaker, is secured to the top wall of the base housing **602**. The sound device **612** is positioned to extend inside the recess such that one end of the sound device **612** is aligned with the top wall **604** of the base housing **602**. The sound device **612** is, for example, a sub-woofer.

In one embodiment, an upper housing structure **614** is mounted on top of the top wall **604**. The upper housing structure **614** is a generally cylindrical shaped structure that encloses a space **616** directly above the sound device **612**. On the top end of the upper housing structure **614** is a top wall **618** that encloses the structure. A side wall **620** of the upper housing structure **614** may include a plurality of openings **622** provided to release the air that is trapped within the enclosed space **616**. The number and size of the openings **622** are design choices that affect the sound quality.

Optionally, an internal wall structure **624** may be disposed within the enclosed space **616** for aesthetic reasons to, for example, cover or hide the sub-woofer.

In one embodiment, the subwoofer assembly **600** may include lighting effects. The lighting effects allow the user to change the appearance of the base housing **602** and the upper housing structure **614** using colored light that permeates through the walls to provide different lighting hues. In one embodiment, the lighting effects may be provided using LED strip lighting that is strategically placed along various portions of the base housing **602**. The LED light strips may be coupled together or controlled independently using an LED controller **626** and LED power inverter **628**.

In one embodiment, the subwoofer assembly **600** may include other features. For example, the upper housing structure **614** may be surrounded by a bracket **630** that secures the upper housing structure in position. In one embodiment, decorative features may be added to the subwoofer assembly **600**. These features may include at least one to a plurality of freestanding panels **632** hold in position using decorative brackets **634**. The panels **632** may be made of any suitably decorative material for example, plastic or glass.

In one example, with no intent to be limiting, the subwoofer assembly may have the following characteristics:
Speaker output: 150 Watts
Impedance: about 6 Ohms
Frequency response: 20 Hz-300 Hz
Dimensions: (L×W×H) 28"×22"×11.5"
Decibel: about 91 dB

FIG. **7**A illustrates a perspective view of an exemplary speaker assembly **700** in accordance with another aspect of the disclosure. In this example, the speaker assembly **700** may be configured as a subwoofer for generating lower-end frequency audio. In particular, the speaker assembly **700** comprises an upper housing **702** disposed and securely mounted on a lower housing or base **710**. The upper housing **702** may be configured in any shape. However, in this example, the upper housing **702** is configured generally rectangular in shape, including a plurality of sidewalls **704** and a top wall **706**. Further, in accordance with this example, the upper housing **702** does not include a bottom wall.

The upper housing **702** may include one or more holes **708** to facilitate the flow of air between the interior and exterior of the upper housing **702** caused by the operation of an internal transducer, as further discussed herein. The one or more holes **708** may be formed through one or more of the sidewalls **704** as shown, and/or through the top wall **706**. The characteristic of the sound generated by the speaker assembly **700** depends on the shape, size and position of the one or more holes **708**, and may be configured to achieve a desired acoustic response for the speaker assembly.

The lower housing **710** may also be configured in any shape. However, in this example, the lower housing **710** is configured generally rectangular in shape, including a plurality of sidewalls **712**, a top wall **714**, and a bottom wall **715**. A plurality of caster wheels **716** may be mounted to the bottom wall **715** to facilitate moving the speaker assembly **700**. A securing mechanism **720**, such as a bolt or screw, may be used to securely attach the upper housing **702** to the lower housing **710**.

FIG. **7**B illustrates a sectional view of the exemplary speaker assembly **700** in accordance with another aspect of the disclosure. This figure illustrates the internal workings of the speaker assembly **700**. In particular, the speaker assembly **700** comprises a transducer **732** (e.g., a subwoofer) mounted to a wooden frame **740** situated within the lower housing **710** and supported therein in a generally horizontal orientation by a plurality of spacers **740** mounted to the bottom wall **714** of the lower housing. The wooden frame **740** and upper wall **714** of the lower housing **710** comprises registered holes through which a portion of the transducer **732** from the lower housing to the upper housing.

A decorative structure **734**, for example, in the form of a pyramid, may be disposed on the upper wall **714** of the lower housing **710**, and positioned centrally over the transducer **732**. The decorative structure **734** may be of individual glass pieces configured to form the decorative pyramid structure and also cover the transducer **732** for aesthetic reasons. The decorative structure **734** may include openings throughout to allow air flow caused by the operation of the transducer **732**. A light source **742**, for example, in the form of a lighting strip, may extend circularly around the transducer **732** and below the decorative pyramid structure **734**, and configured to illuminate the decorative structure with different hues for aesthetic purposes. An amplifier **738** may be incorporated into the lower housing **710**, and adapted to amplify an input audio signal to generate an output audio signal for driving the transducer **732**. Additionally, spacers **736** may be provided through which the securing mechanism **720** extends from the upper housing **702** to the lower housing **710**, whereby the lower end of the securing mechanism is attached to a bottom surface of the wooden frame **740**.

While the invention has been described in connection with various embodiments, it will be understood that the invention is capable of further modifications. This application is intended to cover any variations, uses or adaptation of the invention following, in general, the principles of the invention, and including such departures from the present disclosure as come within the known and customary practice within the art to which the invention pertains.

What is claimed is:

1. An audio speaker assembly, comprising:

a housing configured to produce sound with a first frequency response;

an elongated planar membrane supported in a vertical orientation by the housing, wherein the elongated planar membrane includes an entire lower region configured to produce sound with a second frequency response and an entire upper region configured to produce sound with a third frequency response, wherein the first frequency response favors relatively low frequencies, wherein the third frequency response favors relatively high frequencies, and wherein the second frequency response favors frequencies between the relatively low and relatively high frequencies; and

a first transducer configured to produce vibrational energy in the housing and in the elongated planar membrane.

2. The audio speaker assembly of claim **1**, further comprising a second transducer directly coupled to the housing.

3. The audio speaker assembly of claim **2**, wherein the first transducer is directly coupled to the elongated planar membrane.

4. The audio speaker assembly of claim **3**, wherein the first transducer is configured to more efficiently generate vibrational energy in the elongated planar membrane than in the housing, and further wherein the second transducer is configured to more efficiently generate vibrational energy in the housing than in the elongated planar membrane.

5. The audio speaker assembly of claim **4**, further comprising a first filtering element configured to receive an input audio signal and output therefrom a first audio signal component that better matches the second and third frequency responses of the elongated planar membrane than the first frequency response of the housing, wherein the first audio signal component is used for driving the first transducer.

6. The audio speaker assembly of claim **5**, further comprising a second filtering element configured to receive the input audio signal and output therefrom a second audio signal component that better matches the first frequency response of the housing than the second and third frequency responses of the elongated planar membrane, wherein the second audio signal component is used for driving the second transducer.

7. The audio speaker assembly of claim **1**, wherein the elongated planar membrane comprises light transparent or opaque material.

8. The audio speaker assembly of claim **7**, further comprising a light source adapted to produce light with a defined hue through the elongated planar membrane.

9. The audio speaker assembly of claim **8**, further comprising a wireless receiver adapted to receive a control signal for controlling the defined hue of the light.

10. The audio speaker assembly of claim **1**, wherein the elongated planar membrane comprises a curved edge or one or more holes at the entire upper region of the elongated planar membrane.

11. The audio speaker assembly of claim **10**, wherein the entire lower region of the elongated planar membrane is substantially rectangular in shape.

12. The audio speaker assembly of claim **1**, wherein the housing forms an enclosure, and wherein at least a portion of the elongated planar membrane is situated within the enclosure of the housing.

13. The audio speaker assembly of claim **12**, wherein the housing comprises an upper wall including a slot through which the elongated planar membrane extends in a substantially fitted configuration.

14. The audio speaker assembly of claim **13**, further comprising an anchor securely attaching the elongated planar membrane to the housing, wherein the anchor is situated within the enclosure of the housing.

15. The audio speaker assembly of claim **12**, further comprising a light source situated within the enclosure of the housing, wherein the light source is configured to emit light through the elongated planar membrane.

16. The audio speaker assembly of claim **15**, further comprising a user interface configured to allow a user to control a hue of the light emitted by the light source.

17. The audio speaker assembly of claim **16**, wherein the user interface comprises a wireless interface to allow the user to control the hue of the light using a remote control.

18. The audio speaker assembly of claim **12**, wherein the first transducer is situated within the enclosure of the housing.

19. The audio speaker assembly of claim **18**, further comprising a second transducer configured to produce vibrational energy in the housing and in the elongated planar membrane, wherein the second transducer is situated within the enclosure of the housing.

20. The audio speaker assembly of claim **19**, further comprising:

an audio amplifier configured to generate an amplified audio signal from an input audio signal;

a first filter configured to generate a first filtered audio signal from the amplified audio signal, wherein the first transducer is configured to be driven by the first filtered audio signal; and

a second filter configured to generate a second filtered audio signal from the amplified audio signal, wherein the second transducer is configured to be driven by the second filtered audio signal;

wherein the audio amplifier, the first filter, and the second filter are situated within the enclosure of the housing.

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