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(54) SUSPENSION SYSTEM FOR MICRO-SPEAKERS

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(51) **Int. Cl.**
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H04R 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 9/043*** (2013.01); *H04R 2400/03* (2013.01); *H04R 2499/15* (2013.01)

(58) **Field of Classification Search**
USPC 381/398, 301, 306, 333, 334, 388, 403; 181/171, 166, 172
See application file for complete search history.

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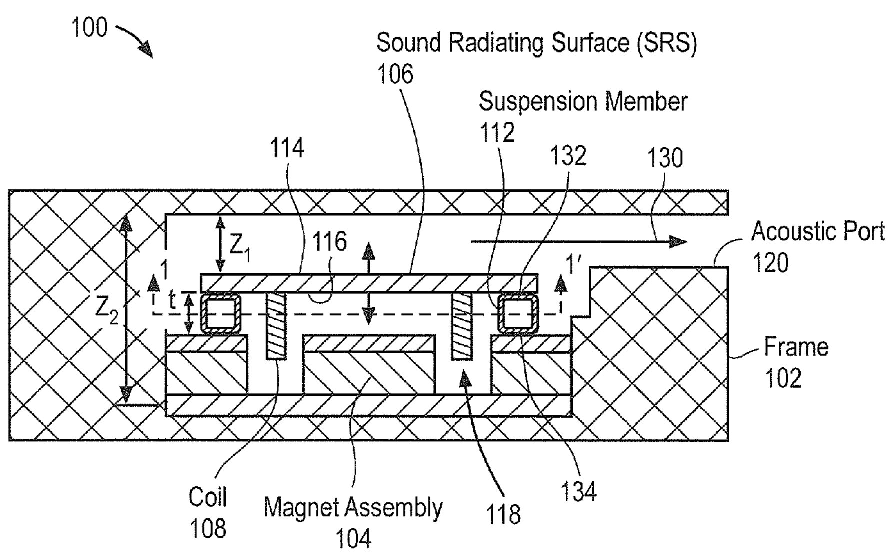
(74) *Attorney, Agent, or Firm* — Blakely, Sokoloff, Taylor & Zafman LLP

(57) **ABSTRACT**

A speaker driver including a frame and a magnet assembly positioned within the frame. A sound radiating surface may be suspended over the magnet assembly. The sound radiating surface may include a top face and a bottom face, and the bottom face may face the magnet assembly. A suspension member may suspend the sound radiating surface over the magnet assembly. The suspension member may include a top side connected to the bottom face of the sound radiating surface and a bottom side connected to the magnet assembly. A voice coil extends from the bottom face of the sound radiating surface.

18 Claims, 7 Drawing Sheets



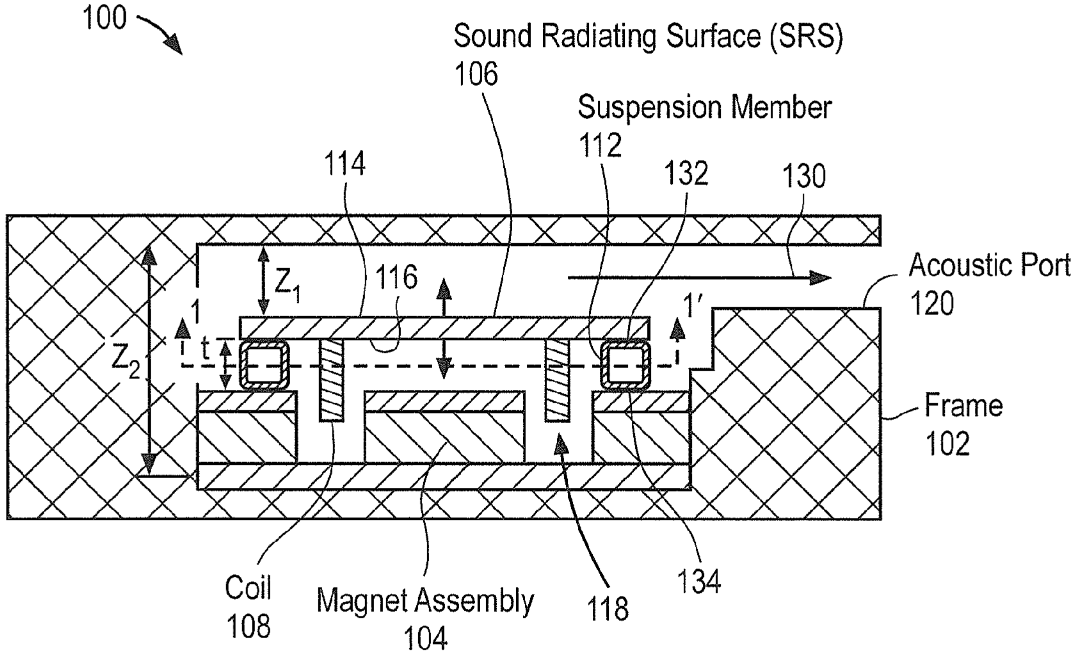

100
Sound Radiating Surface (SRS)
106
Suspension Member
112
114
132
130
116
Acoustic Port
120
Z_1
1
1′
Z_2
t
Frame
102
Coil
108
Magnet Assembly
104
118
134

FIG. 1A

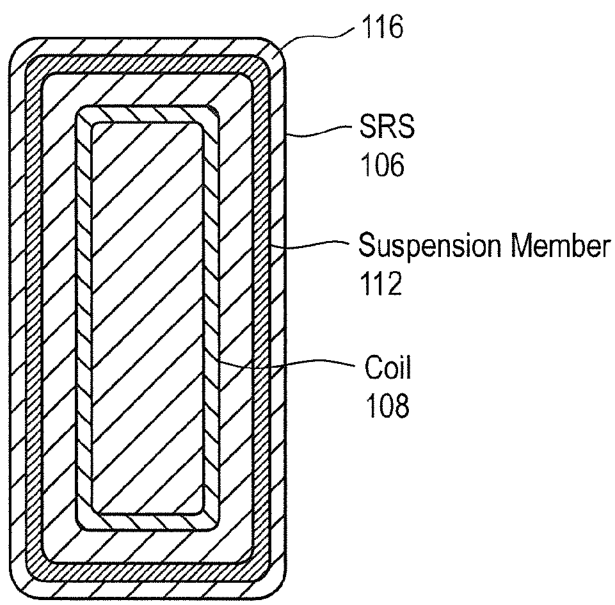

116
SRS
106
Suspension Member
112
Coil
108

FIG. 1B

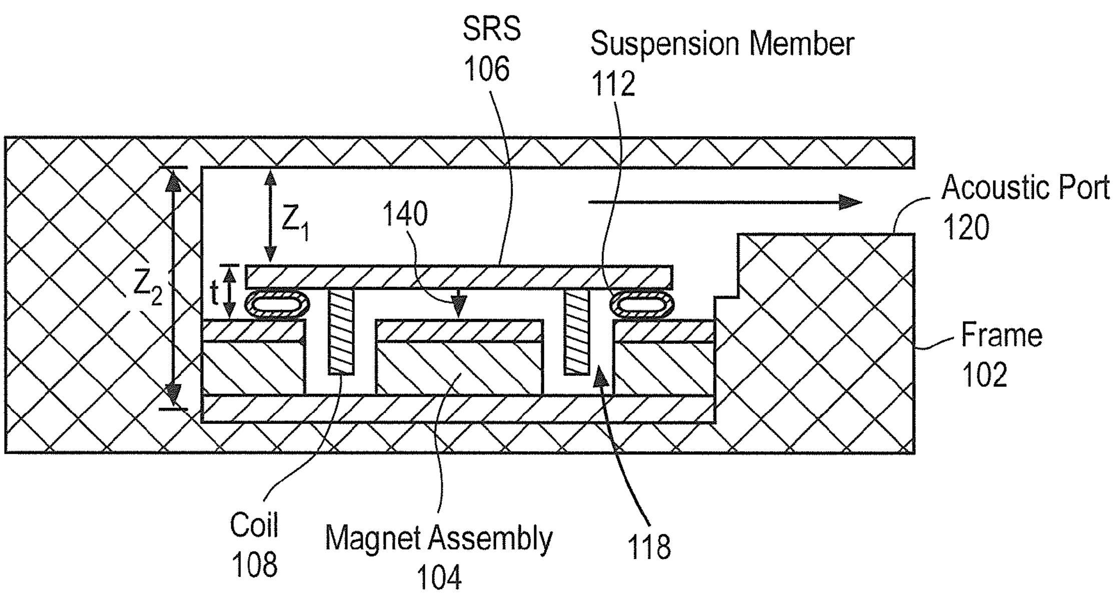

SRS
106
Suspension Member
112
Z1
140
t
Z2
Acoustic Port
120
Frame
102
Coil
108
Magnet Assembly
104
118

FIG. 1C

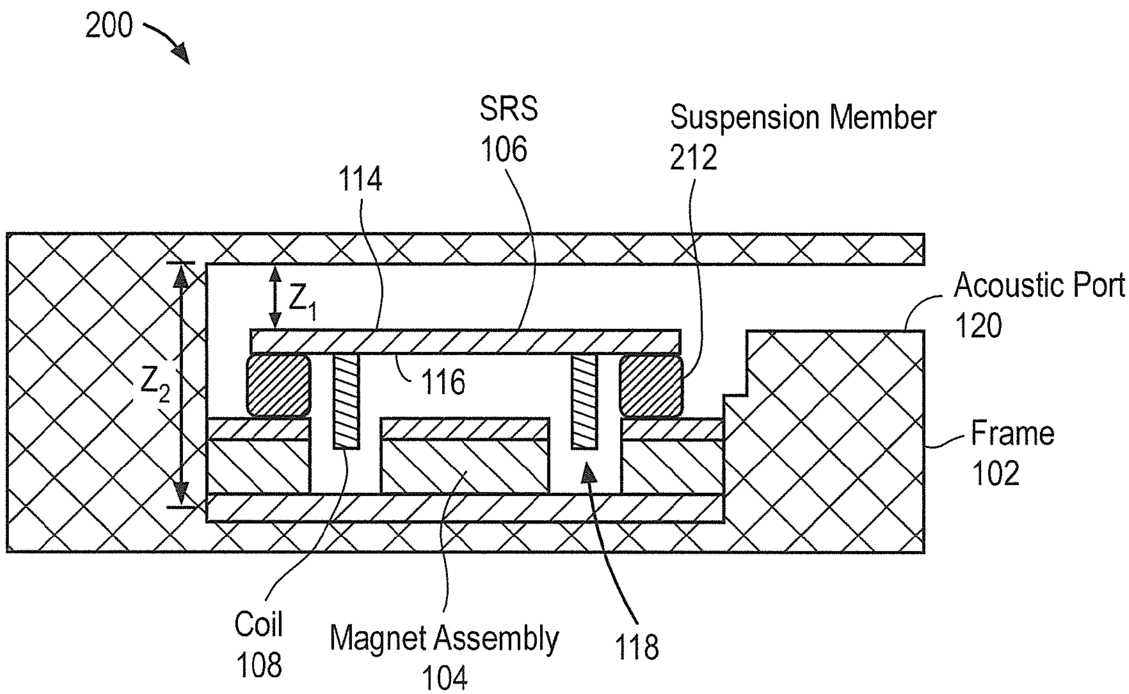

200
SRS
106
Suspension Member
212
114
Z_1
Acoustic Port
120
Z_2
116
Frame
102
Coil
108
Magnet Assembly
104
118

FIG. 2

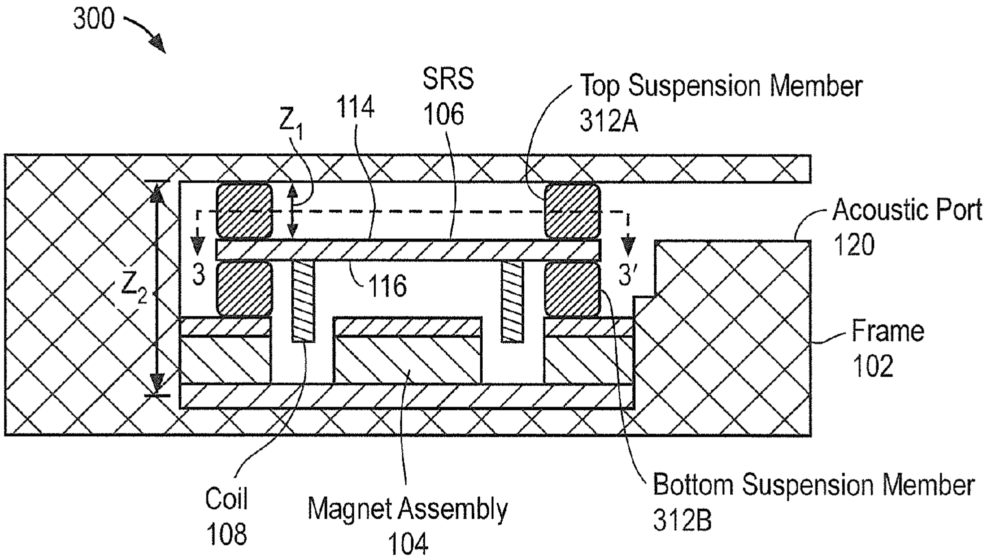

300
SRS
106
Top Suspension Member
312A
Z_1
114
Acoustic Port
120
Z_2
3
116
3'
Frame
102
Coil
108
Magnet Assembly
104
Bottom Suspension Member
312B

FIG. 3A

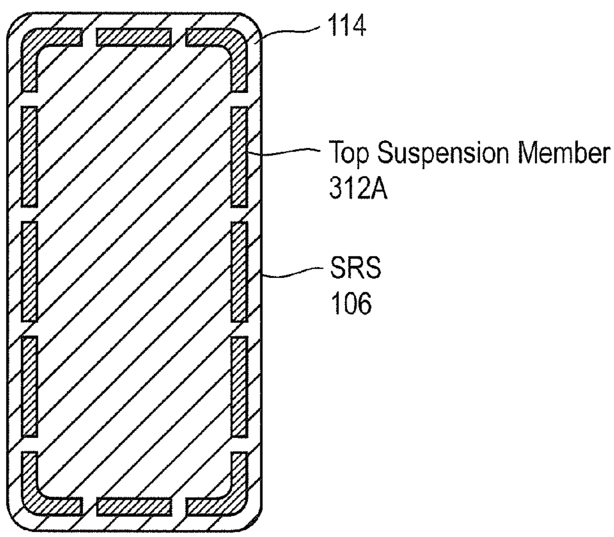

114
Top Suspension Member
312A
SRS
106

FIG. 3B

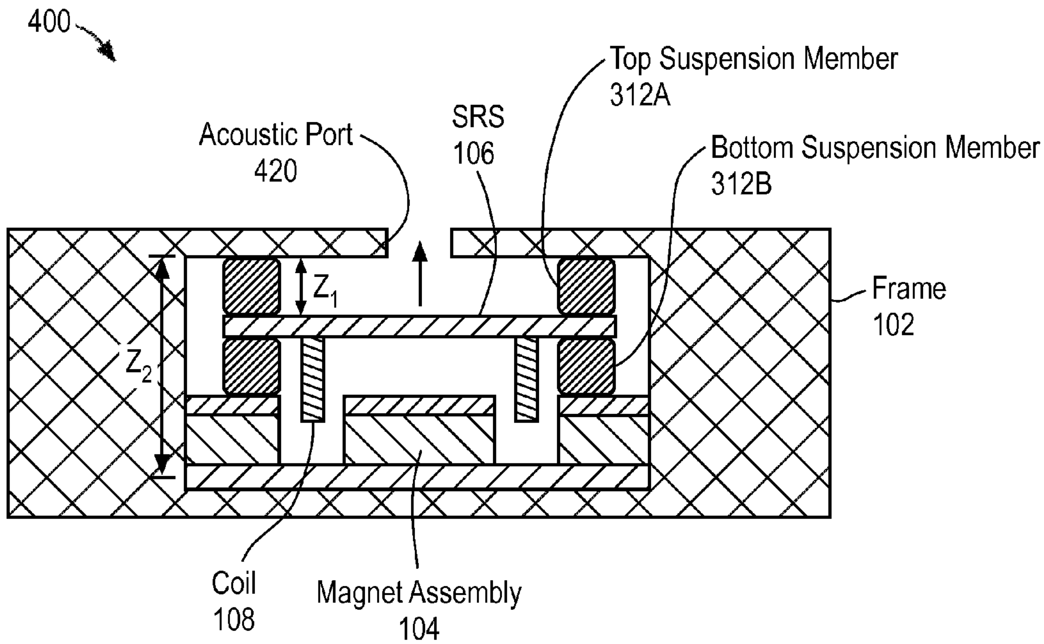

400
Acoustic Port
420
SRS
106
Top Suspension Member
312A
Bottom Suspension Member
312B
Z1
Z2
Frame
102
Coil
108
Magnet Assembly
104

FIG. 4

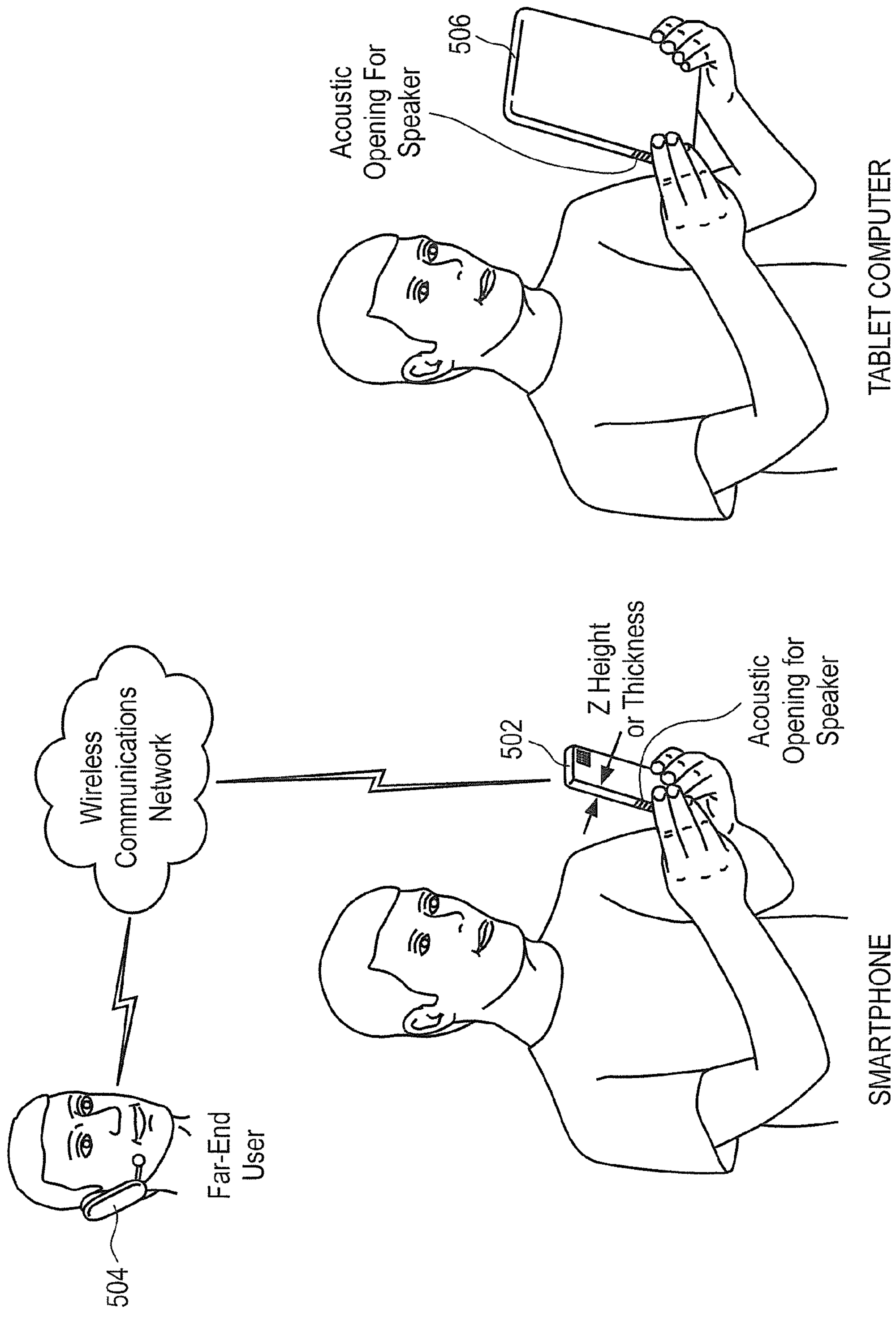

504
Far-End User
Wireless Communications Network
502
Z Height or Thickness
Acoustic Opening for Speaker
SMARTPHONE
506
Acoustic Opening For Speaker
TABLET COMPUTER

FIG. 5

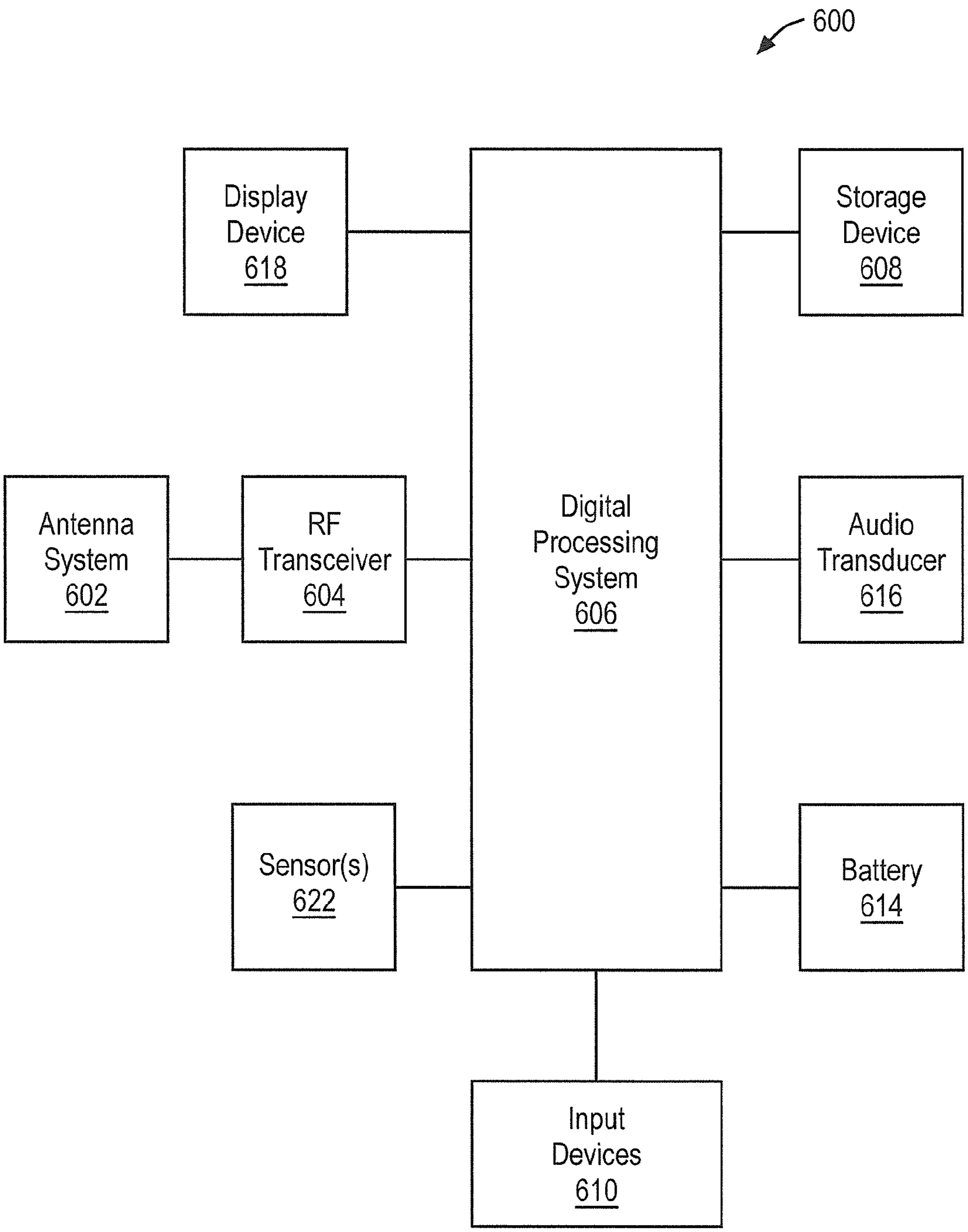

600
Display Device 618
Digital Processing System 606
Storage Device 608
Antenna System 602
RF Transceiver 604
Audio Transducer 616
Sensor(s) 622
Battery 614
Input Devices 610

FIG. 6

SUSPENSION SYSTEM FOR MICRO-SPEAKERS

FIELD

An embodiment of the invention is directed to a speaker assembly suspension system for low rise micro-speakers. Other embodiments are also described and claimed.

BACKGROUND

In modern consumer electronics, audio capability is playing an increasingly larger role as improvements in digital audio signal processing and audio content delivery continue to happen. There is a range of consumer electronics devices that are not dedicated or specialized audio playback devices, yet can benefit from improved audio performance. For instance, smart phones are ubiquitous. These devices, however, do not have sufficient space to house high fidelity speakers. This is also true for portable personal computers such as laptop, notebook, and tablet computers, and, to a lesser extent, desktop personal computers with built-in speakers. Such devices typically require speaker enclosures or boxes that have a relatively low rise (i.e. height or thickness as defined along the z-axis), as compared to, for instance, stand alone high fidelity speakers and dedicated digital music systems for handheld media players.

SUMMARY

An embodiment of the invention is a speaker assembly (e.g. a speaker driver) including a frame, a magnet assembly, a sound radiation surface, a suspension member and a voice coil. The magnet assembly is positioned within the frame and the sound radiating surface is suspended over the magnet assembly by the suspension member. The suspension member may have a top side connected to a bottom face of the sound radiating surface and a bottom side connected to the magnet assembly such that it extends in the z-height direction of the speaker driver. The voice coil may extend from the bottom face of the sound radiating surface such that it is aligned with a magnetic flux gap formed within the magnet assembly. The suspension member may be resilient such that it can expand and contract in the z-height direction in response to movement of the sound radiating surface. In addition, the suspension member may be confined to an area below the sound radiating surface and within a footprint of the sound radiating surface such that it does not extend radially beyond the perimeter of the sound radiating surface. In this aspect, an acoustic radiation surface area of the sound radiating surface may be improved, e.g., increased.

In some embodiments, the speaker assembly may be a micro-speaker assembly which is integrated within a portable audio device. In this aspect, an acoustic output port of the speaker assembly may be aligned with an acoustic opening of the portable audio device such that sound generated by the speaker assembly may be output from the portable audio device.

The above summary does not include an exhaustive list of all aspects of the embodiments disclosed herein. It is contemplated that the embodiments may include all systems and methods that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the Detailed Description below and particularly pointed out in the claims filed with the application. Such combinations may have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments disclosed herein are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and they mean at least one.

FIG. **1**A is a cross-sectional side view of an embodiment of a speaker assembly.

FIG. **1**B is a bottom plan view of the sound radiating surface of one embodiment of the speaker assembly along line **1-1'** of FIG. **1**A.

FIG. **1**C is a cross-sectional side view of the speaker assembly of FIG. **1**A having a compressed suspension member.

FIG. **2** is a cross-sectional side view of one embodiment of a speaker assembly.

FIG. **3**A is a cross-sectional side view of one embodiment of a speaker assembly.

FIG. **3**B is a top plan view of the sound radiating surface of one embodiment of the speaker assembly along line **3-3'** of FIG. **3**A.

FIG. **4** is a cross-sectional side view of an embodiment of a speaker assembly.

FIG. **5** depicts two instances of consumer electronics devices that typically specify low rise speakers in which the speakers disclosed herein may be implemented.

FIG. **6** is a block diagram of a system in which embodiments of a speaker assembly may be implemented.

DETAILED DESCRIPTION

In this section we shall explain several preferred embodiments with reference to the appended drawings. Whenever the shapes, relative positions and other aspects of the parts described in the embodiments are not clearly defined, the scope of the embodiments is not limited only to the parts shown, which are meant merely for the purpose of illustration. Also, while numerous details are set forth, it is understood that some embodiments may be practiced without these details. In other instances, well-known structures and techniques have not been shown in detail so as not to obscure the understanding of this description.

FIG. **1**A is a cross-sectional side view of an embodiment of a speaker assembly. Speaker assembly **100** may be any type of electroacoustic transducer or driver that produces sound in response to an electrical audio signal input. Representatively, in one embodiment, speaker assembly **100** may be a micro-speaker. Speaker assembly **100** is built into frame **102**, which may be of a typical material used for speaker enclosures, such as plastic. Frame **102** may include an acoustic port **120** for output of sound from speaker assembly **100** in the direction illustrated by arrow **130**. In the illustrated embodiment, frame **102** includes acoustic port **120** along its side such that speaker assembly **100** may be considered "side firing", meaning that sound is output in a sideways direction as illustrated by arrow **130**. Frame **102** may be part of, or mounted within, an electronic device enclosure whose z-height (or rise or thickness) is considered to be relatively small. For example, the enclosure z-height may be in the range of about 8.5 millimeters (mm) to about 10 mm. The concepts described herein, however, need not be limited to speaker enclosures whose height is within these ranges. As seen in FIG. **5**, such a speaker assembly **100** may be a speakerphone unit that is integrated within a consumer electronic device **502** such as a smart phone with which a user can conduct a call with a far-end user of a communications device **504** over a wireless communications network; in another example, the speaker assembly **100** may be integrated within the housing of a tablet computer **506**. These are just two examples of where the speaker assembly may be used.

Speaker assembly **100** may include a magnet assembly **104**, sound radiating surface (SRS) **106** and coil **108** (also referred to as a voice coil). SRS **106** may be any type of speaker or micro-speaker diaphragm capable of inter-converting mechanical motion and sound. Coil **108** may be attached to a bottom face **116** of SRS **106** in any suitable manner, e.g., chemical bonding, mechanically attached or the like. Coil **108** may be any type of voice coil suitable for use in a speaker, for example, a micro-speaker. Magnet assembly **104** may define a magnetic flux gap **118** within which a portion of coil **108** may be positioned. A magnetic field of magnet assembly **104** helps to drive an up and down movement of coil **108**, which in turn vibrates or moves SRS **106** in a similar manner with respect to magnet assembly **104** (as illustrated by arrows) to generate sound waves.

SRS **106** may be movably suspended over magnet assembly **104** by a suspension member **112**. Suspension member **112** may be positioned between the bottom face **116** of SRS and magnet assembly **104** such that it suspends SRS **106** above magnet assembly **104**. In addition to facilitating vibration of SRS **106** back and forth as illustrated by the arrows, suspension member **112** helps to maintain side to side alignment of coil **108** within gap **118**.

In some embodiment, suspension member **112** is dimensioned to suspend a resilient portion of SRS **106** above magnet assembly **104** without extending into an area above top face **114** of SRS **106** (i.e. the area between top face **114** and the top wall of frame **102**). In this aspect, a z-height between top face **114** of SRS **106** and frame **102** (illustrated as Z_1), and in turn an overall z-height of frame **102** (illustrated as Z_2) need not be increased to accommodate suspension member **112**. As such, a z-height of speaker assembly **100** can be reduced, as compared to speakers using radially extending half-arc suspension systems that extend above the diaphragm they are suspending. Consider for example a typical speaker assembly having a Z_1 to Z_2 height ratio of about 1 to 5, speaker assembly **100** may allow for this ratio to be reduced such that Z_1 to Z_2 is, for example, from about 1 to 4, or from 1 to 3, or 1 to 2. The reduced z-height of speaker assembly **100** allows speaker assembly **100** to be integrated within relatively low rise devices.

In addition to not extending above SRS **106**, suspension member **112** is substantially confined to an area below SRS **106**, in other words SRS **106** overlaps suspension member **112**. Described another way, suspension member **112** is substantially within a footprint of SRS **106** such that it does not extend radially beyond a perimeter of SRS **106**. In this aspect, the acoustic radiation surface area of SRS **106** is improved (i.e. increased). The acoustic radiation surface area generally refers to the surface area of SRS **106** which can vibrate and produce sound. Representatively, the area of the frame within which a typical SRS is supported has a predefined length and width. When the SRS is suspended within the frame using a suspension system that extends radially from the SRS to the frame (e.g. a half-arc suspension system), the overall area of the SRS must be reduced to accommodate the surrounding suspension system. Since suspension member **112**, however, does not extend radially beyond a perimeter of SRS **106**, the acoustic radiation surface area of SRS **106** does not need to be reduced to accommodate suspension member **112**. Rather, SRS **106** can extend into the area of frame **102** typically reserved for a radially extending suspension member thereby increasing its acoustic radiation surface area. In addition, because suspension member **112** extends vertically between SRS **106** and magnet assembly **104**, SRS **106** has a higher stiffness in the in-plane direction, as compared to diaphragms suspended using radially extending suspensions. This in turn helps to stabilize SRS **106** displacement and minimize rocking or tilting of SRS **106**.

Suspension member **112** can be any size, shape and/or material suitable for suspending SRS **106** above magnet assembly **104** in the manner previously discussed. Representatively, suspension member **112** may be made of any structure and/or materials which allow suspension member **112** to be contracted down to the excursion limit of SRS **106**, with the excursion limit being one which avoids coil **108** from contacting frame **102**. In addition, the structure and/or material of suspension member **112** should be that which allows maximal and symmetrical displacement of SRS **106** in the upward direction so as to minimize rocking of SRS **106**. In this aspect, suspension member **112** should be resilient and capable of expanding and contracting along the z-height direction to accommodate SRS movement with respect to magnet assembly **104**. Representatively, suspension member **112** may be made of a resilient material including, but not limited to, silicone, rubber, or a gel material encapsulated within any of these materials, or any combination of these materials. In some embodiments, suspension member **112** is made of any non-metal material.

In one embodiment, suspension member **112** may be an elongated structure which is attached along its top side **132** to the bottom face **116** of SRS **106** and along its bottom side **134** to magnet assembly **104**. Suspension member **112** may be attached to an area of bottom face **116** which is outside of coil **108** and near the edge of SRS **106** as illustrated in FIG. **1**B, which shows a plan view of the bottom face **116** of SRS **106** along line **1-1'** of FIG. **1**A. As further illustrated in FIG. **1**B, suspension member **112** may be a continuous structure which acoustically seals SRS **106** to magnet assembly **104** such that the area below SRS **106** is acoustically isolated from the area above SRS **106**. In this aspect, sound waves produced by bottom face **116** of SRS **106** are not directed out of acoustic port **120**. In other embodiments, suspension member **112** may be made of discrete units (see, for example, suspension member **312**A of FIG. **3**B). In either case, suspension member **112** may be attached to SRS **106** in any suitable manner, such as, for example, an adhesive, laser welding, a thermoforming technique or the like.

Representatively, in some embodiments, suspension member **112** may be made of a hollow tube which can expand or contract in the z-height direction. Representatively, FIG. **1**A illustrates a tubular suspension member **112** having a thickness (t) (or z-height) which is substantially equivalent to a distance between the bottom face **116** of SRS **106** and the magnet assembly **104**. In FIG. **1**A, the tubular suspension member **112** is not compressed or contracted. Rather, the tubular suspension member **112** is in its resting state. As illustrated by FIG. **1**C, however, as SRS **106** moves in the direction of magnet assembly **104** (as illustrated by arrow **140**) the tubular suspension member **112** is compressed and its overall thickness decreases. The tubular suspension member **112** will in turn expand back to its resting state (i.e. the thickness will increase) when SRS **106** moves away from magnet assembly **104**. Although suspension member **112** is illustrated as having a substantially square cross-sectional shape, suspension member **112** may have any cross-sectional shape, for example, a substantially round, rectangular, concave, or convex shape.

FIG. **2** illustrates a cross-sectional side view of another embodiment of a speaker assembly in which suspension member **212** is substantially similar to suspension member **112** except that in this embodiment, suspension member **212** is made of a substantially solid structure. Representatively, suspension member **212** may be a solid elongated structure which is made of a resilient material which allows for suspension member **212** to expand and contract in the z-height or thickness direction in response to movement of SRS **106**. Suspension member **212** may be made of one material, or a composite structure made of several materials. For example, suspension member **212** could be made entirely of a silicon or rubber material, or could include an outer portion made of one of these materials and an inner portion made of another of these materials, or a gel material. Similar to the previously discussed suspension member **112**, suspension member **212** is confined to an area below SRS **106** and within a footprint of SRS **106** such that it does not extend radially beyond the bounds of SRS **106**. Similar to speaker assembly **100**, because suspension member **212** is confined to an area below SRS **106**, speaker assembly **200** has a relatively low Z_1 to Z_2 height ratio, for example, a Z_1 to Z_2 ratio of from about 1 to 4, or from 1 to 3, or 1 to 2. Speaker assembly **200** may be substantially similar to speaker assembly **100** and, therefore, also includes frame **102**, SRS **106**, coil **108** and magnet assembly **104**. Suspension member **212** may be attached around the bottom face **116** of SRS **106** in a similar manner to those previously discussed in reference to FIG. **1**A (e.g., an adhesive, laser welding, a thermoforming technique or the like).

FIG. **3**A illustrates a cross-sectional side view of another embodiment of a speaker assembly. In this embodiment, speaker assembly **300** includes a dual suspension member system. Representatively, speaker assembly **300** includes a top suspension member **312**A attached to top face **114** of SRS **106** and a bottom suspension member **312**B attached to bottom face **116** of SRS **106**. Top suspension member **312**A is attached at its top side to frame **102** and its bottom side to top face **114** of SRS **106**. In addition, similar to the previously discussed suspension members, bottom suspension member **312**B is attached at its top side to bottom face **116** of SRS **106** and its bottom side to magnet assembly **104**. Top suspension member **312**A and bottom suspension member **312**B may be substantially similar in material and structure to the suspension members previously discussed in reference to FIG. **1**A and FIG. **2**, except that in this embodiment one of them may be continuous while one of them may be made of discrete units. Representatively, bottom suspension member **312**B may be made of a continuous structure such as a tubular member that seals SRS **106** to magnet assembly **104**. Top suspension member **312**A may be made of discrete units as illustrated in FIG. **3**B, which is a top plan view of top face **114** of SRS **106** along line **3-3'** of FIG. **3**A. In this aspect, sound generated by SRS **106** can travel from top face **114** and out the side acoustic port **120** formed in frame **102**. In addition, it is further to be understood that top suspension member **312**A may have a thickness sufficient to fill the gap between the top side of frame **102** and top face **114** of SRS **106** without substantially increasing the z-height (i.e. Z_1) of frame **102**. In this aspect, speaker assembly **300** has a relatively low Z_1 to Z_2 height ratio as previously discussed (e.g. a Z_1 to Z_2 ratio of from about 1 to 4, or from 1 to 3, or 1 to 2). The remaining components of speaker assembly **300** may be substantially similar to those previously discussed in reference to FIG. **1**A. Representatively, speaker assembly **300** further includes coil **108** suspended from SRS **106** and magnet assembly **104** mounted within frame **102**, below SRS **106** and coil **108**.

FIG. **4** illustrates another embodiment of a speaker assembly. Speaker assembly **400** is substantially similar to speaker assembly **300** described in reference to FIG. **3**A except in this embodiment, speaker assembly **400** is a "top firing" speaker system which includes acoustic port **420** along a top side of frame **102**. In this aspect, sound generated by SRS **106** is output through a top side of frame **102**. Since the sound need not travel through the top suspension member **312**A to any of the previously discussed side acoustic ports, top suspension member **312**A can be made of a continuous structure which seals SRS **106** to frame **102**. Bottom suspension member **312**B may also be a continuous structure as previously discussed, or may be made of discrete units since the area above SRS **106** is already acoustically isolated from the area below SRS **106** by top suspension member **312**A. Although two suspension members **312**A and **312**B are illustrated in FIG. **4**, it is contemplated that the "top firing" speaker system may also be formed using only one suspension member, e.g., bottom suspension member **312**B, and the other omitted.

A process of manufacturing any one or more of the speaker assemblies described above, and in particular a speaker assembly including a frame **102**, magnet assembly **104**, SRS **106**, coil **108** and one or more suspension members **112**, **212**, **312**A-**312**B may proceed as follows. Coil **108** may be obtained as a pre-wound unit, which is then secured to SRS **106**. Next, the magnet assembly **104** is mounted within frame **102** and, at the same time, or just before or just after, the suspension member (for example, suspension member **112**) is attached to magnet assembly **104**. Alternatively, the suspension member may first be attached to SRS **106**. SRS **106**, which may be a rigid plate or dome having coil **108** attached thereto, is then attached to a top side of the suspension member.

As previously discussed, FIG. **5** illustrates exemplary consumer electronic devices **502** and **506** within which any of the previously discussed speaker assemblies may be implemented. In this aspect, an acoustic output port of any of the previously discussed speaker assemblies may be aligned with an acoustic opening of the portable audio device such that sound generated by the speaker assembly may be output from the portable audio device. These, however, are just two examples of where the speaker assembly may be used. Other types of devices within which the speaker assembly may be used may include, but are not limited to, a notebook computer or other portable computing device, a digital media player, such as a portable music and/or video media player, entertainment systems or personal digital assistants (PDAs), or general purpose computer systems, or special purpose computer systems, or an embedded device within another device, or cellular telephones which do not include media players, or devices which combine aspects or functions of these devices (e.g., a media player, such as an iPod®, combined with a PDA, an entertainment system, and a cellular telephone in one portable device).

FIG. **6** shows a block diagram of an embodiment of a wireless device **600** within which any of the previously discussed speaker assemblies may be implemented. In the illustrated embodiment, wireless device **600** is a wireless communication device. The wireless device **600** may be included in the devices shown in FIG. **5**, although alternative embodiments of handheld devices **502** and **506** may include more or fewer components than the wireless device **600**.

Wireless device **600** may include an antenna system **602**. Wireless device **600** may also include a radio frequency (RF) transceiver **604**, coupled to the antenna system **602**, to transmit and/or receive voice, digital data and/or media signals through antenna system **602**.

A digital processing system **606** may further be provided to control the digital RF transceiver and to manage the voice, digital data and/or media signals. Digital processing system

606 may be a general purpose processing device, such as a microprocessor or controller for example. Digital processing system **606** may also be a special purpose processing device, such as an ASIC (application specific integrated circuit), FPGA (field-programmable gate array) or DSP (digital signal processor). Digital processing system **606** may also include other devices to interface with other components of wireless device **600**. For example, digital processing system **606** may include analog-to-digital and digital-to-analog converters to interface with other components of wireless device **600**.

A storage device **608**, coupled to the digital processing system, may further be included in wireless device **600**. Storage device **608** may store data and/or operating programs for the wireless device **600**. Storage device **608** may be, for example, any type of solid-state or magnetic memory device.

One or more input devices **610**, coupled to the digital processing system **606**, to accept user inputs (e.g., telephone numbers, names, addresses, media selections, etc.) or output information to a far end user may further be provided. Exemplary input devices may be, for example, one or more of a keypad, a touchpad, a touch screen, a pointing device in combination with a display device or similar input device.

Display device **618** may be coupled to the digital processing system **606**, to display information such as messages, telephone call information, contact information, pictures, movies and/or titles or other indicators of media being selected via the input device **610**. Display device **618** may be, for example, an LCD display device. In one embodiment, display device **618** and input device **610** may be integrated together in the same device (e.g., a touch screen LCD such as a multi-touch input panel which is integrated with a display device, such as an LCD display device). It will be appreciated that the wireless device **600** may include multiple displays.

Battery **614** may further be provided to supply operating power to components of the system including digital RF transceiver **604**, digital processing system **606**, storage device **608**, input device **610**, audio transducer **616**, sensor(s) **622**, and display device **618**. Battery **614** may be, for example, a rechargeable or non-rechargeable lithium or nickel metal hydride battery. Wireless device **600** may also include audio transducers **616**, which may include one or more speakers (e.g. speaker assemblies **100-400**), receivers and at least one microphone.

Sensor(s) **622** may be coupled to the digital processing system **606**. The sensor(s) **622** may include, for example, one or more of a light and/or proximity sensor. Based on the data acquired by the sensor(s) **622**, various responses may be performed automatically by the digital processing system, such as, for example, activating or deactivating the backlight, changing a setting of the input device **610** (e.g., switching between processing or not processing, as an intentional user input, any input data from an input device), and other responses and combinations thereof. It is noted that other types of sensors may also be included in wireless device **600**, such as an accelerometer, touch input panel, ambient noise sensor, temperature sensor, gyroscope, a hinge detector, a position determination device, an orientation determination device, a motion sensor, a sound sensor, a radio frequency electromagnetic wave sensor, and other types of sensors and combinations thereof.

In addition, although not illustrated, other types of devices and/or components may also be associated with wireless device **600**, for example, a camera.

While certain embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive, and that the embodiments disclosed herein are not limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those of ordinary skill in the art. For example, although the drawings show a substantially rectangular SRS, it is contemplated that SRS may have any shape and size suitable for use in a speaker assembly, for example, SRS may be round. In addition, although the speaker assembly is described as a micro-speaker assembly, it is further contemplated that suspension members such as those described herein may be used to suspend any type of diaphragm used in any type of speaker assembly, for example, a diaphragm used in high fidelity speaker systems for stereo systems, radios, televisions or the like. The description is thus to be regarded as illustrative instead of limiting.

What is claimed is:

1. A speaker driver comprising:

a frame;

a magnet assembly positioned within the frame;

a sound radiating surface suspended over the magnet assembly, the sound radiating surface having a top face and a bottom face, and wherein the bottom face faces the magnet assembly;

a suspension member for suspending the sound radiating surface over the magnet assembly, the suspension member having a top side connected to the bottom face of the sound radiating surface and a bottom side directly connected to, and in contact with, the magnet assembly, and wherein the suspension member comprise a resilient material and is configured to compress and expand in a z-height direction in response to a movement of the sound radiating surface; and

a voice coil extending from the bottom face of the sound radiating surface.

2. The speaker driver of claim **1** wherein the suspension member comprises a resilient tube.

3. The speaker driver of claim **1** wherein the suspension member is configured to acoustically seal the sound radiating surface to the magnet assembly.

4. The speaker driver of claim **1** wherein the suspension member is a first suspension member, and the speaker driver further comprises a second suspension member connected to a top face of the sound radiating surface and the frame.

5. The speaker driver of claim **1** wherein the suspension member is confined to an area within a footprint of the sound radiating surface.

6. The speaker driver of claim **1** wherein the suspension member is confined to an area between the bottom face of the sound radiating surface and the magnet assembly.

7. The speaker driver of claim **1** wherein the suspension member is configured to stabilize a rocking motion of the sound radiating surface.

8. A micro-speaker assembly comprising:

a frame;

a magnet assembly positioned within the frame;

a sound radiating surface suspended over the magnet assembly, the sound radiating surface having a top face and a bottom face, and wherein the bottom face faces the magnet assembly;

a suspension member for suspending the sound radiating surface over the magnet assembly, wherein the suspension member is confined to an area below the bottom face of the sound radiating surface and extends in a z-height direction from the bottom face of the sound radiating surface and directly contacts the magnet assembly, and wherein the suspension member comprises a resilient material and is configured to compress and expand in a z-height direction in response to a movement of the sound radiating surface; and

a voice coil extending from the bottom face of the sound radiating surface.

9. The micro-speaker assembly of claim **8** wherein the suspension member does not extend radially beyond a perimeter of the sound radiating surface.

10. The micro-speaker assembly of claim **8** wherein the suspension member comprises a hollow tube that seals the sound radiating surface to the magnet assembly.

11. The micro-speaker assembly of claim **8** wherein the suspension member comprises a thickness substantially equivalent to a distance between the bottom face of the sound radiating surface and the magnet assembly.

12. The micro-speaker assembly of claim **8** wherein the z-height is a first z-height corresponding to a distance between the sound radiating surface and a top of the frame and the micro-speaker assembly further comprises a second z-height corresponding to a distance between the top of the frame and a bottom of the frame, and wherein a ratio of the first z-height to the second z-height is less than 1 to 4.

13. A portable audio device comprising:

an outer case having a speaker associated acoustic hole formed therein; and

a speaker assembly positioned within the outer case and acoustically coupled to the speaker associated acoustic hole, the speaker assembly having a diaphragm, a voice coil, and a magnet assembly, wherein the diaphragm is suspended over the magnet assembly by a suspension member that extends in a z-height direction from a bottom face of the diaphragm and directly contacts the magnet assembly, and wherein the suspension member comprises a resilient material and is configured to compress and expand in a z-height direction in response to a movement of the sound radiating surface.

14. The portable audio device of claim **13** wherein the acoustic radiation surface area of the diaphragm substantially overlaps the suspension member.

15. The portable audio device of claim **13** wherein the suspension member is connected to a portion of a bottom face of the diaphragm surrounding the voice coil.

16. The portable audio device of claim **13** wherein the suspension member comprises a resilient material that forms a seal between the diaphragm and the magnet assembly.

17. The portable audio device of claim **13** wherein the suspension member is a first suspension member, and the device further comprises a second suspension member comprising sections of a resilient material that are attached to a top face of the diaphragm.

18. The portable audio device of claim **13** wherein the speaker assembly is a side firing speaker assembly.

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