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(54) **METHOD AND APPARATUS FOR ADJUSTING SOUND QUALITY**

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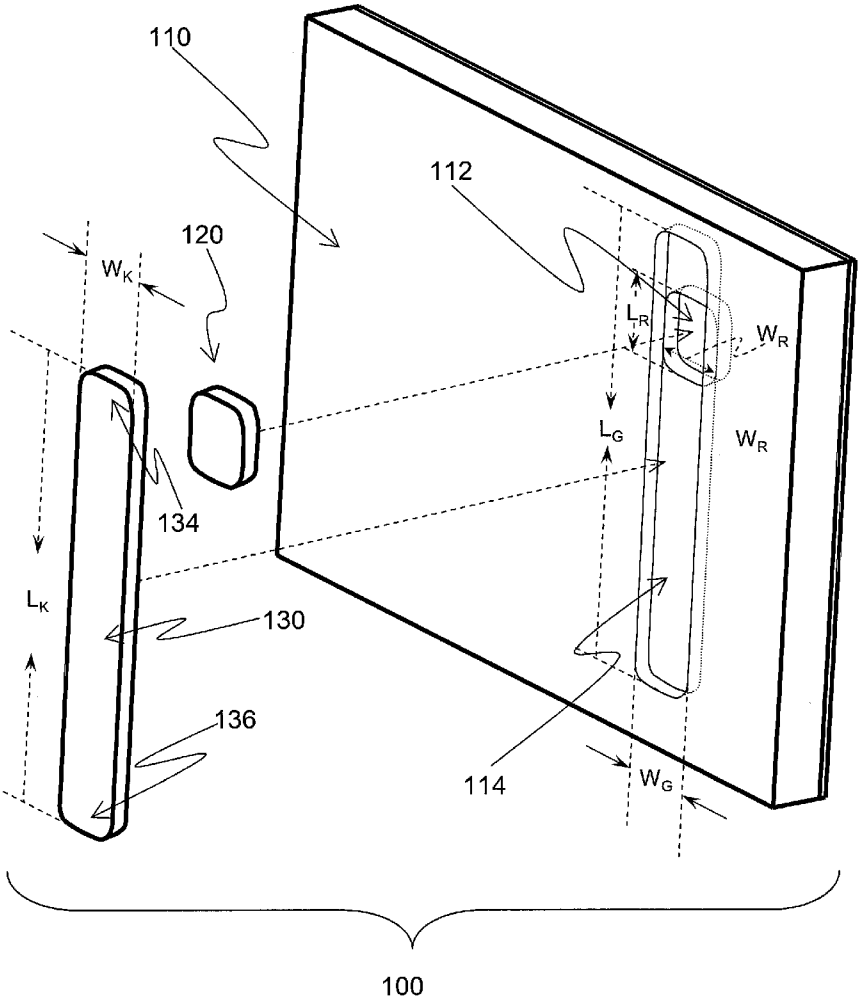
(57) **ABSTRACT**

An electronic apparatus and a method for providing a sound system of the electronic apparatus are provided herein. The electronic apparatus has a housing, a speaker and a bracket. The housing has a space and a channel, which is coupled to the space. The speaker is placed in the space. The bracket has a first end coupled to the channel and is movable relative to the housing. A sound mode of the electronic apparatus may be switched from a first mode to a second mode by positioning a second end of the bracket from a first position in the channel to a second position away from the channel.



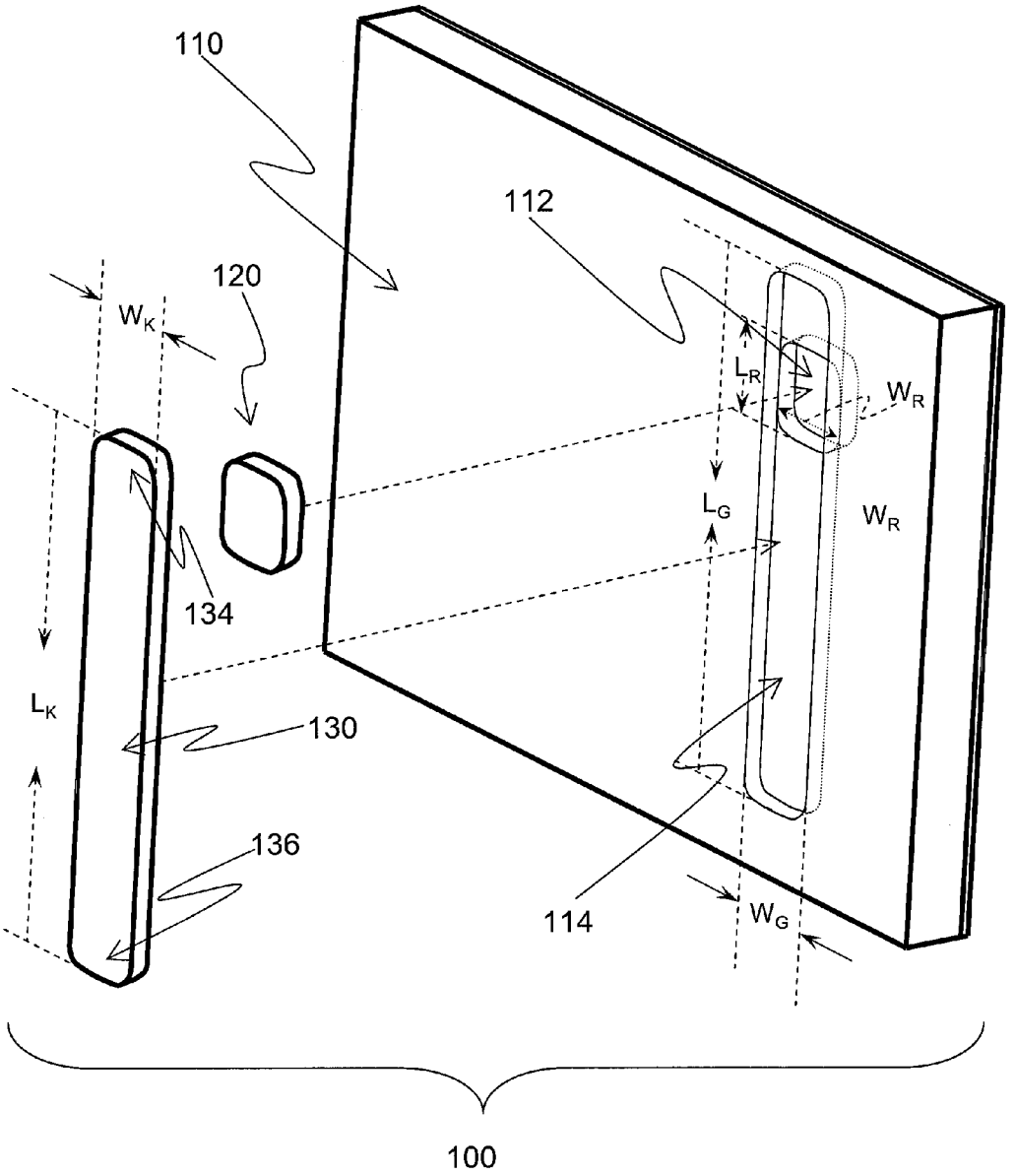


FIG. 1

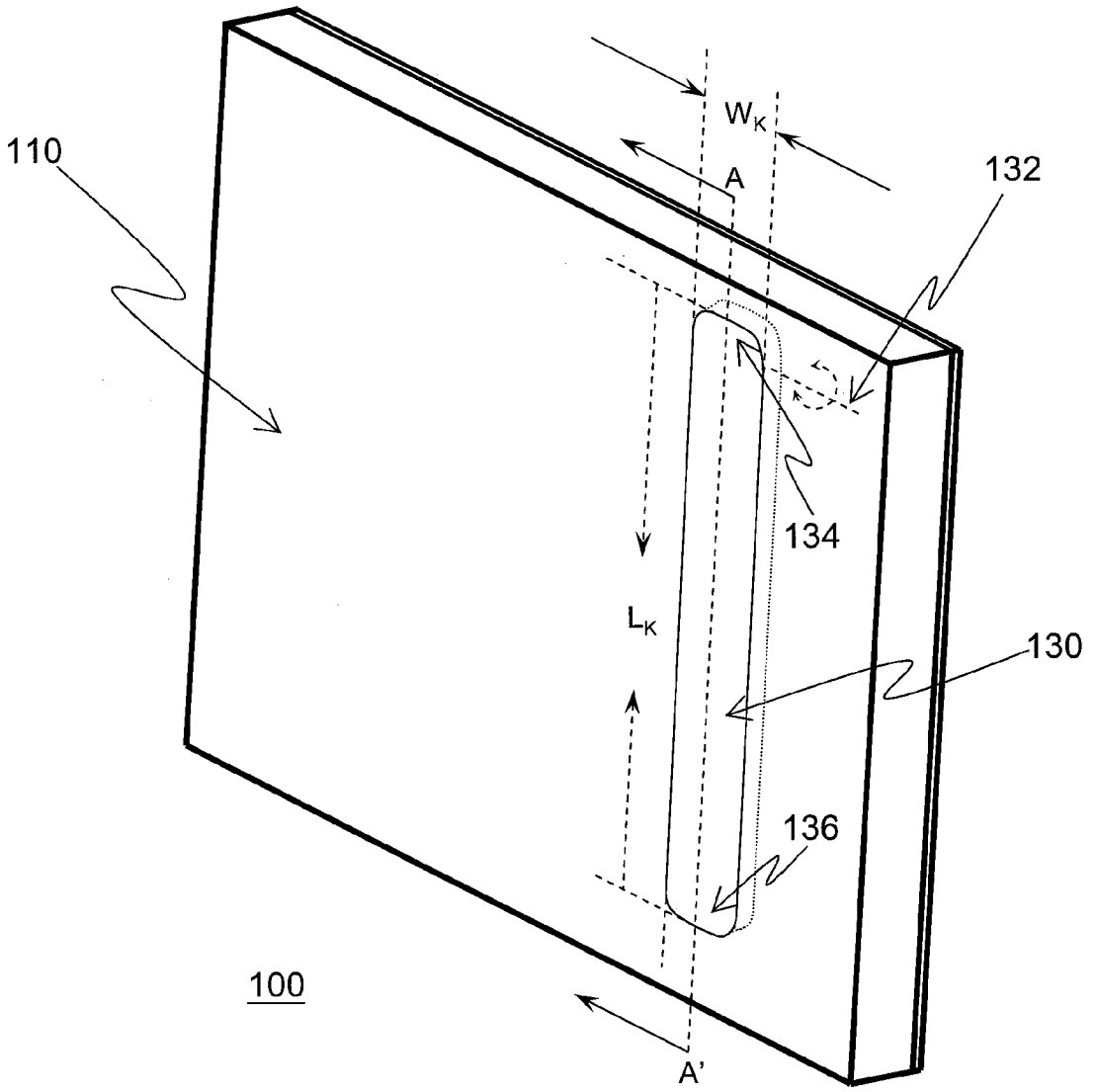


FIG. 2

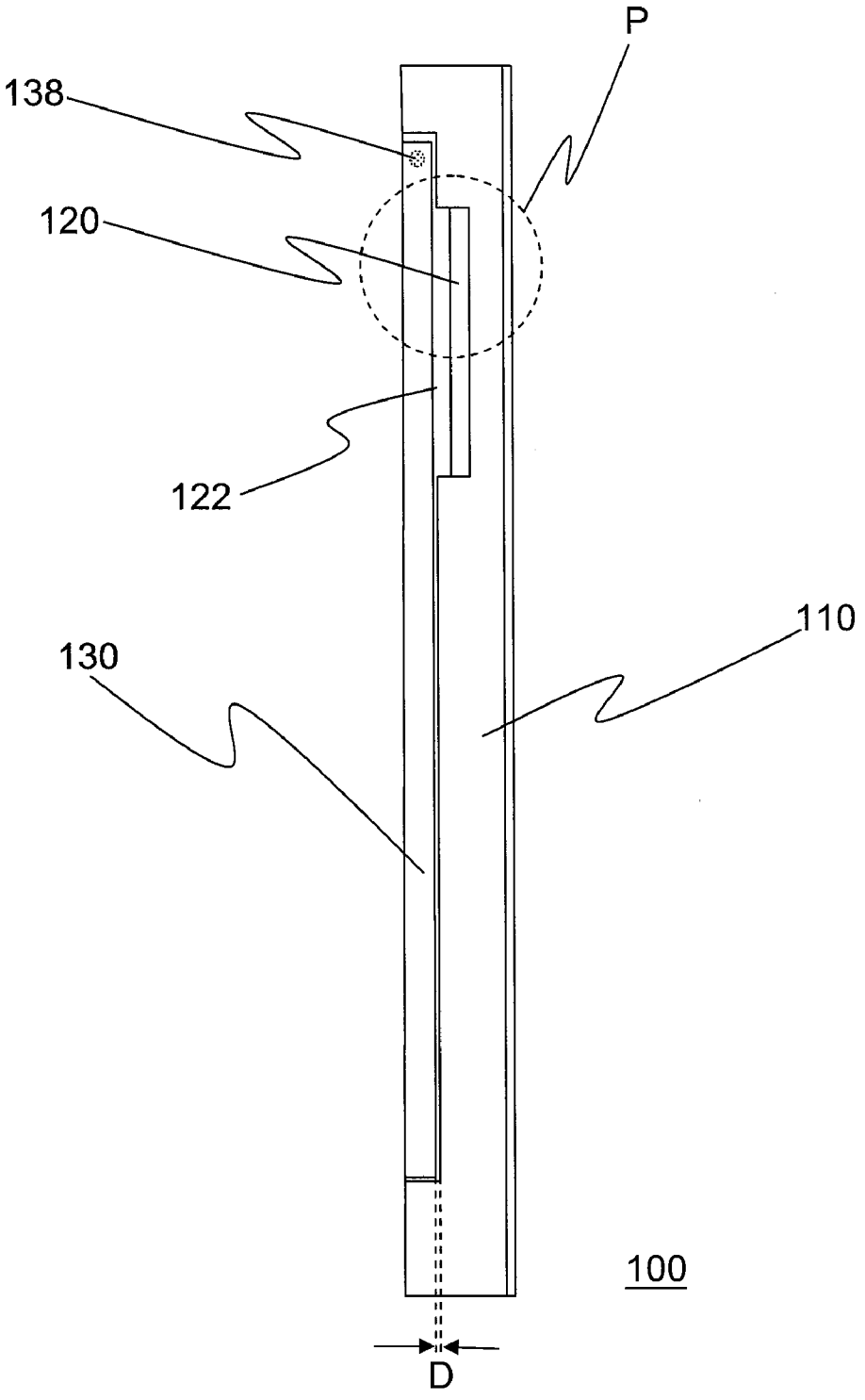


FIG. 3

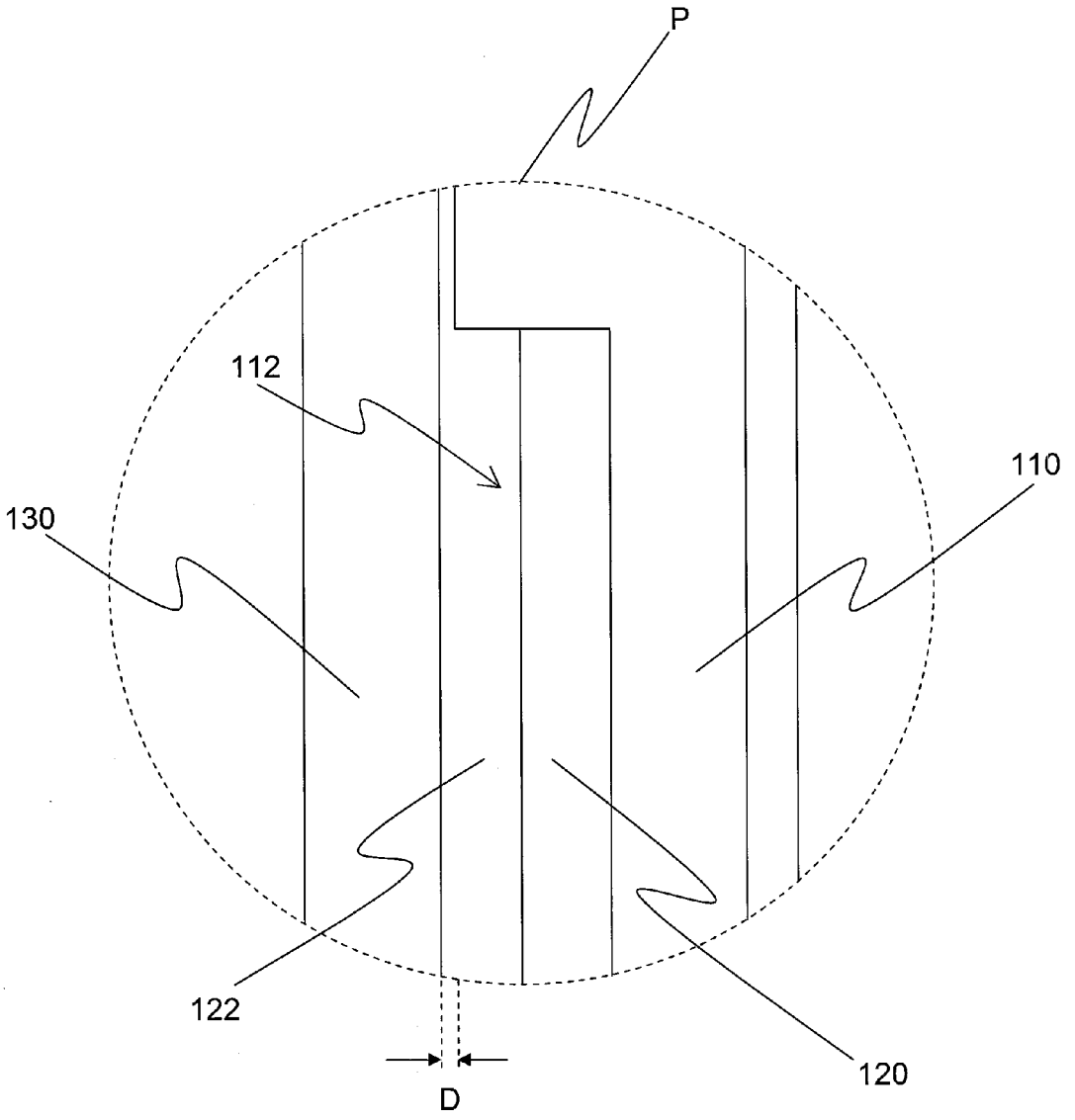


FIG. 4

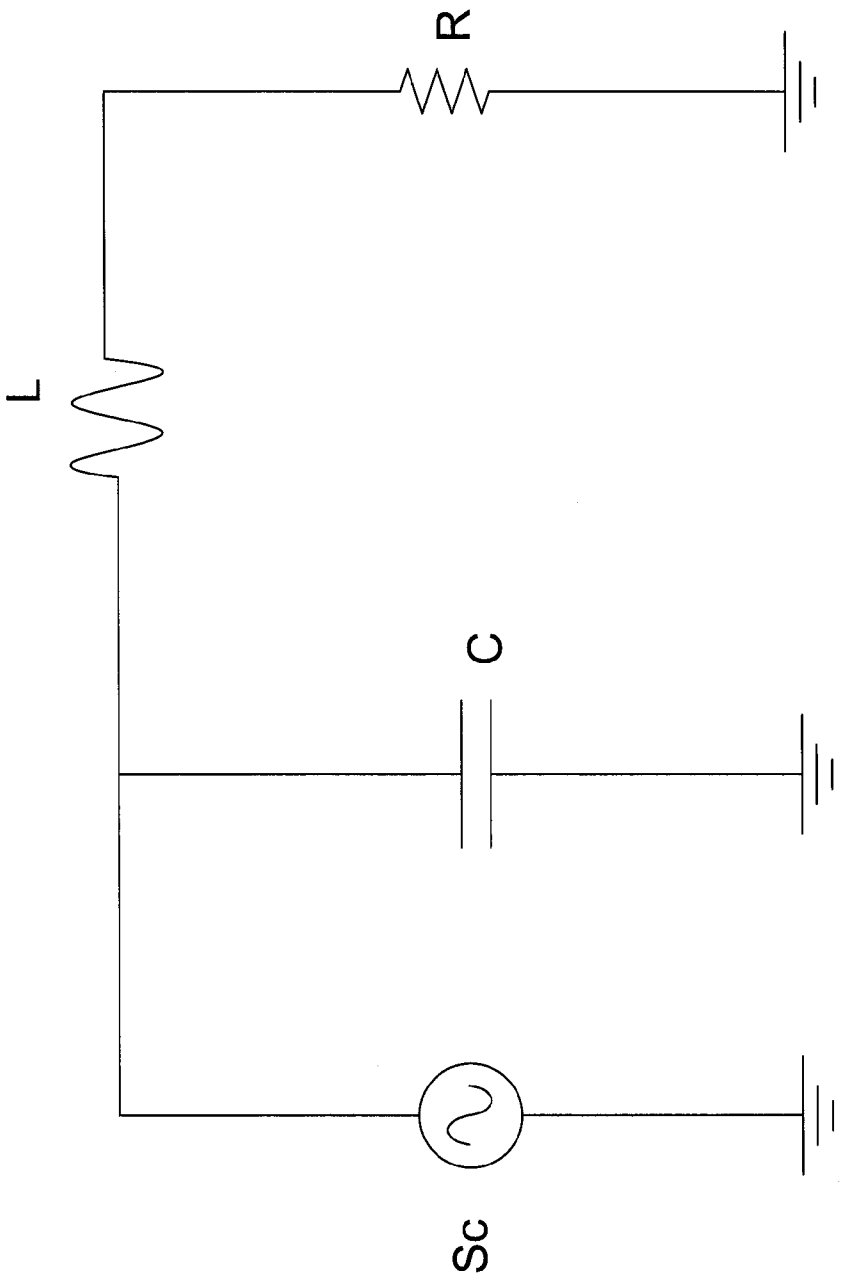


FIG. 5

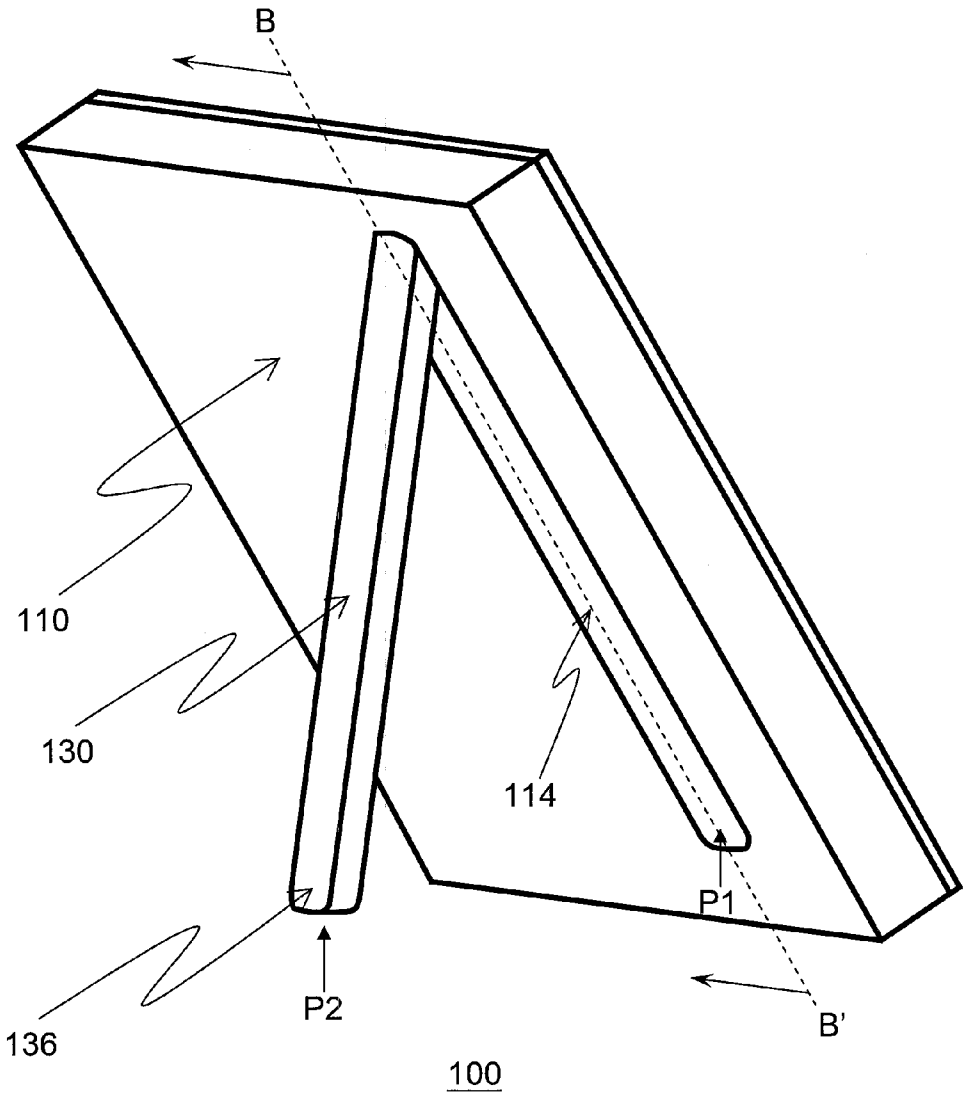


FIG. 6

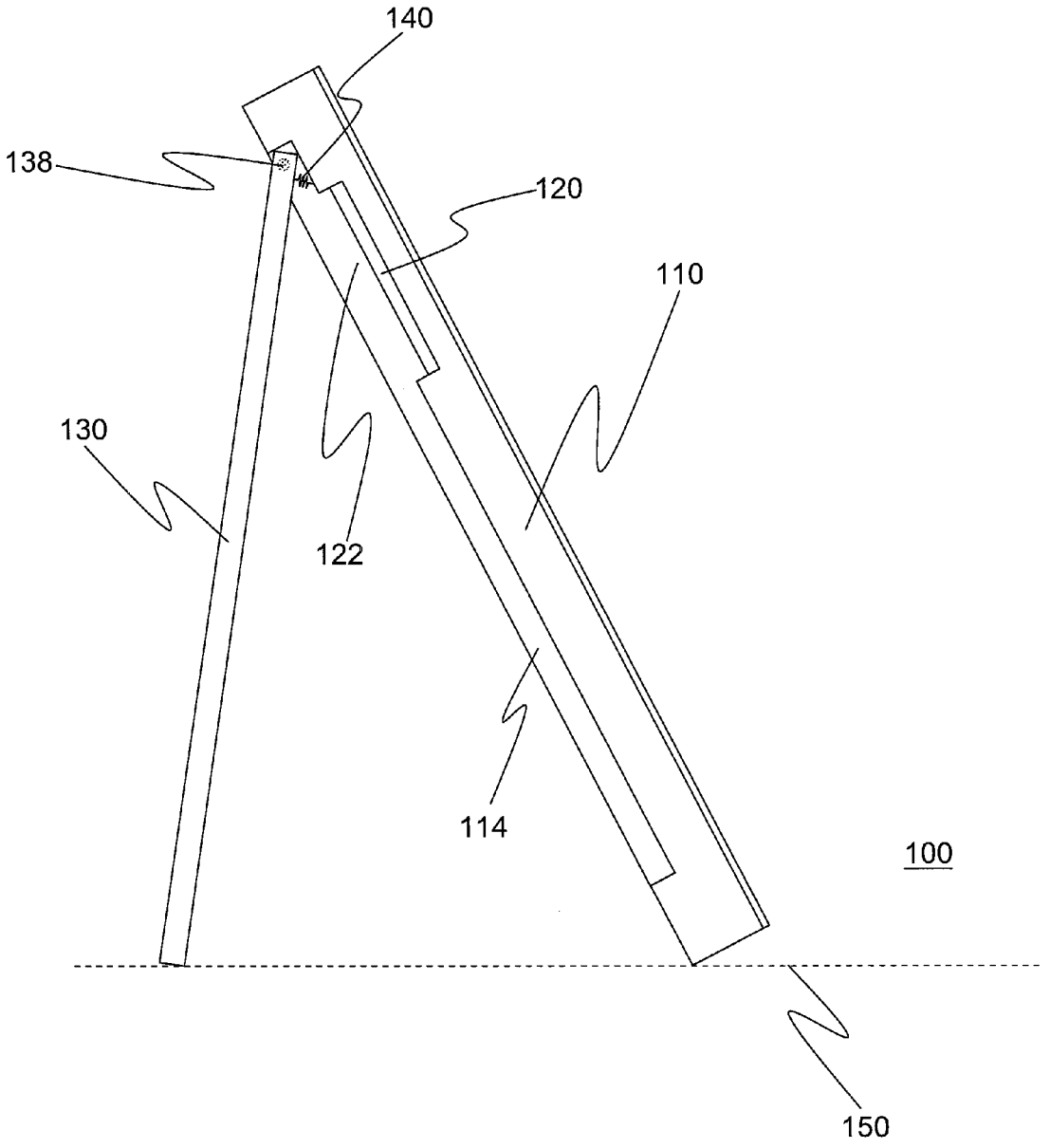


FIG. 7

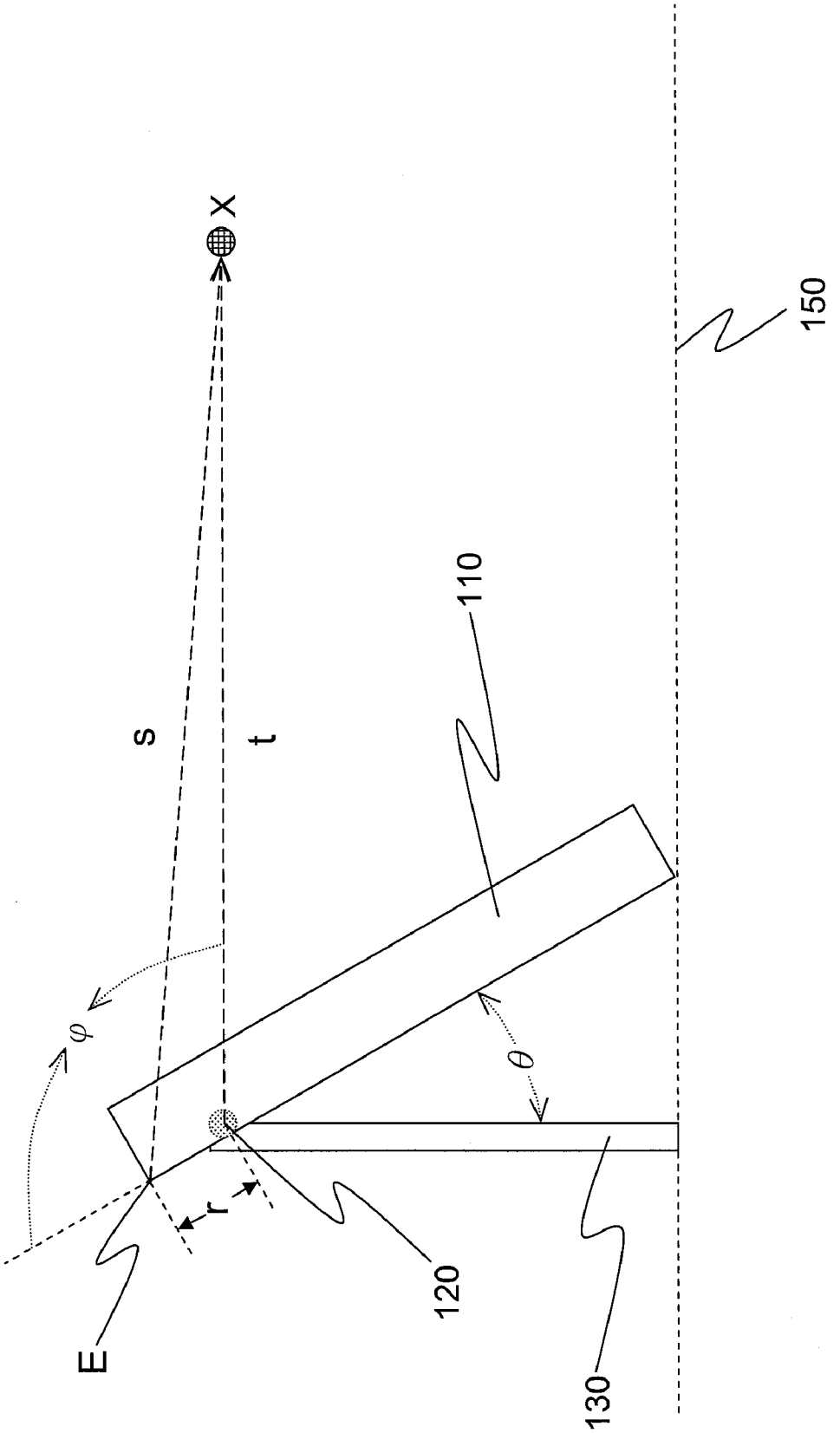


FIG. 8

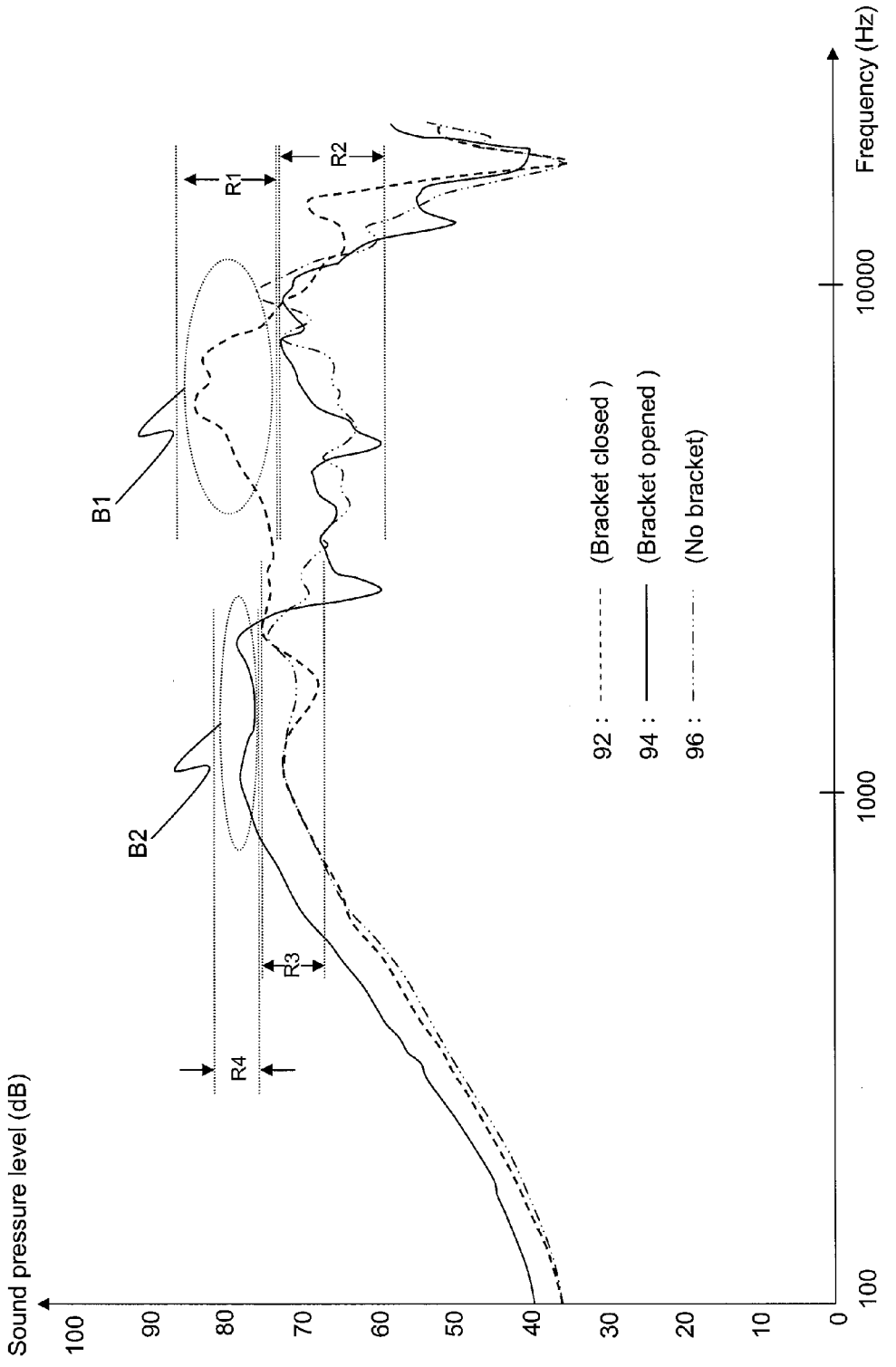

Sound pressure level (dB)
100
90
80
70
60
50
40
30
20
10
0
100
1000
10000
Frequency (Hz)
B1
B2
R1
R2
R3
R4
92 : (Bracket closed)
94 : (Bracket opened)
96 : (No bracket)

FIG. 9

METHOD AND APPARATUS FOR ADJUSTING SOUND QUALITY

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority benefit of U.S. A. provisional application Ser. No. 61/446,055, filed on Feb. 24, 2011. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

1. TECHNICAL FIELD

[0002] The present disclosure relates to an electronic apparatus with a speaker and a method for providing a sound system of the electronic apparatus, and more particularly to an electronic apparatus with a bracket and a speaker and method for providing a sound system of the electronic apparatus.

2. BACKGROUND

[0003] With the development of the science and technology, the use of a portable electronic apparatus (e.g. a mobile phone, a tablet computer, etc.) already becomes more and more popular. Different from a common electronic apparatus, for the sake of portability, the shape of the portable electronic apparatus is usually designed to be light, thin, and small. Accordingly, the size of the speaker embedded in the portable electronic apparatus also decreases gradually. However, due to decrease of the size of the embedded speaker, the sound quality usually becomes worse, so some users who have high requirements for the sound quality become unsatisfied.

SUMMARY

[0004] The present disclosure provides an electronic apparatus with a bracket and a speaker. A sound mode of the electronic apparatus may be switched between two modes to adjust acoustic middle range sound quality and acoustic bass sound quality of the electronic apparatus respectively.

[0005] The present disclosure provides a method for providing a sound system of an electronic apparatus. By changing the placement position of a bracket of the electronic apparatus, acoustic middle range sound quality and acoustic bass sound quality of the electronic apparatus may be respectively adjusted.

[0006] The application discloses an electronic apparatus. The electronic apparatus includes a housing, a speaker and a bracket. The housing has a space and a channel, and the space and the channel couples with each other. The speaker is disposed in the space. The bracket has a first end coupled to the channel. The bracket is movable relative to the housing.

[0007] The application discloses a method for providing a sound system of an electronic apparatus. The method includes positioning a speaker of the electronic apparatus in a space of a housing of the electronic apparatus. The method further includes coupling a bracket to a channel of the housing. The space and the channel are coupled with each other. The bracket is movable relative to the housing.

[0008] In an embodiment of the present disclosure, the bracket is placed in the channel.

[0009] In an embodiment of the present disclosure, a sound pressure level of an acoustic middle range sound from the electronic apparatus with the bracket is increased comparing with a sound pressure level of the acoustic middle range sound from an electronic apparatus without the bracket.

[0010] In an embodiment of the present disclosure, a gap is formed between the bracket and the channel when the bracket is placed in the channel.

[0011] In an embodiment of the present disclosure, a resonant frequency of a middle range boost of the electronic apparatus depends on the volume of the gap.

[0012] In an embodiment of the present disclosure, an inner chamber is formed between the bracket and the speaker when the bracket is placed in the channel.

[0013] In an embodiment of the present disclosure, the resonant frequency of the middle range boost of the electronic apparatus is represented by f_0.

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}.$$

L is an inductance value equal to

$$\frac{1.21 \times L_K}{W_K \times D},$$

C is a capacitance value equal to

$$\frac{V}{1.21 \times 343},$$

D is a numerical portion of the volume of the gap, W_K is a numerical portion of the width of the bracket, L_K is a numerical portion of the length of the bracket, V is a numerical portion of the volume of the inner chamber.

[0014] In an embodiment of the present disclosure, the electronic apparatus further comprises a hinge coupling the bracket to the channel.

[0015] In an embodiment of the present disclosure, the electronic apparatus further comprises a spring coupling the bracket to the channel.

[0016] In an embodiment of the present disclosure, the length of the channel is more than twice as much as the length of the space.

[0017] In an embodiment of the present disclosure, the channel is placed along a midline of the housing.

[0018] In an embodiment of the present disclosure, the channel is placed at one end of the housing.

[0019] In an embodiment of the present disclosure, the electronic apparatus further comprises a touch screen to be used as an interface for operating the electronic apparatus.

[0020] In an embodiment of the present disclosure, the bracket further comprises a second end which is movable between a first position in the channel to a second position away from the channel.

[0021] In an embodiment of the present disclosure, the second end which is moved away from the channel and forming an angle between the bracket and housing, the relationship between the angle and distance between a user is represented by

$$s^2 = r^2 + t^2 - 2 \times r \times t \times \cos\varphi \text{ and } \varphi = \frac{\pi}{2} + \theta.$$

r is a distance from the speaker to a top of the housing, s is a distance from the top to the ear of the user, t is a distance from the speaker to the ear of the user, ϕ is an included angle between the bracket and a sound path from the speaker to the ear of the user, and θ is an included angle between the bracket and the housing.

[0022] In an embodiment of the present disclosure, a sound pressure level of an acoustic bass range sound from electronic apparatus with the second end of the bracket moved to the second position is increased comparing with a sound pressure level of the acoustic bass range sound from an electronic apparatus without the bracket.

[0023] In an embodiment of the present disclosure, the method further comprises positioning the second end of the bracket from the first position in the channel to the second position away from the channel.

[0024] In an embodiment of the present disclosure, the method further comprises placing the bracket in the channel. A gap is formed between the bracket and the channel, and an inner chamber is formed between the bracket and the speaker.

[0025] Based on the embodiments of the present disclosure, by changing the placement position of the bracket of the electronic apparatus, acoustic middle range sound quality and acoustic bass sound quality of the electronic apparatus are adjusted respectively.

[0026] In order to make the aforementioned and other objectives and advantages of the present disclosure comprehensible, embodiments accompanied with figures are described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

[0028] FIG. **1** is an exploded view of an electronic apparatus according to an embodiment of the present disclosure.

[0029] FIG. **2** is a three-dimensional schematic view of the electronic apparatus in FIG. **1** when a bracket of the electronic apparatus is closed.

[0030] FIG. **3** is a sectional view along a dashed line A-A' of the electronic apparatus in FIG. **2**.

[0031] FIG. **4** is a partial enlarged view at a position P of the electronic apparatus in FIG. **3**.

[0032] FIG. **5** is an equivalent circuit diagram of the electronic apparatus in FIG. **3**.

[0033] FIG. **6** is a three-dimensional schematic view when the bracket of the electronic apparatus in FIG. **2** is translated or moved to a second position.

[0034] FIG. **7** is a sectional view along a dashed line B-B' of the electronic apparatus in FIG. **6**.

[0035] FIG. **8** illustrates a sound diffraction situation of an electronic apparatus according to an embodiment of the present disclosure.

[0036] FIG. **9** is a sound frequency response graph of an electronic apparatus in opened position and closed position referred to FIG. **2** and FIG. **6**.

DESCRIPTION OF THE EMBODIMENTS

[0037] A summary of certain embodiments disclosed herein is set forth below. It should be understood that these aspects are presented merely to provide the reader with a brief summary of these certain embodiments and that these aspects are not intended to limit the scope of this disclosure. Indeed, this disclosure may include a variety of aspects that may not be listed below.

[0038] Reference will now be made in detail to the present embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0039] Please refer to FIG. **1** as an exploded view of an electronic apparatus **100** according to an embodiment of the present disclosure, the electronic apparatus **100** comprises a housing **110**, a speaker **120** and a bracket **130**. The housing **110** comprises a space **112** and a channel **114**. The space **112** is coupled to the channel **114**. The speaker **120** is placed in the space **112** and capable of generating sound waves. The speaker may be piezoelectric, magnetostrictive, electrostatic, ribbon magnetic, planar magnetic, bending wave, distributed mode, or flat panel speaker. The speaker **120** may comprise an array of speakers for sound producing. The bracket **130** may be a stand or bracket made out of metal, polymer, plastic or combination of such with structuring or texturing at surface of bracket. The bracket **130** may be contoured to follow the shape of housing **110**. The present disclosure describes the electronic apparatus **100** as mobile, portable or handheld electronic device, such as a tablet computer, or mobile phone. Additionally, the channel **114** mentioned above may be formed at any location of the housing **110**. In an embodiment of the present disclosure, the channel **114** may be placed along a midline of the housing **110**. That is, the channel **114** has equal distances away from the left side and the right side of the housing **110**. However, the present disclosure is not limited thereto. In other words, the distance between the channel **114** and the left side of the housing **110** may be greater or less than the distance between the channel **114** and the right side of the housing **110**. In an embodiment of the present disclosure, the width W_G of the channel **114** may be equal to or greater than the width W_R of the space **112**. In addition, the length L_G of the channel **114** is greater than the length L_R of the space **112**. In an embodiment of the present disclosure, the length L_G of the channel **114** is more than twice as much as the length L_R of the space **112**.

[0040] Please refer the FIG. **2** as a three-dimensional schematic view when the bracket **130** of the electronic apparatus **100** is closed, the bracket **130** is placed in the channel **114** and has a first end **134** and a second end **136**. The first end **134** and the second end **136** may be opposite to each other. When the bracket **130** is closed and the bracket **130** is placed in the channel **114**, both the first end **134** and the second end **136** are placed in the channel **114**, and the electronic apparatus **100** is adjusted to a first mode. As a user usually closes the bracket **130** during a call, the first mode may also be referred to as a voice mode.

[0041] FIG. **3** is a sectional view along a dashed line A-A' of the electronic apparatus **100** in FIG. **2**. FIG. **4** is a partial enlarged view at a position P of the electronic apparatus **100** in FIG. **3**. In an embodiment of the present disclosure, when the bracket **130** of the electronic apparatus **100** is translated to close to the channel **114**, a gap D is formed between the bracket **130** and the housing **110**. The gap D may be greater than 0.1 millimeter. Additionally, as the volume of the space **112** is greater than the volume of the speaker **120**, when the bracket **130** is placed in the channel **114**, an inner chamber

122 is formed between the bracket **130** and the speaker **120**. The sound generated by the speaker **120** resonates between the bracket **130** and the housing **110** through the inner chamber **122** to the gap D.

[0042] Please refer to FIG. **5** as an equivalent circuit diagram of an electronic apparatus **100** in FIG. **3**, which represents an equivalent circuit of the electronic apparatus **100** when the bracket **130** is closed. A signal source Sc represents an electronic signal received by the speaker **120**. C represents an equivalent capacitance value of the inner chamber **122**. L represents an equivalent inductance value between the bracket **130** and the housing **110**. R represents a resistance value when the sound transmitted to the air. The size of the inner chamber **122** affects the value of the capacitance value C. The size of the gap D affects the value of the inductance value L. The equivalent circuit of the electronic apparatus **100** is a resistor-inductor-capacitor (RLC) oscillator circuit. The resonant frequency of the middle range boost of the electronic apparatus **100** is represented by f_0, f_0 is equal to

$$\frac{1}{2\pi}\sqrt{\frac{1}{LC}}.$$

The middle range is the most significant part of the audible sound spectrum, the region where the most fundamentals emitted by musical instruments and, most importantly, human voice, lie. This region contains most sounds which are the most familiar to the human ear, and where discrepancies from faithful reproduction are most easily observed. It is therefore paramount that a middle range driver of good quality be capable of low-distortion reproduction. Therefore, it is important to achieve a good quality of middle range frequency for reproducing the human voice when user is on the phone. The resonant frequency f_0 of the middle range boost of the electronic apparatus **100** depends on the value of the gap D. In an embodiment of the present disclosure, during the design of the electronic apparatus **100**, the resonant frequency f_0 of the middle range boost of the electronic apparatus **100** is at 6 kHz by setting the size of the gap D, so that the electronic apparatus **100** has a desirable voice and music performance.

[0043] In addition, the inductance value L is equal to

$$\frac{1.21\times L_K}{W_K\times D},$$

and the unit thereof is the Henry. D is a numerical portion of the volume of the gap D in the unit of square meters. The capacitance value C is equal to

$$\frac{V}{1.21\times 343},$$

and the unit thereof is Farad. W_K is a numerical portion of the width of the bracket **130** in the unit of meter. L_K is a numerical portion of the length of the bracket **130** in the unit of meter. V is a numerical portion of the volume of the inner chamber **122** in the unit of square meters. Therefore, the greater the gap D is, the higher the resonant frequency f_0 of the middle range boost of the electronic apparatus **100** is.

[0044] Please refer to FIG. **6** and FIG. **2**. FIG. **6** is as a three-dimensional schematic view when the bracket **130** of the electronic apparatus **100** is translated or moved to a second position P**2**. The first end **134** is coupled to the housing **110** and is capable of rotating along an axis **132**. The second end **136** is capable of moving from a first position P**1** in the channel **114** to the second position P**2** away from the channel **114** due to the rotation of the first end **134**. When the bracket **130** is opened so that the second end **136** is moved to second position P**2** out of the channel **114** due to the rotation of the first end **134**, the electronic apparatus **100** is adjusted to a second mode for producing sound. As an angle is formed between the bracket **130** and the housing **110**, the electronic apparatus **100** may stand on a surface of an object (e.g. a table). The user usually opens the bracket **130** when playing a multimedia file (e.g. a music file, a video file, etc.), so the second mode may also be referred to as a multimedia mode. The sound quality of the electronic apparatus **100** may be adjusted by changing the placement position of the bracket **130**, and the housing **110**, the speaker **120** and the bracket **130** may be regarded as a sound system of the electronic apparatus **100**.

[0045] Please refer to FIG. **7** as a sectional view along a dashed line B-B' of the electronic apparatus **100** in FIG. **6**. When the bracket **130** is opened so that the second end **136** is removed from the channel **114** due to the rotation of the first end **134**, as an angle is formed between the bracket **130** and the housing **110**, the electronic apparatus **100** may stand on a surface **150** of an object (e.g. a table). The bracket **130** may comprise a bearing or hinge **138** for connecting the first end **134** in a manner that the first end **134** is capable of rotating along the axis **132**. A spring **140** may be coupled to the bearing or hinge **138** with the channel **114** so the bracket **130** may be put out of the channel **114** by the spring force when in open position. In addition, the bearing or hinge **138** may be replaced by other connectors. The sound generated by the speaker **120** is transmitted through the inner chamber **122** to the surface **150**. As the surface **150** reflects the sound generated by the speaker **120**, when the bracket **130** is opened and stands on the surface **150**, the user hears the indirect sound reflected by the surface **150**. Therefore, the sound pressure level of the acoustic bass sent by the electronic apparatus **100** is increased. Bass is low frequency or range sound. In popular music, the bass part most often provides harmonic and rhythmic support, such that bass is important for playing multimedia sound.

[0046] Please refer to FIG. **8** as it illustrates a sound diffraction situation of the electronic apparatus **100**. In this embodiment, a sound path from the speaker **120** to the ear X of a user may be simulated as a sound isolation wall. If the sound pressure of the speaker **120** is P_i and the sound pressure at the ear X of the user is P_o, the relationship between sound pressures P_i and P_o may be represented by Equation (1) in the following:

$$\left(\frac{P_o}{P_i}\right)_{dB} = -20\times\log_{10}\left(3+40\times\frac{r+s-t}{343.15}\times f\right) \quad (1)$$

[0047] The unit of the ratio between the sound pressures P_i and P_o is decibel (dB), f is the frequency of the signal source Sc, r is a distance from the speaker **120** to a top E of the housing **110**, s is a distance from the top E to the ear X of the user, and t is a distance from the speaker **120** to the ear X of the

user. The unit of the distances r, s and t is meter. According to Equation (1), when the frequency of the signal source Sc increases, the sound pressure P_o decreases, so Equation (1) may be regarded as a bass boost equation. As may be seen, when the bracket **130** is opened, the sound pressure level of the acoustic bass sent by the electronic apparatus **100** may be increased.

[0048] In addition, it is assumed that the bracket **130** is perpendicular to the surface **150**. An included angle between the bracket **130** and the housing is θ. An included angle between the sound path and the bracket **130** is ϕ. Therefore, the relationships of the distances r, s, t and the included angles θ, ϕ are represented by Equations (2), (3):

$$s^2 = r^2 + t^2 - 2 \times r \times t \times \cos\varphi \tag{2}$$

$$\varphi = \frac{\pi}{2} + \theta \tag{3}$$

[0049] Please refer to FIG. **9** as a sound frequency response graph of an electronic apparatus **100** in opened position and closed position referred to FIG. **2** and FIG. **6**. The horizontal axis represents a frequency of a sound generated by the electronic apparatus **100**. The vertical axis represents a sound pressure level corresponding to each frequency of a sound generated by the electronic apparatus **100** in unit of decibel (dB). A frequency response curve **92** is a sound frequency response curve of the electronic apparatus **100** measured when the bracket **130** is closed as showed in FIG. **2**. The frequency response curve **94** is a sound frequency response curve of the electronic apparatus **100** measured when the bracket **130** is opened as showed in FIG. **6**. The frequency response curve **96** is a sound frequency response curve of an electronic apparatus without the use of the bracket **130**. As shown in FIG. **9**, the frequency response curve **92** has a middle range boost B**1**, which represents that when the bracket **130** is placed in the channel **114**, a sound pressure level of the acoustic middle range sound sent by the electronic apparatus **100** is increased. In other words, when the second end **136** of the bracket **130** is placed in the channel **114**, the sound pressure level of the acoustic middle range sound sent by the electronic apparatus **100** is falls within a first range R**1**. When the second end **136** is removed from the channel **114** due to the rotation of the first end **134**, the sound pressure level of the acoustic middle range sound sent by the electronic apparatus **100** falls within a second range R**2**. The first range R**1** is higher than the second range R**2**. In addition, the frequency response curve **94** has a bass boost B**2**, which represents that when the second end **136** is removed from the channel **114** due to the rotation of the first end **134**, a sound pressure level of an acoustic bass sent by the electronic apparatus **100** is increased. In other words, when the second end **136** of the bracket **130** is placed in the channel **114**, the sound pressure level of an acoustic bass sent by the electronic apparatus **100** falls within a third range R**3**. When the second end **136** is removed from the channel **114** due to the rotation of the first end **134**, the sound pressure level of the acoustic bass sent by the electronic apparatus **100** falls within a fourth range R**4**. The third range R**3** is lower than the fourth range R**4**. In such a manner, the sound mode of the electronic apparatus may be switched between two modes, so that the acoustic middle range sound quality and acoustic bass sound quality of the electronic apparatus may be respectively adjusted.

[0050] In an embodiment of the present disclosure, the electronic apparatus **100** is a mobile phone or a tablet computer. However, the present disclosure is not limited thereto. In addition, according to an embodiment of the present disclosure, the electronic apparatus **100** may further include a touch screen to be used as an interface for the user to operate the electronic apparatus **100**.

[0051] The embodiments of the present disclosure, by changing a placement position of a bracket of the electronic apparatus, the acoustic middle range sound quality and acoustic bass sound quality of the electronic apparatus are respectively adjusted.

[0052] It will be apparent to those skilled in the art that various modifications and variations may be made to the structure of the present disclosure without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the present disclosure cover modifications and variations of this disclosure provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. An electronic apparatus, comprising:

a housing, having a space and a channel, wherein the space and the channel coupled to each other;

a speaker, disposed in the space; and

a bracket, comprising a first end coupled to the channel, wherein the bracket is movable relative to the housing.

2. The electronic apparatus according to claim **1**, wherein the bracket is placed in the channel.

3. The electronic apparatus according to claim **2**, wherein a sound pressure level of an acoustic middle range sound from the electronic apparatus with the bracket is increased comparing with a sound pressure level of the acoustic middle range sound from an electronic apparatus without the bracket.

4. The electronic apparatus according to claim **1**, wherein a gap is formed between the bracket and the channel when the bracket is placed in the channel.

5. The electronic apparatus according to claim **4**, wherein a resonant frequency of a middle range boost of the electronic apparatus depends on the volume of the gap.

6. The electronic apparatus according to claim **4**, wherein an inner chamber is formed between the bracket and the speaker when the bracket is placed in the channel.

7. The electronic apparatus according to claim **6**, wherein a resonant frequency of a middle range boost of the electronic apparatus is represented by f_0,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}},$$

L is an inductance value equal to

$$\frac{1.21 \times L_K}{W_K \times D},$$

C is a capacitance value equal to

$$\frac{V}{1.21 \times 343},$$

D is a numerical portion of the volume of the gap, W_K is a numerical portion of the width of the bracket, L_K is a numerical portion of the length of the bracket, V is a numerical portion of the volume of the inner chamber.

8. The electronic apparatus according to claim **1** further comprising a hinge coupling the bracket to the channel.

9. The electronic apparatus according to claim **1** further comprising a spring coupling the bracket to the channel.

10. The electronic apparatus according to claim **1**, wherein the length of the channel is more than twice as much as the length of the space.

11. The electronic apparatus according to claim **1**, wherein the channel is placed along a midline of the housing.

12. The electronic apparatus according to claim **1**, wherein the channel is placed at one end of the housing.

13. The electronic apparatus according to claim **1**, further comprising a touch screen to be used as an interface for operating the electronic apparatus.

14. The electronic apparatus according to claim **1**, wherein the bracket further comprises a second end which is movable between a first position in the channel and a second position away from the channel.

15. The electronic apparatus according to claim **14**, wherein the second end which is moved away from the channel and forming an angle between the bracket and housing, the relationship between the angle and distance between a user is represented by

$$s^2 = r^2 + t^2 - 2 \times r \times t \times \cos\varphi, \text{ and}$$

$$\varphi = \frac{\pi}{2} + \theta,$$

where r is a distance from the speaker to a top of the housing, s is a distance from the top to the ear of the user, t is a distance from the speaker to the ear of the user, ϕ is an included angle between the bracket and a sound path from the speaker to the ear of the user, and θ is an included angle between the bracket and the housing.

16. The electronic apparatus according to claim **14**, wherein a sound pressure level of an acoustic bass range sound from electronic apparatus with the second end of the bracket moved to the second position is increased comparing with a sound pressure level of the acoustic bass range sound from an electronic apparatus without the bracket.

17. A method for providing a sound system of an electronic apparatus, comprising:

positioning a speaker of the electronic apparatus in a space of a housing of the electronic apparatus; and

coupling a bracket to a channel of the housing, wherein the space and the channel are coupled with each other,

wherein the bracket is movable relative to the housing.

18. The method according to claim **17**, wherein the bracket comprises a first end which is coupled to the channel.

19. The method according to claim **17**, wherein the bracket comprises a second end which is movable between a first position in the channel to a second position away from the channel.

20. The method according to claim **19**, further comprising:

positioning the second end of the bracket from the first position in the channel to the second position away from the channel.

21. The method according to claim **20**, wherein a sound pressure level of an acoustic bass range sound from the electronic apparatus with the second end of the bracket moved to the second position is increased comparing with a sound pressure level of the acoustic bass range sound from an electronic apparatus without the bracket.

22. The method according to claim **17**, further comprising:

placing the bracket in the channel;

wherein a gap is formed between the bracket and the channel, and an inner chamber is formed between the bracket and the speaker.

23. The method according to claim **22**, wherein a sound pressure level of an acoustic middle range sound from the electronic apparatus with the bracket is increased comparing with a sound pressure level of the acoustic middle range sound from an electronic apparatus without the bracket.

24. The method according to claim **17**, wherein the length of the channel is more than twice as much as the length of the space.

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