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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04R 25/00 A1

(11) International Publication Number: WO 95/07014

(43) International Publication Date: 9 March 1995 (09.03.95)

(21) International Application Number: PCT/US94/09931

(22) International Filing Date: 31 August 1994 (31.08.94)

(30) Priority Data:
08/114,898 1 September 1993 (01.09.93) US

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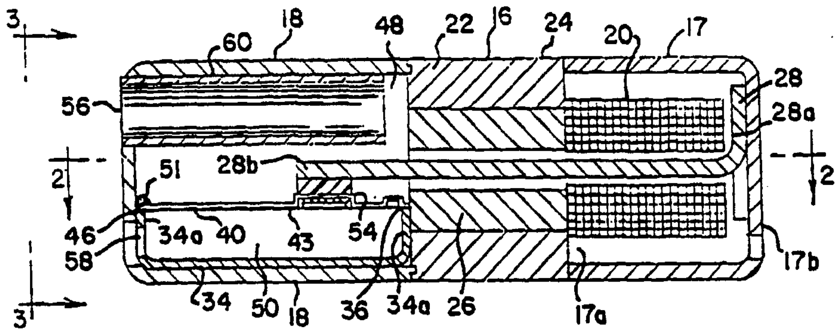
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: RECEIVER FOR A HEARING AID



(57) Abstract

A compact receiver for a hearing aid is disclosed. According to one embodiment, the receiver includes a housing portion. A diaphragm having a plurality of peripheral edges is disposed within the housing portion and defines first and second acoustical chambers. One of the diaphragm peripheral edges is pivotally coupled to the housing. The remaining edges are compliantly coupled to the housing. An electromagnetic motor includes an armature. A compliant bond couples the armature to the diaphragm to move the diaphragm at frequencies in accordance with an electrical signal applied to the motor. First and second outlet ports extend through the housing. The first outlet port is acoustically coupled to the first chamber, and the second outlet port is acoustically coupled to the second chamber. The first and second outlet ports, in conjunction with the first and second chambers, cooperate to cancel low frequency sound, resulting in the receiver having a generally high-frequency band pass frequency response. In another embodiment, the first port is eliminated, resulting in the receiver having a generally broad band frequency response. In a still further embodiment, two of the broad band receivers are combined back-to-back, resulting in a receiver having twice the output amplitude as a single one of the receivers, while reducing vibration, as the respective armatures vibrate 180° out-of-phase. A cerumen blocking boot is also disclosed for preventing entry of cerumen into the receiver sound port.

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RECEIVER FOR A HEARING AID

DESCRIPTION

Technical Field

The invention relates to a miniaturized receiver, as for a hearing aid.

Background Prior Art

Miniaturized receivers, such as for use in hearing aids, are known. Often such receivers are designed to provide a certain frequency response characteristic to accomplish a particular result. For example Carlson, U.S. Patent No. 5,068,901, discusses the fact that hearing loss for many people is primarily at higher frequencies. Accordingly Carlson provided a dual outlet passage hearing aid transducer, having a pair of elongated sound transmission tubes, which produced a high pass band. This receiver was able to better assist the user at the higher frequencies of hearing impairment, yet which effectively eliminated low frequency transmission. To permit the user to hear low frequencies, a low frequency sound transmission channel was provided parallel to the hearing aid. This sound transmission channel bypassed the hearing aid, to permit the user to directly hear low frequencies.

The hearing aid transducer of Carlson worked satisfactorily for many applications; however, the elongated sound transmission tubes tended to make further miniaturization of the hearing aid difficult.

The present invention is provided to solve these and other problems.

Summary of the Invention

It is an object of the invention to provide a compact band pass receiver for a hearing aid, such as for use in combination with a hearing aid for use by an individual having a high frequency hearing impairment.

In accordance with the invention, the receiver includes a housing, being for example D-shaped in cross section. The D-shape configuration permits the receiver to more readily be placed in the canal portion of the hearing aid. A diaphragm is provided having a plurality of peripheral edges. The diaphragm is disposed within the housing and defines first and second acoustical chambers in the housing. One of the diaphragm peripheral edges is pivotally secured to the housing. This pivotable edge may also be further secured to the housing by a cement, such as an epoxy, to prevent lateral movement. The remaining edges of the diaphragm are compliantly secured to the housing. An electromagnetic motor, including an armature, forms a portion of the housing, and means are provided for coupling the armature to the diaphragm to move the diaphragm at frequencies in accordance with an electrical signal applied to the motor. First and second outlet ports extend through the housing. The first outlet port is acoustically coupled to the first chamber via a tube, and the second outlet port is acoustically coupled to the second chamber. The first and second ports provide an exit path for acoustical vibrations generated as a result of diaphragm movement. The first and second acoustical chambers cooperate to cancel low frequency acoustical waves, while generating high frequency acoustical waves at the frequencies of interest. This phenomenon is more fully explained in the above referenced Carlson patent.

It is contemplated that the armature is coupled to the diaphragm by a compliant compound, such as compliant RTV having a durometer of 22 Shore A, or less.

It is further contemplated that the receiver includes a tube disposed within the first acoustic chamber. The tube terminates substantially flush with the first port.

In a further aspect of the invention, the above receiver is provided, but without the tube and the first outlet port. Accordingly, low frequency acoustical waves are not cancelled, and, hence, the receiver has a broad band frequency response.

It is a still further aspect of the invention to combine two of the above receivers in back-to-back relationship, to provide a generally oval-shaped receiver having twice the output as a single receiver. Vibration is reduced in this embodiment because the respective armatures move 180° out-of-phase.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

Brief Description of Drawings

Figure 1 is a side sectional view of a receiver in accordance with one aspect of the invention;

Figure 2 is a top sectional view taken along line 2-2 of **Figure 1**;

Figure 2a is an enlarged view of a portion of **Figure 2**;

Figure 2b is an enlarged view of another portion of **Figure 2**;

Figure 3 is an end view taken along line 3-3 of **Figure 1**;

Figure 4 is an exploded view of the receiver of **Figure 1**;

Figure 5 is a logarithmic frequency response curve for the receiver of **Figure 1**;

Figure 6 is an isometric view of the receiver of **Figure 1** in combination with a hearing aid;

Figure 7, is a perspective view of an alternative embodiment of a receiver for a hearing aid in accordance with the invention;

Figure 8 is a side sectional view of the receiver of **Figure 7**;

Figure 9 is a logarithmic frequency response curve for the receiver of **Figure 7**;

Figure 10 is a perspective view of a modification to the receiver of **Figure 7**;

Figure 11 is a logarithmic frequency response curve for the receiver of **Figure 10**;

Figure 12 is a perspective view of a further modification to the receiver in **Figure 7**;

Figure 13 is a logarithmic frequency response cover for one version of the receiver of **Figure 12**;

Figure 14 is a logarithmic frequency response curve for another version of the receiver of **Figure 12**;

Figure 15 is a perspective view of a further alternative embodiment of a receiver for a hearing aid in accordance with the invention; and

Figure 16a-16e are perspective views of various embodiments of a protective boot for a receiver for a hearing aid.

Detailed Description

While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail, preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspects of the invention to the embodiments illustrated.

The receiver disclosed in the above referenced Carlson patent worked satisfactorily as a high-frequency band pass receiver, yet the two elongated tubes presented an obstacle to further hearing aid miniaturization. The frequency response of the Carlson receiver had three peaks. The middle peak occurred at approximately 4.5 kHz, and was a result of motor resonance. The lower peak occurred at a frequency of approximately 3 kHz and was a result of the resonance of the first elongated tube in combination with the first chamber. The upper peak occurred at a frequency of approximately 5.7 kHz and was a result of the resonance of the second elongated tube in combination with the second chamber. Elimination of the tubes was considered as a way to permit further miniaturization of the Carlson receiver, yet this was found to degrade the overall frequency response of the receiver because it eliminated the lower and upper resonant peaks. A design goal of the miniaturized receiver was to provide a 100dB spl response at 4 kHz into a 2 cc. cavity. Accordingly, it was also considered to eliminate the second tube, thereby eliminating the upper resonant peak (5.7 kHz) out of the pass band, while also moving the first tube into the housing. Thus, it was believed that this change would maintain the lower (3 kHz) and middle (4.5 kHz) resonant peaks, while permitting downsizing of the receiver. By doing so, it was determined that this change resulted in the response at 4 kHz being too low. The 4 kHz response was occurring in a "valley" between the lower and middle resonant peaks. Moving the peaks closer together to raise the valley to the desired level was considered. Conventionally, one would move the second, or higher, peak, which was a result of the tube now located in the housing, by varying the tube dimension. However, this change did not provide the desired result because varying the dimension of the tube also varied the frequency of the first, or lower, resonant peak as well. Thus any improvement gained by moving the frequency of the second resonant peak was countered by detrimental movement of the frequency of the first resonant peak.

Applicants recognized that the first resonant peak could be raised by reducing the effective mass of the system seen by the armature. The armature bends about a point, located generally where the armature is attached to the housing. Applicants realized that the effective mass of the system seen by the armature could be reduced by attaching the diaphragm to the housing of the receiver along the edge of the diaphragm opposite the point where the armature is coupled to the diaphragm so that the diaphragm would pivot about an effectively shorter lever arm. Conventionally when a diaphragm is pivotally connected to a housing, the diaphragm is driven by a drive rod coupled to the motor armature. The drive rod was able to flex slightly to compensate for the pivot action of the diaphragm which is pivoting about a different axis than the armature. However, in the present miniaturized receiver, there was insufficient space to locate the drive rod. Accordingly, applicants have developed a novel means for attaching an armature to a pivotable diaphragm, wherein the attachment is rigid along the coupled axis while being compliant along the shear axis.

A more detailed explanation of the operation of a band pass transducer can be found in the Carlson patent, the specification of which is expressly incorporated by reference.

In accordance with the invention, a compact band pass receiver 10 for a hearing aid 11 (**Figure 6**) is illustrated in **Figures 1-4**. As discussed in greater detail below, the receiver 10 is extremely compact, yet provides a commercially satisfactory band pass frequency response as shown in **Figure 5**. In the disclosed embodiment, the receiver 10 has a high frequency band pass characteristic.

The receiver 10 comprises an electromagnetic motor, generally designated 16, and a first housing portion 18. The electromagnetic motor 16 has a second housing portion 17, a conventional coil 20, a magnet housing 22 formed of conventional nickel/iron alloy laminations 24 and two permanent magnets 26, and an armature 28. The second housing portion 17 is a generally D-shaped cup, formed of conventional nickel/iron alloy and has substantially open 17a and closed 17b ends. The armature 28 has a fixed end 28a and a free end 28b. The coil 20 is disposed within the second housing portion 17. The armature fixed end 28a is uniquely secured, as by welding, to the closed end 17b of the second housing portion 17. The magnet housing 22 adjoins the substantially open end 17a of the second housing portion 17, and is secured thereto by projection welding. Laser welding is also being considered. The armature free end 28b extends outwardly from the magnet housing 22. A gap of 0.003" is provided between the armature 28 and the magnets 26.

The first housing portion 18 is also generally a D-shaped cup having open 18a and closed 18b ends. The housing portion open end 18a adjoins the magnet housing 22 opposite the second housing portion 17, such that the armature free end 28b extends into the first housing portion 18. The first housing portion 18 is also projection welded, or alternatively laser welded, to the magnet housing 22. A supporting cup 34 (shown in phantom in **Figure 2**) is disposed in the housing portion 18, providing a peripheral ledge 36 circumferentially about each of four walls 34a of the acoustical housing portion 18. The overall length of the receiver 10 is 0.244". The overall width at the base of the receiver 10 is 0.118".

A generally square diaphragm 40 is provided comprising a generally rigid, aluminum paddle 42 secured to a conventional diaphragm membrane 43. In certain conventional diaphragms, the membrane extends outwardly from the paddle from all four sides of the paddle, for compliant connection within the receiver housing. According to such prior art diaphragms, the diaphragm effectively pivots about the fixed end 28a of the armature 28 when acted upon by its respective armature. However, in the present embodiment, as with certain other conventional diaphragms, the membrane 43 extends outwardly from three sides of the paddle 42, forming a compliant peripheral annulus 44 about the three sides. The annulus 44 thus terminates at three peripheral edges 40a. The annulus 44 about the three edges 40a is secured to the respective ledges 36 of the cup 34, providing a compliant connection therebetween. In other words, the paddle 42 is spaced from the cup 34 along these three edges by the annulus 44, as illustrated in **Figure 2a.** A fourth edge 40b of the diaphragm 40 has no annulus. Rather the paddle 42 extends to the inside edge of the cup 34, as illustrated in **Figure 2b.** The membrane 43 extends beyond the edge of the paddle 42, to be secured to the respective ledge 36. In other words, the paddle 42 is not spaced from the cup 34 by the annulus 44 along the fourth edge 40b. Accordingly, the fourth edge 40b is rigidly secured to the cup 34, rather than compliantly secured thereto.

The diaphragm 40 is disposed across the first housing portion 18, supported by the peripheral ledge 36 of the cup 34. The diaphragm 40 defines first and second acoustical chambers, generally designated 48,50. The second acoustical chamber 50 includes all air space within the electromagnetic motor 16. The three sides forming the peripheral annulus 44 of the diaphragm 40 are compliantly secured to the ledge 36 by a film of 0.0005" thickness, such as urethane. The fourth edge 40b of the diaphragm 40, which is generally rigid due to the coextensive paddle 42, rests along the remaining side of the edge 36. To insure that the fourth edge 40b of the diaphragm 40 remains along the remaining side of the edge 36, so as to eliminate any possible unwanted resonance, a drop or two of epoxy 51 may be applied. It should be noted that this pivotal connection of the diaphragm 40 reduces the amplitude of the receiver output, because the pivotal diaphragm moves less air per unit motion of the armature as compared to convention complaint coupling of the diaphragm. However, this amplitude reduction was considered a necessary tradeoff to obtain the desired frequency response.

In prior receivers having a pivotable diaphragm, the diaphragm was spaced from the armature by approximately 0.060", and they were operatively coupled by a drive rod. The drive rod could slightly flex, to conform to the action of the diaphragm moving along a different arc than the moving armature. However, in the present receiver 10, the armature 28 is spaced from the diaphragm 40 by only about 0.002"-0.003", which does not provide sufficient room to assemble a drive rod. Further, such a shortened drive rod would have a diameter to length ratio too great to flex sufficiently. Accordingly, in the present invention, the armature free end 28b is compliantly coupled to the diaphragm 40, by a compliant compound, such as a compliant RTV having a durometer of 22 Shore A, or less. The diaphragm 40 pivots about the rigid edge 40b by the motion of the armature 28 at frequencies in accordance with an electrical signal applied to the motor 16. Because the diaphragm 40 pivots about the rigid edge 40b, the effective mass of the diaphragm 40, as seen by the armature 28, is reduced, thereby increasing the frequency of the motor resonance peak.

A locating embossment 54 is provided on each of the paddle 42 and the membrane 43 of the diaphragm 40 to assist in the assembly of the receiver 10 by locating placement of the RTV bonding the diaphragm 40 to the armature 28.

First and second outlet ports 56,58 extend through the housing portion 18. The first outlet port 56 is acoustically coupled to the first chamber 18, and the second outlet port 58 is acoustically coupled to the second chamber 50. The first and second outlet ports 56,58 extend through the substantially closed end 18b of the housing portion 18. A generally round tube 60 having a diameter of 0.018" is disposed in the first acoustic chamber 18. The tube 60 is preferably 0.1" long, though its length and/or radius can be modified to adjust the frequency of both peak frequencies. Specifically, increasing radius, or decreasing length of the tube 60 increases the frequency of each of the peak frequencies.

The structure of the above described receiver 10 lends itself to relatively simplified linear assembly, in that the receiver 10 comprises, in effect, three subassemblies.

The first subassembly comprises the armature 28 attached to the inner rear wall of the second housing portion 17. Typically, the armature of prior art receivers was a part of the motor, rather than separately connected directly to the housing. For added support of the armature 28, the closed end 17b of the second housing portion 17 is 0.006" thick, while the sides are 0.005" thick. The first subassembly further includes a tab 64 for electrical terminations.

The second subassembly comprises the magnet housing 22, the magnets 26 and the coil 20. The magnets 26 are glued within the magnet housing 32 in mutually spaced relation, and the coil 20 is glued to the magnet housing 22. The second subassembly is unique in that the magnet housing 22, which functions as a magnet return flux path, actually forms part of the receiver housing. While this design sacrifices flux leakage, the design permits significant reduction in the overall size of the receiver 10.

The third subassembly comprises the diaphragm 40 secured to the open end of the cup 34 and disposed in the first housing portion 18. The third subassembly further comprises the tube 60 which is spot welded in the first housing portion 18. Thus the receiver 10 can be assembled in a linear manner by inserting the armature free end 28b of the first subassembly through the coil 20 of the second subassembly, and laser welding the second housing portion 17 to the magnet housing 22. The armature free end then extends outwardly from the opposite end of the magnet housing 22. A drop of the RTV in uncured, liquid form is placed on the locating embossment 54 of the paddle 42, and the first housing portion 18 is brought into engagement with magnet housing 22, and are laser welded together. The armature free end 28b contacts the liquid RTV in blind attach fashion, and the RTV is permitted to cure and the assembly is complete.

Referring to **Figure 6**, the receiver 10 is shown positioned in the hearing aid 11. The hearing aid includes a shell 66, a vent 68 and a sound port 70. The vent 68 permits passage of low frequency sound which is below the pass frequencies of the band pass receiver 10. The sound port 70 permits passage of sound from the receiver 10 into a user's ear canal, not shown.

In accordance with a second aspect of the invention, a receiver 10′ is illustrated in **Figures 7** and **8, and** having a frequency response as illustrated in **Figure 9**. The receiver 10′ has the same general construction of the previously described receiver 10, but for the following differences.

The primary difference is an elimination of the tube 60 and the corresponding first port 56. A further difference is an elimination of the rigid, pivotal attachment of the paddle 42 of the diaphragm 40 to the fourth edge 40b of the cup 34. Rather, the annulus 44 extends around all four edges of the diaphragm 40, for compliant connection to all four ledges 36 of the cup 34. As discussed above, the pivotal connection of the diaphragm 40 to the cup 34 of the first described receiver 10 was to reduce the effective mass of the armature to raise the resonant frequency of the receiver 10. As this increase of resonant frequency is not necessary with respect to the second described receiver 10′, the more traditional compliant connection of the diaphragm to the cup is used so as to obtain the maximum amplitude of receiver output.

Further modifications to the second receiver 10′ are also contemplated, as discussed below.

Figure 10 discloses a modification to the receiver 10′ wherein a screen 100 is disposed over the port 58. This screen 100 operates to smooth (or dampen) the peak of the resonant frequency response, as illustrated in **Figure 11**.

Figure 12 discloses a still further modification to the receiver 10′ wherein a back cavity port 104 has been placed in the second housing portion 17. The back cavity port 104 vents the second acoustical chamber 50 (See **Figure 1**). Because of the venting, air is not compressed in the second acoustical chamber 50, which results in a greater output magnitude and reduces the resonant frequency. A back cavity screen 106 can be used to reduce the effective opening dimension of the back cavity and, hence, change the output magnitude and resonant frequency. Placement of an adjustable variable mesh screen would permit a user to adjustably control the output magnitude and resonant frequency. **Figure 13** discloses a frequency response curve for the receiver 10′ having a 0.020" x 0.080" back cavity port 104 covered by the back cavity screen 106 having a mesh with 33% light transmission. By utilizing both the port screen 100 and the back cavity screen 106, and by varying the relative mesh densities of the port screen 100 and the back cavity screen 106, one can vary the sharpness of the resonant peak while also varying the output magnitude and resonant frequency..

In another embodiment, two of the receivers 10′ are placed back-to-back, forming in effect a generally oval, dual receiver 10" (in cross section). The dual receiver 10" has double the output magnitude of the previously discussed single receiver 10′, yet exhibits reduced mechanical vibration, because the respective armatures 28 of each of the individual receivers are moving 180° out-of-phase. Thus the center of mass of the dual receiver 10" remains fixed. This reduction in vibration is significant, because vibration can be picked up by the hearing aid microphone (not shown), resulting in feed back.

A final aspect of the invention relates to various embodiments of a protective boot for placement over the ported end of the receiver, to prevent cerumen from entering the ports of the receiver.

The first boot 110 is illustrated in **Figure 16a** comprising a molded form of urethane approximately 0.001" thick with sufficient resiliency to snugly fit over the ported end of a receiver. The first boot 110 has a depth "d" of approximately .050"-.070", which is believed sufficient to retain the boot 110 on the receiver. Any cerumen collecting on the boot 110 from the user's ear canal can simply be wiped away by the user's finger, or other device.

The second boot 114 is shown in **Figures 16b** and **16c**. The second boot 114 comprises a resilient cup 118 and a urethane film 120. Preferably, the cup 118 would be adhesively bonded to the receiver.

The third boot 126 is generally similar to the second boot 114, but includes a screen 128 disposed in spaced relationship from the urethane film 120 by a spacer ring 130. As discussed above, a screen over a sound port can be used for various frequency response modifying purposes. However, because sound ports are directed into a user's ear canal, the screen can often become quickly clogged by cerumen, adversely affecting the sound quality of the receiver. The third boot 126 provides cerumen protection for the screen 128, which can easily be wiped clean.

It will be understood that the invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present examples and embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein.

CLAIMS

1. A compact band pass receiver for a hearing aid comprising:

a housing portion;

a diaphragm having a plurality of peripheral edges, the diaphragm disposed within the housing portion and defining first and second acoustical chambers;

means for pivotally coupling one of the diaphragm peripheral edges to the housing;

an electromagnetic motor;

a compliant compound coupling the motor to the diaphragm to move the diaphragm at frequencies in accordance with an electrical signal applied to the motor; and

first and second outlet ports through the housing portion, the first outlet port acoustically coupled to the first chamber and the second outlet port acoustically coupled to the second chamber.

2. The receiver of claim 1 wherein the compliant compound comprises compliant RTV.

3. The receiver of claim 2 wherein the RTV has a durometer of Shore A 22, or less.

4. The receiver of claim 1 wherein the means for pivotally coupling one of the diaphragm peripheral edges to the housing comprises a rigid membrane edge.

5. The receiver of claim 1 including a tube disposed within the first acoustic chamber and acoustically coupled to said first port.

6. The receiver of claim 5 wherein the first acoustic chamber has a length, and the tube extends substantially the length of the first acoustic chamber.

7. The receiver of claim 5 wherein the tube terminates substantially flush with the first port.

8. The receiver of claim 1 wherein the housing portion is substantially D-shaped in cross section.

9. The receiver of claim 1 including a peripheral ledge disposed within the second chamber, wherein the diaphragm is coupled to the peripheral ledge.

10. The receiver of claim 9 wherein the ledge is formed of a cup disposed within the second acoustic chamber.

11. A hearing aid comprising a main housing adapted for insertion in an ear of a hearing aid user in combination with the receiver of claim 1 disposed within the main housing.

12. A compact band pass receiver for a hearing aid, the receiver comprising:

a housing portion;

a diaphragm having a plurality of peripheral edges, the diaphragm disposed within the housing portion and defining first and second acoustical chambers;

an electromagnetic motor including an armature having a fixed end and a free end;

means for pivotally coupling one of the diaphragm peripheral edge to the housing;

means comprising a compliant compound for coupling the armature free end to the diaphragm to move the diaphragm at frequencies in accordance with an electrical signal applied to the motor; and

first and second outlet ports through the housing portion, the first outlet port acoustically coupled to the first chamber and the second outlet port acoustically coupled to the second chamber.

13. The receiver of claim 12 wherein the compliant compound comprises compliant RTV.

14. A compact band pass receiver for a hearing aid, the receiver comprising:

a motor housing;

an electromagnetic motor having a coil, a magnet housing and an armature, the armature having a fixed end and a free end, wherein the coil is disposed within the motor housing, the armature fixed end is fixedly secured to the motor housing, the magnet housing adjoins the substantially open end of the motor housing, and the armature free end extends outwardly from the magnet housing;

a housing portion having substantially open and closed ends, the housing portion open end adjoining the magnet housing such that the armature free end extends into the housing portion;

a diaphragm having a plurality of peripheral edges, the diaphragm disposed within the housing portion and defining first and second acoustical chambers;

means for pivotally coupling one of the diaphragm peripheral edges to the generally closed end of the housing portion;

a compliant compound for compliantly coupling the armature free end to the diaphragm to move the diaphragm at frequencies in accordance with an electrical signal applied to the motor; and

first and second outlet ports through the housing portion, the first outlet port acoustically coupled to the first chamber and the second outlet port acoustically coupled to the second chamber.

15. The receiver of claim 14 wherein the first and second outlet ports extend through the substantially closed end of the housing portion.

16. The receiver of claim 14 wherein the compliant bonding means comprises compliant RTV.

17. A compact band pass receiver for a hearing aid comprising:

a housing portion;

a diaphragm having a plurality of peripheral edges, the diaphragm disposed within the housing portion and defining first and second acoustical chambers;

means for pivotally coupling one of the diaphragm peripheral edges to the housing;

an electromagnetic motor;

a compliant compound coupling the motor to the diaphragm to move the diaphragm at frequencies in accordance with an electrical signal applied to the motor; and

an outlet port extending through the housing portion and acoustically coupled to the second chamber.

18. The receiver of claim 17 wherein the compliant compound comprises compliant RTV.

19. The receiver of claim 18 wherein the RTV has a durometer of Shore A 22, or less.

20. The receiver of claim 17 wherein the means for pivotally coupling one of the diaphragm peripheral edges to the housing comprises a pivotal membrane edge.

21. The receiver of claim 17 wherein the housing portion is substantially D-shaped in cross section.

22. The receiver of claim 17 including a peripheral ledge disposed within the second chamber, wherein the diaphragm is coupled to the peripheral ledge.

23. The receiver of claim 22 wherein the ledge is formed of a cup disposed within the second acoustic chamber.

24. A method of assembling a receiver for a hearing aid, the method including the steps of:

providing a first subassembly, the first subassembly comprising a first cup-shaped housing portion having an inner rear wall, and a motor armature having a fixed end secured to said inner rear wall and having a free end extending outwardly therefrom;

providing a second subassembly, said second subassembly comprising a magnet housing, a pair of spaced magnets disposed within the magnet housing, and a coil secured to said magnet housing and extending therefrom;

providing a third sub-assembly, the third subassembly comprising a second housing portion, a cup having an open end disposed within said second housing portion, and a diaphragm extending across said cup open end;

attaching said first sub-assembly to said second sub-assembly such that said armature free end extends between said spaced magnets of said second sub-assembly; and

attaching said second sub-assembly to said third sub-assembly such that said armature free-end engages and attaches to said diaphragm.

25. A receiver housing for a hearing aid, the receiver housing comprising:

a first housing portion;

a magnet housing; and

a second housing portion, wherein said first housing portion, said magnet housing and said second housing portion are mutually interconnected.

26. A receiver for a hearing aid, the receiver comprising:

a magnet housing;

first and second magnets disposed in spaced relationship within said magnet housing;

a generally cup-shaped housing portion having a closed end defining an inner rear wall;

an armature having a fixed end secured to said housing portion and having a free end extending between said spaced magnets.

27. The receiver of claim 26 wherein said armature is secured to said inner rear wall of said housing portion.

28. A generally oval shaped receiver for a hearing aid, the receiver comprising a pair of generally D-shaped receivers combined in back-to-back relationship.

29. The oval shaped receiver of claim 28 including means for modifying the resonant frequency of said receiver.

30. The oval-shaped receiver of claim 29 wherein:

each of said D-shaped receivers has a back cavity; and

said modifying means comprises means for modifying external venting of said back cavity.

31. The oval-shaped receiver of claim 30 wherein said external venting modifying means comprises a screen.

32. The receiver of claim 26 or 30, having a sound port, and including a cerumen blocking boot for preventing entry of cerumen into the port.

FIG. 1

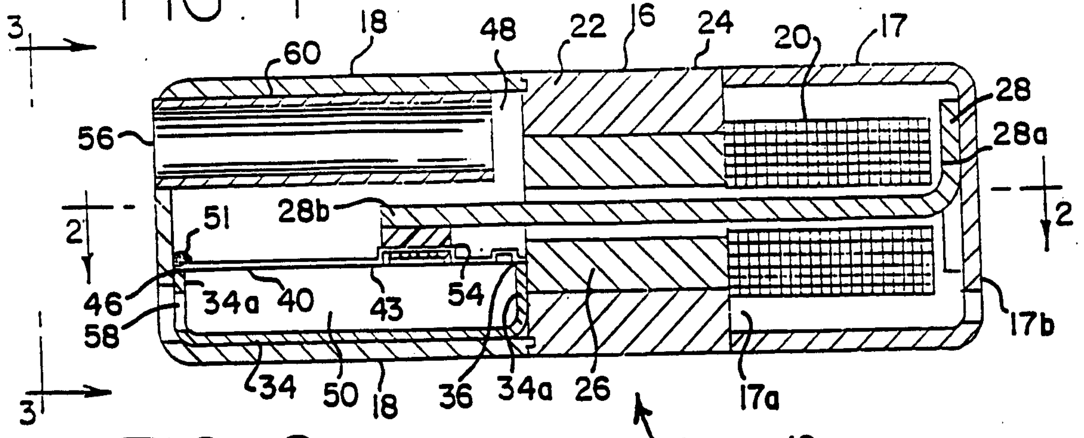


FIG. 2

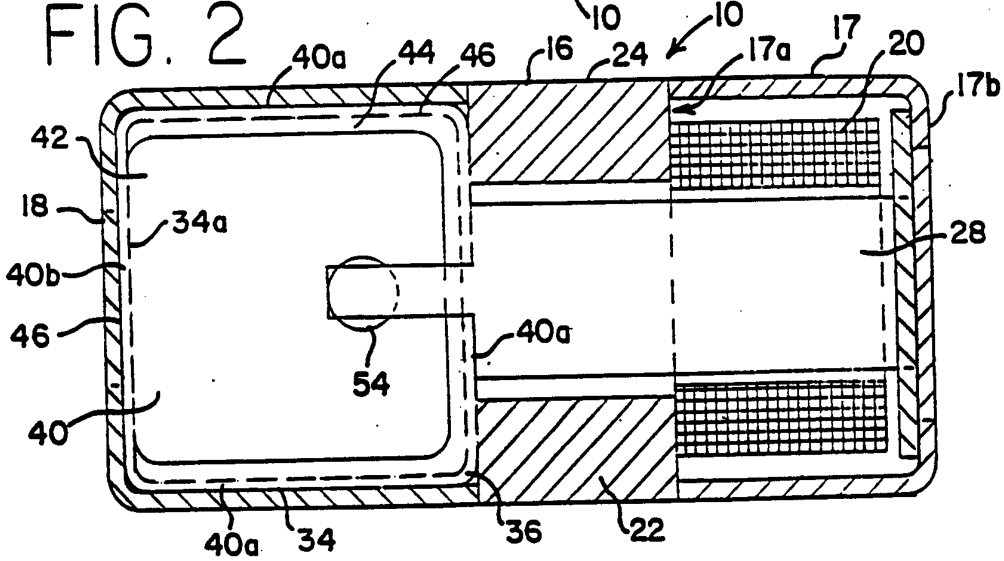


FIG. 2A

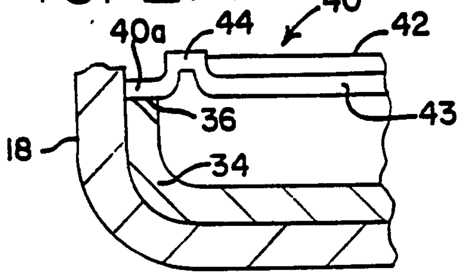


FIG. 2B

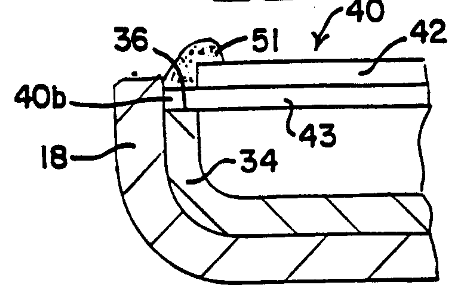
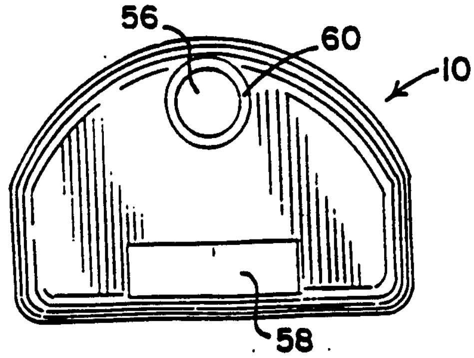
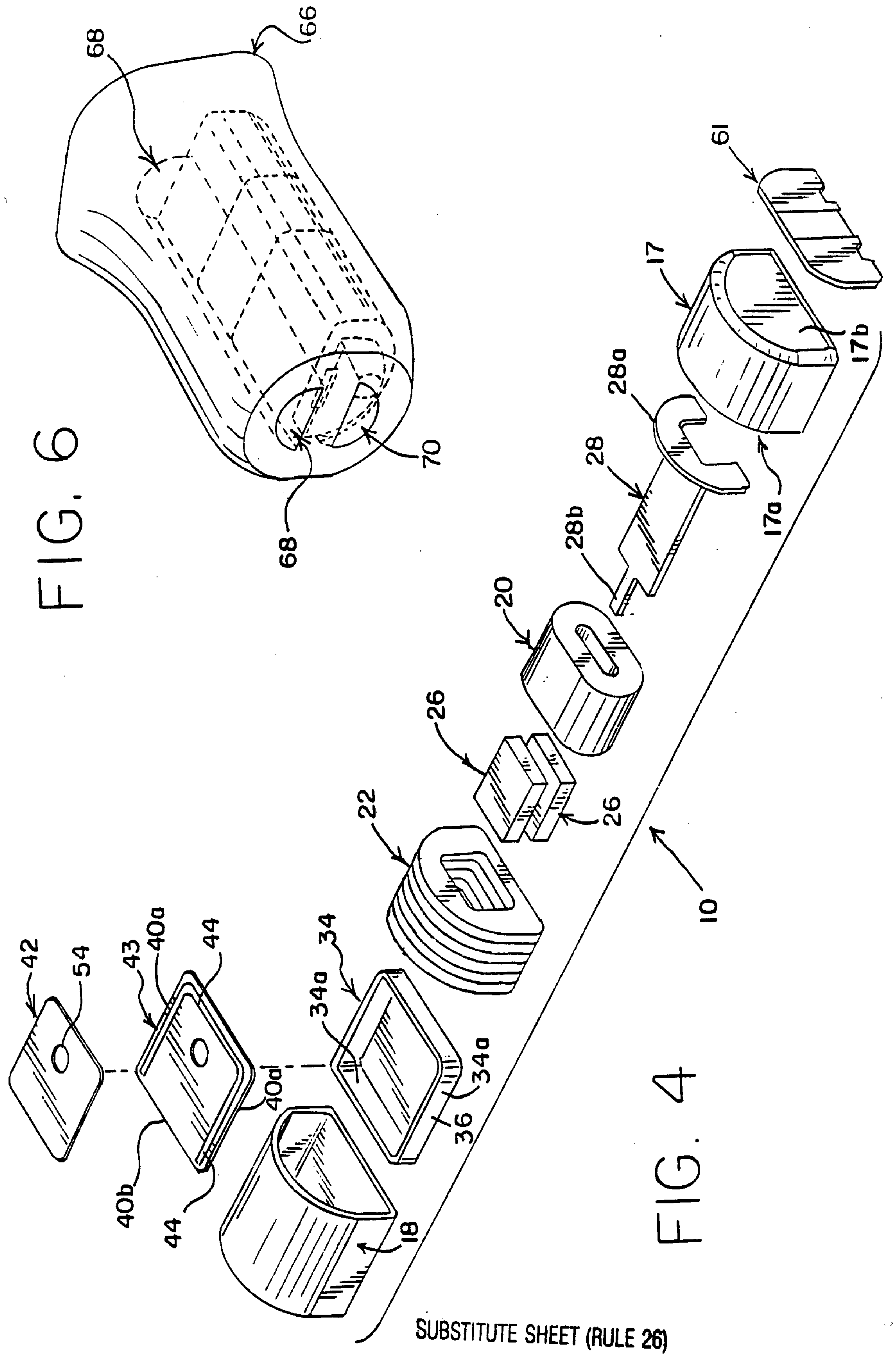


FIG. 3




66
68
68
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61
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17b
17a
28a
28
28b
20
26
26
22
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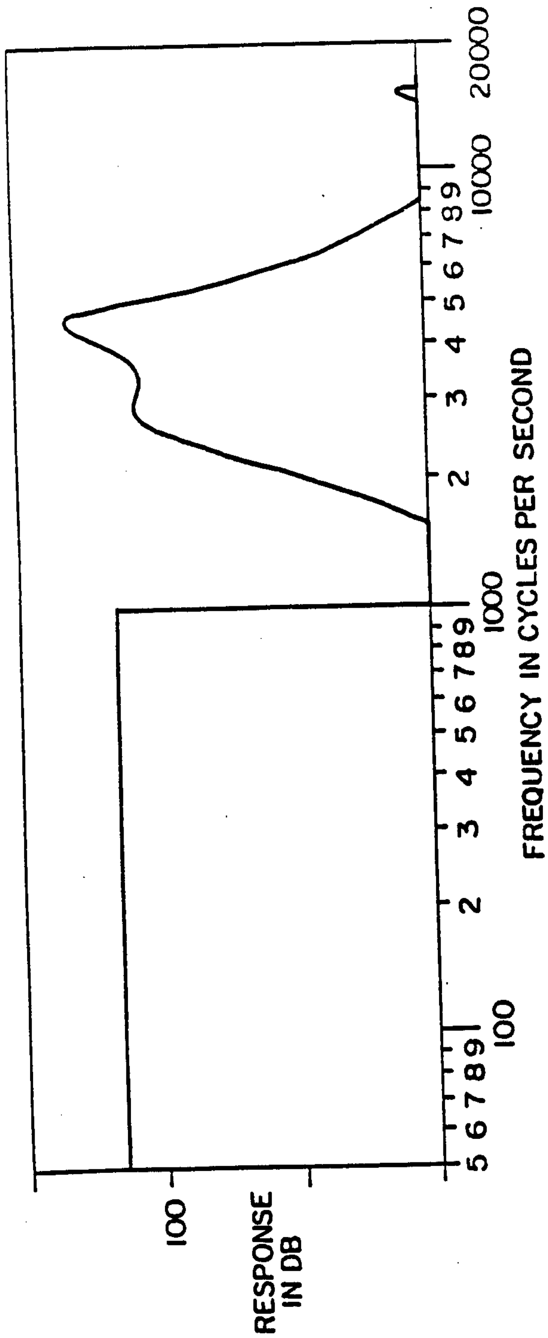
43
40a
44
34
34a
34a
40a
36
40b
44
18

FIG. 6

FIG. 4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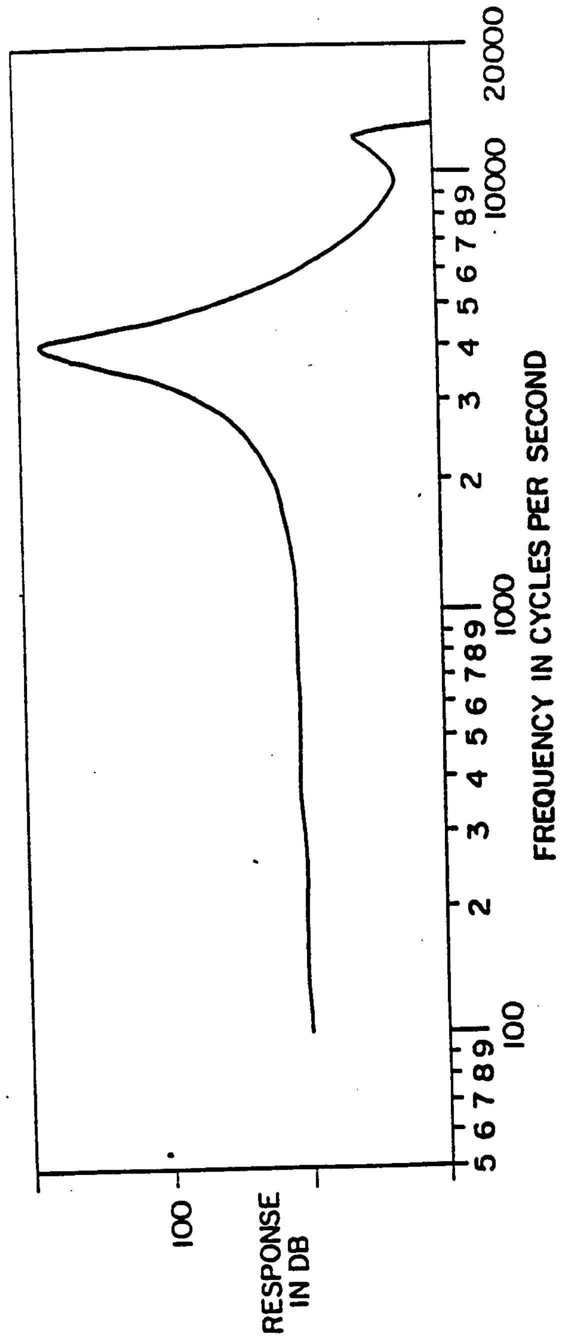
FREQUENCY IN CYCLES PER SECOND
5 6 7 8 9 100 2 3 4 5 6 7 8 9 1000 2 3 4 5 6 7 8 9 10000 20000

FIG. 5


RESPONSE IN DB
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FREQUENCY IN CYCLES PER SECOND
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FIG. 9

FIG. 7

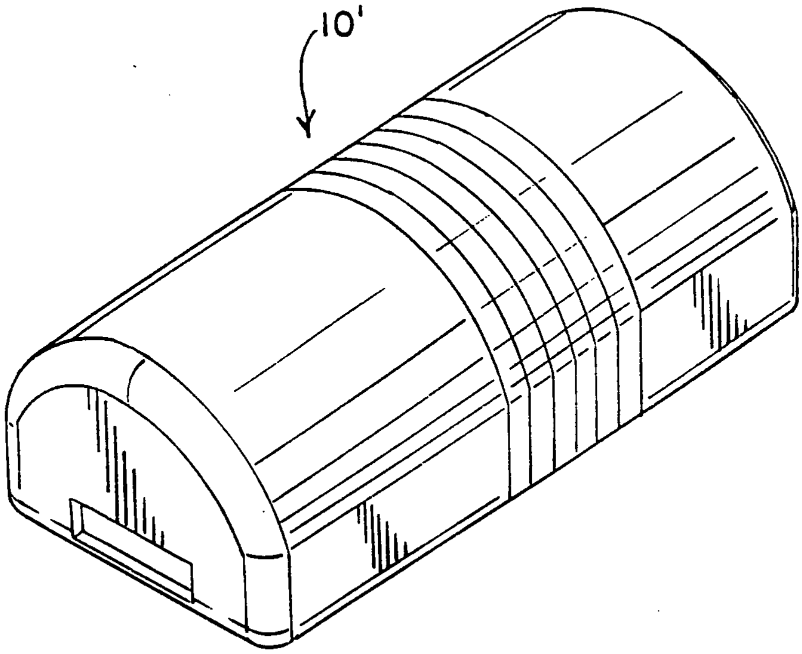
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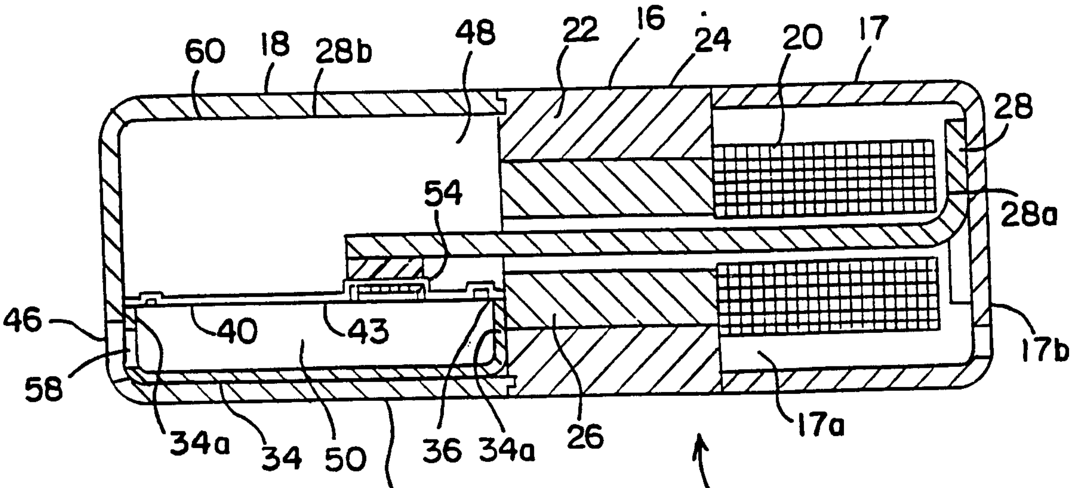
FIG. 8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16
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28a
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17b
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34a
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26
17a
18
10'

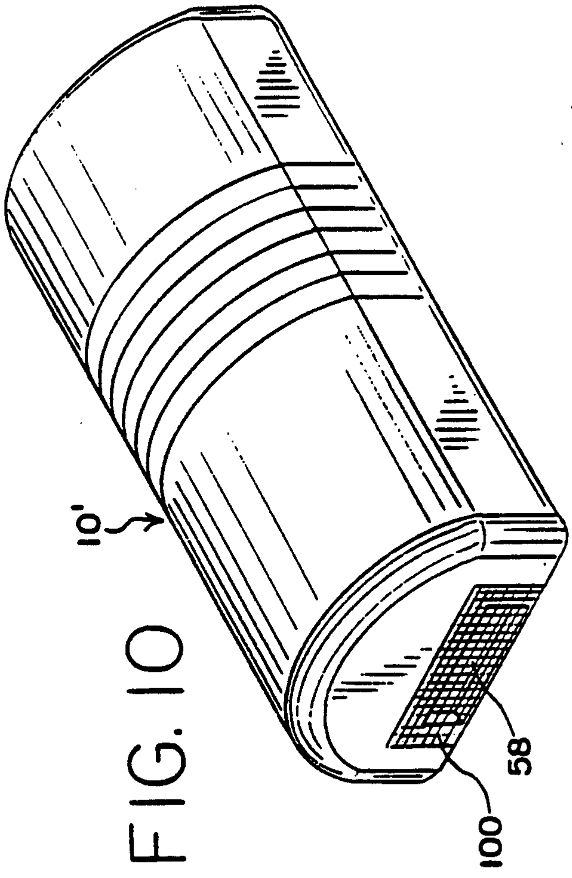
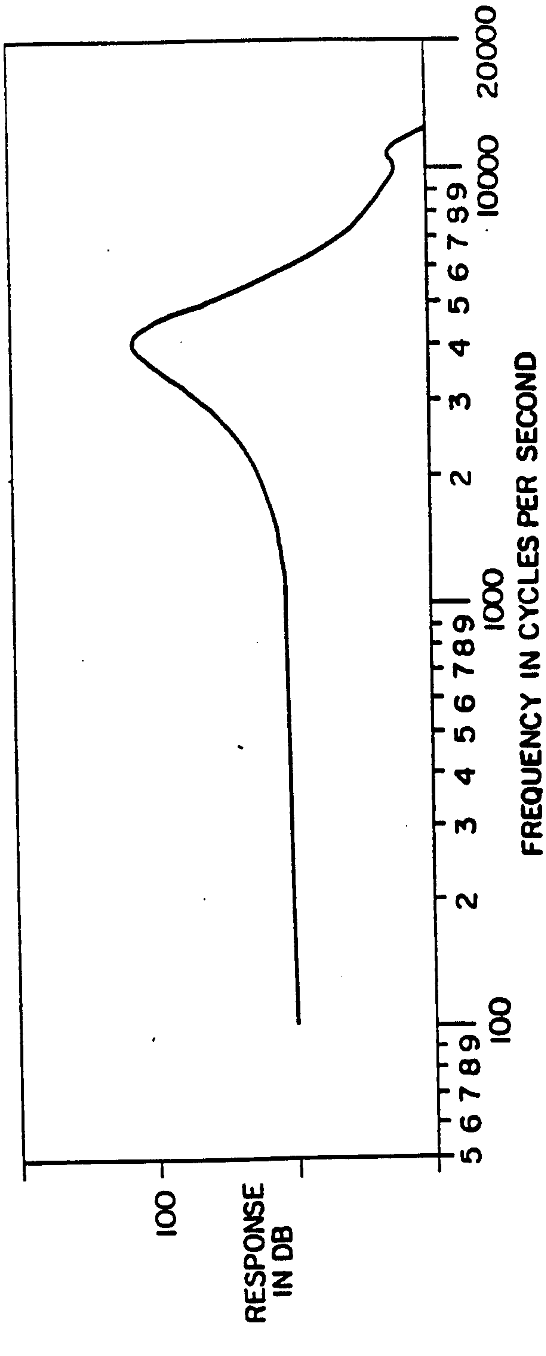

10'
58
100

FIG. 10


RESPONSE IN DB
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FREQUENCY IN CYCLES PER SECOND
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2 3 4 5 6 7 8 9 1000
2 3 4 5 6 7 8 9 10000
20000

FIG. 11

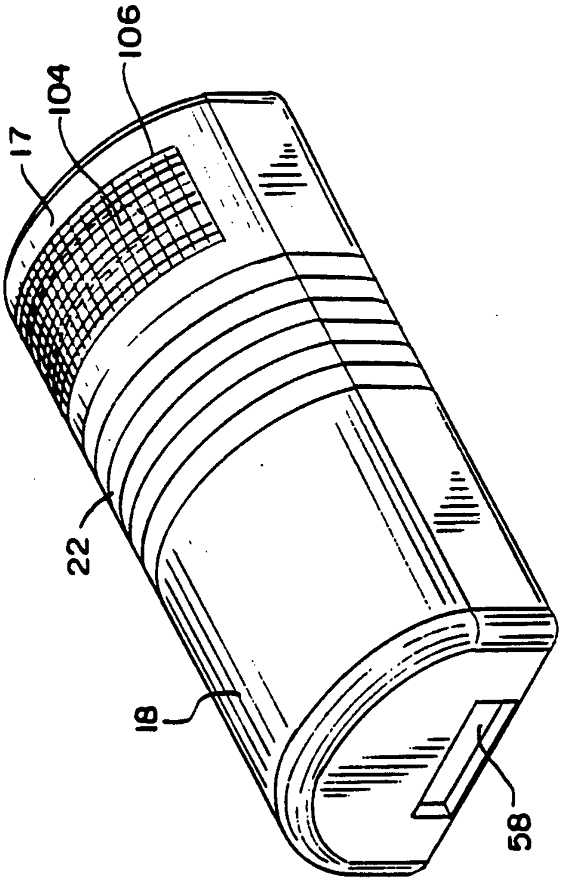
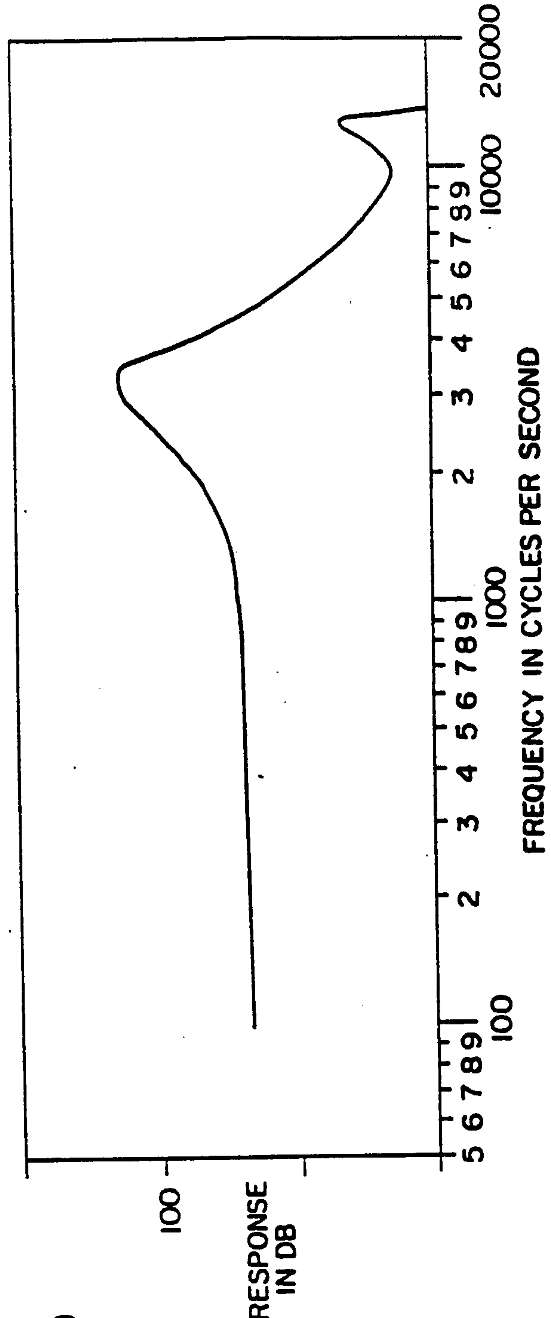

17
104
106
22
18
58

FIG. 12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FREQUENCY IN CYCLES PER SECOND
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FIG. 13

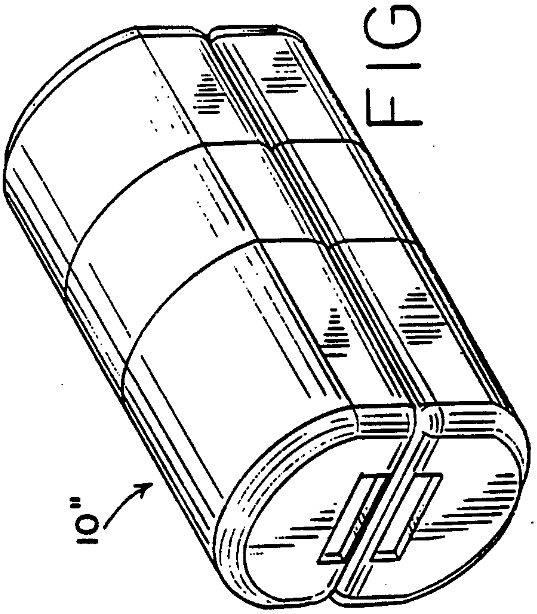
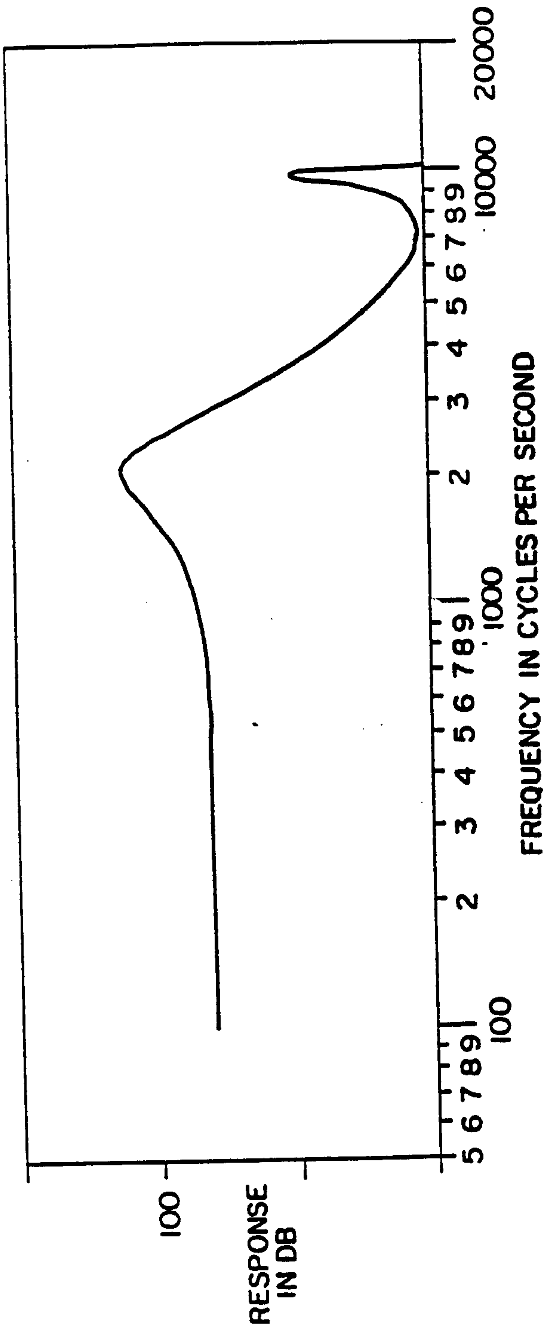

10"

FIG. 15


RESPONSE IN DB
100
FREQUENCY IN CYCLES PER SECOND
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2
3
4
5
6
7 8 9
1000
2
3
4
5
6 7 8 9
10000
20000

FIG. 14

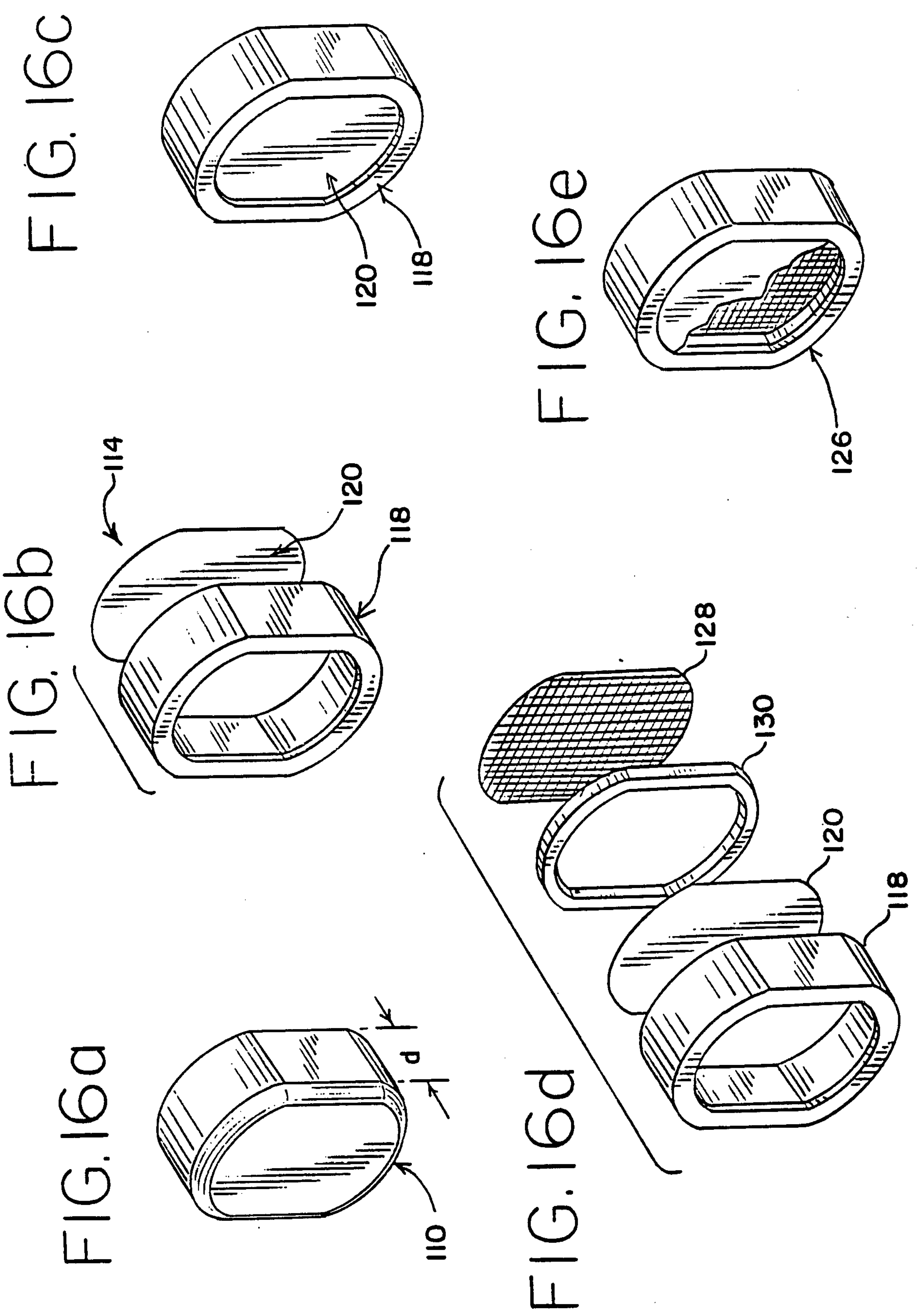
FIG. 16a
110
d
FIG. 16b
114
120
118
FIG. 16c
120
118
FIG. 16d
128
130
120
118
FIG. 16e
126

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 94/09931

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04R25/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04R G01L G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 956 868 (CARLSON) 11 September 1990 see column 3, line 4-28; figures 1-3 ---	1,4,8, 11,12, 14,17, 20,21, 24-27
A	US,A,4 450 930 (KILLION) 29 May 1984 see column 1, line 19-29 see column 2, line 47-64 see column 3, line 29-57 ---	1,4,11, 12,14,17
A	US,H,595 (LAFAW) 7 March 1989 see column 4, line 30-46; figure 2 --- -/--	1-3, 12-14, 16-19

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
1 December 1994	11. 01. 95
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Zanti, P

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 94/09931

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 077 764 (FISHER CONTROLS) 27 April 1983 see page 6, line 23 - page 8, line 14; figures 2,3 see page 10, line 16 - page 11, line 20 ---	1,9,10, 17,22, 23,28,29
A	EP,A,0 377 074 (INDUSTRIAL RESEARCH PRODUCTS) 11 July 1990 see column 2, line 41 - column 5, line 16 see column 5, line 33 - column 6, line 28 ---	1,5-7,32
A	US,A,3 876 843 (MOEN) 8 April 1975 see column 4, line 49 - column 7, line 32 see figures 2-6 ---	29-31
A	EP,A,0 455 203 (KNOWLES) 6 November 1991 cited in the application see column 4, line 23 - column 6, line 9 -----	1,5-8, 11,12, 14,15, 17,21, 24-28

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US 94/09931

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US-H-595	07-03-89	NONE		
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		AU-A-	8935382	19-04-84
		CA-A-	1183011	26-02-85
		JP-A-	58076719	09-05-83
		US-A-	4559832	24-12-85
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		CA-A-	1297575	17-03-92
		DE-D-	68917891	06-10-94
		DK-B-	169509	14-11-94
		JP-A-	2226998	10-09-90
		JP-B-	6048879	22-06-94
US-A-3876843	08-04-75	NONE		
EP-A-0455203	06-11-91	US-A-	5068901	26-11-91