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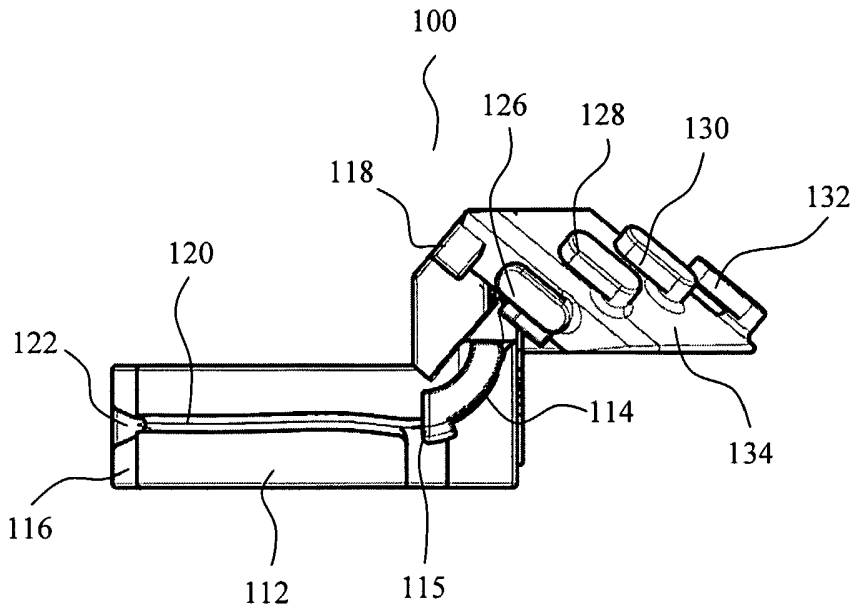
(54) **Title:** A METHOD FOR PROVISION OF A SOUND TUBE WITH A PRE-FORMED SHAPE



(57) **Abstract:** The present invention relates to a simplified manufacturing method for provision of a sound tube with a pre-formed shape, especially a sound tube for use in a BTE (BehindThe-Ear) hearing aid utilizing a holder with an external surface for imparting the shape of the surface to the sound tube, a first attachment element that is adapted to receive and hold a first connector at a first end of the sound tube, and a second attachment element that is adapted to receive and hold a second connector at a second end of the sound tube thereby keeping the sound tube in abutting contact with at least parts of the external surface whereby the external surface imparts the shape of the surface to the sound tube.

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A METHOD FOR PROVISION OF A SOUND TUBE WITH A PRE-FORMED SHAPE

FIELD OF THE INVENTION

The present invention relates to a simplified manufacturing method for provision of a sound tube with a pre-formed shape, especially a sound tube for use in a BTE (Behind-The-Ear) hearing aid.

BACKGROUND OF THE INVENTION

Behind-the-ear hearing aids wherein sound signals propagate as acoustic signals from a receiver positioned in the hearing aid housing behind the ear and through a sound tube into the ear canal are well known in the art.

In order to position the sound tube securely and comfortably in the ear canal, an earpiece, shell, or earmould is provided for attachment to the sound tube and insertion into the ear canal of the user.

Typically, a first end of the sound tube is attached to a first connector for coupling of the sound tube to the BTE housing containing the electronics of the hearing aid, and a second end of the sound tube is attached to a second connector for coupling of the sound tube to the earpiece. The sound tube is typically flexible so that the sound tube is allowed to bend and provide the required arcuate propagation path of the sound from the receiver output.

In the BTE hearing aid disclosed in EP 1 448 014, the sound tube has a pre-formed shape that includes a first bend extending from the first connector over the top of the ear of the user and a second bend extending from an outside of the ear into an ear canal of the user when the hearing aid is worn by the user.

It is also known to manufacture the sound tube with the first and second connectors in one unit in different standard sizes, for example with different lengths between the first and the second bend, e.g. 4 different lengths, and different lengths between the second bend and the earpiece, e.g. 2 different lengths, to fit the human anatomy of the ear of most users. Further, the sound tubes may be fitted with earpieces or shells of different sizes e.g. 3 different standard sizes, or custom mold. Finally, the sound tube has to be manufactured with bends adapted to the right ear and bends adapted to the left ear. The present example leads to 48 (4*2*3*2) standard sizes of the unit to be manufactured and to be kept in stock by the hearing aid dispensers. Still further, the sound tube may be delivered with various diameters.

In WO 99/04601 a method of producing a sound tube with a pre-formed shape is disclosed, comprising the steps of overmoulding a connector member and an earpiece to respective ends of the sound tube, positioning of a formed wire within the tube, thus bending the tube to the desired shape, heating of the tube with the wire to about 120 °C to shape the tube, cooling, and removal of the wire. Upon cooling, the tube retains the shape of the wire.

This method is cumbersome, slow and labour intensive. Thus, there is a need for a more expedient and cost effective method of producing a sound tube with a pre-formed shape.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, the above and other objects are fulfilled by provision of a holder for shaping a sound tube for a BTE hearing aid, the holder comprising attachment elements for holding specific parts of the sound tube in respective specific positions thereby imparting a specific shape to the sound tube.

In one embodiment of the invention, sound signals propagate as acoustic signals from a receiver positioned in the hearing aid housing behind the ear and through the sound tube into the ear canal.

Sound signals may alternatively propagate through a conductor as electrical signals from the output of a signal processor in the hearing aid housing behind the ear to a receiver that is positioned in the ear canal for emission of sound towards the eardrum.

Throughout the present description, the sound tube may be adapted for conduction of acoustic signals, or, may be adapted for conduction of electrical signals.

Inherent tensions in the sound tube material may lead to differences between a) the specific shape imparted to the sound tube by the holder before heating and cooling and b) the desired shape assumed by the sound tube upon cooling and release from the holder. Resilience of the sound tube may for example straighten the sound tube slightly upon release from the holder whereby the radius of curvature of bends of the sound tube is slightly increased. The person skilled in the art will know how to compensate for this effect by provision of a holder imparting a specific shape to the sound tube from which specific shape the sound tube will assume the desired shape upon heating, cooling, and release from the holder.

In one embodiment, the attachment elements comprises gripping devices, each gripping device holding a specific part of the sound tube in a specific position thereby imparting the specific shape to the sound tube.

The attachment elements may be adapted to impart a first bend to the sound tube, the first bend being intended to extend from a BTE hearing aid housing to be worn behind the ear and over the top of the ear of a user when the user wears the hearing aid.

The attachment elements may further be adapted to impart a second bend to the sound tube, the second bend being intended to extend from an outside of the ear into an ear canal of the user when the user wears the hearing aid.

The holder may further comprise a surface for imparting the specific shape to the sound tube, and the attachment elements may further be adapted for fixing the sound tube to the holder keeping the sound tube in abutting contact with at least parts of the surface.

The surface of the holder may be curved to impart the first bend to the sound tube, the first bend being intended to extend from a BTE hearing aid housing to be worn behind the ear and over the top of the ear of a user when the user wears the hearing aid with the pre-formed sound tube.

The surface imparting the first bend may further comprise a groove for reception and accommodation of the sound tube.

The surface of the holder may further be curved to impart the second bend to the sound tube, the second bend being intended to extend from outside the ear into the ear canal of the user when the user wears the hearing aid with the pre-formed sound tube.

Preferably, the holder has a flat bottom surface for easy positioning of the holder on a conveyor belt.

The first end of the sound tube may be attached to a first connector for coupling of the sound tube to the BTE housing containing the electronics of the hearing aid. Further, the second end of the sound tube may be attached to a second connector for coupling of the sound tube to the earpiece.

The attachment elements of the holder may comprise a first element that is adapted to receive and hold the first connector for connection of the sound tube with the BTE hearing aid housing.

The attachment elements of the holder may further comprise a second element that is adapted to receive and hold the second connector for connection of the sound tube with the earpiece.

Thus, in one embodiment of the invention, a holder is provided for shaping a sound tube for a BTE hearing aid, the sound tube having a first end with a first connector and

a second end with a second connector, the holder having an external surface for imparting the shape of the surface to the sound tube, a first attachment element that is adapted to receive and hold the first connector, a second attachment element that is adapted to receive and hold the second connector thereby keeping the sound tube in abutting contact with at least parts of the external surface whereby the external surface imparts the shape of the surface to the sound tube.

The first connector may be over-moulded onto the sound tube. Alternatively, the first connector may be moulded and bonded to the tube thereafter.

Likewise, the second connector may be over-moulded onto the sound tube, or, the second connector may be moulded and bonded to the tube thereafter.

The second connector may comprise a plug to be connected with the earpiece for attachment of the sound tube to the earpiece, e.g. by bayonet coupling or gluing, etc.

The sound tube and the first and second connectors may be moulded to form one integrated unit.

In a preferred embodiment of the invention, the sound tube has an inner diameter ranging from about 0.5 mm to about 2 mm. The tube is preferably formed of a material with a durometer of 50 to 85 Shore D.

In a preferred embodiment of the invention, the earpiece is provided in standard sizes substituting custom made earpieces. In order for the standard sized earpiece to be comfortably and reliably fastened in the ear canal of a user, the earpiece is provided with at least one resilient fibre that is connected to the earpiece for abutting a surface of the outer ear when the earpiece is inserted in the ear canal thereby providing retention of the earpiece in the ear canal of the user.

In a preferred embodiment, the at least one fibre is connected to the earpiece via the sound tube. However, in another embodiment the at least one fibre is connected directly to the earpiece.

The earpiece is configured to fit within the ear canal, preferably, without blocking the ear canal so that sound from outside the ear is allowed to propagate through the ear canal, past the earpiece, and to the tympanic membrane. Preferably, the fibre is adapted for abutting the outer ear at the bottom of the ear, e.g. behind the antitragus at the lower part of the concha, at which position the fibre is substantially invisible and provides secure retention of the earpiece in the ear canal.

The earpiece, the sound tube, the connectors, and the fibre may be moulded to form one integrated unit, or, the sound tube, the connectors, and the fibre may be moulded to form one integrated part to be assembled with the earpiece.

Alternatively, the fibre may be connected to the sound tube with a connector member. The connector member may be over-moulded onto the sound tube and the fibre. Alternatively, the connector member may be moulded first and then bonded to the tube and fibre, respectively.

Preferably, the fibre has an outer diameter of about 1.0 to 1.6 mm, more preferred, about 1.2 mm.

The fibre is preferably produced from a material, which can be formed in a pre-formed shape and exhibits sufficient rigidity to hold the earpiece within the ear canal and retains its shape when positioned in the ear. Examples of fibre materials include REP Teflon, Nylon, PEBAX, silicone, polyurethane, PTFE (polytetrafluoroethylene), EVA (ethylvinylacetate), etc. The material of the fibre may have a shore hardness of about 65 to 85 Shore D, preferably about 72 Shore D.

The resilience of the fibre allows the fibre to apply a force to the earpiece towards the ear canal to retain the earpiece in a position in which the earpiece is pressed against an anatomical feature within the ear canal.

The earpiece material may be a soft elastomer, such as silicone rubber or other soft plastic. The earpiece material preferably has a durometer of about 30 Shore A.

The holder may comprise further attachment elements that are adapted to receive and hold the resilient fibre that is connected to the sound tube and intended for abutting a lower part of the concha when the hearing aid is worn thereby providing retention of the hearing aid earpiece in the ear canal of the user.

Due to its complex geometry, the holder is preferably manufactured utilising selective laser sintering wherein a laser beam is scanned over the surface of a tightly compacted powder made of a thermoplastic material. Heat from the laser melts the powder where it strikes causing sintering of the powder.

Preferably, the holder is made of a material, such as a plastic material, such as polystyrene, etc., that has thermal properties compatible with the material of the sound tube so that the holder follows the thermal extension and compression of the sound tube during heating and cooling. The holder may endure more than a thousand heating and cooling cycles.

According to a second aspect of the present invention, the above and other objects are fulfilled by provision of a method of imparting the specific shape to the sound tube for a BTE hearing aid, comprising the steps of unreeling a desired length of sound tube from a storage reel, cutting the desired length of sound tube, overmoulding the first connector, overmoulding the second connector, mounting the sound tube onto the holder by attaching the first connector to the first attachment element, bending the sound tube along the external surface and attaching the second connector to the second attachment means, and heating the holder with the sound tube, cooling the holder with the sound tube, and removing the sound tube from the holder.

BRIEF DESCRIPTION OF THE DRAWINGS

Below, the invention will be further described and illustrated with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of a prior art BTE hearing aid with an open earpiece,

Fig. 2 is a photo providing a side view of a prior art BTE hearing aid positioned at a user's right ear,

Fig. 3 is a perspective view of a holder according to the present invention,

Fig. 4 is a top view of the holder shown in Fig. 3,

Fig. 5 is a perspective view from the other side of the holder shown in Fig. 3,

Fig. 6 is a photo of the holder shown in Figs. 3-5 viewed from above and with the sound tube attached,

Fig. 7 is a photo of the front of the holder of Fig. 6,

Fig. 8 is a photo of the holder of Fig. 6 from the side,

Fig. 9 shows in perspective attachment elements comprising gripping devices,

Fig. 10 shows the positions of the gripping devices during heating, and

Fig. 11 illustrates release of the sound tube from the gripping devices upon cooling.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 shows in perspective a prior art BTE hearing aid 10. The BTE hearing aid 10 comprises a hearing aid housing 12, a sound tube 14 having a pre-formed shape for conducting sound from the hearing aid housing 12 to the ear canal (not shown), and an earpiece 16 attached to the sound tube 14 for insertion into the ear canal.

The hearing aid housing 12 is configured to be worn behind the ear of a user and contains a battery, a microphone, a processor, and a receiver (not shown) for generating sound that is input into the sound tube 14.

The pre-formed shape of the sound tube 14 includes a first bend 18 extending from the case over the top of the ear of the user and a second bend 20 extending from an outside of the ear into an ear canal of the user when the hearing aid 10 is worn by the user.

The earpiece 16 is configured to fit within the ear canal and, preferably, allows sounds outside and within the ear to pass through the ear canal around the earpiece.

Further, the hearing aid 10 has an arcuate, preferably resilient, fibre 22 with one end 24 that is connected to the first connector. The fibre 22 is adapted for abutting a surface of the outer ear when the earpiece 16 has been inserted in the ear canal thereby providing retention of the earpiece 16 in the ear canal of the user.

Fig. 2 is a photo that illustrates correct positioning of the hearing aid shown in Fig. 1 at the ear of a user. The fibre and the sound tube have been coloured to make them more visible on the photograph for illustration purposes only. The fibre 22 is adapted for abutting the outer ear 26 at the lower part of the concha 28 behind the antitragus 30 at which position the fibre 22 is substantially invisible and provides secure retention of the earpiece 16 in the ear canal 32.

The resilience of the fibre allows the fibre to apply a force to the earpiece towards the ear canal to retain the earpiece in a position in which the earpiece is pressed against an anatomical feature within the ear canal.

The illustrated earpiece is provided in standard sizes and is comfortable to wear and aesthetical and the fibre 22 enables it to be securely and comfortably fastened in the ear canal of a user.

Figs. 3 to 8 illustrate a holder according to the present invention from different sides. Figs. 6-8 are photos of the holder with the sound tube attached.

The holder 100 has a surface 112, 114 imparting the specific shape to the sound tube, and attachment elements 116, 118 for fixing the sound tube to the holder 110 keeping the sound tube in abutting contact with the surface 112, 114.

The surface 112 of the holder 100 is curved to impart a first bend to the sound tube, the first bend being intended to extend from a BTE hearing aid housing to be worn behind

the ear and over the top of the ear of a user when the user wears the hearing aid with the pre-formed sound tube.

The surface 112 imparting the first bend further comprises a groove 120 for reception and guidance of the sound tube.

The surface 114 of the holder 100 further imparts a second bend intended to extend from outside the ear into the ear canal of the user when the user wears the hearing aid with the pre-formed sound tube. As shown in Fig. 4, the first bend that coincides with the groove 120 extends along a curve in a plane perpendicular to the plane of the drawing, and likewise, the second bend coinciding with the surface 114 extends along a curve in the plane of the drawing, i.e. substantially perpendicular to the plane of the first bend.

The surface 114 is formed by an arcuate protrusion perpendicular to the surface from which it protrudes. The arcuate protrusion contains a small tap 115 for passage of the sound tube underneath the tap 115.

The attachment element 116 comprises a groove 122 adapted to receive and hold the sound tube, and the groove 122 ends in a compartment (not visible) for accommodating the first connector of the sound tube. The compartment has a conical shape facilitating insertion of the first connector into the compartment and preventing unintentional removal of the sound tube upon mounting of the sound tube in the holder 100.

The attachment element 118 is shaped as a protrusion holding the second connector substantially in the plane of the second bend, or as a fork or a "U" for reception and accommodation of the second connector. The resilience of the sound tube urges the second connector into abutment of the base of the protrusion or the bottom of the fork or "U" 118 thus assisting in keeping the sound tube attached to the holder 100 until intentional removal.

Further, the holder 100 has a flat bottom surface 124 for easy positioning of the holder for example on a conveyor belt (not shown).

The holder 100 comprises further attachment elements 126, 128, 130, 132 that are adapted to receive and hold the resilient fibre that is connected to the sound tube and intended for abutting a lower part of the concha when the hearing aid is worn thereby providing retention of the hearing aid earpiece in the ear canal of the user. The attachment elements 126, 128, 130, 132 form L-shaped protrusions from a curved surface 134 imparting the specific curved shape to the fibre, providing a space between

the surface 134 and the legs of the L-shaped protrusions that are slightly less than the diameter of the fibre for easy insertion into and detainment of the fibre by the protrusions 126, 128, 130, 132. The holder 100 comprises a further attachment element 136 in the form of a protrusion with a height that corresponds to the fibre diameter for retention of the fibre underneath the L-shaped protrusions.

Holders 100 of different sizes corresponding to respective standard sizes of sound tubes may be made in different colours for easy recognition.

The holders 100 may further contain markings 138 integrated in the material, e.g. indicating left or right, and/or colour, ID number, size code, etc.

In one embodiment, the manufacturing process of a standard sized sound tube comprises the steps of unreeling a desired length of sound tube from a storage reel, cutting the desired length of sound tube, overmoulding the first connector, overmoulding the second connector including the fibre, mounting the sound tube onto the holder 100 by first inserting the first connector into the compartment, bending the sound tube along the groove 120 and inserting the sound tube underneath the tap 115 following the surface 114, and inserting the second connector underneath the protrusion 118, or in the fork shaped attachment element 118, inserting the fibre underneath the L-shaped elements 126, 128, 130, 132 behind the protrusion 136, positioning the holder with the sound tube for example onto a conveyor belt, moving the holder and sound tube through a heating tunnel followed by a cooling tunnel, and finally removing the pre-formed sound tube from the holder.

An indication 140 of the type, e.g. size and right or left side, may be printed on the second connector as shown in Fig. 8.

Figs. 9-11 illustrate an embodiment with attachment elements comprising gripping devices 150, 152; 154, 156. In the illustrated embodiment, the sound tube 14 is attached to two gripping devices 150, 152; 154, 156 at its end points, however, other embodiments may comprise more than two gripping devices 150, 152; 154, 156, and the gripping devices may hold other specific parts of the sound tube 14 in other specific positions thereby, in cooperation, imparting the desired shape to the sound tube 14. The mechanical structure supporting the gripping devices 150, 152; 154, 156 is not shown. The gripping device 150, 152 encloses a chamber that fits the first connector of the sound tube 14 and is divided into a first part 150 and a second part 152 that is closed around the first connector whereby the first connector is attached to the gripping device 150, 152. Likewise, the gripping device 154, 156 encloses a chamber that fits the second connector and the fibre 22 and is divided into a first part 154 and a second

part 156 that is closed around the second connector whereby the second connector is attached to the gripping device 154, 156.

The gripping devices 150, 152; 154, 156 may for example be attached to a robot (not shown) that controls the positions of the opening and closing of the gripping devices 150, 152; 154, 156 and the positioning of the gripping devices 150, 152; 154, 156. After attachment of the sound tube 14 to the gripping devices 150, 152; 154, 156, the robot moves the gripping devices 150, 152; 154, 156 into the positions as illustrated in fig. 10 thereby imparting the desired shape to the sound tube 14. Then, heating of the sound tube is performed. Upon cooling, the robot opens the gripping devices 150, 152; 154, 156 to release the sound tube 14 in its desired shape.

CLAIMS

1. A holder for shaping a sound tube for a BTE hearing aid, the sound tube having a first end with a first connector and a second end with a second connector, the holder having

an external surface for imparting the shape of the surface to the sound tube,

a first attachment element that is adapted to receive and hold the first connector,

a second attachment element that is adapted to receive and hold the second connector thereby keeping the sound tube in abutting contact with at least parts of the external surface whereby the external surface imparts the shape of the surface to the sound tube.

2. A holder according to claim 1, wherein the external surface is adapted to impart a first bend to the sound tube, the first bend being intended to extend from a BTE hearing aid housing to be worn behind the ear and over the top of the ear of a user when the hearing aid is worn by the user.

3. A holder according to claim 2, wherein the external surface comprises a groove for accommodation of the sound tube.

4. A holder according to any of the preceding claims, wherein the external surface is adapted to impart a second bend to the sound tube, the second bend being intended to extend from an outside of the ear into an ear canal of the user when the hearing aid is worn by the user.

5. A holder according to any of the preceding claims, further comprising attachment elements adapted to receive and hold a resilient fibre that is connected to the sound tube and keeping the fibre in abutting contact with at least parts of the external surface of the holder whereby the external surface imparts the shape of the surface to the fibre.

6. A holder according to any of the preceding claims, that is adapted for removably receiving and holding the sound tube.

7. A method of shaping a sound tube for a BTE hearing aid utilizing a holder according to any of the preceding claims, comprising the steps of

unreeling a desired length of sound tube from a storage reel,

cutting the desired length of sound tube,

overmoulding the first connector,

overmoulding the second connector,

mounting the sound tube onto the holder by

attaching the first connector to the first attachment element,

bending the sound tube along the external surface and

attaching the second connector to the second attachment means, and

heating the holder with the sound tube,

cooling the holder with the sound tube, and

removing the sound tube from the holder.

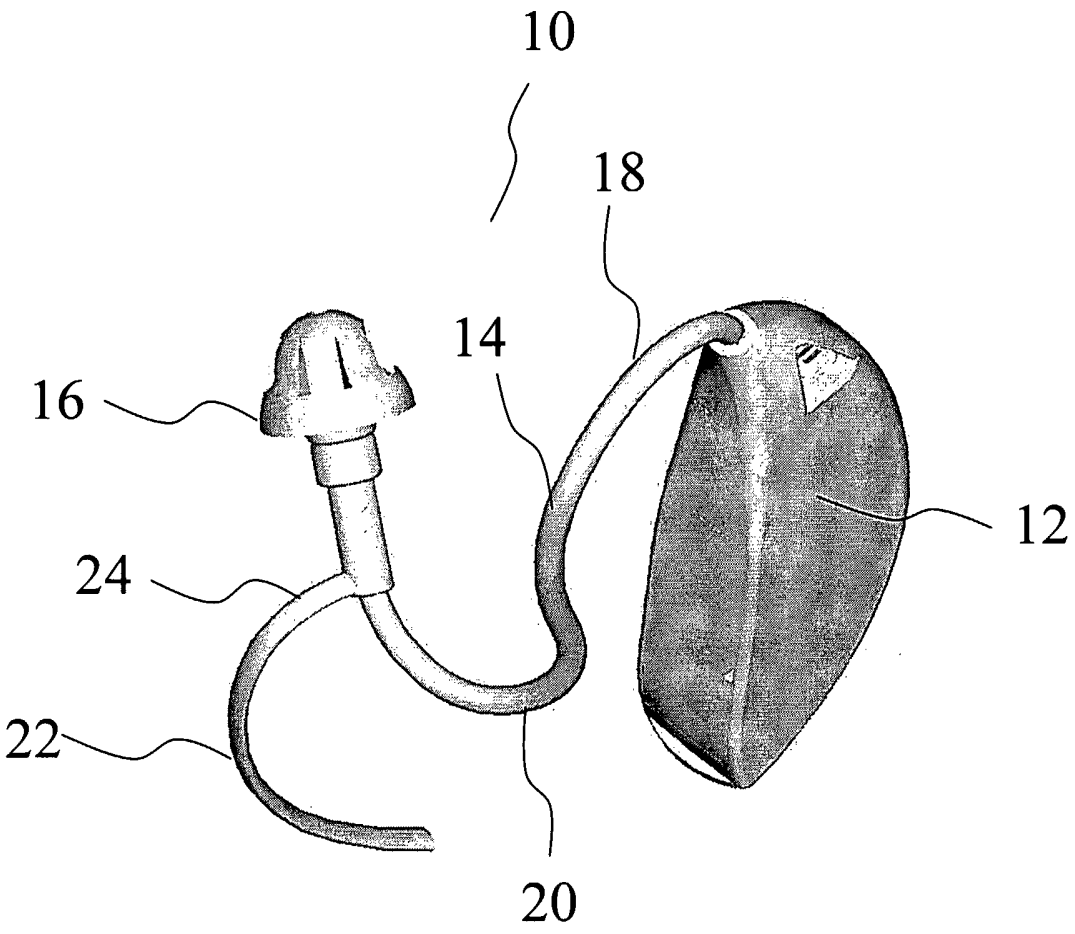

Fig. 1

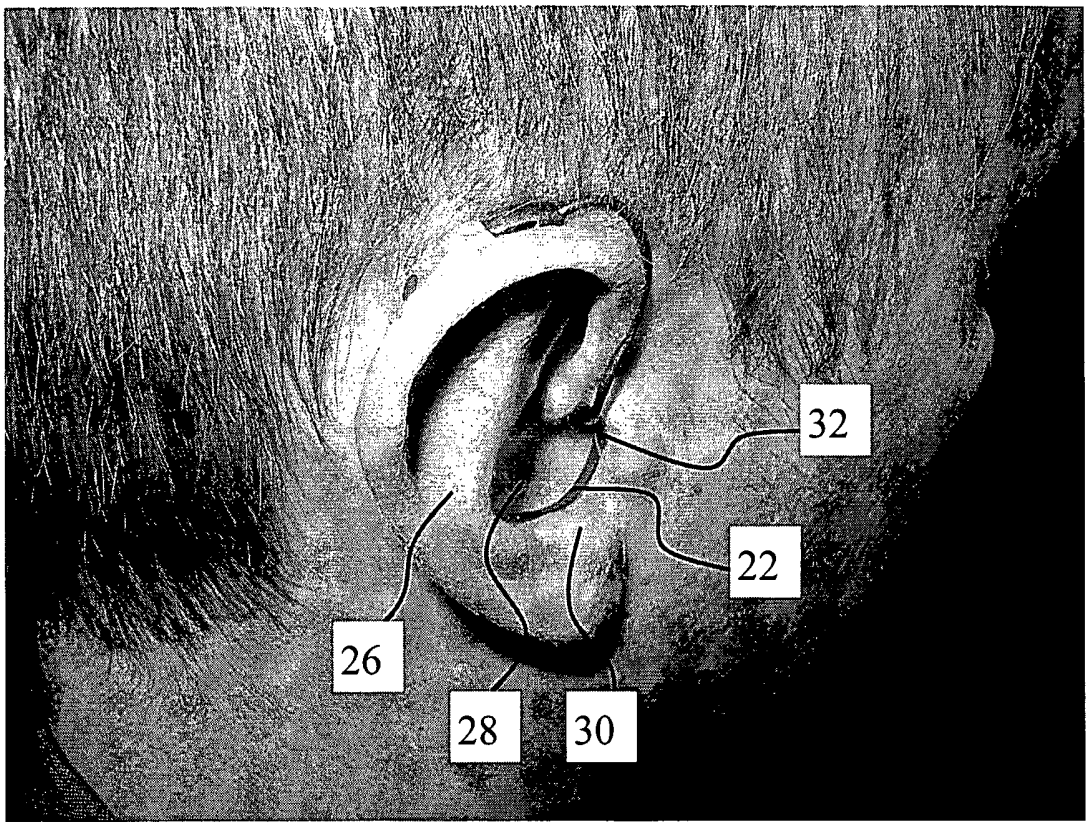

Fig. 2

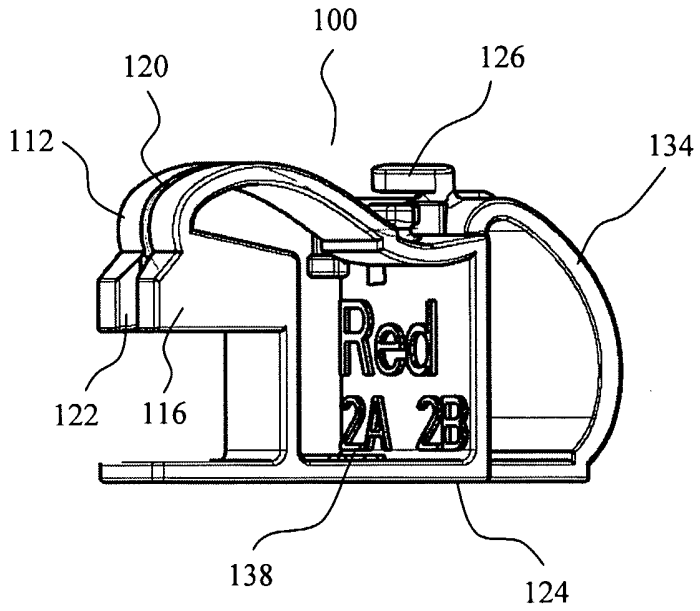
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Fig. 3

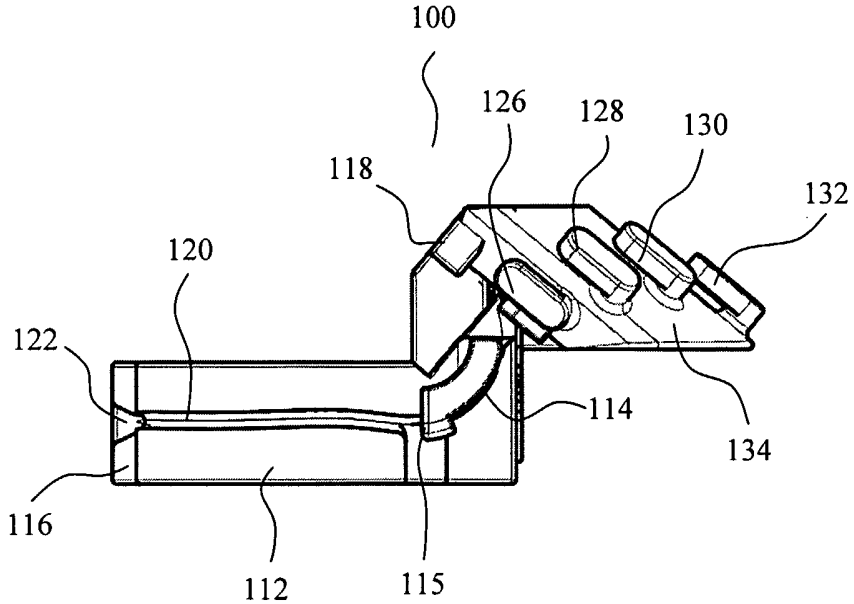
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Fig. 4

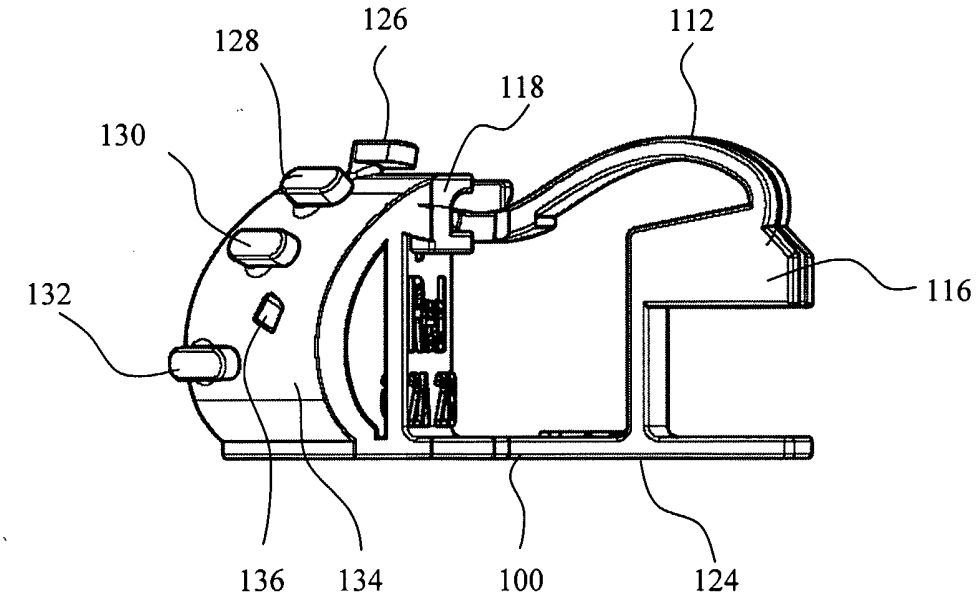
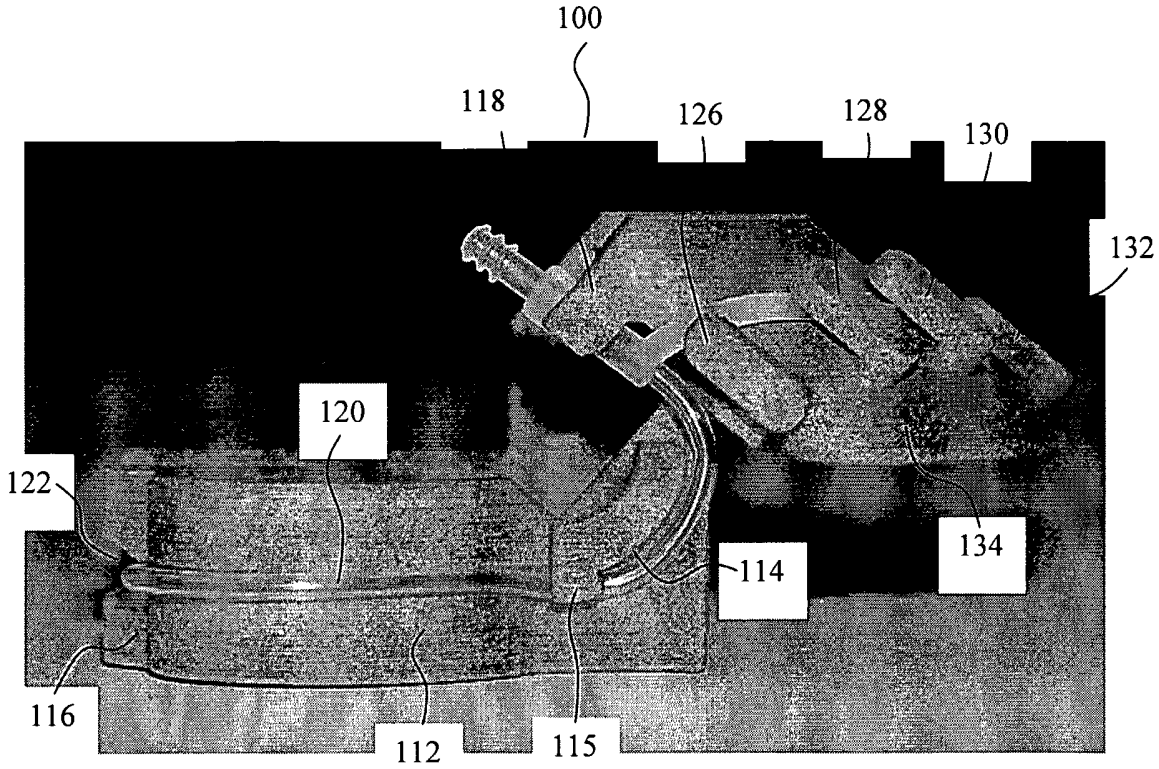


Fig. 5



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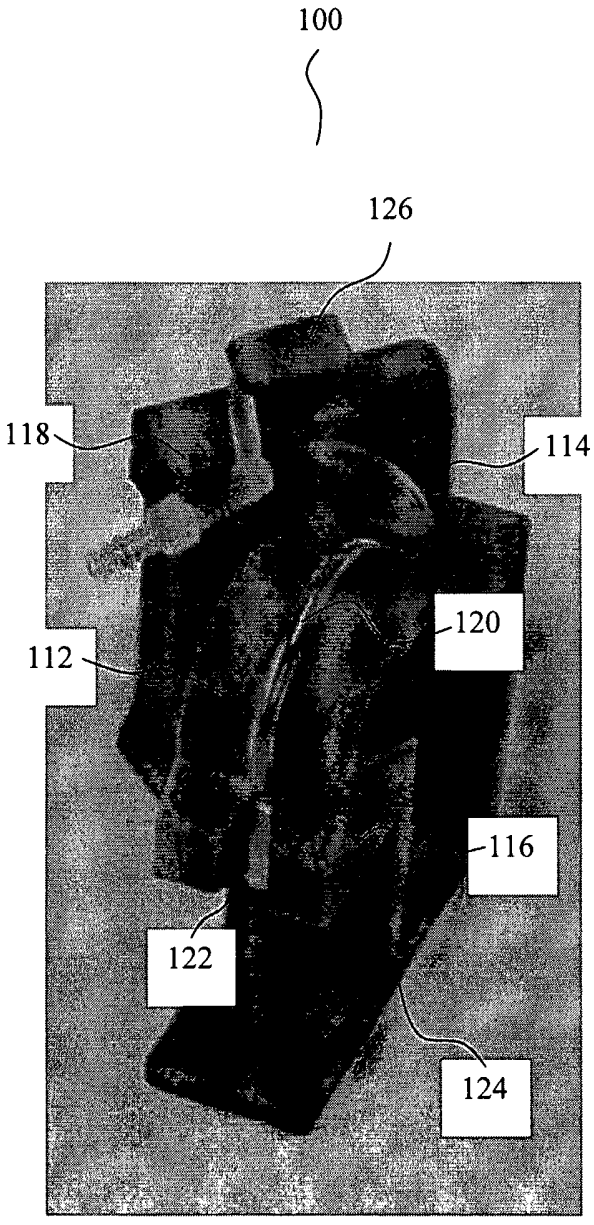

Fig. 7

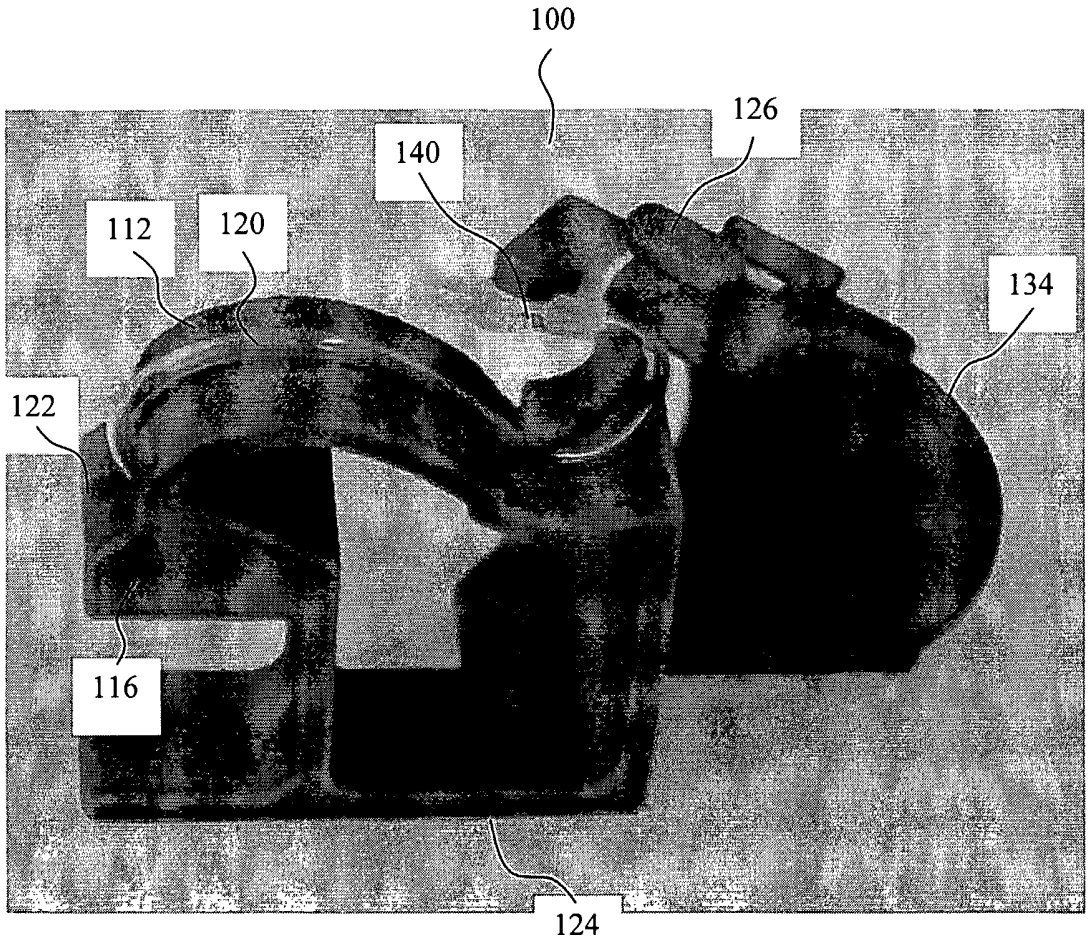

Fig. 8

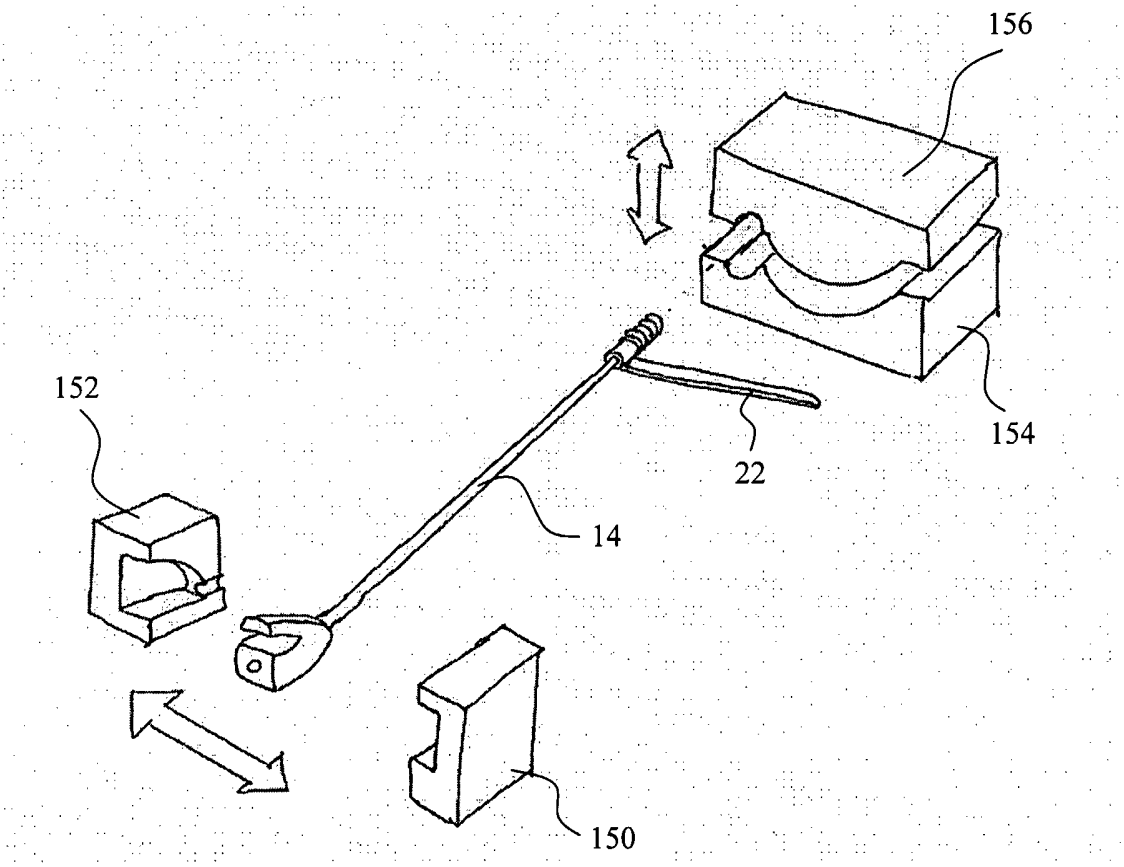

Fig. 9

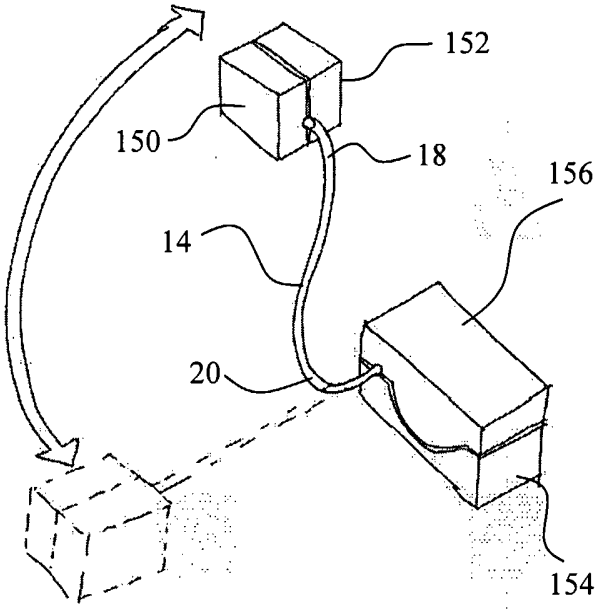

Fig. 10

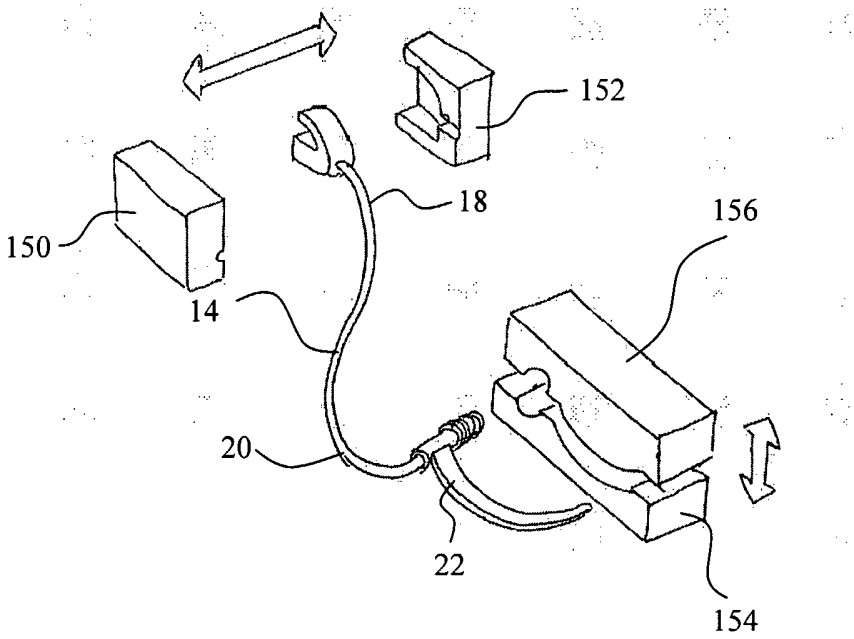

Fig. 11