

A method and a tool for shaping an elongated deformable member for a hearing aid.

The present invention relates to a method and a
5 tool for shaping an elongated deformable member for a hearing aid, as well as to a method for manufacturing such a tool.

BTE-type hearing aids generally have a hearing aid housing comprising a hard shell in which all of
10 the electronics, including input and output transducers, of the hearing aid are typically located. The hard shell is worn Behind The Ear, hence the abbreviation BTE. If the output transducer is located in the hearing aid housing, the output sound from the
15 hearing aid is conducted via a sound tube to an earplug placed in an ear of the person wearing the hearing aid. Both the sound tube and the earplug constitute replaceable parts, which can be, and normally are, replaced with regular intervals. The sound tube
20 is typically replaced less frequently than the earplug, because it is less prone to be soiled, e.g. by cerumen.

The sound tube has to have a three dimensional curvature in order to allow the sound tube to fit the
25 hearing aid at its first end whilst allowing the other end, to which the ear plug is attached, to point in a direction into the ear canal together with the ear plug.

In order to attach the first and second ends of
30 the sound tube to the hearing aid and earplug, respectively, both ends are provided with connection means. These connection means are normally provided by insert moulding around the respective ends of a

length of tube. The tube is normally prefabricated in long lengths in a continuous process such as extrusion, and the desired length of tube is cut from this long length. The actual length of the desired length
5 of tube depends on the user for which the resulting sound tube is desired. Even though the actual length of the desired length of tube depends on the user, usually only a few standard lengths are used, e.g. three. This is sufficient because differences in the
10 individual needs, may be compensated by an appropriate choice of curvature of the sound tube.

In particular when using soft earplugs, the sound tube has to have a stable form, maintaining more or less a predefined curvature from the hearing aid to
15 the earplug by itself, thereby aiding in the positioning of the earplug.

Because the length of tube, on which the connection means are placed by insert moulding, is cut from a longer length of tube, it will per se not have
20 the right three-dimensional curvature to suit the user. Rather, to the extent that the length of tube is not straight, it will typically have a two-dimensional curvature reflecting the fact that it was delivered as a coil of tube.

25 On this background it is the object of the present invention to provide a method and a tool for shaping an elongated member, such as or comprising a sound tube for a hearing aid.

A first aspect of the present invention
30 provides a tool for shaping an elongated deformable member comprising a sound tube for a hearing aid, wherein the tool is manufactured using a rapid prototyping process.

By the use of a rapid prototyping process it is achieved that the elongated member may be shaped individually to the individual characteristics of the ear of the actual user to use the elongated member in connection with e.g. a BTE hearing aid. By this individual shaping, the elongated member may be made to lie closer to the ear, and thus be less conspicuous. Moreover, in addition to the individual shaping of the elongated member to be less conspicuous, the use of a rapid prototyping process allows the tool to be individually shaped, in order to impart the elongated member a curvature that takes up any excessive length not needed. Thus only a few specific standard lengths of elongated members, e.g. three, need to be kept in stock.

A second aspect of the invention provides a tool according to claim 1, wherein the tool is made of a plastic material.

Thereby it is achieved that the sound tube can be held in a position with a desired curvature for a time long enough for it to set in a desired shape corresponding to this curvature and maintain this shape after cooling.

According to a preferred embodiment of the first aspect of the invention, the tool is made of a plastic material. Plastic is inexpensive, and since

the invention does not involve any high temperatures, it has sufficient durability. Moreover, using a plastic material is preferable in that it allows the use of rapid prototyping processes such as
5 stereolithography or selective laser sintering.

Thus, according to a further preferred embodiment, the rapid prototyping process is a stereolithography process. The stereolithography process is itself advantageous in that a high degree
10 of precision in the manufacture of the tool may be achieved. Preferred materials for this are plastic materials selected from the group comprising acryl and epoxy, but in principle any material typically used in this process may be used. If fine details of the tool
15 are needed, epoxy would be preferred.

However, according to another preferred embodiment, the rapid prototyping process is a selective laser sintering process. Compared to stereolithography, selective laser sintering allows
20 the tools to be made more durable. Currently it is preferred to use a plastic material such as a polyamide, but also metals, such as aluminium, or even ceramics could be used.

According to an especially preferred embodiment
25 of the invention, the tool is manufactured on the basis of recorded data concerning an individual's ear. Having once recorded the data concerning the individual's ear, the method according to the invention allows any number of tools to be manufactured, be it
30 locally at the audiologist's, in a remote manufacturing plant, or any other appropriate place without need for sending any physical models. Instead, the

data may simply be transmitted over a computer network.

In another embodiment the tool is adapted to shape an elongated object having a predetermined length. This adaptation is facilitated by the use of a rapid prototyping process, and allows a limited number of elongated elements to be kept in stock.

Thus, according to a further embodiment the tool is adapted to shape an elongated object having a length selected among a number of predetermined lengths, said number being larger than one and preferably smaller than four. Thus the number of elongated is very limited, e.g. to three, bearing in mind that the elongated elements may be shaped to fit either the right ear or the left ear.

In a preferred embodiment of the method according to the invention, said rapid prototyping process is a stereolithography process. As mentioned already, the stereolithography process is precise, and relies
5 on inexpensive materials, in particular a plastic material selected from the group comprising acryl and epoxy .

In an alternative, but also preferred embodiment, said rapid prototyping process is a selective
10 laser sintering process. Compared to stereolithography, selective laser sintering allows the tools to be made more durable. Currently it is preferred to use a

plastic material such as a polyamide, but also a metal, such as aluminium, or even a ceramic could be used.

In an especially preferred embodiment of the method according to the invention, said rapid prototyping process involves the use of pre-recorded data about an individual's ear. This allows the individual shaping of the tool to produce an individually shaped elongated element, in particular comprising a sound tube, for the wearer.

According to a further preferred embodiment of the method, the pre-recorded data about the individual's ear are obtained by laser scanning of the ear. This allows a quick and clean establishment of the data, rather than having to involve a cast of the ear.

According to yet another preferred embodiment the data obtained by the laser scanning is transmitted online to a manufacturing facility remote from the location where the scanning takes place. This allows the shaping tools to be manufactured centrally. They may then either be shipped to the audiologist in order for him to use them for shaping the elongated members whenever the user is in need for new ones. Alternatively, the elongated members could also be shaped to the user's individual needs at the central facility, and then be shipped to the audiologist or even directly to the user.

The invention will now be described in greater detail based on non-limiting exemplary embodiments of the invention illustrated in the drawings. In the
5 drawings,

fig. 1 shows a BTE hearing aid with an elongated member comprising a sound tube shaped according to the invention,

10
figs. 2a and 2b, respectively, show the elongated member before and after it is shaped, and

figs. 3a to 3f show a tool according to the invention for shaping an elongated member for a hearing aid.

Fig. 1 shows a BTE hearing aid, with the hearing aid housing 1 placed behind an ear 2 of a user. An elongated member 3 comprising a sound tube 4 conducts sound from an output transducer in the hearing aid housing 1 to an earplug 5 attached to the distal end of the elongated member 3 and inserted in the ear canal 6 of the user. The earplug 5 is held in place behind tragus 7, by means of an adjustable loop formed by means of an auxiliary part in the form of a strip 8.

In fig. 2a, the elongated member 3 is shown in an initial straight condition. The elongated member 3 may have a slight curvature (not shown), stemming from the fact that this part of the elongated member, which is typically a single-lumen sound tube 4, is manufactured in a separate process, such as extrusion and cut into a suitable length. Typically the sound tube 4 is made of a transparent plastic material, such as a polyamide type plastic, in order not to make it too conspicuous. Because the sound tube 4 is produced in longer lengths, it will typically be delivered as a coil, and may thus have set with a slight curvature over time at storage temperature.

In the following description it will be assumed that the elongated element comprises a single-lumen sound tube 4, but all considerations would apply equally to multi-lumen sound tubes, or elongated elements comprising electrical conductors.

In the manufacturing process, an appropriate length of sound tube 4 is cut from the longer lengths delivered. Typically only three different lengths are used, because one of these would fit most people's ears. It is currently preferred to use three lengths of tube for adults, namely approximately 52 mm, 56 mm and 59 mm. This length of sound tube 4 is provided with appropriate attachment means 9, 13 for attaching the resulting elongated member 3 comprising the sound tube 4 to an earplug 6 and the hearing aid 1, respectively.

Thus, in the illustrated example one end of the sound tube 4 is provided with a cylindrical earplug attachment means 9, comprising a circumferential recess 10. The earplug attachment means 9 may further comprise the strip 8 and an eyelet 11 for receiving and retaining the strip 8, by means of a number of recesses 12 therein. The strip 8 has recesses 12 on either side thereof allowing it to be inserted and retained in the eyelet 11 from either side thereof, depending on whether the elongated member 3 is to be used with a left or a right ear. Thus, the arrangement of the earplug attachment means 9 and the parts it comprises is generally symmetrical about a plane (not indicated). The other end of the sound tube 4 is provided with hearing aid attachment means 13. The hearing aid attachment means 13, comprises a through passage 14, not intersecting the lumen of the sound tube 4. The cross section of the hearing aid attachment means 13 is slightly oval in order to match the hearing aid housing 1 and make a smooth and aesthetic transition to the sound tube 4. The shape of the oval cross section is so that it generally extends in the

direction of the above-mentioned plane, and is symmetrical about this plane.

The reason that the shape of the oval and the strip 8 generally extend in the same plane is because both of the attachment means 9, 13 are normally provided around the ends of the sound tube 4 by means of a single insert moulding process. In this insert moulding process it is convenient to place the longer dimensions along the plane separating two halves of the mould. The attachment means 9, 13 formed in this insert moulding process may also typically be made of a polyamide type plastic, differing, however, from that of which the sound tube 4 is made.

From the generally straight and two-dimensional condition shown in fig. 2a, the deformable elongated object 3 has to be given a three-dimensional shape, e.g. as shown in fig. 2b. The shape of the elongated member 3 shown in fig. 2b is suitable for the right ear, as illustrated in fig. 1. Since, however, the elongated member is symmetrical in the initial condition shown in fig. 2a it might just as well have been shaped to fit a left ear. Moreover, the shape illustrated in fig. 1 and 2b is only an example, the actual shape would depend on the individual user, in order to allow parts of the elongated member to lie as close as possible to the head of the user, and disappear as soon as possible behind pinna.

For this, a tool 20 according to the invention is made. In figs. 3a to 3f, an exemplary tool 20 corresponding to the shape of the elongated member 3 illustrated in fig. 2b, is shown. The inventors have realised that for the specific purpose of shaping the elongated member 3 of a hearing aid, a tool 20 manu-

factured in a rapid prototyping process has sufficient strength and durability, even if the rapid prototyping process is one, such as stereolithography or selective laser sintering, using a plastic material.

5 The tool 20 is thus manufactured using a rapid prototyping process. Apart from those mentioned above, a number of different rapid prototyping processes, with which the tool 20 according to the invention may be manufactured, exist. It is, however, currently preferred to use stereolithography because it has a high

10 degree of precision, but selective laser sintering could also be used. Typical materials, which may be used for stereolithography in this context, are acryl and epoxy. For selective laser sintering, a polyamide

15 could be used.

Using the rapid prototyping processes mentioned above allows a tool 20 to be manufactured specifically to shape the elongated member 3 to a fit matching exactly the specific dimensions and shapes of an

20 individual's ear 2. Thus, the elongated members 3 may be shaped in such a way that their appearance is as discrete as possible when placed in the user's ear 2.

For this the necessary data regarding the user's ear is recorded. This may be done directly by

25 laser scanning of the user's ear 2, or it may be done indirectly based on a cast of the user's ear 2, which is then scanned.

This laser scanning may be performed directly at the audiologist's or it may be done remotely in a

30 production facility. If done at the audiologist's, the resulting data about the user's ear 2 may be transmitted to a remote production facility where the tool 20 is produced by means of said rapid prototyp-

ing process, based on said data. The tool 20, or several copies thereof, may then be shipped back to the audiologist's in order to allow him to shape elongated members 3 for the user upon his request. Alternatively, the audiologist may order a number of shaped elongated members 3 from a supplier, who would shape them with the tool 20 produced in the remote production facility.

Irrespective of where said shaping of the elongated member 3 takes place, the elongated member 3 would be placed in the tool 20, heated and cooled in order to obtain the desired, predetermined shape, and then removed from the tool 20, which may then be re-used. In order to obtain the desired shape, the elongated member 3 will normally be heated in an oven to a temperature between 90°C and 120°C for a period of e.g. 4 minutes or less, depending on the oven type used, and then be cooled down again to normal room temperature or less before removal from the shaping tool 20. If this process is performed by the audiologist, it may conveniently be performed by means of heating in boiling water and subsequent cooling in cold tap water. In this case, the heating period would be shorter, e.g. less than 30 seconds.

These temperature values and times would also apply if a shaping tool in the form of a deformable wire is used. The wire being inserted into the lumen of the elongated member. The wire and elongated member then being suitably deformed, heated, cooled, before extraction of the deformable wire again.

The details of an exemplary tool 20 for shaping a deformable elongated object according to the inven-

tion will now be explained based on figs. 3a to 3f, showing the tool 20 from different angles.

As best seen in figs. 3a, 3b, 3e and 3f, the tool comprises a first holding means in the form of a generally cylindrical hole 21 for receiving a first end of the elongated member 3 comprising the generally cylindrical earplug attachment means 9. The cylindrical hole 21 has a longitudinal slit defined by edges 22, allowing the narrow part, i.e. the sound tube 4, of the elongated member 3 to be inserted sideways into the cylindrical hole 21. When the tube has been inserted in the cylindrical hole 21, the cylindrical earplug attachment means 9 may be pulled into the cylindrical hole along the axis thereof, until it abuts a shoulder 23 forming the transition to a narrower cylindrical part 24 having a diameter corresponding essentially to the external diameter of the sound tube 4. The shoulder 23 thus secures the position of the elongated member 3 in a direction along the longitudinal axis thereof. As can best be seen from fig. 3e, a recess 25 is formed in the side wall of the cylindrical hole 21. When the earplug attachment means 9 is pulled into the cylindrical hole 21, the recess 25 will receive the part in which the eyelet 11 is provided and secure the earplug attachment means 9 against rotation.

Thus secured, the elongated member may be twisted by an angle and placed in the positioning means. The actual angle will depend on the actual user's need, but would typically be approximately 90°. The positioning means comprise a first protrusion 26 having an undercut 27 and a second protrusion 28 having an undercut 29. The elongated member 3 is

placed in the positioning means by being wrapped slightly around the first protrusion 26 and around the second protrusion 28, where it is in either case held laterally in the respective undercuts 27 or 29.

5 The positioning means may further comprise a groove 30 in the transition between the narrower cylindrical part 24 and the undercut 27 under the first protrusion 26.

Following this, the hearing aid attachment

10 means 13 is placed in a second holding means. The second holding means comprises a shallow recess 31 corresponding to the shape of either side of the hearing aid attachment means 13. Moreover the shallow recess 31 has a raised part or protrusion 32, adapted

15 to engage the through passage 14 in the hearing aid attachment means 13. The engagement between the protrusion 32 and the passage 14 helps securing the hearing aid attachment means 13 laterally and longitudinally in the shallow recess 31.

20 The tool 20 furthermore comprises a third holding means for holding the strip 8. The third holding means comprises a curved groove 33. When the earplug attachment means 9 is placed in the cylindrical hole 21 with the protrusion comprising the eyelet 11 in

25 place in the recess 25, the strip 8 will extend in a direction tangential to the groove 33. The strip may now be placed in the groove 33 so as to be tensioned against the outer wall thereof and protruding from the opening 34. It is held in place in the groove 34

30 by means of a protrusion 35, under which it is slipped when placed in the groove 34.

The strip 8 will thus also gain a predetermined shape when exposed to the heating and cooling treat-

ment of the invention. This predetermined shape will indicate to the user, from which direction the strip 8 is to be introduced in the eyelet 11, in order to form an appropriate loop, as seen in fig. 1.

5 It should be noted that the above description of the invention has been given as examples. The skilled person will understand that numerous possible variations exist within the scope of the claims. Thus, the skilled person will know that e.g. the tem-
10 perature ranges mentioned will depend on the actual materials from which the elongated member 3 is made and the time accepted for the material to set in the desired shape. Also, the materials selected for the tool 20 are preferred materials only. The skilled
15 person will know that any material used in a rapid prototyping process, which is sufficiently durable to withstand the temperatures used in the shaping process may be suitable.

P A T E N T C L A I M S

1. A tool for shaping an elongated deformable member comprising a sound tube for a hearing aid, wherein the tool is manufactured using a rapid proto-
5 typing process.

2. A tool according to claim 1, wherein the tool is made of a plastic material.

3. A tool according to any one of claims 1 or 2, wherein the rapid prototyping process is a stereo-
10 lithography process.

4. A tool according to any one of the preceding claims, wherein the tool is made of a material selected from the group comprising acryl, epoxy and polyamide.

15 5. A tool according claim 1, wherein the rapid prototyping process is a selective laser sintering process.

6. A tool according to any one of the preceding claims, wherein the tool is manufactured on the basis
20 of recorded data concerning an individual's ear.

7. A tool according to any one of the preceding claims, wherein the tool is adapted to shape an elongated object having a predetermined length.

8. A tool according to any one of the preceding
25 claims, wherein the tool is adapted to shape an elongated object having a length selected among a number of predetermined lengths, said number being larger than one and preferably smaller than four.

9. Method for providing a tool for shaping a deformable elongated member comprising a sound tube for a hearing aid, wherein the method comprises manufacture of the tool by means of a rapid prototyping
5 process.

10. Method according to claim 9, wherein said rapid prototyping process is a stereolithography process.

11. Method according to any one of claims 9 or
10 10, wherein the tool is made of a plastic material selected from the group comprising acryl, epoxy and polyamide.

12. Method according to claim 9, wherein said rapid prototyping process is a selective laser sin-
15 tering process.

13. Method according to any one of claims 10 to 12, wherein said rapid prototyping process involves the use of pre-recorded data about an individual's ear.

20 14. Method according to claim 13, wherein the pre-recorded data about the individual's ear are obtained by laser scanning of the ear.

15. Method according to claim 14, wherein the data obtained by the laser scanning is transmitted
25 online to a manufacturing facility remote from the location where the scanning takes place.

16. The use of a method according to any one of claims 9 to 15 for the manufacture of a tool according to any one of claims 1 to 8.