Nov. 4, 1947. E. L. KELSEY 2,430,229

HEARING AID EARPIECE

Filed Oct. 23, 1943 3 Sheets-Sheet 1

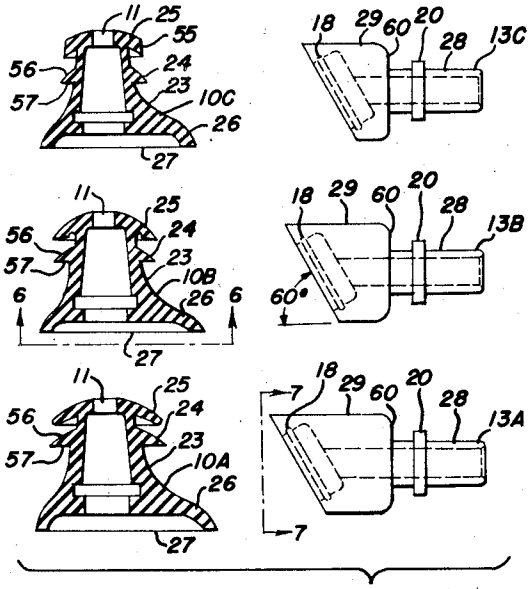

Fig. 5

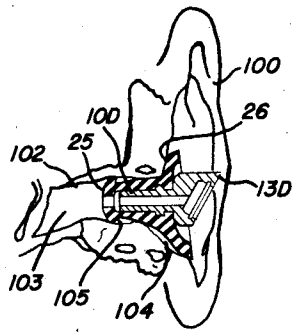

Fig. 11

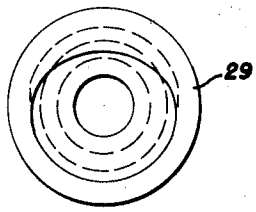

Fig. 7

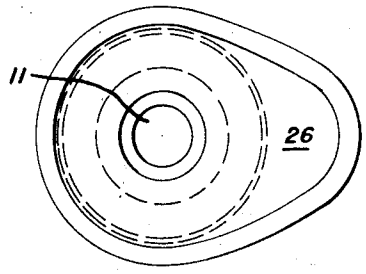

Fig. 6

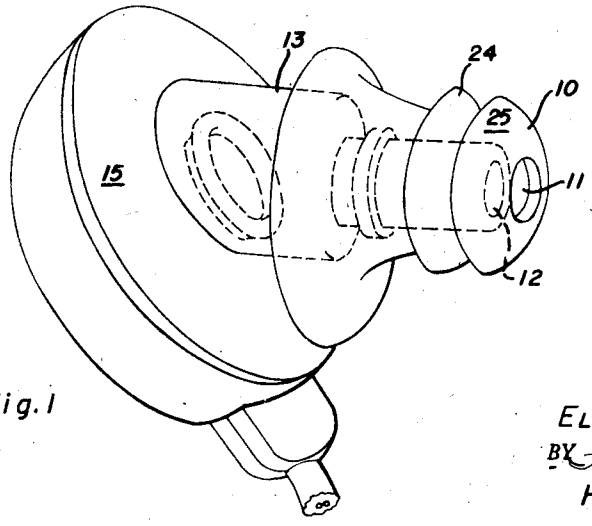

Fig. 1

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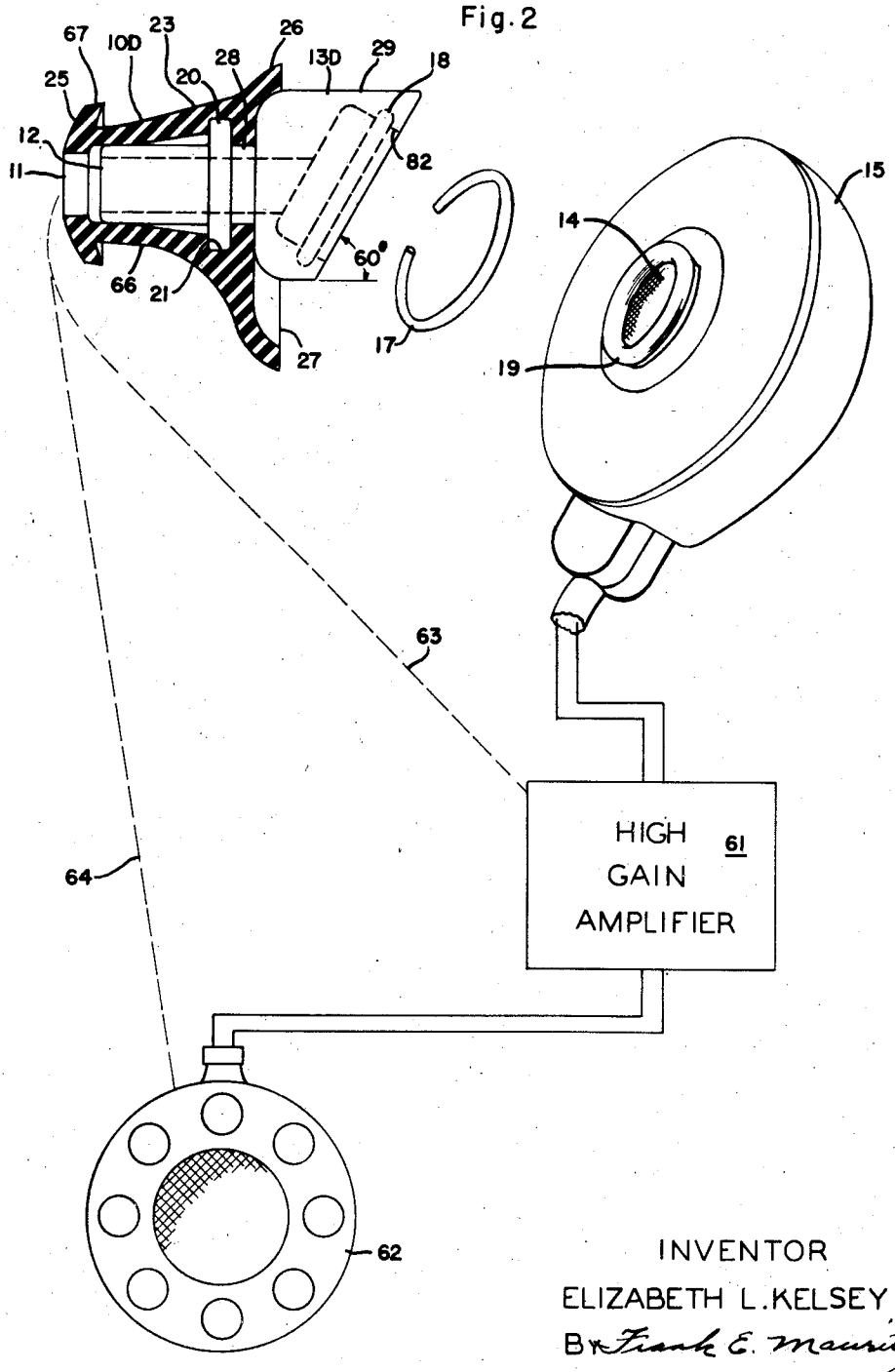
Fig. 2



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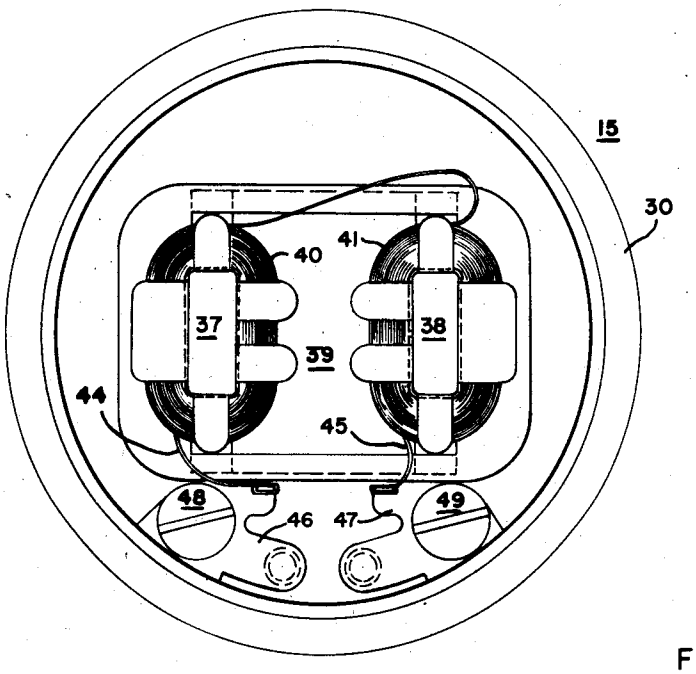


Fig. 3

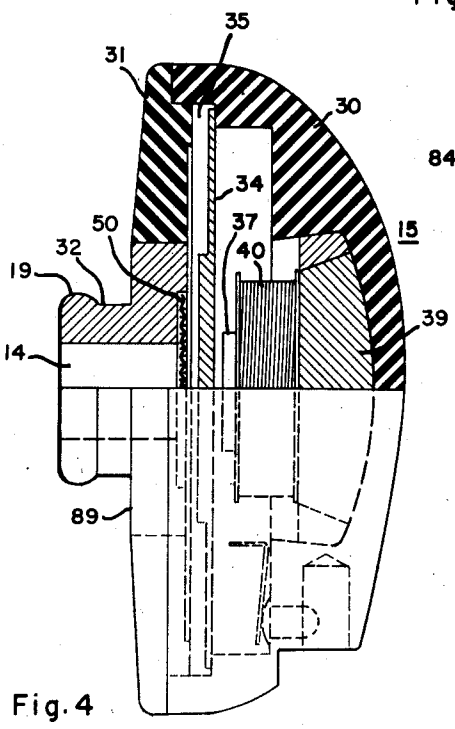


Fig. 4

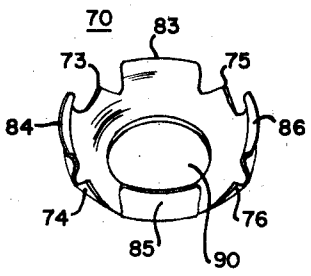
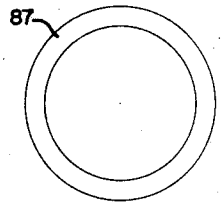


Fig. 8

Fig. 10



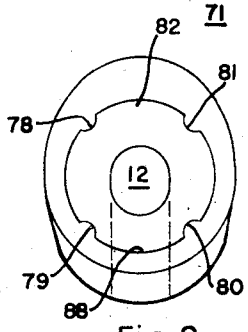


Fig. 9

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UNITED STATES PATENT OFFICE

2,430,229

HEARING AID EARPIECE

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Application October 23, 1943, Serial No. 507,438

3 Claims. (Cl. 179—182)

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This invention relates to hearing aid apparatus of the air conduction type.

It is desirable to make hearing aid apparatus of small size suitable for inconspicuous wear by the user, and especially those components including the earphone and earpiece mounted near or in the ear of the user. The earpiece must give minimum discomfort to the user and yet be of such design and shape as to fit the individual user whereby it is firmly supported in place and whereby acoustical feedback and masking effects from outside noises picked up by the ear simultaneously with sound arriving through the earpiece are eliminated.

In hearing aid circuits including a high gain amplifying device connected between the microphone and speaker wherein the microphone and speaker, or earpiece, are in relatively close proximity to one another, sound emitted from the speaker, or earpiece, may impinge on the microphone or elements of the high gain amplifying device in sufficient intensity to cause an annoying singing or buzzing noise in the earpiece. It is desirable, of course, to prevent such singing or buzzing noise from being superimposed upon the desired sound impinging on the microphone. It is therefore an object of this invention to provide an improved sound sealing means to fit between the body of an earpiece and the contacting portions of the ear of a user such that a high gain amplifying device may be used to advantage without disturbing effects.

In addition to the above described qualities, the earpiece preferably is of such material and size and shape as to conform to the size and shape of individual ears differing within normal limits.

Therefore, another object of this invention is to provide an improved construction of an earpiece adapted to the differing sizes and shapes of individual ears, and further to provide certain details and features of construction which tend to increase the efficiency and desirability of such a device when used with a sound producing element for properly transferring sound to the ear without feedback or losses in frequency response due to shape, size or acoustical coupling of the earpiece or connection thereto.

Another object of this invention is to provide improved apparatus for the carrying of sound from a source thereof to the ear, such apparatus being particularly adaptable for use with hearing aids, radio sets, transceivers, dictaphones, and electro-stethoscopes, the size and shape of such apparatus permitting use under headgear, such

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as helmets, by individuals using sound reproducing apparatus in connection with activities such as aviation, armored divisions or deep sea diving.

Another object of this invention is to provide an improved earpiece supported substantially within the external auditory canal, that is, the external auditory meatus, and arranged to support the earphone connected to such earpiece solely by the earpiece supported within that auditory canal.

Still another object of this invention is to provide an improved form of soft rubber earpiece of small size suitable for inconspicuous wear by the user.

Still another object of this invention is to provide an improved earpiece for use with hearing aid apparatus having a high gain amplifier connected between the microphone and sound reproducing device or speaker.

Yet another object of this invention is to provide a set of such earpieces for use in any individual ear differing in size and shape within normal limits.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which:

Figures 1 and 2 show, respectively, an assembled and an exploded view of parts of an improved earphone and associated apparatus embodying the present invention;

Figs. 3 and 4 show in detail the construction of apparatus shown in Figs. 1 and 2;

Fig. 5 shows groups of earpiece apparatus embodying the present invention;

Figs. 6 and 7 show, respectively, end views of apparatus taken substantially on line 6—6 and line 7—7 of Fig. 5;

Figs. 8–10 show modified apparatus for realizing certain features of the present invention, and

Fig. 11 shows hearing aid apparatus embodying the present invention in a human ear.

Referring to the drawings, wherein the same numerals are applied throughout to similar parts, Figs. 1 and 2 show respectively an assembled view and an exploded view of parts of hearing aid apparatus arranged to be supported substantially entirely by engagement of an earpiece 10 within the external auditory canal, or meatus, of indi-

vidual ears differing in size and shape. These parts comprise an earpiece or plug 10 formed of material such as soft rubber havig a sound transmitting channel 11 extending therethrough arranged in communication with sound transmitting channel 12 of earpiece holder or angular earphone stud 13, the earpiece holder or stud 13 being releasably and resiliently held within earplug 10 and having its sound transmitting channel 12 in communication with the sound emitting opening 14 of speaker unit 15 by means of a resilient split ring 17 loosely held in an annular groove 18 within stud 13 and arranged to engage the inner edge of speaker flange 19. The split ring 17 may take other forms as shown in Fig. 3 for the same purpose.

The sound channels 11, 12 and 14 are preferably round in cross section and are made as large as possible consistent with suitable strength in the wall thickness of the studs, earpieces and earphone. It has been found that when such sound channels have a diameter which is too small, unsuitable transfer of sound energy takes place. In the hearing aid apparatus shown herein suitable transfer of sound energy takes place when the diameter of the openings 11, 12 and 14 are in the order of one-tenth of an inch.

The earpiece 10 is releasably and resiliently held on its holder or stud 13 by cooperation of the flange 20 on stud 13 within the enlarged annular inner groove 21 of earpiece 10, the earpiece or plug 10 being attached to and detached from its holder 13 by distorting the shape of the rubber earpiece 10 and moving it off the holder 13. Such easy removal allows a resilient earpiece of any suitable size to be conveniently attached to holder 13 or removed therefrom so that a user may readily select and try different sizes and shapes of earpieces forming a set.

The earpiece 10, and other similar ones shown herein, are made of soft resilient material, not only for allowing earpieces of different sizes comprising a set to be readily attached to and detached from the holder 13 but also to provide soft expansible surfaces arranged to avoid injury or discomfort to the ear when inserted therein and to cause a suitable engagement or sound seal between the body of the earpiece 10 and the walls of the external auditory canal.

Specifically, earpiece 10 comprises a resilient body portion 23 having integrally formed spaced flanges 24 and 25 arranged to engage the walls of any individual auditory canal differing in size and shape, the rearward portion of the earpiece 10 having a flared portion 26 arranged to seal the mouth of such canal and to limit the depth to which the earpiece 10 is inserted in the auditory canal. The forward soft resilient flange 25, not braced by holder 13, when it is in operative position, provides a soft cushion so as to avoid injury or discomfort to the ear when the earpiece is inserted into the auditory canal. The particular arrangement and shape of the flanges 24 and 25 and the flared portion 26 serve, when in the external auditory canal, to provide a relatively large resistance to movement or shifting of the earpiece 10 in such canal because of a good air seal between flared portions 26 and flange 24 and also between flanges 24 and 25, and because flanges 24 and 25 are not easily deflected out of operative position when an attempt is made to remove the earpiece from the ear.

Because of the soft resilient nature of earpiece 10, only four earpieces, each suitably and differently dimensioned, are necessary to fit all but most unusually large or small ear canals.

The earpiece holder 13 is preferably made of a transparent, light and easily moulded material such as Lucite or polystyrene, which presents a pleasing appearance and in the manufacturing process is machined easily. Specifically, holder or stud 13 comprises a cylindrical portion 28 of small diameter with integrally formed flange 20 therein and a larger hollow angularly truncated cylindrical portion 29 within which there is the inner annular spring retaining groove 18.

Spring 17 of spring steel, or of other suitable material having springlike properties, is split so as to be readily inserted in groove 18 of holder 13 in the manufacturing process, within which groove it is normally retained by the user so as to be in position to engage and hold resiliently the inner edge of speaker flange 19.

Speaker 15, releasably held on stud 13 by means of resilient spring 17, is preferably of the type shown and described in the copending patent application of Gilbert E. Gustafson, Serial No. 484,153, filed April 23, 1943, and assigned to the assignee of the present invention, such speaker, or earphone, including a diaphragm movable in response to electric currents of voice frequency whereby sound pressures varying at voice frequency are transmitted through channels 14, 12 and 11 to the auditory nerves of the ear when the earphone is in operative position.

Speaker 15 shown in detail in Figs. 3 and 4 has a housing 30 with a cover 31 suitably fastened thereto, said cover having a cylindrical outwardly projecting portion 32 with an annular flange portion 19 thereon arranged to cooperate with spring member 17 in holder 13 so as to maintain speaker 15 on stud 13, from which it may be readily separated by exerting a relatively small tension force between the speaker 15 and stud 13.

A circular sound pressure producing diaphragm 34 of magnetic material, mounted in a suitable recess 35 in housing 30, has its center portion normally attracted to the right in Fig. 4 by the magnetic flux from pole pieces 37 and 38, which flux is set up by a permanent magnet 39 having opposite magnetic poles abutting and maintaining members 37 and 38 in spaced relationship, the pole pieces 37 and 38 and magnet 39 being firmly fixed to housing 30 by a cementlike material, as explained in the above mentioned Gustafson patent application.

Diaphragm actuating coils 40 and 41, wound respectively on pole pieces 37 and 28, are serially connected, so that a magnetic flux of voice frequency passes through the magnetic circuit including pole pieces 37 and 38, magnet 39 and the center portion of diaphragm 34 when voltages of voice frequency are applied to coil leads 44 and 45, connected respectively to binding posts 46 and 47, the binding posts 46 and 47 being fastened to the housing 30 by means of screws 48 and 49. Such magnetic flux of voice frequencies causes the inner portion of diaphragm 34 to move with corresponding frequency and amplitude whereby corresponding sound pressures are transmitted through channel 14 to the auditory nerves of the user.

A suitable dust filter 50 is carried by cover 31 and covers the opening of speaker sound channel 14, such dust filter 50 allowing sound transmission therethrough but being impervious to solid materials, so as to maintain the inner portion of speaker 15 free of dust and other foreign materials.

Because of the resilient nature and shape of the soft rubber earpiece 10 and the shape of holder or stud 13, only four such earpieces 10 and four studs or holders 13 of suitably different dimensions are necessary to fit comfortably the ears of individual adults and children differing in size and shape within normal limits.

In Figs. 5 through 8, the set of earpieces or plugs 10A, 10B, 10C and 10D, having the shapes and relative sizes shown, together with the set of holders or studs 13A, 13B, 13C and 13D, having shapes and relative sizes shown, allow sixteen possible combination sets, such sixteen combination sets being sufficient to fit comfortably the ears of all adults and children differing in size and shape within normal limits. Any one of the earpieces 10 fits on any one of the holders or studs 13 as shown in Fig. 1.

In Fig. 5, the group of earpieces 10A, 10B and 10C comprises a large size earpiece 10A, a medium size earpiece 10B and a small size earpiece 10C, each having a pair of spaced flanges 24 and 25 near its forward end and a flared portion of larger diameter 26 at the back end, the maximum diameters of the flanges and flared portion of a particular earpiece being progressively larger along the axial length of the earpiece from the forward end to the back end, and the corresponding flange on each earpiece having a diameter $\frac{1}{32}$ inch smaller than the corresponding flange on the next larger size earpiece. Also, in each earpiece the cross section of each flange 24 or 25 is such that the soft resilient material comprising such flange is displaced more easily by contacting portions of the ear when the earpiece is inserted in the ear than is the case when the earpiece is removed from the ear. That is, each earpiece encounters more resistance to its motion out of the auditory canal than the resistance encountered to its motion into the canal. It is easy to insert an earpiece into the ear but it requires sufficiently greater force to remove that earpiece so that the random forces encountered in the wearing of the earphone are not sufficient to distort its position. This feature allows a particular stud 13 and speaker 15 to be supported solely by engagement of the earpiece with the walls of the auditory canal.

In particular, in Fig. 5 each earpiece has a tip 25, not braced by the body portion of a connected stud when it is in operative position, and a convex faced flange 24 which is positioned and shaped so as to be easily depressed when the earpiece is inserted in the auditory canal and to cause considerable resistance to motions of the earpiece when attempt is made to move it from its normal operative position in the ear. This feature allows the earpiece to be inserted in the ear without discomfort and to be held firmly therein so as to provide a good sound seal between the body of the earpiece and walls of the auditory canal when in operative position. Also, an improved sound seal is provided between the forward flange 25 and the walls of the auditory canal by the termination of the convex flange portion 25 in a substantially flat portion 55, the flat portion 55 contacting the walls of the auditory canal over a substantial area when the earpiece is in operative position.

In Fig. 5, the second flange 24 on each one of the earpieces comprising the group 10A, 10B and 10C has a convex face 56 facing the forward end of the earpiece and a plane face 57 lying substantially in a plane perpendicular to the axis of the earpiece. Such shape provides that the resilient material comprising the second flange is more easily deflected toward flared portion 26 when the earpiece is inserted in operative position in the ear than toward flange 25 when attempt is made to remove the earpiece from such operative position. The maximum diameter of the second flange 24 is somewhat greater than the maximum diameter of the tip flange 25 so that both flanges make suitable contact with the walls of the auditory canal and define a sound deadening air space between the two flanges.

The flared portion 26 on each one of the earpieces 10A, 10B and 10C, joined to the second flange 24 by solid portion 23 and of different and suitable size and shape in each earpiece comprising a set, provides a seal for the mouth of the auditory canal and provides a stop for limiting the distance the earpiece is inserted in the ear. Such flared portion 26 terminates in a plane 27 extending substantially perpendicular to the axis of the earpiece, which plane is substantially coplanar with the plane of the ear concha when the earpiece is in operative position.

In Fig. 5, each of the group of earpiece holders or studs 13A, 13B and 13C has a small cylindrical portion 28 with an integrally formed flange 20 and a hollow cylindrical angularly truncated portion 29 having the inner annular spring retaining groove 18 therein arranged to loosely hold spring 17 in semi-permanent position. Each of the relatively large cylindrical portions 29 shown herein is truncated at an angle of substantially 60° to the axis of the small cylindrical portion 28 as shown in Fig. 5. In each of the earpiece holders 13A, 13B and 13C the dimensions of the smaller cylindrical portion 28 and the radial and axial thickness of flange 20 are the same. The axial length of enlarged truncated portion 29 is different in each one of the studs 13A, 13B and 13C although its outer diameter and dimensions of the spring retaining groove 18 are the same in each one.

The front face 60 in each one of the studs 13A, 13B and 13C in Fig. 5, when in operative position in the ear, is substantially coplanar with the plane of the ear concha, since the outer plane 27 of the earpiece 10 is coplanar with that plane, and the axial dimension of enlarged portion 29 then determines the distance that speaker 15 is displaced from the entrance to the external auditory canal. The studs 13A, 13B and 13C have the portions 29 of such differing axial lengths as to allow suitable support of speaker 15 in relation to the geometry of individual adult ears differing within normal limits.

In other words, one of the set of rubber earpieces 10A, 10B, 10C and 10D in Fig. 5 conforms suitably to the geometry of the external auditory canal of substantially all individual ears differing in size and shape within normal limits, and one of the sets of studs or holders 13A, 13B, 13C and 13D in Fig. 5 conforms suitably to the geometry of ear portions projecting beyond the mouth of the external auditory canal such that speaker 15 may be conveniently carried on the stud 13.

In all of the earpieces shown in Fig. 5 there are three sound seals for greatly attenuating sound pressures transmitted through the central earpiece opening 11 in their path back out of the ear between the outside wall of the earpiece and the wall of the ear canal so as substantially to prevent such feedback. Without such precautions, the sound pressure fed back would influence the operation or behavior of parts of the com-

posite hearing aid apparatus which causes such sound pressures to exist. For example, in hearing aid apparatus wherein the microphone is normally mounted in relatively close proximity to the user's ears, sound pressures fed back from an unsuitable earpiece influence the operation of the microphone to such an extent that a continuous singing or buzzing noise is heard by the user when listening to other sounds. This behavior is particularly objectionable when, as shown in Fig. 2, the hearing aid apparatus is provided with high gain amplifying means 61 connected between the microphone 62 and sound reproducing device or speaker 15. In such case sound waves taking the paths 63 and 64 from the sound emitting opening 11 to the high gain amplifier 61 and microphone 62 respectively may cause such singing or buzzing noise to appear. In my apparatus this singing and buzzing noise effect is prevented by the previously mentioned sound seals.

Earpieces of my construction are particularly applicable for use with such high gain apparatus of the type shown in the copending patent application of John G. Prentiss, Serial No. 504,958, filed October 4, 1943, assigned to the same assignee as the present application. The flanges 24 and 25 and flared portion 26 not only provide means for supporting a complete earphone unit in a user's ear by engagement of an earpiece with the walls of the auditory canal but also provide three sound seals with an intermediate sound deadening air space between adjacent flanges and flared portions.

Fig. 2 shows a small earpiece 10D mounted on a small earpiece holder or stud 13D, such earpiece 10D and stud 13D forming one of a set with the earpieces and studs shown in Fig. 5. Earpiece 10D and stud 13D are especially arranged for use by a child or by adults having very small ears. In such case the set of earpieces 10A, 10B, 10C and set of studs 13A, 13B, 13C are available to children having somewhat larger ear canals than normal size.

In Fig. 2, earpiece 10D is characterized by the fact that it has but one flange, a tip flange 25, and an integrally formed flared portion 26 joined to the tip flange 25 by a hollow conical shaped portion 66. The tip flange 25 is of soft resilient material, has a convex surface facing the forward direction and is not braced by the solid body portion of stud 13D so that it is quite resilient and enters the ear without discomfort.

In order to provide a good sound seal between the body of the earpiece and the wall of the auditory canal, a beveled surface 67 of suitably large area is arranged to engage a relatively large area of the auditory canal surface so that a closed air chamber between tip flange 25 and flared portion 26 exists when the earpiece is in operative position in the auditory canal.

The flange 25 in Fig. 1 is so formed as to be readily deflected by contact with the walls of the auditory canal when it is inserted in the ear and is not easily pulled out of engagement with such wall when random forces are encountered during wearing of the earphone, such forces tending to withdraw or shift the earpiece from its operative position.

Earpiece 10D and stud 13D, although respectively of different shapes and sizes from earpieces 10A, 10B and 10C and studs 13A, 13B and 13C, are so made that they may be readily interchanged in the set in any manner in effecting a suitable combination. That is, sixteen possible combinations are available when the set comprises the interchangeable earpieces 10A, 10B, 10C and 10D and studs 13A, 13B, 13C and 13D.

In all of the studs 13A, 13B, 13C and 13D the enlarged cylindrical portion 29 in Figs. 1 and 5 is truncated at an angle of 60°. This feature allows an attached earphone 15 to be held close to the body of the outer ear structure within the space defined by the antihelix, tragus and antitragus.

It is realized that the spring 17 shown in Fig. 1 may take forms and shapes for providing a quick releasable connection between the holder 13 and earphone 15. Fig. 8 shows a modified and preferred spring member 70 arranged to be held in a modified earpiece holder or stud 71 shown in Fig. 9.

Member 70 of resilient material has four corners 73, 74, 75 and 76 arranged to be held respectively under four small raised projections 78, 79, 80 and 81 on the inner wall 82 of the stud 71 corresponding to inner wall 82 of the stud shown in Fig. 1. The four raised resilient lips 83, 84, 85 and 86 of member 70 are arranged to resiliently and tightly hold flange 19 of speaker 15 in operative position, with the sound transmitting channel 14 of speaker 15 in communication with sound transmitting opening 12 of stud 71. Once member 70 is inserted in operative position in stud 71, the relatively sharp corners 73, 74, 75 and 76 penetrate to a small degree into the material comprising projections 78, 79, 80 and 81 and a permanent connection between spring member 70 and holder 71 exists with resilient lips 83, 84, 85 and 86 in operative position to resiliently engage flange 19 of speaker 15 so as to hold face 88 of stud 71 tightly against face 89 (Fig. 4) of speaker 15, with opening 90 allowing passage of sound.

In order to prevent sound energy from being transferred around the outer surface of flange 19 of speaker 15, a resilient washer 87 in Fig. 10 of small thickness and of the dimension of face 88 is interposed between speaker face 89 and stud face 88.

Fig. 11 shows an earpiece 10D and stud 13D of the types shown in Fig. 1 in an operative position within a human ear 100. It is seen that the tip 25 positively engages the wall 102 of the external auditory canal 103 and that the earpiece flared portion 26 seals the mouth 104 of the auditory canal with a sound deadening space 105 between the body of the earpiece 10D and the walls 102 of the external auditory canal.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and therefore the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In combination, an earpiece of soft, resilient material having a cylindrical sound transmitting channel extending therethrough, said channel being easily closed by relatively small forces exerted on said earpiece, an earpiece holder of generally cylindrical shape having a hollow cylindrical portion thereof extending snugly into the earpiece channel sufficiently that said earpiece is held on the holder by the resilient nature of the earpiece, said cylindrical portion having a sound opening therethrough registering with said sound channel and being of such length and so disposed that the transmitting channel of the earpiece remains open when said relatively small forces are exerted

on said earpiece, said holder having a hollow angularly truncated substantially cylindrical portion and a snap connector on said truncated portion arranged to connect the sound opening of the sound reproducing device with the hollow in said truncated portion and with said sound opening in said holder, in a readily attachable and detachable manner, the angle between the axis of said earpiece holder and the axis of said sound reproducing device attached at said connector being determined by the angle of truncation of said earpiece holder.

2. An adapter, including a cylindrical portion having an opening therethrough arranged to allow passage of sound and an annular ring thereon for receiving and holding open the easily closed sound opening in an earpiece of soft, resilient material, and an enlarged, angularly truncated, cylindrical portion integral with said first mentioned cylindrical portion, having an opening therethrough to allow passage of sound, the axis of said opening in said truncated portion being at an angle with the axis of the opening in said first mentioned cylindrical portion, the openings in the two cylindrical portions registering together to form a continuous sound opening, said truncated portion being provided with a snap connector ring.

3. In combination, an earpiece of soft resilient material having a cylindrical sound transmitting channel extending therethrough, said channel being easily closed by relatively small forces exerted on said earpiece, an earpiece holder of cylindrical

shape having a hollow cylindrical portion thereof extending snugly into the earpiece channel such that said earpiece is held on the holder by the resilient nature of the earpiece, said cylindrical portion being of such length and so disposed that the transmitting channel of the earpiece remains open when said relatively small forces are exerted on said earpiece, said holder having a hollow angularly truncated cylindrical portion integrally formed with said first hollow portion and extending a predetermined distance away from said earpiece, a sound reproducing device having a sound transmitting channel, and means on said truncated portion arranged to hold said sound reproducing device in quickly attachable and detachable relationship and with the axis of the sound transmitting channel of the sound reproducing device displaced at an angle with the sound transmitting channel through the earpiece.

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