June 24, 1941. V. O. KNUDSEN 2,246,737

EAR STOPPER

Filed Aug. 7, 1939

Fig. 1.

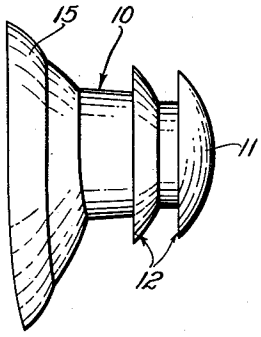


Fig. 2.

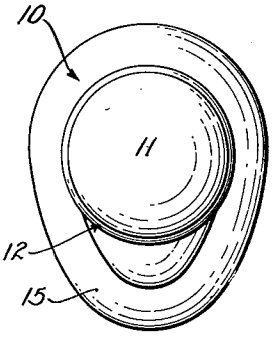


Fig. 3.

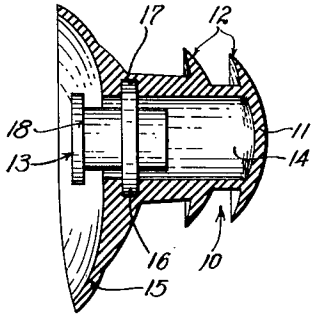


Fig. 4.

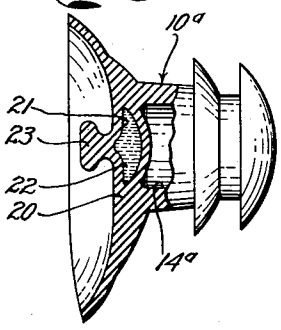


Fig. 6.

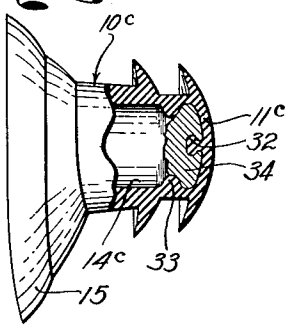


Fig. 5.

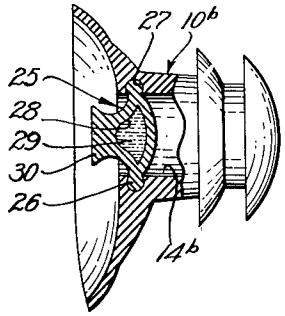
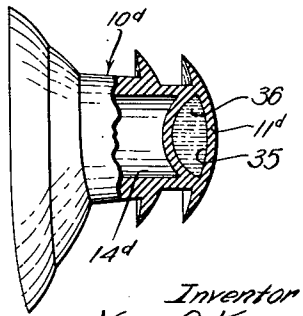


Fig. 7.



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UNITED STATES PATENT OFFICE

2,246,737

EAR STOPPER

Vern O. Knudsen, Los Angeles, Calif.

Application August 7, 1939, Serial No. 288,812

15 Claims. (Cl. 128—152)

This invention relates to ear stoppers or ear protectors and it is a general object of the invention to provide safe, comfortable and particularly effective ear defenders or ear protectors, useful by those who are subjected to heavy or persistent noises such as gun fire, riveting, detonating, machinery noises, etc., by those that are disturbed by noises or unpleasant sounds and by swimmers and others that wish to prevent the entrance of water and other material into the ears.

Ear stopples or protectors of various kinds have been proposed and introduced but for one reason or another have not proven effective or acceptable. The ear protectors that have been made to tightly fit the ears in order to have good sealing engagement with the walls of the auditory canal are uncomfortable, are often painful to insert and remove, and have a tendency to set up irritation in the ears. Other types of ear stopples or protectors that have been constructed to be easily inserted and removed and to be comfortable when in place are usually ineffective in protecting the ears against loud or excessive noises or against the entrance of foreign materials.

Another object of this invention is to provide ear stoppers that are easily and painlessly inserted and removed, that are comfortable and non-irritating when in place, and that are very effective in protecting the ears against the injurious effects of disturbing sounds and foreign materials. The ear stoppers of the present invention combine comfort with effective sound insulation and a fluid-tight closure of the auditory canals.

Another object of this invention is to provide ear stoppers embodying sets or combinations of acoustical elements related and connected to provide a substantial sound transmission loss or audio-insulation throughout a wide range of audible frequencies and to be comparable in their sound insulation characteristics with the anatomical structures that surround and embed the human internal ear or cochlea so that the residual sound reaching the internal ear may be limited to that which is transmitted by bone conduction or by other routes than the normal one through the external and middle ear.

Another object of this invention is to provide ear stoppers of the character mentioned embodying series of inertances or mass impedances coupled by compliances or compliance impedances to form particularly effective sound insulation networks, the said elements being constructed, related, and proportioned to make the protectors easy of insertion and removal and comfortable when in place.

Another object of this invention is to provide ear protectors of the character mentioned in which the inertances or at least certain of the inertances are formed of a fluid, semi-fluid, or plastic material allowing the protectors to readily conform to the auditory passages of the external ears. The inertances or mass impedance elements of the protectors provided by this invention are preferably fluid or plastic to yield or flow when the protectors are placed in the auditory passages and allow the protectors to conform to the contours of the passages without pain or discomfort while maintaining perfect sealing contact with the walls of the passages.

Another object of this invention is to provide ear stoppers or protectors of the character mentioned provided with novel and very effective sealing flanges that readily conform to and seal against the walls of the auditory passage of the concha and external auditory meatus to fully close the same without subjecting the user to discomfort or irritation.

Another object of this invention is to provide ear protectors that are characteristically shaped to correctly fit the auditory passages and the entrances to the same of the average person. The shape of the protectors of the present invention is the result of an extensive study of the ears of a large number of people and the protectors of the invention are designed and constructed to properly and most effectively fit and seal with the auditory passages of the average person.

A further object of this invention is to provide ear stoppers of the character mentioned in which the fluid, semi-fluid, or plastic material or materials forming the acoustical inertances are retained or contained in novel dependable manners.

The various objects and features of my invention will be fully understood from the following detailed description of typical preferred forms and applications of the invention, throughout which description reference is made to the accompanying drawing, in which:

Fig. 1 is a side elevation of one of the ear stoppers of the present invention. Fig. 2 is a front view of one form of ear stopper of the invention. Fig. 3 is a longitudinal detailed, sectional view of the stopper shown in Fig. 2. Fig. 4 is a side elevation of an ear stopper of the invention with the forward portion broken away to illustrate one form of mass impedance means in cross section. Fig. 5 is a view similar to Fig. 4 illustrating an-

other form of forward mass impedance means. Fig. 6 is a side elevation of an ear protector with a portion broken away to illustrate one form of inner mass impedance means in cross section and Fig. 7 is a view similar to Fig. 6 illustrating another form of inner mass impedance means.

The form of the invention illustrated in Figs. 1, 2 and 3 of the drawing may be said to comprise, generally, a yielding body 10 closed at its inner end to have an inner part 11, sealing rims or flanges 12 on the body 10, and a plug 13 in the outer portion of the body 10, constituting an acoustical impedance.

The body 10 is in the nature of a plug or stopper for the auditory passage being an elongate, generally cylindrical member proportioned to be readily entered into the passage. Where I herein employ the terms "auditory passage" and "auditory canal" I refer to the canal of the concha and the external auditory meatus. In accordance with the invention the body 10 is tubular or hollow having a central longitudinal opening 14 extending inwardly from its outer end. An annular or continuous skirt 15 is provided on the forward end of the body 10 to engage in and seal with the chamber or space in the mouth of the auditory canal. The shape of the skirt 15 is important as it assures the correct fit of the protector in the ear and provides an outer or initial seal at the mouth of the auditory canal. The skirt 15 flares forwardly and laterally and has a rather thin wall to most effectively conform to the configuration of the ear. The upper portion of the skirt 15 has a margin or edge that is generally concentric to the longitudinal axis of the body 10 while the lower portion of the skirt 15 is excentric or lobe-like.

The part 11 closes the inner end of the hollow body 10 and acts as an inertance element as well as a closure for the body. The part 11 may be an integral wall of the body and its external surface is convex or partially spherical to assist in guiding the protector into the auditory canal. In the particular form of the invention illustrated in Fig. 3 the wall thickness of the part 11 is comparable with that of the other portions of the body 10, it being understood, however, that the part 11 may have a greater wall thickness to be more effective as an inertance. The inner end portion of the body 10 adjacent the part 11 is preferably slightly reduced in diameter. The body 10 just described is preferably an integral member formed of soft gum rubber or its equivalent and is soft, pliable, and flexible and possesses considerable resiliency.

The sealing rims or flanges 12 are provided to seal with the walls of the auditory canal and are of such character and formation that they produce very effective seals without causing discomfort to the user. There is preferably a plurality of spaced annular or continuous flanges 12 on the body 10. In the typical case illustrated there are two longitudinally spaced flanges 12. One flange 12 is arranged at the inner end of the body 10 to have its inwardly facing surface constitute a continuation of the spherical external surface of the body part 11. The second flange 12 is spaced some distance outwardly from the first mentioned flange 12 and is spaced a considerable distance from the outer end of the body 10. The flanges 12 have laterally and forwardly curved front and rear surfaces and are tapered in cross section to terminate at rather thin marginal edges. The flanges 12 are formed and proportioned so that their cooperation with the wall of the auditory canal of an average ear results in their flexure so that they lie against or in close proximity to the surface of the body 10. As illustrated in the drawing the flanges 12 may be integral parts of the body 10 and in any case are flexible, yielding, and resilient.

The resiliency of the flanges 12 urges the flanges outwardly into effective sealing engagement with the walls of the auditory canal to provide spaced lines or zones of sealing contact with the wall of the auditory canal. The spaced flanges 12 may leave an air space in the auditory canal in surrounding relation to the body 10 and the spaced outer flange 12 and skirt 15 may leave a similar space, the spaces acting to improve the effective sound insulation of the protectors. The flanges 12 are adapted to enter and fit the varied shapes and contours often present in the auditory canal, to assure the correct engagement of the protector in the canal. While the ear protectors herein described are designed to fit a wide variety of shapes and sizes of ears it may be found desirable or necessary to provide two or more sizes and to make certain modifications in respect to the shape to suit all ears, including such modifications as may be found necessary or desirable to make the ear protectors in pairs for use in the left and right ears. The cooperation of the skirt 15 with the mouth of the auditory canal assists in providing effective fluid tight seals and assures the proper retention of the protector.

The plug 13 is an inertance element arranged in the forward portion of the body 10. In practice the plug 13 is a closure for the forward end of the body opening 14. The plug 13 is of sufficient size and mass to form an effective impedance or inertance and is preferably formed of a material having a substantial specific gravity. For example, the plug 13 may be formed of brass, bronze, copper, ferrous metals or suitable alloys of such metals. It is also contemplated that the plug 13 may be formed of hard rubber, ebony, ivory, a thermoplastic, or the like. As best illustrated in Fig. 3 of the drawing the plug 13 may be a generally cylindrical block-like part entering the outer end of the body opening 14. The plug 13 is suitably secured in the flexible yielding body 10. In the case illustrated an annular flange 16 is provided on the plug 13 and cooperates with a groove 17 in the wall of the opening 14 to retain the plug in place. The flange 16 is preferably spaced between the ends of the plug 13 so that a substantial portion of the plug extends inwardly beyond the flange. The body of the plug 13 is preferably of less diameter than the opening 14 to have substantial clearance with the wall of the opening. This allows the body 10 to flex or compress with little or no interference from the plug 13. The plug 13 preferably projects from the forward end of the body 10 to have its forward part within the cupped skirt 15.

The plug 13 may have an annular flange or knob 18 at its outer end to be grasped by the user when inserting and removing the protector. The rigid plug 13 set or positioned in the forward portion of the body 10 lends considerable rigidity to the protector without appreciably interfering with the flexure of the body.

In the use or operation of the improved ear protectors, a protector may be inserted in the auditory canal of each ear to protect the ears against intense or undesirable sounds or to prevent the entrance of materials into the ears.

When a protector is entered in an ear passage the flanges 12 are bent or flexed toward the external surface of the protector body 10 and the skirt 15 may be contracted to some extent through engagement with the chamber at the mouth of the auditory canal. The flanges 12 seal outwardly against the wall of the auditory canal through their inherent resiliency providing spaced dependable seals without scratching, irritating, or exerting excessive pressure to the walls of the auditory canal. The soft, readily deformed, resilient flanges 12 conform to all irregularities of the auditory canals and each has full and most effective sealing engagement with the walls of the canal throughout its circumference. The lobe-like lower portion of the skirt 15 usually readily cooperates with the lower portion of the chamber in the external ear adjacent the opening of the auditory canal but a slight turning of the protector about its longitudinal axis may in some cases facilitate the complete closure of the canal.

The ear protector described above is a particularly efficient sound insulation unit. The dense metal plug 13 constitutes an efficient inertance element and has a very small acceleration or displacement imparted to it by the force of the incident sound waves, explosion waves, or the like. The wall of the yielding body 10 forms a loose coupling or acoustical compliance. The metal plug 13 and the soft yielding body 10 constructed and combined as described above transmit or communicate only a small fraction of the sound energy that reaches the protector. The inner wall part 11 of the body 10 constitutes an inertance and being formed of a soft yielding material may also act as a compliance. However, in some cases the wall 11 may be of substantial thickness to operate principally as an acoustical inertance. In general the parts 13, 10 and 11 are acoustical elements having inertance, compliance and resistance respectively. By varying the size and mass of the plug 13, the yieldability of the body 10 and the thickness, mass and yieldability of the part 11, the sound transmission and insulating characteristics of the protector may be altered to adapt the device or protector for practically any use. The protector assures a transmission loss or sound insulation of a high rating throughout a wide range of audible frequencies.

Figs. 4 and 5 of the drawing illustrate forms of outer or forward inertances that may be embodied in the protector of the invention. In the construction illustrated in Fig. 4 of the drawing the body 10^a has a forward wall 20 closing the forward end of its opening 14^a. The forward body wall 20 is of substantial thickness and may be of the same material as the body 10^a. In accordance with the invention a space or chamber 21 is provided in the wall 20. The chamber 21 is of substantial depth and is preferably of substantially the same diameter as the opening 14^a. A fluid, semi-fluid or plastic material 22 is contained in the chamber 21. In practice the material 22 is preferably mercury to be highly efficient as an inertance means. The wall 20 may have a knob 23 useful in inserting and removing the protector. The wall 20 may be wholly or partially formed separate from the body 10^a to facilitate the introduction of the material 22 to the chamber 21 or, if desired, the material 22 may be introduced through a small opening which is later closed or sealed. The other parts of the protector illustrated in Fig. 4 may be the same as in the preceding form of the invention.

The protector illustrated in Fig. 4 is used in the same manner as the other forms of the invention. The mercury or material 22 has the same function as the plug 13, that is, it serves as an inertance. The material 22 being liquid does not resist flexure or distortion of the protector and allows the protector to conform to auditory canals of practically any shape and configuration. The liquid material 22 remains fully operative following distortion or flexure of the body 10^a resulting from its insertion in the auditory canal. It will be observed that the liquid material 22 of a high specific gravity is surrounded by and is in direct contact with the soft yielding material of the body wall 20 so that the structure provides the combination of an efficient inertance means contacting and surrounded by compliance.

The form of the invention illustrated in Fig. 5 comprises a plug element 25 arranged in the forward portion of the body opening 14^b. The plug element 25 may be formed of rubber, or the like, that is flexible and resilient but somewhat less yielding than the material of the body 10^b. The plug element 25 may be secured in the body 10^b in any selected manner as by cementing, vulcanizing, etc. In the construction illustrated the plug element 25 has an annular flange or bead 26 set or secured in a groove 27 in the wall of the opening 14^b. The bead 26 may be partially circular in cross section to have interlocking engagement with the groove 27. In accordance with the invention the plug element 25 is hollow, being provided with a cavity or chamber 28. The cavity 28 contains a plastic, fluid or semi-fluid material 29 which serves as an inertance. I prefer to employ mercury as the material 29. The chamber 28 is preferably of substantial diameter and depth to contain a considerable volume of the inertance material 29 although the proportions of the chamber 28 may be varied to suit different applications of the invention. A handle or knob 30 may project outwardly from the plug element 25.

The ear protector shown in Fig. 5 of the drawing embodies a plug element 25 containing or carrying an inertance means that yields to allow flexure and distortion of the protector structure. In some instances the plug element 25 may distort or change its shape when the body 10^b of the protector is positioned in the auditory canal and the material 29 being fluid does not resist this change in configuration but changes its shape with the distortion of the plug element. The novel inertance of the structure shown in Fig. 5 of the drawing offers little or no resistance to change in the shape of the protector so that the protector is safe and comfortable even though distorted to an appreciable extent when in its operative position.

Figs. 6 and 7 of the drawing illustrate inertances arranged in the inner portions of the protector bodies. The inertance means shown in these figures may be embodied in any of the previously described constructions as conditions may require or warrant.

In the construction shown in Fig. 6 the inner part 11^c of the body 10^c is provided with an internal or forwardly projecting knob 32. A rib or flange 33 is provided on the wall of the body opening 14^c in spaced relation to the part 11^c. A body or mass 34 of a plastic material is provided in the inner part of the opening 14^c

and is normally retained in position by the knob 32 and the flange 33. The mass 34 may be any suitable material that is plastic or formable at body temperatures. I have found that a mixture of wax, resin, and turpentine constitutes a suitable material for the mass 34 although such materials as latex, soft rubber, synthetic plastics, etc., may be employed. The mass 34 is introduced to the opening 14c and is pressed in the inner part of the opening to engage about the knob 32 and to engage behind the flange 33. At normal temperatures and at body temperatures the mass 34 is dependably retained in place by the knob and the flange. However, in the event that the material or mass 34 becomes displaced or flows from its normal position the protector may be warmed or heated and arranged in an upright position with its skirt 15 uppermost so that the mass 34 flows back to its operative position. The plastic or semi-plastic mass 34 contained in the inner portion of the body 10c is efficient as an inertance. The mass 34 is formable and yields so that it allows the adjacent portions of the protector to flex and distort when the protector is arranged in place in the auditory canal or passage. When the mass 34 is used in conjunction with the plug 13 or the materials 22 or 29, described above, the protector embodies a particularly effective acoustical network consisting of an outer inertance, an inner inertance and a compliance connecting the two inertances.

The construction shown in Fig. 7 of the drawing includes an inner body part 11d provided with a space or chamber 35. The external configuration of the part 11d may be the same as that of the part 11 described above, and the part 11d may be a continuation of the adjacent parts of the body 10d. The chamber 35 contains a formable or fluid material 36 that serves as an inertance means. The material 36 may be any material of substantial specific gravity that is fluid or plastic to offer little or no resistance to flexure and distortion of the adjacent parts of the protector. In practice the material 36 may be mercury. As shown, the chamber 35 may be of substantially the same diameter as the body opening 14d and may be of substantial depth. The material 36 operates in the same manner as the mass 34 described above constituting an inner inertance means and coupled with the outer inertance by the compliance or yielding body walls. The material 36 may be introduced into the chamber 35 in any practical manner, and the body part 11d may be formed integral with the body 10d, may be in part integral with the body 10d or may be a separately formed unit similar to the plug element 25 of Fig. 5, vulcanized or otherwise secured to the body.

Having described only typical preferred forms and applications of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. An ear protector comprising a body to be inserted in the auditory passage and formed of yielding material, and a liquid inertance element carried by the body.

2. An ear protector comprising a yielding body to be inserted in the auditory passage, and a mass of fluid material of substantial specific gravity in the body forming an inertance.

3. An ear protector comprising a body to be inserted in the auditory passage, and a flexible resilient sealing flange on the body having a convex entering side and a concave trailing side to readily contract toward or against the body through contact with the internal wall of the passage when the body is inserted, the flange being adapted to seal with the said wall through its resiliency.

4. An ear protector comprising a body to be inserted in the auditory passage, and a yielding resilient sealing flange around the body, the trailing and entering sides of the flange sloping laterally and rearwardly relative to the entering end of the body so that the flange contracts through engagement with the internal wall of the passage when the body is inserted, the trailing side of the flange being in outwardly converging relation to said entering side, the flange operating to seal with the wall of the passage through its resiliency when so contracted.

5. An ear protector comprising a body to be inserted in the auditory passage, and a plurality of longitudinally spaced resilient sealing flanges around the body, the forward faces of the flanges sloping laterally and rearwardly relative to the entering end of the body so that the flanges contract through engagement with the internal wall of the passage and seal with the wall of the passage through their resiliency, the rear faces of the flanges being concave to render the flanges more yielding.

6. An ear protector comprising a yielding hollow body to be inserted in the auditory passage to form an acoustical compliance, a liquid mass of substantial specific gravity contained in one end portion of the body forming an inertance, and means retaining said mass in said end portion of the body and allowing flexure and distortion of the body.

7. An ear protector comprising a yielding body to be inserted in the auditory passage to form an acoustical compliance, the body having a longitudinal cavity, an inertance means at the outer end of the cavity, a wall across the inner end of the cavity, a dense inertance carried by said wall, and a sealing flange on the inner portion of the body forming a continuation of said wall and flaring rearwardly relative to the entering end of the body to contract through contact with the wall of the passage.

8. An ear protector comprising a yielding body to be inserted in the auditory passage to form a compliance unit, the body having a longitudinal opening, a yielding plug closing an end of the opening and having a closed chamber, and fluid of high specific gravity in the chamber forming an inertance.

9. An ear protector comprising a yielding body to be inserted in the auditory passage to form an acoustical compliance, the body having a longitudinal cavity, an inertance means at the outer end of the cavity comprising a metal plug in the outer end of the cavity, a yielding wall spaced inwardly from the plug for closing the inner end of the cavity forming an inertance and presenting a convex external surface at the inner end of the body, and a flaring yielding flange on the inner portion of the body for sealing with the wall of the passage, the surface of the flange forming an even continuation of the first named surface.

10. An ear protector comprising a yielding body adapted to be inserted in the auditory passage to form an acoustical compliance, the body having substantially longitudinally aligned cavities,

and fluid material in at least one of the cavities forming an inertance.

11. An ear protector comprising a yielding body adapted to be inserted in the auditory passage to form an acoustical compliance, the body having substantially longitudinally aligned cavities, and mercury in one of said cavities forming an inertance.

12. An ear protector comprising a yielding body adapted to be inserted in the auditory passage to form an acoustical compliance, the body having an inner longitudinal cavity and an outer cavity, and a dense fluid material in the outer cavity forming an inertance.

13. An ear protector comprising a yielding body adapted to be inserted in the auditory passage to form an acoustical compliance, the body having aligned inner and outer cavities, and a dense fluid material in the inner cavity forming an inertance.

14. An ear protector comprising a yielding body adapted to be inserted in the auditory passage to form an acoustical compliance, the body being hollow and provided with spaced transverse yielding walls dividing its interior into closed cavities, and a fluid of high specific gravity in at least one of the cavities forming an inertance.

15. An ear protector comprising a yielding hollow body to be inserted in the auditory passage to form a compliance unit, a mass contained in one end of the hollow body comprised of a material which is fluid at body temperature, and means for retaining said mass in said end of the body comprising a projection on the interior of the body extending into said mass.

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