Oct. 27, 1970 J. A. AILEO 3,535,710

SOUND-ATTENUATING EARCUP AND HELMET CONTAINING SAME

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Fig. 1.

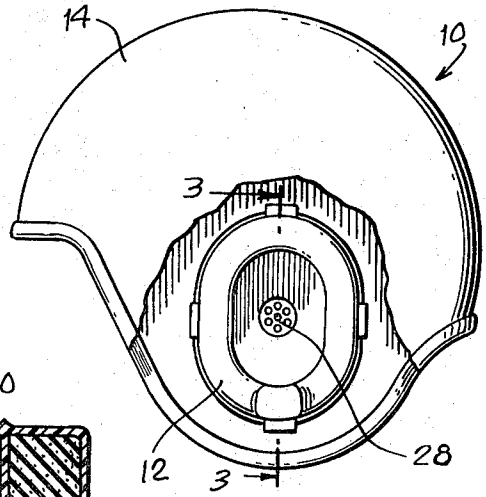


Fig. 3.

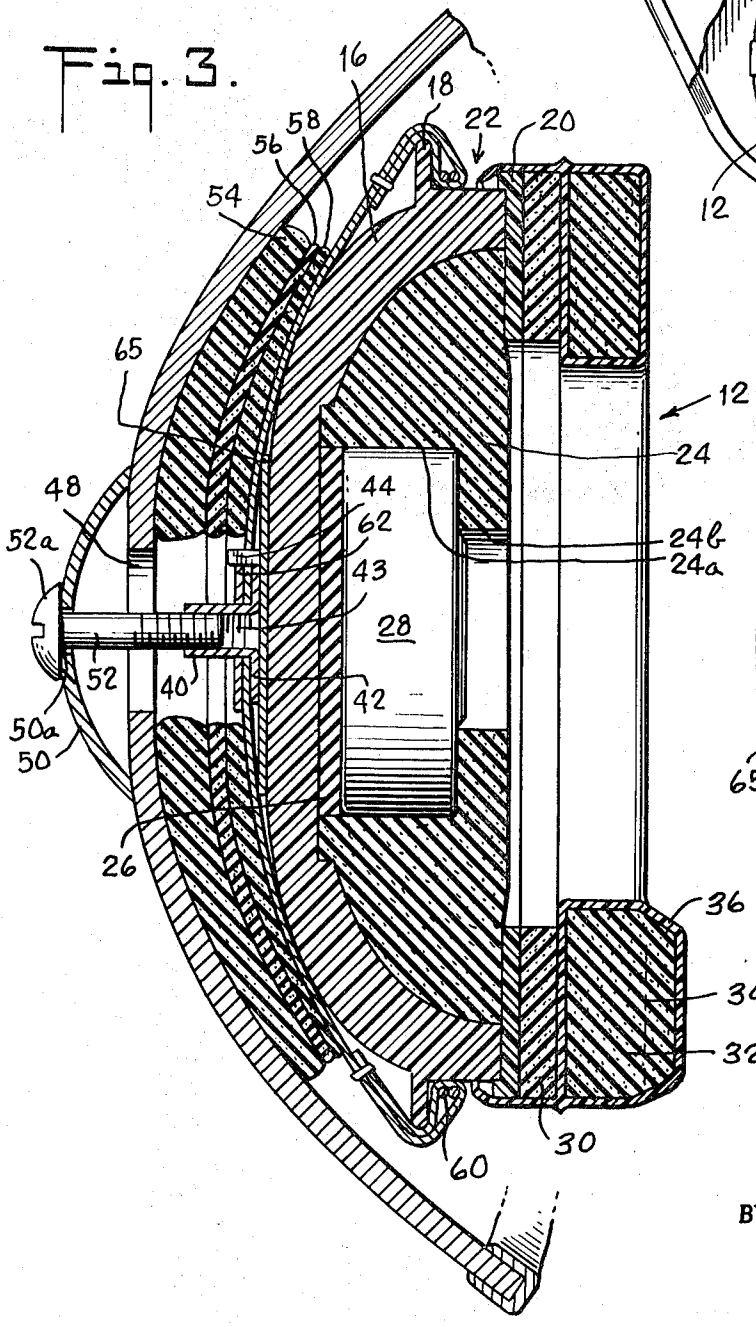
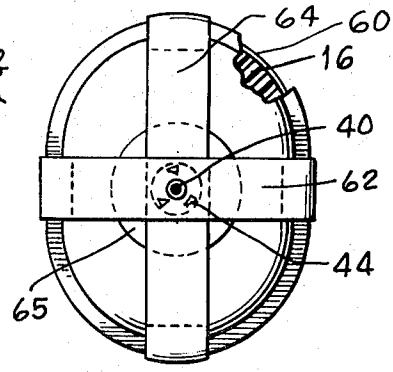


Fig. 2.



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SOUND-ATTENUATING EARCUP AND HELMET CONTAINING SAME

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Fig. 4.

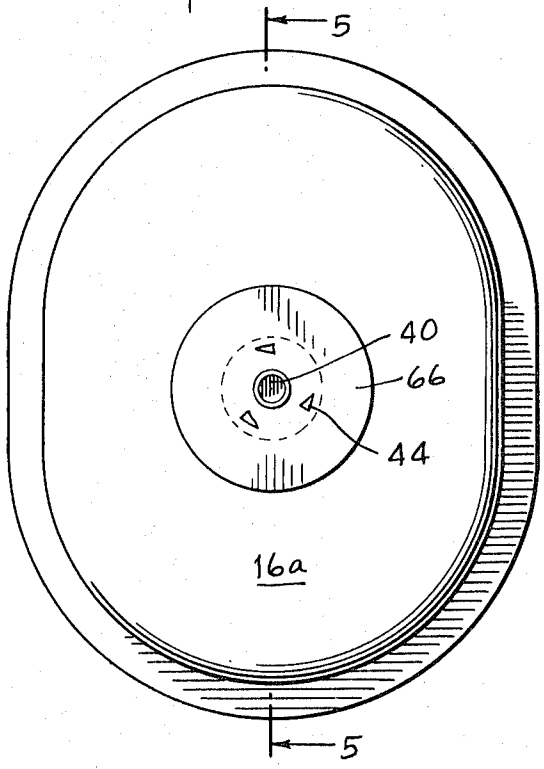


Fig. 5.

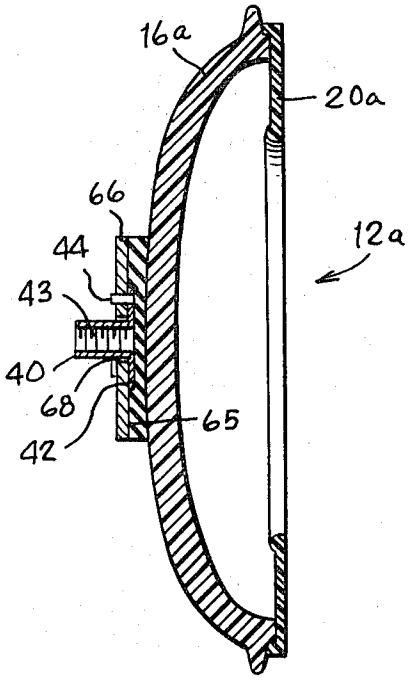


Fig. 6.

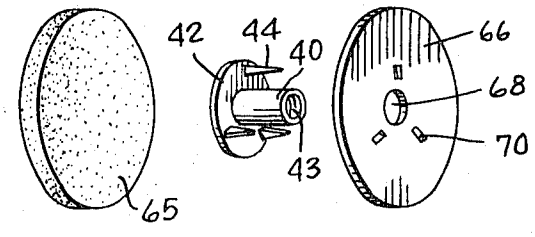


Fig. 7.

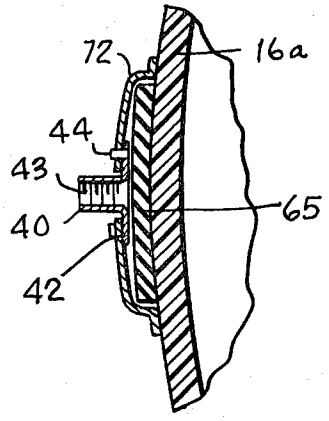
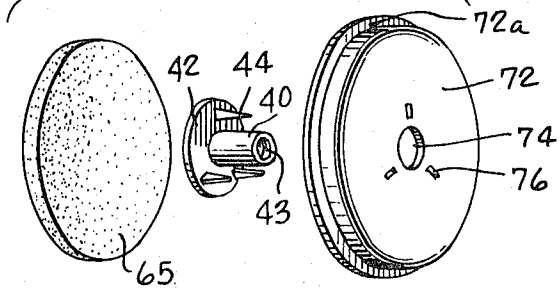


Fig. 8.



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Fig. 10.

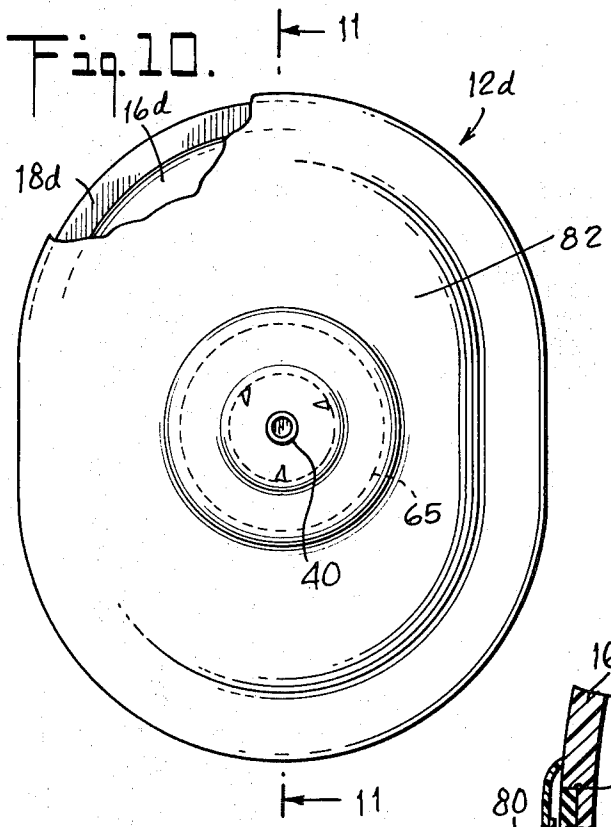
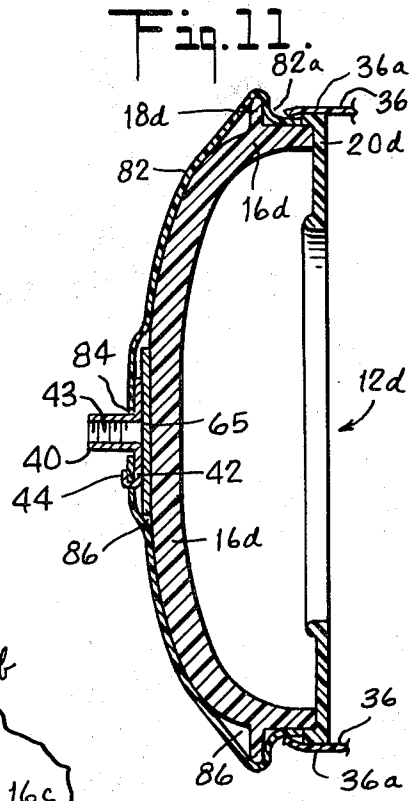


Fig. 11.



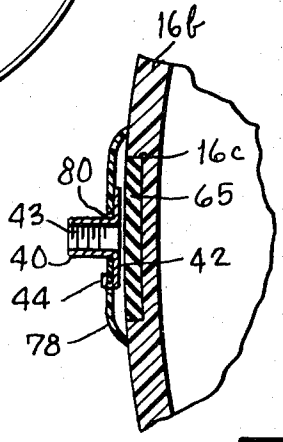


Fig. 9.

Fig. 12.

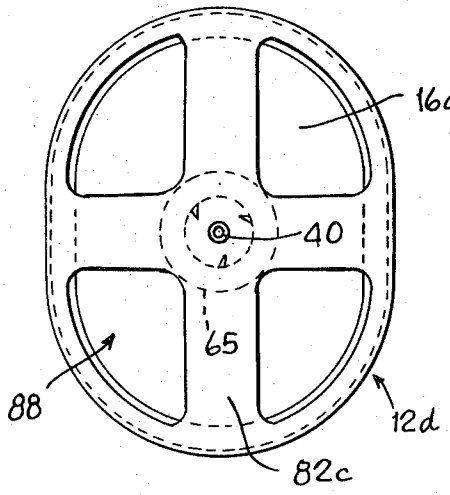
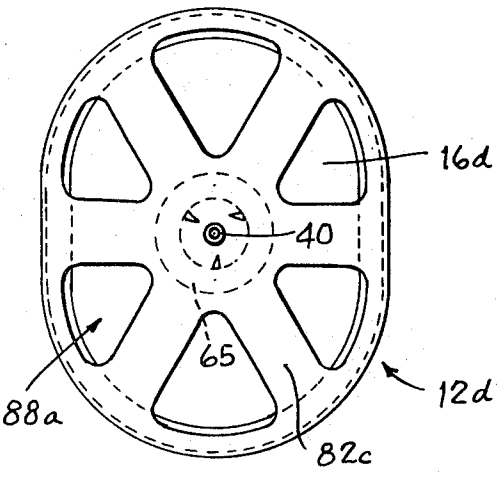


Fig. 13.



United States Patent Office 3,535,710 Patented Oct. 27, 1970

3,535,710

SOUND-ATTENUATING EARCUP AND HELMET CONTAINING SAME

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Continuation-in-part of application Ser. No. 637,148, May 9, 1967. This application Jan. 10, 1969, Ser. No. 790,423

Int. Cl. A41d 21/00

U.S. Cl. 2—209 21 Claims

ABSTRACT OF THE DISCLOSURE

Structure for attaching a sound attenuating earcup to a rigid helmet shell, including a threaded stud associated with a rigid outer wall of the earcup, a sound-attenuating gasket located between the stud and the earcup for insulating the earcup against sound or other vibrations transmitted through the stud, and a retaining member for holding the stud on the outer wall of the earcup. A threaded screw projects inwardly through an aperture in the rigid shell and engages the threaded stud to hold the earcup in position within the helmet shell.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of applicant's copending application, Ser. No. 637,148, filed May 9, 1967, now Pat. No. 3,456,263, for Rigid Shell Helmet With Earcup.

BACKGROUND OF INVENTION

The present invention relates to helmets with sound-attenuating earcups and, in particular, to structures for mounting rigid earcups on a rigid helmet shell or like head-engaging support. Helmets having such earcups may be used by persons employed in occupations requiring not only protection of the head against impacts but also protection of the ears against potentially damaging levels of ambient noise and/or shielding of the ears against ambient noise to permit reception of voice communication through earphones mounted in the earcups.

Various arrangements are known for connecting rigid sound-attenuating earcups to a rigid shell helmet, in such manner as to permit positional adjustment of the earcups in relation to the helmet, as desired for comfort of the wearer. However, the means for adjusting the earcups in these known structures is usually complex and the means for mounting the earcups to the helmet frequently creates stress in the rigid outer wall of the earcup by permitting transmission of waves emanating from loads and vibrations on the rigid shell. If the mounting means is allowed to transmit vibrations, sound attenuation by the earcups will be hindered (i.e. by transmission of sound vibrations through the mounting means to the earcups) and fatigue may be created in the earcup outer wall. Thus a simple mounting is desirable which insulates the earcup from sound or other vibrations while permitting ready translational and rotational adjustment of the earcup relative to the helmet.

In applicant's aforementioned copending application there is shown a construction for mounting a rigid earcup to a rigid helmet shell, including a stud held against the earcup outer wall by means of crossed flexible straps which extend over the earcup outer wall and are secured at their ends to a cord or like band embracing the periphery of the earcup. The stud has a head disposed in facing relation to the earcup outer wall, and an internally threaded

shank which projects outwardly through a pair of coincident apertures respectively formed in the crossed portions of the two straps, the stud and straps interengaging in such manner that the stud is held fixed in relation to the straps. In the adjacent side portion of the helmet shell is an aperture substantially larger in diameter than the diameter of the stud. A dished washer is located on the outside of the helmet, extending over the helmet aperture, and a threaded screw projects inwardly through the washer to engage the threaded stud; thus the screw provides an anchorage between the earcup and the helmet shell. Compressible pads (containing apertures to accommodate the screw stud) are interposed between the earcup outer wall and the shell to absorb vibrations and sound waves.

The described construction permits limited translational as well as rotational adjustment of the earcup relative to the helmet shell, owing to the fact that the helmet aperture is large enough to afford a substantial range of positions for the screw and stud extending therethrough, while the dished washer maintains secure connection of the screw to the helmet in all of these positions. At the same time, the pads interposed between the earcup and helmet serve to insulate the earcup against sound transmitted through the helmet shell, and the mounting of the stud on flexible straps rather than directly on the earcup contributes further to this end. However, if the head of the rigid stud is permitted to impinge against the rigid earcup wall, such contact provides a path for transmission of sound or other vibrations to the earcup, i.e. from the helmet shell successively through the washer, screw and stud, all of which are essentially rigid elements transmissive to sound; therefore, direct contact between the stud and earcup impairs desired isolation of the earcup external vibrations.

SUMMARY OF THE INVENTION

The present invention broadly contemplates an improvement in a sound-attenuating earcup including a rigid earcup shell having a doomed outer surface; a stud having a shank interengageable with fastening means for holding the stud in fixed relation to a helmet, and an enlarged head formed at one end of the shank, disposed at a central locality of the earcup outer surface with the stud head facing the shell and the shank projecting outwardly therefrom; and a retaining member extending over the outwardly facing surface of the head and having an aperture through which the shank projects, fixedly engaging the stud and mounted in fixed relation to the earcup. Earcups having the foregoing structure are disclosed in the aforementioned copending application, as discussed above. Specifically, the improvement of the present invention comprises the provision of a gasket of sound-deadening material interposed between the stud head and earcup outer surface and mounted in fixed relation to the earcup outer surface, for insulating the earcup from vibration transmitted by the stud. Through the use of this gasket, the earcup may be essentially completely isolated from contact with any external, rigid, vibration-transmissive element yet the advantages of a mounting including the stud, with respect to adjustable positioning of the earcup and secure connection of the earcup to a helmet, are still achieved.

The stud may (for example) have an internally threaded shank for engagement with a screw, as described in the aforementioned copending application. In one embodiment of the invention, the flexible crossed retaining straps described in applicant's copending application may constitute the retaining means, and may be arranged to hold the stud in the same manner as therein shown, the gasket of the present invention being secured (e.g. cemented) to the earcup beneath the stud head.

In other embodiments of the invention, the retaining means may be a disc-shaped plate, e.g. fabricated of a rigid plastic, and secured either directly to the earcup shell (with a dished central portion to accommodate the gasket. which may be located either on the doomed outer wall of of the earcup shell or within a recess in that wall) or, preferably, secured as by cementing to the gasket which in turn is secured as by cementing to the earcup shell. Preferably, in the last-mentioned embodiment the gasket is a disc-shaped body of elastomeric sound-deadening material characterized by high shear strength. This arrangement provides, in an advantageously simple and economic structure, complete isolation of the earcup from any external rigid vibration-transmitting element. The retaining member may also be a cup-shaped flexible plastic shield which extends entirely over the doomed outer wall of the earcup shell and is removably secured thereto, a gap or air space being formed between the shield and the shell and serving further to attenuate sound, and the shield being either continuous or having apertures therein so as to structurally resemble flexible crossed retaining straps.

The invention further contemplates the provision of a rigid shell helmet, including an earcup having mounting structures as described above with a sound-deadening gasket interposed between the stud and cup, wherein the helmet shell has an enlarged aperture in its side portion, through which a screw projects for engagement with the stud, the screw being mounted in a dished washer that extends over the helmet shell aperture. The arrangement of the helmet, screw and washer may be as shown in the aforementioned copending application and, as further shown therein, compressible pads may be interposed between the earcup and helmet shell to insulate the earcup from sound and other vibrations transmitted by the shell.

BRIEF DECRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view, partly broken away, of a rigid safety helmet having an earcup embodying the present invention in a particular form;

FIG. 2 is an elevational view, partly broken away, of the earcup of FIG. 1, and the portion of the helmet to which it is secured;

FIG. 2 is an enlarged cross-sectional view taken along the line 3—3 of FIG. 1;

FIG. 4 is an elevational view of another embodiment of the earcup structure of the invention;

FIG. 5 is a cross-sectional view taken along the line 5—5 of FIG. 4;

FIG. 6 is an exploded perspective view of the mounting structure of the earcup of FIG. 4;

FIG. 7 is a partial sectional view of a further embodiment of the invention;

FIG. 8 is an exploded perspective view of the mounting structure of the embodiment of FIG. 7;

FIG. 9 is a partial sectional view of still a further embodiment of the invention;

FIG. 10 is an elevational view of still another embodiment of the invention;

FIG. 11 is a cross-sectional view taken along the line 11—11 of FIG. 10.

FIG. 12 is an elevational view of another embodiment of the invention similar to FIG. 10; and

FIG. 13 is an elevational view of still another embodiment of the invention similar to FIGS. 10 and 12.

DETAILED DESCRIPTION

Referring first to FIGS. 1–3, there is shown a helmet **10** (FIG. 1) having mounted therein, adjacent to the inner walls of opposite side portions of the helmet, a pair of sound-attenuating earcups, one such earcup being shown at **12**. The helmet **10** comprises a rigid shell **14** fabricated of a suitable conventional material, such as a plastic, and shaped to receive the head of a wearer, with depending side portions for covering the wearer's ears.

Within the helmet there may be mounted a rigging (not shown, but e.g. conventional in form) for supporting the shell in spaced relation to the wearer's head. The shell, with its rigging, serves to protect the wearer's head against impacts or blows.

The construction of the earcups **12** and the structure for mounting the earcup to the rigid shell **14** are shown in FIGS. 2 and 3. Each earcup **12** comprises a rigid earcup shell **16** (e.g., of a high-impact, stryene type, thermoplastic resin, such as that commercially available under the trademark "Cycolac") defining a space for enclosing an ear of the wearer, and having a domed outer wall, with an elliptically annular rim. Adjacent to the shell rim is an outwardly extending annular flange **18**, formed integrally with the shell. A second elliptically annular flange **20**, bonded to the shell rim and positioned to surround the wearer's ear, extends both inwardly and outwardly of the earcup shell wall; the inwardly projecting portion of flange **20** defines a generally elliptical opening into the interior of the earcup **12**, for receiving the wearer's ear, while the outward projection of the flange **20** cooperates with the flange portion **18** to define a groove **22** surrounding the earcup rim.

A cushion body **24**, conforming in shape to the interior of the earcup shell **16**, is disposed within the earcup and held in place by the inward projection of flange **20**. Centrally located within cushion body **24** is a generally cylindrical cavity **24***a* which opens toward the wearer's ear through a smaller cylindrical passage **24***b* in the cushion body **24**. A circular pad **26**, located within the cavity **24***a* and positioned against the interior domed surface of the earcup shell, cooperates with the cushion body **24** to form a cushioned nest holding an earphone or the like communications device **28**, from which sound may pass to the wearer's ear through the passage **24***b*. As will be understood, in the illustrated embodiment the earcup **12** serves not only to protect the wearer's ear from damage that might otherwise result from exposure to excessively high ambient noise levels, but also to enable the wearer to receive communications through the earphone **28**, by effectively shutting out ambient noise that might interfere with such communication even if not sufficiently intense to cause actual damage to the ear. If the earphone **28** is omitted, the earcup nevertheless functions to shield the wearer's ear from annoying and/or damaging ambient noise.

A relatively thin elliptically annular cushion **30**, conforming in shape to the flange **20**, is secured to the surface of that flange facing the wearer's head. Detachably secured over the second annular flange **20** and against the annular cushion **30** is an elliptically annular sound-attenuating seal **32**, which engages the wearer's head in the area surrounding the ear to prevent passage of sound between the earcup and head and also to provide a comfortable seat for the earcup against the wearer's head. This seal **32** comprises a resilient compressible pad **34**, e.g. fabricated from sponge rubber, sponge plastic, or the like, covered with a layer **36** of flexible plastic film material.

The mounting structure of the earcup **12** includes a stud **40**, which has a flat, disc-shaped head portion **42** and an internally threaded shank **43** projecting perpendicularly from the center of one surface of head portion **42**. Located eccentrically on the head portion **42** are a plurality of pointed spurs or prongs **44**, projecting from the same surface of the head portion, and in the same direction, as the internally threaded shank **43**. The stud is disposed at a central locality of the domed outer wall of the earcup shell **16** with head portion **42** facing the earcup wall and shank **43** projecting outwardly therefrom, i.e. away from the earcup. The stud is secured to the earcup in this position by means hereinafter described.

Located on the side portion of the helmet shell **14** is an aperture **48**, positioned for register with the shank **43** of stud **40**, i.e. so that when the helmet is on the wearer's head with the earcup enclosing his ear, the stud shank projects toward this aperture. The aperture **48** is very

substantially larger in diameter than the stud shank **43**. A concave dished washer **50**, larger in diameter than aperture **48** and itself having a centrally located aperture **50***a*, is located on the outside of the helmet shell **14** and extends over the aperture **48** with the concave side of the washer facing the helmet and its edge engaging the exterior helmet shell surface in surrounding relation to the aperture.

An externally threaded screw **52**, having a head **52***a* larger than the washer aperture **50***a* projects inwardly through aperture **50***a* of the washer **50** and through the aperture **48** in the helmet shell **14**, the screw head portion **52***a* bearing against the outer surface of the washer **50**. The shank of screw **52** threadedly engages the internally threaded stud shank **43** to hold the earcup **12** securely in a selected position within the helmet shell, as hereinafter further explained.

While the illustrated stud shank **43** and screw **52** are respectively internally and externally threaded, as exemplary of interengaging fastening elements, it will be appreciated that the shank **43** may be replaced with an externally threaded shank, and that the screw **52** may correspondingly be replaced with a fastening element comprising a head and a shank having an internally threaded bore for engaging such externally threaded stud shank. Also, the shank **43** and the fastening element exemplified by screw **52** may be arranged to interengage in some alternative manner, i.e. other than threaded engagement, providing a secure, fixed fastening connection.

Between the earcup **12** and the helmet shell **14** are disposed a plurality of compressible pads, e.g. a thick pad **54** and a pair of thin pads **56**, **58**, each fabricated from a suitable sponge plastic, and each having a central aperture corresponding in diameter to the helmet shell aperture **48** for accommodating the stud shank **43** and the screw **52**. The pads **54**, **56**, **58** are compressed between the earcup and the helmet shell and aid in supporting the earcup securely while insulating the earcup against sound or other vibrations transmitted through the helmet shell.

In the embodiment of the earcup mounting structure shown in FIGS. 2 and 3, the retaining member for holding the stud **40** on the earcup comprises a pair of flexible straps **62**, **64** preferably formed of a high tensile strength material (e.g. braided nylon), which extend over the domed outer wall of the earcup shell **16** in crossed relation to each other, as best seen in FIG. 2. The crossed portions of the two straps **62** and **64** (positioned at a central locality on the earcup outer wall) have coincident apertures through which the shank **43** of stud **40** projects outwardly, the stud head **42** being disposed between the straps and the domed earcup wall. The prongs **44** projecting from the stud head **42** extend outwardly through small slots or openings in the crossed portions of straps **62**, **64** and their ends are turned over to fasten the head portion **42** and the crossed portion of the straps together, thereby securing the stud against rotation (about the axis of shank **43**) relative to the straps, i.e. to prevent the stud **40** from rotating when the screw **52** is being threaded in the shank. Glue may also be employed to further secure the straps **62**, **64** and the stud **40**.

A cord **60** encircles the earcup shell **16** within the annular groove **22**, the cord being fabricated of a high tensile strength material, e.g. braided nylon, and being tightly secured within the groove **22**. Each end of each retaining strap **62**, **64** is secured to the cord **60**, for example by looping each strap end about the cord and sewing the looped ends, so that the straps are held under tension against the domed earcup wall. In this way, a stable and secure mounting is provided for the stud **40** on the earcup shell.

Since the stud is securely held on the earcup shell **16** by the straps, threaded engagement of the screw **52** with the stud shank **43** tends to pull the earcup outwardly toward the helmet shell and against the pads **54**, **56** and **58**, which causes the dished washer **50** to bear against the outer surface of the helmet shell, thus holding the earcup clamped in place. Owing to the relatively larger diameter of the helmet shell aperture **48**, the earcup may be adjusted in position by translational movement, i.e. by loosening the screw **52**, shifting the earcup as desired (thus changing the location of the screw and stud shank within the large aperture **48**), and retightening the screw when the earcup is in the selected new position. Also, the earcup may be rotated again by loosening the screw **52**, turning the earcup to the desired angular orientation, and retightening the screw. Further, the distance between the earcup and the helmet may be adjusted, by tightening or loosening the screw **52** to vary the degree of compression of the stack of pads **54**, **56**, **58**, and/or by adding pads to or removing pads from the stack. This three-way adjustability of the earcup relative to the helmet enables precise positioning of the earcup for optimum comfort and snugness of fit on the head of the individual wearer.

The foregoing arrangement of the earcup, helmet and means for mounting the earcup on the helmet is disclosed in the aforementioned copending application. As a particular feature of the present invention, in combination with the above-described structures there is provided a gasket **65** of sound-deadening material, which is interposed between the stud head **42** and the outer domed wall of the earcup shell **16**. In the form shown, the gasket **65** is an essentially disc-shaped (i.e. circular) pad of relatively soft material, e.g. chamois, which may be glued or cemented to the domed outer wall of the earcup shell at a central locality therein so as to be engaged by the stud head. The gasket may alternatively be formed of other sound deadening material such as leather of various types or foam plastic. Preferably, the gasket is substantially larger in diameter than the stud head **42**.

Since the domed wall of the earcup shell curves outwardly to an apex at this central locality, the tension in the straps **62** and **64** serves to drive the stud head **42** against the gasket **65**, so that the stud **40** is very securely located and has no degrees of freedom. The gasket isolates the rigid earcup shell from direct contact with the rigid stud **40**, so as to insulate the earcup from sound or other vibrations transmitted by the stud and thereby to enhance the sound-attenuating effect of the earcup and mounting structure.

In FIGS. 4–6, there is shown a modified embodiment of the invention including a sound-attenuating earcup **12***a* with a rigid shell **16***a* generally similar to the shell **16** of the structure of FIGS. 1–3, i.e. having a domed outer wall and an elliptically annular rim which bears an inwardly projecting flange **20***a* corresponding to the flange **20** of FIGS. 1–3. Flange **20***a* defines a generally elliptical opening for receiving a wearer's ear, and may support a resilient elliptically annular seal (not shown) for engaging the wearer's head.

The stud **40**, which may have the construction already described, is positioned (as before) at a central locality of the domed outer wall of the earcup shell, with the stud head **42** facing the earcup, and the internally threaded shank **43** and prongs **44** projecting perpendicularly outward therefrom. The sound-attenuating gasket **65**, which again is disc-shaped and substantially larger in diameter than the stud head, has one major surface securely cemented or otherwise bonded to the central portion of the outer domed earcup wall; the stud head **42** bears against the central portion of the other (outwardly facing) major surface of the gasket.

In place of the retaining straps **62** and **64** of the embodiments of FIGS. 1–3, there is provided a more or less rigid disc-shaped retaining plate **66**, e.g. fabricated of a suitable plastic, having the same diameter as the gasket **65**. The retaining plate **66** engages the outwardly facing surface of the stud head **42**; the shank **43** projects outwardly through a central aperture **68** in the plate **66**, while the prongs **44** project through small eccentrically disposed

slots **70** in the plate and have their outer ends bent over to secure the stud to the plate. This engagement of the prongs with plate **66** prevents rotation or other movement of the stud relative to the plate.

The central plate aperture **68** may be made somewhat larger in diameter than the outer diameter of the shank **43**, so that there is clearance between the edge of aperture **68** and the shank, which is concentrically positioned therein. Thus there is no sound-transmitting contact between the shank and the retaining plate, only the head and prongs of the stud being in direct contact with the plate.

Plate **66** is mounted on and securely cemented to the outwardly facing major surface of the gasket **65**. As shown in FIG. 5, the gasket is sufficiently compressible so that the central portion of its outer surface is depressed by the stud head, permitting flush engagement between the annular peripheral portion of the gasket outer surface (beyond the stud head) and the corresponding annular peripheral portion of the inwardly facing surface of plate **66**, i.e. affording a continuous annular contact surface between the plate and gasket, surrounding the stud head, for cementing or other bonding of the plate to the gasket. In this way, there is provided a structurally simple, yet effective and secure mounting for the stud, and the earcup shell is completely isolated by the gasket **65** both from the stud and from the rigid retaining plate **66** that holds the stud. Transmission of sound or other vibrations through the stud to the earcup is thereby advantageously minimized.

Very preferably, the gasket **65** is in the embodiment of FIGS. 4–6 is fabricated of an elastomer of relatively high density, characterized by good sound-attenuating properties and also (since it provides the structural connection between the stud and the earcup) by high shear strength. One example of a material meeting these requirements and particularly satisfactory for the gasket **65** is polyvinylchloride foam. By way of illustration, the gasket may be a disc of polyvinylchloride foam about one-eighth inch thick. An example of a type of adherent bonding suitable for securing the gasket to the earcup shell (i.e. as an alternative to cementing the gasket to the shell) is solvent bonding, wherein a solvent for the gasket and earcup shell, such as a ketone, is placed on the facing surfaces of the gasket and shell to effect some degree of softening or solution of the material at these surfaces, the surfaces being then pressed together and permitted to resolidify to form a bond. This solvent-bonding technique may also be used to bond the retaining plate **66** to the gasket.

The earcup **12***a* of FIGS. 4–6 may be mounted on a rigid helmet shell in the same manner as shown in FIGS. 1 and 3, i.e. by means of a screw **52** engaging and extending inwardly from a dished washer **50** through a relatively large aperture **48** in the helmet shell to threadedly engage the stud shank **43**; compressible pads **54**, **56**, **58** may be interposed between the earcup and helmet, also as shown in FIG. 3.

The embodiment of the invention illustrated in FIGS. 7 and 8 again includes a rigid earcup shell **16***a*, a disc-shaped sound-attenuating gasket **65**, the stud **40** (having the same form as already described), and a rigid disc-shaped retaining plate for holding the stud. The retaining plate of FIGS. 7 and 8, which is designated by reference numeral **72** and may be fabricated e.g. of a suitable plastic, is somewhat larger in diameter than the gasket **65** and is dished. The stud head **42** is received within the concave side of the dished retaining plate; the shank **43** projects outwardly through a central circular aperture **74** (preferably larger in diameter than the external diameter of the shank) and the prongs **44** project outwardly through slots **76** in the retaining plate, the ends of these prongs being bent over as before to hold the stud in fixed position relative to the retaining plate. As shown, the concave side of the retaining plate faces the earcup shell **16***a*, and the edge of the plate is bent to form an annular

flange **72***a* which engages the earcup shell surface at a central locality in the domed outer wall of the shell. Flange **72***a* is ultrasonically sealed or otherwise bonded, e.g. by a solvent bonding technique as described above, to the earcup shell so as to hold the retaining plate **72** (and thus to hold the stud **40**) securely in fixed position relative to the earcup. Gasket **65** is received within the concave space defined between the earcup shell and the retaining plate **72**, and may be cemented or otherwise bonded to the shell surface and/or to the retaining plate. The gasket may be fabricated of a material such as leather or of an elastomer such as polyvinylchloride foam. Once again, the gasket **65** constitutes a sound-attenuating layer interposed between the stud **40** and the earcup shell, for minimizing transmission of sound or other vibrations from the stud to the shell.

In FIG. 9, there is shown an embodiment of the invention similar to that illustrated in FIGS. 7 and 8, including a rigid earcup shell **16***b*, a sound-attenuating gasket **65**, a stud **40**, and a rigid dished, disc-shaped stud-retaining plate **78**, which may be fabricated of a suitable plastic and which should be larger in diameter than the gasket **65**. Again the stud head **42** is disposed within the concave portion of the retaining plate **78** and is secured thereto by prongs **44** which project outwardly through slots in the retaining plate, the ends of the prongs being bent over so as to hold the stud in fixed position relative to the retaining plate; the shank **43** of the stud **40** projects outwardly through a central circular aperture **80** (preferably larger in diameter than the external diameter of the shank) in the retaining plate **78**. The annular end of the retaining plate engages the earcup shell surface at a central locality in the domed outer wall of the shell and is secured thereto by ultrasonic sealing, solvent bonding (e.g. using a ketone, as described above), or like means so that the retaining plate **78** is held in fixed position relative to the earcup. In this modification, the sound attenuating gasket **65** is located within a recess **16***c* formed in the outer surface of the domed wall of the earcup shell and may be cemented or otherwise bonded to the earcup shell. Again the gasket **65** may be fabricated of a flexible material such as leather or polyvinylchloride foam.

The embodiment of the invention shown in FIGS. 10–13 includes a sound-attenuating earcup **12***d* with a rigid shell **16***d*, generally similar to the shell **16** of the embodiment of FIGS. 1–3, and an outwardly extending annular flange **18***d* formed integrally with the shell. The stud **40** is positioned (as before) at a central locality of the domed outer wall of the earcup shell **16***d*, with the stud head **42** facing the earcup, and the shank **43** and prongs **44** projecting outwardly therefrom. Again a disc-shaped, sound-attenuating gasket **65**, fabricated, e.g., of leather, polyvinylchloride foam, or other suitable material, and substantially larger in diameter than the stud head **42**, is interposed between the earcup domed outer wall and the stud head **42**.

Instead of retaining straps (FIGS. 1–3) or a retaining plate (FIGS. 4–9), there is provided a flexible cup-shaped retaining shield **82**, e.g. molded in one piece from a suitable plastic, which extends substantially continuously over the entirety of the domed outer wall of the earcup shell **16***d* for retaining the stud **40** in position on the domed outer wall. The periphery of the retaining shield **82** is turned inwardly to form an elliptically annular flange **82***a*; shield **82** is detachably fastened to the earcup shell, without bonding, by means of annular flange **82***a*, which is fitted over the annular flange **18***d* of the earcup shell and grippingly engages flange **18***a*. Very preferably, the interengaging flanges **18***a* and **82***a* constiute the sole attachment of the shield to the earcup shell; i.e. there is no adhesive or other surface-to-surface bonding between the shell and shield. The retaining shield **82** contains a central aperture **84** (preferably somewhat larger in diameter than the outer diameter of the shank **43** of the stud **40**), through which the shank **43** projects outwardly so that the

shield engages the outwardly facing surface of the stud head **42**, the head **42** being secured thereto by means of the prongs **44**, which extend through the shield and have their ends bent over to prevent movement of the stud **40** relative to the shield. In this way, there is again provided a structurally simple, yet effective and secure mounting for the stud **40**, wherein the stud is isolated by the gasket **65** from the earcup shell **16***d*.

The material of which shield **82** is made is ordinarily or preferably somewhat softer and more sound-absorbent than the relatively hard and high density material (e.g. "Cycolac" styrene-type resin) of which the earcup shell is made. One example of a suitable material for the shield **82** is polyethylene. The shield thus constitutes an outer sound-deadening barrier or layer extending over the exterior of the earcup, and contributes to the desired sound-attenuating function of the earcup. Moreover, in use of a continuous flexible retaining shield which extends entirely about the surface of the domed outer wall of the earcup shell **16***d* and which is capable of accommodating itself thereto, a space or air gap **86** is defined between the shield and the earcup shell, as best seen in FIG. 11. This space **86** augments the sound-attenuating effect of the earcup. If desired, a layer of sound absorbing material, such as a silicone, a textile, an elastomeric foam, or the like (not shown), may be interposed between the earcup shell and shield **82** to provide further sound attenuation. While the shield **82** is shown as arranged to serve as a retaining member in combination with a stud **40** and gasket **65**, the shield also has utility to enhance the sound-attenuating properties of an earcup in structures wherein the earcup is secured to a helmet by means other than a threaded stud.

As in the case of the embodiments previously described, a rigid, inwardly projecting annular flange **20***d* is bonded to the rim of the earcup shell **16***d*, and may support a resilient sound-attenuating annular seal similar to the seal **32** shown in FIG. 3, for engaging the head of a wearer. The flange **82***a* of shield **82** preferably extends to the outer edge of flange **20***d*, in generally conforming relation to the portion of earcup **16***d* between flange **18***d* and flange **20***d*. Preferably, also, there is provided an outwardly extending annular flap **36***a* of the flexible film layer of the aforementioned annular seal, this flap **36***a* projecting beyond the outer edge of flange **20***d* so as to surround the periphery of shell **16***d* and to overlie flange **82***a* of shield **82**, thereby cooperating with flange **82***a* to provide sound-attenuating enclosure for the earcup adjacent to flange **20***d*.

Although the retaining shield **82** is preferably a continuous, cup-shaped member extending uninterrupted over the earcup shell outer surface (as shown in FIG. 11), a retaining shield **82***c* (as shown in FIG. 12) may be employed having a plurality of relatively large apertures **88** so arranged that the shield structurally resembles the flexible retaining straps of the embodiment of FIGS. 1–3. A shield having a larger number of smaller apertures **88***a* may also be used (as shown in FIG. 13), wherein the shield will appear to have three or more crossed flexible retaining straps. However, if a retaining shield **82***c* with a plurality of apertures **88** or **88***a* is utilized, the shield will not provide an additional barrier to sound transmission (as is the case when the shield is continuous), although it will still provide a desirable means for retaining the stud **40** on the earcup shell **16***d* in such manner that sound is not transmitted between the stud and the earcup shell.

I claim:

1. A sound-attenuating earcup including:

(a) a rigid earcup shell having a domed outer surface;

(b) a stud having a shank interengageable with fastening means for holding said stud in fixed relation to a helmet, and an enlarged head formed in one end of the shank, disposed at a central locality of said shell outer surface with said head facing the shell and said shank projecting outwardly therefrom; and

(c) a retaining member extending over the outwardly facing surface of said head, said shank projecting outwardly beyond said retaining member, said retaining member fixedly holding said stud and mounted in fixed relation to said shell;

wherein the improvement comprises:

(d) a gasket of sound-deadening material interposed between said head and said shell outer surface and mounted in fixed relation to said shell outer surface for insulating said shell from vibrations transmitted by said stud.

2. An earcup as defined in claim **1**, wherein said stud shank is a threaded member, wherein said stud head bears a plurality of centrally disposed prongs projecting outwardly through said retaining member for holding said stud against rotation about the shank axis relative to said retaining member, and wherein said retaining member comprises a pair of crossed straps each extending substantially diametrically across said shell outer surface, and includes means positioned adjacent to the periphery of said shell for holding the ends of the straps fixed in relation to the shell, said straps having coincident apertures located in their respective crossed portions, said shank projecting outwardly through said coincident apertures.

3. An earcup as defined in claim **2**, wherein the improvement further comprises said gasket being disc-shaped and having a major surface adherently secured to said shell outer surface.

4. An earcup as defined in claim **1**, wherein the improvement further comprises said gasket being disc-shaped, and said retaining member being a substantially rigid disc-shaped plate having a central aperture through which said shank projects outwardly.

5. An earcup as defined in claim **4**, wherein the improvement further comprises said retaining member aperture being larger in diameter than, and having an edge spaced away from, said stud shank.

6. An earcup as defined in claim **4**, wherein the improvement further comprises said gasket being substantially larger in diameter than said stud head and having one major surface adherenetly secured to said shell outer surface, and said retaining member being substantially equal in diameter to said gasket and being adherently secured to the other major surface of said gasket.

7. An earcup as defined in claim **6**, wherein the improvement further comprises said gasket being fabricated of an elastomer of high shear strength.

8. An earcup as defined in claim **7**, wherein the improvement further comprises said elastomer being polyvinylchloride foam.

9. An earcup as defined in claim **4**, wherein the improvement further comprises said retaining member being of dished configuration larger in diameter than said gasket, disposed with the concave surface of said retaining member facing said shell outer surface and having an annular edge bonded to said shell outer surface in surrounding relation to said gasket.

10. An earcup as defined in claim **9**, wherein said gasket is disposed within a recess in said shell outer surface.

11. An earcup as defined in claim **1**, wherein said retaining member comprises a flexible, cup-shaped retaining shield extending substantially entirely about said shell outer surface nad being secured thereto, said retaining shield having an aperture located centrally therein, and said shank projecting outwardly through said aperture.

12. An earcup as defined in claim **11**, wherein said earcup shell bears an annular, outwardly projecting peripheral flange, and wherein said shield has an annular, inwardly projecting peripheral flange fitting over and engaging said earcup shell flange to secure said shield to said earcup shell.

13. An earcup as defined in claim **12**, wherein said shield is fabricated of a material substantially softer and

more sound absorbent than the material of which said earcup shell is made.

14. An earcup as defined in claim 12, further including a layer of sound absorbing material interposed between said shield and said shell.

15. An earcup as defined in claim 11, wherein said retaining shield is a continuous member.

16. An earcup as defined in claim 11, wherein said retaining shield contains a plurality of apertures disposed therein such that said retaining member structurally resembles flexible crossed straps.

17. A sound-attenuating earcup comprising:

(a) a rigid earcup shell having a domed outer surface;

(b) a disc-shaped gasket of sound-deadening material having opposed major surfaces one of which is adherently secured to said shell outer surface at a central locality of the shell outer surface;

(c) a stud having a disc-shaped head smaller in diameter than said gasket and bearing against the other major surface of said gasket, and a threaded shank smaller in diameter than said head and projecting perpendicularly outward therefrom, said head bearing a plurality of eccentrically disposed and outwardly projecting prongs; and

(d) a disc-shaped retaining plate larger in diameter than said head, having a central aperture through which said shank projects and a plurality of eccentrically disposed apertures through which said prongs respectively project, said retaining disc extending over the outer surface of said head and said other major surface of said gasket and being adherently secured to said last-mentioned gasket surface.

18. A helmet with a sound-attenuating earcup, comprising:

(a) a rigid helmet shell including means defining a mounting aperture through a lateral portion of said helmet shell;

(b) an earcup including

(i) a rigid earcup shell having a domed outer surface facing the helmet shell inner surface adjacent to said mounting aperture;

(ii) a stud having a threaded shank and an enlarged head formed at one end of the shank, disposed at a central locality of said earcup shell outer surface with said head facing the earcup shell and said shank projecting therefrom toward said mounting aperture; and

(iii) a retaining member extending over the outwardly facing surface of said head, said shank projecting outwardly beyond said retaining member, said retaining member fixedly holding said stud and mounted in fixed relation to said earcup shell;

(c) a compressible pad interposed between the inner surface of said helmet shell and said earcup shell; and

(d) means located at the outer surface of said helmet shell, bearing against portions thereof surrounding said mounting aperture, and including a threaded portion threadedly engaged with said shank through said mounting aperture;

wherein the improvement comprises:

(e) a gasket of sound-deadening material interposed between said stud head and said earcup shell outer surface and mounted in fixed relation to said earcup shell outer surface for insulating said earcup shell from vibrations transmitted by said stud.

19. Structure as defined in claim 18, wherein the improvement further comprises said gasket being a disc-shaped body of sound-deadening elastomeric material substantially larger in diameter than said stud head and having one major surface adherently secured to said earcup shell outer surface, and said retaining member being a disc-shaped plate at least about equal in diameter to said gasket and having a central aperture through which said stud shank projects outwardly.

20. A sound-attenuating earcup comprising:

(a) a rigid earcup shell having a domed outer surface; and

(b) a flexible cup-shaped shield extending substantially entirely over said domed outer surface of said earcup shell and secured only peripherally to said shell.

21. An earcup as defined in claim 12, further including an annular head-engaging seal secured to the periphery of the earcup shell, said seal having an outwardly-projecting flexible annular flap surrounding the periphery of the earcup shell and overlying said peripheral flange of said shield.

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U.S. Cl. X.R.

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