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NOISE ATTENUATING EAR PROTECTORS

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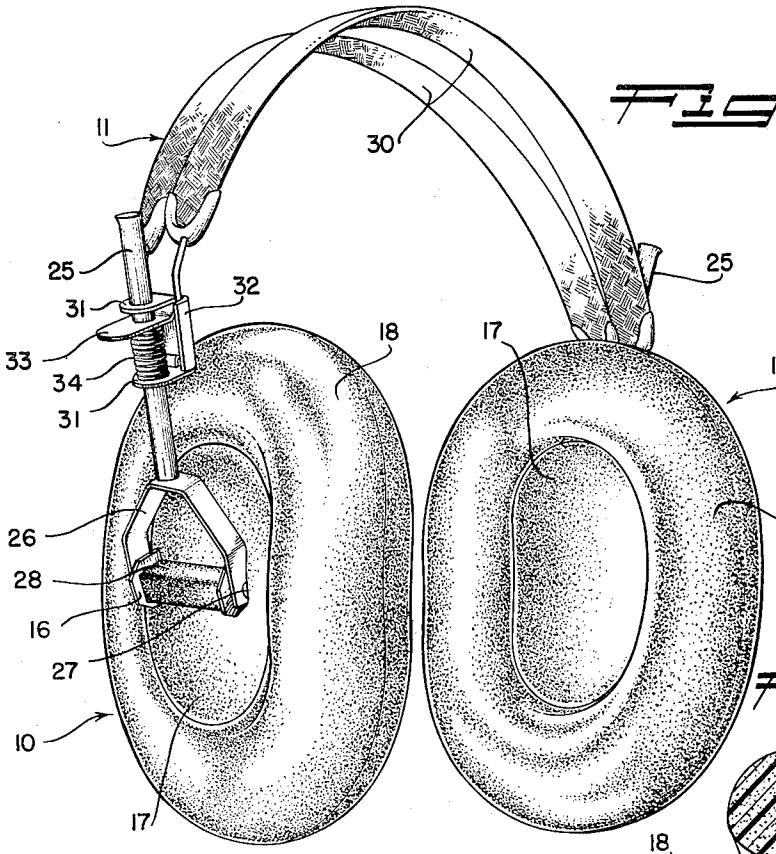

Fig. 1

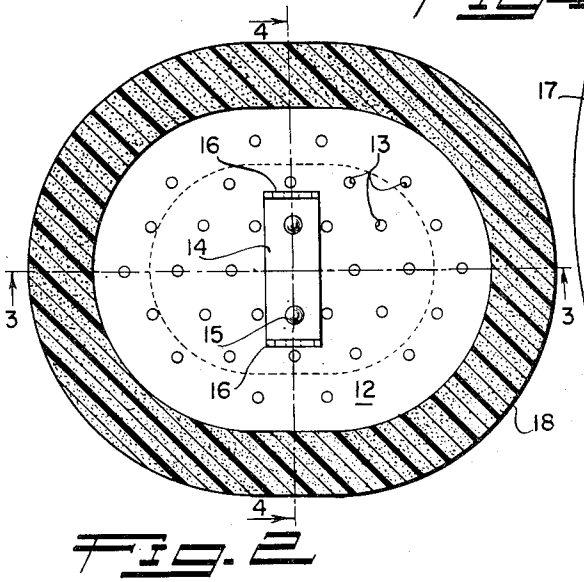

Fig. 2

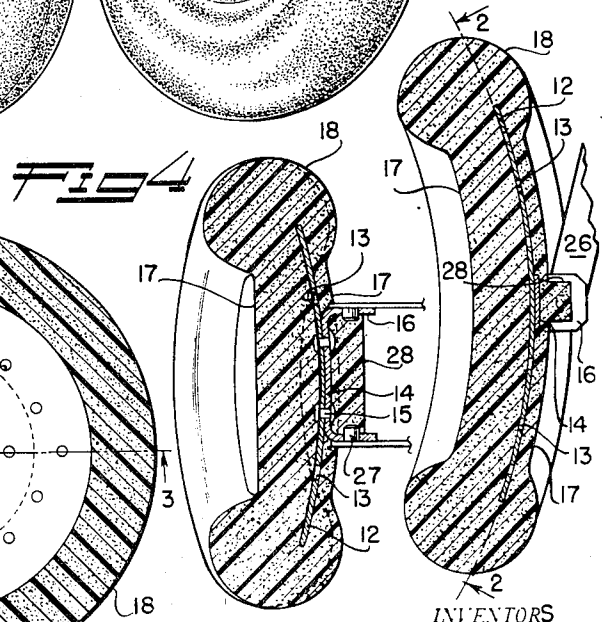

Fig. 3

Fig 4

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NOISE ATTENUATING EAR PROTECTORS

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3 Claims. (Cl. 2—209)

This invention is concerned with the protecting of the human auditory system and relates more particularly to sound or noise attenuating ear protectors.

Workmen, mechanics, engineers, and others, are often subjected to high volume or high intensity noise which may produce deleterious physiological effects. For example, mechanics and engineers who work adjacent the test stands of aircraft jet engines are definitely affected by the engine noises unless precautions are taken to protect them against the action of the intense sound. While various pads, ear plugs, ear protectors, and the like, have been introduced for this purpose, they have not proven to be entirely satisfactory, owing primarily to poor sound attenuating characteristics, the inability to conform to the head and ears, and to the fact that they, themselves, cause physical discomfort to the wearers.

It is an object of the present invention to provide ear protectors having or producing effective attenuation of sound vibration within the ranges of frequencies that are annoying and injurious, for example the range of frequencies produced by jet engines during run-up and testing. The devices of the invention are characterized by ear enclosing pads constructed in part of special isocyanate-plastic foam possessing the ability to absorb such sound energy to a remarkable degree and, therefore, greatly attenuate the transmission of the sound energy to the auditory system. It has been found that the pads of the invention constructed of this foamed cellular or porous plastic are much more effective in the attenuation of sound than pads constructed of cotton, rubber, foamed rubber, and other such materials heretofore employed.

Another object of the invention is to provide ear protectors of this character that are comfortable to use or wear and that are physiologically safe whereby they may be worn for long periods of time without discomfort and with no injurious effects to the ears or the skin. The ear enclosing muffs or pads of the protectors are constructed of a flexible, resilient sound attenuating material of peculiar or special physical characteristics whereby the pads may closely conform with the head or cranial contours without exerting excessive force or pressure to cause discomfort or injury. The material has the ability to readily conform to the contours of the head and has a sufficient degree of resiliency to remain in sound tight contact with the head but has a slow, gentle elastic return so that the pads do not press against the head with excessive force or in a manner to annoy the user or cause any discomfort. The material of the ear pads resembles human flesh in its yielding and slow gentle elastomeric return characteristics.

Another object of the invention is to provide ear protectors including ear covering muffs or pads shaped to most effectively attenuate the sound vibration, to seal the outer air passages of the ears against vibration and to readily conform to widely varying cranial contours without appreciable distortion of the pinna, lobe, helix or other portions of the external ear and, therefore, may be worn for long periods of time without discomfort.

A further object of the invention is to provide simple,

practical and effective ear protectors of this kind characterized by simple yet effective means for securing or anchoring the head bands to the ear pads.

Other objectives and features of our invention will become apparent from the following detailed description of a typical preferred embodiment illustrated in the accompanying drawings wherein:

Figure 1 is a perspective view of the ear protecting device of the invention;

Figure 2 is an enlarged generally vertical detailed sectional view of one of the ear pads, being a view taken substantially as indicated by line 2—2 on Figure 3;

Figure 3 is a longitudinal detailed sectional view taken as indicated by line 3—3 on Figure 2; and

Figure 4 is a transverse detailed sectional view taken as indicated by line 4—4 on Figure 2.

As illustrated in Figure 1, the ear protector of the invention includes two ear enclosing muffs or pads **10** and an adjustable band means **11** extending between and connecting the pads.

The ear enclosing muffs or pads **10** are preferably alike or identical and each includes an internal plate **12**. The plates **12** are the strengthening or reinforcing elements of the pads **10** and are preferably constructed of a metal such as an aluminum alloy although they may be made of a suitable plastic or plastic impregnated fiberglass fabric, or the like, if desired. As shown in Figure 2, the plates **12** are oval in outline and, as illustrated in Figures 3 and 4, are dished to present concave inner faces and convex external faces or sides. It is preferred to make the plates **12** relatively thin to be light in weight and to be capable of deformation or shaping, to some extent, by the user. Thus, if desired or necessary, the individual user may bend or shape the plates **12**, at least to some extent to obtain a closer or more comfortable engagement of the pads **10** on his head. For the purpose to be described below the plates **12** are perforated, each having a plurality of spaced relatively small openings **13**. Each plate **12** is provided with a mounting part or metal clip **14**. The clips **14** are secured to the outer sides of the plates **12** by rivets **15**, or the like, to extend generally horizontally. The opposite ends of the clips **14** have outwardly projecting flanges or lugs **16**.

The bodies or major portions of the pads **10** are yielding, flexible and resilient to conform to the regions of the human head around or adjacent the external ear and are sound attenuating elements effectively preventing the passage of annoying and injurious sound vibrations to the ears. Each pad **10** has a main web **17** and a marginal roll or bead **18**. The platforms or webs **17** are designed to cover or extend across the external ear including the pinna, lobe, helix, etc. and are generally oval in shape or outline, being elongated in the vertical direction and having rounded upper and lower boundaries. As shown in Figure 3, the inner and outer surfaces of the webs **17** are curved or dished, the inner surfaces being curved in the vertical direction to be concave and the outer surfaces being curved in the vertical direction to be convex. However, as shown in Figure 4, the inner surfaces of the platform or webs **17** may be substantially straight in the generally horizontal direction while the outer surfaces of the webs are curved to be convex in this direction. The platforms or webs **17** are relatively thick, the thickness depending to a large extent upon the intended application or use of the ear protectors and upon the sound attenuating characteristics or abilities of the material of which they are constructed. As clearly illustrated in Figures 3 and 4, the web **17** embed or encase the plates **12** with the exception of the marginal regions of the plates which extend into the beads **18**. The foam plastic material of the web **17** occupies or fills the openings **13** so that the portions of the web at the opposite sides of the plate **12** are

integrally tied together at a plurality of spaced points. It is preferred to have the internal reinforcing plate **12** lie relatively close to the external surface of the web **17** of each pad **10** to leave the major inner portions of the pads free for easy deformation so as to more readily conform to the cranial contours of the user. If desired, the outer surfaces of the webs **17** may substantially parallel or conform with the curvatures of the plates **12**. This is best illustrated in Figures 3 and 4 of the drawings.

The rolls or beads **18** which are integral with the webs **17** extend throughout the boundaries or margins of the webs and are thickened with respect to the webs to be the elements or parts which contact or engage the head and face of the wearer in the regions around the external ears. As best seen in Figures 1 and 2, the beads **18** are oval in outline and are generally partially cylindrical in cross section to present rounded convex external surfaces. The centers of the beads **18** are preferably offset inwardly with respect to their related webs **17** so that the beads project inwardly from the inner sides of the webs greater distances than from the outer faces of the webs. The thick projecting beads **18** present smooth rounded convex surfaces for directly contacting the head and face regions of the user adjacent or around the external ears. These rounded convex surfaces of the yielding resilient beads **18** are adapted to deform or distort to readily conform to the surfaces of the head and face, initially having substantially line contact with the head and face and then flattening or deforming into conformance therewith to have broad or extensive sound sealing engagement with the head and face. It will be observed in Figure 3 that the rolls or beads **18** follow generally the curvature of the webs **17** so that their crests at the inner sides of the pads **18** follow concave paths or lines. It has been found that this configuration is most suitable for the typical or average human head. However, as already indicated, the pads **10** are capable of some intentional alteration in shape by bending the plates **12** so that the user may alter, to at least some degree, the contours and shape of the pads to better adapt them to his particular needs.

The bodies of the pads **10**, comprising the above described webs **17** and beads **18**, are molded cellular or expanded synthetic resin members preferably being constructed of the general type of cellular plastic described in the application of Eli Simon and Frank W. Thomas, Serial Number 354,380, filed May 11, 1953, and assigned to the assignee of the present application. While the pad bodies may be molded of any selected or suitable foamed plastic of this type, we have found that satisfactory resutls are obtained by constructing the pad bodies of the cellular, flexible and resilient plastics prepared according to the following formulation.

	Parts by weight.
Polyester resin—H_2O content 1½%—acid number 10 to 50	45
Poly propylene glycol—average molecular weight 400	30
Aluminum stearate	2
Carbon black	½
Cyclohexyl levulinate	5
Meta toluene diisocyanate containing 6 parts ethyl cellulose per 100 parts of the meta toluene diisocyanate	22
Wetting agent	1

The resin of the above formulation is prepared from 4 mols trimethylol propane, 2½ mols adipic acid and ½ mol phthalic anhydride. The ethyl cellulose which is premixed or compounded with the meta toluene diisocyanate, may have a viscosity of from 50 to 200 centipoises and preferably approximately 100 centipoises, and an ethoxyl content of from 45 to 49.5%. The wetting agent above enumerated is a sodium 2, ethyl hexyl derivative of tripolyphosphoric acid. If it is desired to make the bodies of the ear pads **10** somewhat harder, the above formulation may be modified by substituting methyl abietate for

the cyclohexyl levulinate in the same proportion. Again, the flexible, resilient cellular plastic of the ear pads may be made somewhat softer and more yielding by reducing the proportion of the isocyanate component in the above formulation to 20 parts by weight and by reducing its ethyl cellulose component to 2 parts for each 100 parts of the meta toluene diisocyanate. The above general formulation is capable of other modifications to control the physical characteristics of the resultant cellular foamed plastic as the conditions of use of the ear protectors may dictate.

It is characteristic of the cellular or foamed plastics above described that they may be prepared by simply mixing the component ingredients together to form a liquid reactant mixture which is capable of being poured into a suitable die or mold to react and foam up and then set and cure to form the ear pad bodies comprising the webs **17** and beads **18**. It is preferred to use aluminum dies having mirror-mooth faces or surfaces to provide a good parting action and a wax or a petrosene, wax-toluene mixture may be provided on the die surfaces to constitute a mold release agent or parting agent. A parting agent of this kind is preferably applied to the die when at a temperature of 150 to 160° F. and any excess parting agent is removed while the die is hot. It will usually be found desirable to employ split molds with the above described plate **12** and clip **14** properly located therein. The plates **12** are preferably cleaned and then, if desired, primed prior to being positioned in the dies. Following the preparation of the die or dies the liquid reactant mixture is simply poured into the dies which are preferably preheated to from 130 to 150° F. The dies containing the reactant mixture are placed in an oven at a temperature of 250° F. for from 20 to 30 minutes, the resinous-isocyanate mixture reacting and foaming up at atmospheric pressure to fill the die cavities with the porous or cellular plastic. Following the above oven setting and curing the dies may be opened and the pads **10** removed therefrom.

The muffs or pads **10** produced in this manner are flexible and yielding to readily conform to the cranial contours of the user and have a characteristic slow return so as to remain in effective sound sealing contact with the head and face regions around the external ears without exerting excessive or undesirable resilient pressure against the skin. The material of the pads **10** may in practice be compounded or prepared to have a rate of return or recovery, after deformation, that is many times slower than cellular natural or synthetic rubbers. In fact the gradual return of the pads to their original shape and dimensions, after being deformed may take several minutes, depending upon the composition of the material from which they are constructed. The plastic foam or cellular foam retains its flexibility throughout a temperature range of from 32° F. to 200° F. and is non-toxic to the skin, hair, etc. The foamed plastic pads **10** are capable of being washed and dried without the loss of their original properties, they are long wearing and tough and, if desired, may be coated with a vinyl compound, a polyethylene, or the like, to protect them against penetration by oil, solvents, water, etc. In actual test evaluations it has been found that the foamed plastic material of the pads **10** has an excellent sound attenuation curve for sound frequencies in the range of from ½ to 23 kc. while also having highly effective sound attenuation at the lower frequencies.

The pads **10** constructed as above described have the spring lugs **16** projecting from their outer sides for facilitating attachment of the head band means **11**. This means **11** includes a rod or post **25** for each pad **10**, each post being provided at its lower end with a fork or yoke **26**. The yokes **26** are preferably hinged or pivoted on the lower ends of the posts **25** and straddle the lugs **16**. Rivets or pins **27** pivotally connect the arms of the

yokes **26** with the lugs **16** of the pads **10**. As shown in Figures 1, 3 and 4, the webs **17** of the pads **10** may have raised parts or ribs **28** extending between their lugs **16** to cover the inner sides of the lugs. The means **11** further includes a pair of flexible resilient straps or bands **30** adapted to extend across or over the head of the user. The bands **30** may be spring steel wires or strips covered with a suitable fabric and provided at their ends with clips **32** having vertically spaced ears **31** freely slidable on the posts **25**. The clips **32** have pivoted brake levers **33** and the levers are also adapted to slide on the posts **25**. Springs **34** are arranged under compression between the lower ears **31** and the brake levers **33** to urge the latter to pitched or inclined positions where they bind on the posts **25**. This binding action of the lever **33** holds the head straps **30** in selected or adjusted positions on the posts **25**. By depressing the levers **33** the clips **32** may be adjusted up and down on the posts to alter or adjust the bands **30** with respect to the ear pads **10**.

It is believed that the use or operation of the ear protectors of the present invention will be readily understood from the foregoing detailed description. The pads **10** may be easily and quickly adjusted to comfortable positions where they completely enclose the external ear and where they are gently urged inwardly against the sides of the head by the spring head bands **30**. This yielding pressure engagement of the pads **10** against the head results in sufficient flexure or distortion of the beads **18** to assure adequate and continuous engagement of the yielding material beads with the head so as to accurately conform with the various cranial contours. As above described, the pads **10** constructed to have the relatively thick beads **18** and the thick extensive platforms or webs **17** are highly efficient in preventing the passage or conduction of the annoying and/or injurious sound energy to the air passages of the ears. The flexible, resilient, resin-isocyanate cellular plastic of the pads **10** has been found to be particularly efficient in the attenuation of the sounds accompanying operation and running up of the turbine and jet engines of aircraft and, of course, in the attenuation of other annoying and injurious sounds.

Having described only typical forms of the invention we do not wish to be limited to the specific details herein

set forth, but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

We claim:

1. A sound attenuating ear protector comprising an ear enclosing pad of resilient deformable foamed polyester resin-isocyanate plastic having a slow gentle elastomeric return characteristic following deformation, said pad comprising a main web for extending across the external ear, said web having a concave inner surface, a thickened marginal bead on said web, said bead having a rounded inner edge presenting line contact with the head of the user, said bead following the concave configuration of the web, said web being offset rearwardly with respect to the rounded inner edge of said bead, a thin, dished, bendable reinforcing plate encased in said web, said bead extending in part beyond said plate, said plate having a concave face generally conforming to the concavity of said web, said plate being encased in the rear portion of said web so as to leave the major inner portions of said pad free for easy deformation in order to more readily conform to the cranial contours of the user.

2. A sound attenuating ear protector as in claim 1 and wherein the marginal regions of said plate extend into said bead for supporting said bead.

3. A sound attenuating ear protector as in claim 1 and wherein the marginal regions of said plate extend into said bead for supporting said bead, and said plate having a plurality of spaced openings for bonding portions of said web at opposite sides of said plate together at a plurality of spaced points.

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