A representative embodiment of a lightweight headgear free of protuberances includes an elongate panel formed of a pair of layered, pliable sections joined together at one end and terminating in a fastener at the other end. The headgear is worn kerchief-style and the pliant sections, consisting of alternating layers of sound attenuating materials, block ambient noise. Proper selection of headgear materials and dimensioning permit the hearing of relatively low frequency speech while attenuating higher frequency noise. By being formed of a pliant material readily conforming to the contours of the head free from protuberances, the headgear is wearable at all times, especially during sleep without undue discomfort to attenuate ambient noise.
NOISE PROTECTIVE DEVICE

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Protection of the ears from high intensity, ambient noise has long been a problem. "Mickey Mouse"-type ear protectors, enclosing the ears in cup-shaped chambers, have proven a successful design where their bulk and silhouette pose no problems. Similarly, helmet-type designs afford adequate protection from ambient noise, but are quite cumbersome and unacceptable where unrestricted motion is required or where they must be worn for prolonged periods of time such as during sleeping. Another sound attenuation attempt, while not burdening the wearer with the bulbous ear cups or helmets, called for inserting ear plugs into each ear's concha. This approach relied upon a frictional fitting of the ear plug and when great activity was demanded, the plugs tended to loosen allowing noise to bypass them. Also, the ear plugs were unsuitable for use while sleeping, since, as a sleeper tosses and rolls, the ear plugs fell out. In all these contemporary hearing protectors ambient sound is masked out rather uniformly across the acoustic spectrum blocking low frequency speech as well as higher frequency noise, to isolate the wearer from conversations and communications while the protectors are worn.

SUMMARY OF THE INVENTION

The present invention is directed to providing a noise attenuation headgear formed of a relatively flat, pliable, elongate panel shaped to closely conform to the lateral contours of the head that includes two sections of noise attenuating strata, each positioned contiguously adjacent a separate ear area. Each section pliably accommodates the lateral contours of its separate ear area while presenting an outer surface free of protuberances. The panel is wrapped about the head, kerchief style, and secured beneath the chin to snugly hold the two sections contiguously adjacent their respective ear areas. Upon fitting the headgear to allow its comfortable wearing for prolonged periods of time, especially during sleep, ambient noise is effectively attenuated.

A prime object of the invention is to provide a superior noise attenuation headgear.

Another object of the invention is to provide a headgear free of lateral protuberances allowing its use during sleep.

Yet another object is to provide a pliable headgear configured to pliably conform to the lateral contours of a wearer's head making it comfortable when worn for extended periods of time.

Yet another object is to provide a noise attenuation headgear allowing the communication of speech while attenuating higher frequency noise.

A further object is to provide a sound attenuating headgear that is readily adjustable to be fitted onto differently shaped heads.

Still another object is to provide a noise attenuating headgear uncomplicated in design to lower its per unit cost. These and other objects of the invention will become more readily apparent from the ensuing specification when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a preferred form of the invention. FIG. 2 is a top view of the embodiment shown in FIG. 1. FIG. 3 is a side view of the invention. FIG. 4 is a cross-sectional view of the invention taken generally along lines 4-4 in FIG. 1. FIG. 4a is a detailed showing of the cross-sectional view of FIG. 4. FIG. 5 shows an alternate manner of fitting the preferred embodiment. FIG. 6 shows the headgear comfortably accommodating a sleeping wearer. FIG. 7 is a modified form of the invention. FIG. 8 is another modification of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Refering now to the drawings, FIG. 1 shows a preferred form of the noise protective headgear 10 wrapped about the head. Upon removing the noise protective headgear and laying it on a flat surface, a relatively flat, pliant, elongate panel 11 longitudinally extends and terminates in pairs of drawstrings 14 and 15. In this preferred form, the panel contains a lateral seam 11a separating it into a first and second section 12 and 13.

The drawstrings, see FIG. 4, are carried inside a pair of fabric tublets 14a provided in the lateral, peripheral extremes of the first and second sections, only section 12 is shown for simplicity in the drawing. When the drawstrings are drawn and tied together, as shown in FIG. 1, pliant section 12 comfortably accommodates the outer contour of ear 16 and the ear is acoustically shut off from the outside by the drawstrings firmly bearing along surfaces 16a and 16b of the head. Furthermore, by simply using more or less of the drawstrings' length to position and secure the elongate panel, the headgear possesses the capability to be fitted on to differently shaped heads with no structural modification.

The width of each section, for example along lines 4-4 in FIG. 2, is no more than 3 or 4 inches, a width sufficient to cover the ear, and its thickness is no more than one-half inch to attenuate more than 25db. of sound energy when fabricated in accordance with the following teachings. The above described design is adaptable to be worn as shown in FIG. 5 when, for example, a strap holds a microphone beneath the chin and there is a possibility of entangling the drawstrings and the mike strap.

In either event, the same high degree of noise attenuation is provided and, since no protuberances are presented by the flexible, low-silhouette elongate panel, it is comfortably worn while sleeping to provide hearing protection on a "round-the-clock" basis. FIG. 6 demonstrates that the flexibly accommodating configu-
ration of the head gear presents no lumps or protuberances that unduly interfere with the wearer's comfort. Thus, a practical means for ensuring uninterrupted, restful sleep for those who must remain in a noisy locale is available. Moreover, the headgear does not resort to inserting uncomfortable ear plugs or similar devices in the ear canal and its cushioning effect, if anything, aids in sleeper comfort while attenuating high energy noise.

Protecting of the sound attenuating strata within sections 12 and 13 is provided for by encasing them in a thin rayon, or similar material, sheath 17. Consistent with the overall design considerations inherent in the invention, the sheath also has a dual purpose, the first being headgear protection from snagging and tearing, and the second being to provide a non-scratchy, comfortable surface next to the skin. Optionally, when protection is not paramount, a soft layer of flexible polyurethane foam is substituted to increase comfort.

The superior acoustic noise attenuation characteristics afforded by the headgear are directly attributed to the novel method of laminating materials having dissimilar sound attenuation characteristics. It was first theorized and later empirically proved that the magnitude of sound attenuation across a barrier consisting of an impervious layer, a limp panel or septum, and an adjacent porous layer, consisted of additive components directly attributed to the two layer's densities, velocity of sound transmission, physical dimensions, and the frequency of the impinging acoustic energy.

An impinging incident sound wave experiences a reflection loss while passing from one medium to another as well as experiencing a loss while traveling through the medium. Instrumentation is available from which a direct reading of energy loss or attenuation is provided.

The attenuation or transmission loss attributed to the septum alone is predictable by the classic weight law which is derived and treated in depth in “Fundamentals of Acoustics”, second edition 1966, John Wiley and Sons, Inc., p. 138. The weight law is stated,

\[(TL) = 20 \log_{10} \left( \frac{\pi}{1} \right) + 20 \log_{10} \rho f \]

(1)

where \( \rho \) is the density of air, \( c \) is the speed of sound in air, \( \sigma \) is the surface density of the septum expressed in lbs/ft\(^2\) and \( f \) is the impinging frequency.

Equation 1 reduces to,

\[(TL) = 28.54 + 20 \log_{10} \rho f \]

(2)

It is immediately apparent that the attenuation increases as a function of frequency alone with a particular septum.

A thin, flexible septum 18 of tin-loaded vinyl having a surface weight of 0.1 lbs/ft\(^2\) was selected for purposes of providing some attenuation values over a frequency range between 200 and 8,000 hertz. The values are shown in Table 1.

<table>
<thead>
<tr>
<th>f (hertz)</th>
<th>transmission loss (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>7</td>
</tr>
<tr>
<td>500</td>
<td>13</td>
</tr>
<tr>
<td>1,000</td>
<td>19</td>
</tr>
<tr>
<td>2,000</td>
<td>25</td>
</tr>
<tr>
<td>4,000</td>
<td>31</td>
</tr>
<tr>
<td>8,000</td>
<td>35</td>
</tr>
</tbody>
</table>

It is observed in Table 1 that the db attenuation attributed to the septum, alone, markedly increases as a function of increasing frequency. Septums having a similar surface weight as the tin-loaded vinyl such as lead-loaded vinyl, flexible resin sheets, etc. showed a similar attenuation characteristic over the above frequency range.

The attenuation attributed to passing a measured amount of acoustic energy through a porous medium alone that diffuses and absorbs the energy is theoretically predicted by consulting charts and graphs which set forth the degree of attenuation a particular porous medium effects to different frequencies of acoustic energy. Representative tables and charts, as well as the theory behind their use are set forth in the "Journal of the Acoustic Society", volumes 19 and 21, pages 556, 419f, respectively, by Leo L. Beranek, particularly with respect to his analysis of the attenuation characteristics of the soft acoustic blankets and "Noise Control, Fundamentals Underlying", by Beranek, McGraw-Hill (1960), pp. 270f.

From graphs included in the Beranek articles, Table 2 was compiled for a fibrous glass blanket 19 having a density of 0.05 gm/cm\(^3\), a volume coefficient of elasticity of 1.2 \( \times \) 10\(^8\) and a specific flow resistance (resistance of a cubic centimeter of material to steady air flow) of 28, and a porosity (ratio of voids to the total volume) of 0.96.

Similarly to the tin-loaded vinyl septum, the blanket of fibrous glass attenuated acoustic energy in increasing amounts as frequency increased, noting Table 2,

<table>
<thead>
<tr>
<th>f (hertz)</th>
<th>attenuation (db/cm of thickness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>8</td>
</tr>
<tr>
<td>500</td>
<td>1.3</td>
</tr>
<tr>
<td>1,000</td>
<td>1.7</td>
</tr>
<tr>
<td>2,000</td>
<td>2.4</td>
</tr>
<tr>
<td>4,000</td>
<td>3.3</td>
</tr>
<tr>
<td>8,000</td>
<td>4.6</td>
</tr>
</tbody>
</table>


Since both the septum and the porous blanket attenuate higher frequency sound much greater than the lower frequencies (which dominate the normal speech range) combining in layers the septum and the porous blankets should, in theory, produce an acoustic attenuation allowing the passing of low frequency speech while effectively attenuating higher frequency noise.

That their additive calculated attenuations are a function of increasing frequency is shown in Table 3 under the heading "Calculated Additive Attenuation (db)."

<table>
<thead>
<tr>
<th>f (hertz)</th>
<th>Calculated Additive Attenuation (db)</th>
<th>Actual Attenuation (db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>1.8</td>
<td>0.0</td>
</tr>
<tr>
<td>500</td>
<td>8.3</td>
<td>0.0</td>
</tr>
<tr>
<td>1,000</td>
<td>14.7</td>
<td>0.0</td>
</tr>
<tr>
<td>2,000</td>
<td>21.4</td>
<td>0.0</td>
</tr>
<tr>
<td>4,000</td>
<td>29.3</td>
<td>0.0</td>
</tr>
<tr>
<td>8,000</td>
<td>36.6</td>
<td>32.0</td>
</tr>
</tbody>
</table>

However, in actual practice, constructing a head gear formed of the materials described above and arranged as depicted in FIG. 4 and 4a produced the attenuation values measured by a sound level meter, set forth under column “Actual Attenuation (db).”
There is no attenuation for the lower frequencies and considerable attenuation for the higher frequencies. The discrepancies between the calculated values and the actual attenuation levels as measured are, in all probability, due to the fitting of the headgear, temperature changes, humidity, etc.

While the above analysis relied upon a single septum and porous blanket, an additional tin-loaded vinyl septum 20 is included to provide the two-fold purpose of securing additional attenuation and to maintain the structural integrity of the headgear and may, in part, be responsible for the discrepancy between the calculated and measured attenuation levels.

The thickness of the sandwiched septums and fibrous blanket is maintained below one-half of an inch to provide the attenuation listed in Table 3, greater than 25 db of noise attenuation at the 4,000 hertz level.

Further modifications of the configuration of the headgear to achieve substantially the same attenuation characteristics optionally assume the shape of the headgear shown in FIG. 7. A baseball-styled cap 21 includes a pair of earflapper sections, only section 21a is shown in FIG. 7, which are either resiliently held in place by a stay-like arrangement or are tied down beneath the chin by a pair of drawstrings. The earflapper sections also are fashioned to reach around the back of the head to cover the ears and are designed roughly along the same lines as conventional cold weather headgear.

A resilient pliably accommodating headgear is further modifiable noting the headgear shown in FIG. 8. In this embodiment, a single wrap-around, elongate panel 22 is held in position by a pair of biasing strips 23 which serve to grip the head and, simultaneously, secure the headgear on the head.

Any number of other modifications of the laminated, sound attenuating panel, such as building up several septum-blanket layers for greater attenuation, are foreseeable within the scope of the invention. However, the above disclosed designs having a minimum of bulk, are most adaptable to ensure comfort while sleeping. Also, the fasteners are alternately one of many different types, snaps, buttons, straps, etc., their purpose being to position the sound attenuating panel while facilitating the exclusion of ambient noise.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than as specifically described.

What is claimed is:
1. A noise attenuation headgear comprising: elongate panel means including two sections of noise attenuating strata each having at least one pliable porous layer shaped to conform to the lateral contours of the head sandwiched between two pliable impervious layers having protuberance-free smooth outer surfaces also shaped to conform to the lateral contours of the head to permit comfortable prolonged wearing of said headgear even while sleeping, said porous layer and said impervious layers are formed from materials acoustically cooperating to effect a 25 db noise attenuation at predetermined frequencies and to ensure the higher attenuation of said noise in the frequency range above the range of normal speech when each strata is positioned to cover a separate ear and faster means carried on opposite ends of said elongate panel means configured for self engagement to snugly position and hold said two sections in their pliable accommodating relationship about the head to allow the comfortable wearing of said headgear for prolonged periods of time especially during sleep and to further ensure noise attenuation.
2. A headgear according to claim 1 in which said porous layer is fibrous glass for absorbing said noise and each of said impervious layers is a tin-loaded vinyl compound for reflecting and attenuating said noise to effect said 25 db noise attenuation at predetermined frequencies.
3. A headgear according to claim 2 in which said elongate panel means further includes, a sheath element carried on the external surfaces of said elongate panel means being formed of a tough snap-resistant pliable material for protecting said headgear.
4. A headgear according to claim 2 in which said elongate panel means has a thickness not greater than one-half inch to ensure comfortable prolonged wearing and is formed with a longitudinally extending flexible tubelet on opposite longitudinal sides and said faster means is a drawstring disposed in each said longitudinally extending flexible tubelet.
5. A headgear according to claim 2 in which elongate panel means and said fastener means are configured to be optionally worn in a kerchief manner and a turban manner.
6. A headgear according to claim 2 in which said elongate panel means is shaped in a skull cap configuration, said two sections are dependent ear flap members and said fastener means is a pair of drawstrings each secured to a separate ear flap member.
7. A headgear according to claim 2 in which said elongate panel means is shaped to reach around the back of the head and cover the ear areas and said fastener means is a pair of biasing strips clamping said elongate panel onto the skull covering the ear areas.

* * * *