(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 047 712**
B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **31.10.84**

(51) Int. Cl.³: **A 42 B 3/00**

(21) Application number: **81630050.3**

(22) Date of filing: **26.08.81**

(54) **Shock attenuation system for headgear.**

(30) Priority: **08.09.80 US 185208**

(43) Date of publication of application:
17.03.82 Bulletin 82/11

(45) Publication of the grant of the patent:
31.10.84 Bulletin 84/44

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI NL SE

(56) References cited:
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FR-A-2 375 840
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EP 0 047 712 B1

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Courier Press, Leamington Spa, England.

Description

The present invention concerns a shock attenuation system for headgear including a liner comprising a series open-ended tubes disposed in generally parallel side-by-side relation, and means for securing the liner on the inside of a shell of the headgear the longitudinal axes of the tubes being generally parallel to the internal surface of the shell.

This invention involves an improvement in shock attenuation systems for protective headgear of the type, such as shown for example in U.S. patents 3 292 180, 3 462 763, 3 600 714, 3 609 764, 3 668 704 and 3 887 076, comprising a deformable liner secured to the internal surface of an outer protective shell of the headgear, the liner deforming under an impact load applied to the shell for attenuating the shock upon the wearer. While the liners of prior systems initially provide adequate shock attenuation they lose a substantial part of their shock attenuation properties with each impact, with the result that after a relatively small number of impact loadings of relatively high magnitude, they no longer provide adequate shock attenuation. The loss of shock attenuation properties is not, however, accompanied by any visible changes in the liners of prior systems, and a user cannot determine by visual inspection whether a particular piece of headgear which has been previously used still provides adequate protection.

In US—PS 3 829 900 the liner is made of tubes formed from a crushable material which permanently deforms when the helmet is impacted to accomplish the necessary shock attenuation. Once the tubes are crushed, they are no longer effective for absorbing impact energy. Accordingly, the liner must be replaced after each impact.

Among the several objects of this invention may be noted the provision of an improved shock attenuation system of the above-described type which provides a higher level of shock attenuation than prior systems; the provision of such a system which continues to provide an adequate level of shock attenuation after being subjected to numerous impact loadings; the provision of such a system which, if it were to become defective in use, would be visually detectable as such; the provision of such a system which is detachably secured to the outer protective shell of the headgear to enable removal of a defective system and installation of a replacement therefore; the provision of such a system which provides improved air ventilation in the headgear; the provision of such a system which is relatively compact and lightweight, and the provision of such a system which is relatively simple and economical to manufacture.

The shock attenuation system according to the invention is characterized in that said tubes are made of elastomeric material so that they are elastically deformable under loads applied against the sides thereof, said tubes being so positioned with respect to one another that when one tube deforms under a load it is engageable with the sides of adjacent tubes for deforming them when the headgear is worn by a wearer and subjected to an impact load, the sides of the tubes in the area of impact deforming elastically under the load into engagement with the sides of adjacent tubes and thereby deforming said adjacent tubes for attenuating the shock upon the wearer.

In order that the invention may be fully understood, reference is made on the following drawings, wherein:

Fig. 1 is a front elevation of headgear having a shock attenuation system of this invention with a portion of the headgear broken away to show a liner of the system and with parts of the liner broken away;

Fig. 2 is a horizontal section of the headgear on line 2—2 of Fig. 1;

Fig. 3 is an enlarged fragmentary horizontal section of the headgear;

Fig. 4 is a fragmentary vertical section of the headgear on line 4—4 of Fig. 1;

Fig. 5 is a view similar to Fig. 3 showing a second embodiment of the shock attenuation system;

Fig. 6 is a view similar to Fig. 3 showing a third embodiment of the system; and

Fig. 7 is a view similar to Fig. 3 showing a fourth embodiment of the system.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring first to Figs. 1—4 of the drawings, there is indicated at 1 a headgear, such as a football helmet, comprising an outer protective shell 3 of a suitable relatively lightweight plastic material, such as acrylonitrile-butadiene-styrene (ABS) resin or polypropylene having a relatively high impact resistance, and a shock attenuation system 5 of this invention comprising a liner 7 at the internal surface of the shell 3. To facilitate installation of the liner 7 in the shell 3 with the liner 7 held in close conformance to the curved internal surface thereof, the liner preferably has, as shown in Fig. 1, a lower section 9 at the lower edge margin of the shell and a separate upper section 11 above the lower section extending toward but stopping short of the crown of the shell. A suspension harness indicated at 13 in Fig. 2 is provided in the headgear 1 at its crown for protecting the top of the wearer's head.

In accordance with this invention, the liner 7 comprises a series of elastically deformable tubes 15 of generally circular section extending up within the shell with their axes generally parallel to the internal surface of the shell, and a layer 17 of cushioning material at the interior periphery of the series of tubes. As shown in Fig. 2, the layer 17 of cushioning material com-

prises a plurality of pads 19 of a suitable closed-cell elastomeric foam such as a foamed vinyl resin at spaced intervals along a carrier sheet 21 of suitable material detachably secured to the tubes 15 by conventional fasteners 23, such as snaps or hook and pile fasteners. The inner surface of the layer 17 of cushioning material is engageable with the head for providing a snug, comfortable fit of the headgear on the wearer's head. The thickness of the layer 17 may be varied within a range (e.g. 0.635 to 1.58 cm) to enable use of one size of shell 3 for a range of head sizes.

As shown in Figs. 1 and 2, the tubes 15 are secured together in side-by-side relation with adjacent tubes joined by a layer of suitable adhesive or integrally formed as by extrusion, and they are detachably secured to the shell 3 by conventional fastening means 25 such as rivets, "t" nuts and screws, or snaps. In accordance with this invention, the tubes are of an elastomeric material, such as polybutylene, polyurethane, polyethylene, a polyarylate resin such as that sold under the trade name "Ardel" by Union Carbide Corp., of New York, New York, or a synthetic rubber such as that sold under the trade name "Hytrel" by E. I. Du Pont De & Nemours Co., Inc. of Wilmington, Delaware, and are open at their ends to enable them readily to deform elastically from their normal circular section to an elliptical section under loads applied against their sides. The open ends of the tubes allow air to flow out of the tubes upon being deformed, and also to flow through the tubes to ventilate the headgear 1.

With the headgear 1 worn on a wearer's head, the system 5 attenuates the shock upon the wearer from an impact load applied to the headgear by distributing the loading over an increased area of the head and by increasing the period of time during which loading is applied to the head, thereby decreasing the shock (which is a time derivative of the loading). Upon the application of an impact load to the headgear, the tubes 15 in the area of impact deform to an elliptical section with their major axes generally parallel to the internal surface of the shell 3 thereby causing the adjacent tubes to deform to an elliptical section with their major axes perpendicular to the shell and to apply force against the wearer's head, thus increasing the area of the head over which loading is applied. Time being required to deform the tubes upon application of the impact load and time being required for the tubes to return to their original circular section after the impact load has been applied, the overall period of time during which loading is applied to the head is increased.

In contrast to the prior shock attenuation systems in which the level of shock attenuation decreases significantly upon subjecting the systems to repeated impact loadings, the system of this invention provides a level of shock attenuation on subsequent impact loadings which is approximately equal to that for the initial impact loading. It is only upon the cracking or fracture of a tube 15 of the liner 7, which may occur after a large number of impact loadings, that there is a substantial decrease in the level of shock attenuation of the system. In further contrast to the prior systems in which visual inspection of the systems does not reveal whether they are still capable of providing adequate protection, in the system of this invention the series of tubes 15 may be easily and quickly removed from the shell 3 and inspected for cracks and fractures, and the headgear 1 may be reconditioned by replacing a series of tubes 15 found to be defective.

Comparison tests of the shock attenuation properties of a football helmet having a shock attenuation system 5 of this invention and three football helmets having prior shock attenuation systems were conducted based on the "Standard Method of Impact Test and Performance Requirements for Football Helmets" established by the National Operating Committee on Standards in Athletic Equipment (NOCSAE) as revised April, 1977. In each test, a helmet was placed on a test head form having a triaxial accelerometer at its center of gravity, and was dropped ten times in guided free fall from a height of 23.6 cm onto a rigid anvil in accordance with the test procedures with the front of the helmet impacting the anvil. The "Severity Index" (as specified in the test procedure) of the shock experienced by the head form was calculated for each drop. NOCSAE standards require that the severity index for a helmet not exceed 1500 upon the first or second drop of the helmet.

The four helmets tested were designated A, B, C and D. Helmet A had a liner embodying the shock attenuation system 5 of this invention, comprising tubes of polyurethane having a 0.95 cm inner diameter and a 1.27 cm outer diameter, and a layer of 0.95 cm thick vinyl resin foam. Helmet B was of the type such as that shown for example in U.S. patent 3 462 763 having an air suspension shock attenuation system. Helmet C was of the type such as that shown for example in U.S. patent 3 609 764 having a shock attenuation system comprising a liner of a dual composition vinyl resin foam. Helmet D was of the type such as that shown for example in U.S. patent 3 600 714 having a hydraulic suspension shock attenuation system. During the testing, it was observed that the Severity Index of the initial drop for the helmets B—D was greater than that for the helmet A, and that the Severity Index of each of the helmets A—D increased on succeeding drops with the increase for helmets B—D on succeeding drops being greater than that for helmet A. Table 1 is a tabulation of the number of times, up to ten, each helmet was dropped until the Severity Index first exceeded 1500.

TABLE 1
Number of drops until the Severity Index first exceeded 1500

Helmet	Number of drops
A	Not Applicable (Severity Index did not exceed 1500 in ten drops)
B	3
C	5
D	4

From the Table, it will be observed that the Severity Index for each of helmets B—D exceeded 1500 prior to or upon the fifth drop of the helmet, whereas the Severity Index of helmet A did not exceed 1500 even on the tenth drop.

A second embodiment 27 of the shock attenuation system of this invention is shown in Fig. 5. It is similar to the system 5 except that its liner 29 comprises a series of tubes 15 laced together by lacing 31 extending through holes in the sides of the tubes.

Referring to Fig. 6, a third embodiment 33 of the shock attenuation system of this invention is shown, also similar to the system 5 except that its liner 35 comprises a series of tubes 15 joined to a common carrier sheet 37, which may be of the same elastomeric material as the tubes, with an elongate strip 39 of a suitable elastomeric foam extending around the interior periphery of the series of tubes. As shown in Fig. 5, adjacent tubes 15 may be spaced apart a predetermined distance on the carrier sheet and the fastening means 19 may have a projection 41 extending between adjacent tubes.

Referring to Fig. 7, a fourth embodiment 43 of the shock attenuation system is shown, similar to the system 5 except that its liner 45 further comprises first and second strips 47, 49 of suitable material such as a fabric secured together, as by stitching, at spaced intervals to form means defining a plurality of pockets 51 each receiving a tube 15. This arrangement is advantageous in that it enables replacement of only those tubes found to be defective upon inspection of the liner 45 rather than an entire series of tubes. Like the system 33, adjacent tubes 15 of this system may be spaced apart a predetermined distance and the layer 17 of cushioning material may comprise an elongate strip of elastomeric foam extending around the interior periphery of the series of tubes. As shown in Fig. 7, lacing 53 may be used to secure the layer 17 to the first and second strips 47, 49.

While the shock attenuation systems of this invention have been shown and described as being incorporated in football helmets, it is to be understood that they could be incorporated into other protective headgear, such as aviation helmets and military helmets including those having a bullet-proof outer protective shell. For such applications, the systems of this invention would provide improved ventilation to enable the helmet to be worn for extended periods of time, and would attenuate noise such as that from aircraft engines or gunfire.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Claims

1. A shock attenuation system for headgear (1) including a liner (7) comprising a series of open-ended tubes (15) disposed in generally parallel side-by-side relation, and means (25) for securing the liner (7) on the inside of a shell (3) of the headgear (1), the longitudinal axes of the tubes (15) being generally parallel to the internal surface of the shell (3), characterized in that said tubes (15) are made of elastomeric material so that they are elastically deformable under loads against the sides thereof, said tubes being so positioned with respect to one another that when one tube (15) deforms under a load it is engageable with the sides of adjacent tubes (15) for deforming them when the headgear (1) is worn by a wearer and subjected to an impact load, the sides of the tubes (15) in the area of impact deforming elastically under the load into engagement with the sides of adjacent tubes (15) and thereby deforming said adjacent tubes (15) for attenuating the shock upon the wearer.

2. Shock attenuation system according to claim 1 characterized in that the liner (7) further comprises an inner layer (17) of cushioning material engageable with the wearer's head.

3. Shock attenuation system according to claims 1 and 2, characterized in that adjacent tubes (15) of the liner (7) are joined together at their sides.

4. Shock attenuation system according to claims 1 and 2 characterized in that the tubes (15) are laced together by lacing (31) extending through the sides of the tubes (15).

5. Shock attenuation system according to claim 1, characterized in that the liner (7) further comprises a carrier sheet (37), said tubes (15) being joined to said sheet (37).

6. Shock attenuation system according to claim 1 characterized in that the liner (45) further comprises means (47, 49) forming pockets (51) at spaced intervals adapted to receive said tubes (15).

7. Shock attenuation system according to claim 1, characterized in that the sides of the adjacent tubes (15) of the liner (7) are spaced apart.

8. Shock attenuation system according to claim 1 characterized in that with the liner (7) secured in the shell (3) the axis of each tube (15) extends generally vertically.

9. Shock attenuation system according to claim 1, characterized in that the liner (7) is engageable with and conformable to the internal surface of the shell (3).

10. A shock attenuation system according to claim 1 characterized in that said tubes (15) are adapted for communication with the interior of the headgear (1) whereby when the tubes (15) are deformed during an impact air is adapted to flow out of the tubes (15) and into the interior of the shell for ventilating the headgear.

11. A shock attenuation system according to claim 1 characterized in further comprising a plurality of pads (19) of cushioning material detachably secured to the tubes (15) on the inside thereof for engagement with the head.

Revendications

1. Système amortisseur de chocs pour casque (1) comportant un revêtement intérieur (7) comprenant une série de tubes (15) ouverts aux extrémités disposés généralement parallèles l'un à l'autre côte à côte, et un dispositif (25) pour fixer le revêtement intérieur à la surface intérieure d'une enveloppe extérieure (3) du casque (1), les axes longitudinaux des tubes (15) étant généralement parallèles à la surface intérieure de l'enveloppe (3) caractérisé en ce que ces tubes (15) sont réalisés en une matière élastomère de sorte qu'ils sont élastiquement déformables sous les charges appliquées contre les côtés de ceux-ci, ces tubes étant positionnés l'un par rapport à l'autre de telle sorte que, lorsqu'un tube (15) se déforme sous une charge, il peut venir contre les côtés des tubes (15) adjacents pour les déformer lorsque le casque (1) est porté par un utilisateur et est soumis à une charge d'impact, les côtés des tubes (15) dans la zone d'impact se déformant élastiquement sous la charge pour venir contre côtés des tubes (15) adjacents et ainsi déformer ces tubes (15) adjacents pour amortir le choc sur l'utilisateur.

2. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que le revêtement intérieur (7) comprend également une couche intérieure (17) d'une matière d'amortissement pouvant venir contre la tête de l'utilisateur.

3. Système amortisseur de chocs selon les revendications 1 et 2, caractérisé en ce que les tubes adjacents (15) du revêtement intérieur (7) sont réunis l'un à l'autre per leurs côtés.

4. Système amortisseur de chocs selon les revendications 1 et 2, caractérisé en ce que les tubes (15) sont attachés l'un à l'autre par des lanières (31) s'étandant au travers des côtés des tubes (15).

5. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que le revêtement intérieur (7) comprend également une feuille support (37), ces tubes (15) étant réunis à cette feuille (37).

6. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que le revêtement intérieur (45) comprend également des éléments (47, 49) formant, à intervalles espacés, des alvéoles (51) conçues pour recevoir ces tubes (15).

7. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que les côtés des tubes adjacents (15) du revêtement intérieur (7) sont espacés l'un de l'autre.

8. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que, lorsque le revêtement intérieur (7) est fixé dans l'enveloppe (3), l'axe de chaque tube (15) s'étend généralement verticalement.

9. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que le revêtement intérieur (7) peut venir contre la surface intérieure de l'enveloppe (3) en en épousant le contour.

10. Système amortisseur de chocs selon la revendication 1, caractérisé en ce que ces tubes (15) sont adaptés pour communiquer avec l'intérieur du casque (1) de sorte que, lorsque les tubes (15) sont déformés pendant un choc, de l'air puisse s'écouler hors des tubes (15) et dans l'intérieur de l'enveloppe pour ventiler le casque.

11. Système amortisseur de chocs selon la revendication 1, caractérisé en ce qu'il comprend en outre une pluralité de tampons (19) de matière d'amortissement fixés de façon amovible aux tubes (15) à l'intérieur par rapport à ceux-ci pour venir contre la tête.

Patentansprüche

1. Stoßdämpfungssystem für eine Kopfbedeckung (1) mit einem Futter (7), das eine Reihe von offenendigen Rohren (15) aufweist, die insgesamt parallel nebeneinander angeordnet sind, und mit einer Vorrichtung (25) zum Befestigen des Futters (7) an der Innenseite einer Schale (3) der Kopfbedeckung (1), wobei die Längsachsen der Rohre (15) insgesamt parallel zu der Innenoberfläche der Schale (3) sind, dadurch gekennzeichnet, daß die Rohre (15) aus elastomerem Material bestehen, so daß sie unter Belastungen, die auf ihre Seiten ausgeübt werden, elastisch verformbar sind, wobei die Rohre in bezug auf einander so angeordnet sind, daß, wenn ein Rohr (15) sich unter einer Belastung verformt, es mit den Seiten von benachbarten Rohren (15) in Berührung bringbar ist, um diese zu verformen, wenn die Kopfbedeckung (1) von einem Träger getragen wird und eine Stoßbelastung auf sie ausgeübt wird, die Seiten der Rohre (15) sich in dem Stoßbereich unter der Belastung bis in Berührung mit den Seiten von benachbarten Rohren (15) elastisch verformen und dadurch die benachbarten

Rohre (15) verformen, um den auf den Träger ausgeübten Stoß zu dämpfen.

2. Stoßdämpfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß das Futter (7) weiter eine innere Schicht (17) aus Puffermaterial aufweist, die mit dem Kopf des Trägers in Berührung bringbar ist.

3. Stoßdämpfungssystem nach den Ansprüchen 1 und 2, dadurch gekennzeichnet, daß benachbarte Rohre (15) des Futters (7) an ihren Seiten miteinander verbunden sind.

4. Stoßdampfungssystem nach den Ansprüchen 1 und 2, dadurch gekennzeichnet, daß die Rohre (15) mittels Band (31), das durch die Seiten der Rohre (15) gefädelt ist, zusammengeschnürt sind.

5. Stoßdampfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß das Futter (7) weiter eine Tragplatte (37) aufweist, mit der die Rohre (15) verbunden sind.

6. Stoßdämpfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß das Futter (45) weiter Einrichtungen (47, 49) aufweist, die in gegenseitigen Abständen angeordnete Taschen (51) zum Aufnehmen der Rohre (15) bilden.

7. Stoßdämpfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß die Seiten der benachbarten Rohre (15) des Futters (7) gegenseitigen Abstand aufweisen.

8. Stoßdämpfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß sich bei in der Schale (3) befestigtem Futter (7) die Achse jedes Rohres (15) insgesamt vertikal erstreckt.

9. Stoßdämpfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß das Futter (7) mit der Innenoberfläche der Schale (3) in Berührung bringbar ist und sich der Innenoberfläche anpassen kann.

10. Stoßdämpfungssystem nach Anspruch 1, dadurch gekennzeichnet, daß die Rohre (15) mit dem Inneren der Kopfbedeckung (1) in Verbindung sind, wodurch, wenn die Rohre (15) während eines Stoßes verformt werden, Luft aus den Rohren (15) und in das Innere der Schale strömen kann, um die Kopfbedeckung zu belüften.

11. Stoßdämpfungssystem nach Anspruch 1, gekennzeichnet durch mehrere Polster (19) aus Puffermaterial, die zur Berührung mit dem Kopf an den Rohren (15) auf deren innerer Seite lösbar befestigt sind.

FIG.1

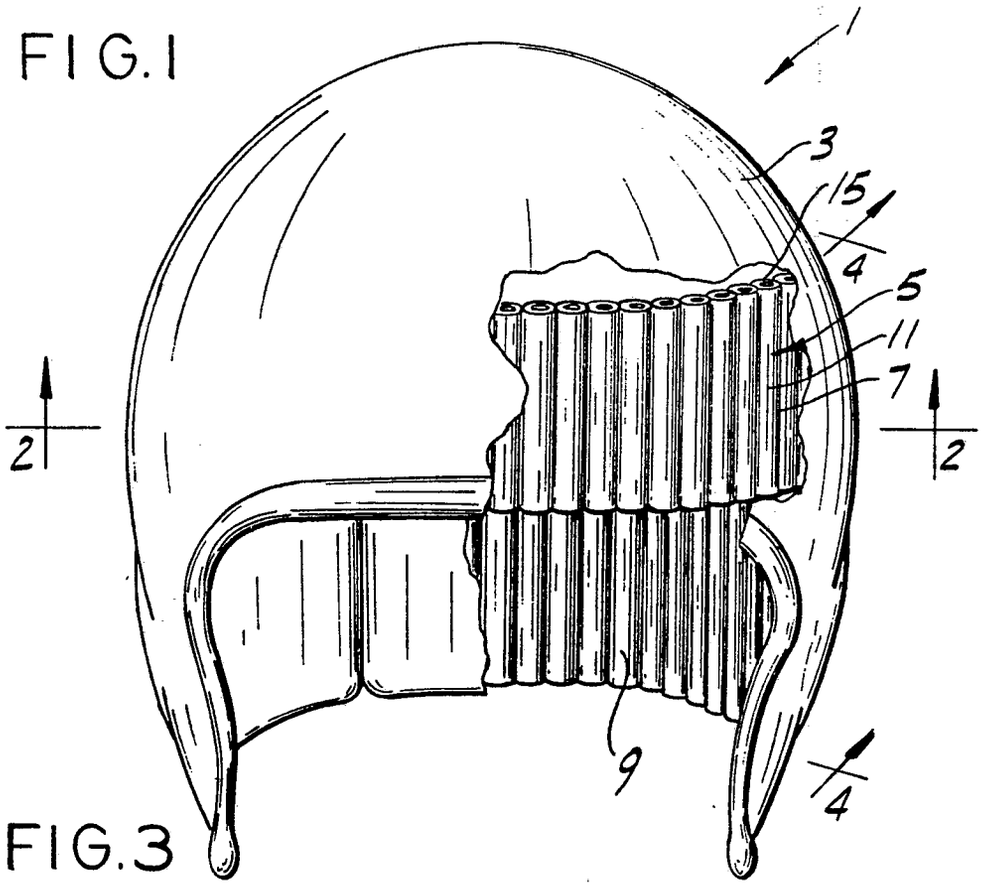


FIG.3

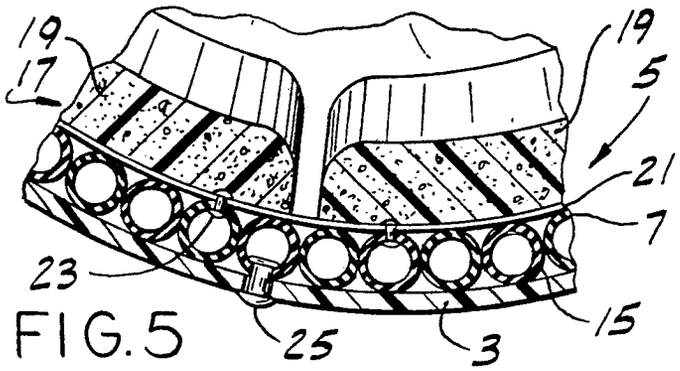


FIG.4

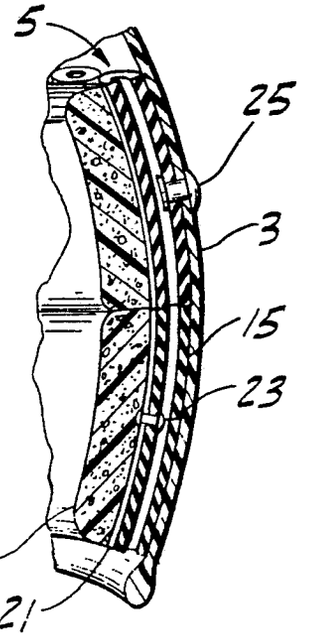


FIG.5

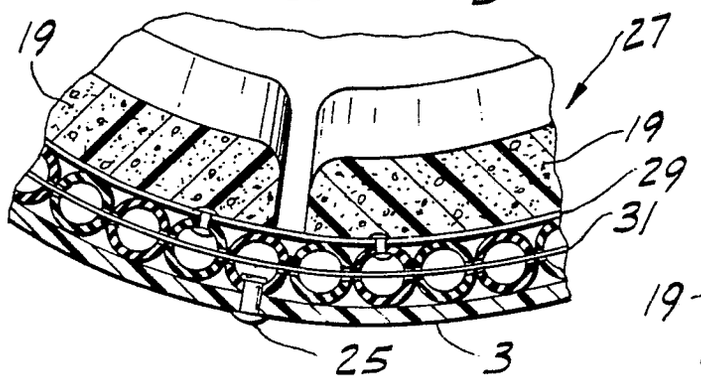


FIG. 2

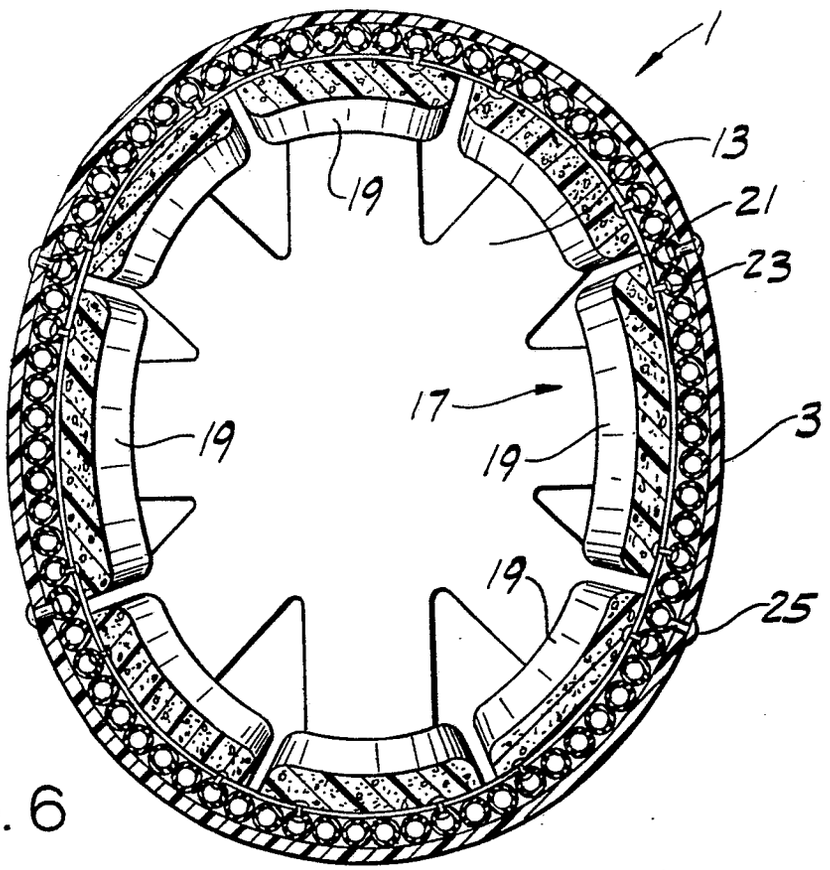


FIG. 6

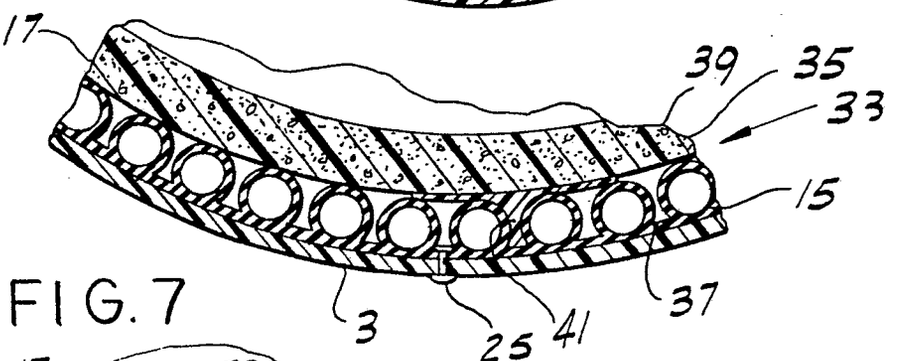


FIG. 7

