United States Patent [19]

Penberthy

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[54] **SAFETY HELMET**

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[52] **U.S. Cl.** .... **2/3 R,** 24/1, 24/201 R, 24/73 C

[51] **Int. Cl.** **A42b 3/00**

[58] **Field of Search** .... 2/3, 5, 6, 324, 314, 315, 2/316; 24/201 R, 222, 245, DIG. 3, 230, 73 C, 1; 292/253

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Primary Examiner—James R. Boler

[57] **ABSTRACT**

A safety helmet is provided with a crown suspension comprised of relatively inelastic crown straps secured to the helmet shell with energy-absorbing links. The links incorporate an energy-absorbing midsection designed to deform and elongate under substantially constant transmitted force conditions to a predetermined point and to thereafter rapidly transmit higher impact forces with only slight further elongation.

10 Claims, 7 Drawing Figures

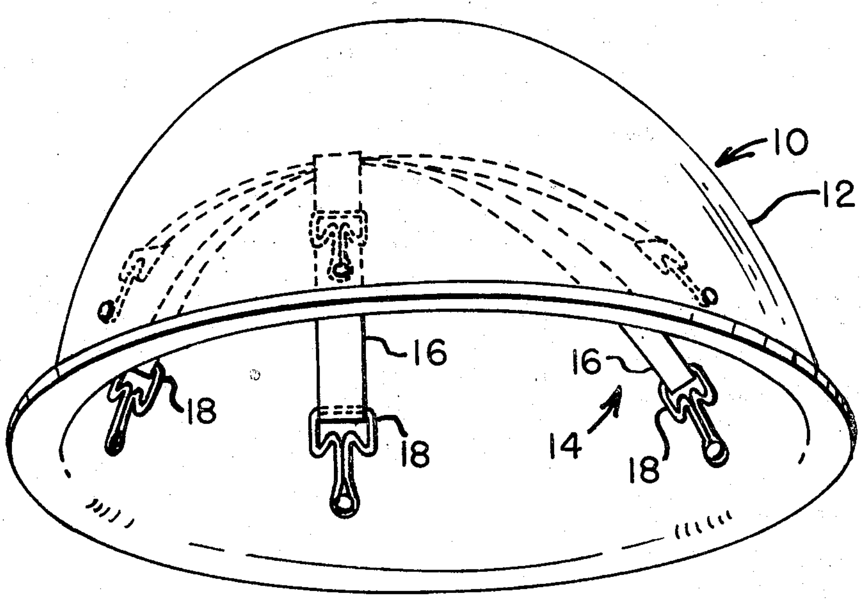

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FIG. 1

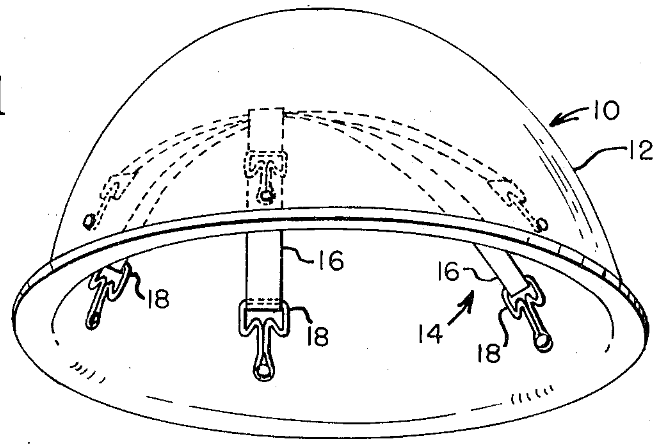


FIG. 3

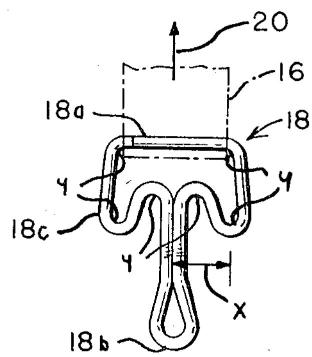
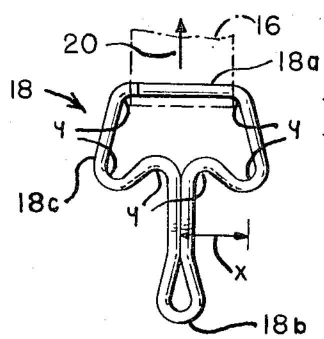


FIG. 4



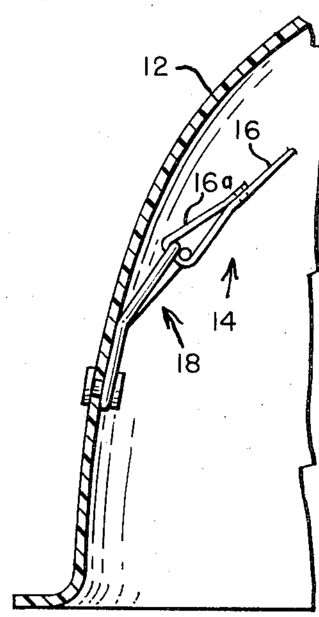


FIG. 2

FIG. 5

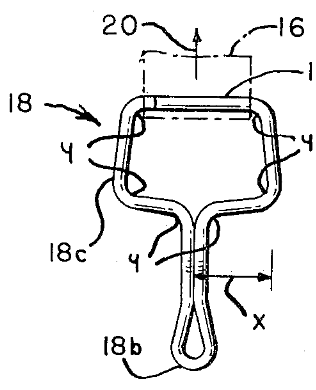


FIG. 6

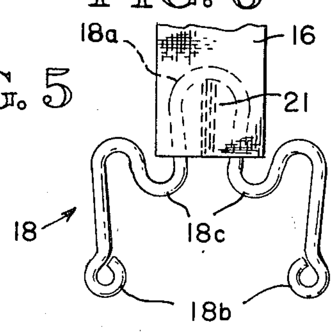
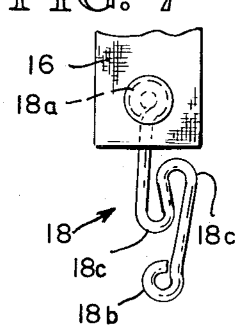


FIG. 7



SAFETY HELMET

This invention relates to safety helmets, particularly to climbing helmets.

The American National Standard Institute, Inc., has promulgated safety requirements for industrial head protection directed to protective helmets. (ANSI - Z89.1 - 1969). Generally, the requirements for safety helmets meeting this specification are that the helmet must have a dome-shaped shell of one-piece seamless construction, an adjustable headband, and a helmet suspension assembled to form a cradle for supporting the helmet shell on the wearer's head such that the distance between the top of the head and the underside of the shell cannot be adjusted to less than 1 – 1-¼inches as measured by section 8.32 of ANSI - Z89.1 - 1969. The helmet must have a penetration resistance as measured by section 8.4 of ANSI - Z89.1 - 1969 such that the shell will not be pierced more than ⅜ – 7/16 inches. The helmet must have an impact resistance as measured by section 8.3 of ANSI - Z89.1 - 1969 such that the helmet will not transmit an average force of more than 850 pounds.

In order to meet the impact and penetration resistance requirements, the helmet suspension cannot deform under impact conditions more than about ¾ inches in order to maintain adequate protective clearance, against piercing objects, between the top of the wearer's head and the underside of the shell. This requires that the helmet suspension must be capable of withstanding higher forces without significant deformation once the ¾ inch limit is reached. From the standpoint of climbing helmet design, exceeding the ¾ inch limit could result in such a substantial lessening of chin strap tension that the helmet would be dislodged if the climber fell, for example, as a result of an impact from a falling rock.

The prior art has proposed the utilization of a cradle strap suspension employing relatively inelastic cradle straps secured to the helmet shell by energy-absorbing devices. The energy-absorbing devices are designed to plastically deform under impact conditions, absorbing the energy of impact during deformation so as to reduce the transmitted impact force. Examples of such devices are disclosed in U.S. Pat. No. 2,758,305 issued to A. G. Gross. It is applicant's observation that the energy-absorbing geometry of devices of this type, which is a generally coil or serpentine geometry oriented in line with the force acting on each such device, will, when applied to safety helmets, transmit a total force greater than 850 pounds, when tested in accordance with ANSI procedures and when constrained to the ¾ inch deformation limit.

A primary object of the present invention is to provide a safety helmet crown suspension that will transmit an impact force of less than 850 pounds when tested in accordance with ANSI procedures and when constrained to a deformation of about ¾ inches. Another object is to provide such a crown suspension that will not significantly deform beyond the ¾ inch limit while withstanding significantly higher impact forces. Still another object is to provide an energy-absorbing linkage suitable for use in a safety helmet crown suspension meeting the above-noted objects.

In brief, the present invention, as applied to safety helmets, is a crown suspension comprising a plurality of crown straps assembled to support a helmet shell in

spaced relation to a wearer's head, and a plurality of energy-absorbing links securing the crown straps to the helmet shell. The material from which the crown straps is fabricated must be sufficiently "inelastic" (i.e.. sufficiently non-elongative and non-energy-absorbing) as to transmit a large portion of an impact force asserted against the helmet to the energy-absorbing links, thereby enabling the links to deform by elongation during impact. (This, of course, does not preclude the utilization of additional energy-absorbing means such as plastic foam liners.) The energy-absorbing links are fabricated as hereinafter described.

The present invention, as applied to safety devices in general, comprises an energy-absorbing link, as hereinafter described.

FIG. **1** is a perspective view depicting the invention applied to a safety helmet.

FIG. **2** is a partial side elevation view of the helmet further depicting the invention.

FIG. **3** is a full scale plan view of the energy-absorbing device of this invention.

FIGS. **4** and **5** are full scale plan views of the FIG. **3** device depicting the appearance of the device at two successive stages of deformation and elongation.

FIGS. **6** and **7** depict other energy-absorbing devices of this invention.

Referring specifically to the Figures, the helmet **10** comprises a shell **12** and a crown suspension **14**. The crown suspension includes a plurality of crown straps **16** secured to the helmet shell by a plurality of energy-absorbing links **18**. In the preferred embodiment depicted, three crown straps are anchored with six links.

Each energy-absorbing link **18** consists of a wire fabricated into a geometry having a strap-engaging section **18*a*** at one end, a shell-engaging section **18*b*** at the opposite end, and an energy-absorbing midsection **18*c***. The energy-absorbing midsection **18*c*** consists of two side-by-side serpentine segments oriented generally transversely to the link. Thus, the legs of each segment are oriented generally in the direction of the strap length with the inside leg of each segment merging into the shell-engaging section **18*b*** and the outside legs of each segment merging into the strap-engaging section **18*a***. Both segments are equally energy-absorbing and are oriented transversely to the line of impact force, applied to the link by the strap, as illustrated by the force vector **20**. As a result of the transverse orientation of the serpentine segments, an impact force will cause the links to deform and elongate in the manner shown in FIGS. **4 – 5.**

The initial reaction of the link to an impact force is deformation of the serpentine segments by the segment intermediate legs being translated to a position substantially perpendicular to the force vector **20**. Initially, for a very short distance, elastic deformation occurs. As translation of the segment intermediate legs continues, however, the elastic limit is exceeded, the force moment arms (indicated by double-headed arrow "x" for one segment) gradually increase, and the segment knees "y" become work hardened. The increase in the force moment arms reduces the force required to continue link deformation and extension. The work hardening of the segment knees increases the force required to continue link deformation and extension and substantially offsets the affect of the increased force moment arms. Consequently, once plastic deformation commences, the force transmitted through the cradle suspension will stabilize at a substantially constant level until the segment intermediate legs attain the aforementioned perpendicular position. The extent of link elongation at a substantially constant transmitted-force level may be increased or decreased by respectively increasing or decreasing the lengths of the segment legs.

Continued link deformation beyond the point depicted in FIG. **5** will effect a straightening in the segment knees between the outer and intermediate legs. Consequently, the force moment arms will shorten, work hardening of the segment knees will increase, and the force transmitted through the cable suspension will increase rapidly. The overall elongation of the link during the above-noted continued link deformation will be small compared to the elongation occurring initially.

The link shown in FIG. **3** is a preferred embodiment for application to a climbing helmet designed to meet the criteria of ANSI - Z89.1 - 1969. The link **18** is fabricated of 0.080 inch diameter mild steel wire. The wireform ends are welded together in a side-by-side relation to form the strap-engaging section **18***a*, as seen in FIG. **2.** Positioning the wireform ends in this manner provides an area of increased contact for the strap **16,** thereby reducing the degree of force localization on the strap loop **16***a*. The helmet shell anchoring end **18***b* is bent inward at an angle of about 20° so that the energy-absorbing midsection **18***c* is coplanar with the strap secured to the link. The link shown in FIG. **3** is designed to absorb impact energy in the following manner. The initial elastic deformation, which is generally in accordance with Hooke's Law, will occur with an elongation of not more than about 0.1 inches, at which point the elastic limit is reached. At the onset of plastic deformation, the transmitted force will reach a stabilized, substantially constant level. The transmitted force will remain at that level during further link elongation, about 0.65 inches. Thereafter, the transmitted force will rise rapidly with relatively little subsequent elongation.

The link will commence relaxation at a dynamically-applied force of about **120** pounds and will plastically deform at about that force level until deformed to the position depicted by FIG. **5.** Six of the links, therefore, provide a transmitted force level of about 720 pounds. The ANSI impact resistance test procedures impart an impact energy of 480 inch pounds to the helmet shell. A helmet provided with six of the preferred link embodiment is calculated to absorb about 546 inch pounds without exceeding the 850 pound transmitted force limit and the ¾ inch deformation limit.

The configuration of the anchoring ends of the link may be modified to accomodate other anchoring means so long as the character and function of the energy-absorbing midsection are not lost. For example, the wireform may be designed such that the free ends are located at the helmet shell-engaging end rather than the crown strap-engaging end. Further, both anchoring ends could be designed for attachment to cradle straps. The energy-absorbing segments may be the same image (i.e., appear identical) or the mirror image of each other.

The FIG. **6** embodiment is substantially similar to the FIG. **3** embodiment. The intermediate energy-absorbing midsection **18***c* is the same. The anchoring ends, however, are modified to suit other link anchors. The strap-engaging end **18***a* is designed for insertion into a strap loop and confinement therein by means such as stitching **22.** The helmet-engaging end **18***b* is designed for anchoring at two points rather than at only one point.

The FIG. **7** embodiment is essentially one-half of the preceeding embodiments. The energy-absorbing midsection **18c** constitutes a single, transversely oriented serpentine section and the anchoring ends **18***a* and **18***b* are designed for anchoring by means of rivets or other similar devices.

In appropriate circumstances, the energy-absorbing links could be employed between cradle strap segments. Thus, the links need not necessarily be secured at one anchoring end to the cradle shell. However, for ease of assembly, securing the links to the helmet shell is preferred.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A safety helmet having a helmet shell and means for supporting the helmet shell in spaced relation to the wearers head; an energy absorbing link secured to the helmet shell and to the supporting means, said link fabricated to provide opposite ends for securement to the shell and supporting means, and an energy absorbing mid-section comprising two side-by-side serpentine segments generally transversely to the link said link means fabricated in a wire form wherein the free ends of the wire form are secured together to provide a closed loop configuration and are oriented transversely to the link.

2. A safety helmet having a helmet shell in a plurality of crown straps supporting the helmet shell in spaced relation to a wearers head with each crown strap being provided with anchor loops, an energy absorbing link fabricated to provide opposite ends for anchoring and an energy absorbing mid-section comprising at least one serpentine segment oriented generally transversely to the link, said link being fabricated in a wire form with one anchoring end and a segment oriented transversely to the link and secured to the crown strap anchor loop and the other anchoring end secured to the helmet shell.

3. A safety helmet and a helmet shell and means for supporting the helmet shell in spaced relation of the wearers head, an energy absorbing link fabricated to provide opposite ends for anchoring and an energy absorbing mid-section comprising two side-by-side serpentine segments oriented generally transversely to the link, said link being fabricated in a wire form wherein the free ends of the wire form are formed to provide two anchoring points at one anchoring end for attachment to the helmet shell; and wherein one anchoring end is secured to the helmet shell and the other anchoring end secured to the helmet shell supporting means.

4. A safety helmet and a helmet shell and means for supporting the helmet shell in spaced relation to the wearers head, an energy absorbing link fabricated to provide opposite ends for anchoring an energy absorbing mid-section comprising at least one serpentine segment oriented generally transversely to the link, said link being fabricated in a wire form wherein the free ends of the wire form are formed to provide an anchoring point at each anchoring end wherein the link is incorporated into the helmet shell supporting means to provide a principal means of impact resistance.

5. In a safety helmet comprised of a helmet shell and a crown suspension, the crown suspension comprising relatively inelastic means for supporting the helmet shell in spaced relation to a wearer's head and energy-absorbing means, the improvement comprising the provision of a plurality of energy-absorbing links as said energy-absorbing means, each link having end anchor point sections and an energy-absorbing midsection comprising at least one serpentine segment oriented generally transversely to the link.

6. The helmet of claim **5** wherein each link comprises two side-by-side serpentine segments oriented generally transversely to the link.

7. The helmet of claim **6** wherein each link is fabricated in a wireform, the free ends of which are secured together to provide a closed loop configuration for attachment to the inelastic means.

8. The helmet of claim **6** wherein the inelastic means comprises a plurality of crown straps and wherein each link is fabricated in a wireform with one anchoring end comprising a segment oriented generally transversely to the link and secured to a crown strap.

9. The helmet of claim **6** wherein each link is fabricated in a wireform, the free ends of which are formed to provide two anchoring points attached to said helmet shell.

10. The helmet of claim **5** wherein each link is fabricated in a wireform, the free ends of which are formed to provide one anchoring point attached to said helmet shell and another anchoring point attached to said inelastic means.

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