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Bielefeld et al.

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(54) **RATCHET MECHANISM WITH UNITARY KNOB AND PINION CONSTRUCTION**

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A42B 1/22 (2006.01)

(52) **U.S. Cl.** **2/418**; 2/DIG. 11

(58) **Field of Classification Search** ..... 2/417, 2/418, 419, 420, 416, 183, DIG. 11, 8; 132/59; 24/68 B, 274 WB, 664, 578.15
See application file for complete search history.

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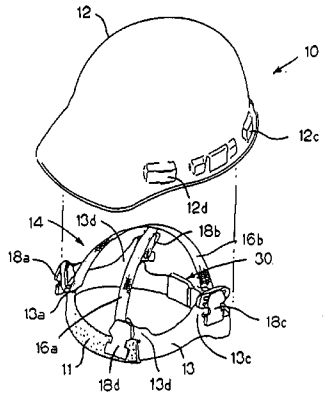
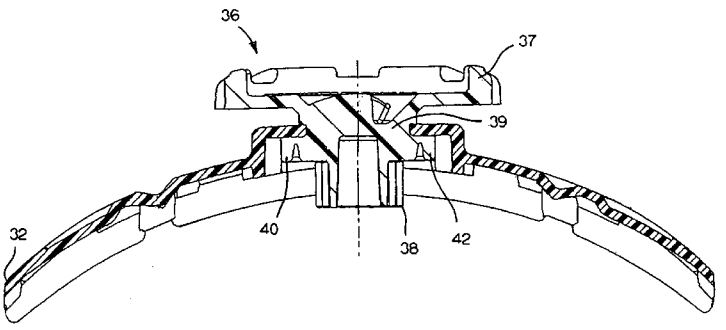
(57) **ABSTRACT**

A ratchet mechanism for the headband of a protective helmet or other headgear minimizes the number of components while ensuring precise, reliable operation of the rack and pinion arrangement of the ratchet mechanism. A headband of a protective helmet or similar headgear generally has overlapping rear end portions which are enclosed in a housing. The ratchet mechanism includes a rotational element, which in this case is a unitary body that includes an adjustment knob portion which is positioned on an exterior side of the outer housing section and a pinion portion which is positioned on an interior side of the outer housing section is adapted to mate with and engage the respective rack gears of the overlapping rear end portions of the headband.

10 Claims, 8 Drawing Sheets





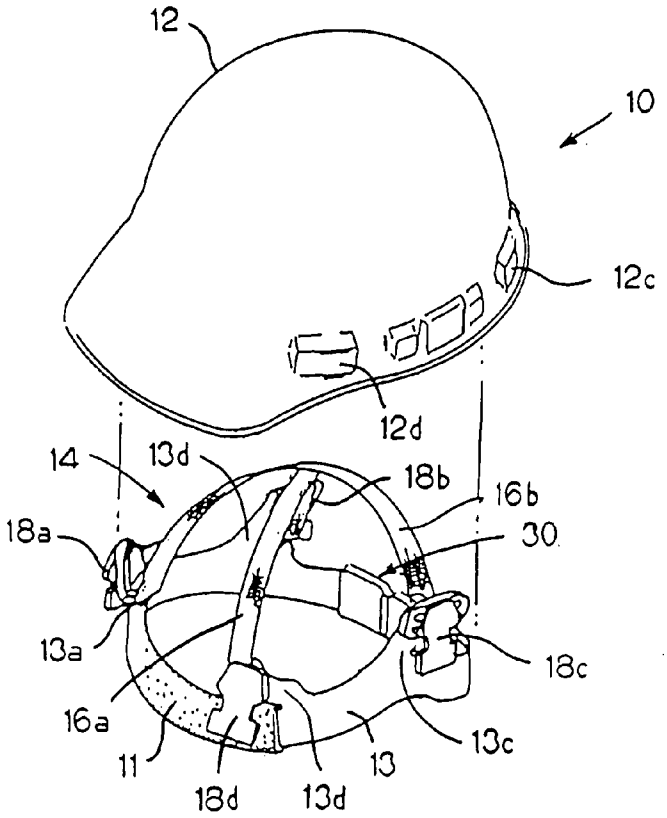

12
10
12c
12d
14
13d
18b
16b
18a
30
13a
18c
16a
13c
11
13
18d
13d

FIG. 1

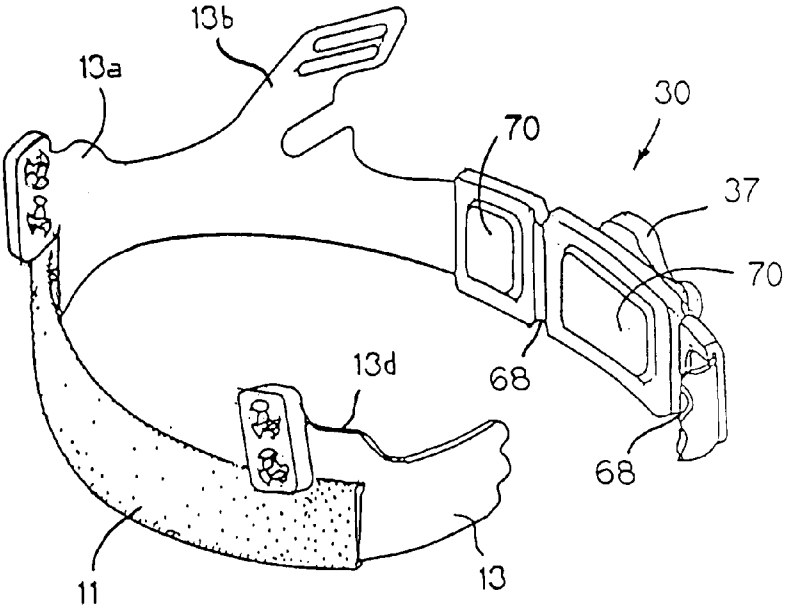
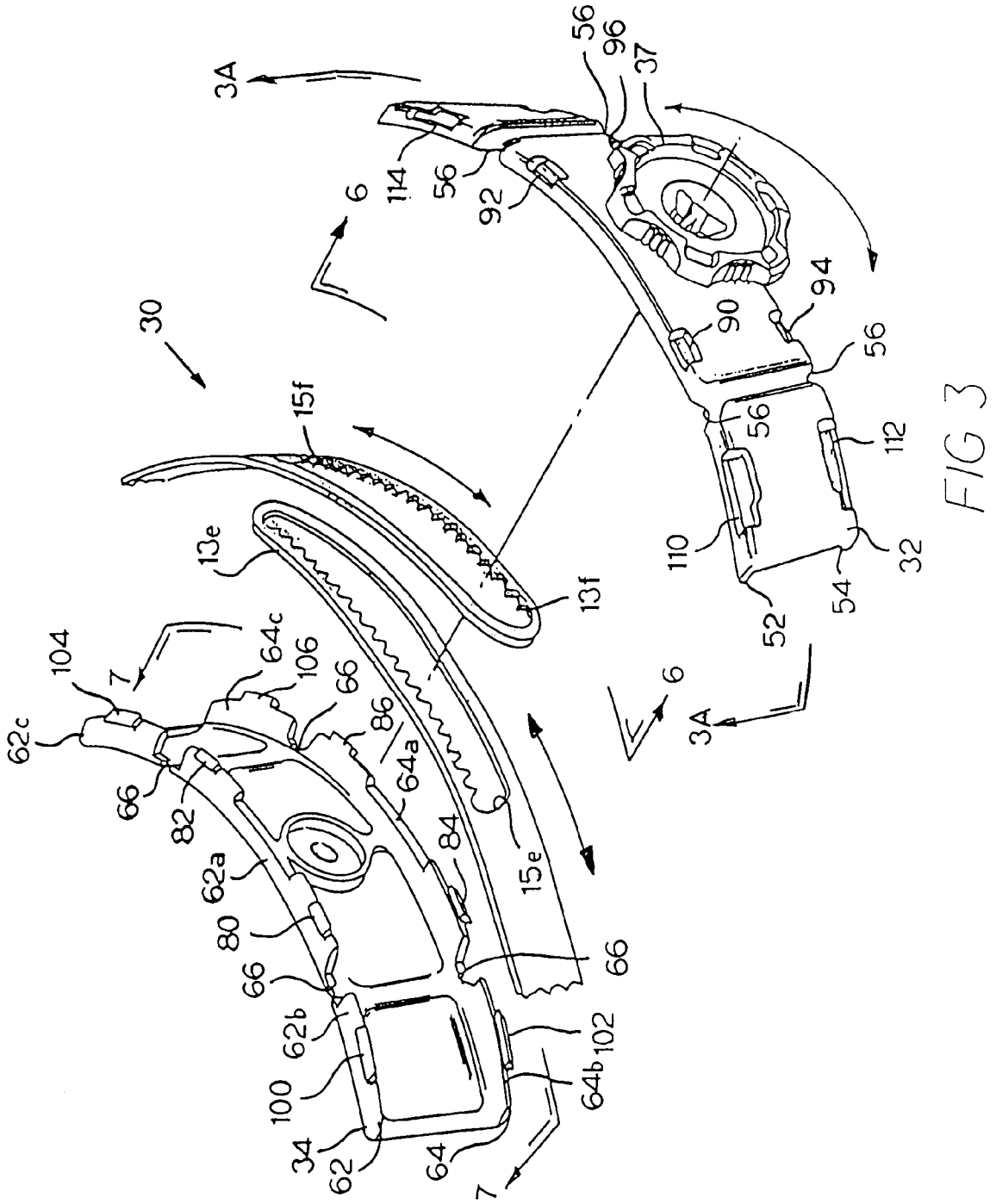

13b
13a
30
70
37
70
13d
68
68
11
13

FIG. 2


3A
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96
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114
56
92
30
94
90
56
15f
56
112
13e
110
13f
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54
52
6
3A
104
7
64c
106
62c
66
86
66
64a
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62a
15e
80
66
66
62b
102
100
64b
34
62
64
7

FIG 3

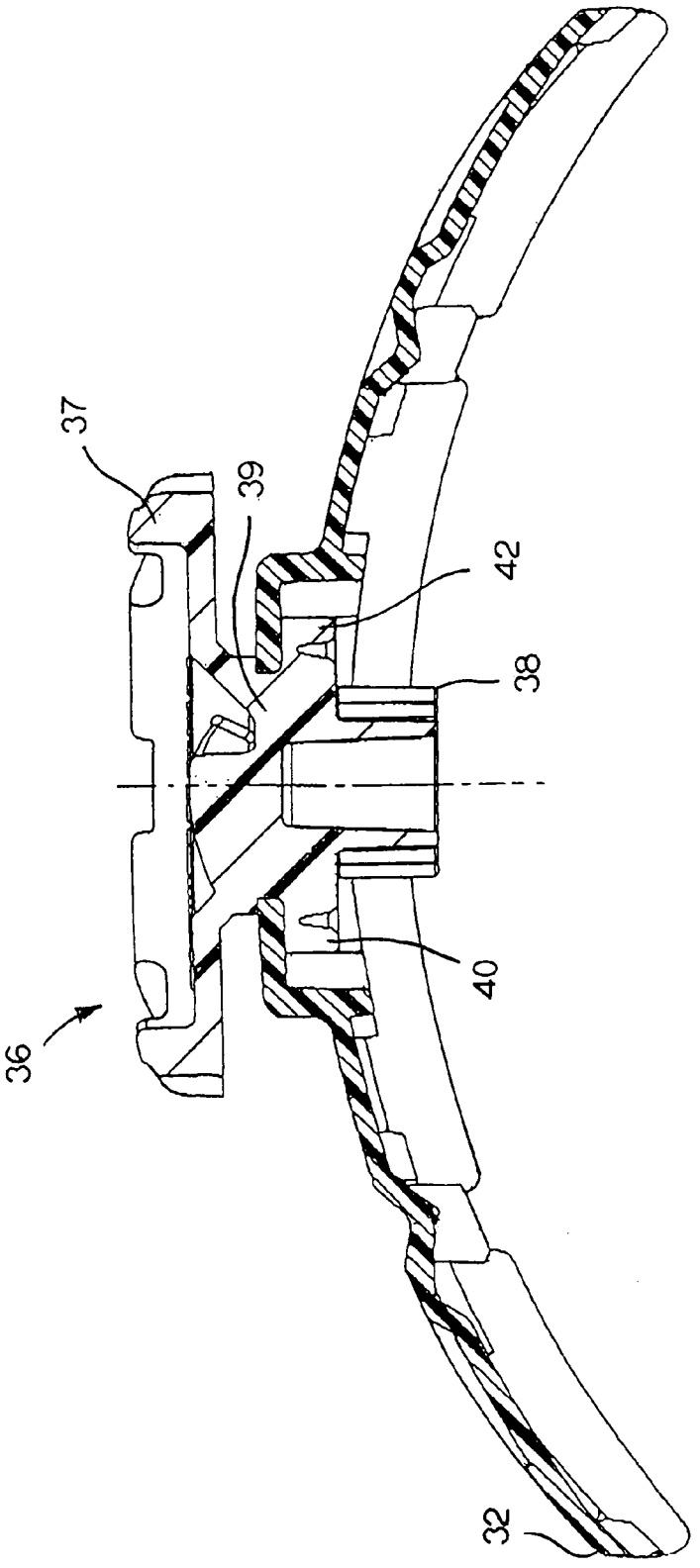


FIG. 3A

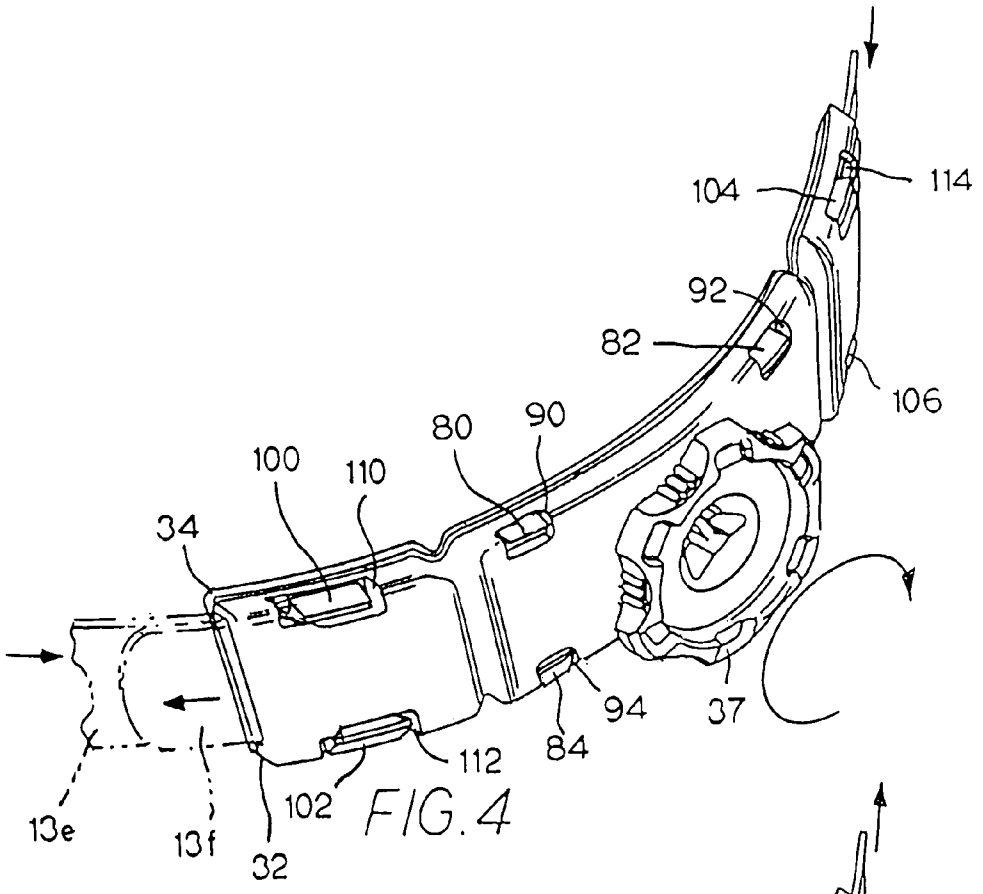
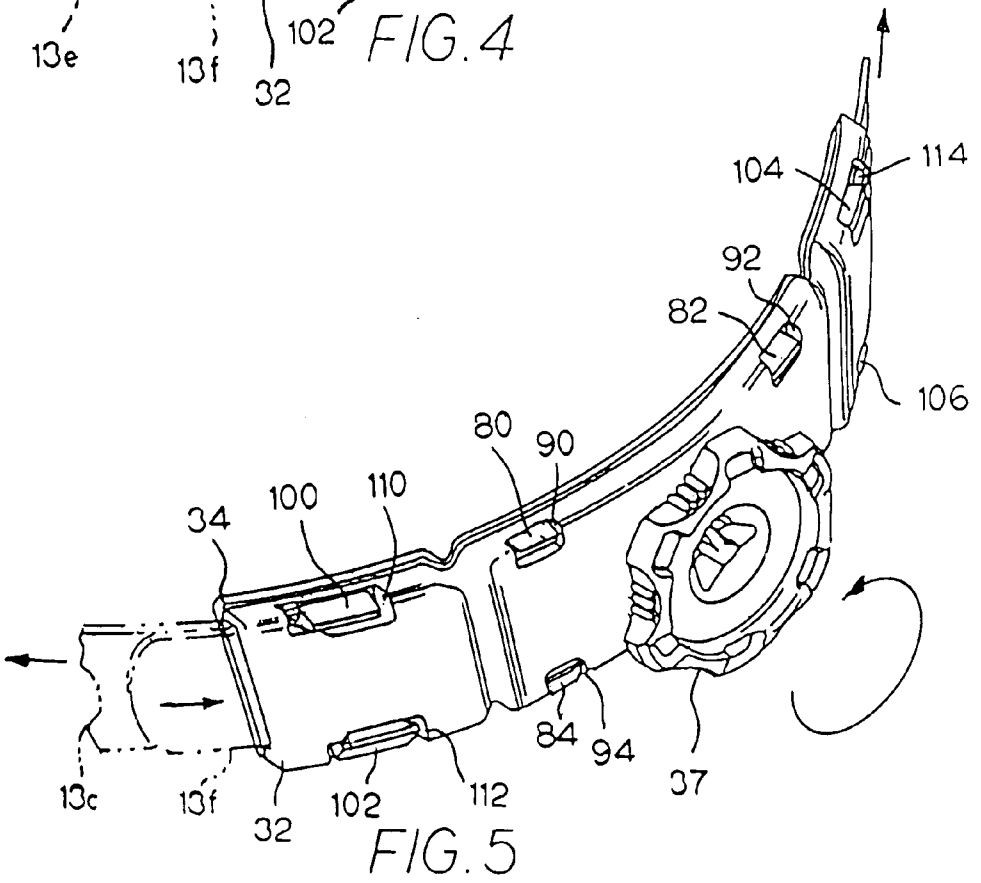

104
114
92
82
106
80
90
100
110
34
94
37
84
112
102
13e
13f
32

FIG. 4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106
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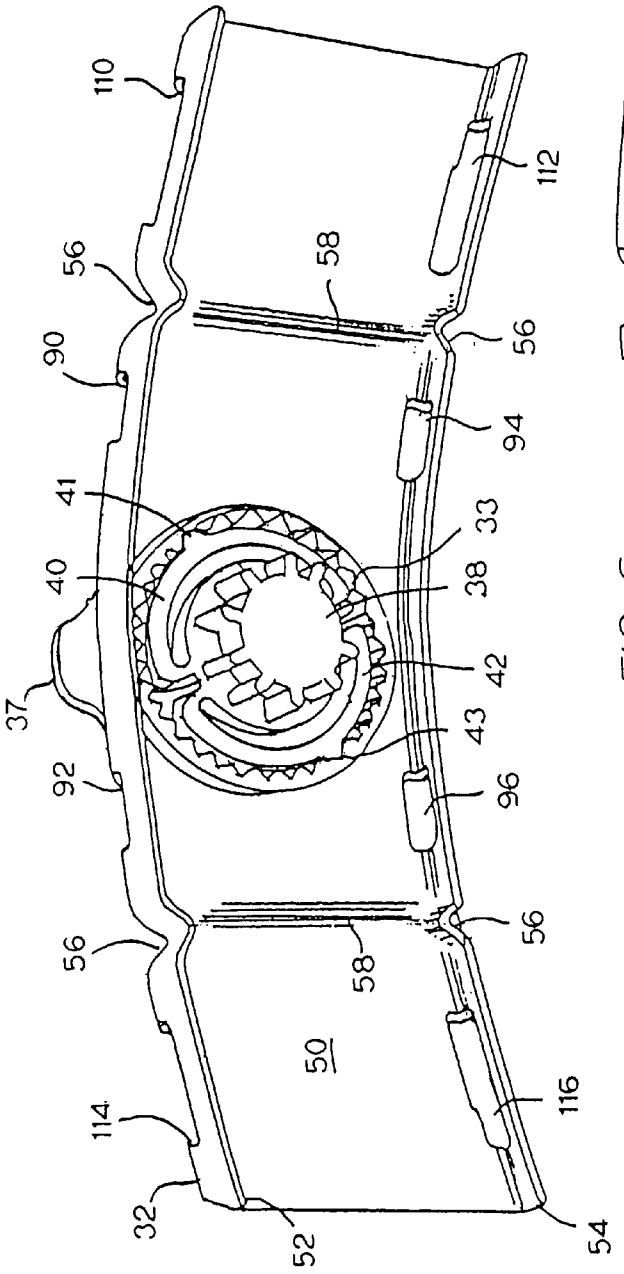
110
34
84
94
37
112
102
13c
13f
32

FIG. 5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56
90
94
41
33
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38
42
37
43
92
96
56
58
56
50
114
116
32
52
54

FIG. 6

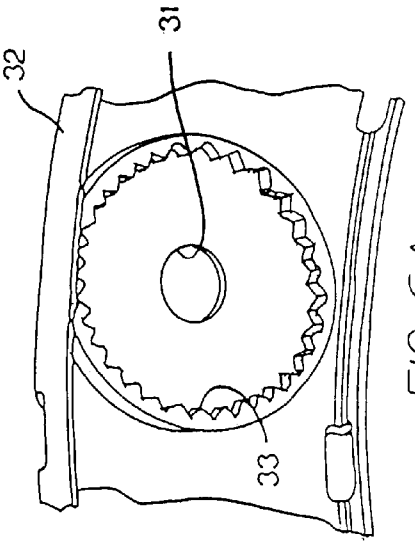
31
32
33

FIG. 6A

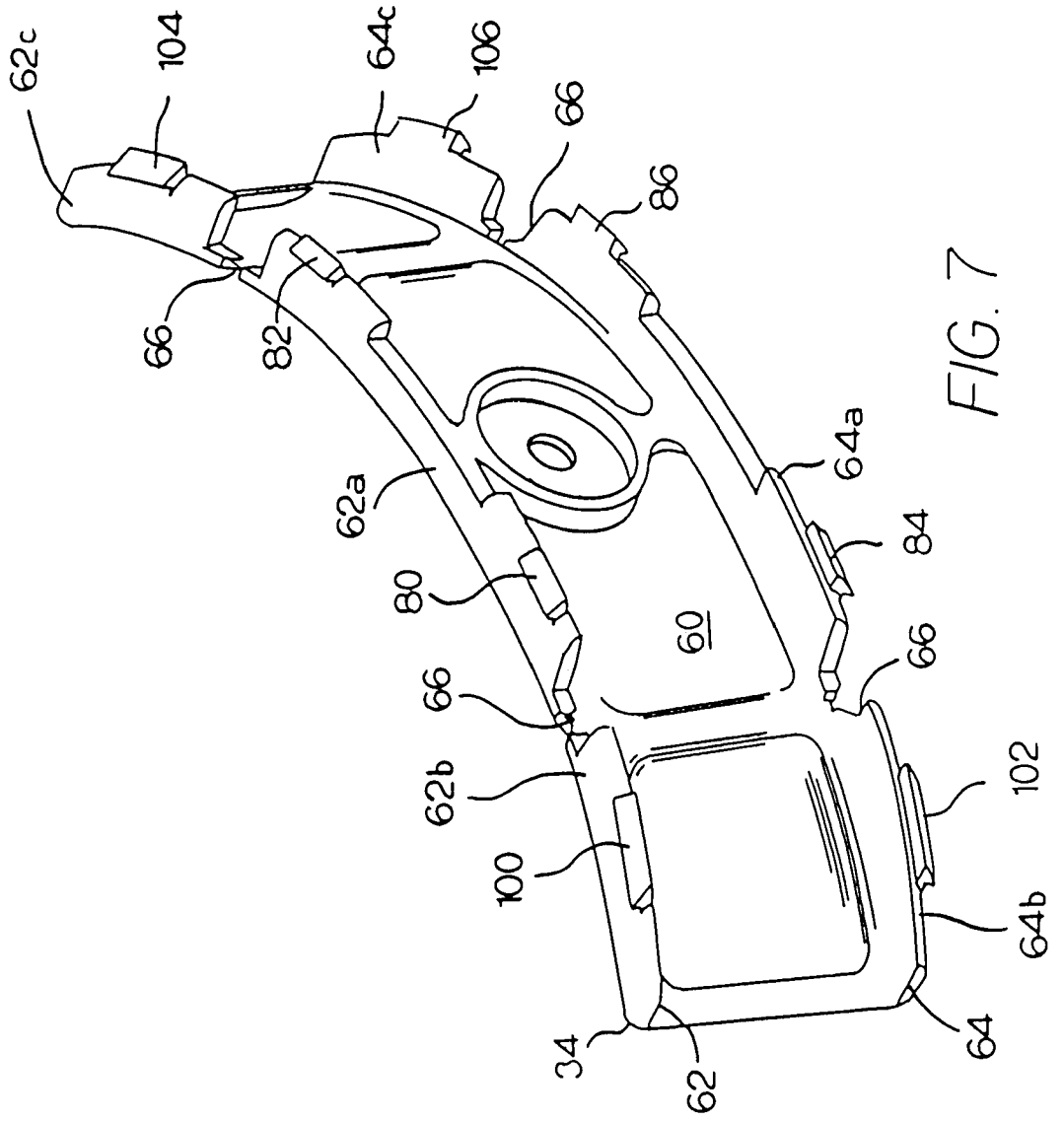
62c
104
64c
106
66
86
66
82
62a
64a
84
80
60
66
66
62b
102
100
64b
34
62
64

FIG. 7

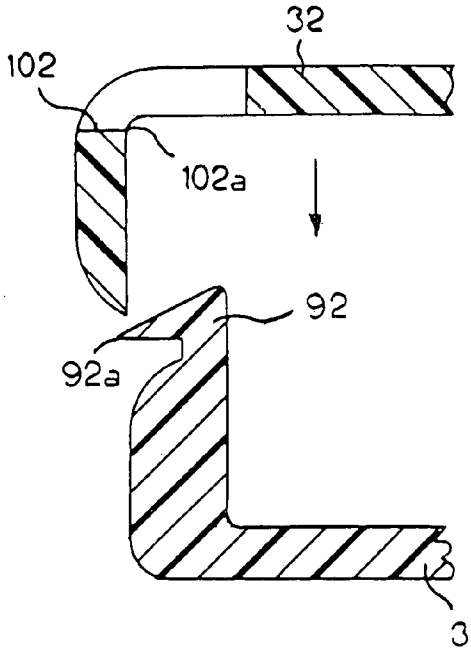

FIG. 8

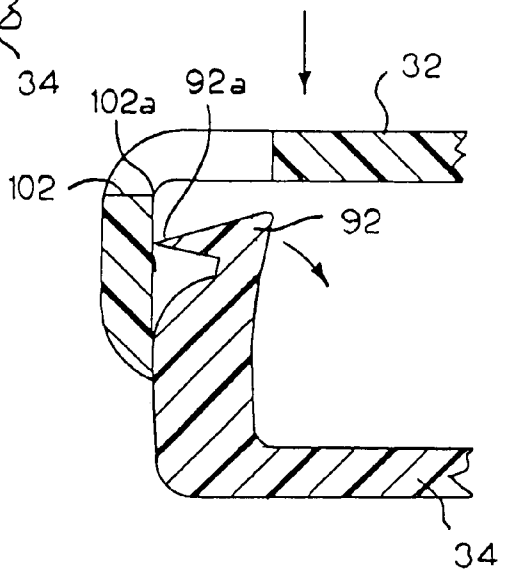

FIG. 9

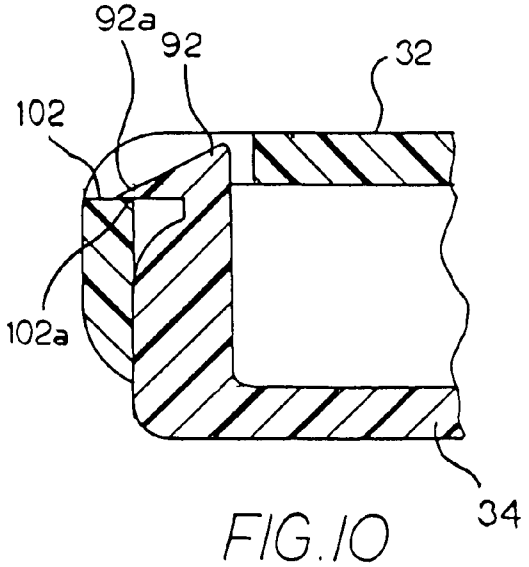

FIG. 10

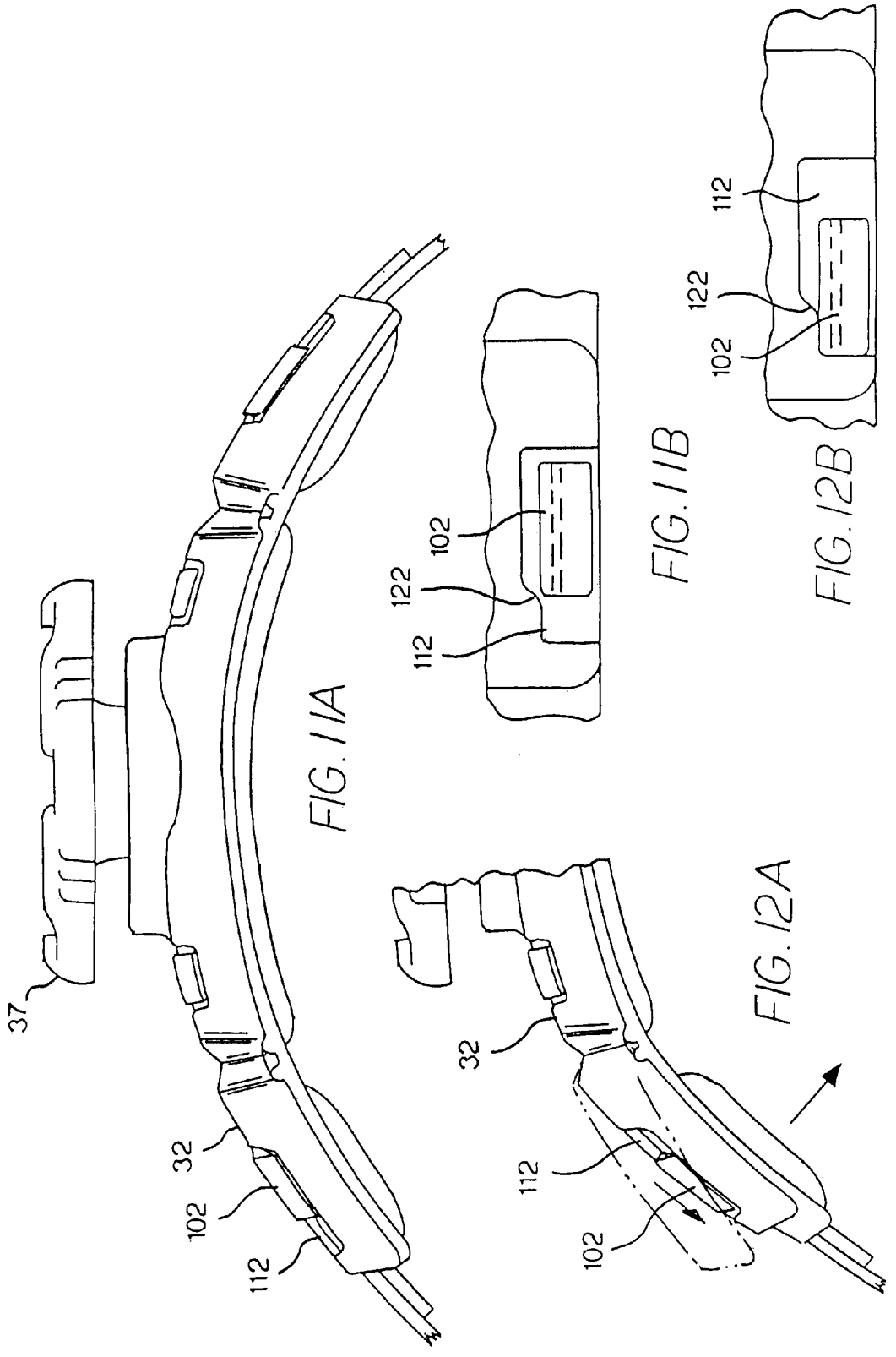

FIG. 11A

FIG. 11B

FIG. 12B

FIG. 12A

RATCHET MECHANISM WITH UNITARY KNOB AND PINION CONSTRUCTION

BACKGROUND OF THE INVENTION

The present invention relates to a ratchet mechanism for the headband of a protective helmet or similar headgear, a mechanism that allows for adjustment of the size and fit of the headband.

Protective helmets are commonly worn in the industrial workplace to prevent or reduce the likelihood of head injuries. The hard hat is the most common and well-recognized protective helmet. A hard hat consists of three primary components—a shell, a headband, and a suspension system—which cooperate to reduce the potential for injury by attenuating some translational energy of the force of an impact to the helmet.

With respect to the construction and protection afforded by a hard hat, the American National Standards Institute ("ANSI") promulgates minimum performance requirements for protective helmets and further classifies helmets based on their ability to reduce the forces of impact and penetration, as well as their ability to protect against high voltage electric shock. See, for example, ANSI Z89.1-1997 (R1998), American National Standard for Industrial Head Protection.

As mentioned above, a hard hat or similar protective helmet is comprised primarily of: a shell, a headband, and a suspension system. These primary hard hat components cooperate to provide the requisite level of protection. The hard hat shell itself causes any force of impact to be spread across the surface area of the shell. The hard hat suspension separates the wearer's head from the shell such that there is an air gap between the shell and the wearer's head that provides for further attenuation of the force of an impact to the shell. Specifically, when an object strikes the shell of the hard hat, the shell itself flexes inward and the straps of the suspension system will stretch. The air gap accommodates the flexing of the shell and stretching of the straps, but, under normal conditions, prevents the wearer's head from contacting the hard hat shell.

Of course, for a hard hat to provide the appropriate level of protection, it must fit snugly on the wearer's head. In this regard, it is common for the headband of a hard hat to be adjustable to provide for such a snug fit. In this regard, a headband typically has one of two common sizing mechanisms, a pin-lock arrangement or a ratchet mechanism. Regardless of the chosen sizing mechanism, the headband is commonly a flexible, one-piece member that has overlapping rear end portions. With a pin-lock mechanism, a first of the rear end portions of the headband is provided with a pin, and the second of the rear end portions is provided with series of holes at spaced intervals. As such, the pin of the first rear end portion can be inserted through one of the holes of the second rear end portion, thus forming a loop of a selected circumference to fit snugly around the wearer's head. With a ratchet mechanism, lateral movement of the overlapping rear end portions of the headband is effectuated through a rack and pinion arrangement or similar gear arrangement.

As one example of a ratchet mechanism, reference is made to U.S. Pat. No. 4,888,831 issued to Oleson, a patent that is incorporated herein by this reference. As described in the '831 Patent, a preferred ratchet mechanism is often a rack and pinion arrangement which operates within elongated overlapping slots defined by the rear end portions of the headband, each of said slots defining a series of teeth of a rack gear. The rack and pinion arrangement and the overlapping rear end portions of the headband are housed between a pair of adjoining arc-shaped housing sections which generally conform to the contour of the wearer's head. The rear end portions of the headband are seated for slidable, lateral movement within the arc-shaped housing sections.

Referring still to the '831 Patent, and specifically FIG. **3**, one preferred rack and pinion arrangement includes five components: (1) an adjusting knob; (2) a first sprocket that is operably secured to the adjusting knob and engages mating gear teeth defined by the outer housing section, the rearward facing of the two housing sections that enclose the headband; (3) a second sprocket that is operably secured to the first sprocket and engages the teeth of the rack gears of the overlapping rear end portions of the headband; (4) a plate or washer interposed between the first and second sprockets; and (5) a spring or similar biasing member interposed between the first sprocket and the plate so as to bias the first sprocket into engagement with the mating gear teeth defined by the outer housing section. The adjusting knob, first sprocket, and the second sprocket all turn together, with clockwise rotation of the adjusting knob tightening the headband, and counterclockwise rotation of the adjusting knob loosening the headband. The interposed plate and spring bias the first sprocket into engagement with the mating gear teeth defined by the outer housing section so that the rear end portions of the headband do not slide or move without appropriate action by the wearer. In other words, since the interposed plate and spring bias the first sprocket into engagement with the mating gear teeth defined by the outer housing section, the position of the rear end portions of the headband is locked absent manipulation of the adjustment knob by the wearer.

For another example of a rack and pinion arrangement, reference is made to U.S. Pat. No. 5,950,245 issued to Binduga. Again, the headband has overlapping rear end portions. Elongated slots are defined by the rear end portions of the headband, with each of said slots defining a series of teeth of a rack gear. As described in the '245 Patent with reference to FIGS. **1** and **2**, the rack and pinion arrangement preferably includes (1) an adjustment knob with a first end section for providing a grip member suitable for gripping and turning by the wearer and a second end section that is a generally circular cog, the circular cog engaging the teeth of the rack gears defined by the overlapping rear end portions of the headband; (2) a spring assembly integral with or otherwise secured to the adjustment knob; (3) a housing having outer and inner arc-shaped sections that collectively define an internal cavity; and (4) a ring gear assembly fixed within the housing that cooperates with the spring assembly to provide resistance to rotation of adjustment knob. Thus, in practice, rotation of the adjustment knob causes lateral movement of the overlapping rear end portions of the headband relative to one another. However, because the spring assembly has at least one spring tooth projecting radially and adapted for mating with radially projecting teeth of the ring gear assembly, the position of the rear end portions of the headband is essentially locked absent manipulation of the adjustment knob by the wearer.

For yet another example of a rack and pinion arrangement, reference is made to U.S. patent application Ser. No. 10/899,467, which is also incorporated herein by reference. Again, the rack and pinion arrangement and the overlapping rear end portions of the headband are housed between a pair of adjoining arc-shaped housing sections which generally conform to the contour of the wearer's head. The rear end portions of the headband are seated for slidable, lateral movement within the arc-shaped housing sections, again in

response to the rotation of an adjustment knob. Furthermore, as described in U.S. patent application Ser. No. 10/899,467, the arc-shaped housing sections have an inherent flexibility that provides for better fit of the headband and increased comfort to the wearer.

However, the rack and pinion arrangements described in the prior art are generally comprised of a number of individual parts, requiring labor-intensive assembly and also increasing the risk of imprecise or flawed operation of the rack and pinion arrangement. For example, the adjustment knob and pinion (also referred to as a sprocket or cog in some of the prior art references) are often separate parts that are assembled together after the shaft of the adjustment knob is passed through the outer housing section. Alternatively, as described in the above-referenced '245 Patent, if the adjustment knob and pinion are a unitary part, the outer housing section must be comprised of multiple parts to allow assembly of the components of the rack and pinion arrangement

It would therefore be desirable to provide an improved construction for a ratchet mechanism for the headband of a protective helmet or other headgear so as to minimize the number of components and ensure precise, reliable operation of the rack and pinion arrangement of the ratchet mechanism.

SUMMARY OF THE INVENTION

The present invention is a ratchet mechanism for the headband of a protective helmet or other headgear that minimizes the number of components while ensuring precise, reliable operation of the rack and pinion arrangement of the ratchet mechanism.

The headband of a protective helmet or similar headgear generally has overlapping rear end portions which are enclosed in a housing, which is preferably comprised of an outer substantially arc-shaped housing section joined to a inner substantially arc-shaped housing section, thus defining an internal cavity for receiving the overlapping rear end portions of the headband. Of particular importance to the present invention, the ratchet mechanism also includes a rotational element, which in this case is a unitary body that includes an adjustment knob portion which is positioned on an exterior side of the outer housing section, and a pinion portion which is positioned on an interior side of the outer housing section and within the internal cavity defined by the housing. This rotational element therefore may be characterized as having a unitary construction. In any event, the pinion is adapted to mate with and engage the respective rack gears of the overlapping rear end portions of the headband such that rotation of the pinion causes lateral movement of the overlapping rear end portions with respect to one another.

Furthermore, the outer housing section of the ratchet mechanism is also a unitary body in that it is not comprised of multiple discrete components. Because of this unitary construction of the rotational element and the unitary nature of the outer housing section, these two components can not be joined or assembled to one another in a traditional sense. Rather, these components must be manufactured substantially simultaneously, with the rotational element essentially being molded around the outer housing section.

Therefore, as a result of the unitary knob and pinion construction, assembly of the ratchet mechanism is significantly simplified, and there are no small parts that require tedious and time-consuming assembly efforts. Furthermore, through the molding process, dimensional tolerances can be tightly controlled, leading to improved reliability and performance.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of a hard hat having an exemplary ratchet mechanism made in accordance with the present invention;

FIG. **2** is an enlarged perspective view of a portion of the headband and associated ratchet mechanism of the hard hat of FIG. **1**;

FIG. **3** is an exploded perspective view of the exemplary ratchet mechanism of the hard hat of FIG. **1**;

FIG. **3**A is a sectional view of a portion of the exemplary ratchet mechanism of FIG. **1** taken along line **3**A—**3**A of FIG. **3**;

FIG. **4** is a perspective view of the exemplary ratchet mechanism of FIG. **1**, illustrating movement of the rear end portions of the headband caused by clockwise rotation of an adjustment knob;

FIG. **5** is a perspective view of the exemplary ratchet mechanism of FIG. **1**, illustrating movement of the rear end portions of the headband caused by counterclockwise rotation of the adjustment knob;

FIG. **6** is a perspective view of the outer housing section of the exemplary ratchet mechanism of FIG. **1** taken along line **6**—**6** of FIG. **3**, with the rotational element received in the ring gear;

FIG. **6**A is a perspective view of the outer housing section of the exemplary ratchet mechanism of FIG. **1**, similar to the view of FIG. **6**, but with the rotational element removed to better illustrate the ring gear;

FIG. **7** is a perspective view of the inner housing section of the exemplary ratchet mechanism of FIG. **1** taken along line **7**—**7** of FIG. **3**;

FIGS. **8**–**10** are sectional views of the inner and outer housing sections of the exemplary ratchet mechanism of FIG. **1**, illustrating how the respective housing sections are joined to one another;

FIG. **11**A is a partial side view of the exemplary ratchet mechanism of FIG. **1**, illustrating the relationship between an outer tab and a retaining bump when the exemplary ratchet mechanism is in a resting position;

FIG. **11**B is a detailed view of the relationship between the outer tab and the retaining bump when the exemplary ratchet mechanism is in the resting position illustrated in FIG. **11**A;

FIG. **12**A is a partial side view of the exemplary ratchet mechanism of FIG. **1**, illustrating the relationship between an outer tab and a retaining bump when the exemplary ratchet mechanism is in a flexed position; and

FIG. **12**B is a detailed view of the relationship between the outer tab and the retaining bump when the exemplary ratchet mechanism is in the flexed position illustrated in FIG. **12**A.

DESCRIPTION OF THE INVENTION

The present invention is a ratchet mechanism for the headband of a protective helmet or other headgear that minimizes the number of components while ensuring precise, reliable operation of the rack and pinion arrangement of the ratchet mechanism.

FIG. **1** is an exploded perspective view of an exemplary hard hat **10** that includes a ratchet mechanism made in accordance with the present invention. As shown, this hard

hat **10** generally includes: a substantially rigid shell **12** shaped to protect the wearer's head, said shell **12** defining a bottom opening and an internal cavity for receiving the wearer's head; a headband **13** with an absorbent brow pad **11**; and a suspension **14**. In this exemplary embodiment, the hard hat **10** has a 4-point suspension **14** comprising two intersecting straps **16***a*, **16***b*. A key **18***a*, **18***b*, **18***c*, **18***d* is secured to each end of each of the straps **16***a*, **16***b*. Thus, to secure the suspension **14** to the shell **12** of the hard hat **10**, the shell **12** includes four key sockets spaced about the periphery of the shell **12**, each such key socket being molded into the shell **12** and adapted to receive one of the keys (generally and collectively indicated by reference numeral **18**). In this regard, key sockets **12***c* and **12***d* are illustrated and labeled in FIG. **1**. It is contemplated and preferred that the keys **18** be constructed such that they can be "locked" into the key sockets. For further detail regarding one preferred construction of the keys **18** and associated key sockets, reference is made to U.S. Pat. No. 6,609,254, which is incorporated herein by reference.

As shown in FIGS. **1** and **2**, the headband **13** has a plurality of upwardly extending appendages **13***a*, **13***b*, **13***c*, **13***d*. Each such appendage **13***a*, **13***b*, **13***c*, **13***d* corresponds with a respective key **18***a*, **18***b*, **18***c*, **18***d* of the suspension **14**, such that the keys **18** can be secured to the headband **13**, completing assembly of the essential components of the hard hat **10**.

Nevertheless, the attachment of the headband **13** and suspension straps **16***a*, **16***b* to the shell **12** of the hard hat **10** is not the focus of the present application. Indeed, it is recognized that various attachment means could be employed without departing from the spirit and scope of the present invention. Rather, the present invention relates to a ratchet mechanism for the headband **13** of a hard hat **10** or other protective headgear, as generally indicated by reference numeral **30** in FIGS. **1** and **2**.

Referring now to FIG. **3**, the preferred components of a ratchet mechanism **30** made in accordance with the present invention are illustrated. First, the headband **13** itself has overlapping rear end portions **13***e*, **13***f*. Each of these portions **13***e*, **13***f* preferably defines an elongated slot **15***e*, **15***f* and associated rack gear, the rack gear of one portion **13***e* defined along the upper edge of the slot **15***e*, and the rack gear of the second portion **13***f* defined along the lower edge of the slot **15***f*.

The overlapping rear end portions **13***e*, **13***f* are enclosed in a housing, which is preferably comprised of an outer substantially arc-shaped housing section **32** joined to an inner substantially arc-shaped housing section **34**, thus defining an internal cavity for receiving the overlapping rear end portions **13***e*, **13***f* of the headband **13**. Each of these housing sections **32**, **34** is preferably made of polypropylene or a similar plastic material. Of particular importance to the present invention, the ratchet mechanism **30** also includes a rotational element **36**, which in this case is a unitary body that includes an adjustment knob portion **37** which is positioned on an exterior side of the outer housing section **32**, and a pinion portion **38** which is positioned on an interior side of the outer housing section **32** and within the internal cavity defined by the housing. This rotational element **36** therefore may be characterized as having a unitary construction, the details of which are further described below.

In any event, the pinion **38** is adapted to mate with and engage the respective rack gears of the overlapping rear end portions **13***e*, **13***f* of the headband **13** such that rotation of the pinion **38** causes lateral movement of the overlapping rear end portions **13***e*, **13***f* with respect to one another.

Furthermore, similar to prior art constructions, the rotational element **36** is further provided with an integral spring assembly, which, in this exemplary embodiment, is comprised of two substantially semi-circular arch portions **40**, **42** disposed on opposite sides of the central axis of rotation of the rotational element **36**. A spring tooth **41**, **43** extends from each of the arch portions **40**, **42**. As best shown in FIGS. **6** and **6**A, the outer housing section **32** defines a ring gear **33** that circumscribes an opening **31** through which a shaft portion **39** of the rotational element **36** passes. Thus, the respective spring teeth **41**, **43** extending from each of the arch portions **40**, **42** of the spring assembly mate with and engage the teeth of the ring gear **33**, locking the position of the rotational element **36**, and thus the rear end portions **13***e*, **13***f* of the headband **13** relative the outer housing section **32**. However, when the adjustment knob **37** of the rotational element **36** is manually turned by a wearer, the spring teeth **41**, **43** are forced over the teeth of the ring gear **33** by radially inward compression of the arch portions **40**, **42** of the spring assembly. In other words, by imparting a sufficient torque on the rotational element **36**, the wearer can overcome the spring force and effectuate lateral movement of the overlapping rear end portions **13***e*, **13***f* of the headband **13** relative to one another. As shown in FIG. **4**, clockwise rotation of the adjustment knob **37** moves the rear end portions **13***e*, **13***f* of the headband toward one another, decreasing the circumference of the headband **13**. On the other hand, as shown in FIG. **5**, counterclockwise rotation of the adjustment knob **37** moves the rear end portions **13***e*, **13***f* of the headband away one another, increasing the circumference of the headband **13**. Once the wearer ceases rotation of the adjustment knob **37**, the spring teeth **41**, **43** are restored to engagement with the teeth of the ring gear **33**, again locking the position of the rear end portions **13***e*, **13***f* of the headband **13**.

Returning to the construction of the rotational element **36**, reference is now made to the sectional view of FIG. **3**A. Again, the rotational element **36** is a unitary body that includes an adjustment knob portion **37** which is positioned on an exterior side of the outer housing section **32**, and a pinion portion **38** which is positioned on an interior side of the outer housing section **32** and within the internal cavity defined by the housing. Furthermore, this unitary body includes the above-referenced integral spring assembly, which, in this exemplary embodiment, is comprised of two substantially semi-circular arch portions **40**, **42** with a spring tooth **41**, **43** extending from each of the arch portions **40**, **42**.

As shown in FIG. **3**A, the outer housing section **32** of the ratchet mechanism **30** is also a unitary body in that it is not comprised of multiple discrete components, with the ring gear **33** mentioned above being molded into and integral with the outer housing section **32**. Because of this unitary construction of the rotational element **36** and the unitary nature of the outer housing section **32**, these two components can not be joined or assembled to one another in a traditional sense. Rather, these components must be manufactured substantially simultaneously, with the rotational element **36** essentially being molded around the outer housing section **32**. In other words, the rotational element **36** is molded through the opening **31** defined by the outer housing section **32**, with the adjustment knob portion **37** and the pinion portion **38** positioned on opposite sides of the outer housing section **32**.

This molding process is generally accomplished using a two-shot molding in which a plastic, such as polypropylene, for forming the outer housing section **32**, including the integral ring gear **33**, is first injected into a mold cavity (i.e.,

the "first shot"). Once the preform is adequately cooled, a second plastic, such as a thermal plastic elastomer (TPE), is injected into the mold cavity for forming the rotational element **36** around the outer housing section **32** (i.e., the "second shot"). Specifically, one preferred means by which to accomplish this two-shot molding is by using a rotary method with an index plate in which the first shot produces a preform, which is then rotated 180° by the index plate to a second injection position where the second shot is used to complete the molding. For example, one preferred mold press for accomplishing the molding required by the present invention is the Van Dom Multi™ mold press, which is manufactured and distributed by the Demag Plastics Group Corp. of Strongsville, Ohio, and allows for an L-position second injection unit to inject the second shot from the offside of the press. Furthermore, with respect to the plastics used in the molding process, various plastic materials may be used without departing from the spirit and scope of the present invention, with the understanding that different plastics must be used for the outer housing section **32** and the rotational element **36**, so that they will not become bonded together during the molding process.

As a result of the unitary knob and pinion construction, assembly of the ratchet mechanism **30** is significantly simplified, requiring only positioning of the rear end portions **13***e*, **13***f* of the headband **13** in engagement with the pinion portion **38** of the rotational element **36** before securing the inner housing section **34** to the outer housing section **32**. There are no small parts that require tedious and time-consuming assembly efforts. Furthermore, through the molding process, dimensional tolerances can be tightly controlled, leading to improved reliability and performance. For example, the torque required to turn the adjustment knob **37** should be very consistent among multiple ratchet mechanisms **30** manufactured and assembled in accordance with the present invention. Finally, there is no way for the adjustment knob **37** to become disengaged from the pinion portion **38** of the rotational element **36** absent catastrophic failure of the rotational element **36**.

Furthermore, as described in U.S. patent application Ser. No. 10/899,467, the arc-shaped housing sections **32**, **24** in this exemplary embodiment have an inherent flexibility that provides for better fit of the headband and increased comfort to the wearer, although such flexibility is immaterial to the unitary nature of the rotational element **36** described above.

Referring again to FIG. **6**, the outer housing section **32** of a ratchet mechanism **30** made in this exemplary embodiment is substantially segmented into multiple discrete portions such that the outer housing section **32** is flexible along defined boundaries between the discrete portions. Specifically, in this exemplary embodiment, the outer housing section **32** has a broad wall surface **50** with a height that is slightly greater than the width of the rear end portions **13***e*, **13***f* of the headband **13**. Shorter walls **52**, **54** extend from the upper and lower edges of this broad wall surface **50**. In other words, the outer housing section **32** has a substantially C-shaped cross-section. To obtain the desired flexibility, these walls **52**, **54** are provided with detents **56** at spaced intervals. Each detent **56** is formed by angled wall portions that meet at a point. Furthermore, it is preferred that these angled wall portions have a thickness that is less than the nominal thickness of the wall **52**, **54**, creating a weakened area in the walls **52**, **54** that causes "collapse" of the walls at the detent **56**, creating a precisely located flex point. Then, by connecting each corresponding pair of detents **56** in the upper and lower walls **52**, **54** of the outer housing section **32** with a channel or groove **58** in the broad wall surface **50**, defined boundaries are created, and the outer housing section **32** is substantially segmented into multiple discrete portions. Thus, the outer housing section **32** is flexible along the defined boundaries between the discrete portions.

Referring now to FIG. **7**, the inner housing section **34** of the ratchet mechanism **30** in this exemplary embodiment is also substantially segmented into multiple discrete portions such that it is flexible along defined boundaries between the discrete portions. Similar to the outer housing section **32**, the inner housing section **34** has a broad wall surface **60** with shorter walls **62**, **64** that extend from the upper and lower edges of this broad wall surface **60**. These upper and lower walls **62**, **64** are designed to mate with the corresponding upper and lower walls **50**, **52** of the outer housing section **32** to join the two housing sections **32**, **34** together, as is further described below. However, rather than be provided with detents, these walls **62**, **64** are broken at spaced intervals that correspond with the position of the detents **56** defined in the upper and lower walls **52**, **54** of the outer housing section **32**. Furthermore, notches **66** are defined in the broad wall surface **60**, again to correspond with the position of the detents **56** defined in the upper and lower walls **52**, **54** of the outer housing section **32**. By connecting each corresponding pair of notches **66** with a channel or groove **68** (as shown in FIG. **2**) in the broad wall surface **60**, defined boundaries are created, substantially segmenting the inner housing section **34** into multiple discrete portions.

To join the outer housing section **32** and the inner housing section **34**, various techniques could be used with departing from the spirit and scope of the present invention. In this exemplary embodiment, the outer and inner housing sections **32**, **34** are fastened together in a snap-fit relationship with the shorter walls **62**, **64** of the inner housing section **34** fitting inside of and adjacent to the shorter walls **52**, **54** of the outer housing section **32**. Specifically, referring still to FIG. **7**, the center wall segments **62***a*, **64***a* of the inner housing section **34** each include a pair of integral projecting tabs **80**, **82**, **84**, **86**, with each such tab extending from a respective wall segment **62***a*, **64***a* in a substantially parallel relationship to the broad wall surface **60**. Referring again to FIG. **6**, the outer housing section **32** is provided with mating openings **90**, **92**, **94**, **96**. As such, when the housing sections **32**, **34** are pressed together, the projecting tabs **80**, **82**, **84**, **86** of the inner housing section **34** are received and retained by the mating openings **90**, **92**, **94**, **96** of the outer housing section **32**, as generally illustrated in FIGS. **4** and **5**, and as will be described in further detail below with reference to FIGS. **8**–**10**.

Furthermore, in this exemplary embodiment, each of the outside wall segments **62***b*, **62***c*, **64***b*, **64***c* of the inner housing section **34** are fastened to the corresponding portions of the walls **52**, **54** of the outer housing section **32** using a snap-fit relationship. Specifically, referring again to FIG. **7**, the outside wall segments **62***b*, **62***c*, **64***b*, **64***c* each include an integral projecting tab **100**, **102**, **104**, **106**, with each such tab extending in a substantially parallel relationship to the broad wall surface **60**. Referring again to FIG. **6**, the outer housing section **32** is provided with mating openings **110**, **112**, **114**, **116**. As such, when the housing sections **32**, **34** are pressed together, the projecting tabs **100**, **102**, **104**, **106** of the inner housing section **34** are received and retained by the mating openings **110**, **112**, **114**, **116** of the outer housing section **32**, as generally illustrated in FIGS. **4** and **5**. Unlike the openings **90**, **92**, **94**, **96** defined through the center portion of the outer housing section **32**, however, the outer openings **110**, **112**, **114**, **116** each has a width that is larger than that of the corresponding tab **100**, **102**, **104**, **106**.

As such, each tab **100**, **102**, **104**, **106** can "ride" or move within the corresponding openings **110**, **112**, **114**, **116**. As such, when the ratchet mechanism **30** is flexed along the defined boundaries, the openings **110**, **112**, **114**, **116** allow for some limited movement of the outside segments of the outer and inner housing sections **32**, **34** relative to one another, thus compensating for any shearing motion between the outer and inner housing sections **32**, **34** when the housing is flexed.

To further explain the snap-fit relationships described above, FIGS. **8**–**10** are sectional views that illustrate how one projecting tab **92** of the inner housing section **34** is received and retained by an opening **102** of the outer housing section **32**. As illustrated in FIGS. **8**-**10**, as the outer section **32** is pressed against the inner housing section **34**, the triangular shape of the projecting tab **92** causes it to flex and rotate inwardly. This continues until the tip **92***a* of the tab **92** clears the lip **102***a* of the opening **102**. Then, the projecting tab **92** returns to its original, upright position with the tip **92***a* of the tab **92** engaging the lip **102***a* of the opening **102**. Each of the other projecting tabs has a similar construction, creating the snap-fit relationship that joins the inner housing section **34** to the outer housing section **32**.

Finally, as described above, when the ratchet mechanism **30** is flexed inwardly along the defined boundaries, each outer tab **100**, **102**, **104**, **106** will "ride" along the corresponding opening **110**, **112**, **114**, **116** until it reaches the end of that opening **110**, **112**, **114**, **116**. The position of the tabs **100**, **102**, **104**, **106** in relation to the openings **110**, **112**, **114**, **116** at this point defines a yield point for the snap-fit function. If the ratchet mechanism **30** is flexed beyond this yield point, the natural reaction is for the tabs **100**, **102**, **104**, **106** to begin to move away from and disengage the lips of the respective openings **110**, **112**, **114**, **116**, thus reversing the snap-fit motion illustrated in FIGS. **8**–**10**. In short, the snap-fit would fail. Therefore, as a further refinement to control and prevent failure, each of the openings **110**, **112**, **114**, **116** in this exemplary embodiment includes a retaining bump. On such retaining bump **122** is illustrated in FIGS. **11**A, **11**B, **12**A, and **12**B. When the ratchet mechanism **30** is flexed inwardly toward the yield point, the tab **102** will move between the retaining bump **122** and the edge of the opening **112**, as illustrated in FIGS. **12**A and **12**B. If the housing is flexed beyond the yield point, the retaining bump **122** will retain the tab **102** in a locked position relative to the opening **112**. In this regard, it should be recognized that the natural or resting position of the ratchet mechanism **30**, as illustrated in FIGS. **11**A and **11**B, is the suggested position when the ratchet mechanism **30** is assembled. This position allows each outer tab **102** adequate clearance from the retaining bump **122**, so that the tab **102** can momentarily flex and then "snap" or lock onto the opening **112** as described above with reference to FIGS. **8**–**10**.

Again, although the exemplary embodiment described above includes arc-shaped housing sections **32**, **24** that have an inherent flexibility, such flexibility is immaterial to the unitary nature of the rotational element **36** described above.

Thus, the ratchet mechanism **30** of the present invention allows for adjustment of the size and fit of the protective helmet **10** or other headgear, and because of the unitary knob and pinion construction, the number of components is minimized, while a precise, reliable operation of the rack and pinion arrangement is ensured. Furthermore, as mentioned above, although the exemplary ratchet mechanism described herein is incorporated into a hard hat, the ratchet mechanism of the present invention can certainly be incorporated into other types of headgear that have an adjustable headband, such as faceshields and respirator hoods, without departing from the spirit and scope of the present invention.

It will be obvious to those skilled in the art that further modifications may be made to the embodiments described herein without departing from the spirit and scope of the present invention.

What is claimed is:

1. A ratchet mechanism for a headband that has overlapping rear end portions, each such portion defining an elongated slot and associated rack gear, comprising:

a housing, including an outer housing section joined to an inner housing section, thus defining an internal cavity for receiving the overlapping rear end portions of said headband; and

a rotational element that has a one piece construction, including a pinion portion which is adapted to mate with and engage the respective rack gears of the overlapping rear end portions of said headband, and an adjustment knob portion extending from said housing and adapted to be grasped and rotated by a wearer to cause lateral movement of the overlapping rear end portions of said headband with respect to one another;

wherein the outer housing section defines an opening therethrough, the rotational element being molded through said opening with the adjustment knob portion and the pinion portion positioned on opposite sides of the outer housing section; and

wherein, because of the molding of the rotational element through said opening, neither the adjustment knob portion nor the pinion portion can be drawn through said opening, and as such, the rotational element remains engaged with and can not be separated from the outer housing section absent a catastrophic failure of the ratchet mechanism.

2. The ratchet mechanism as recited in claim **1**, wherein the outer housing section is substantially segmented into multiple discrete portions such that the outer housing section is flexible along defined boundaries between such discrete portions, and wherein the inner housing section is similarly and substantially segmented into corresponding discrete portions such that the inner housing section is also flexible along defined boundaries between such discrete portions, such that, when the outer and inner housing sections we joined, the housing of the ratchet mechanism has a flexibility that allows it to conform to the head shape of a wearer.

3. The ratchet mechanism as recited in claim **1**, wherein the outer housing section is first formed in a mold cavity, and then the rotational element is molded and formed around the outer housing section in said mold cavity.

4. The ratchet mechanism as recited in claim **1**, wherein a first plastic is used to form the outer housing section, and a second, dissimilar plastic is used to form the rotational element.

5. The ratchet mechanism as recited in claim **1**, wherein the rotational element further includes an integral spring assembly comprised of two substantially semi-circular arch portions, with a spring toot extending from each of said arch portions and adapted to engage the teeth of a ring gear defined by the outer housing section, thus locking the position of the rotational element unless a wearer imparts a sufficient torque on the adjustment knob portion of the rotational element.

6. The ratchet mechanism as recited in claim **1**, wherein the rotational element further includes an integral shaft portion passing through the opening defined through said outer housing section and joining the adjustment knob portion, which is positioned on an exterior side of the outer

housing section, to the pinion portion, which is positioned on an interior side of the outer housing section.

7. A ratchet mechanism for a headband that has overlapping rear end portions, each such portion defining an elongated slot and associated rack gear, comprising:

a housing defining an internal cavity for receiving the overlapping rear end portions of said headband; and

a rotational element that has a one piece construction, said rotational element including a pinion portion adapted to mate with and engage the respective rack gears of the overlapping rear end portions of said headband, and an adjustment knob portion adapted to be grasped and rotated by a wearer to cause lateral movement of the overlapping rear end portions of said headband with respect to one another;

wherein the rotational element is molded around the housing and through an opening defined by said housing, with the pinion portion positioned within the internal cavity defined by said housing and the adjustment knob portion positioned on an exterior side of the housing; and

wherein, because of the molding of the rotational element round the housing and through the opening defined by said housing, neither the adjustment knob portion nor the pinion portion can be drawn through said opening, and as such, the rotational element remains engaged with and can not be separated from the housing absent a catastrophic failure of the ratchet mechanism.

8. The ratchet mechanism as recited in claim **7**, wherein the rotational element further includes an integral shaft portion which joins the adjustment knob portion to the pinion portion said shaft portion passing through the opening defined through said housing.

9. The ratchet mechanism as recited in claim **7**, wherein the rotational element further includes an integral spring assembly comprised of two substantially semi-circular arch portions, with a spring tooth extending from each of said arch portions and adapted to engage the teeth of a ring gear associated with the housing, thus locking the position of the rotational element unless a wearer imparts a sufficient torque on the adjustment knob portion of the rotational element.

10. In a ratchet mechanism for a headband that has overlapping rear end portions, each such portion defining an elongated slot and associated rack gear and being enclosed in a housing, the improvement comprising:

a rotational element molded around the housing and through an opening defined by said housing and having a one piece construction, said rotational element including a pinion portion adapted to mate with and engage the respective rack gears of the overlapping rear end portions of said headband, and an adjustment knob portion extending from said housing and adapted to be grasped and rotated by a wearer to cause lateral movement of the overlapping rear end portions of said headband with respect to one another;

wherein, because of the molding of the rotational element around the housing and through the opening defined by said housing, neither the adjustment knob portion nor the pinion portion can be drawn through said opening, and as such, the rotational element remains engaged with and can not be separated from the housing absent a catastrophic failure of the ratchet mechanism.

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