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(54) **KNEE PROTECTION DEVICE**

(57) A protection device (1) for the protection of a knee or knee protector is described. The protection device (1) includes a support structure (2) surrounding at least partially a knee joint, at least one transformable element (5) able to assume a first condition and a second condition, and one or more tie members (8) able to connect said support structure (2) to said inflatable element (5). In a condition between said first condition and second condition of the transformable element (5), the tie members (8) are in an at least partially stretched condition and are able to exert a pulling action on the support structure (2).

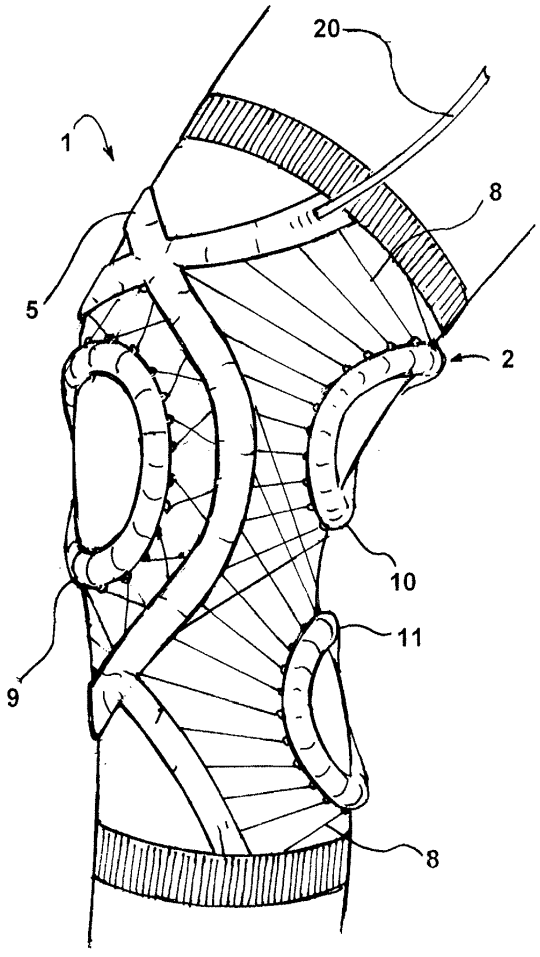

FIG.1

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Description

[0001] The present disclosure relates to a knee protector, for protecting the knee joint and preferably preventing any injuries to the knee in the event of impacts and/or falls, or for acting "in advance" so as to prevent any non-physiological movements, or for avoiding the consequences of an impact or a fall during a sporting and/or working activity of a user, for example a motorcycle rider or passenger, a skier, a horse rider, a football player and basket player, or a similar user.

[0002] As is well known, the knee joint is formed by two bones, the thigh bone and the shin bone. The knee cap also forms part of the front joint. A fourth thin bone located on the side of the shin bone (calf bone) completes the joint. All the articular surfaces are lined with cartilage. Further protection from trauma and wear is provided by the presence of two menisci which act as cushioning pads. The knee is furthermore stabilized by four strong ligaments, two side ligaments and two internal ligaments. Precisely owing to the presence of numerous anatomical structures, the pathological processes which may affect the knee are extremely numerous.

[0003] Over the years therefore the need has arisen to protect the functionality of the knee by means of knee pads, guards or other devices provided with a more or less rigid frame and bandage-like portions which are designed to control *a priori* the various movements of the knee.

[0004] One drawback identified by the author of the present disclosure consists in the fact that the known guards or knee pads have a structure and form which can be designed only beforehand, namely which are predetermined depending on the use of the guard or device which is to be made. The known structures therefore are not suitable for protecting the knee of a user in a spontaneous manner, at the time when an actual need arises.

[0005] One technical problem forming the basis of the present disclosure is that of providing a protection device for the protection of a knee, the structure of which may be configured only at the moment when a real need arises and is therefore able to overcome said drawback and/or achieve further advantages.

[0006] This problem is solved by a protection device for the protection of a knee according to the respective independent claim. Secondary characteristic features forming the subject of the present disclosure are defined in the corresponding dependent claims.

[0007] The present disclosure relates to a knee protection device including a support structure able to surround at least partially a knee joint, at least one transformable element able to be modified in the event of an impact and/or a fall and able to assume a first condition and a second condition, and tie members able to connect said support structure to said transformable element. Said tie members are able to assume a first tensile condition and a second tensile condition depending on the conditioned assumed by the transformable element and consequently achieve a variation of the pulling action on the support structure.

[0008] When the tie members are in an increased tensile condition they exert a pulling force on the support structure which may be tightened around the knee and perform an action which opposes any movements and/or rotations of the knee.

[0009] The term "support structure" is understood as meaning one or more support elements able to act as structural elements for the entire device and provide a suitable rigidity and also create a support for the tie members. The support elements may be ring-shaped elements or similar hollow elements or could be solid elements, such as plate-like elements. Preferably, the support elements are arranged around the knee or on opposite sides of the knee so that the tie members may "pull" one support element towards the other one and create a support structure around the knee.

[0010] The term "transformable element" is understood as meaning that the element may change its shape or form or configuration between at least two different conditions, also in a sudden and spontaneous manner depending on an operating or dynamic condition of the user, or it may be a element which may modify in general the tension of the tie members or exert an action on the tie members. The change in form or configuration or shape or the action which they exert in general has an effect on the tie members which, in turn, tension the support structure. The transformable element may be modified when a given condition of the user is detected, for example a condition associated with a dynamic response of the user, or a physiological condition, such as increase of the heart beat. Basically, the pulling action exerted on the tie members occurs when a danger situation is detected on the basis of a change in condition of the user. In other words, the term "transformable element" is understood as meaning an element which, in the event of danger or a fall or other situation where the knee risks injury, modifies its structure or configuration. This modification results in a pulling force or tensioning of the tie members and, consequently, causes tensioning of the entire support structure and provides the device with a greater rigidity.

[0011] The device may therefore be associated with or include accelerometers, roll sensors, pressure sensors, potentiometers, or the like. Preferably, these consist of accelerometers. Basically, a condition detected may be a condition relating to a speed value, quantity of movement, acceleration, kinetic energy, an inclination, a variation in pressure, an electric pulse or similar information which is closely associated with the user and/or which is associated with a dangerous situation for a user.

[0012] More particularly, when the transformable element is in a condition between said first condition and a second condition of the transformable element, the tie members are in an at least partially stretched condition and are able to exert, in turn, a pulling action on the support structure such as to tension the entire protection

device. For example, the first condition of the transformable element is a rest condition and the second condition of the transformable element is an active condition. The transformable element is able to assume the active condition from the rest condition in the event of a user falling, a danger situation or an impact where a user hits an obstacle, and is able to tension the entire support structure.

[0013] In one embodiment of the present disclosure, the transformable element is an inflatable element. Basically, the transformable element modifies its condition assuming a more inflated form and therefore occupying a larger space or volume which in turn produces a pulling action on the tie members. Even more preferably, the device comprises a gas generator and activation means able to activate inflation of the inflatable element in the event of impact.

[0014] Alternatively, transformable elements may include a ratchet or spring mechanism able to fix the tie member or wind it up so as to ensure a pulling force.

[0015] Alternatively also, in accordance with further embodiments, the transformable element may be shape-memory element.

[0016] In accordance with a further embodiment the tie members are also made of a shape-memory material such a shape-memory alloy.

[0017] The shape-memory materials are typically nickel-titanium (NiTi) alloys; the most well-known shape-memory material is called Nitinol.

[0018] In some embodiments of the present disclosure, the support structure is also a transformable structure, namely it may modify its structure and configuration in order to increase the pulling action on the tie members. The support structure or the support elements may be inflatable elements or elements made of shape-memory material.

[0019] It should be pointed out that, in accordance with an embodiment of the present disclosure, the protection device can be used in the sporting sector, namely in order to protect a user during a sporting activity, such as skiing, cycling or other dynamic activities of a sporting nature, or for use in a rehabilitation context.

[0020] In accordance with another embodiment of the present disclosure, the protection device may be used in non-sporting sectors, namely in order to protect a user during a non-sporting activity, such as a working activity, or in the case of users with weak knees or users exposed to a situation where there is the risk of falling. Further characteristic features and modes of use forming the subject of the present disclosure will become clear from the following detailed description of a number of preferred examples of embodiment thereof, provided by way of a non-limiting example. It is nevertheless evident that each embodiment may have one or more of the advantages listed above; in any case it is nevertheless not necessary that each embodiment should have simultaneously all the advantages listed.

[0021] Reference will now be made to the figures in the attached drawings in which:

- Figure 1 shows an axonometric view of a protection device according to an embodiment of the present disclosure;
- Figure 2 shows a front view of the device according to Figure 1;
- Figure 3 shows a front view of a protection device according to a further embodiment of the present disclosure;
- Figure 4 shows a side view of a protection device according to an alternative embodiment of the present disclosure;
- Figure 5 shows an axonometric view of a protection device according to a further embodiment of the present disclosure;
- Figure 6 shows a view, from the front, of the device according to Figure 1 in an operating condition;
- Figure 7 shows a view, from the rear, of the device according to Figure 1 in an operating condition.

[0022] With reference to the accompanying figures, the reference numbers 1, 101, 102, 103 indicate respective embodiments of a knee protection device according to the present disclosure. It is also pointed out that the protection device 1, 101, 102, 103 may be a separate wearable device or may be included in a garment or may form an integral part of a garment. In the embodiments shown in the drawings, the protection device is worn by a skier. Even more particularly, the protection device according to Figure 1 and Figure 2 is configured as a knee pad or bandage. The bandage may be fixed to a garment or fixed to the knee by means of elastic elements or additional strip-like edges. Further solutions for fixing the protection device are described with reference to Figures 3-5 below.

[0023] As can be seen in the attached Figures 1-7 the protection device according to the present disclosure is worn in the area of the knee joint. Every spatial reference in the present description and in the following claims, such as "rear", "front", "upper", "lower", "central" or similar references, is to be understood, for greater linguistic clarity, as referring to when the device is worn by a user in the region of the knee.

[0024] It should also be pointed out that the protection device 1, 101, 102, 103 may be a single device, namely a device placed on a single knee, or include a pair of devices arranged on both knees. In the description below reference will be made to a single device, it being understood that the same description may be applicable to both the devices on the two knees.

[0025] In particular, the protection device 1, 101, 102, 103 comprises a support structure 2, transformable element 5 and one or more tie members 8 which connect the support structure 2 to the transformable element 5.

[0026] In particular, preferably, the transformable element 5 is an inflatable element which has the form of a casing and inside which an internal chamber is defined. The inflatable element is able to assume substantially a first rest condition or deflated condition, and a second

active condition or inflated condition. The modes of inflating the inflatable element will be described in the description below.

[0027] In the example of embodiment shown in Figures 1-5 the support structure 2 surrounds the knee, for example in front of and behind the knee, and includes a first body 9, which is for example plate-shape or ring-shaped and placed in the front area of the knee, for example centred on the knee cap, and a second body 10 and a third body 11, each of which is plate-shaped or ring-shaped. The second body 10 and the third body 11 are placed in the upper rear area of the shin bone (top of the calf muscle) and the lower rear area of the thigh bone (lower thigh). The three bodies have preferably a rigid or semi-rigid consistency and are made of plastic material. The three bodies have the function of giving the protection device "structure" and surrounding the knee and may also be of the "transformable" type. The transformable element 5 is preferably shaped so as to form one or more, preferably two, intersection zones 6, 7 in front of the knee.

[0028] In the embodiment shown, a first intersection zone 6 is located above the knee cap and a second intersection zone 7 is located underneath the knee cap.

[0029] Preferably, the transformable element 5 is a single body and therefore the two intersection zones 6, 7 are connected together so as to surround the first body 9 of the support structure, namely create a transformable zone around the knee cap.

[0030] A gas generator 12, in the example a pressurised gas cylinder, is included in the rear area of a garment so as to be able to inflate the inflatable element in the event of an accident.

[0031] In some embodiments it could be convenient to extend the inflatable element also to the end edge portions of the knee pad, preferably formed by elastic strips, so as to have a sufficiently rigid structure. One of these ends could be inserted inside the boot as indicated below.

[0032] As mentioned, the protection device 1, 101, 102, 103 comprises a plurality of tie members 8 distributed and stably connected to respective portions of the transformable element 5 and the three bodies of the support structure 2. The term "tie member 8" is understood as meaning an element or part which has the function of keeping joined together or fastened or fixed, by means of tensile force, two or more parts of the inflatable element and the support structure, at least when the inflatable element is in the inflated condition.

[0033] In the example, the tie members 8 have a thread-like form and are flexible and unextendable elements. Therefore, they are suitably designed in terms of dimensions such that, when the inflatable element is in the rest condition, they are preferably in a loose condition and not subject to tension. When the inflatable element is in the inflated condition, the tie members 8 are tensioned and may therefore tightly wrap the knee joint and pull in directions opposite to each other the first body 9 relative to the second body 10 and the third body 11.

[0034] Even more precisely, the tie members 8 are flexible ties and have a thread-like form and are made for example of polyester or polyamide and have ends fixed to the respective portions of the support structure 2 and to the inflatable element. Alternatively the tie members may be in the form of thin strips.

[0035] The fixing methods may be of the known type and are, for example, realized by means of simple insertion and interweaving, or by means of binding, or similar systems for fixing the tie members inside holes formed on the perimeter of the inflatable element and in the bodies 9, 10, 11 respectively.

[0036] The inflatable element 2 may be like that described in WO 2010-067288 A1.

[0037] In an alternative embodiment, the inflatable element and the tie members 8 form part of a single textile structure, for example a knitted body obtained during a single manufacturing operation, for example by means of a straight knitting machine. Further information regarding the processing of a knitted body may be found in the Italian patent application TO-2013-A-472, which describes the manufacture of knitted bodies.

[0038] With reference to Figures 3-5, further protection devices 101, 102, 103 are described, these including, like the protection device 1 described above, the support structure 2, the inflatable element 5 and the tie members 8. In particular, the elements of the protection devices 101, 102, 103 shown in Figures 3-5 include the same functional elements as the protection device shown in Figure 1 and Figure 2 and retain the same reference numbers.

[0039] More particularly, differently from the protection device 1, the protection device according to Figure 3 is configured to include an underwear garment 110 such as, for example, underpants. Basically it consists of a wearable protection device 101 which is made of light material and is worn underneath a normal garment. The protection device 101 acts as a support for the inflatable elements 5. The under-garment or underpants 110 may also act as a connection between the two knees of the user and be able to counteract any twisting movements of the knee. The protection device 101 may also envisage a fixing system surrounding the foot sole. As regards the protection device 102 shown in Figure 4, it is configured to be fixed and directly supported on a ski boot. In this case also the ski boot may act as a support element counteracting any twisting movements of the knee. In this case, the fixing system may be realized by means of a strap 111 with Velcro, or other fixing system of the known type, preferably of the type suitable for the textile sector. It can be seen the system for fixing to the boot could also be situated inside the boot itself and be "reinforced" by means of inflation at the moment of activation, so as to increase the cohesion between knee pad and boot.

[0040] As regards the protection device 103 shown in Figure 5, it is configured to include inflatable elements and optionally tie members 8 which extend as far the area of the user's pelvis. In accordance with this embod-

iment, the inflatable element may extend also into the zone of an elastic waistband so as to create a sufficiently rigid bandage.

[0041] It is to be understood that combinations of the embodiments shown in Figures 1-5 may be envisaged: for example the use of an under-garment and at the same time the system for fixing to the ski boot, or the use of the under-garment and an extension of the inflatable element as far as the pelvis, may be envisaged. Alternatively, any one of the inflatable elements according to Figures 1-5 may be replaced with an element made of shape-memory material such as a shape-memory material alloy.

[0042] In order to perform inflation of the inflatable element, in the event of a fall and/or sliding and/or unexpected impact involving a user or a travel means, such as the skis on which the user is moving, the protection device 1, 101, 102, 103 according to the present invention is able to cooperate with suitable activation means (not visible in the drawings). The activation means are operationally connected to inflation means, including - shown merely by way of example in the figures - the cold compressed gas cylinder 12, for example placed on a user's back and connected by means of a pipe or tube 20 to a shut-off valve (not shown in the figures) which allows the introduction of an inflation fluid into the inflatable element. Alternatively, these inflation means may comprise gas generators of the pyrotechnic or other hybrid type or other types known according to the state of the art.

[0043] Said inflation means are controlled by a control unit depending on detection of the state of the vehicle/rider system; for example said control unit may implement a system for predicting the fall which allows early identification of the fall event and a reliable prediction of this event by accelerometer sensor means fixed to the vehicle (or rider) and a unit for processing the signals produced by the said sensors. In addition to the accelerometer sensors, inertial platforms, potentiometric sensors and extensometer sensors may also be envisaged.

[0044] In any case the aforementioned activation and inflation means may be integrated in the protection device 1, 101, 102, 103 according to the present invention or located on the outside thereof.

[0045] It should also be noted that the activation modes, although being an aspect of particular importance for effective operation of the device, will not be further described in greater detail since they are methods which are essentially already known to a person skilled in the art of protection of an individual from sudden impacts.

[0046] It should be understood moreover that the protection device 1, 101, 102, 103 according to the present disclosure may be integrated or combined with other devices for providing protection from impacts which can be worn by a user, such as the protection device described in international patent application No. WO 2010-067288 A1, or integrated in a garment such as that described in international patent application No. WO 2010-067289.

[0047] Moreover it may be pointed out that the protection device 1, 101, 102, 103 may be configured for activation only on the right leg or left leg, or in a different manner for each knee, depending on the type of fall or position of the user.

[0048] The protection device 1, 101, 102, 103 may further comprise a deflation valve (not shown in the drawings) communicating on one side with the internal chamber and on the other side with the external environment, in order to allow the deflation of the inflatable element following activation and when a protective action is no longer required. Alternatively, the protection device may be configured in such a way that the inflatable element may deflate on its own after relative rapid inflation, without the need for a deflation valve.

[0049] The subject-matter of the present disclosure has been described hitherto with reference to preferred embodiments thereof. It is to be understood that other embodiments relating to the same inventive idea may exist, all of these falling within the scope of protection of the claims which are attached below.

Claims

1. Protection device (1, 101, 102, 103) for the protection of a knee or knee protector, wherein said protection device (1, 101, 102, 103) includes a support structure (2) able to surround at least partially a knee joint, at least one transformable element (5) able to assume a first condition and a second condition, and one or more tie members (8) able to connect said support structure (2) to said transformable element (5), wherein, in a condition between said first condition and second condition of the transformable element (5), the tie members (8) are in an at least partially stretched condition and are able to exert a pulling action on the support structure (2).

2. Protection device (1, 101, 102, 103) according to claim 1, wherein the first condition of the transformable element (5) is a rest condition and the second condition of the transformable element (5) is an active condition, and said transformable element (5) is able to assume the active condition from the rest condition in the event of a user falling, a danger situation or an impact where a user hits an obstacle, and is able to tension the entire support structure (2).

3. Protection device (1, 101, 102, 103) according to any one of the preceding claims, wherein the transformable element (5) is an inflatable element.

4. Protection device (1, 101, 102, 103) according to claim 3, comprising a gas generator (12) and activation means able to activate inflation of the inflatable element in the event of an impact.

5. Protection device (1, 101, 102, 103) according to any one of the preceding claims, wherein the support structure (2) includes a plurality of plate-shaped or ring-shaped bodies (9, 10, 11) able to be placed in a front area of the knee and rear area of the knee respectively.

6. Protection device (1, 101, 102, 103) according to claim 5, wherein the plurality of bodies includes a first body (9) able to be placed in the front area of the knee cap, a second body (10) able to be placed in the upper rear area with respect to the knee joint and a third body (11) able to be placed in the lower rear area with respect to the knee joint.

7. Protection device (1, 101, 102, 103) according to claim 6, wherein a first group of tie members (8) connects the first body (9) to the transformable element and a second group of tie members (8) connects the second body (10) and the third body (11) to the transformable element (5).

8. Protection device (1, 101, 102, 103) according to any one of the preceding claims, wherein the transformable element (5) includes one or more intersection zones (6, 7) in front of the knee.

9. Protection device (1, 101, 102, 103) according to claim 8, wherein the intersection zones include a first intersection zone (6) able to be placed above the knee cap and a second intersection zone (7) able to be placed below the knee cap.

10. Protection device (1, 101, 102, 103) according to claim 9, wherein the intersection zones (6, 7) surround the first body (9) of the support structure.

11. Protection device (1, 101, 102, 103) according to any one of the preceding claims, wherein the support structure (2) is able to surround at least partially the knee.

12. Garment including, or integrally incorporating, a protection device (1, 101, 102, 103) according to any one of the preceding claims 1 to 11, or garment coincident with a protection device (1, 101, 102, 103) according to any one of the preceding claims 1 to 11.

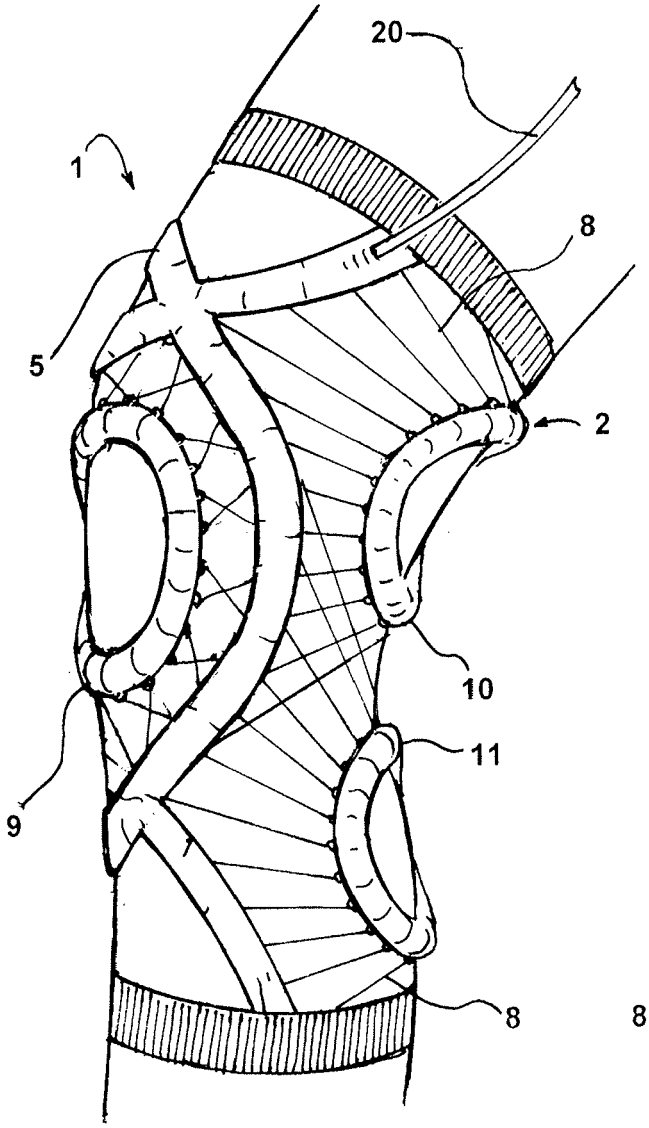

FIG.1

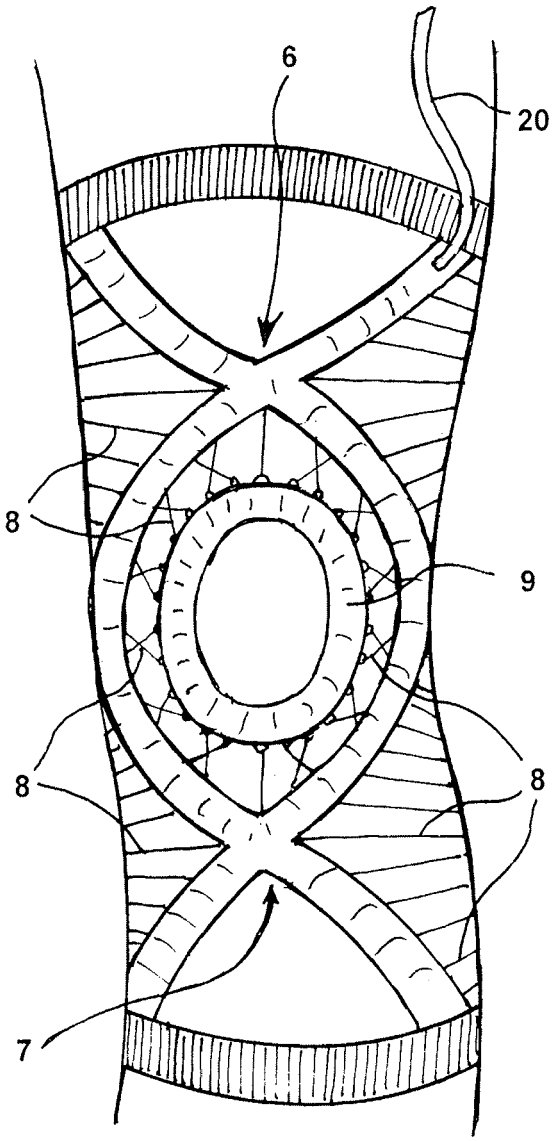

FIG.2

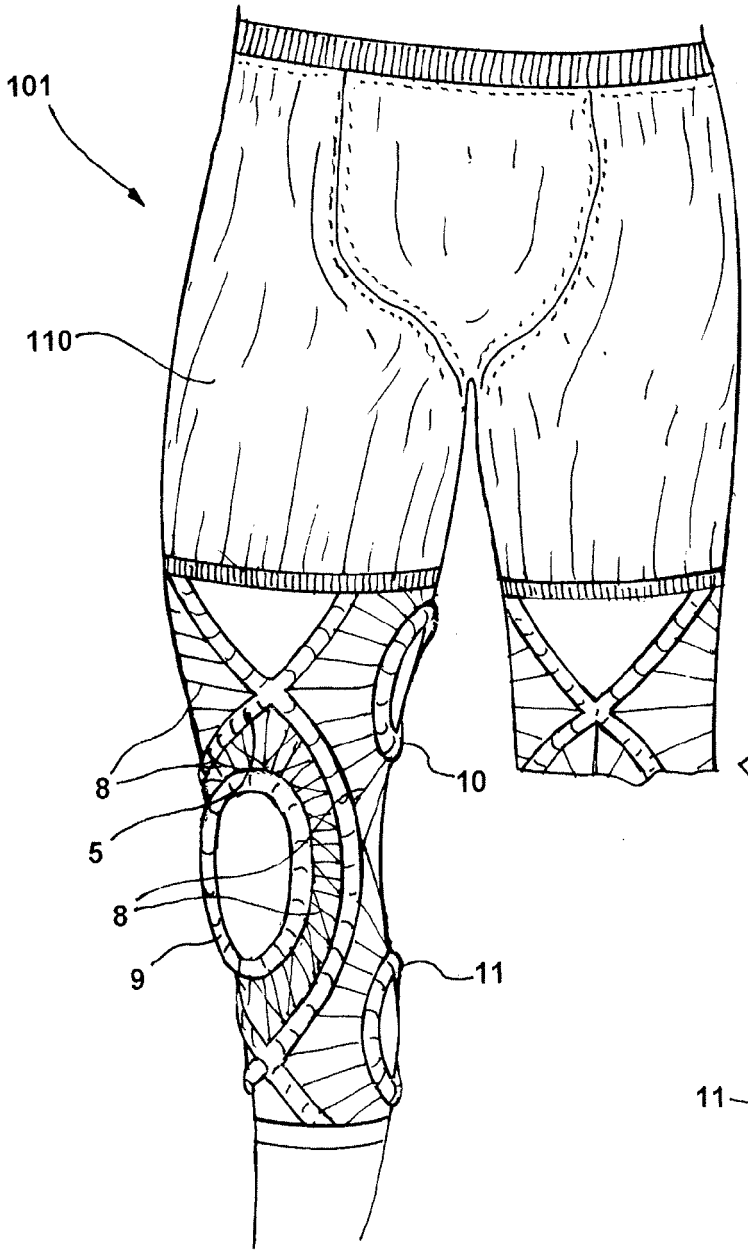

FIG.3

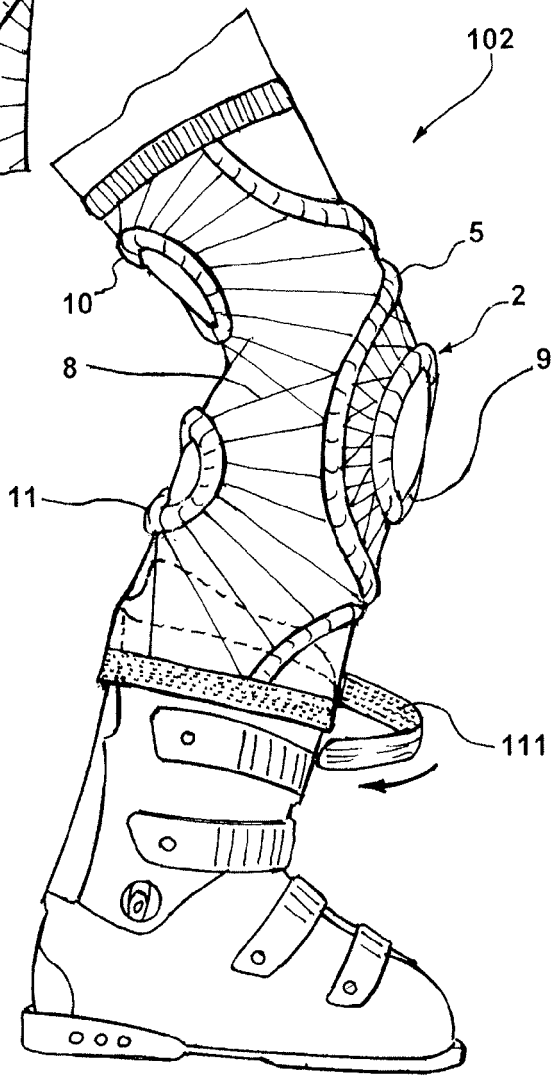

FIG.4

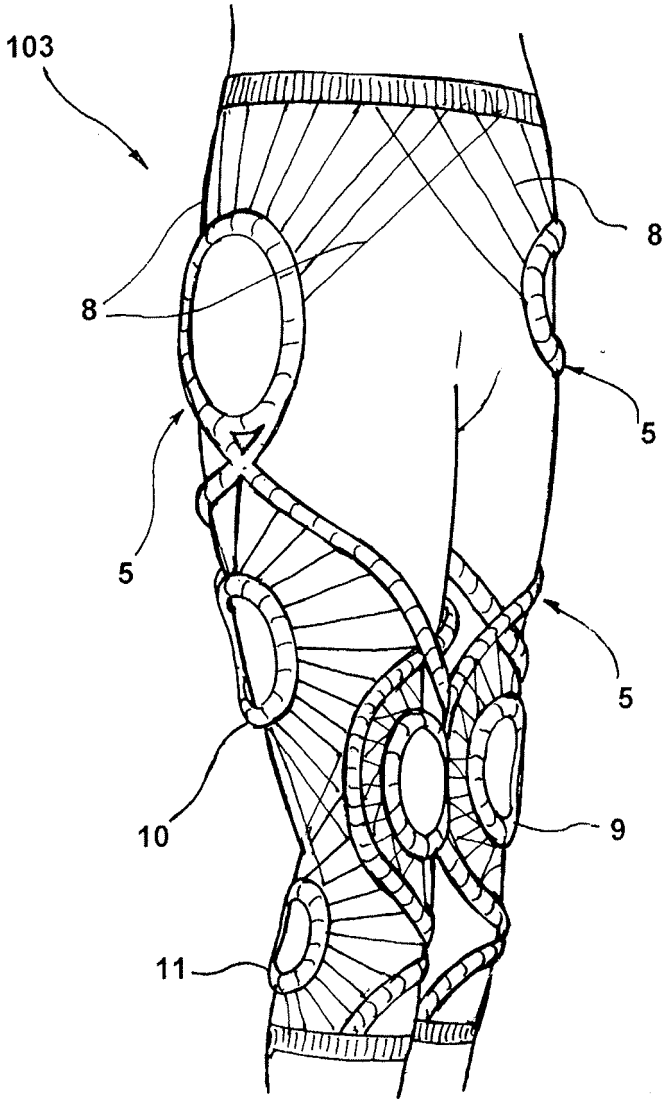

FIG.5

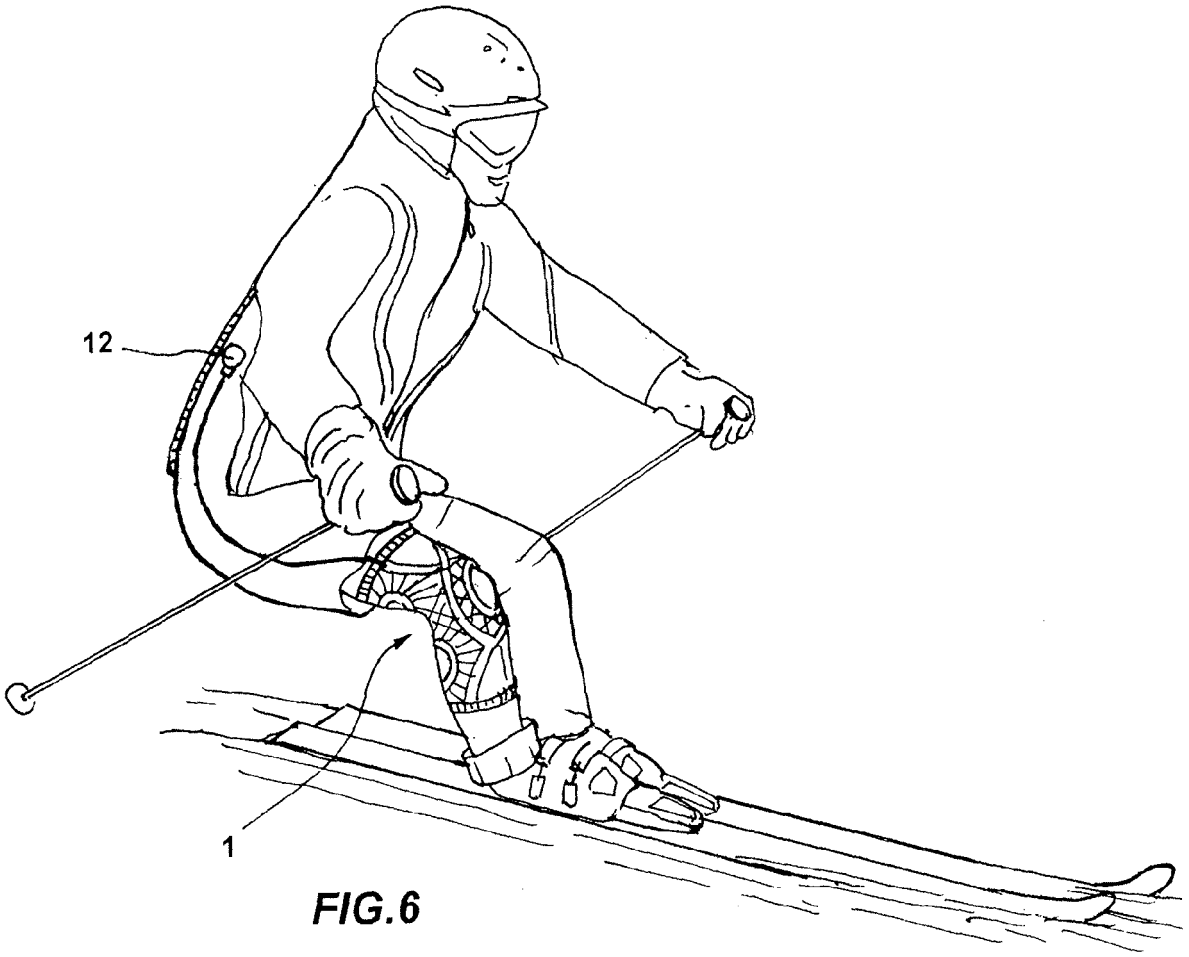

FIG.6

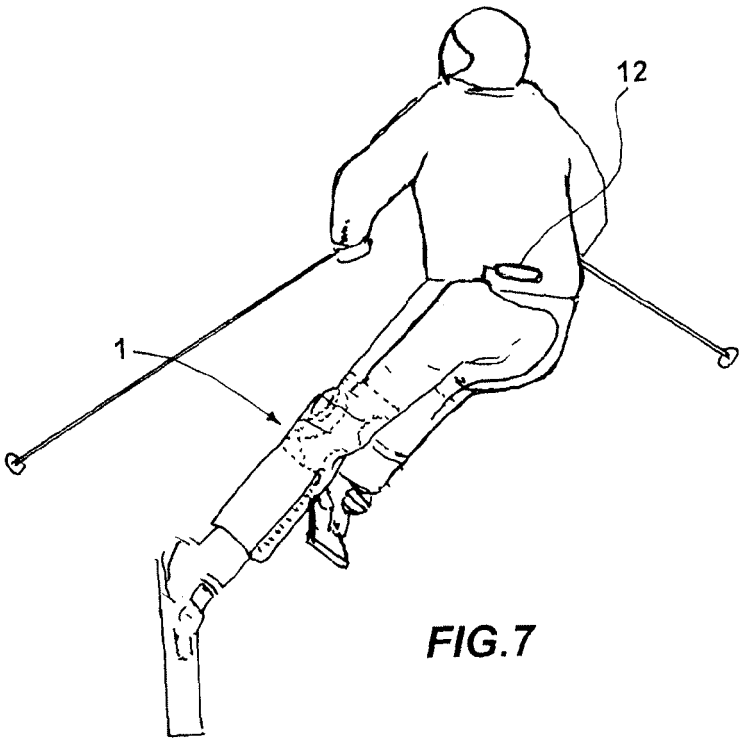

FIG.7

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 0983

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 4 872 448 A (JOHNSON JR GLENN W [US]) 10 October 1989 (1989-10-10) * column 2, line 61 - line 68 * * column 3, line 50 - column 5, line 19; figures 1-13B *	1,3,4,8, 9,11,12 5-7,10	INV. A41D13/06 A41D13/018
X	WO 2010/036988 A2 (NIKE INC [US]; NIKE INTERNATIONAL LTD [US]; BAUCOM JIM [US]; GERBER CL) 1 April 2010 (2010-04-01) * paragraphs [0089], [0090], [0094]; figure 7 *	1,2,11	
X	WO 2015/074070 A1 (BOA TECHNOLOGY INC [US]) 21 May 2015 (2015-05-21) * paragraph [0053] - paragraph [0061]; figures 1-3 *	1,11	
A	US 2006/267779 A1 (ISHIKAWA MURIEL Y [US] ET AL) 30 November 2006 (2006-11-30) * abstract; figures 7,12C,12D,12E,13A,17A * * paragraph [0114] - paragraph [0129] *	1-12	

TECHNICAL FIELDS SEARCHED (IPC)
A41D A61F A63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 April 2018	Thielgen, Robert

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 20 0983

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