

(19) **DANMARK**

(10) **DK/EP 3661383 T3**



(12)

Oversættelse af europæisk patentskrift

Patent- og
Varemærkestyrelsen

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- (51) Int.Cl.: **A 43 B 21/26 (2006.01)** **A 43 B 7/06 (2006.01)** **A 43 B 7/14 (2022.01)**
A 43 B 13/12 (2006.01) **A 43 B 13/18 (2006.01)**
- (45) Oversættelsen bekendtgjort den: **2022-08-01**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2022-05-11**
- (86) Europæisk ansøgning nr.: **18759409.8**
- (86) Europæisk indleveringsdag: **2018-08-02**
- (87) Den europæiske ansøgnings publiceringsdag: **2020-06-10**
- (86) International ansøgning nr.: **IB2018055824**
- (87) Internationalt publikationsnr.: **WO2019026025**
- (30) Prioritet: **2017-08-03 IT 201700089835**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
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- (54) Benævnelse: **ANORDNING TIL INTEGRATION I FODTØJSSÅLER, FUNGERENDE SOM AFFJEDRINGS-, ENERGISPREDNINGS- OG STABILISERINGSMIDDEL**
- (56) Fremdragne publikationer:
US-A- 5 086 574
US-A- 5 718 063
US-A1- 2003 208 929
US-A1- 2008 263 894

DESCRIPTION

[0001] The present invention relates to a device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means.

[0002] As it is known, a footwear is made of two main elements: the upper and the sole. The upper, that is the upper part of the shoe, is specifically designed to wrap the foot in an ergonomic and comfortable way, while the sole, the part on which the sole of the foot lies, is designed to cushion and stabilize the walk. In order to assure that the sole is able to adequately carry out the functions for which it is imagined, the same sole is typically made of a light, soft and flexible midsole made of an expanded material, and of a more compact tread able to assure a greater resistance to abrasion and a suitable friction with the ground. Indeed, it is known from biomechanical studies that, during a walk cycle, the more critical phase for the human body is the stand of the heel, the so-called "heel-strike", that is the first moment of the interaction foot-soil. This is the phase during which the heel of the foot is projected onwards and, in a fraction of a second, discharges on the ground a force that changes from one time and one time and a half of the body weight of an individual and may also quintuplicate during a jump. The reaction force is, only partially, diminished by the human body through a three-dimensional complex movement of the foot comprised between the area of the heel and the metatarsal, while the remaining part is transmitted at first to the heel, then to the ankles, to the knees, to the pelvis and then, little by little, along the vertebral column up until the cervical area. Such an intense reaction force, if not adequately softened through a sole with cushioning characteristics, can cause serious damages to the tendinous and musculoskeletal structures of the user. This requirement is much more important in the field of occupational safety (Individual Protection Devices), so much that it is regulated through the international regulations ISO 20345:2011 that fixes to 20 Joule the limits of the minimal absorption of energy in the area of the heel, so that a professional footwear can be regarded as adequate.

[0003] Many solutions are designed to cushion and reduce the negative effect of the reaction forces created during the interaction foot-soil.

[0004] The simplest and cheapest known solutions describe cushioning soles made of a midsole made of a soft and light material, mainly Ethylene Vinyl Acetate (EVA), for what concerns the field of sports footwears, and Expanded Polyurethane (E-PU), in the field of safety (Individual Protection Devices). As a matter of fact, since the levels of stability and cushioning change depending on the values of density and hardness of the material, choosing conveniently the mixture it is possible to attribute to the sole the desired properties.

[0005] However, the optimization of the values of density and hardness is made depending on a predetermined load. Since these materials, first of all the EVA, are characterized by a reduced resilience, the resulting peculiarities of the sole cannot be guaranteed depending on the applied load. The application of a recurrent load or higher than that designed, such as that of a worker having a body weight greater than the designed load and/or prolonged use, on a

footwear with a midsole made of EVA, could cause a plastic deformation of the latter, in this particular case a reduction of the thickness, that would cause a reduction of the capacity of desired stability and cushioning.

[0006] An evolution of the aforementioned footwears with a midsole made of EVA is that of soles with specific cushioning devices, such as systems with springs or elements made of a thermoplastic material with a gel effect, with an air cushion or an encapsulated liquid.

[0007] A first example of this kind is outlined by the patent US4768295 which describes a solution achieved by cushioning elements inserted in the bottom of the sole, made of gel bearings.

[0008] A second example is outlined by the patent US5493792 which describes a solution achieved through cushioning elements inserted between the midsole and the tread, made of an encapsulated liquid.

[0009] Another example is the patent US7832118 that describes a solution achieved through cushioning elements inserted in the midsole, some realized by elastomeric materials and the others by thermoplastic material gel effect with a high damping coefficient.

[0010] In addition, the patent US6266897 describes a solution achieved through cushioning elements with a tridimensional geometry inserted in the tread, filled with incompressible fluids, such as gas or other materials like liquids, foams, viscous materials and/or viscoelastic materials.

[0011] Still, the patent US5704137 describes a solution achieved through a hydrodynamic bearing as cushioning element inserted in the sole.

[0012] The patent US4934072 describes a solution achieved through a bearing positioned in the area of the heel, made of a sealed element divided in two chambers, one containing a mixture of viscous liquids and the other containing gas.

[0013] The patent US4815221 describes a solution achieved through a cushioning system made with strings, positioned in the area of the heel.

[0014] The patent US4342157 describes a solution achieved through the insertion of cushioning elements with an encapsulated liquid such as water, glycerin or mineral oil, positioned in the bottom of the midsole in the area of the heel and the metatarsal heads.

[0015] The patent US7000335 describes a solution that considers the insertion of a cushioning element in the area of the heel, achieved through an encapsulated fluid.

[0016] All these solutions involve, however, several issues, including an inadequate stabilization while walking. Because of this, in case of hyper pronation or hyper supination of

the foot, such solutions contort mainly exactly in the area of maximum load and react facilitating the movement of the foot until it can cause a dislocation. In addition, these are solutions really expensive because of the complexity of their implementation.

[0017] For what concerns the accident prevention footwear, an example of a cushioning sole alternative to that with a midsole made of EP is the sole realized inserting a big portion made of expanded thermoplastic polyurethane (E-TPU) in the area of the heel, right under the assembly insole. It is a solution of "passive" type, that is its energy absorbing capacities rely exclusively on the chemical and physical features of the material, and whose rheologic behavior cannot be modified in a controlled way on the basis of the changing of the load. The known portion is made of a material commercially known as "Infinergy", made by BASF for the athletic field. This hyperelastic material has been tested in compliance with the ISO 8307 standard (sphere bounce test) and DIN 53512 standard (palybalometer test). Right on the basis of the sports applications for which it has been designed, tests made on this kind of sole have highlighted that during the phase predating the detachment of the heel, the material responds to the reduction of the load with an impulsive reaction also known as "rebound" effect. If on one hand such behavior is really useful and appreciated in the athletic field (running, volley, basket) because it assists and supports the propulsive phase of a running or a jump, on the other hand it could reveal itself as extremely dangerous in the "safety" field, where the footwear should dissipate the absorbed energy during a jump not giving it back as an impulsive force. In fact, for applications related to safety, the phase that comes first the "heel off", that is the moment preempting the detachment of the heel from the ground, turns out to be as critical as the support phase of the heel to the ground called "heel strike". In order for the walk to be relaxing and comfortable, during this stage the sole should react to the reduction of the load with a modulated push depending on the weight, which helps and accompanies the lifting of the heel gradually. An impulse-type reaction in this phase could, instead, cause micro-traumas to the tendinous and musculoskeletal structures, thus being injurious to the user. This is true, even more so, for a worker who has to make a jump in order to overcome a difference in height, perhaps by wearing very heavy equipment or loads of different kind. Moreover, the technological limits linked to the low density of molding of the aforementioned material (200-300 gr/1), already mentioned as a favorable condition for sports footwears, especially regarding the competition kind, also lead to a particularly yielding product which causes hyper pronation or hyper supination in case of a decentralized load with respect to the heel center, resulting in a high probability of dislocation in the malleolar area.

[0018] Another type of solution that is applied in the "safety" field is represented by the soles obtained by inserting special shock-absorbing devices in a gel-effect thermoplastic material in the area of the heel. Although especially designed for this purpose, these products are characterized by a defined geometry which does not vary according to the exercised pressure. Therefore, even in this case, these solutions have a "passive" operational mode, that is, their energy absorption capacities rely exclusively on the chemical and physical characteristics of the material, and whose rheological behavior cannot be modulated in a controlled manner as the load changes. The solutions known so far do not therefore have a mechanical response to the exercised pressure, such as to avoid issues such as dislocations or incorrect positioning of

the foot during the walk. The possibility of modulating the mechanical response of the device according to the load could therefore, by analogy, be defined as an "active" type mode of operation. Devices with such a functioning are not yet present in the current state of the art.

[0019] In addition, it is known a device, described in the European patent application Nr EP12192518.4 by Arbesko, commercially known as "Energy Gel". It is a device of rectangular shape with dimensions of approximately 40 x 50 x 15 mm, made of a very elastic thermoplastic material, inserted under the plantar and wedged in a hole formed in the insole and in the polyurethane sole. The aim of the Arbesko's solution is to increase the absorption of energy, thanks to a higher elastic deformation capacity, compared to that of the polyurethane surrounding it.

[0020] Another known example, very similar to the Arbesko's product, is described in the European patent proposed by Steitz Secura Nr. DE 10 2005 037 781.5, called "Vario System". Even in this case, the cushioning element is made of a thermoplastic material with an elastic effect, very soft, inserted under the plantar and wedged in a hole formed in the insole and in the polyurethane sole. Its shape is pear-shaped, similar in size to Arbesko's product. Unlike the latter, the product of Steitz is available in four variants, each of them being characterized by a more or less yielding material, depending on the user's body weight.

[0021] For both of the said solutions it is possible to point out some limitations related to the reduced overall dimensions of the same inventions and to the rheological behavior of the material of which they are made up. As a matter of fact, the small sizes of both solutions lead to an absorption capacity restricted to the sole area under the calcaneus. In a real leaning condition, the heel sinks into this little easily deformable element while the surrounding part of the foot impact against the remaining part of the sole which is made of a stiffer material. It follows that as a result of the lab dynamometer tests, the measured energy turns out to be higher than the energy actually absorbed by the user under real-use conditions. In fact, the dynamometric tools focus the applied force on an area smaller than the sizes of said prior art solutions. Furthermore, such a significant difference between the sole stiffness compared to that of the invention, discomforts the user who feels a decreased comfort sensation clearly sensing the transition between the two elements.

[0022] A not negligible aspect, in addition, is the flexibility of this kind of materials which, showing a distinctly elastic reaction, act with an impulsive force, proportional to the amount of the absorbed energy.

[0023] This produces a pressure peak on the user's heel, with resulting potential micro shocks for each footstep of the walk.

[0024] Moreover, being included under the plantar and embedded in a hole created in the insole and in the sole, the use of this kind of prior art solutions is limited to the safety field application since it doesn't allow the placement of the anti-drilling insert, made of fabric, currently used in nearly all of the European protective footwears, as mounting insole.

[0025] A solution to these issues is described in the patent US5718063, where a single structure, or part, and an upper attached to it is described. The sole includes a midsole that absorbs force and a flexible wear resistant sole. The midsole including at least a cushioning element made of a viscoelastic material (gel type, preferably silicone), and a conditioning element of the cushioning element, on which is placed the cushioning element.

[0026] A further solution to these issues is described in the patent US2003208929, that refers to a shoe sole, especially sports shoes, in which the sole includes a cartridge cushioning system that includes a plate that distributes the load and deformation elements placed in an area of the sole forefoot in order to provide support and/or cushioning to the forefoot. The shoe sole can include a second cartridge cushioning system which includes a second plate for the deformation of the load and functional elements placed in an area of the heel of the sole in order to drive the foot in a neutral position after the first contact with the ground.

[0027] A further solution to these issues has been described in the patent DE19839657 which refers to a polypropylene biaxially oriented multilayer film comprising an intermediate layer containing wax, that grants good barrier properties and a high brightness.

[0028] However, also the aforementioned kind of soles don't allow the spill of the air from the interstices of the cushioning element, since this is a sealed system. The air, for this reason, interacts during the compression phase not allowing an optimal control of the mechanical response of the sole.

[0029] Furthermore, in the known solutions, there are issues related to the minor perception of comfort that the user feels, due to the small sizes and to the steadiness of the heel along the direction tibia/fibula in order to prevent the movements of pronator fellows (or supinates) from turning into hyper pronation movements (or hyper supination) with a consequent high probability of sprains in the malleolus area, or of modulation of the reaction time of the invention with reference to the reduction of the load, so that the push given to the heel during the preparation phase of the flying phase of the walk is adequate and biomechanically compliant.

[0030] Another solution is described in the patent US5086574 which reports an impact damping system for application to sport shoes having a hollow housing of flexible elastomeric material which is softer and more resilient than the insole material of the sport shoe which it is to be removably placed in a cavity in the heel area of the shoe. The inner and outer surfaces of the housing side which are smooth and homogeneous, and there is a top cover with an overhang lip which rests on the insole. One or more replaceable damping discs are inserted into the housing and are held therein by the cover which has downwardly extending pins to engage a groove in the disc and a peripheral flange at the lower end of the housing. This patent discloses a sole shaped in such a way that only a vertical deformation is allowed. The mechanical response of the damping system disclosed in patent US5086574 is elastic and vertically directed, being a typical sport shoe response.

[0031] Another solution is described in the patent US2008263894 that discloses a footwear sole including a plurality of shock absorbing elements that extend from upper and lower plates. In one embodiment, the shock absorbing elements include a plurality of receptacles extending from the lower plate and a plurality of protrusions extending from the upper plate. Each protrusion is associated with one receptacle, and a portion of each protrusion extends into the receptacle. A resilient sleeve surrounds each associated protrusion and receptacle. In another embodiment, a plurality of shock absorbing elements extends from a bridge on one of the upper and lower plates. Anyway, the cited patent doesn't disclose through holes and channels able to push out the air when the device is subjected to a compression load

[0032] The problem of these solutions is that the air can't discharge efficiently from the shoes during the compression, in use, by a user.

[0033] Another problem of known solutions is that the sole is not able to sustain a high load and to act as stabilizing and propulsion mean, not allowing any optimal control of the mechanical response of the sole.

[0034] The purpose of the present invention is to provide a device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means and allowing the efficient discharge of the air from the shoes during the compression by a user.

[0035] The purpose of the present invention, having geometrical and mechanical features so as to obtain a different kind of reaction depending on the amount of the load it is subjected to, allowing an optimized mechanical behavior and a distribution of loads and stresses, so as to be practical, comfortable and functional both with the user standing still and while walking or making a jump, therefore having characteristics such as to overcome the limits which still affect the known systems for cushioning, energy dissipation and stabilization.

[0036] According to the present invention, a device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means is provided, as defined in claim 1.

[0037] For a better understanding of the present invention it is now described a preferred embodiment, purely by way of non-limiting example, with reference to the accompanying drawings, in which:

- figure 1 shows a schematic three-dimensional exploded top view of a device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means, an example not according to the invention;
- figure 2 shows an axonometric top view of a first embodiment of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means, according to the invention;
- figure 3 shows schematic views along the sections A-A, B-B, C-C, D-D of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation

and stabilization means at the time preceding the "heel strike" phase, that is, before the application of the load, according to the invention;

- figure 4 shows a cross-section of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means, before (A) and after (B) the application of the load, according to the invention;
- figure 5 shows an axonometric bottom view of the second embodiment of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means, according to the invention;
- figures 6a-6b show a top view of the second embodiment of the device as shown in figures 4 and 5, and of the cushioning element of the second embodiment, according to the invention;
- figure 7 shows section A-A, B-B, C-C, D-D and E-E of the second embodiment of the device as shown in figures 4 and 5, according to the invention;
- figure 8 shows section A-A of the device as shown in figure 7 in detail, according to the invention;
- figures 9.a-9.e show sectional and top views of portions of the second embodiment of the device as shown in figures 5 and 6, according to the invention;
- figure 10 shows operational schemes during the compression stage of the second embodiment of the device as shown in figures 4 and 5, according to the invention;
- figures 11.a-11.c show holographic diagrams of the second embodiment as shown in figures 4 and 5, respectively at rest (11.a) and in use (11.b and 11.c), according to the invention;
- figure 12 shows schematic top views from above and in side view of the second embodiment of the device, with indication of the proportions depending on different shoe sizes, according to the invention;
- figure 13 shows a geometric characterization in longitudinal and transverse section of the second embodiment of the device, according to the invention;
- figure 14 shows schematic views of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means applied to the left and right soles of a footwear, according to the invention.

[0038] With reference to these figures and, in particular, to figure 1, a device 200 suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means is shown.

[0039] In particular, the device 200, 300 suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means, as shown in figures 1 and 4, is a modular device comprising a cushioning element 201, 301, made of a first material having a viscoelastic behavior, positioned over a conditioning element 202, 302 of the cushioning element 201, 301. The conditioning element 202, 302 is made of a second material having a viscoelastic behavior, and more rigid than the first material having a viscoelastic behavior of which the cushioning element 201, 301 is made.

[0040] According to an aspect of the invention, the device 300 also comprises a containing element 303 positioned above the cushioning element 301 and covering also the conditioning element 302.

[0041] The device 200, 300 is formed by the non-hermetic coupling between the cushioning element 201, 301, the conditioning element 202, 302 and the containing element 203, 303 such as to allow the spill of the air contained in predefined interstices, for example a plurality of holes 201g, 201h and channels 201i, included between the cushioning elements 201, 301, the conditioning elements 202, 302 when the device 200, 300 is subjected to a compression load, in use. In fact, the air present in the interstices at rest, when in use the device is subjected to a compressive stress due, for example, to the walk of a user, pours out from the plurality of holes 201g, 201h, 301f, 301c, and channels 201i, 301i formed in the cushioning element 201, 301 and in the conditioning element 202, 302.

[0042] Advantageously, this plurality of holes and channels and the non-hermetic coupling between the elements allows the device 200, 300 to have a controlled and not influenced by the presence of air mechanical response to the compressive stresses.

[0043] According to an aspect of the invention, the conditioning element 302 is made of a flexible material but with not negligible features of stiffness.

[0044] According to another aspect of the invention, the containing element 303 is made of a flexible material but with not negligible features of stiffness.

[0045] Preferably, the conditioning element 202, 302 and the containing element 203, 303 are made of a material chosen among: Polyurethane, rubber, TPU (thermoplastic polyurethane), EVA (ethylene vinyl acetate), polypropylene and other materials that are suitable for the functioning.

[0046] In particular, the effect of non-hermetic coupling between the elements allows the device 200, 300 to cause air to come out and, therefore, to have a controlled mechanical response to compressive stresses, not influenced by the presence of air. This non-hermetic coupling is achieved through a pre-defined alternation of regions full of the aforementioned material and of regions empty the same material, which are substantially hollow and, therefore, empty.

[0047] In fact, for example, the cushioning element 201 and 301 consists of a structure that comprises a pre-defined alternation of first regions full of the first viscoelastic material and of first regions empty of the first viscoelastic material, able to couple with a corresponding pre-defined alternation of second regions empty of the second viscoelastic material and of second regions full of the second viscoelastic material, or protrusions, of the conditioning element 202 and 302, when the device 200, 300 is subjected to a compression load. In this way, a balance of these regions of the cushioning element 201 and 301 and of the conditioning element 202 and 302 is achieved, in such a way as to allow the spill of air from the empty regions and the

desired deformation of the cushioning elements 201 and 301 and of the conditioning elements 202 and 302, so as to confer the desired mechanical features to the device 200, 300.

[0048] According to an aspect of the invention, second empty regions of conditioning element 302 are a plurality of second holes 301h and channels 301i that allow the cushioning element 301 to be deformed and adapted in a controlled manner. There are also second holes and smaller channels, able to spill the air contained inside the device, when it is subjected to a compression force. Moreover, the conditioning element 302 comprises peripheral upper protrusions having different heights for a differentiated support, to act as a support. Finally, the surfaces of the peripheral upper protrusions are sloped, creating a central concave surface configured to react to the application of an external load force and to straight foot toward the center of the heel, allowing the device to react to a load application with a centripetal reaction force able to align back any decentralized loads with respect to the center of the heel.

[0049] According to an aspect of the invention, the cushioning elements 301, conditioning elements 302 and containing elements 303 have a substantially oval shape. In particular, containing element 303 has a concave surface which follows a heel's curvature and, together with the conditioning element, defines a volume within which the cushioning element can warp.

[0050] According to a second embodiment of the device 200 not part of the invention, as shown in figure 1, the containing element 203 has a central ventilation hole 203a and the cushioning element 201 has a central protrusion 201a able to be coupled to the central hole 203a.

[0051] Advantageously the central hole 203a of the containing element 203 increases the user's comfort perception and facilitate the discharge of the air during the use. Alternatively, the same function of the containing element 203 can be carried out directly by the midsole of the shoe.

[0052] Advantageously, the shape of conditioning elements 302 and containing elements 303 influence the mechanical behavior of element 201, 301 by means of a pre-defined succession of full material portions and empty portions, as holes and channels, conveniently balanced.

[0053] Advantageously according to the invention, the materials of the cushioning element 301, of the conditioning element 302 and of the containing element 303 and their shape allow the device 300 to have an "active" operation mode, that is to be able to obtain a different reaction response in function of the load amount to which it is subjected. This active operation mode, caused by the shape and the materials of the device 300, prevent the incurring of sprains, twist and injuries. The device 300 is therefore different from the state of the art, describing mentioned 'passive' systems, that is systems able to absorb energy by means exclusively of chemical-physical characteristics of the material. Known devices and systems also have a rheologic behavior that cannot be modulated in a controlled manner with the changing of the load.

[0054] According to an aspect of the invention, the cushioning element 301 is made of a material having a high elastic deformation capacity and it is configured to be positioned in the area under the heel of the user. In this way, the cushioning element 301 enhances the energy absorbing characteristics of the device 300 during loading ("heel strike"), so as to amortize and slow down the impact velocity between the user's heel and the soil. The cushioning element 301 is made of a material having a rheological behavior that has a delay in the response to a load variation. Therefore, during the phase preceding the "Heel off" moment, i.e. the instant preceding the detachment of the heel, the device 300 is able to gradually return the energy absorbed and generate a biomechanically compatible thrust that is comfortable, anti-fatigue and above all not harmful to the user's tendon and musculoskeletal structure.

[0055] Advantageously according to the invention, the holes and channels formed in the conditioning element 302 and in the containing element 303 facilitate the air eventually comprised in interstice spaces to spill out. Another function of said holes and channels is to allow the cushioning element 301 to deform, also thanks to empty regions, that act as expansion positions of cushioning element and that characterizes the shape and geometry of the device, highly increasing the energy dissipation capacity of the device 300. Indeed, only a part of the energy absorbed during the loading phase will be transmitted to the user during the unloading phase, or in the phase preceding the detachment of the heel, in the form of a thrust that facilitates the lifting of the heel ("heel off") in a biomechanically compatible manner.

[0056] Advantageously according to the invention, the conditioning element 302 is made of a second viscoelastic material, more compact than other elements, and its shape, together with the containment function of containment element 303, is configured to make all the reaction forces converge at a same point. In this way the heel is always brought in axis along the tibia/fibula direction, whatever the direction of the applied stress is (pronation or supination).

[0057] Figure 4 shows a cross section, for example, of device 200 but the same applies to device 300, before the application of the load (Fig. 4A) and after the application of the load (Fig. 4B). Before the application of the load (Fig. 4A) the device 200 is not compressed; elements 202 and 203 define a volume within which the cushioning element 201 can deform. In the figure 3, arrows identify the deformation directions of the cushioning element 201. In the following phase, a compression load F is applied to the device 200 (Fig. 4B); the cushioning element 201 deforms according to the directions indicated in figure 4A, until the shape of the cushioning 201 is defined by components 202 and 203 jointly. Arrows in figure 4B indicate the direction of reaction forces of the device 200 upon application of the load. Thanks to the geometry and shape of elements 202 and 203, the reaction forces converge towards a single point, acting so as to bring back any loads off-centered with respect to the heel center or having a direction different from a reference condition, ensuring the stabilization of the heel along the tibia/fibula direction.

[0058] The Applicant verified that, during the compression of the device 200, 300 by a user, three types of behavior can be identified:

- Low loads: this is the load condition corresponding to a user standing or during a walk. In this phase the response of the device 200, 300 is characterized by a low elastic modulus (that corresponds to a high elastic deformation under reduced loads). In this condition the device 200, 300 slows down the speed of the impact on the ground of the heel and is easily deformed. In case of a user standing upright, the device dampens all the small movements, thus reducing deleterious stresses that may be transmitted to user's musculoskeletal structure. During this phase, the elastic component of the device 200, 300 works more, therefore a large part of the energy will be returned to the user during the unloading phase, with a modulated thrust, in order to facilitate and unload the walk.
- Intermediate loads: this is the load condition corresponding to a user's fast walk, eventually carrying heavy equipment. In this phase the cushioning element 201, 301 deforms according to the geometry defined by both elements 202, 302 and 203, 303. The mechanical response of the device 200, 300 is characterized by a higher modulus of elasticity, the damper component increases and a considerable part of the energy absorbed in this phase will be dissipated, and therefore it will not be returned to the user during discharge phase.
- High loads: this is the reference condition for a user during a jump, possibly carrying heavy equipment. In this phase the cushioning element 201, 301 continues to deform and begins to apply a pressure also on the side portion of containing element 203, 303. Mechanical behavior of the device 200, 300 is characterized by an even higher modulus of elasticity. During this phase the damping component of the device 200, 300 is mostly used, therefore a large part of the energy will be dissipated and will not be returned to the user during the unloading phase. Instead, during the decompression phase there is a delay in the device response. The device 200, 300, therefore, does not instantly recovery the deformations caused by compression, when the load is removed this kind of device mechanical behavior ensures a biomechanically compatible thrust on the user's heel.

[0059] A second embodiment is shown in Figures 5 and 6, in which the device 300 comprises a substantially oval shaped cushioning element 301, comprising a central plane region 301a substantially oval shaped, provided with first through holes 301f and with further channels 301fa, which allow an improved passage of air inside the device 300 and the sole; and also with a regulating deformation crown 301b, for a controlled deformation, peripheral to the central plane region 301a, provided with a plurality of second through holes 301c (shown in figure 6), at least eight, and with C-shaped side protrusions 301d, at least four per side and grouped between them two by two. The regulating deformation crown 301b is also provided with at least four C-shaped back gathered protrusions 301e, grouped between them, all extending from the upper surface to the lower surface of the cushioning element 301. The side protrusions 301d and the back gathered protrusions 301e extend from the upper surface to the lower surface of the cushioning element 301. The conditioning element 302 of the device 300 is a flat element comprising at the top a central hollow region 302a able to engage the central

plane region 301a, and a peripheral region having a plurality of side protrusions 302b, preferably two on each side, and a back protrusion 302c. Moreover, all the protrusions 302b and 302c are spaced out with empty portions 302d, at least four, to receive and be a seat for the cushioning element 201, 301, allowing its deformation when a load force is applied.

[0060] The containing element 303 is an internally hollow element comprising on its upper surface a central hole 303a. Inside the central hole 303a, the central plane region 301a and the central hollow region 302a respectively of the cushioning element 301 and of the conditioning element 302, are included.

[0061] Advantageously according to the invention, the central hole 303a of the containment element 303 has the function of increasing user's comfort and facilitate the spill of air during the use of a sole including the device 300.

[0062] Advantageously according to the invention, two of the protrusions 301d and 302b are placed laterally inside the sole and are useful in the case of supinator foot, other two protrusions 301d and 302b are placed laterally outside the sole and are useful in case of pronator foot.

[0063] Advantageously according to the invention, the rear protrusions 301e and back protrusion 302c allow to stabilize the foot, to provide propulsion and to favor walking during the "heel off" phase.

[0064] Advantageously according to the invention, the protrusions 301d, 301e, 302b and 302c optimize and increase the comfort of a user's foot.

[0065] Figure 6 shows an upper view of the device 300 and an upper view of the cushioning element 301, wherein three different functionality areas of the cushioning element 301 are indicated. Figure 7 shows section view, in particular A-A, B-B, C-C, D-D and E-E, of device 300, wherein the proportions between height of the cushioning element 301 and the height of the conditioning element 302 in the three areas of figure 6 are shown. In particular, zone 1 indicates an area corresponding to the central plane region 301a of cushioning element 301, area 2 indicates the region corresponding to lateral C-shaped protrusions 301d, and area 3 indicates the area of back gathered protrusions 301e of cushioning element 301.

[0066] According to an aspect of the invention, as shown in figure 7, along section A-A the ratio between the cushioning element 301 and the conditioning element 302 in area 3 is comprised in the range 0.45-0.55, while in area 1 it is comprised in the range 0.08-0.10. Along B-B section, the ratio between the cushioning element 301 and the conditioning element 302 is comprised in the range 0.08-0.10 in area 1, and 0.10-0.15 in area 2. Along C-C section the same ratio is comprised in the range 0.08-0.10 in area 1, and 0.20-0.25 in area 2. Along the section D-D said ratio is comprised in the range 0.25-0.30 in area 1, and 0.30-0.40 in area 2.

[0067] In E-E section, shown in figure 7, the flow of air through the conditioning element 302,

which passes through the cushioning element 301 and spill out of the containment element 303.

[0068] Advantageously according to the invention, the cushioning element 301 comprises through holes and non-through holes, and the conditioning element 302 comprises channels 301i, said holes and said channels allowing the air to flow out of the device 300.

[0069] Figure 8 shows a side section of the device 300, in particular the compenetration of cushioning element 301 in conditioning element 302 is shown. Device 300 has a tapered end, that is an upper surface that tends to go downwards, allowing an interpenetration so that the dimension D1 is greater than the dimension D2, both shown in figure 8, D2 having a height comprised between 0 mm and 10 mm, and the upper surface of the device 300 decrease, that is have a decreasing height towards a front end, with an angle comprised between 15° and 20° with respect to an horizontal axis x-x.

[0070] Figure 9 shows differentiated load bearing capacity regions of the device 300. In particular, figure 9.a shows, a section of cushioning element 301 coupled to the conditioning element 302, in which a low bearing region corresponds to the central body, with the main function of cushioning at the heel spine area. In the same figure 9.a is also shown, with a different filling sign, a back portion having high load bearing capacity, for stabilization and propulsion. Moreover, figures 9.b and 9.c shows, respectively a side view and an upper view, of a medium bearing capacity region, corresponding to independent side protrusions radially arranged to the low-bearing capacity region. The functions of medium-bearing region are to stabilize and bring the foot axis back to a neutral position. Back gathered protrusions 301e have a high bearing capacity compared to side protrusions 301d, that have medium bearing capacity, and are higher in order to provide an increased support and stability. Moreover, back gathered protrusions 301e are advantageously characterized by an upper inclined surface to provide an adequate propulsion during the detachment of the foot from the ground during the deambulation.

[0071] Figure 9.c shows the cushioning element 301 of the device 300, highlighting the high bearing capacity region corresponding to the side protrusions and a crown region for connecting the different areas. The crown region is important to obtain a controlled deformation being correlated to the type of mechanical response that the device 300 should provide.

[0072] Figure 9.d shows a conditioning element 302 in which are highlighted, in addition to the previous regions, expansion seats for the cushioning element 301 to be deformed under un applied load.

[0073] Figure 10 shows a mechanical behavior of the device 300 in use, i.e. the progress of the device reaction depending on the compression force applied to it.

[0074] Figure 11 shows the device 200, 300 integrated in a sole of a footwear and worn by a

user. Fig. 11.a shows that the axis of the sole forms a certain angle with the axis of the leg at rest, i.e. before the action of the force of compression due to the deambulation. The force of compression F can act centrally with respect to the axis of the sole or sideways, towards inside in case of pronation of the foot, or towards outside in case of supination of the foot. Figure 11.b shows that, as a result of the action of the force of compression F , the device 200, 300 deforms only in the stressed region, without involving the adjacent region. In particular, the device 200, 300 returns a force of reaction to the compression such as to bring the user's leg back on axis, this way preventing mechanical traumas on the lower joints.

[0075] Such an advantageous behavior of the device 200, 300 is due to the geometry of the elements 301, 302, 303, to their shape and to the mutual arrangement of full and empty regions. Furthermore, the presence in the device 200, 300 of regions characterized by a differentiated load bearing capacity and the presence of holes and channels that allow the spill of the air, optimize the mechanical response to the compression loads.

[0076] Figure 11.c shows how the device 200, 300, thanks to independent areas of reaction, that is regions with differentiated load bearing capacity, is able to dampen any possible roughness from the bottom of the floor or of the ground, advantageously avoiding the rotation of the sole on which the device is applied and the consequent rotation of a user's leg axis. Such an undesired rotation could in fact lead to dislocations and distortions. Therefore, the variable geometry of the device allows an 'active' and advantageous behavior.

[0077] Figure 12 shows the definition of three different measurements of the device 200, 300 in relation to three shoe size macro-groups. Advantageously, the obtained proportion allows to guarantee the correct relationship between the mechanical response of the device and the body weight of a user.

[0078] Figure 13 shows views in section, highlighting geometrical characteristics of the device, in particular side and rear inclinations which allow an easy deambulation, especially when the foot is detached from the ground. In particular, the angle formed between the lower surface of the cushioning element 301 and the ground, with respect to the central axis passing through the heel of the shoe, is called Ω , while the angle formed between the back gathered protrusions 301e of the cushioning element 301 and the level of the conditioning element 302 is called δ .

[0079] Finally, figure 14 shows an upper view of the device 300 when integrated in the sole of a shoe, where the angles α , β and γ , which define a top view profile of the device 200, 300, are highlighted. In particular the angle α is comprised between 5° and 8° , the angle β is comprised between 18° and 20° , while the angle γ is comprised between 21° and 22° . These angles are configured to ensure greater comfort and support in use. Furthermore, figure 14 highlights the positioning of the device 200, 300 when integrated in a sole of footwear, in the rear portion of the footwear itself, near the heel of a user. In order to ensure the correct functioning, the comfort and a maximum stability, the device 200, 300 occupies almost the entire heel portion of the sole supporting the whole area of the heel. The device 300 is therefore integrated in a

sole portion corresponding to the heel of a user, at a distance D3 from the outer perimeter of the sole, D3 being comprised between 0% and 18% of a width D4 of the sole in its rear portion corresponding to the heel, as shown in Figure 14.

[0080] According to an aspect of the invention, the device 300 is integrated in the sole of a footwear, in such a way that the conditioning element 302 is an integral part of the sole, being integrated in a sole portion corresponding to the heel of a user, and the cushioning element 301 is arranged above that portion. In particular, the conditioning element 302 corresponds to a portion of the tread of the footwear.

[0081] Therefore, the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means according to the invention allows to absorb and dissipate the energy generated during the first instant of foot-ground interaction ("heel strike") and to limit the deleterious stresses transmitted to the bony joints.

[0082] A further advantage of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means according to the invention is to be able to adequately modulate the force of reaction during the discharge stage, also known as "rebound" force, in such a way that this is compatible with the user's biomechanical requirements.

[0083] Another advantage of the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means according to the invention is to ensure the stabilization of the heel along the tibia / fibula direction while walking and to avoid one of the main causes of injury on the work, that is the dislocations.

[0084] Furthermore, the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means according to the invention maximizes comfort and stability thanks to the positioning in correspondence with almost the entire heel of the sole, supporting the entire area of the heel.

[0085] Finally, the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means according to the invention allows to maintain its characteristics for the entire life cycle of the footwear.

[0086] It is finally clear that the device suitable for being integrated in footwears soles, acting as cushioning, energy dissipation and stabilization means described and illustrated herein can be subject to modifications and variations without departing from the scope of the present invention, as defined in the appended claims.

REFERENCES CITED IN THE DESCRIPTION

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Patentkrav

1. Anordning (300), der er egnet til integration i fodtøjssåler og fungerer som affjedrings-, energisprednings- og stabiliseringsmiddel, som omfatter:

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– et affjedringselement (301), der er fremstillet af et materiale, der har en viskoelastisk funktionsmåde, og som omfatter en foruddefineret ændring af første områder, der er fyldt med det første viskoelastiske materiale, og af første områder, der ikke indeholder noget af det første viskoelastiske materiale, som er første gennemgående huller (301f) og andre gennemgående huller (301c) og kanaler (301i), så luft kan strømme ud af anordningen (300), når anordningen (300) udsættes for en kompressionsbelastning;

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– et konditioneringselement (302), hvor affjedringselementet er placeret på konditioneringselementet, og konditioneringselementet er fremstillet af et andet materiale, der har en viskoelastisk funktionsmåde, som er mere stift end det første materiale, der har viskoelastisk funktionsmåde, som omfatter en foruddefineret ændring af andre områder, der er fyldt med det andet viskoelastiske materiale, og af andre områder, der ikke indeholder det andet viskoelastiske materiale, de første områder, der er fyldt med det første viskoelastiske materiale, og de første områder, der ikke indeholder det første viskoelastiske materiale i konditioneringselementet (301), er konfigureret til at forbinde med de tilsvarende andre områder, der ikke indeholder det andet viskoelastiske materiale, og med de andre områder, der er fyldt af det andet viskoelastiske materiale i konditioneringselementet (302), når anordningen (300) udsættes for en kompressionsbelastning og

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– et indeholdende element (303), der er placeret over affjedringselementet (301) og også dækker konditioneringselementet (302); **kendetegnet ved, at** de første fyldte områder af affjedringselementet (301) er sidefremspring (301d) og bagsidefremspring (301e), sidefremspringene (301d) og bagsidefremspringene (301e) stikker frem fra den øverste flade til den nederste flade på affjedringselementet (301).

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2. Anordningen (300) ifølge kravet **kendetegnet ved, at** sidefremspringene (301d) og bagsidefremspringene (301e) er C-formede.
- 5 3. Anordningen (300) ifølge krav 1, **kendetegnet ved, at** sidefremspringene (301d) er mindst fire og samlet af to på hver side, og bagsidefremspringene (301e) er mindst fire samlede fremspring.
- 10 4. Anordningen (300) ifølge krav 1, **kendetegnet ved, at** affjedringselementet (301) omfatter et centralplansområde (301a), der omfatter de første gennemgående huller (301f) og kanaler (301fa); og en regulerende deformationskrone (301b) perifert for centralplansområdet (301a) og omfatter de andre gennemgående huller (301c) og sidefremspringene (301d) og bagsidefremspringene (301e).
- 15 5. Anordningen (300) ifølge krav 1, **kendetegnet ved, at** de andre fyldte områder af konditioneringselementet (302) er to sidefremspring (302b) på hver side og et bagsidefremspring (302c).
- 20 6. Anordningen (300) ifølge krav 1 og 5, **kendetegnet ved, at** opberedningselementet (302) er et fladt element, der omfatter et øverste centralt hult område (302a), der har en perifer del, der omfatter sidefremspringene (302b) og bagsidefremspringene (302c).
- 25 7. Anordningen (300) ifølge krav 1, 4 og 6, **kendetegnet ved, at** det indeholdende element (303) er et internt hult element, der på sin øverste flade omfatter et centralt hul (303a), og er placeret henholdsvis i forbindelse med det centrale plans områder (301a) og det centrale hule område (302a) på affjedringselementet (301) og på konditioneringselementet (302).
- 30 8. Anordningen (300) ifølge krav 1 og 4, **kendetegnet ved, at** affjedringselementet (301) og konditioneringselementet (302) omfatter:

– et område med lav bærekapacitet, som svarer til centralplansområdet (301a), som er konfigureret til at bære en let belastning og fungere som affjedringsmiddel;

5 – et bagområde, der omfatter bagsidefremspringene (301e), der har høj bærekapacitet, som er konfigureret til at bære en høj belastning og fungere som stabilisations- og fremdriftsmiddel;

10 – et område med mellem bærekapacitet, som svarer til sidefremspringene (301d), der er radialt arrangeret i området med lav bærekapacitet, og fungerer som stabilisations- og udretningsmiddel for at bringe fodaksen tilbage til en neutral position.

9. Sål, der omfatter en anordning (300), der er egnet til integration i fodtøj og fungere som affjedrings-, energisprednings- og stabiliseringsmiddel, ifølge kravene 1-8.

DRAWINGS

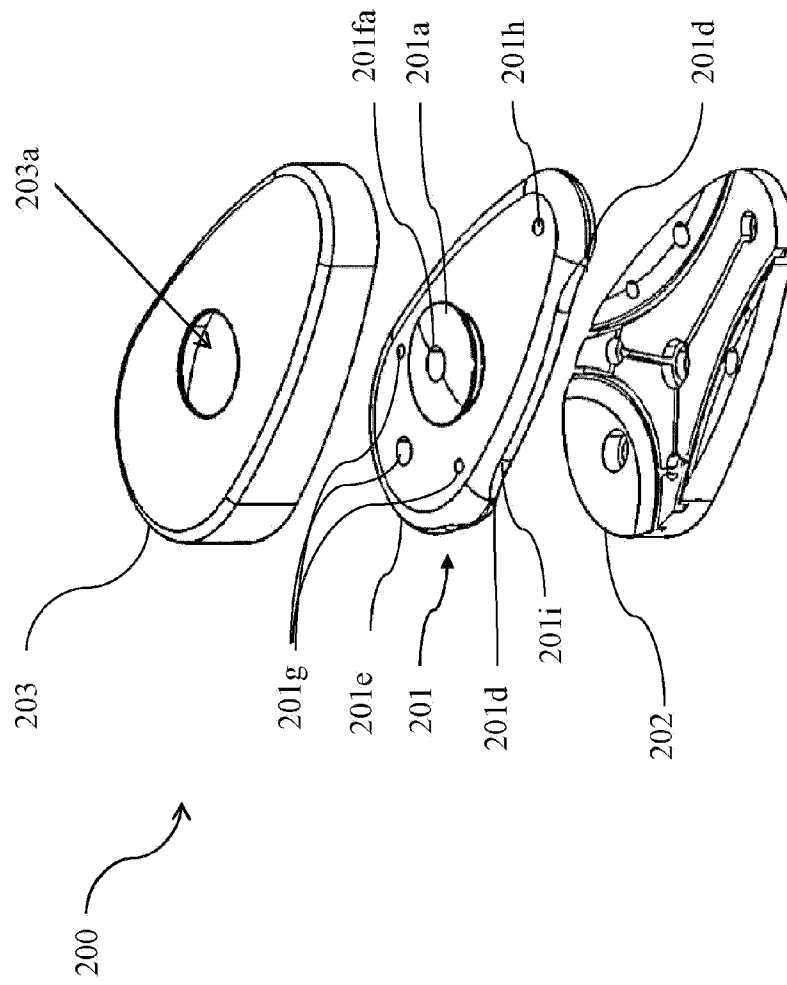


Fig. 1

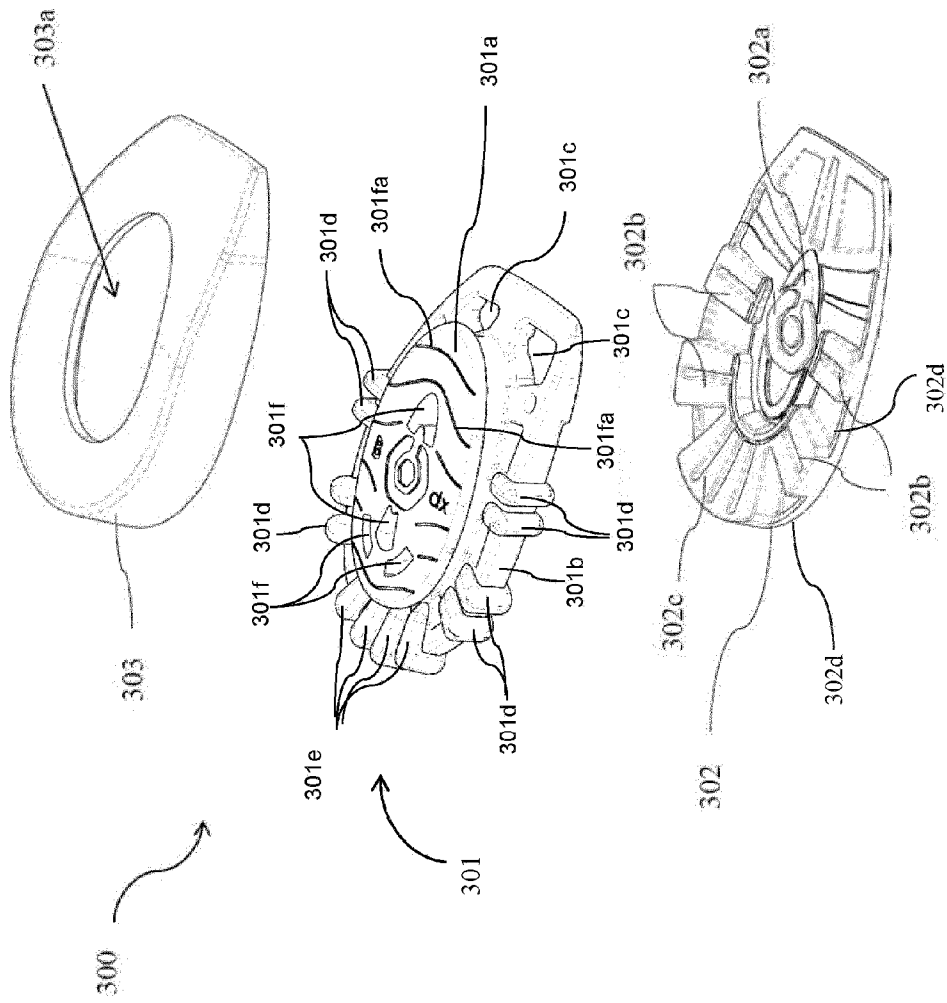


Fig.2

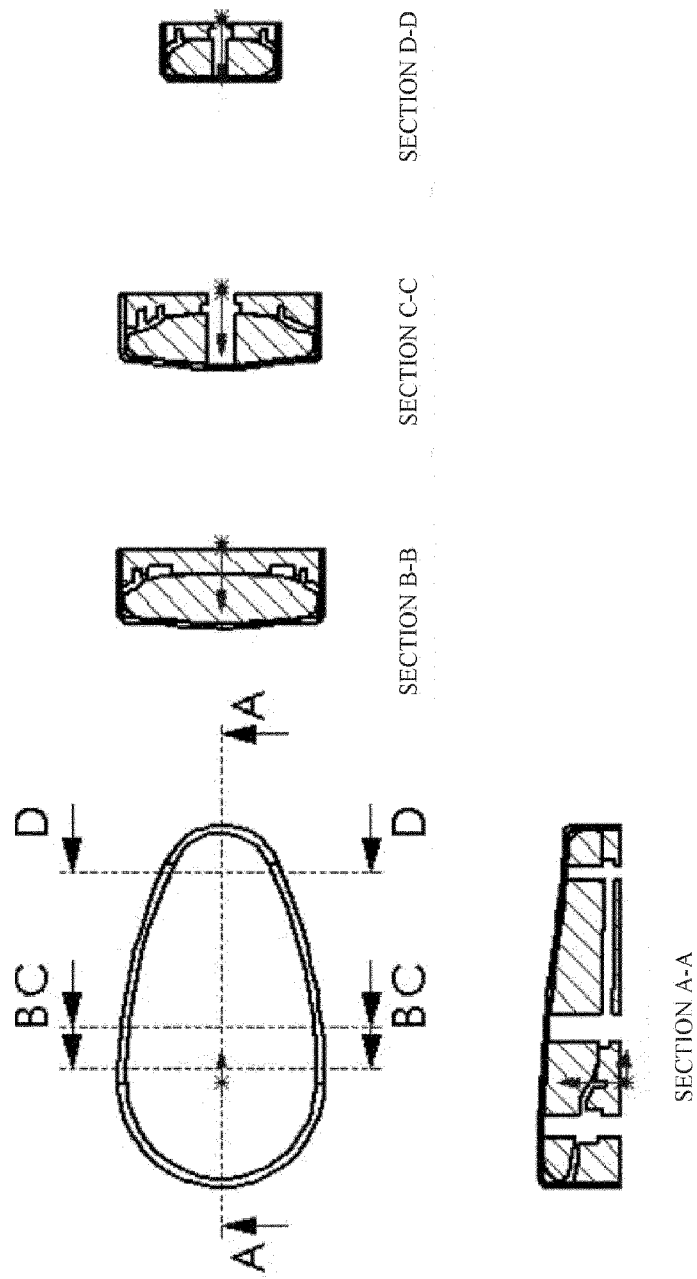


Fig.3

Fig.3A

Fig.4A

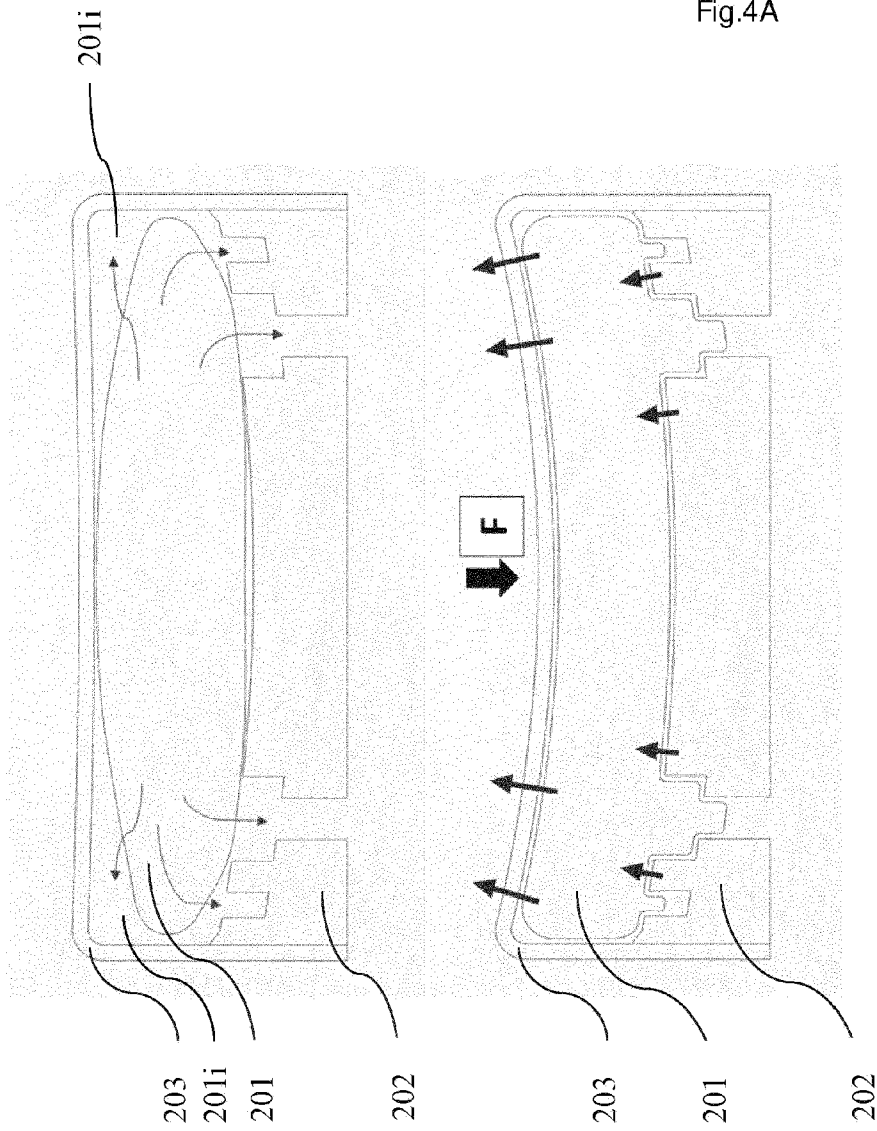


Fig. 4

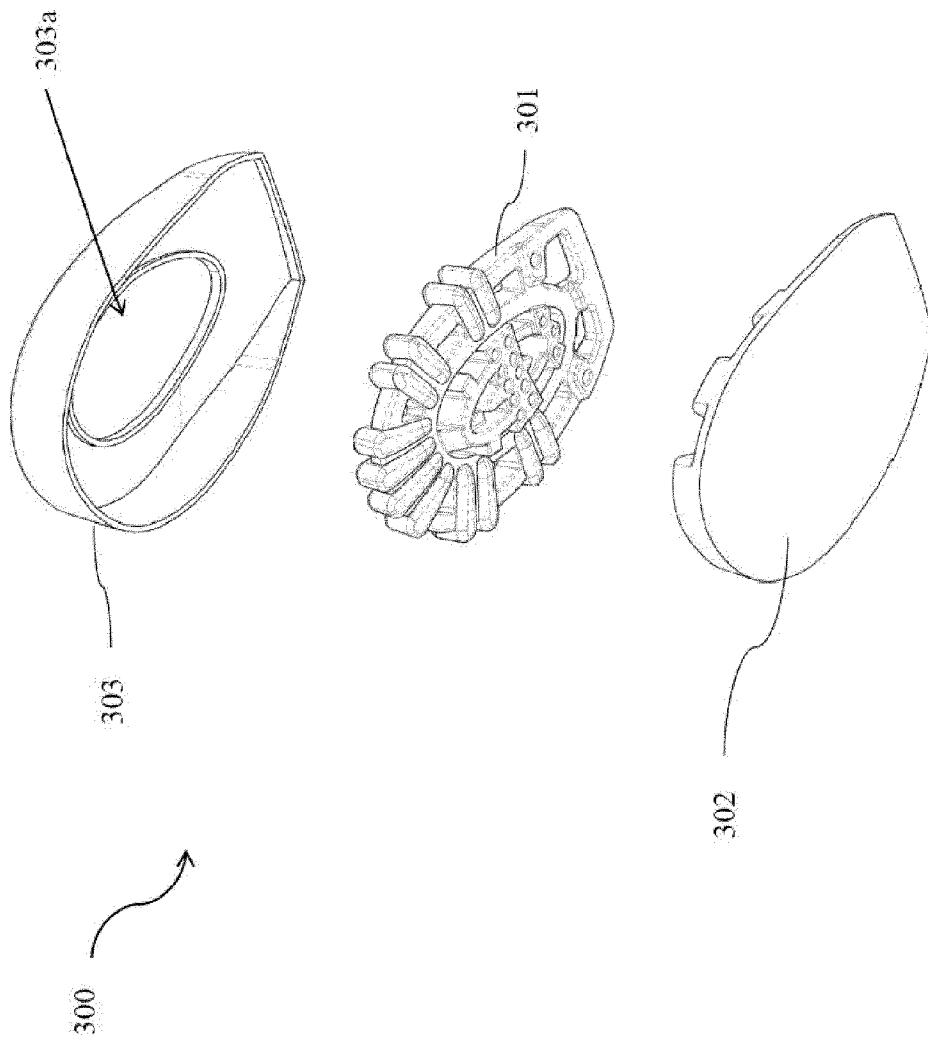


Fig. 5

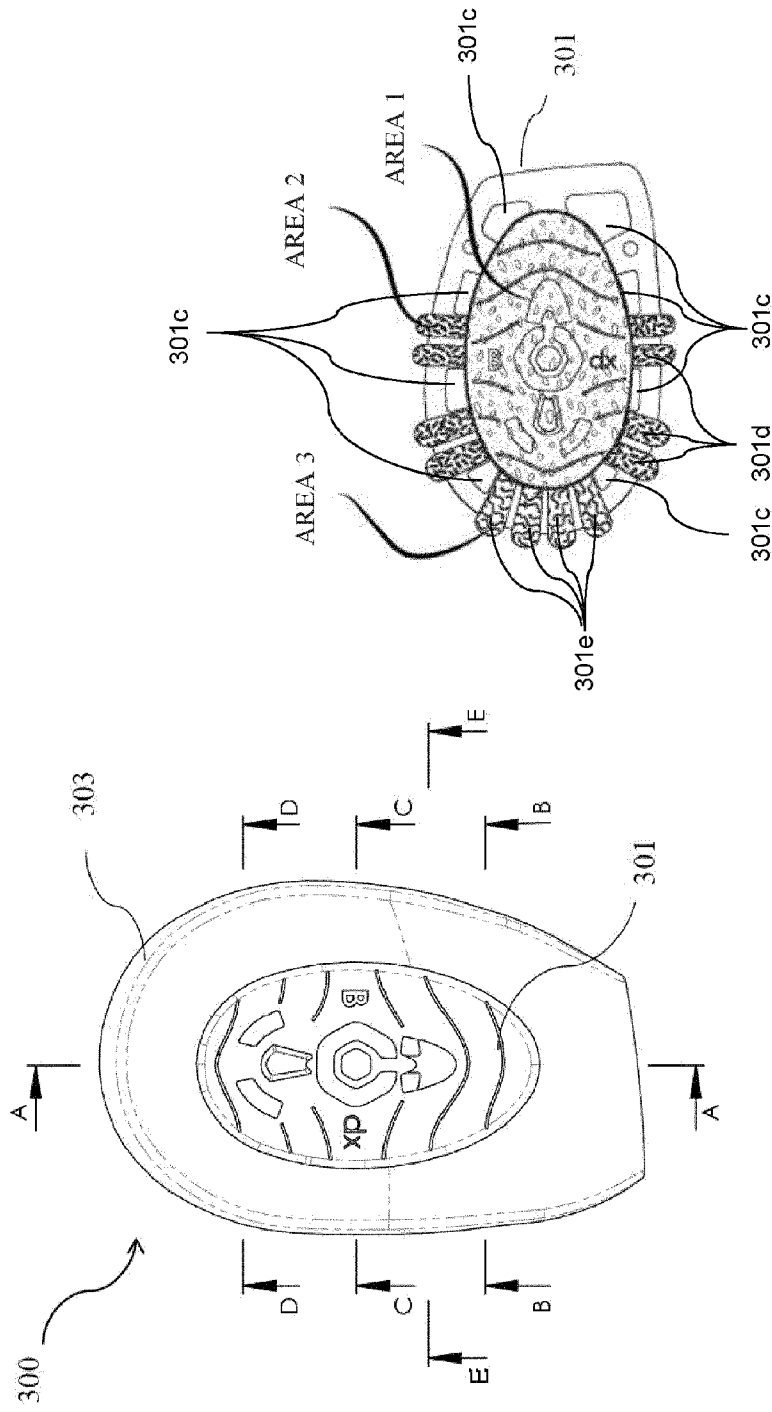


Fig.6.a

Fig.6.b

Fig.6

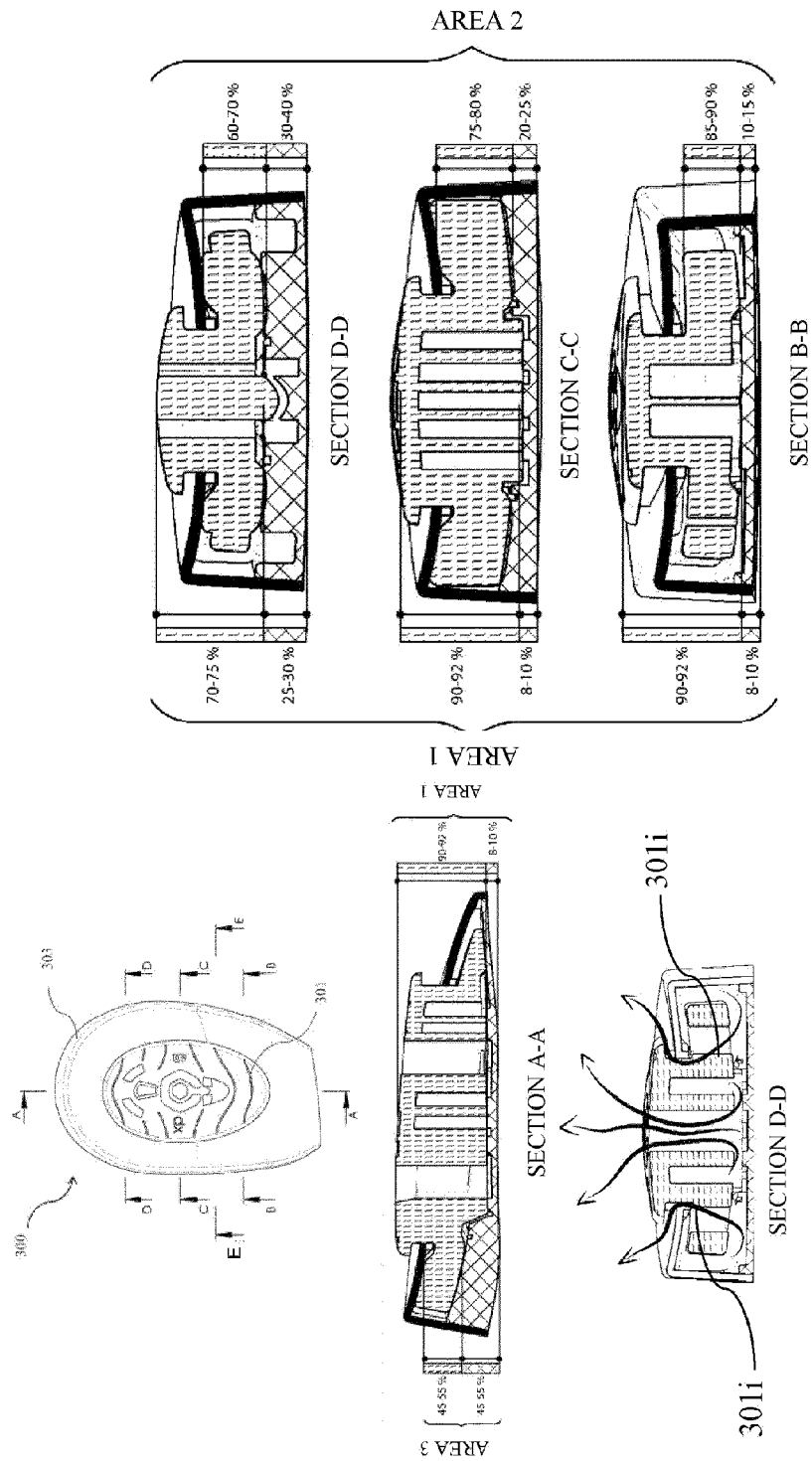


Fig. 7

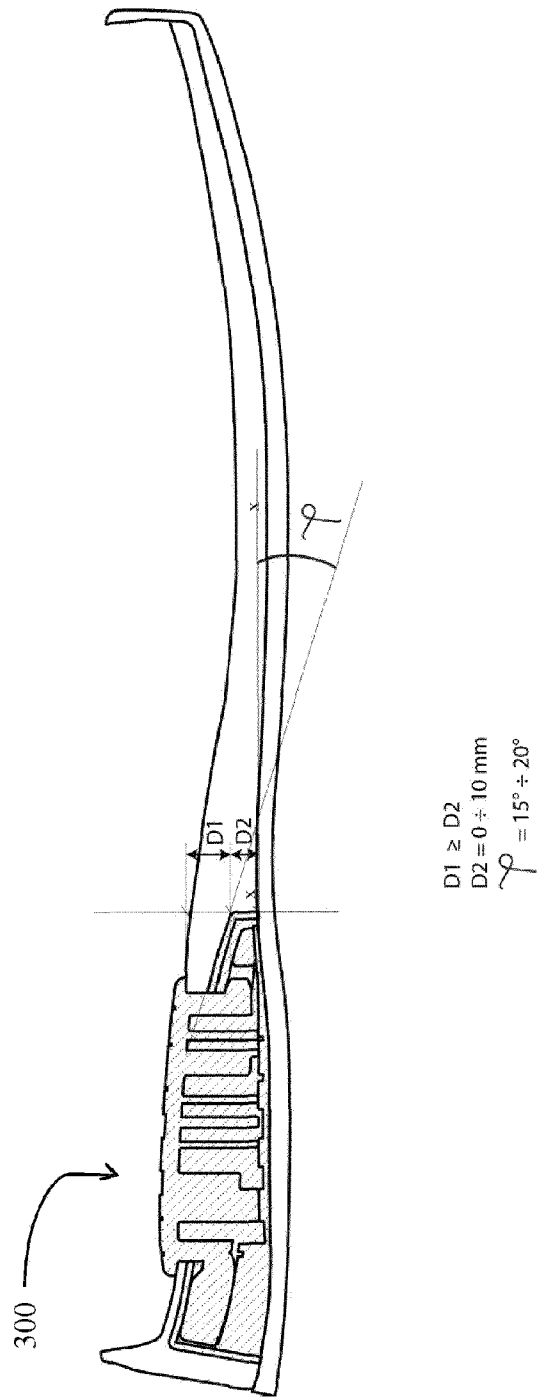


Fig.8

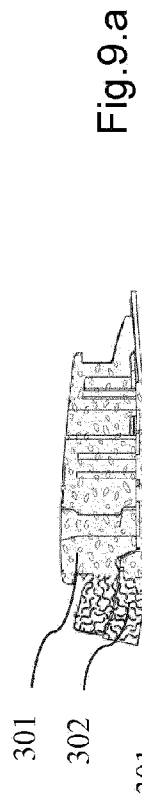


Fig. 9.a

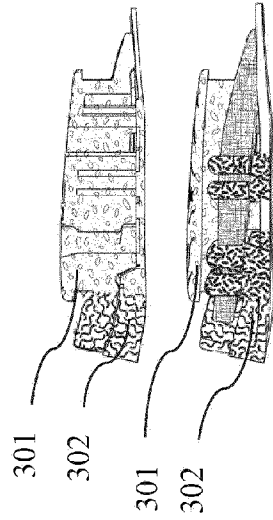


Fig. 9.b

FOOT INNER SIDE THE FOOT

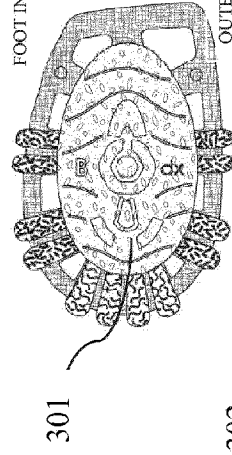


Fig. 9.c

OUTER SIDE OF THE FOOT

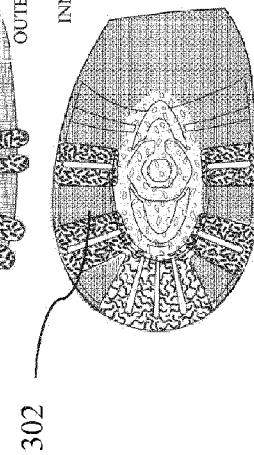


Fig. 9.d

OUTER SIDE OF THE FOOT

OUTER SIDE OF THE FOOT

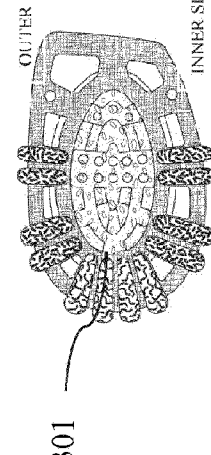


Fig. 9.e

INNER SIDE THE FOOT

Fig. 9

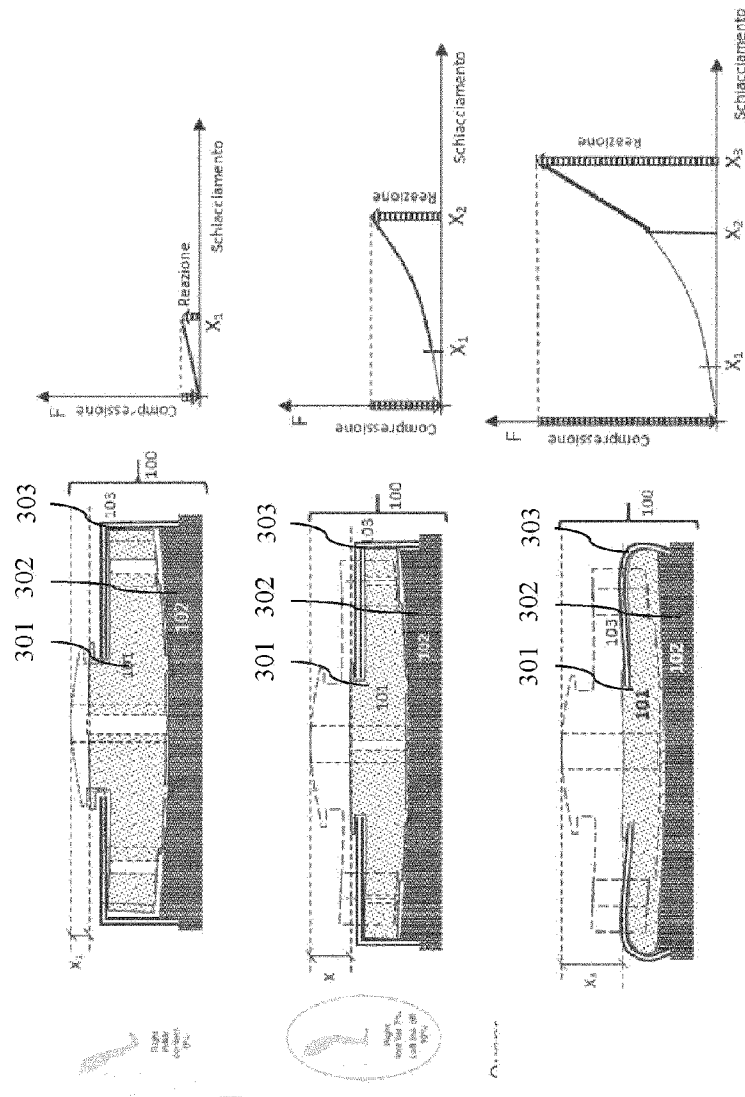


Fig.10

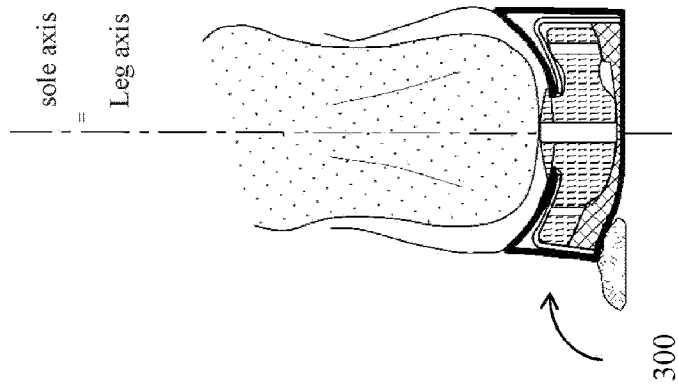


Fig.11.c

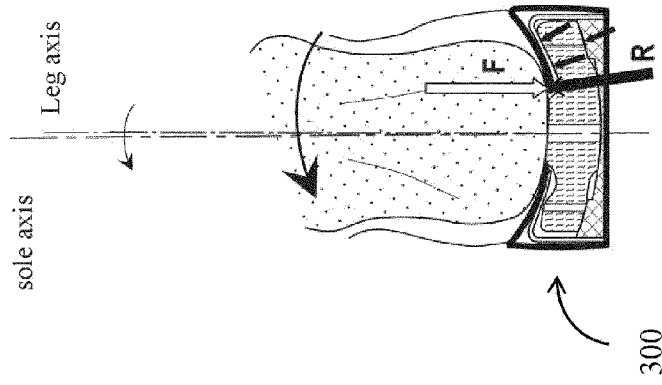


Fig.11.b

Fig.11

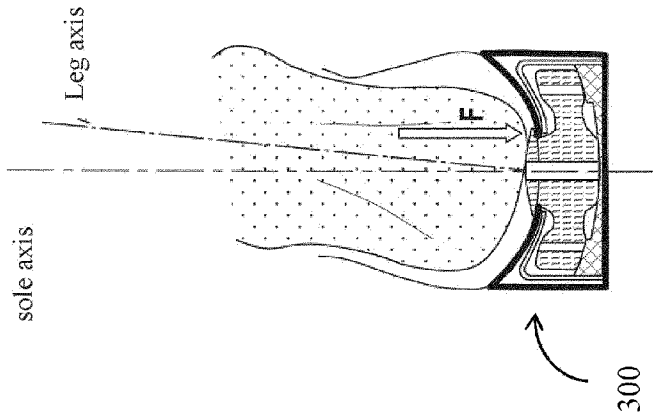


Fig.11.a

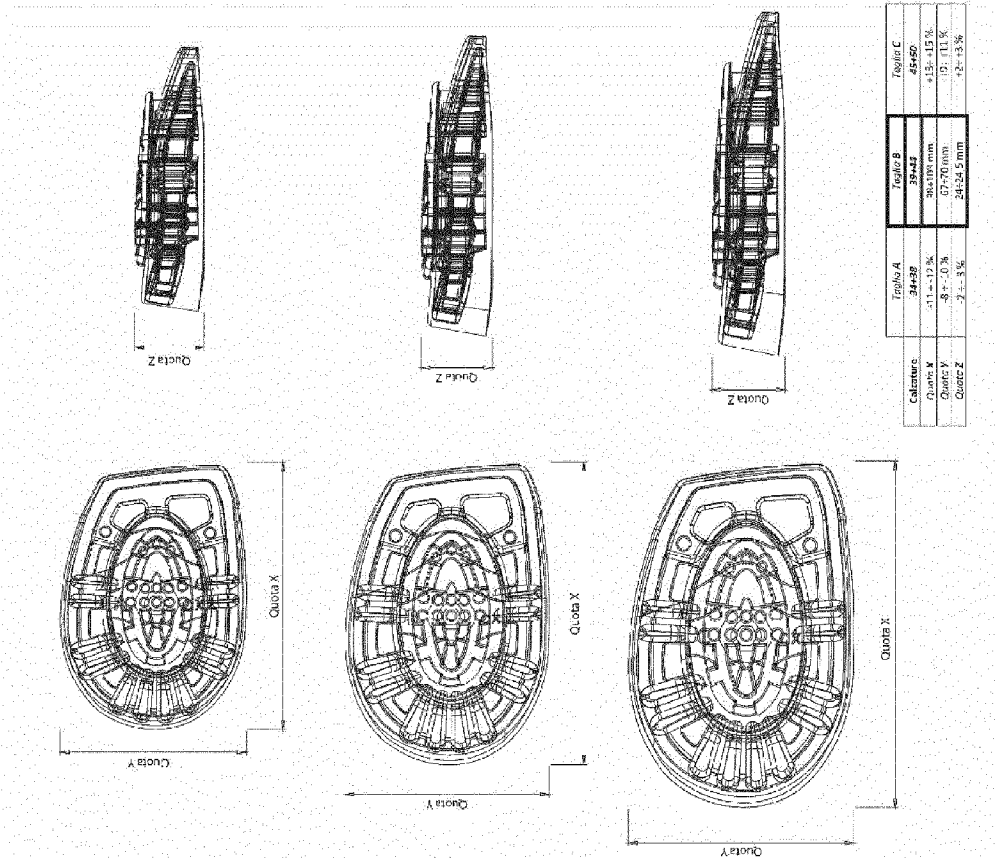


Fig.12

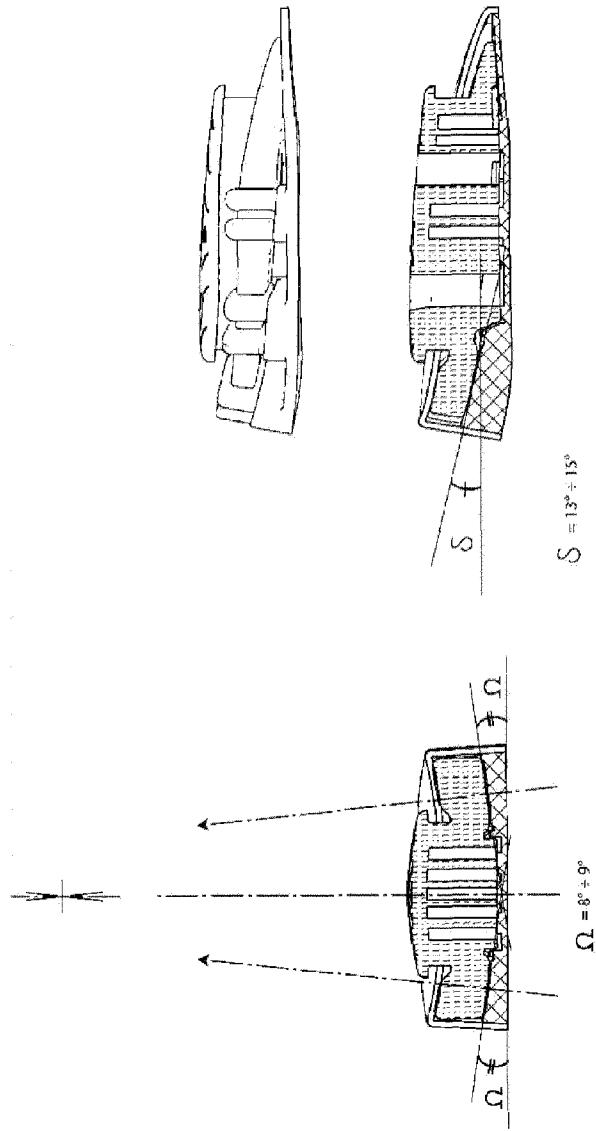


Fig.13

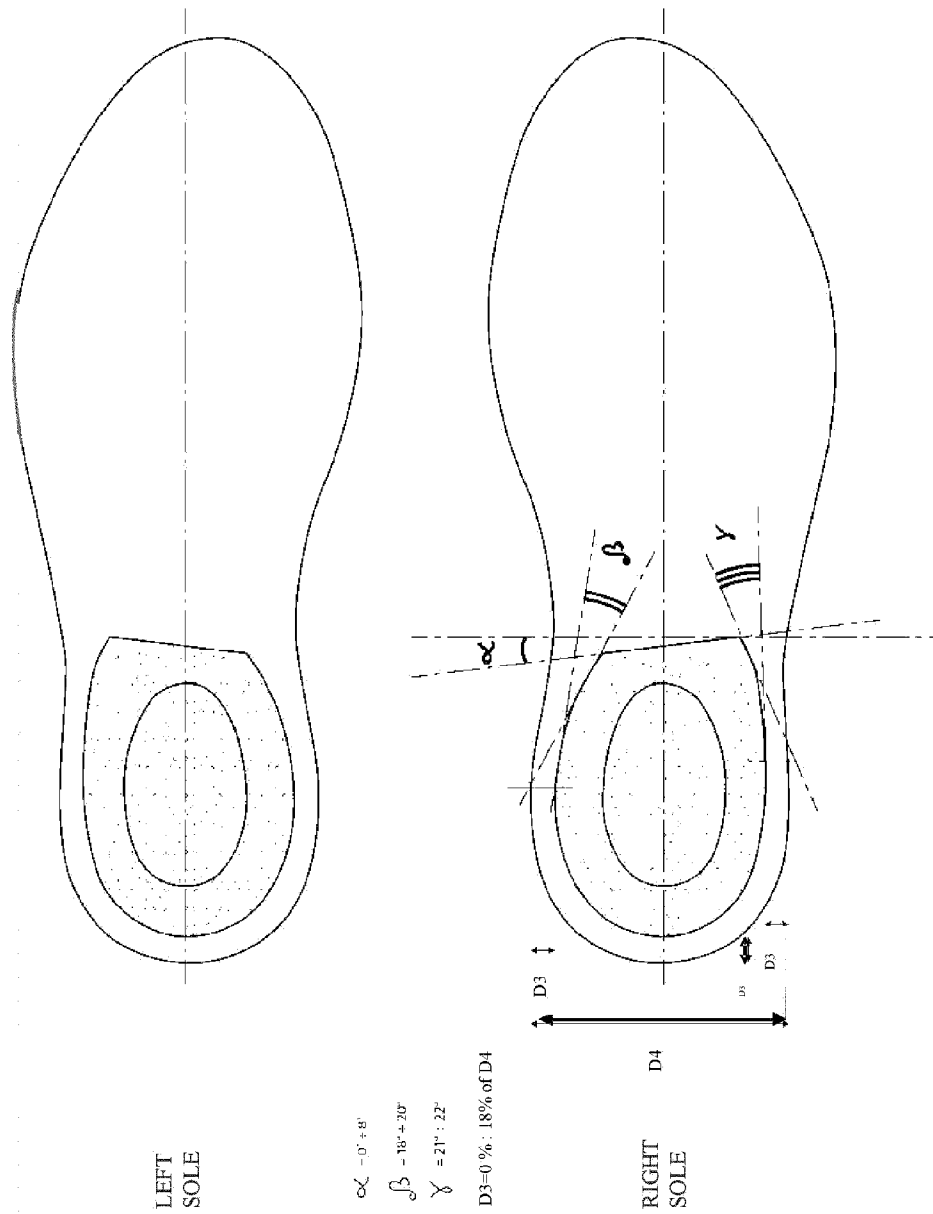


Fig.14