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SPORTS FOOTWEAR WITH A SOLE UNIT COMPRISING AT LEAST ONE COMPOSITE MATERIAL LAYER PARTLY INVOLVING THE SOLE UNIT ITSELF

This invention relates to footwear, in particular sports footwear, in accordance with the introduction to the main claim.

The characteristics of sports footwear vary considerably. In particular, over the years it has been sought to design sports footwear or shoes which restore to the user part of the energy which he directs towards the ground or resting surface during walking, running, jumping or other movements. A large number of designs tending to achieve this object are therefore known, they generally comprising elastic inserts arranged within the sole unit preferably at the heel. Although these known designs achieve satisfactory results, they have various drawbacks. These include: excessive footwear weight leading to obvious problems of premature tiredness for the user (for example an athlete) during use; considerable constructional complexity leading to imperfect mounting of the sole unit and/or of the insert positioned in it with consequent imperfect energy return to the user's foot; a non-anatomical shape of the sole unit or insole positioned in contact with it, hence penalizing the user during use. To this can be added the fact that a rubber sole absorbs moisture during use and, in particular, retains soil on muddy ground, leading to a further footwear weight increase with obvious consequences for the user.

An object of the present invention is to provide footwear, in particular sports footwear, which is lightweight, returns energy to the user's foot on being lifted after contact with the ground, absorbs virtually no or very little moisture, and adequately supports the user's foot.

A further object of the invention is to provide footwear of the aforesaid type the use of which cannot excessively tire the user and which cannot in any way damage his bone and muscolar structure.

These and further objects which will be apparent to the expert of the art are attained by footwear, in particular sports footwear, in accordance with the accompanying claims.

The present invention will be more apparent from the accompanying drawing, which is provided by way of non-limiting example and in which:

Figure 1 is an exploded view of footwear according to the invention;
Figure 2 is a view of the footwear of Figure 1 from below;
Figure 3 is a view of the footwear of Figure 1 from the rear;
Figure 4 is an exploded view of a first modification of the invention;
Figure 5 is an exploded view of a second modification of the invention.

With reference to Figures 1, 2 and 3, footwear 1, in particular sports footwear, comprises a vamp 2, an insole 3 and a sole unit 4. This latter comprises a first portion 5 or sole piece of composite woven material (ie. comprising weft fibres T and warp fibres O bound together as in a usual fabric); these fibres can be carbon fibres impregnated with thermosetting resin (or carbo-resin) and/or fibres of material known by the commercial name of Kevlar (aramid fibres impregnated with thermosetting resin). If carbon fibres are combined with aramid fibres, a fabric is obtained in which for example the weft is of carbon fibres and the warp of aramid or Kevlar fibres). Said weft fibres T (or warp fibres O) are all parallel to each other, all lying at a predetermined angle to a longitudinal axis X of the shoes (the weft fibres however being perpendicular to the warp fibres).

With the first portion 5 there is associated a second portion of woven composite material 6 positioned to correspond with the plantar arch of the user and a third portion of woven composite material 7 positioned to correspond with the metatarsal region of the user (which, as in the embodiment shown on the figures, can cover the entire part between the front end 8 of the shoe 1 and the portion 6). The second portion 6 and third portion 7 define a second sole piece of composite material 55. The first portion comprises lateral flanges 5A and 5B.

More specifically, in the case of Figures 1, 2 and 3 in which the sole pieces 5 and 55 are coupled together, the first and second portion 5 and 6 have their fibres (carbon, aramid or the like) arranged mutually crossed to achieve considerable torsional rigidity of the corresponding sole piece. In other words, the weft fibres T and warp fibres O in one portion (for example the portion 5) are arranged with different spatial angulation from the weft fibres T' and warp fibres O' of the second portion 6. For example the fibres T are positioned at 45° to the longitudinal axis X of the sole pieces and the fibres T' are positioned at 90° to said axis X. In particular, in the plantar arch region the superposing of the portion 5 on the portion 6 defines a torsionally very rigid assembly. The plantar arch part is also rigid against flexure.

The constituent fibres of the portion 7 (weft fibres T" and warp fibres O") are arranged in a single orientation, this orientation being such that all the weft and warp fibres present in this portion are arranged parallel to each other in a predetermined spatial orientation, or all with a predetermined angle to the axis X (they still being arranged at 90° to each other). The fibres T" and O" of the portion 7 are orientated parallel to those fibres T and O of the sole pieces 5 which are at least present in that part of this latter which is to cooperate with the portion 7. The mono-orientated fibres of the portion 7 and of the corresponding sole piece 5 (having the weft

fibres T and T" and the warp fibres O and O" parallel to each other) provide flexibility to the sole metatarsal portion (in the direction of the arrow F) even when the portion 7 is associated with the portion 5 to enable this portion to undergo normal bending about an axis W perpendicular to the longitudinal axis X of the footwear and positioned between the end 8 of the footwear 1 and the portion 6.

The portion or sole piece 5 in any event possesses its own limited flexibility due to the particular mono-orientated arrangement of its weft and warp fibres.

With the footwear of the invention, the lower part of the sole unit is divided (see Figure 2) into three regions, namely the metatarsal region 7A (corresponding to the portion 7), the plantar arch region 6A (corresponding to the portion 6) and the heel region 10. Preferably the metatarsal region 7A and the heel region 10 are covered with a layer of rubber 11 and 12 fixed to the portions 5 and 7, for example by adhesive or similar fixing means.

Preferably, in correspondence with the heel region 10, the portion 5 comprises a part 13 which is concave towards the bottom of the shoe (ie towards the ground). The concave part 13 acts as a spring element arranged to return to the user part of the energy which he transfers to the ground during his movement. This is achieved without the need to insert into the shoe 1 shown in the figures any additional elastic body (such as those known in the state of the art) acting as an element for returning energy to the user's foot.

During use, the sole unit according to the invention is sufficiently rigid to adequately support the user's foot during his movement. However as the metatarsal region 7A is sufficiently flexible, the sole unit possesses

adequate "yieldability" to the extent of not negatively influencing the bone and muscolar structure of the user's foot, so preventing microfractures which could be extremely dangerous, particularly if the user is an athlete. In addition the flexibility of the region 7A, covered by the portion 7 extending from the end 8 of the footwear to the region 6A, is such as to enable it to act as an element for returning the maximum possible amount of the energy directed by the user towards the ground during his movement, and to generate a considerable thrust effect (which is very advantageous in sports, for example in athletics and basket ball). This effect, when added to that of the part 13, results in a considerable return of energy to the user during his movement.

According to a first modification of the invention, shown in Figure 1, from the portion 6 there extends a projection 17 lying coplanar therewith. The projection 17 (or tongue), preferably of woven composite material comprising weft and warp fibres orientated in the same manner as those of the portion 5 and parallel to them (ie mono-orientated), penetrates into a corresponding seat 18 in the rubber layer 12. This embodiment results in increased stability of the shoe 1 and hence correct support of the user's foot on the ground.

A further modification is shown in Figure 4, in which parts corresponding to those described are indicated by the same reference numerals. In the embodiment shown in the figure under examination, the portion 5 (represented schematically only by its weft fibres T) is not coupled to any other portion of woven composite material but comprises, in contrast to the corresponding portion 5 of Figure 1, a mono-layer metatarsal part 5E of mono-orientated fibres (in the aforesaid sense) and a part 5F, in correspondence with the plantar arch, comprising at least two superposed layers. Each layer comprises its own weft and warp fibres woven in the usual manner. The weft (and warp) fibres of the two layers are however

at a different angle to the axis X so as to define overall a portion 5F consisting of crossed fibres. In correspondence with the user's heel or the region 10 of the sole unit the portion or sole piece 5 comprises a single layer of woven fibres of composite material such as that 5E and comprises an annular rim 40 (flexible as the part 5E) which extends along the perimetral edge of said region. In this manner the region 10 can also house an elastic insert 41 able to restore to the user a part of the energy which he transfers to the ground during his movement. This insert is of known type (for example as described in US 5369896 or US 509206) and will not be further described. In particular, the insert 41 can be housed in a seat 42 provided in the portion 5 (bounded by the rim 40) and/or in a seat 43 provided in the rubber layer 12 associated with the portion 5 in the heel region 10. If required, a further insert 41A can be inserted into a seat 42A provided in a metatarsal region of the portion or sole piece 5 and/or in a seat 43A provided in the layer 12. The insert 41A has identical or equivalent characteristics to the insert 41.

The embodiment of Figure 4 results in increased stability of the shoe 1 and hence correct support of the user's foot on the ground. In this respect, the sole piece 5 is torsionally rigid in the region 6A of the sole unit and flexible in the region 7A about the axis W.

In the modification of Figure 5, in which parts corresponding to those of the already described figures are indicated by the same reference numerals, the portion 5 (analogous to that of Figure 1) only involves the regions 6A and 7A of the sole unit, no composite material layer (comprising carbon, aramid or other fibres) being present in the heel region 10. In the modification under examination, the sole unit also comprises a lower rubber part 50 involving the entire sole unit 4. The embodiment under examination results in lower production costs for the footwear 1.

In a further very exemplified embodiment, the sole unit 4 can also comprise just the portions 6 and 7 associated directly with the insole 3 (and hence not comprising the portion 5 as in Figures 1 and 5), the portion 6 comprising two layers of fabric, the weft and warp of one layer being of different spatial inclination to the axis X than the weft and warp of the other layer.

Various modifications of the invention have been described. All comprise a sole unit 4 consisting at least of: a plantar arch region 6A comprising at least two superposed portions of textile fibres of composite material (of carbon, aramid, carbon-aramid combination, or the like), the weft and warp fibres of a first portion having a first inclination to the footwear longitudinal axis and the weft and warp fibres of the second portion having a different inclination to said axis, said fibres of the first and second portion hence being crossed; and a metatarsal region 7A (ie that sole region between the region 6A and its end 8) defined by a portion 7 or 5E of woven composite material having its weft and warp fibres all with equal inclination to the footwear longitudinal axis, said fibres hence being mono-orientated. The reason for this is to achieve a sole unit which is rigid in correspondence with the plantar arch and flexible towards the front, while maintaining the necessary torsional rigidity. With said portions there can be associated a further sole piece 5 of composite material woven with weft and warp fibres arranged at different inclinations from the corresponding ones of the portion 6 positioned within the plantar arch 6A but with identical inclination to those of the portion present within the metatarsal region 7A.

In a further embodiment of the invention, instead of the portions 5, 6 and 7 or 6 and 7 or merely 5 (as in Figure 4) being constructed of composite materials comprising fibrous components, the portions 5, 6 and 7 or 6 and

7 or merely 5 are constructed of composite materials sintered in accordance with the known art. In particular, in this further embodiment, the non-flexible and torsionally rigid region (such as 6A) is obtained by sintering procedures comprising at least one stage of pressing carbon, aramid or similar powder associated with the relative resin, at a particular pressure different from the pressure to which the powder is subjected for defining the region 7A, which is flexible about the aforeindicated axis W. The reason for this is to achieve the desired flexibility of this latter layer.

Alternatively, the different behaviour (flexible or rigid) of the different sole pieces or portions of woven composite material is obtained by making these latter of different thicknesses depending on their different mechanical behaviour. This ensures the required flexibility of the metatarsal region 7A of the sole unit and the rigidity of the arch region 6A.

If the portions or layers 5, 6 and 7 are obtained as in the accompanying figures, the footwear can be constructed by the following steps: the vamp is drawn over a last having the shape of a foot of an average user or of a particular athlete (or generic user) for whom the shoe is produced. A layer of known porous material (known as EVA or ethyl vinyl acetate) or of polyurethane or low-density rubber is arranged on the sole portion of this last to define the insole 3, after which one or more previously formed sole pieces of composite material are associated with this layer. Each of these sole pieces is formed by placing the already woven composite material impregnated with resin, for example epoxy resin, on a foot cast having the negative shape of the sole of said foot. In this manner a sole preform is obtained, to be cut according to the dimensions of said foot.

Preferably after constructing said preform, on at least one of its opposing faces (that to be fixed to the rubber layer of the sole unit) there is applied a fabric impregnated with the same resin with which the composite

material is impregnated. By virtue of its nature, this fabric has substantial surface roughness.

The preform obtained in this manner, still associated with the last, is then placed in an enclosure to which vacuum is applied. This enclosure together with its contents is placed in an environment at high pressure, much higher than atmospheric (for example between 8 and 15 bar). With these operations, initially (by means of the vacuum) the layer of composite material assumes the shape of the sole of the foot and then (by means of the pressure) the fibres of this layer are highly compacted by the expulsion from this latter of the excess resin present between and on said fibres. This latter operation gives flexibility to the composite material layer for example about an axis perpendicular to the longitudinal axis of the sole.

The sole piece shaped in this manner (and removed from its enclosure) is now dried at relatively high temperature (exceeding 100-120°C) in an environment of relatively high pressure (5-7 bar) for a relatively long time (between 8 and 14 hours). The choice of said drying temperature, the pressure at which it occurs, together with said time, is made on the basis of the composite material used and the thickness of the sole piece.

After this treatment, the sole piece is cleaned of any burrs and the fabric associated with its faces is separated therefrom. Because of the roughness of this fabric, small impressions remain on said faces, allowing better fixing by the glue used for securing the sole piece to the other parts of the shoe (rubber parts and vamp). The sole piece is then secured to these parts by gluing.

It has been surprisingly found that the use of biadhesive tapes for this securing to said shoe parts achieves a more uniform distribution of the adhesive material between the contacting parts, so improving their bond.

The sole piece obtained in this manner is anatomical and hence has the shape of the user's foot.

Finally, when securing the sole piece (or sole pieces 5 and 55) to the other parts of the shoe, elastic inserts for returning to his foot the energy transferred by the user to the ground during his movement can be positioned in the sole piece.

Because of the particular method used to secure the composite material portions 5 (or 6 and 7) to the insole 3, this material becomes shaped in accordance with the sole of a (particular or average) user's foot. The anatomical shape of the portion or sole piece 5 (or layers 6 and 7 if this portion is not present) results in improved comfort of the shoe (containing one or more additional insoles positioned between the insole 3 and the user's foot), which is safer for the user to the extent of preventing the ever possible small injuries to his foot musculature caused by a particular sporting activity or a particular prolonged use of the footwear.

The footwear 1 according to the invention is lightweight and does not tire the user. In addition, it results in optimum return to the user of the energy transferred by him to the ground during his movement. This is achieved even without the further insertion of elastic elements (suitable for this purpose) into the sole unit 4.

Additionally, usual segments or studs for use by particular athletes, such as footballers or sprinters, can be simply glued to the individual composite material layers of the shoe 1, without this gluing operation (executed for

example with epoxy resins) resulting in detachment of said segments or studs with time. Hence the complex moulding operations used for associating said segments or studs with sports footwear provided with a sole unit of rubber or a similar material are no longer necessary.

In addition, the rubber layer (or layers) associated with each portion of composite material (of woven fibres or sintered material) can be considerably reduced compared with known arrangements, resulting in a reduction in moisture (and possibly soil) absorption from the ground on which the user moves (such moisture not being absorbed by any composite material layer). This results in a considerable reduction in the weight increase of the footwear during its use.

Various embodiments of the invention have been described. Others, in the form of sports or walking shoes, can however be provided (such as one in which the layers 5, 6 and 7 are partly sintered and partly of fibre-based composite material). In particular, sole units can be formed with composite material inserts of different shapes for the different sports for which the footwear 1 is used. For example, the portion 7 may only partly involve the region 7A of the sole unit. In a first embodiment this portion is shaped with a central recess and lateral flanges which extend in proximity to the edges of the sole unit as far as the end 8 of the footwear. In a second embodiment, these flanges extend only slightly beyond the axis W of the region 7A. These different embodiments are chosen on the basis of the speed which the athlete wishes to achieve and hence on the basis of the sport which he practises.

Likewise the portion 6 can be flat (for example for an athletics contest and marathon shoe), can be arch shaped (for example for training), or can comprise lateral reinforcements which follow, and are superposed to a

greater or lesser extent on, the flanges 5A and 5B of the portion 5 (enabling the antitwist effect of the shoe to be modified).

Finally, in the region 10 the portion 5 (or the possible projection 17) can be substantially of dovetail shape to achieve an anti-pronation effect and improve the shoe damping and stabilization.

These modifications (or combinations thereof) are to be considered as falling within the scope of the present invention.

Claims:

1. Footwear, in particular sports footwear (1), comprising a vamp (A) associated with a substantially flat lower part or sole unit (4) supporting the foot, the sole unit (4) comprising at least one sole piece (5, 55) constructed of composite material, said sole piece (5, 55) comprising a rigid first portion (5F, 6) positioned in correspondence with the plantar arch region (6A) of the sole unit (4), and a flexible second portion (5E, 7) positioned between the front end (8) of the footwear and the plantar arch region (6A), said second portion (5E, 7) being able to flex about at least one axis (W) positioned between said front end (8) and the plantar arch region (6A) of the footwear, characterised in that the composite material comprises woven fibres, the fibres of the rigid first portion (5F, 6) being crossed and the fibres of the flexible second portion (5E, 7) being mono-orientated.

2. Footwear as claimed in claim 1, characterised in that the sole pieces of woven composite material are anatomical.

3. Footwear as claimed in claim 1, characterised in that the woven composite material comprises carbon, aramid or similar fibres.

4. Footwear as claimed in claim 1, characterised in that the composite material comprises carbon fibres and aramid fibres woven together to define a fabric.

5. Footwear as claimed in claim 1, characterised in that the rigid first portion (5F, 6) of the sole unit (4) comprises at least two layers of woven composite material, a first layer comprising weft and warp fibres lying spatially at a first angle to a longitudinal axis (X) of the footwear, the weft and warp fibres of the second layer lying spatially at a second angle to

said axis, different from that of the corresponding fibres of the first layer, and hence crossing these latter.

6. Footwear as claimed in claim 1, characterised in that the flexible second portion (5E, 7) of the sole unit (4) comprises at least one layer of woven composite material, the weft and warp fibres of which lie spatially at an identical angle to the footwear longitudinal axis (X), or are mono-orientated.

7. Footwear as claimed in claim 6, characterised in that the flexible second portion (5E, 7) of the sole unit (4) comprises a plurality of superposed layers of woven composite material, the weft and warp fibres of all the layers lying spatially at an identical angle to the longitudinal axis (X) of the footwear.

8. Footwear as claimed in claim 1, characterised in that the sole unit (4) comprises a third portion (5) of woven composite material supporting the first and second portion (6, 7) and arranged at least in correspondence with the metatarsal region (7A) and with the plantar arch (6A) of the sole, said further portion (5) having its weft and warp fibres lying spatially in an identical manner to the corresponding fibres of the second portion (7), said fibres hence lying spatially in a different manner to the corresponding fibres of the first portion, which they cross.

9. Footwear as claimed in claim 8, characterised in that the third portion (5) involves every region (6A, 7A, 10) of the sole unit (4).

10. Footwear as claimed in claim 8, characterised in that the third portion (5) involves only part of the heel region (10) of the sole unit (4).

11. Footwear as claimed in claim 1, characterised in that in correspondence with the heel region (10) of the sole unit (4) there is provided a flexible annular part (40) of woven composite material extending from the rigid portion (5F) positioned in correspondence with the plantar arch (6A).

12. Footwear as claimed in claim 11, characterised in that the annular part (40) bounds a cavity (42) in which there is positioned an elastic insert (41) arranged to return to the user part of the energy transferred by him to the ground during his movement.

13. Footwear as claimed in claim 1, characterised in that the second portion (5E) comprises a seat (42A) for a further elastic insert (41A) arranged to return to the user part of the energy transferred by him to the ground during his movement.

14. Footwear as claimed in claim 8, characterised in that the third portion (5) comprises, positioned in correspondence with the user's heel, a part (13) having a ground-facing concavity.

15. Footwear as claimed in claim 1, characterised in that at least part of said first and/or said second portion (6, 7) is covered with a layer of rubber (11, 12, 50).

16. Footwear as claimed in claim 15, characterised in that at least part of the first and second portion (5F, 6; 5E, 7) has a rough surface able to allow better fixing of a gluing element for securing said portions to the rubber layer (11, 12, 50).

17. Footwear as claimed in claim 1, characterised in that a rubber part (12) positioned in correspondence with the heel region (10) of the sole unit

comprises a seat (18) accommodating a projection (17) extending from the first rigid portion (6), of woven composite material with mono-orientated fibres.

18. Footwear as claimed in claim 1, characterised in that a rubber part (12) positioned in correspondence with the heel region (10) of the sole unit comprises a seat (43) into which an insert (41) is inserted to restore to the user part of the energy transferred by him to the ground during his movement.

19. Footwear as claimed in claim 1, characterised in that the flexible second portion (7) supports segments or studs glued to said portion.

20. Footwear as claimed in claims 1 and 2, characterised in that the composite material is sintered.

21. Footwear as claimed in claim 16, characterised in that the sintered composite material defining the rigid first portion (6) has a greater thickness than that defining the flexible second portion (7).

22. A method for constructing footwear claimed in claim 1, characterised by comprising the following steps: covering a foot last with a vamp (2), associating with this latter a known porous material layer, said layer being positioned in correspondence with the sole of the foot last, with the layer there then being associated a sole piece (5, 55) of woven composite material which has the shape of the sole of the foot, with said sole piece there then being associated a rubber layer (50).

23. A method as claimed in claim 22, characterised in that the sole piece (5, 55) of woven composite material is obtained by laying said

material impregnated with resins on a foot cast having the negative form of the sole of the foot, so as to shape said sole piece.

24. A method as claimed in claim 23, characterised in that a layer of surface-rough fabric is associated with at least one face of the sole piece.

25. A method as claimed in claim 23, characterised in that the shaped woven composite material associated with the cast is put under vacuum and is then subjected to pressure treatment.

26. A method as claimed in claim 25, characterised in that after the pressure treatment the sole piece (5, 55) is subjected to drying.

27. A method as claimed in claim 26, characterised in that the drying takes place in a pressurized environment for a time exceeding five hours but less than eighteen hours.

28. A method as claimed in claims 24 and 26, characterised in that after drying, the fabric associated with at least one face of the sole piece (5, 55) is removed.

29. A method as claimed in claim 22, characterised in that the sole unit is secured to the various parts of the shoe, ie to the vamp (2), to the insole (3) and to the rubber layer (50), by biadhesive glue.