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(54) **FOOTWEAR ARTICLE WITH PRESSURE SENSOR**

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(57) **ABSTRACT**

An article of footwear including a pressure sensor arranged in the sole structure, where the sensor includes elongated pressure-sensing cells, each of which has an axis of main extension, each cell having a first and a second carrier film, which are attached to one another by a spacer film having an elongated opening oriented along the axis of main extension, as well as a first and a second electrode on the first and the second carrier film, respectively, where the electrodes are arranged in facing relationship with each other, so that a contact area between them increases with increasing pressure, and an electrically insulating layer is arranged within the opening having a shape such that it locally prevents direct contact between the electrodes where the insulating layer is present and enables the direct contact where it is absent, where the shape is constant or repetitionary along the axis of main extension of the cell.

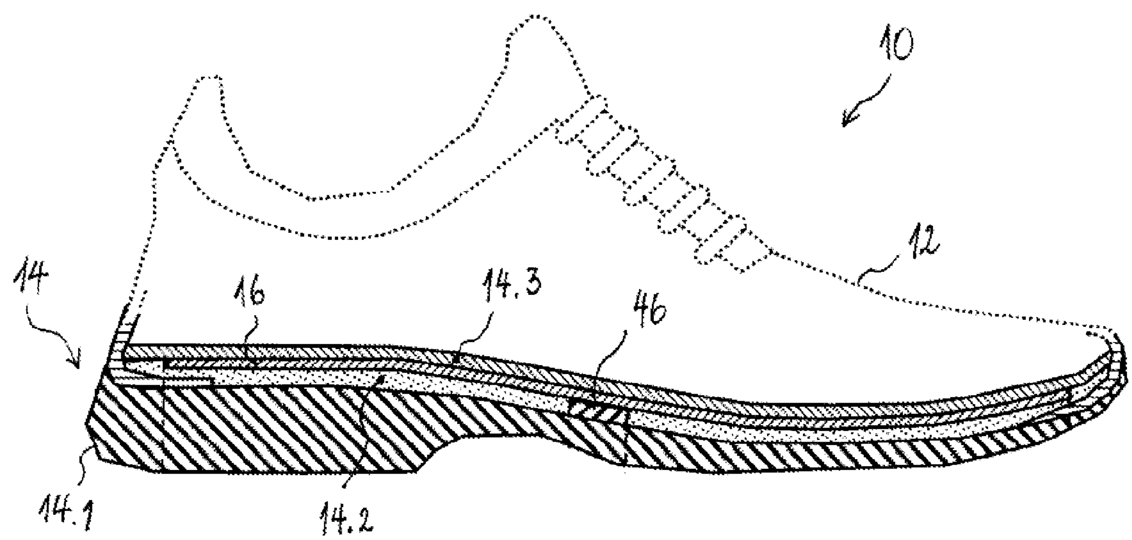


Fig. 1

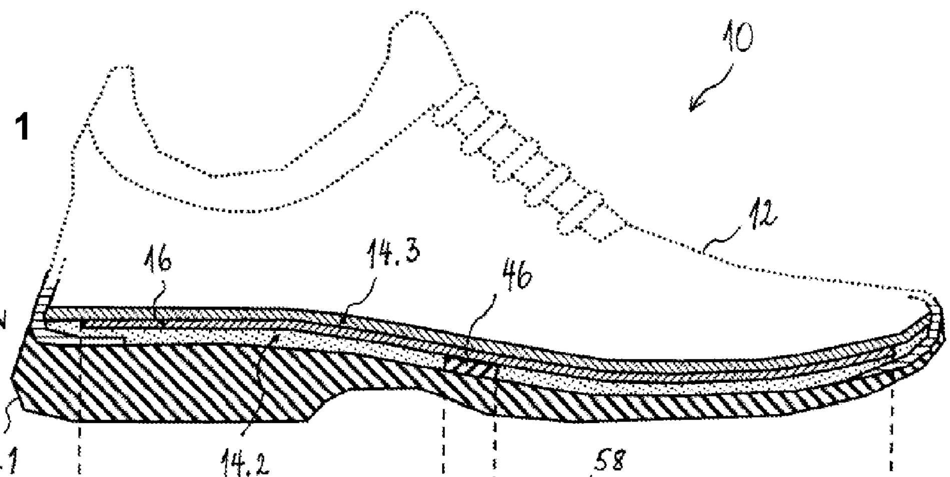


Fig. 2

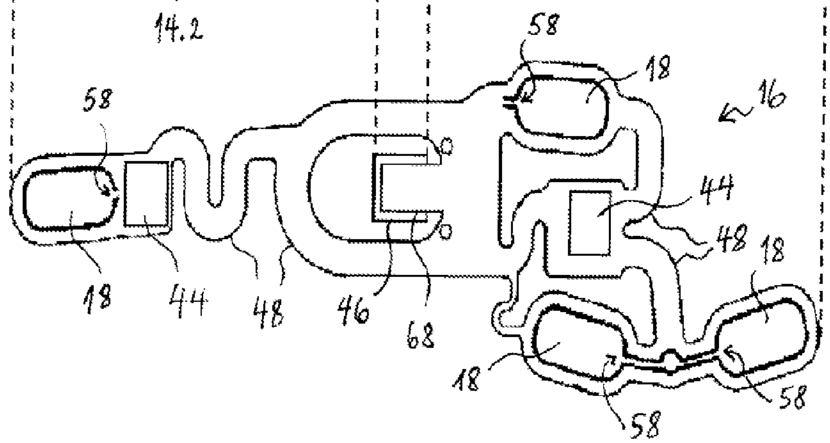


Fig. 3

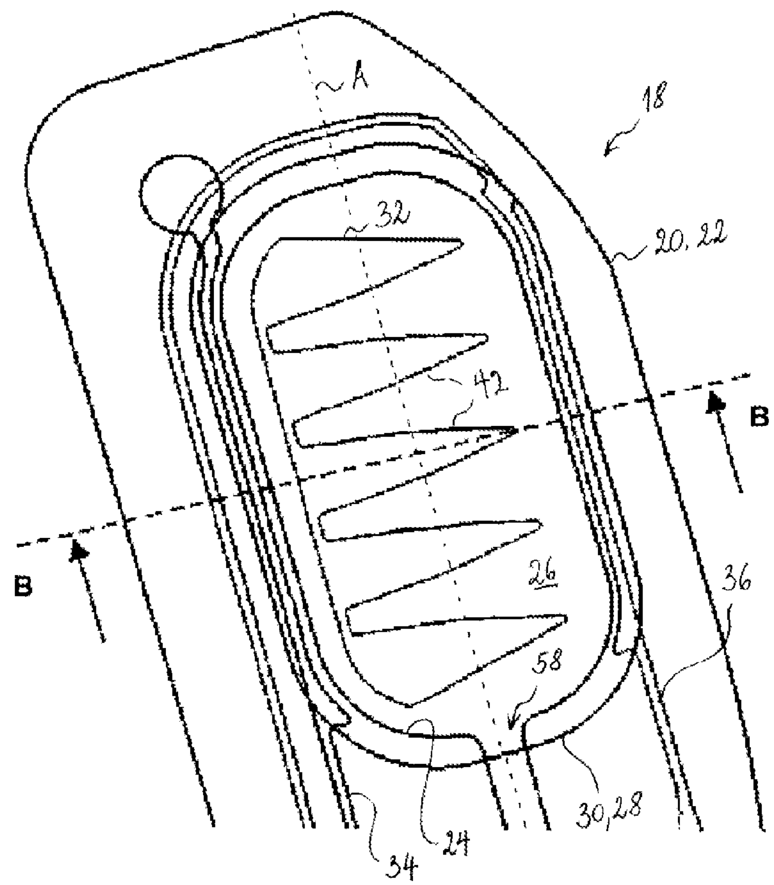


Fig. 4

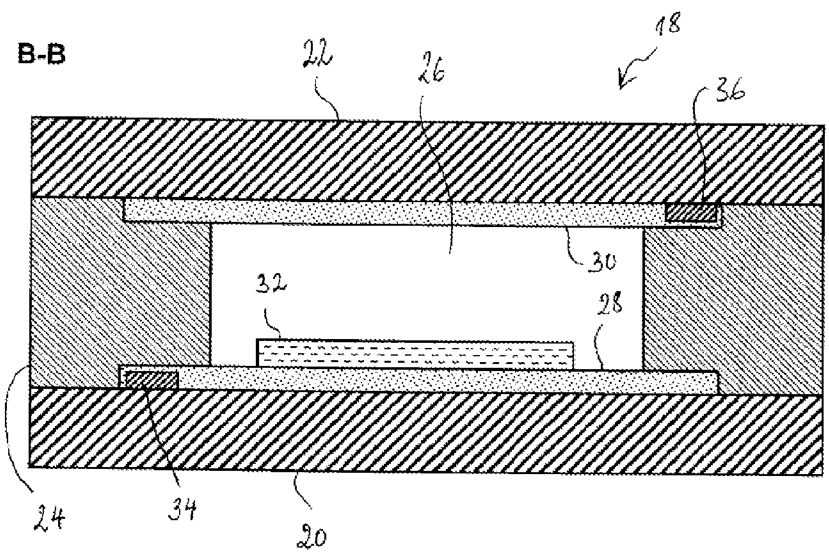


Fig. 5

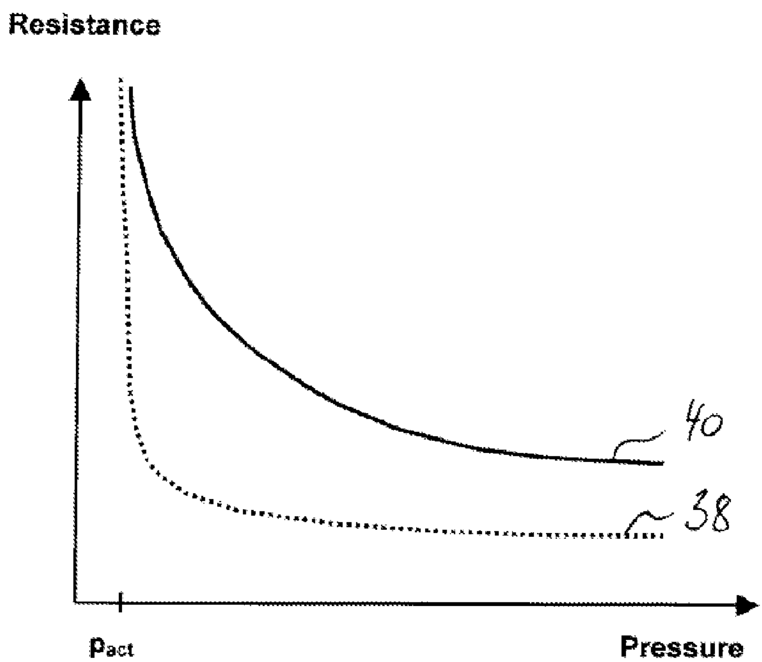

Resistance
40
38
p_{act}
Pressure

Fig. 6

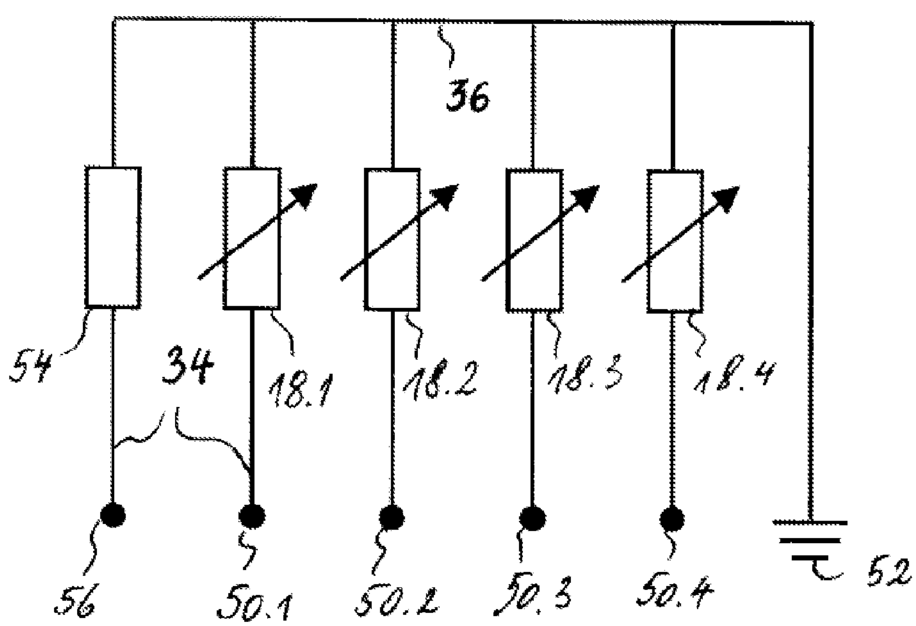

36
54
34
18.1
18.2
18.3
18.4
56
50.1
50.2
50.3
50.4
52

Fig. 7

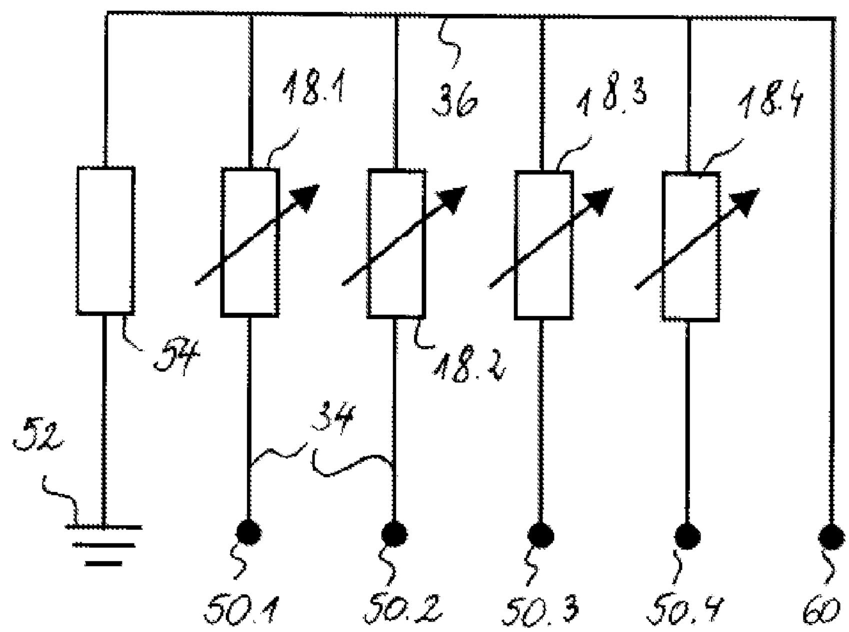

18.1
36
18.3
18.4
54
18.2
34
52
50.1
50.2
50.3
50.4
60

Fig. 8

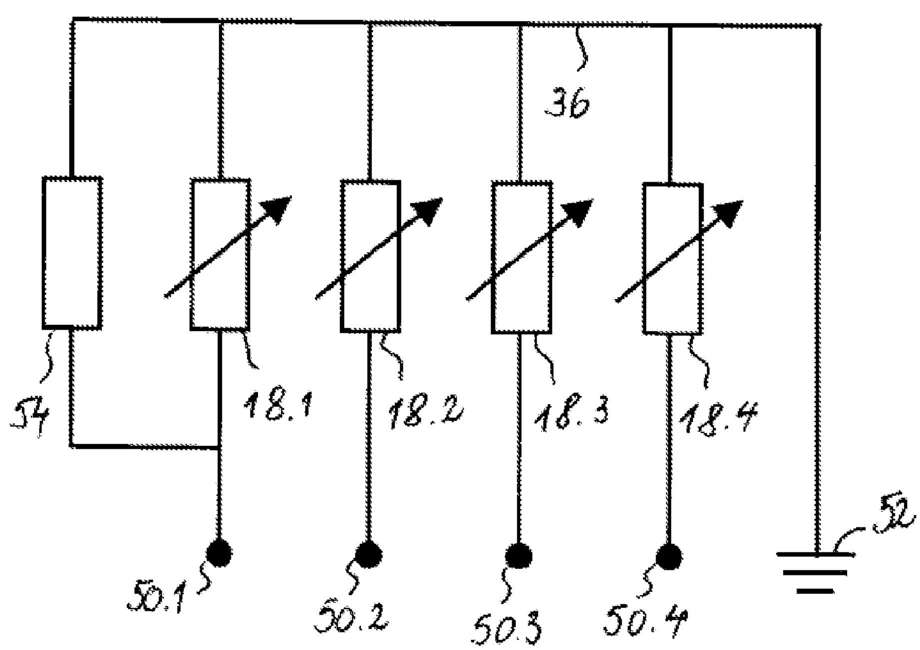

36
54
18.1
18.2
18.3
18.4
52
50.1
50.2
50.3
50.4

Fig. 9

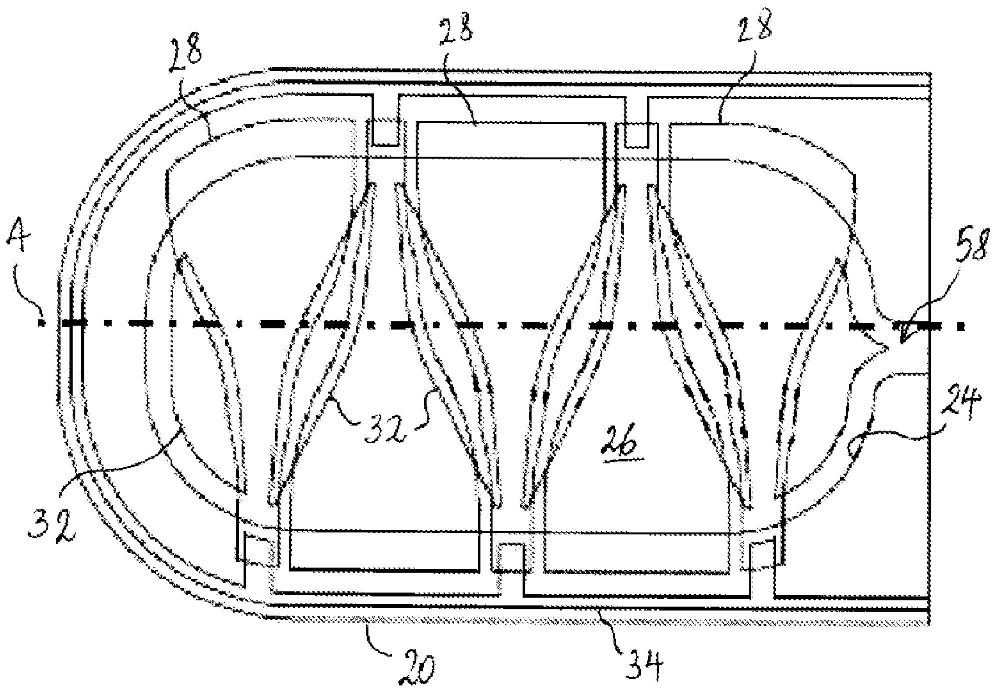


Fig. 10

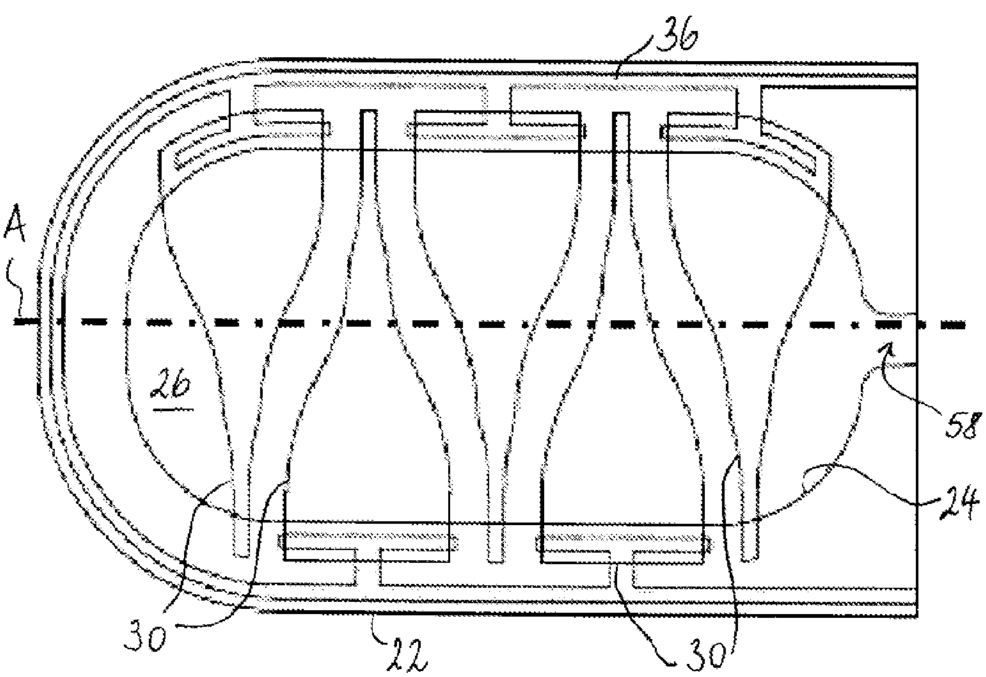


Fig. 11

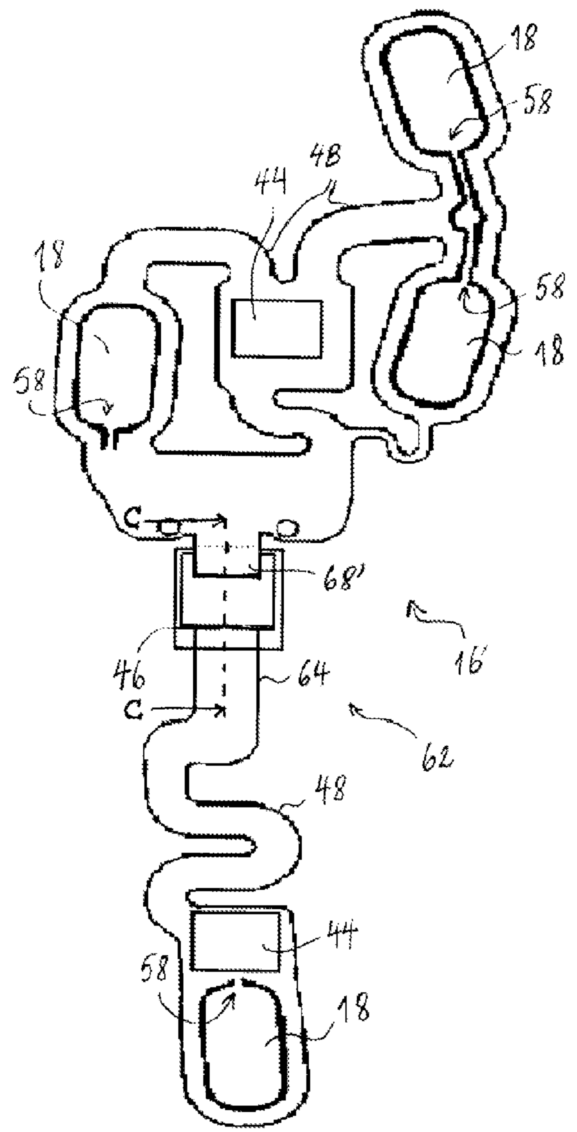
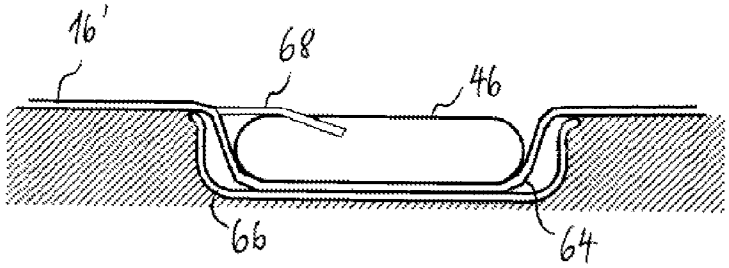


Fig. 12



FOOTWEAR ARTICLE WITH PRESSURE SENSOR

TECHNICAL FIELD

[0001] The present invention generally relates to an article of footwear, such as e.g. a shoe, a boot, a sandal or the like, in particular an article of footwear equipped with a pressure sensor for measuring pressure exerted by the wearer's foot on the sole structure.

BACKGROUND ART

[0002] Document U.S. 2010/0063779 discloses a shoe with an integrated sensor system. The sensor system collects performance data that are transferred for further use via a communication port. The shoe contains a force sensor arranged in the sole structure for measuring, in a plurality of areas, pressure (force) exerted by the wearer's foot on the sole structure, and an electronic module configured to gather data from the sensors. The module is configured for transmitting the data to an external device for further processing. In one of the embodiments disclosed in U.S. 2010/0063779, the pressure sensor comprises four elongated pressure-sensing cells, each of which contains a first and a second electrode as well as a force-sensitive resistive material disposed between the electrodes to electrically connect the electrodes together. When pressure is applied to the force-sensitive material, its resistivity changes, and the resulting change in resistance is detected by the electronic module. Materials exhibiting volume-based resistance behavior are used as the force-sensitive material: when such material is compressed, conductive particles contained therein move closer together, whereby conductive paths are formed and the resistance decreases. If another resistance vs. pressure characteristic is needed, a suitable force-sensitive material has to be found, which may be difficult.

BRIEF SUMMARY

[0003] The disclosure provides an article of footwear including a pressure sensor, wherein the resistance vs. pressure characteristic of the pressure sensing cells enables more flexible adjustments.

[0004] The proposed article of footwear (in particular a sports shoe, such as e.g. a running shoe, a tennis shoe or the like) comprises a sole structure for supporting a wearer's foot, an upper for holding the wearer's foot onto the sole structure and a pressure sensor arranged in the sole structure for measuring a pressure exerted by the wearer's foot on the sole structure. The pressure sensor comprises one or more elongated pressure-sensing cells, each of which has an axis of main extension. Each cell comprises a first flexible carrier film and a second flexible carrier film, the first and second carrier films being attached to one another by a spacer film having an elongated opening oriented along the axis of main extension, a first electrode arranged on the first carrier film and a second electrode arranged on the second carrier film, the first and second electrodes being arranged in facing relationship with each other in the opening, in such a way that the first and second electrodes may be brought into contact with each other when pressure is exerted on the cell and that a contact area between the first and second electrode increases with increasing pressure. According to the invention, an electrically insulating layer is arranged within the opening of the spacer. The electrically insulating layer has a shape such that it locally prevents a direct contact between the first and second electrodes where the electrically insulating layer is present and enables the direct contact where the electrically insulating layer is absent. The shape of the electrically insulating layer is constant or repetitionary along the axis of main extension of the cell.

[0005] The above-described shape of the electrically insulating layer ascertains that the response of the pressure sensing cell remains at least approximately the same when the point of application of the force (and thus the area of contact between the elements on the first carrier film and the elements on the second carrier film) is displaced along the axis of main extension of the cell. In other words, the response of the pressure sensing cell is at least approximately invariant under a translation along the axis of main extension of the point of application of the force (within the boundaries of the cell). Those skilled in the art will appreciate that this feature will render pressure sensing less dependent on the size of the wearer's foot by suitably positioning and orienting the pressure-sensitive cell(s) in the sole structure. As a consequence, a pressure sensor as used in the context of the invention may be suitable for footwear of different sizes.

[0006] Preferably, the one or more elongated sensor cells are located in the sole structure in areas expected to be subjected to pressure maxima when the wearer is standing still, is walking or is running. Advantageously, each sensor cell is located in an area corresponding to a bone or part of bone of a wearer's foot selected from the heel bone, the head of the first metatarsal bone, the head of the fourth or fifth metatarsal bone, the head of the second or third metatarsal bone and the head of the first phalange. Those skilled will appreciate that pressure maxima are typically located under the heel bone, under the heads of the fourth and/or fifth metatarsal bone and under the head of the first phalange when the wearer is standing at rest; when the wearer is walking, the pressure maxima are usually under the heel bone, under the heads of the second and/or third metatarsal bone and under the head of the first phalange.

[0007] Preferably, the axis of main extension of each cell is oriented along an axis of main extension of a vertical projection onto the sole structure of the bone to which it corresponds.

[0008] The pressure sensing cells are preferably oval, elliptical or rectangular with rounded angles.

[0009] According to a preferred embodiment of the invention, the shape of the electrically insulating layer comprises a sequence of generally triangular tooth portions arranged in the manner of a toothed rack in parallel with the axis of main extension.

[0010] Preferably, at least one of the first and second electrodes is made of resistive material, e.g. graphite or carbon black. The electrically insulating layer is preferably made of electrically insulating ink.

[0011] For equalization of gas pressure inside the opening, each of the pressure sensing cells advantageously comprises a ventilation hole. The ventilation hole may be in fluid communication with the exterior of the pressure sensor (e.g. the atmosphere) or with a gas (e.g. air) reservoir within the pressure sensor. Such gas reservoir could e.g. be a cavity between the first and second carrier films.

[0012] As those skilled will appreciate, the pressure sensor could be arranged in different part of the sole structure. For instance, the pressure sensor being arranged on or in the insole. Alternatively, the pressure sensor may be arranged on or in the midsole.

[0013] According to a preferred embodiment, the one or more pressure-sensing cells are at least two pressure-sensing cells. The pressure sensor in this case preferably comprises one or more connection strips interconnecting the at least two pressure sensing cells, the one or more connection strips being integrally formed with the at least two pressure sensing cells. The connection strips preferably bear conductors for connecting the first and second electrodes of each pressure-sensing cell with an electronic control module. The connection strips are preferably configured having a serpentine shape in order to offer a greater resiliency to the pressure sensor as a whole.

[0014] Preferably, the pressure-sensing cells are configured (in particular by tailoring of the shape of the electrically insulating layer) in such a way that pressures in the range from about 0.1 bar to 7 bar translate into a steady change of the contact area between the resistive electrodes from 0% (at the turn-on pressure, i.e. at the about 0.1 bar) and about 100% (full contact at about 7 bar).

[0015] A preferred embodiment of a pressure sensor for an article of footwear comprises a flexible multilayer film structure that includes a forefoot portion and a heel portion. The forefoot portion and the heel portion are connected to each other by a connection strip, which is integrally formed with the multilayer film structure. According to this embodiment, the pressure sensor further comprises a trough-shaped receptacle for an electronic control module, which the connection strip is arranged across and which the connection strip is bonded to. This embodiment of a pressure sensor for an article of footwear has the advantage that stresses occurring in the middle region of the article of footwear during rolling off of the foot are at least partially taken up by the receptacle instead by the connection strip. Additionally, buckling of the pressure sensor is efficiently avoided in this region of the article of footwear.

[0016] Preferably, the trough-shaped receptacle is made of plastic material, e.g. PET or epoxy. The edges of the receptacle are preferably rounded where the connection strip crosses them in order to avoid that the connection strip is cut off under the action of mechanical loads.

[0017] Advantageously, in the connection strip, the upper (second) carrier film of the pressure sensor is interrupted and detached from the spacer film and the first carrier film in such a way that a tongue or flap is formed, that tongue or flap carrying connection terminals for electrically connecting the multilayer film structure (in particular the pressure-sensing cells thereof) to the electronic control module. Preferably, the tongue or flap is equipped with a crimp connector portion for releasable connection with the electronic control module.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] A preferred embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

[0019] FIG. **1** is a longitudinal cross sectional view of the sole structure of a sports shoe with a pressure sensor;

[0020] FIG. **2** is a top view of the pressure sensor of the sports shoe of FIG. **1**;

[0021] FIG. **3** is a top schematic view of one of the pressure sensing cells of the pressure sensor of FIG. **2**;

[0022] FIG. **4** is a schematic cross sectional view of the B-B plane of FIG. **3**;

[0023] FIG. **5** is a graph illustrating the difference in the electrical responses of a pressure-sensing cell without an electrically insulating layer and one with such a layer;

[0024] FIG. **6** is a block diagram of the electrical circuit of the pressure sensor illustrated in FIG. **2**;

[0025] FIG. **7** is a schematic block diagram of an alternative electrical circuit for the pressure sensor of FIG. **2**;

[0026] FIG. **8** is a schematic block diagram of another alternative electrical circuit for the pressure sensor of FIG. **2**;

[0027] FIG. **9** is a top schematic view of the components on the first carrier film in a pressure-sensing cell according to another configuration;

[0028] FIG. **10** is a top schematic view of the components on the second carrier film in a pressure-sensing cell according to that configuration;

[0029] FIG. **11** is a top view of a variant of the pressure sensor of FIG. **2**;

[0030] FIG. **12** is a schematic cross sectional view of the C-C plane of FIG. **11**.

DETAILED DESCRIPTION

[0031] An article of footwear, in form of a sports shoe **10** is depicted in FIG. **1** as including an upper **12** and a sole structure **14**. The upper **12** is secured to sole structure **14** and defines chamber for receiving a foot. The sole structure **14** includes an outsole **14.1**, a midsole **14.2**, and an insole **14.3**, which forms the bottom of the foot-receiving chamber of the sport shoe **10**.

[0032] In the illustrated embodiment, the midsole **14.2**, which is preferably formed of impact-attenuating material, has a film-type pressure sensor **16** attached to its upper surface. When the insole is in place, the pressure sensor **10** is thus sandwiched between the insole **14.3** and the midsole **14.2**.

[0033] As best shown in FIG. **2**, the pressure sensor **16** comprises a plurality of pressure-sensing cells **18**, located in different areas of the sole structure **14**, for measuring pressure exerted by the wearer's foot on the sole structure **14**.

[0034] The configuration of the pressure sensing cells **18** will now be described with reference to FIGS. **3** and **4**. FIG. **3** shows the contours of the elements of a pressure-sensing cell **18**. The pressure sensor **16** comprises a multilayered structure including a first carrier film **20**, a second carrier film **22**, and a spacer **24**. The spacer **24** is typically a double-sided adhesive, with which the first and second carrier films **20**, **22** are laminated together. The first and second carrier films **20**, **22** are preferably made of PET but other materials such as PEN, PI, PEEK etc. are also possible. Each of the carrier films may comprise a single film layer or comprise a plurality of film layers of the same or different materials. The spacer **24** preferably comprises a PET, PEN, PI, PEEK, etc. film layer with an adhesive coating applied on each side thereof. At each pressure-sensing cell **18**, the spacer comprises an oblong opening **26**, within which the first and second carrier films **20**, **22** may be pressed together. In each pressure-sensing cell **18**, a first resistive electrode **28** is permanently arranged on the first carrier film **20** and a second resistive electrode **30** is permanently arranged on the second carrier film **22**, in facing relationship with the first electrode **28**. Each electrode **28**, **30** is contacted by a respective strip conductor **34**, **36**, which run alongside the long sides of the opening **26**. At least one of the electrodes **28**, **30** (in this example: electrode **28**) is partially covered with an electrically insulating layer **32** (e.g. a dielectric layer).

[0035] In response to pressure acting on the pressure-sensing cell, at least one of the first and second carrier films **20**, **22**, deflects towards the other carrier film until the carrier films **20**, **22** or the elements on their respective surface come into contact. Once contact is established, the radius of the mechanical contact surface increases with increasing pressure. When a direct contact is established between the electrodes **28** and **30**, the electrical resistance between the conductors **34** and **36** becomes finite and a current may flow in consequence. As the contact area between the first and second electrodes **28**, **30** increases, the resistance measurable between the conductors **34** and **36** decreases. The positions of the contacts between the resistive electrodes **28**, **30** and the respective strip conductor **34**, **36**, the specific resistance of the resistive electrodes, and the shape of the electrically insulating layer **32** determines the pressure-dependent cell resistance.

[0036] The electrical response function of the pressure-sensing cells, i.e. the resistance versus pressure, may be adjusted in a predetermined manner by suitably shaping the insulating layer **32**, because the electrically insulating layer **32** locally prevents a direct contact between the first and second electrodes **28**, **30** whereas the direct contact is possible in those areas where the electrically insulating layer **32** is absent. The other parameters of the pressure-sensitive cells, e.g. the materials of the electrodes, need not be adapted. FIG. **5** schematically illustrates the difference in the electrical response of a pressure-sensing cell without the insulating layer (dotted curve **38**) and one with the insulating layer shaped as in FIG. **3** (continuous curve **40**), all other cell parameters being the same. One notes that for the pressure-sensing cell without the insulating layer the resistance change occurs in a relatively small pressure range starting at the activation pressure p_{act} (the pressure at which the electrodes enter into contact). Above p_{act}, the resistance quickly levels out at a low value. For the cell equipped with the insulating layer, the resistance change spreads over a significantly longer pressure interval. As a consequence, the cell with the insulating layer enables pressure measurement at significantly higher pressures than the cell without the insulating layer.

[0037] The shape of the electrically insulating layer **32** being constant or repetitionary along the axis of main extension A, the electrical response of the cell **18** will be substantially independent of the exact position on axis A of the point of application of the compressive force. In the illustrated embodiment, the electrically insulating layer **32** comprises a sequence of generally triangular tooth portions **42** arranged in the manner of a toothed rack disposed in parallel with the axis of main extension A. As best illustrated in FIG. **2**, the pressure-sensing cells **18** are arranged in areas of the shoe **10**, in which the pressure peaks are expected to occur when the wearer is standing, walking or running. Specifically, a first one of the pressure-sensing cells is positioned in the area of the head of the first phalange (big toe), a second one in the area of the head of the first metatarsal bone, a third one in the area of the head of the fifth metatarsal bone and a fourth one in the area of the calcaneum (heel bone). The axis of main extension of each cell **18** essentially corresponds to the vertical projection onto the sole structure of an axis of main extension of the bone, which the cell is associated with. This renders pressure sensing in the cells less dependent on the size of the wearer's foot. In fact, the described arrangement of the pressure-sensing cells is tolerant, up to a certain extent, regarding discrepancies between the nominal shoe size, which the pressure sensor has been designed for, and the actual size of the wearer's foot. This size tolerance makes it possible to use one size of pressure sensor for a range of shoe sizes (e.g. three consecutive shoe sizes in the Continental European system).

[0038] For fixation of the pressure sensor **16** to the sole structure **14** (in this example the midsole), the pressure sensor **16** comprises one or more fixation pads **44** (see FIG. **2**). The fixation pads **44** preferably comprise a layer of pressure-sensitive or heat-activatable adhesive, initially protected by a release liner, which is removed just before the pressure sensor **16** is attached to its carrier member of the sole structure **14**.

[0039] The pressure sensor **16** further comprises an electronic control module **46**, which is mechanically attached to the multilayer film structure of the pressure-sensor **10**. Connection strips **48** interconnect the pressure sensing cells **18** and the electronic control module **46**. The connection strips **48** are integral part of the multilayer film structure of the pressure sensor **16** and carry conductive tracks that electrically connect the first and second electrodes of each pressure-sensing cell **18** with the electronic control module **46**. One or more of the connection strips **48** have a serpentine shape to act as springs and to thereby increase the pressure-sensor's elasticity in the sensor plane.

[0040] The electronic control module **46** preferably comprises an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a microprocessor, or the like. Advantageously, the electronic control circuit is configured for wirelessly transmitting the collected pressure data or any data derived therefrom to a receiver appliance having a user interface. Such receiver appliance could include a (wrist-) watch, the wrist receiver of a heart rate monitor, a handheld computer, a mobile phone, a portable media player or the like. In the illustrated embodiment, the electronic control module **46** is arranged in a cavity or well of the midsole **14.2**. The cavity or well may be located elsewhere in the sole structure **14** in other embodiments.

[0041] For equalization of gas pressure inside the opening **26** of the spacer **24**, each pressure-sensing cell **18** comprises a ventilation hole **58** (best shown in FIGS. **2** and **3**). The ventilation holes **58** fluidly connect the interiors of the pressure sensing cells to the outside, so that compression of the gas inside the pressure sensing cells is essentially avoided and thus has no significant impact on the response curve of each cell **18**. Additionally or alternatively, the ventilation holes **58** could be connected to a gas reservoir within the film-type pressure sensor.

[0042] FIG. **6** is a schematic block diagram of the flexible circuit of the pressure sensor **16**. The pressure-sensing cells **18** are drawn as variable resistors **18.1-18.4**. The cells are arranged electrically in parallel between a respective terminal **50.1**, **50.2**, **50.3** or **50.4** of the electronic control module (not shown in FIG. **6**) and circuit ground **52**. The electronic control module determines the pressure values based upon the resistance (or the current or the voltage if one of these quantities is kept constant) measured between each terminal **50.1**, **50.2**, **50.3** or **50.4** and circuit ground. It should be noted that the cell response curve is influenced by changes in resistivity of the electrode material, which may vary depending on ageing, temperature, humidity or other environmental influences. To be able to correct or compensate such influence on the pressure values, a reference resistor **54** is provided. The reference resistor **54** is made of the same material as the electrodes **28**, **30**. It is arranged somewhere on the pressure sensor **16** so that it experiences essentially the same environmental influences as the electrodes **28**, **30**. In the illustrated embodiment, the reference resistor **54** is arranged electrically between a reference terminal **56** and circuit ground **52**, in parallel to the pressure sensing cells. The electronic control module measures the resistance of the reference resistor **54**. Any deviation from a nominal value is used to correct the readings of the pressure-sensing cells **18**. The reference resistor **54** may be arranged on either one of the carrier films **20**, **22**. One could also use a plurality of resistors arranged on one or both of the carrier films. Another possibility would be to provide a preloaded pressure-sensing cell (i.e. a pressure-sensing cell wherein the electrodes are permanently kept in contact).

[0043] The reference resistor **54** and the resistive electrodes **28**, **30** of the pressure-sensing cells are preferably obtained by printing of carbon ink on the respective carrier film. The strip conductors **34**, **36** are preferably made of silver ink. The electrically insulating layer **32** in each pressure-sensing cell **18** is preferably also a printed layer. Alternatively, the electrically insulating layer **32** could be laminated on the carrier film and a resistive electrode.

[0044] FIG. **7** is a schematic block diagram of an alternative flexible circuit for the pressure sensor **16**. Unlike in the flexible circuit of FIG. **6**, the reference resistor **54** is arranged electrically between circuit ground **52** and the pressure-sensing cells **18**, drawn again as variable resistors **18.1**-**18.4**, in the manner of a voltage divider. During the measurement, one pressure-sensing cell at a time may be connected to a voltage source (e.g. a battery) by means of its terminal **50.1**, **50.2**, **50.3** or **50.4**. The electronic control module determines the pressure values based upon the voltages measured on measurement terminal **60**. The resistance R_x of one of the pressure-sensing cells **18.1**-**18.4** may be obtained by $R_x=R_{ref}(U_0/U_{meas}-1)$, where R_{ref} is the resistance of the reference resistor, U_o the voltage applied at the terminal **50.1**, **50.2**, **50.3** or **50.4**, and U_{meas} the voltage measured at the terminal **60**. As one supposes that the resistances of the pressure-sensing cells and the reference resistors are subjected to the same changes due to environmental influences (temperature, ageing, etc.), the normalized resistance R_x/R_{ref} is essentially independent of these effects. In all other respects, the circuit for the pressure sensor **16** of FIG. **7** is configured and operates in the same way as the one of FIG. **6**.

[0045] FIG. **8** is a schematic block diagram of another alternative flexible circuit for the pressure sensor **16**. According to this alternative, the reference resistor **54** is arranged in parallel with one of the pressure-sensing cells **18.1**-**18.4**. In this arrangement, the reference resistance is substantially higher than the resistances of the pressure-sensing cells **18.1**-**18.4** in actuated state (i.e. above the activation pressure).

[0046] FIGS. **9** and **10** illustrate an alternative configuration of the pressure-sensing cells **18**. FIG. **9** shows the arrangement of components on the first carrier film **20**, FIG. **10** the corresponding arrangement on the second carrier film **22**. In this variant, the resistive electrodes **28**, **30** comprise a plurality of separate, generally triangular portions, which protrude in interdigitating manner from the long sides of the pressure-sensing cell **18** into the opening **26** so as to form a repetitionary pattern along the axis of main extension A of the cell. Each triangular portion of the second electrode **30** is disposed as the vertical projection of a corresponding triangular portion of the first electrode **28** (and vice-versa). The triangular portions of the first electrode **28** are contacted by the first strip conductor **34** outside of the opening **26** at their tops. The triangular portions of the second electrode **30** are contacted by the second strip conductor outside of the opening **26** at their bases. That arrangement forces currents to flow essentially perpendicular to the axis of main extension A. The electrically insulating layer **32** comprises a plurality of separate, spindle-shaped portions, each of which is arranged so as to cover those areas, in which the sides of neighboring triangular portions of the first electrode **28** run alongside one another. In all other respects, the pressure-sensing cell of FIGS. **9** and **10** is the same as and operates in the same way as the pressure-sensing cell depicted in FIG. **3**.

[0047] FIG. **11** is a top view of a variant **16'** of the pressure sensor **16'** of FIG. **2**. The pressure sensor **16'** is of identical configuration as the pressure sensor **16** of FIG. **2**, except for the middle portion **62**, where the pressure sensor **16'** is connected to the control module **46**. The pressure sensor **16** of FIG. **2** comprises two connection strips extending alongside the electronic control module **46**, which is mechanically and electrically connected to the pressure sensor **16** by means of a connection tongue **68**. It has been found that such connections strips may be subjected to buckling when the foot rolls off. Over time, buckling may lead to deterioration of the connection strips and any strip conductors arranged thereon. The buckling problem is significantly reduced with the pressure sensor **16'** of FIG. **11**. In the pressure sensor **16'**, the connection strip **64** that interconnects the forefoot portion of the sensor **16'** and the heel portion is passed underneath the electronic control module **46**.

[0048] FIG. **12** shows the longitudinal cross section C-C of FIG. **11**. The connection strip **64** is guided though a trough-shaped receptacle **66** for the electronic control module **46**. The receptacle **66** is preferably made of a plastic material (e.g. PET or epoxy). The wall thickness of the receptacle **66** is such that it can withstand the stresses in the middle area of the shoe without substantial deformation and/or breaking. The connection strip **64** is firmly bonded to the bottom of the receptacle **66**, so that it is the receptacle **66** that takes up most of the strains occurring in this area during rolling off of the foot and so that the connection strip **64** is prevented from ejecting the electronic control module **46** out of the receptacle when tension is applied to it.

[0049] In the area of the connection strip **64**, the upper (second) carrier film of the pressure sensor is interrupted and detached from the spacer film and the first carrier film in such a way that a tongue or flap **68'** is formed. This tongue or flap **68** carries those parts of the strip conductors **34**, **36** which are connected to the electronic control module **46**. Preferably, the tongue or flap **68'** is equipped with a crimp connector portion (not shown) to removably connect the electronic control module **46** to the film structure of the pressure sensor **16'**. In the connection strip **64**, the strip conductors are all routed between the bottom (first) carrier film and the spacer. Accordingly, feedthrough contacts are arranged to lead those strip conductors that are normally sandwiched between the second carrier film and the spacer to the first carrier film. Similar feedthrough contacts are provided to lead those strip conductors that are normally sandwiched between the first carrier film and the spacer to the tongue or flap **68'**.

[0050] While specific embodiments have been described in detail, those with ordinary skill in the art will appreciate that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the invention, which is to be given the full breadth of the appended claims and any and all equivalents thereof.

[0051] Specifically, in the embodiment described in detail, the pressure-sensing cells **18** are configured as so-called through-mode pressure-sensing cells. In these cells, the electrodes that are in contact with the conductors leading to each cell are arranged on the first and the second carrier film, respectively. Those skilled will understand that the pressure-sensing cells could also be configured as so-called shunt-mode pressure-sensing cells, wherein a first and a third electrodes are in contact with the conductors leading to each cell and are arranged on the same carrier film. The second electrode is in this case a shunt element, which is brought into contact with the first and the third electrode when pressure is applied. The electrically insulating layer in this case locally prevents a direct contact between the first and the second electrode, and possibly also between the third and the second electrode.

1. An article of footwear, comprising a sole structure for supporting a wearer's foot and an upper for holding the wearer's foot onto the sole structure, wherein said article of footwear comprises a pressure sensor arranged in said sole structure for measuring a pressure exerted by the wearer's foot on the sole structure, said pressure sensor comprising one or more elongated pressure-sensing cells, each of said pressure sensing cells having an axis of main extension and comprising

a first flexible carrier film and a second flexible carrier film, said first and second carrier films being attached to one another by a spacer film having an elongated opening oriented along said axis of main extension,

a first electrode arranged on said first carrier film and a second electrode arranged on said second carrier film, at least one of said first and second electrodes made of resistive material, said first and second electrodes being arranged in facing relationship with each other in said opening in such a way that said first and second electrodes may be brought into contact with each other when pressure is exerted on said pressure-sensing cell and that a contact area between said first and second electrode increases with increasing pressure,

wherein an electrically insulating layer is arranged within the opening of said spacer, said electrically insulating layer having a shape so as to locally prevent a direct contact between said first and second electrodes where said electrically insulating layer is present and to enable said direct contact where said electrically insulating layer is absent, said shape being constant or repetitionary along said axis of main extension.

2. Article of footwear as claimed in claim **1**, wherein said one or more elongated sensor cells are located in said sole structure in areas expected to be subjected to pressure peaks when the wearer is standing still, is walking or is running.

3. Article of footwear as claimed in claim **1**, wherein each of said one or more elongated sensor cells is located in an area corresponding to a bone or part of bone of a wearer's foot selected from the heel bone, the head of the first metatarsal bone, the head of the fourth or fifth metatarsal bone, the head of the second or third metatarsal bone and the head of the first phalange.

4. Article of footwear as claimed in claim **3**, wherein the axis of main extension of each cell is oriented along a vertical projection onto the sole structure of an axis of main extension of the bone to which it corresponds.

5. Article of footwear as claimed in claim **1**, wherein each of said pressure sensing cells is oval, elliptical or rectangular with rounded angles.

6. Article of footwear as claimed in claim **1**, wherein the shape of said electrically insulating layer comprises a sequence of generally triangular tooth portions arranged in the manner of a toothed rack in parallel with said axis of main extension.

7. Article of footwear as claimed in claim **1**, wherein one of said first and second electrodes that is made of resistive material is made of graphite.

8. Article of footwear as claimed in claim **1**, wherein said electrically insulating layer is made of electrically insulating ink.

9. Article of footwear as claimed in claim **1**, wherein each of said pressure sensing cells comprises a ventilation hole, in communication with the exterior or a gas reservoir, for equalization of gas pressure inside said opening.

10. Article of footwear as claimed in claim **1**, wherein said sole structure comprises an insole, said pressure sensor being arranged on or in said insole.

11. Article of footwear as claimed in any one of claim **1**, wherein said sole structure comprises a midsole, said pressure sensor being arranged on or in said midsole.

12. Article of footwear as claimed in claim **1**, wherein said one or more pressure-sensing cells are at least two pressure-sensing cells, and wherein said pressure sensor comprises one or more connection strips interconnecting said at least two pressure sensing cells, said one or more connection strips being integrally formed with said at least two pressure sensing cells, and said one or more connection strips bearing conductors for connecting the first and second electrodes of each pressure-sensing cell with an electronic control module.

13. Article of footwear as claimed in claim **12**, wherein at least one of said connection strips has a serpentine shape.

14. Article of footwear as claimed in claim **1**, wherein said article of footwear is a sports shoe.

15. A pressure sensor for an article of footwear, comprising a flexible multilayer film structure that includes a forefoot portion, a heel portion and a connection strip that connects the forefoot portion to the heel portion, the connection strip being integrally formed with the multilayer film structure, wherein the pressure sensor further comprises a trough-shaped receptacle for an electronic control module, which receptacle the connection strip is arranged across and bonded to.

16. Article of footwear as claimed in claim **1**, wherein the first and second electrodes comprise a plurality of generally triangular portions, which protrude in interdigitating manner from long sides of the pressure-sensing cell into the opening so as to form a repetitionary pattern along the axis of main extension and wherein the electrically insulating layer comprises a plurality of separate, spindle-shaped portions, each of which is arranged so as to cover areas, in which sides of neighbouring triangular portions of the first electrode run alongside one another.

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