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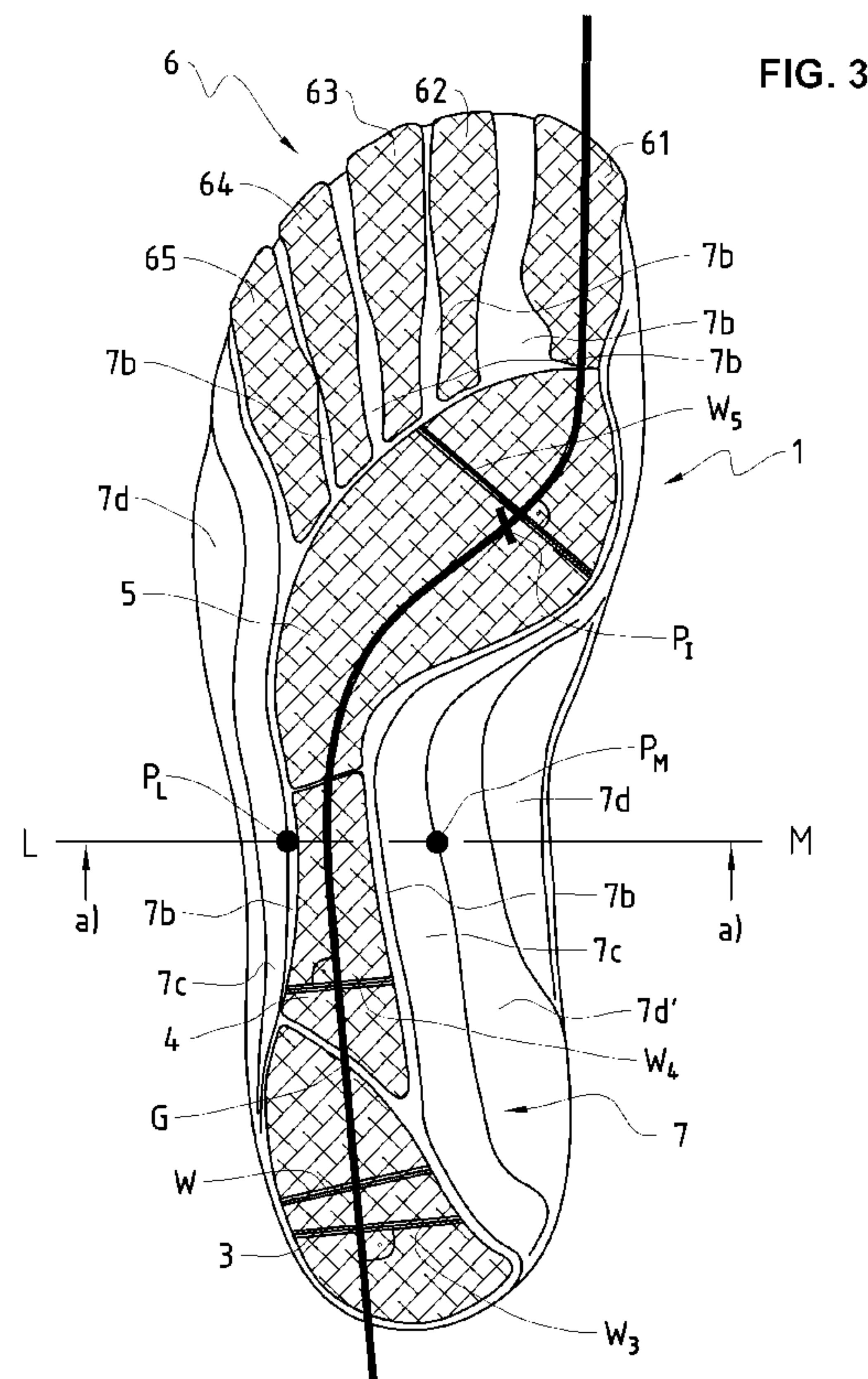
(71) **Demandeurs/Applicants:**
SCHUMACHER, TOBIAS, CH;
SWAGER VAN DOK, JAN, CH

(72) **Inventeurs/Inventors:**
SCHUMACHER, TOBIAS, CH;
SWAGER VAN DOK, JAN, CH

(74) **Agent:** ADE & COMPANY INC.

(54) **Titre : SEMELLE DE CHAUSSURE POUR PERMETTRE UNE CORRECTION DE LA DEMARCHE OU UN MAINTIEN DE LA DEMARCHE**

(54) **Title: SHOE SOLE FOR GAIT CORRECTION OR GAIT PRESERVATION**



(57) **Abrégé/Abstract:**

The invention provides a shoe sole (1), suitable for an article of footwear, comprising in rear-end-to-front-end sequence along the sole a heel portion (3), midfoot portion (4), ball portion (5) and forefoot portion (6), said heel, midfoot and ball portions each being

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adjacent to an arch region below the arch of a foot wearing the shoe sole. The shoe sole comprises first sole portions (11; 11'; 11'') extending along a substantially S-shaped line (G) of optimal ground contact during walking or running, starting at the heel portion, passing along the midfoot and ball portions and ending at the forefoot portion, and second sole portions (12, 13; 12', 13'; 12'', 13'') extending on both sides of said substantially S-shaped line. The local thickness T and/or the local hardness H of a first sole portion (11; 11'; 11'') is/are greater than the local thickness T and/or the local hardness H of a second sole portion (12, 13; 12', 13'; 12'', 13'') adjacent to said first sole portion.

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Shoe sole for gait correction or gait preservation

The present invention relates to a shoe sole which is suitable for an article of footwear.

Typically, such a shoe sole comprises in rear-end-to-front-end
5 sequence along the sole a heel portion, a midfoot portion, a ball portion and a forefoot portion, with the heel, midfoot and ball portions each being adjacent to an arch region below the arch of a foot wearing this shoe sole.

Shoe soles of this type increase user comfort both by providing cushioning elements for the foot in some or all of the heel, midfoot, ball and
10 forefoot portions of the shoe sole primarily for dampening ground impact during running or walking and/or by providing support elements spread throughout the bottom surface of the shoe sole primarily for stabilizing the foot and preventing or at least minimizing any tilt of the foot in a direction transverse to the running or walking direction (longitudinal direction).

15 Wearing shoes equipped with soles of this type over extended periods of time contributes to an attitude of indifference and passiveness in persons using these shoes. In the long run, many of these persons will forget how to walk naturally or "correctly". It has been shown that prolonged unnatural or "incorrect" walking may have deleterious effects on the entire
20 body, such as knee, hip and back problems. On the other hand, there are indications that "rediscovering" how to walk naturally can alleviate or even eliminate many problems in a person's body.

The following sequence has been found for practically all humans to be a natural or "correct" gait (except for sprinting):

- 25 - the first foot initially contacts the ground with its heel or with its heel and midfoot simultaneously;
- the first foot then begins to roll on the ground with slight foot deformation (and ideally without slipping), the sole of the first foot contacting the ground in sequence by its heel or midfoot, its ball and forefoot portions;
- 30 - at the end of this first foot rolling action, the first foot is lifted off the ground,

and at the same time, the second foot initially contacts the ground with its heel or with its heel and midfoot simultaneously;

- the second foot then begins to roll on the ground with slight foot deformation (and ideally without slipping), the sole of the second foot contacting the ground

5 in sequence by its heel or midfoot, its ball and forefoot portions;

- at the end of this second foot rolling action, the second foot is lifted off the ground, and at the same time, the first foot again initially contacts the ground with its heel or with its heel and midfoot simultaneously and the sequence continues.

10 In the above sequence of alternate foot contact with the ground, a more or less broadened/blurred ground contact line is defined on the sole of each foot. In a person having healthy bones, tendons, muscles and nerves and exhibiting natural gait behavior, this optimal ground contact line typically is a substantially/approximately S-shaped line on the sole of each foot starting at
15 the heel portion, passing along the midfoot and ball portions and ending at the forefoot portion, typically on the medial side of the forefoot portion in the region of the first and second metatarsals and the first and second toes.

It is an object of the present invention to help a person stick to this optimal ground contact line during walking and running.

20 The invention provides a shoe sole, suitable for an article of footwear, the shoe sole comprising at its ground-contact surface in rear-end-to-front-end sequence along the sole a heel portion, a midfoot portion, a ball portion and a forefoot portion, said heel, midfoot and ball portions each being adjacent to an arch region below the arch of a foot when wearing the shoe sole;
25 wherein the shoe sole comprises first sole portions extending along a substantially S-shaped line of optimal ground contact during walking or running, which line starts at the heel portion, passes along the midfoot and ball portions and ends at the forefoot portion; the sole comprises second sole portions extending along both sides of said substantially S-shaped line; and
30 wherein the local thickness and/or the local hardness of a first sole portion is/are greater than the local thickness and/or the local hardness of a second sole portion adjacent to said first sole portion. According to the invention, the

shoe sole comprises an insole fixed at the foot-contact surface or embedded underneath the foot-contact surface of the shoe sole, and the insole has a smaller width extension than the shoe sole and extends along said substantially S-shaped line.

5 Due to the insole at or close to the foot-contact surface of the shoe sole, a walker or runner wearing a shoe provided with the shoe sole according to the invention experiences increased or concentrated pressure between the insole and the bottom surface of his foot. As a result, the walker or runner feels the substantially S-shaped line as a pressure line at the bottom surface of his
10 foot.

 Due to this thickness profile and/or hardness profile of the shoe sole in a cross-sectional direction transverse to the locally longitudinal direction or tangential direction along the substantially S-shaped line of optimal ground contact, a person wearing a well-secured inventive shoe sole on each foot will
15 feel more “pressure” or “support” from points located on that line (first sole portions) than from points located outside that line, i.e. off that line (second sole portions) and thus will experience “instant feedback” and “feel” during walking or running whenever he or she deviates from the line of optimal ground contact.

20 The expressions “pressure” or “support” or “pressure force” or “support force” are used as synonyms in the present text and are all defined as average measured force per unit area where the force is measured using a vertically sensitive force meter having a horizontally planar force receiving surface having a defined area. The “pressure” or “support” or “pressure force”
25 or “support force” value is calculated as “the measured vertical force acting on the force receiving surface divided by the area of the force receiving surface”. Typical support force values may relate to the static support forces measured during standing or the instantaneous dynamic support forces measured during walking, more specifically the locally acting reaction forces (ground forces) in
30 the ground-contact regions of the shoe sole during the rolling action of a foot on the ground.

As long as the direction of the dynamic force vector resulting from the static weight and the dynamic force during the rolling action of each foot passes through the line of optimal ground contact, there is no or at least hardly any tilting action on the foot which would cause the foot to tilt laterally (towards
5 the outside) or medially (towards the inside), i.e. in a direction transverse to the walking or running direction, with respect to the shinbone.

However, as soon as the direction of the dynamic force vector resulting from the static weight and the dynamic force during the rolling action of each foot no longer passes through the line of optimal ground contact, there
10 will be some tilting action on the foot which will cause the foot to tilt laterally, i.e. in a direction transverse to the walking or running direction, with respect to the shinbone. This lateral or medial tilt of the foot with respect to the shinbone is easily detected/sensed/felt by a person and thus provides the above-mentioned feedback to the walker or runner wearing the inventive shoe sole.

As a result, the person wearing the well-secured inventive shoe sole on each foot is enabled to slightly reposition his or her entire body (change of posture and thus change of gait = gait-correction) whenever he or she deviates from the line of optimal ground contact. This causes the person to do a more or less conscious active and dynamic "balancing act" during the rolling action
20 with each foot on the corresponding line of optimal ground contact defined by shoe sole hardness and/or shoe sole thickness. This dynamic balancing or feedback-controlled rolling action of each foot involves many parts of the body, i.e. ankle joints, knee joints, hip joints, vertebral column, etc. as well as the associated tendons, muscles, nerves, etc. and has a beneficial influence on the
25 entire body.

The insole extending along the substantially S-shaped line and contacting the foot contributes to the above-described feedback to the walker or runner. Thus, the walker's or runner's senses detect any deviation of his foot or the other above-mentioned body parts from their ideal positions and
30 movements during walking or running (proprioception).

Preferably, the insole is made from a material having a greater hardness than the hardness of the shoe sole material surrounding said insole.

This insole with greater hardness results in further improvement of the walker's or runner's proprioception. In addition, it provides the shoe sole
5 with increased structural stability (form stability), thus preventing the shoe sole from being worn out or losing its overall stiffness too early.

In addition to the above-described first insole, a second insole may be provided, preferably one on top of the other and spaced along the thickness direction of the shoe sole. Using two insoles with similar or different hardness,
10 the structural stability of the shoe sole can be adjusted. As an alternative or in addition to one or two insoles, a dampening insole (insert) may be embedded in the shoe sole. Such dampening insole may be made from a foamed material and may comprise a dampening fluid.

In a first major embodiment of the shoe sole according to the
15 invention, the local thickness of a first sole portion, i.e. a portion located on the substantially S-shaped line of optimal ground contact or "on-line" portion", is greater than the local thickness of a second sole portion adjacent to said first sole portion, i.e. a portion adjacent to the substantially S-shaped line of optimal ground contact or "off-line" portion", and the first sole portion and the second
20 sole portion may have the same hardness. This allows the first and second sole portions to be made from one material, for instance by injection molding one material within one mold. Of course, for each transverse "set" consisting of a first (on-line) portion and one or two second (off-line) portions (typically one on each side of the substantially S-shaped line), a specific material having a
25 specific hardness may be used. In this way, all transverse sets aligned along the substantially S-shaped line in a longitudinal manner may define a hardness profile with different hardness values along the substantially S-shaped line, i.e. an "along-the-line" hardness profile. Thus, an individualized shoe sole may be composed using sets made from different materials and having different shapes
30 and lined up "along the line". Once lined up, these individual sets may be permanently joined by attaching them to each other and/or to a common sole portion such as a midsole by gluing or welding.

In this first major embodiment, the entire shoe sole may consist of one material having one hardness value. This allows the entire sole, i.e. all sets aligned and spaced along the line, to be made using only one molding process, for instance injection molding.

5 Preferably, in this first major embodiment, the shoe sole comprises a protrusion protruding from its ground-facing bottom surface and extending at least along parts of the substantially S-shaped line. As a result, a person wearing this shoe sole on each foot will feel more pressure/support from points located on this protruding line (first sole portions) than from points located off
10 said protruding line (second sole portions). Whenever the person shifts his/her dynamic force vector resulting from the static weight and the dynamic force during the rolling action of each foot such that this dynamic vector no longer passes through this protruding line, the person will experience the above-mentioned "instant feedback" and "feel" during walking or running whenever
15 he/she deviates from this protruding line of optimal ground contact.

This protrusion may have different cross-sectional shapes, i.e. different thickness profiles, that require different levels of skill for dynamically balancing on this line during walking or running.

In a first variant of the first major embodiment, the protrusion may
20 have a trapezoidal cross section (trapezoidal thickness profile) in a plane perpendicular to the substantially S-shaped line and with a first trapezoid base-line defining a plateau-like region of the sole surface and with a second trapezoid base-line defining a sloping transition region between the trapezoidal protrusion and the bulk (rest) of the sole, with the second trapezoid base-line
25 being longer than the first trapezoid base-line. As long as the dynamic force vector passes through the plateau-like region (thicker region), the person will feel strong support from the sole. As soon as the dynamic force vector passes through one of the sloping transition regions (decreasing thickness regions) with weaker support on either side of the plateau-like region, the person will
30 feel a slight reduction of support with a potential slight tilt in the ankle joint.

In a second variant of the first major embodiment, the protrusion may have a rectangular cross section (rectangular thickness profile) in a plane perpendicular to the substantially S-shaped line and with a first rectangular base-line defining a plateau-like region of the sole surface and with a second rectangular base-line defining an abrupt transition region (i.e. very steep slope) between the rectangular protrusion and the bulk (rest) of the sole, with the second rectangular base-line having the same length as the first rectangular base-line. Again, as long as the dynamic force vector passes through the plateau-like region (thicker region), the person will feel strong support from the sole. As soon as the dynamic force vector passes through one of the abrupt transition regions or beyond these regions with weaker support on either side of the plateau-like region, the person will feel a stronger reduction of support with a potentially stronger tilt (stronger than with the trapezoidal cross section) in the ankle joint.

Both the first variant with the trapezoidal thickness profile and the second variant with the rectangular thickness profile define a plateau-like region of the sole surface. The surface of this plateau-like region is preferably planar and may be substantially parallel to the substantially planar upper surface of the shoe sole on which the foot rests.

However, both in the first variant and in the second variant, the preferably planar surface of this plateau-like region may be tilted with respect to the substantially planar upper surface of the shoe sole on which the foot rests. In other words, the protrusion will then have a non-trapezoidal or non-rectangular thickness profile rather than one of the above trapezoidal or rectangular profiles. The angle between the surface of the plateau-like region and the upper surface may be such that the thickness of the sole decreases from the lateral side ("outside of a foot") toward the medial side ("inside of a foot") or vice-versa. As a result, when wearing such a shoe sole during walking or running, the person's dynamic balancing act during walking or running will induce a medial tilt of the feet and shinbones or a lateral tilt of the feet and shinbones when the feet with their shoe soles rest on the ground or during each rolling action of the feet with their shoe soles on the ground. The shoe sole with the plateau-like region tilted toward the lateral side (lateral side

thinner) may be used for correcting the gait of a bow-legged person, whereas the shoe sole with the plateau-like region tilted toward the medial side (medial side thinner) may be used for correcting the gait of a knock-kneed person.

Preferably, these plateau-like ground-contact regions tilted with
5 respect to the substantially planar upper surface of the shoe sole are provided at least in the midfoot portion, but preferably only in the midfoot portion, the ball portion and the forefoot portion of the shoe sole.

Also, the plateau-like region may extend all the way to the lateral
10 side border-line of the shoe sole at least in longitudinal parts of the bottom sole surface, preferably in the midfoot portion. In addition, within parts of the heel portion and/or within parts of the ball portion, the plateau-like region may also extend all the way to the lateral side border-line of the shoe sole.

In a third variant of the first major embodiment, the protrusion may have a curved convex cross section (curved convex thickness profile) in a
15 plane perpendicular to the substantially S-shaped line and with a curved line defining a bead-like or lens-like region of the sole surface and with a base-line defining a transition region between the curved convex protrusion and the bulk (rest) of the sole. With this curved convex cross-sectional thickness profile, it is even more challenging to dynamically balance on the line of strong support
20 than with the rectangular thickness profile, since there is no a priori plateau-like region as in the case of the trapezoidal or rectangular cross-sectional thickness profiles, but only a narrow a posteriori plateau-like region due to the deformation (local compression) of the curved convex profile protrusion resulting from the dynamic force vector (the person's "static plus dynamic
25 weight") acting on this protrusion. Even if the direction of the dynamic force vector deviates only very slightly from this "supported direction" passing through the narrow a posteriori plateau-like region, the person will feel a very strong reduction of support with a potentially much stronger tilt (stronger than with the rectangular cross-section) in the ankle joint. By increasing the
30 hardness of the material, this dynamic balancing act becomes even more difficult and challenging. It may be thought of as similar to the case of a tight-rope walker walking on one single tight rope.

In a fourth variant of the first major embodiment, the protrusion may have a curved concave portion within its convex cross section (globally convex thickness profile with a locally curved concave thickness profile section) in a plane perpendicular to the substantially S-shaped line. This type of thickness profile is often referred to as a “cantilever profile” or “bridge profile”. It defines a trough-like or channel-like region within the protrusion of the sole surface, i.e. a trough-like or channel-like region surrounded by a first raised ridge-like region on one side (the medial side) of the thickness profile and a second raised ridge-like region on the other side (the lateral side) of the thickness profile. In addition, the protrusion may have a transition region of decreasing thickness between at least one of the ridge-like regions on the one hand and the bulk (rest) of the sole on the other. With this “cantilever” or “bridge” thickness profile, it is easier and thus less challenging to dynamically balance on the line of strong support than with the corresponding curved convex thickness profile or rectangular thickness profile or even trapezoidal thickness profile. Again, there is no a priori plateau-like region as in the case of the trapezoidal or rectangular cross-sectional thickness profiles, but a broad a posteriori plateau-like region will be formed due to the relatively strong local compression of each of the raised ridge-like portions of the protrusion on both sides of the trough-like or channel-like portion of the protrusion and the relatively weak local compression or no compression at all of the recessed trough-like or channel-like portion of the protrusion. Unlike the previously described simply curved convex cross-sectional thickness profile, the rectangular thickness profile or even the trapezoidal thickness profile, the more intensely compressed ridge-like portions provide more support than the less intensely or non-compressed trough-like or channel-like portions. Thus, when the dynamic force vector (the person’s “static plus dynamic weight”) acting on this protrusion deviates from a “supported direction” passing through the less intensely or non-compressed protrusion region towards one of the more intensely compressed ridge-like portions, the person will feel a very strong increase in support and it is less challenging to keep the dynamic force vector in between the ridge-like portions, thus making it a lot easier to keep walking on this deformable protrusion with a cantilever or bridge thickness profile, i.e., a less challenging dynamic balancing act.

In a special case where the thickness in between the ridge-like regions and the thickness of the bulk (rest) of the sole are identical, this cantilever or bridge thickness profile can also be thought of as two curved convex cross-sectional thickness profiles next to each other, i.e. two bead-like or ridge-like protrusions each arranged along the substantially S-shaped line and thus in parallel to each other. Again, this less challenging dynamic balancing act may be thought of as having a similar effect as the case of a tight-rope walker walking on two closely spaced parallel tight ropes.

Irrespective of its cross-sectional shapes, i.e. different transverse thickness profiles with respect to the substantially S-shaped line, the protrusion may also have a non-uniform longitudinal thickness profile, as measured along a section following the substantially S-shaped line.

Preferably, the heel portion of the protrusion has a smaller thickness than the midfoot portion of the protrusion, or vice-versa.

Preferably, the heel portion of the protrusion has a smaller thickness than the midfoot portion and the ball portion of the protrusion, or vice-versa.

Combined with the different cross-sectional shapes, i.e. different transverse thickness profiles, the non-uniform longitudinal thickness profile of the protrusion may be used to fine-tune the different levels of skill for dynamically balancing on this line of defined thicknesses during walking or running.

In a second major embodiment of the shoe sole according to the invention, the local hardness of a first sole portion is greater than the local hardness of a second sole portion adjacent to said first sole portion and wherein the first sole portion and the second sole portion have the same thickness. In this case, the first and second sole portions of each "set" are made from different materials. Each of these transverse "sets" has its first (on-line) portion and its one or two second (off-line) portions (typically one on each side of the substantially S-shaped line), with a harder material having a first hardness being used for the on-line portion and a softer material having a

second hardness less than the first hardness being used for each of the off-line portions. Again, as in the first major embodiment, all of these transverse sets aligned along the substantially S-shaped line in a longitudinal manner may define a hardness profile with different hardness values along the substantially S-shaped line, i.e. an “along-the-line” hardness profile. Thus, an individualized shoe sole may be composed using sets made from different materials and having different shapes and lined up “along the line”. Again, once lined up, these individual sets may be permanently joined by attaching them to each other and/or to a common sole portion such as a midsole by gluing or welding.

10 In this second major embodiment, the entire sole may have substantially the same thickness and look like the sole of a “regular” shoe.

Preferably, in this second major embodiment, the shoe sole comprises a hard region having greater hardness than surrounding soft regions of the sole and extending at least along parts of said substantially S-shaped line. As a result, a person wearing this shoe sole on each foot will feel more pressure/support from points located on this harder-material line (first sole portions) than from points located off said harder-material line (second sole portions). Whenever the person shifts his/her dynamic force vector resulting from the static weight and the dynamic force during the rolling action of each foot such that this dynamic vector no longer passes through this harder-material line, the person will again experience the above-mentioned “instant feedback” and “feel” during walking or running whenever he/she deviates from this harder-material line of optimal ground contact.

25 This harder-material line may have different cross-sectional hardness profiles that require different levels of skill for dynamically balancing on this line during walking or running.

In a first variant of the second major embodiment, the hard region has a trapezoidal hardness profile in a plane perpendicular to the substantially S-shaped line defining a maximum hardness core region and a decreasing hardness transition region on each side of said core region, where the hardness decreases from the maximum hardness to a lesser hardness of the

soft regions. As long as the dynamic force vector passes through the maximum hardness core region (harder region), the person will feel strong support from the sole. As soon as the dynamic force vector passes through one of the decreasing hardness transition regions with weaker support on either side of the maximum hardness core region, the person will again feel a slight reduction of support with a potential slight tilt in the ankle joint.

In a second variant of the second major embodiment, the hard region has a rectangular hardness profile in a plane perpendicular to the substantially S-shaped line defining a maximum hardness core region and defining a region having the lesser hardness of the soft regions on each side of the core region. Again, as long as the dynamic force vector passes through the maximum hardness core region (harder region), the person will feel strong support from the sole. As soon as the dynamic force vector passes through one of the abrupt transition regions or beyond these regions with weaker support on either side of the maximum hardness core region, the person will again feel a stronger reduction of support with a potentially stronger tilt (stronger than with the trapezoidal cross-section) in the ankle joint.

Both the first variant with the trapezoidal hardness profile and the second variant with the rectangular hardness profile define a maximum hardness core region of the sole surface. The hardness profile, i.e. the cross-sectional hardness distribution, within this core region is preferably a straight line which may be substantially parallel to the substantially planar upper surface of the shoe sole on which the foot rests.

However, both in the first variant and in the second variant, the preferably straight line of the hardness profile within this core region may be tilted with respect to the substantially planar upper surface of the shoe sole on which the foot rests. In other words, the cross-sectional hardness distribution will then have a non-trapezoidal or non-rectangular hardness profile rather than one of the above trapezoidal or rectangular profiles. The angle between the straight line of the hardness profile within the core region and the upper surface may be such that the hardness values of the sole decrease from the lateral side ("outside of a foot") toward the medial side ("inside of a foot") or vice-versa.

Again, as a result, when wearing such a shoe sole during walking or running, the person's dynamic balancing act during walking or running will induce a medial tilt of the feet and shinbones or a lateral tilt of the feet and shinbones when the feet with their shoe soles rest on the ground or during each rolling
5 action of the feet with their shoe soles on the ground. The shoe sole with the hardness values in the core region decreasing toward the lateral side (lateral side softer) may be used for correcting the gait of a bow-legged person, whereas the shoe sole with the hardness values in the core region decreasing toward the medial side (medial side softer) may be used for correcting the gait
10 of a knock-kneed person.

Preferably, these hard core ground-contact regions with their straight line of the hardness-profile tilted with respect to the substantially planar upper surface of the shoe sole are provided at least in the midfoot portion, but preferably only in the midfoot portion, the ball portion and the forefoot portion of
15 the shoe sole.

Also, the core region with the straight-line hardness value distribution may extend all the way to the lateral side border-line of the shoe sole at least in longitudinal parts of the bottom sole surface, preferably in the midfoot portion. In addition, within parts of the heel portion and/or within parts
20 of the ball portion, the core region with the straight-line hardness value distribution may also extend all the way to the lateral side border-line of the shoe sole.

In a third variant of the second major embodiment, the hard region may have a curved convex hardness profile in a plane perpendicular to the
25 substantially S-shaped line defining a hardness maximum and defining a decreasing hardness transition region on each side of the hardness maximum, where the hardness decreases from the hardness maximum to a lesser hardness of the soft regions. Again, in this case, it is even more challenging to dynamically balance on the line of strong support than with the rectangular
30 hardness profile, since there is no a priori maximum hardness core region as in the case of the trapezoidal or rectangular cross-sectional hardness profiles, but only a narrow a posteriori maximum hardness core region due to the

deformation (local compression) of the curved convex hardness profile resulting from the dynamic force vector (the person's "static plus dynamic weight") acting on this curved convex hardness profile. Even if the direction of the dynamic force vector deviates only very slightly from this "supported
5 direction" passing through the narrow a posteriori maximum hardness core region, the person will again feel a very strong reduction of support with a potentially much stronger tilt (stronger than with the rectangular cross-section) in the ankle joint. By increasing the overall hardness of the material, this dynamic balancing act becomes even more difficult and challenging. Again, it
10 may be thought of as similar to the case of a tight-rope walker walking on one single tight rope.

In a fourth variant of the first major embodiment, the hard region may have a curved concave hardness profile portion within its convex cross-sectional hardness profile (globally convex hardness profile with a locally
15 curved concave hardness profile section) in a plane perpendicular to the substantially S-shaped line. This type of hardness profile may also be referred to as a "cantilever profile" or "bridge profile". It defines a local trough or channel of relatively soft material (locally concave hardness profile) within the overall hard core region (globally convex hardness profile) of the sole surface,
20 i.e. a trough-like or channel-like portion of relatively soft material surrounded by a first region of relatively hard material on one side (the medial side) of the hardness profile and a second region of relatively hard material on the other side (the lateral side) of the hardness profile. In addition, the hard overall hard core region may have a transition region of decreasing hardness between at
25 least one of the two relatively hard regions on the one hand and the bulk (rest) of the sole on the other. With this "cantilever" or "bridge" hardness profile, it is easier and thus less challenging to dynamically balance on the line of strong support than with the corresponding curved convex hardness profile or rectangular hardness profile or even trapezoidal hardness profile. Again, there
30 is no a priori hard core region as in the case of the trapezoidal or rectangular cross-sectional hardness profiles, but a broad a posteriori hard core region will be formed due to the relatively strong local compression of each of the two regions of relatively hard material of the overall hard core region on both sides of the trough-like or channel-like portion of relatively soft material of the overall

hard core region and due to the relatively weak local compression or no compression at all of the trough-like or channel-like portion of relatively soft material of the overall hard core region. Unlike the previously described simply curved convex cross-sectional hardness profile, the rectangular hardness
5 profile or even the trapezoidal hardness profile, the more intensely compressed two regions of relatively hard material provide more support than the less intensely or non-compressed trough-like or channel-like portions of relatively soft material. Thus, when the dynamic force vector (the person's "static plus dynamic weight") acting on this overall hard core region deviates from a
10 "supported direction" passing through the less intensely or non-compressed overall hard core region towards one of the more intensely compressed regions of relatively hard material, the person will feel a very strong increase in support and it is less challenging to keep the dynamic force vector in between the two regions of relatively hard material, thus making it a lot easier to keep walking
15 on this deformable overall hard core region with a cantilever or bridge hardness profile, i.e., a less challenging dynamic balancing act.

In a special case where the thickness in between the two regions of relatively hard material and the hardness of the bulk (rest) of the sole are identical, this cantilever or bridge hardness profile can also be thought of as
20 two curved convex cross-sectional hardness profiles next to each other, i.e. two longitudinally extending hard core regions each arranged along the substantially S-shaped line and thus in parallel to each other. This less challenging dynamic balancing act may be thought of as similar to the case of a tight-rope walker walking on two closely spaced parallel tight ropes.

25 Irrespective of its cross-sectional hardness profiles, i.e. its different transverse hardness profiles with respect to the substantially S-shaped line, the hard core region may also have a non-uniform longitudinal hardness profile, as measured along a section following the substantially S-shaped line.

30 Preferably, the heel portion of the hard region has a smaller hardness than the midfoot portion of the hard region, or vice-versa.

Preferably, the heel portion of the hard region has a smaller hardness than the midfoot portion and the ball portion of the hard region, or vice-versa.

Combined with the different cross-sectional hardness profiles, i.e. different transverse hardness profiles, the non-uniform longitudinal hardness profile of the hard region may be used to fine-tune the different levels of skill for dynamically balancing on this line of defined hardnesses during walking or running.

Preferably, the difference in local thickness and/or in local hardness between a first sole portion and a second sole portion adjacent to said first sole portion is greatest in said midfoot portion extending between said heel portion and said ball portion. As a result, a person with a tendency to medially tilt a foot (towards the inside, i.e. towards the other foot) or with a tendency to laterally tilt a foot (towards the outside, i.e. away from both feet) will experience a particular dynamic balancing challenge during the phase of the rolling action of each foot where the midfoot portion of the sole contacts the ground while providing most of the support during that phase.

Preferably, irrespective of whether the transverse thickness profiles (first major embodiment) and/or the transverse hardness profiles (second major embodiment) are used for defining the substantially S-shaped line, the first sole portions on the substantially S-shaped line and/or the second sole portions on both sides of the substantially S-shaped line may comprise a plurality of transverse slits or "cuts" spaced in the longitudinal direction of the sole along the substantially S-shaped line and extending in a transverse direction of the sole across the substantially S-shaped line. These transverse slits or cuts provide additional bending and twisting flexibility of the shoe sole during the rolling action of each foot.

The features of different variants of the first major embodiment, i.e. a protrusion along the S-shaped line with defined transverse thickness profiles, may be combined independently with features of different variants of the

second major embodiment, i.e. a hard region along the S-shaped line with defined transverse hardness profiles.

Preferably, the longitudinal spacing of these transverse slits is between 1 mm and 10 mm, most preferably between 2 mm and 6 mm.

5 Preferably, the length of these slits, i.e. their first transverse dimension, extends across the entire width of the protrusion and/or across the entire width of the hard region or (overall) hard core region.

 Preferably, the depth of these slits, i.e. their second transverse dimension, extends across 1/3 to 2/3 of the entire thickness of the protrusion
10 and/or across 1/3 to 2/3 of the entire thickness of the hard region or (overall) hard core region.

Preferably, the minimum thickness of the protrusion of the shoe sole is about 2mm. A preferred thickness range of the protrusion of the shoe sole is between 2 mm and 50 mm, preferably between 4 mm and 30 mm.

15 When defining and measuring hardness of shoe soles made of elastomers, preferred elasticity/hardness scales are the Shore hardness scales.

 Preferably, the minimum hardness, i.e. the hardness value of the softest regions of the shoe sole, is about 30 Shore. A preferred hardness
20 range of the shoe sole is between 40 Shore and 80 Shore.

In a preferred embodiment, the shoe sole according to the invention is composed of several different components each of which is fabricated independently using a component-specific material. Preferably, the shoe sole comprises an outsole-portion and an insole-portion.

25 The outsole portion may comprise in rear-end-to-front-end sequence along the sole a heel portion, a midfoot portion, a ball portion and a forefoot portion. Together, these four ground-contact sole portions constitute the

ground-contact region of the shoe sole which ground-contact region includes the substantially S-shaped line of optimal ground contact during walking or running.

5 All or some of these four portions may be formed integrally from a suitable elastomer. Preferably all four portions are formed in one piece with one or several narrow connecting portions between the heel portion and the midfoot portion, between the midfoot portion and the ball portion as well as between the ball portion and the forefoot portion. This guarantees a high amount of flexibility between the interconnected portions of the outsole.

10 Alternatively, all of these four portions may be formed separately as individual pieces each from a suitable elastomer. Again, this guarantees a high amount of flexibility between the portions of the outsole and allows each portion to be made from a suitable material having individual properties. Preferably, the piece constituting the heel portion is made from a softer elastomeric
15 material than the pieces constituting the midfoot portion and the ball portion.

The outsole portion may comprise a base body made from a suitable elastomer to which base body the above-described heel, midfoot, ball and forefoot portions are connected e.g. by welding, gluing or vulcanization. One or more of the four portions, such as the heel portion, may have the same
20 hardness as the base body and may therefore be formed integrally, e.g. by injection molding, from a first elastomer having a first hardness. The other ones of the four portions, such as the midfoot, ball and forefoot portions may be formed, e.g. by injection molding, from a second elastomer having a second hardness, preferably greater than the first hardness of the first elastomer, and
25 then connected to the base body e.g. by welding, gluing or vulcanization.

In addition, an optional first or lower insole portion made of a third elastomer having a third hardness, preferably greater than the hardness of the base body, may be provided between the base body and the four portions of the ground-contact region. Preferably, this lower insole portion may have the
30 shape of a layer which is located between the base body and the ground-contact portions. Most preferably, this lower insole portion may be cut out from

a sheet material such that the cut-out is long enough and wide enough to include and support the substantially S-shaped line of optimal ground contact defined by the protrusion region and/or hard core region in the ground-contact portions underneath the lower insole portion. Preferably, the lower insole
5 portion is a thin layer having a thickness between 1 mm and 5 mm, more preferably between 2 mm and 4 mm. Thus, even if the lower insole material is harder than the base body material, it may still be quite flexible due to its thin shape.

In addition, an optional second or upper insole portion made of a
10 fourth elastomer having a fourth hardness, preferably also greater than the hardness of the base body, may be provided at the upper side of the base body on which the foot rests. Preferably, this upper insole portion may again have the shape of a layer which is located at the upper side of the base body. Most preferably, this upper insole portion may be cut out from a sheet material such
15 that the cut-out is long enough and wide enough to include and support the substantially S-shaped line of optimal ground contact defined by the protrusion region and/or hard core region in the ground-contact portions underneath the base body and/or underneath the lower insole portion. Preferably, the upper insole portion is a thin layer having a thickness between 1 mm and 5 mm, more
20 preferably between 2 mm and 4 mm. Thus, the upper insole is quite flexible due to its thin shape.

Preferably, the contours of the cut-out of the upper insole portion and the lower insole portion are identical. Thus, both the lower and upper optional insole portion can be formed with the same manufacturing equipment.

25 The above-mentioned plurality of transverse slits or "cuts" spaced in the longitudinal direction of the sole along the substantially S-shaped line and extending in a transverse direction of the sole may be provided in any one of the ground contacting portions, the lower insole portion and the upper insole portion. Preferably, the sole flexibility increasing transverse slits are provided
30 as "embedded slits" in the lower and/or upper insole portions only.

In a preferred embodiment, the shoe sole ball portion has a first, second, third, fourth and fifth metatarsal part between the medial side M and lateral side L of the shoe sole, and the following conditions apply to the transverse thickness and/or hardness profile of the ball portion:

- 5 - the thickness and/or hardness of the first metatarsal part is greater than the thickness and/or hardness of the second metatarsal part; and
- the third metatarsal part has a thickness and/or hardness less than the thickness and/or hardness of the fourth metatarsal part; and
- 10 - the fourth metatarsal part has a thickness and/or hardness less than the thickness and/or hardness of the fifth metatarsal part.

As a result, when a foot rolls on the ground with the sole of the foot contacting the ground in sequence by its heel, midfoot, ball and forefoot portions, the above thickness and/or hardness conditions in the ball portion cause the foot to pronate, i.e. the weight acting on the foot is shifted from its
15 initial position in the midfoot portion at the lateral side L of the shoe sole to the subsequent position in the ball portion at the medial side M. In other words, the foot is forced into pronation while the ball portion of the foot and the shoe sole are rolling on the ground. Thus, during a first phase of the foot's rolling on the ground, the weight acting on the lateral side of the midfoot portion and then on
20 the lateral side of the ball portion is shifted from the lateral side of the ball portion toward the medial side of the ball portion, and during a second phase of the foot's rolling on the ground, the weight then acts on the medial side of the ball portion and then on the medial side of the forefoot portion, i.e. the big toe.

Preferably, the second metatarsal part has a thickness and/or
25 hardness less than the thickness and/or hardness of any of the third, fourth and fifth metatarsal parts. This further improves the shifting of the weight acting on the foot from the lateral side to the medial side.

These conditions of the first, second, third, fourth and fifth metatarsal parts in the ball portion of the shoe sole cause the weight during the rolling
30 action of the foot to be shifted from the lateral side L towards the medial side M.

More precisely, after the midfoot portion has rolled on the ground with the weight located on the lateral side L (balancing act), the ball portion then rolls on the ground with the weight being shifted from the lateral side L of the ball portion toward the medial side M of the ball portion, and finally the
5 forefoot portion rolls on the ground with the weight located on the medial side M. At the beginning of this shifting action within the ball portion, the fifth metatarsal part of the ball portion provides more support than the neighbouring fourth and third metatarsal parts of the ball portion. At the end of this shifting action within the ball portion, the first metatarsal part of the ball portion
10 provides more support than the second metatarsal part of the ball portion. In other words, the fifth metatarsal part on the lateral side L causes the foot to pronate, and the first metatarsal part on the medial side M prevents excessive pronation of the foot.

Thus, these conditions of the first, second, third, fourth and fifth
15 metatarsal parts in the ball portion of the shoe sole have an effect similar to two consecutive banked curves placed along the substantially S-shaped line. Using these terms, during the right foot's rolling action along the substantially S-shaped line, the right foot first passes through a banked curve with a left turn at the lateral side L and then through a banked curve with a right turn at the
20 medial side M. Similarly, during the left foot's rolling action along the substantially S-shaped line, the left foot first passes through a banked curve with a right turn at the lateral side L and then through a banked curve with a left turn at the medial side M.

In a further preferred embodiment of the shoe sole, the width, as
25 measured across the S-shaped line, of the locally thicker and/or harder first sole portion of the midfoot portion is smaller than the width, as measured across the S-shaped line, of the locally thicker and/or harder first sole portion of the heel portion.

As a result, during running or walking, when a foot lands on the
30 ground with the shoe sole contacting the ground by its heel, the broader first sole portion of the heel portion provides a safe landing with stable positioning of the heel. The dynamic balancing or feedback-controlled rolling action of

each foot, as defined in the introduction of the description, does not begin until the foot's rolling action reaches the narrower midfoot portion.

Preferably, the width, as measured across the S-shaped line, of the locally thicker and/or harder first sole portion of the midfoot portion is smaller
5 than the width, as measured across the S-shaped line, of the locally thicker and/or harder first sole portion of the ball portion.

As a result, during running or walking, dynamic balancing or feedback-controlled rolling action of each foot is required primarily while the midfoot portion is contacting the ground.

10 In a further, even more preferred embodiment of the shoe sole, the local thickness T and/or the local hardness H of the locally thicker and/or harder first sole portion of the heel portion decreases from the medial side M towards the lateral side L of the shoe sole. Preferably, the thickness T of the heel portion decreases along the width W of the first sole portion (i.e. the
15 harder and/or thicker portion for ground-contact) of the heel portion from the medial side M towards the lateral side L by an amount ΔT such that the inclination of the ground-contact surface of the first sole portion of the heel portion, as measured with respect to a horizontal planar ground surface onto which the shoe sole is placed, has an average slope (grade) between 2% and
20 20%, where slope (grade) is defined as the ratio $\Delta T/W$ of thickness difference ΔT versus width W of the first sole portion of the heel portion. Note that this width W is the width as measured along the gradient line of the heel portion slope. In the case of a shoe sole for a typical medium-size shoe where the above-mentioned width W is around 50mm, this corresponds to a thickness
25 difference of 1mm to 10mm. Preferably, the inclined ground-contact surface of the heel portion is a planar surface or a surface at least 80% of which is planar. As a result, a wedge-shaped gap between the heel portion of the shoe sole at rest and the horizontal planar ground surface is formed.

As a result, during running or walking, when a foot lands on the
30 ground with the shoe sole contacting the ground by its heel, the decreasing local thickness T and/or local hardness H of the first sole portion of the heel

portion guides and/or forces the foot into slight supination, i.e. the weight acting on the foot is shifted from its initial neutral or substantially central position at the moment of landing toward the lateral side L of the shoe sole. Thus, the weight is guided toward the midfoot portion at the lateral side L of the shoe sole. In the above-mentioned preferred case of an inclined planar ground-contact surface, during the guiding action of the heel portion, the wedge-shaped gap between the heel portion and the planar ground surface is closed.

Thus, these conditions of the heel portion of the shoe sole have an effect similar to a substantially straight, but tilted road surface with one road side being higher than the other road side. Using these terms, after the foot's landing at the beginning of the rolling action along the substantially S-shaped line, the foot undergoes a slight tilt towards the lateral side L, and is smoothly guided into the narrow midfoot portion which extends close to and along the lateral side L of the shoe sole.

In a further preferred embodiment, the shoe sole, comprising in rear-end-to-front-end sequence the heel portion, the midfoot portion, the ball portion or metatarsal portion and the forefoot portion or toe portion at the bottom side of the shoe sole base body as defined above, has a special transverse thickness and/or hardness profile in the ball portion. In the ball portion or metatarsal portion, the region of the shoe sole associated with or underneath the second metatarsal bone (M2) has a lesser thickness and/or lesser hardness than the region of the shoe sole associated with or underneath any of the first, third, fourth and fifth metatarsal bones. In addition, the same condition may apply to at least a part of the forefoot portion or toe portion of the shoe sole adjacent to the ball portion, i.e. the region of the shoe sole associated with or underneath the second toe (T2) has a lesser thickness and/or lesser hardness than the region of the shoe sole associated with or underneath any of the first, third, fourth and fifth toes. Preferably, this applies to the part of the forefoot or toe portion adjacent to the ball portion. This concave ("cantilever") and/or soft region in the M2 part of the ball portion and optionally in the T2 part of the adjoining forefoot portion provides some pressure relief for the second metatarsal bone.

In summary, it should be noted that the amount of local support, i.e. the local support forces acting from below on the sole of a foot wearing the shoe sole according to the invention, is determined by the overall thickness and/or hardness profile of the shoe sole. At least the base body and the
5 ground-contact portions connected with the base body contribute with their local hardnesses and local geometries, for instance local thickness distribution and distribution of possible slits, to the resulting amount of local support. In addition, the lower and/or upper insole portions may be provided, with their additional contribution to the resulting amount of local support. The ground-
10 contact portions (heel, midfoot, ball and forefoot portions) and the optional insole portions (lower and/or upper insole portion) of the shoe sole all contribute to the protrusion and/or hard core region extending along the substantially S-shaped line.

The invention will be better understood and additional features of the
15 invention will become apparent to those skilled in the art when read in conjunction with the accompanying drawings showing a preferred embodiment of the shoe sole according to the invention.

Fig. 1 is a side view showing the medial side of the embodiment of the shoe sole according to the invention.

20 Fig. 2 is a side view showing the lateral side of the embodiment of the shoe sole according to the invention.

Fig. 3 is a bottom view showing the ground-contact region of the embodiment of the shoe sole according to the invention.

25 Fig. 4 is a top view showing the foot-contacting region of the embodiment of the shoe sole according to the invention.

Fig. 5 is a perspective bottom view of a first component (base body) of the embodiment of the shoe sole according to the invention.

Fig. 6 is a bottom view of a second component (ground-contact portions) of the embodiment of the shoe sole according to the invention.

Fig. 7 is a top view of the first component (base body) of the embodiment of the shoe sole according to the invention.

5 Fig. 8 is a top view of a third or fourth component (lower or upper insole) of the embodiment of the shoe sole according to the invention.

Fig. 9A is a first preferred cross section along plane M-L of Fig. 3 or Fig. 4, viewed in direction a) of Fig. 3 or Fig. 4, of the embodiment of the shoe sole according to the invention.

10 Fig. 9B is a second preferred cross section along plane M-L of Fig. 3 or Fig. 4, viewed in direction a) of Fig. 3 or Fig. 4, of the embodiment of the shoe sole according to the invention.

Fig. 9C is a third preferred cross section along plane M-L of Fig. 3 or Fig. 4, viewed in direction a) of Fig. 3 or Fig. 4, of the embodiment of the shoe sole according to the invention.

Fig. 10A is a first preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

Fig. 10B is a second preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

Fig. 10C is a third preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

Fig. 10D is a fourth preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

Fig. 10E is a fifth preferred thickness profile or hardness profile
5 along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

Fig. 10F is a sixth preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

10 Fig. 10G is a seventh preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

Fig. 10H is an eighth preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole
15 according to the invention.

Fig. 10I is a ninth preferred thickness profile or hardness profile along plane M-L of Fig. 3 or Fig. 4 of the embodiment of the shoe sole according to the invention.

In Fig. 1 and in Fig. 2, the medial side (side of the arch of the foot)
20 and the lateral side, respectively, of a right foot shoe sole 1 according to the invention is shown together with a right foot last 2. The shoe sole 1 comprises in rear-end-to-front-end sequence a heel portion 3, a midfoot portion 4, a ball portion 5 and a forefoot portion 6 at the bottom side of a shoe sole base body 7 which can be better seen in Fig. 5 (perspective bottom view) and in Fig. 7 (top
25 view). Also, a slope region 7c and an upper edge 7e of the base body 7 are shown. The slope region 7c of the base body 7 constitutes a transition region between a relatively narrow ground-contact region defined by the bottom surfaces of the heel portion 3, the midfoot portion 4, the ball portion 5 and the forefoot portion 6 of the shoe sole 1, as best seen in Fig. 3, and a much

broader foot-contacting region defined by the foot-contacting surfaces of an upper side 7f and an upper insole 8 of an upper foot-contact plateau of the shoe sole 1, as best seen in Fig. 4. The forefoot portion 6 comprises a front joining portion 66 extending in an upward direction for partially covering the front portion of the base body 7 and joining some toe portions 61, 62, 63, 64 and 65 (Figs. 3 and 6).

In Fig. 3, a bottom view of the ground-contact region of the shoe sole 1 according to the invention is shown. The ground-contact region defined by the bottom surfaces of the heel portion 3, the midfoot portion 4, the ball portion 5 and the forefoot portion 6 of the shoe sole 1 includes a substantially S-shaped line G of optimal ground contact during walking or running. This line G starts at the heel portion 3, passes along the midfoot portion 4 and ball portion 5 and ends at the forefoot portion 6. Typically, line G has one inflection point P_i somewhere in the ball portion 5. More specifically, the forefoot portion 6 of the shoe sole 1 comprises a big toe portion 61, a second toe portion 62, a third toe portion 63, a fourth toe portion 64 and a fifth toe portion 65. All or some portions 3, 4, 5, 61, 62, 63, 64, 65 of the ground-contact region are connected to the base body 7 and at least partially surrounded or "framed" by a lower edge 7b of the base body 7. Both on the medial side and on the lateral side of the ground-contact region, the slope region 7c extends from the lower edge 7b towards the much broader foot-contacting region of the upper foot-contact plateau of the shoe sole 1. On the medial side M, this slope region 7c extends from the lower edge 7b to a lower side 7d of the upper foot-contact plateau. On the lateral side L, this slope region 7c extends from the lower edge 7b to a step region 7d'. On the lateral side L, the slope 7c is steeper than on the medial side M. The arch region of the shoe sole comprises this step region 7d' and the rest of the lower side 7d of the upper foot-contact plateau. In this step region 7d', the shoe sole 1 is thicker than in the rest of the lower side 7d on the medial side M and the lateral side L. The extra thickness of step region 7d' gives the base body 7 of the shoe sole 1 more stability.

In Fig. 4, a top view of the foot-contacting region of the embodiment of the shoe sole 1 according to the invention is shown. The foot-contacting region defined by the foot-contacting surfaces of the upper side 7f and the

upper insole 8 of the upper foot-contact plateau of the shoe sole 1 again includes the substantially S-shaped line G of optimal ground contact during walking or running. The upper insole 8 is shaped such that it extends both on the medial side M and on the lateral side L of line G which starts from the heel portion 3 and extends all the way to the forefoot portion 6 typically with one inflection point P_i somewhere in the ball portion 5. The foot-contacting region defined by the upper side 7f and the upper insole 8 is surrounded or “framed” by the upper edge 7e. The upper insole 8 is located in a complementary recess in the upper foot-contacting surface.

In summary, the preferred embodiment of the shoe sole 1 shown in Figs. 1, 2, 3 and 4 comprises: first, the base body 7 (Fig. 5, Fig. 7); second, the ground-contact region located at the bottom side of the base body 7 and defined by the bottom surfaces of the heel portion 3, the midfoot portion 4, the ball portion 5 and the forefoot portion 6 (Fig. 6); and the upper insole 8 located in a recess in the foot-contacting region (Fig. 8). In addition, a lower insole (not shown), preferably having the same shape as the upper insole 8, may be inserted between the base body 7 and the ground-contact region.

In Fig. 5, a perspective bottom view of the base body 7 of the shoe sole 1 according to the invention is shown. Some of the portions of the base body 7 already shown and described in Figs 1, 2 and 3 can be better seen in Fig. 5. The bottom side of the base body 7 has formations that are complementary to the contour of the ground-contact region defined by the heel portion 3, the midfoot portion 4, the ball portion 5 and the forefoot portion 6 shown in Fig. 6. More specifically, the base body 7 has a lower recessed surface 7a surrounded or “framed” by the lower edge 7b. The main portion 7a of the lower recessed surface has the same contour as the recess in the upper foot-contacting surface for receiving a lower insole having the same contour as the upper insole 8. The lower insole (not shown) and the upper insole 8, best seen in Figs. 4 and 8, may be of identical shape, i.e. same contour and same thickness, and may be made from the same material which is preferably harder than the material of the base body 7. The smaller portions 7a1, 7a2, 7a3, 7a4 and 7a5 of the lower recessed surface of the base body 7 correspond to the forefoot portion 6 of the shoe sole 1 and are separated by lower edge portions

7b of the base body 7. The contours of these smaller portions 7a1, 7a2, 7a3, 7a4 and 7a5 are complementary to the contours of the toe portions 61, 62, 63, 64 and 65, respectively. Thus, the heel portion 3, the midfoot portion 4 and the ball portion 5 may be received in the main portion 7a of the lower recessed surface, and the toe portions 61, 62, 63, 64 and 65 of the forefoot portion 6 may be received in the smaller portions 7a1, 7a2, 7a3, 7a4 and 7a5 of the lower recessed surface. On the lateral side L, the slope region 7c extending from the lower edge 7b to the lower side 7d of the upper foot-contact plateau also extends in the longitudinal direction from the smaller portion 7a5 of the lower recessed surface 7a to the heel portion 3. On the medial side L, the slope region 7c extending from the lower edge 7b to a step region 7d' also extends in the longitudinal direction from the ball portion 5 to the heel portion 3. On the lateral side L, the slope 7c is steeper than on the medial side L where the arch of the foot is located.

In Fig. 6, a bottom view of the ground-contact portions 3, 4, 5, 6 of the shoe sole 1 according to the invention is shown. In the transverse direction towards the lateral side L, the heel portion 3, the midfoot portion 4, the ball portion 5 and the forefoot portion 6 all extend almost all the way to the lateral (L) outer contour line of the shoe sole 1, i.e. to the lateral (L) outer contour line of the base body 7. In the transverse direction towards the medial side M, only the rear part of the heel portion 3, the front part of the ball portion 5 and the entire forefoot portion 6 extend almost all the way to the medial (M) outer contour line of the shoe sole 1, i.e. to the medial (M) outer contour line of the base body 7, whereas the mid and front parts of the heel portion 3, the entire midfoot portion 4 and the rear part of the ball portion 5 extend only about half way to the medial (M) outer contour line of the shoe sole 1, i.e. to the medial (M) outer contour line of the base body 7. In the forefoot portion 6, the big toe portion 61, second toe portion 62, third toe portion 63, fourth toe portion 64 and fifth toe portion 65 are separated from each other by slits corresponding to the pattern of the lower edge 7b. In the front part of the forefoot portion 6, the individual toe portions 61, 62, 63, 64, 65 are joined by a joining portion 66. During assembly (e.g. by gluing or welding), the ground-contact portions 3, 4, 5, 6 are inserted into the lower recessed surface 7a. More specifically, the ground-contact portions 3, 4, 5 are inserted into the main portion 7a of the

lower recessed surface, and the ground-contact toe portions 61, 62, 63, 64 and 65 are inserted into the smaller portions 7a1, 7a2, 7a3, 7a4 and 7a5, respectively, of the lower recessed surface.

5 In Fig. 7, a top view of the base body 7 of the shoe sole 1 according to the invention is shown. The upper side 7f has an upper recessed surface 7g for receiving the upper insole 8. Also, the upper edge 7e surrounding the entire upper side 7f and the joining portion 66 of the forefoot-portion 6 extends in an upward direction at the front end of the base body 7 for partially covering the front portion of the base body 7.

10 In Fig. 8, a top view of the lower or upper insole 8 of the shoe sole 1 according to the invention is shown. The lower and upper insole have the same contour, but may consist of different materials and/or have different thicknesses. Preferably, the lower insole 8 and/or the upper insole (not shown) have a thickness profile in the transverse direction, i.e. in a direction extending
15 orthogonally to the substantially S-shaped line of optimal ground contact. In addition, the lower insole 8 and/or the upper insole (not shown) have slits extending in the transverse direction or in a direction orthogonal to the substantially S-shaped line of optimal ground contact.

In summary, the overall transverse thickness profiles and/or
20 hardness profiles of the shoe sole 1 according to the invention, i.e. the thickness profiles and/or hardness profiles in a cross-sectional plane extending in a direction orthogonal to or normal to the substantially S-shaped line G can be determined by the transverse thickness profile(s) and/or hardness profile(s) of the base body 7, by the transverse thickness profile(s) and/or hardness
25 profile(s) of each of the ground-contact portions 3, 4, 5, 6 and by the transverse thickness profile(s) and/or hardness profile(s) of the upper insole 8 and optionally by the transverse thickness profile(s) and/or hardness profile(s) of the lower insole (not shown).

Similarly, the overall longitudinal thickness profiles and/or hardness
30 profiles of the shoe sole 1 according to the invention, i.e. the thickness profiles and/or hardness profiles in a cross-sectional plane extending in a direction

parallel to or tangential to the substantially S-shaped line G can be determined by the longitudinal thickness profile(s) and/or hardness profile(s) of the base body 7, by the longitudinal thickness profile(s) and/or hardness profile(s) of each of the ground-contact portions 3, 4, 5, 6 and by the longitudinal thickness
5 profile(s) and/or hardness profile(s) of the upper insole 8 and optionally by the longitudinal thickness profile(s) and/or hardness profile(s) of the lower insole (not shown).

In addition, the overall flexibility and in particular the torsional flexibility of the shoe sole 1 according to the invention around a longitudinal
10 axis, i.e. the flexibility around an axis parallel to or tangential to the substantially S-shaped line G, can be determined by longitudinally spaced slits extending in a direction transverse to the substantially S-shaped line. These slits may be located in the base body 7, in any one or all of the ground-contact portions 3, 4, 5 and 6, in the upper insole 8 and optionally in the lower insole
15 (not shown).

In Figs. 9A, 9B and 9C, preferred midfoot portion cross sections along plane M-L of Fig. 3 or Fig. 4, viewed in direction a) of Fig. 3 or Fig. 4, of the shoe sole 1 according to the invention are shown, with points P_M and P_L along the plane M-L indicating the corresponding locations in Figs. 3 and 4 and
20 in Fig. 9A. For the sake of simplicity, any structural differences in the cross sections that would be expected to be visible in these cross sections due to a preferred composite or multi-layer structure (base body 7, ground-contact portions 3, 4, 5, 6, upper insole 8, lower insole) are not shown in these cross-sections.

25 The transverse thickness T profile (with constant hardness) of the transverse cross section shown in Fig. 9A is a transverse thickness T profile having a relatively narrow ground-contact plateau-like region 11 including the substantially S-shaped line G of optimal ground contact, and having a first slope region 12 of decreasing thickness towards the medial side M and having
30 a second slope region 13 of decreasing thickness towards the lateral side L. This is an example of a visible protrusion 11, 12, 13 extending at least along a longitudinal part of the substantially S-shaped line G.

The transverse thickness T profile of the transverse cross section shown in Fig. 9B is a transverse thickness T profile having a relatively broad and relatively thick ground-contact plateau-like region 11' including the substantially S-shaped line G of optimal ground contact, and again having a first slope region 12' of decreasing thickness towards the medial side M and again having a second slope region 13' of decreasing thickness towards the lateral side L. In addition to its transverse thickness profile of a first material, this cross section has a transverse thickness profile of a second material of lesser hardness than the hardness of the first material. This is an example of an invisible hard core region 11', 12', 13' extending at least along a longitudinal part of the substantially S-shaped line G.

The transverse hardness H profile, i.e. hardness H curve (with constant thickness), of the transverse cross section shown in Fig. 9C is a transverse hardness H profile having a relatively narrow hard-core region 11'' including the substantially S-shaped line G of optimal ground contact, and having a first slope region 12'' in the hardness curve with decreasing hardness towards the medial side M and having a second hardness slope region 13'' in the hardness curve with decreasing hardness towards the lateral side L. This is another example of an invisible hard-core region 11'', 12'', 13'' extending at least along a longitudinal part of the substantially S-shaped line G.

In Figs. 10A, 10B, 10C, 10D, 10E, 10F and 10G, preferred transverse thickness profiles (protrusions) and/or hardness profiles (hard-core regions) along plane M-L of Fig. 3 or Fig. 4 of the shoe sole 1 according to the invention are shown, again with points P_M and P_L along the plane M-L indicating the corresponding locations in Figs. 3 and 4 and in Fig. 9A. Again, for the sake of simplicity, any structural differences in the cross sections that would be expected to be visible in these cross sections due to a preferred composite or multi-layer structure (base body 7, ground-contact portions 3, 4, 5, 6, upper insole 8, lower insole) are not shown in these cross-sections.

In Fig. 10A, a trapezoidal profile is shown.

In Fig. 10B, a rectangular profile is shown.

In Fig. 10C, a curved convex profile is shown.

In Fig. 10D, a modified trapezoidal profile with a curved concave bottom line (“cantilever trapezoidal profile”) is shown.

5 In Fig. 10E, a modified rectangular profile with a curved concave bottom line (“cantilever rectangular profile”) is shown.

In Fig. 10F, a profile with a laterally tilted straight bottom line (thickness and/or hardness decreasing toward the lateral side) is shown.

In Fig. 10G, a profile with a medially tilted straight bottom line (thickness and/or hardness decreasing toward the medial side) is shown.

10 In Fig. 10H, a profile with a laterally tilted curved convex profile (thickness and/or hardness decreasing toward both sides and decreasing more toward the lateral side) is shown.

In Fig. 10I, a profile with a medially tilted curved convex profile (thickness and/or hardness decreasing toward both sides and decreasing more
15 toward the medial side) is shown.

Preferably, these profiles are used in the midfoot-portion 4. However, some of these profiles may be used in shoe sole portions other than the midfoot-portion 4, such as in the heel portion 3 or in the ball portion 5. In particular, the profile shown in Fig. 10F may be used in the heel portion 3.

20 A cantilever profile, such as the one shown in Fig. 10D or in Fig. 10E, may be provided in the the ball portion 5 and the forefoot portion 6 of the shoe sole 1. The region of the shoe sole 1 associated with the second metatarsal bone (M2) has a lesser thickness and/or lesser hardness than the region of the shoe sole associated with the other metatarsal bones. In addition,
25 at least the part of the forefoot portion 6 or toe portion of the shoe sole adjacent to the ball portion 5, i.e. the region of the shoe sole 1 associated with the second toe (T2) has a lesser thickness and/or lesser hardness than the region

of the shoe sole associated with the other toes. Preferably, this applies to the toe portion 62 of the forefoot portion 6. This design reduces pressure to the second metatarsal (M2) and provides some relief for the joint between the second metatarsal (M2) and the second toe (T2) during walking.

- 5 In addition, the following conditions may apply to the transverse thickness and/or hardness profile of the ball portion 5 having a first metatarsal part M1, a second metatarsal part M2, a third metatarsal part M3, a fourth metatarsal part M4 and a fifth metatarsal part M5 between the medial side M and lateral side L of the shoe sole 1:
- 10 a) The thickness and/or hardness of M2 is less than the thickness and/or hardness of any of M1, M2, M3 and M4, preferably with M1, M3, M4 and M5 all having the same thickness and/or hardness.
 ("M2 < M1, M3, M4, M5 and preferably M1 = M3 = M4 = M5")
- 15 b) The thickness and/or hardness of M1 is greater than the thickness and/or hardness of M2, with M3, M4 and M5 all having a thickness and/or hardness in between the thickness and/or hardness of M1 and M2.
 ("M2 < M3, M4, M5 < M1")
- 20 c) The thickness and/or hardness of M1 is greater than the thickness and/or hardness of M2, with M3, M4 and M5 all having a thickness and/or hardness greater than the thickness and/or hardness of M1.
 ("M2 < M1 < M3, M4, M5")
- 25 d) The thickness and/or hardness of M1 is greater than the thickness and/or hardness of M2, with M3 having a thickness and/or hardness greater than the thickness and/or hardness of M4 and M4 having a thickness and/or hardness greater than the thickness and/or hardness of M5.
 ("M2 < M1 and M3 > M4 > M5")
- 30 e) The thickness and/or hardness of M1 is greater than the thickness and/or hardness of M2, with M3 having a thickness and/or hardness less than the thickness and/or hardness of M4 and M4 having a thickness and/or hardness less than the thickness and/or hardness of M5, preferably with M2 having a thickness and/or hardness less than the thickness and/or hardness of any of M3, M4 and M5. Condition e) is the most preferred condition.
 ("M2 < M1 and M3 < M4 and M4 < M5" and preferably M2 < M3, M4, M5")

Preferably the thickness and/or hardness of M1 is greater than the thickness and/or hardness of M5.

These conditions of the first, second, third, fourth and fifth metatarsal parts M1, M2, M3, M4 and M5 in the ball portion 5 of the shoe sole 1 cause the weight during the rolling action of the foot to be shifted from the lateral side L towards the medial side M.

More precisely, after touching ground with the heel portion 3 and the subsequent rolling action of the midfoot portion 4 on ground with the weight located on the lateral side L (dynamic balancing act), the ball portion 5 then rolls on the ground with the weight being shifted from the lateral side L of the ball portion 5 toward the medial side M of the ball portion 5, and finally the forefoot portion 6 rolls on the ground with the weight located on the medial side M. At the beginning of this shifting action within the ball portion 5, the fifth metatarsal part M5 of the ball portion 5 provides more support than the neighbouring fourth and third metatarsal parts M4 and M3 of the ball portion 5. At the end of this shifting action within the ball portion 5, the first metatarsal part M1 of the ball portion 5 provides more support than the second metatarsal part M2 of the ball portion 5. Thus, the fifth metatarsal part M5 on the lateral side L causes the foot to pronate, and the first metatarsal part M1 on the medial side M prevents excessive pronation of the foot.

In addition, similar conditions may apply to the transverse thickness and/or hardness profile of the forefoot portion 6 having a first toe part T1(=61), a second toe part T2(=62), a third toe part T3(=63), a fourth toe part T4(=64) and a fifth toe part T5(=65) between the medial side M and lateral side L of the shoe sole 1:

a) The thickness and/or hardness of T1 is greater than the thickness and/or hardness of any of T2, T3, T4 and T5, preferably with T2, T3, T4 and T5 all having the same thickness and/or hardness.

(“T1 > T2, T3, T4, T5 and preferably T2 = T3 = T4 = T5”)

b) The thickness and/or hardness of T1 is greater than the thickness and/or

hardness of T2 and the thickness and/or hardness of T2 is greater than the thickness and/or hardness of T3, and the thickness and/or hardness of T3 is greater than the thickness and/or hardness of T4, and the thickness and/or hardness of T4 is greater than the thickness and/or hardness of T5.

5 ("T1 > T2 > T3 > T4 > T5")

c) The thickness and/or hardness of T1 is less than the thickness and/or hardness of any of T2, T3, T4 and T5, preferably with T2, T3, T4 and T5 all having the same thickness and/or hardness.

10 ("T1 < T2, T3, T4, T5 and preferably T2 = T3 = T4 = T5")

d) The thickness and/or hardness of T1 is less than the thickness and/or hardness of T2, and the thickness and/or hardness of T2 is less than the thickness and/or hardness of T3, and the thickness and/or hardness of T3 is less than the thickness and/or hardness of T4, and the thickness and/or hardness of T4 is less than the thickness and/or hardness of T5.

15 ("T1 < T2 < T3 < T4 < T5")

e) The thickness and/or hardness of T1 is greater than the thickness and/or hardness of T2, with T2 having the same thickness and/or hardness as T3, and the thickness and/or hardness of T3 is less than the thickness and/or hardness of T4, with the thickness and/or hardness of T4 being equal or less than the thickness and/or hardness of T5.

20 ("T1 > T2 and T2 = T3 and T3 < T4 and T4 ≤ T5")

25 In the above transverse profiles, the transition between the thickness and/or hardness sections M1, M2, M3, M4, M5 and T1, T2, T3, T4, T5, respectively, may be a stepwise or a smooth transition.

In addition, the following conditions may apply to the transverse thickness and/or hardness profile of the heel portion 3:

30

f) The maximum width W4 and the average of all widths W4 of the locally thicker and/or harder sole portion of the midfoot portion 4 is smaller than the maximum width W3 and the average of all widths W3, respectively, of the

locally thicker and/or harder sole portion of the heel portion 3.
 ("W4 < W3").

g) The local thickness T and/or the local hardness H of the locally thicker
 5 and/or harder sole portion of the heel portion 3 decreases from the medial side
 M towards the lateral side L of the shoe sole 1, for instance as shown in Fig.
 10F. The amount of average inclination of this ground-contact surface of the
 heel portion is 2% to 20% with respect to the horizontal. The inclination of the
 ground-contact surface of the first sole portion (which corresponds to reference
 10 numerals 11, 11' and 11'' in Figs. 9A, 9B and 9C, respectively) of the heel
 portion 3 has an average or constant slope between 2% and 20%, where slope
 is defined as the ratio $\Delta T/W$ of thickness difference ΔT versus gradient line
 width W of the first sole portion of the heel portion 3. Note that this width W is
 the width as measured along the gradient line of the slope of the heel portion 3.
 15 Therefore, W may be identical to the maximum width W3, but more likely will be
 different from W3.

h) The maximum width W4 and the average of all widths W4 of the locally
 thicker and/or harder sole portion of the midfoot portion 4 is smaller than the
 20 maximum width W5 and the average of all widths W5, respectively, of the
 locally thicker and/or harder sole portion of the ball portion 5.
 ("W4 < W5")

Note that the maximum widths W3, W4 and W5 are measured along
 a direction perpendicular to the S-shaped line G in the heel portion 3, the
 25 midfoot portion 4 and the ball portion 5, respectively.

Also, note that the average of the above widths W3, W4 and W5 are
 averaged over all (typically different) widths along the S-shaped line G within
 the heel portion 3, the midfoot portion 4 and the ball portion 5, respectively.

Preferably, at least conditions f) and g) are combined in a shoe sole
 30 1 according to the invention. This will cause the foot to supinate after the heel
 portion 3 lands on the ground and provide a smooth transition from the heel
 portion 3 to the midfoot portion 4.

Most preferably, conditions e) and h) for the ball portion 5, condition f) for the heel and midfoot portions 3 and 4, and condition g) for the heel portion 3 are combined.

With these conditions combined, each foot undergoes the following
5 three phases during its rolling action on the ground:

- 1) During the first phase or forced-supination phase, the foot is forced into supination by the heel portion 3 after landing on the ground. In other words, the shoe sole 1 takes control, and provides forced guidance toward the lateral side L.
- 10 2) During the second phase or dynamic balancing phase, the foot has to be dynamically balanced on the ridge-like midfoot portion 4. In other words, the shoe sole 1 does not take control, and provides no forced guidance. The walker or runner has to rely on the pressure transmitted to the foot sole by the insole 8 and on the feedback from any slight tilt in the ankle joint, etc.
- 15 3) During the third phase or forced-pronation phase, the foot is forced into pronation by the ball portion 5. In other words, the shoe sole 1 again takes control, and provides forced guidance toward the medial side M.

Throughout the foot's rolling action on the ground, the walker or runner feels the substantially S-shaped line of optimal ground contact for
20 walking or running. In other words, there is improved proprioception due to the effect of the insole 8. Total proprioception, based on pressure provided by the insole 8 at or near the foot-contact surface of the shoe sole 1 and by the T and/or H profile of the S-shaped line at the ground-contact surface of the shoe sole 1, is most intense during the dynamic balancing phase in the midfoot
25 portion 4 where it provides feedback to the walker or runner.

Claims

1. Shoe sole (1), suitable for an article of footwear, said shoe sole comprising at its ground-contact surface in rear-end-to-front-end sequence along the sole a heel portion (3), a midfoot portion (4), a ball portion (5) and a forefoot portion (6), said heel, midfoot and ball portions each being adjacent to an arch region below the arch of a foot (2) when wearing the shoe sole (1); wherein the shoe sole comprises first sole portions (11; 11'; 11'') extending along a substantially S-shaped line (G) which starts at the heel portion (3), passes along the midfoot and ball portions (4, 5) and ends at the forefoot portion (6), and second sole portions (12, 13; 12', 13'; 12'', 13'') extending along both sides of said substantially S-shaped line (G); and wherein the local thickness T and/or the local hardness H of a first sole portion (11; 11'; 11'') is/are greater than the local thickness T and/or the local hardness H of a second sole portion (12, 13; 12', 13'; 12'', 13'') adjacent to said first sole portion, characterized in that the shoe sole (1) comprises an insole (8) fixed at the foot-contact surface or embedded underneath the foot-contact surface of the shoe sole (1), said insole (8) having a smaller width extension than the shoe sole (1) and extending along said substantially S-shaped line (G).

2. Shoe sole according to claim 1, wherein said insole (8) is made from a material having a greater hardness than the hardness of the shoe sole material surrounding said insole (8).

3. Shoe sole according to claim 1 or 2, wherein the local thickness of a first sole portion (11) is greater than the local thickness of a second sole portion (12, 13) adjacent to said first sole portion and wherein said first sole portion (11) and said second sole portion (12, 13) may have the same hardness.

4. Shoe sole according to claim 3, wherein the entire sole consists of one material having one hardness value.

5. Shoe sole according to any one of claims 1 through 4, wherein the sole comprises a protrusion (11, 12, 13) protruding from its ground-facing

bottom surface and extending at least along parts of said substantially S-shaped line.

6. Shoe sole according to claim 5, wherein said protrusion has a trapezoidal cross section (trapezoidal thickness profile) in a plane
5 perpendicular to the substantially S-shaped line and with a first trapezoid base-line defining a plateau-like region of the sole surface and with a second trapezoid base-line defining a transition region between the trapezoidal protrusion and the bulk (rest) of the sole, said second trapezoid base-line being longer than said first trapezoid base-line.

10 7. Shoe sole according to claim 6, wherein said protrusion has a rectangular cross section (rectangular thickness profile) in a plane perpendicular to the substantially S-shaped line and with a first rectangular base-line defining a plateau-like region of the sole surface and with a second rectangular base-line defining a transition region between the rectangular
15 protrusion and the bulk (rest) of the sole, said second rectangular base-line having the same length as said first rectangular base-line.

8. Shoe sole according to claim 5, wherein said protrusion has a curved convex cross section (curved convex thickness profile) in a plane perpendicular to the substantially S-shaped line and with a curved line defining
20 a bead-like or lens-like region of the sole surface and with a base-line defining a transition region between the curved convex protrusion and the bulk (rest) of the sole.

9. Shoe sole according to claim 1 or 2, wherein the local hardness of a first sole portion (11'; 11'') is greater than the local hardness of a second sole
25 portion (12', 13'; 12'', 13'') adjacent to said first sole portion and wherein said first sole portion (11'; 11'') and said second sole portion (12', 13'; 12'', 13'') may have the same thickness.

10. Shoe sole according to claim 9, wherein the entire sole has substantially the same thickness.

11. Shoe sole according to any one of claims 1, 2, 9 or 10, wherein the sole comprises a hard region (11'') having greater hardness than surrounding soft regions (12'', 13'') of the sole and extending at least along parts of said substantially S-shaped line.

5 12. Shoe sole according to claim 11, wherein said hard region has a trapezoidal hardness profile in a plane perpendicular to the substantially S-shaped line defining a maximum hardness core region and defining a decreasing hardness transition region on each side of said core region, where the hardness decreases from said maximum hardness to a lesser hardness of
10 said soft regions.

13. Shoe sole according to claim 12, wherein said hard region has a rectangular hardness profile in a plane perpendicular to the substantially S-shaped line defining a maximum hardness core region and defining a region having the lesser hardness of said soft regions on each side of said core
15 region.

14. Shoe sole according to claim 11, wherein said hard region has a curved convex hardness profile in a plane perpendicular to the substantially S-shaped line defining a hardness maximum and defining a decreasing hardness transition region on each side of said hardness maximum, where the hardness
20 decreases from said hardness maximum to a lesser hardness of said soft regions.

15. Shoe sole according to any one of claims 1 through 14, wherein the difference in local thickness and/or in local hardness between a first sole portion and a second sole portion adjacent to said first sole portion is greatest
25 in said midfoot portion (4) extending between said heel portion (3) and said ball portion (5).

16. Shoe sole according to any one of claims 1 through 15, wherein said first sole portions (11; 11'; 11'') on said substantially S-shaped line (G) and/or said second sole portions (12, 13; 12', 13'; 12'', 13'') on both sides of
30 said substantially S-shaped line (G) comprise a plurality of slits spaced in the

longitudinal direction of the sole (1) along said substantially S-shaped line (G) and extending in a transverse direction of the sole across said substantially S-shaped line (G).

17. Shoe sole according to any one of claims 1 through 16, wherein
- 5 the ball portion (5) has a first metatarsal part (M1), a second metatarsal part (M2), a third metatarsal part (M3), a fourth metatarsal part (M4) and a fifth metatarsal part (M5) between the medial side M and lateral side L of the shoe sole (1), and wherein the following conditions apply to the transverse thickness and/or hardness profile of the ball portion (5):
- 10 - the thickness and/or hardness of the first metatarsal part (M1) is greater than the thickness and/or hardness of the second metatarsal part (M2); and
- the third metatarsal part (M3) has a thickness and/or hardness less than the thickness and/or hardness of the fourth metatarsal part (M4); and
- the fourth metatarsal part (M4) has a thickness and/or hardness less than the
- 15 thickness and/or hardness of the fifth metatarsal part (M5).

18. Shoe sole according to claim 17, wherein the second metatarsal part (M2) has a thickness and/or hardness less than the thickness and/or hardness of any of the third, the fourth and the fifth metatarsal parts (M3, M4 and M5).

- 20 19. Shoe sole according to any one of claims 1 through 18, wherein the width, as measured across said S-shaped line, of said locally thicker and/or harder first sole portion (11; 11'; 11'') of said midfoot portion (4) is smaller than the width, as measured across said S-shaped line, of said locally thicker and/or harder first sole portion (11; 11'; 11'') of said heel portion (3).

- 25 20. Shoe sole according to any one of claims 1 through 19, wherein the width, as measured across said S-shaped line, of said locally thicker and/or harder first sole portion (11; 11'; 11'') of said midfoot portion (4) is smaller than the width, as measured across said S-shaped line, of said locally thicker and/or harder first sole portion (11; 11'; 11'') of said ball portion (5).

21. Shoe sole according to any one of claims 1 through 20, wherein the local thickness T and/or the local hardness H of said locally thicker and/or harder first sole portion (11; 11'; 11'') of said heel portion (3) decreases from the medial side M towards the lateral side L of the shoe sole (1).

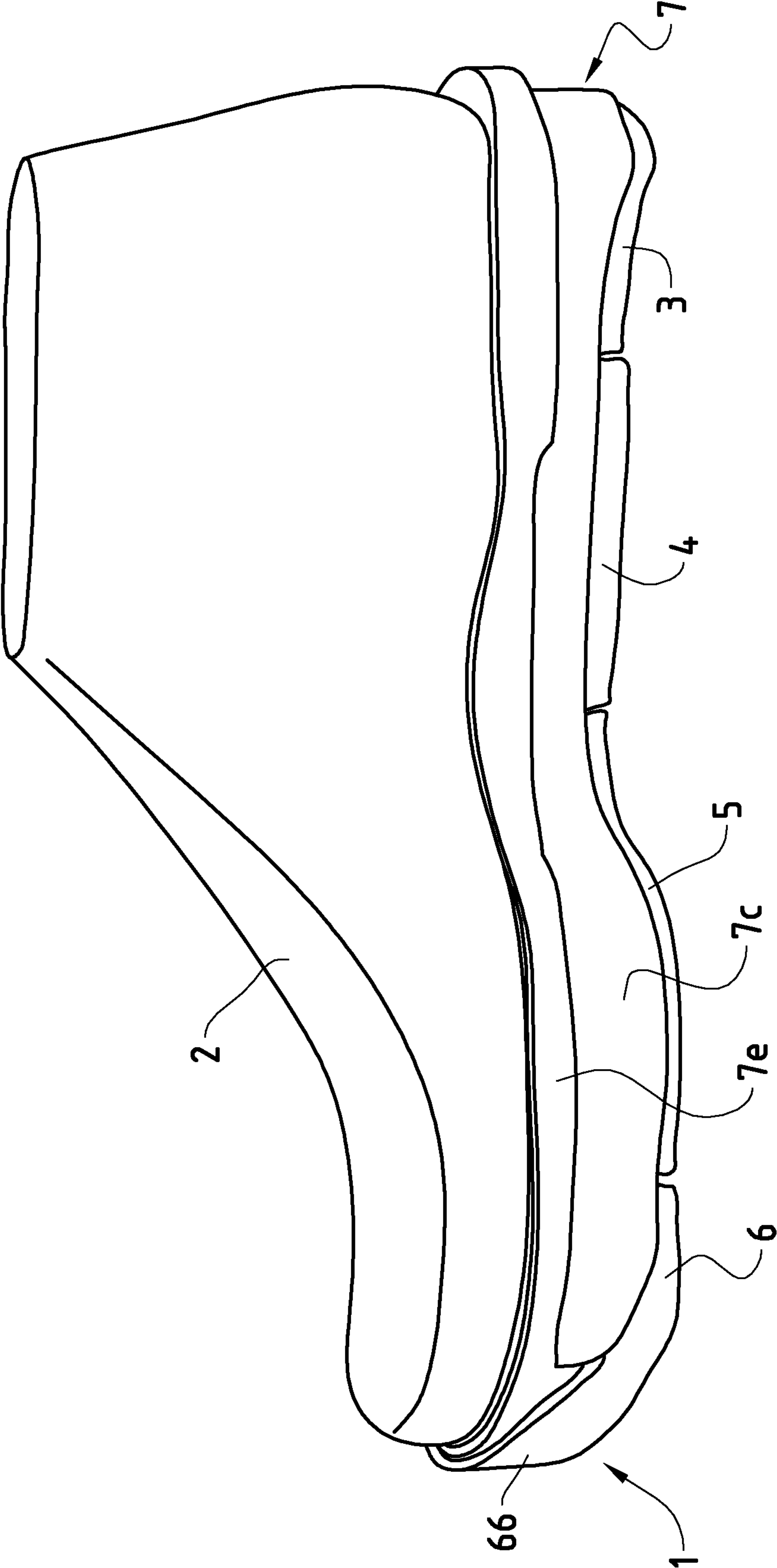


FIG. 1

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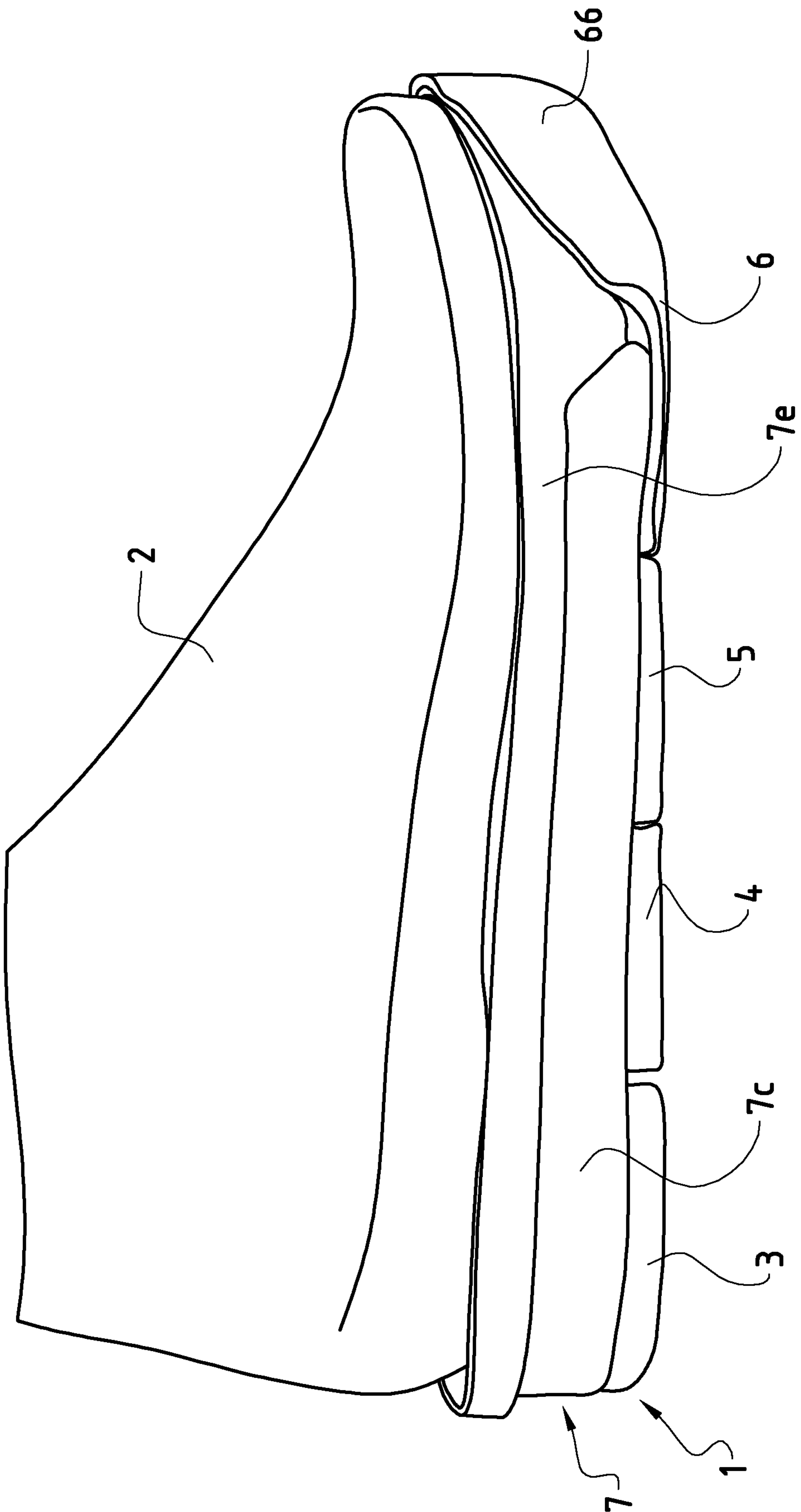


FIG. 2

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FIG. 4

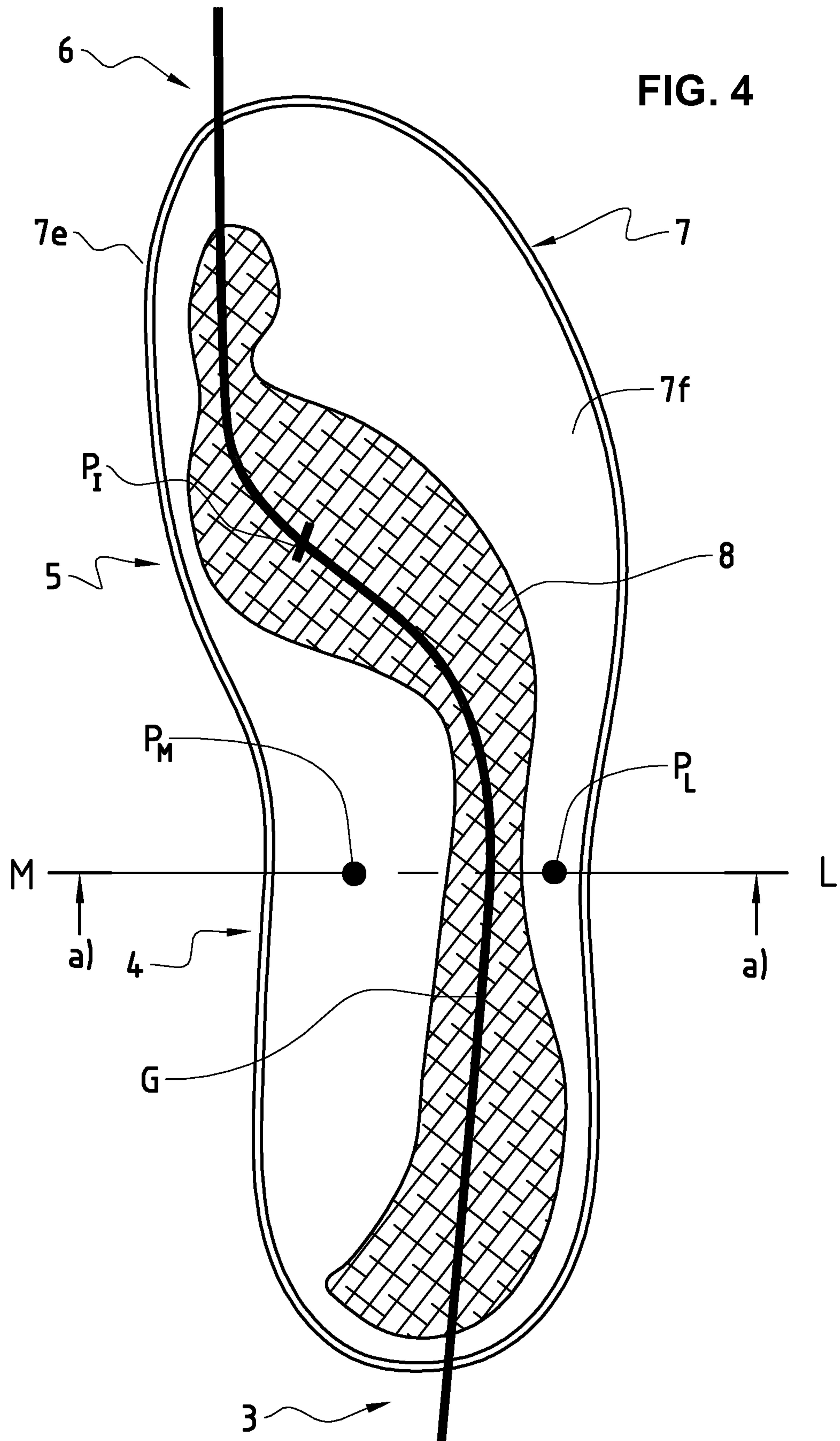
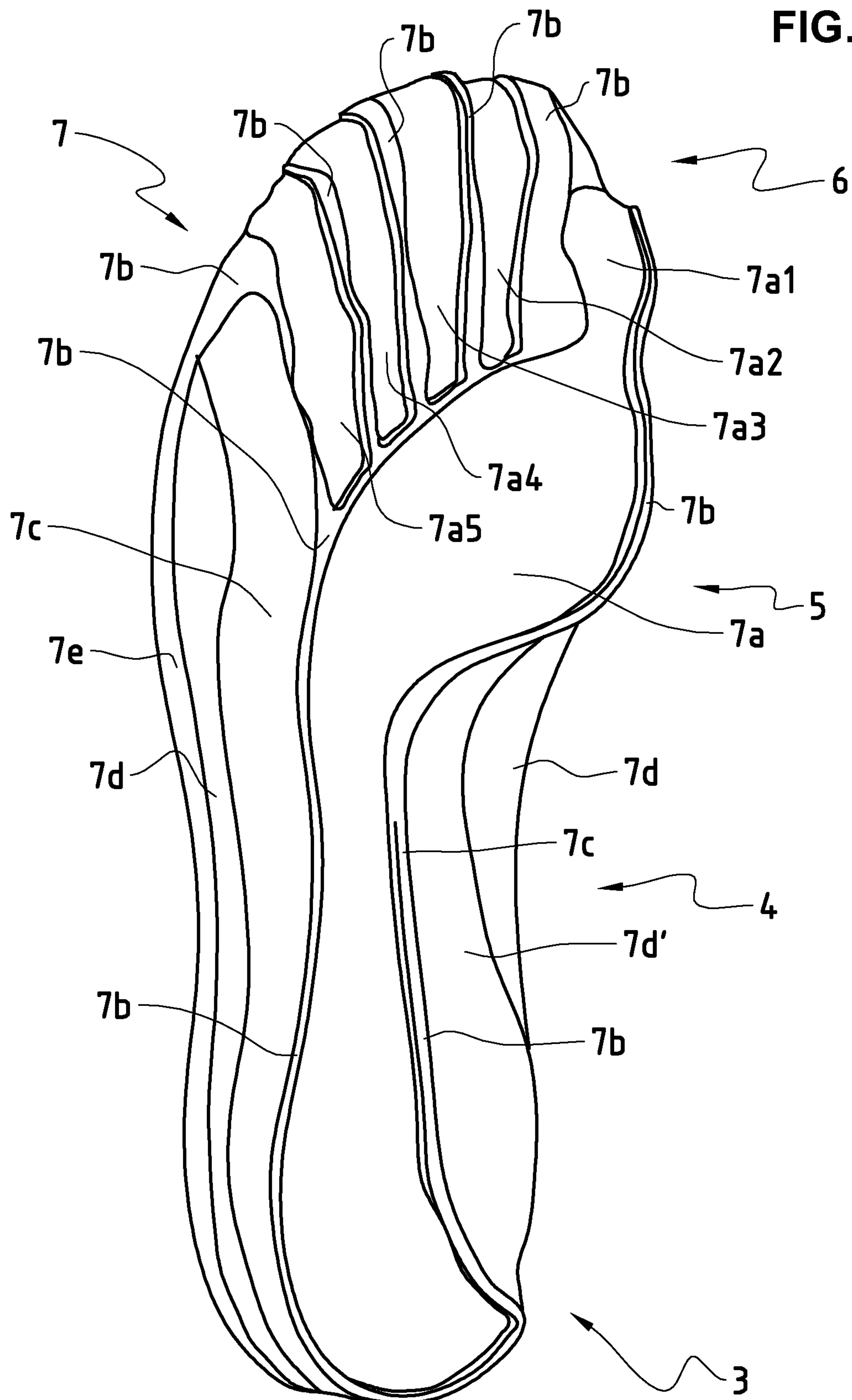
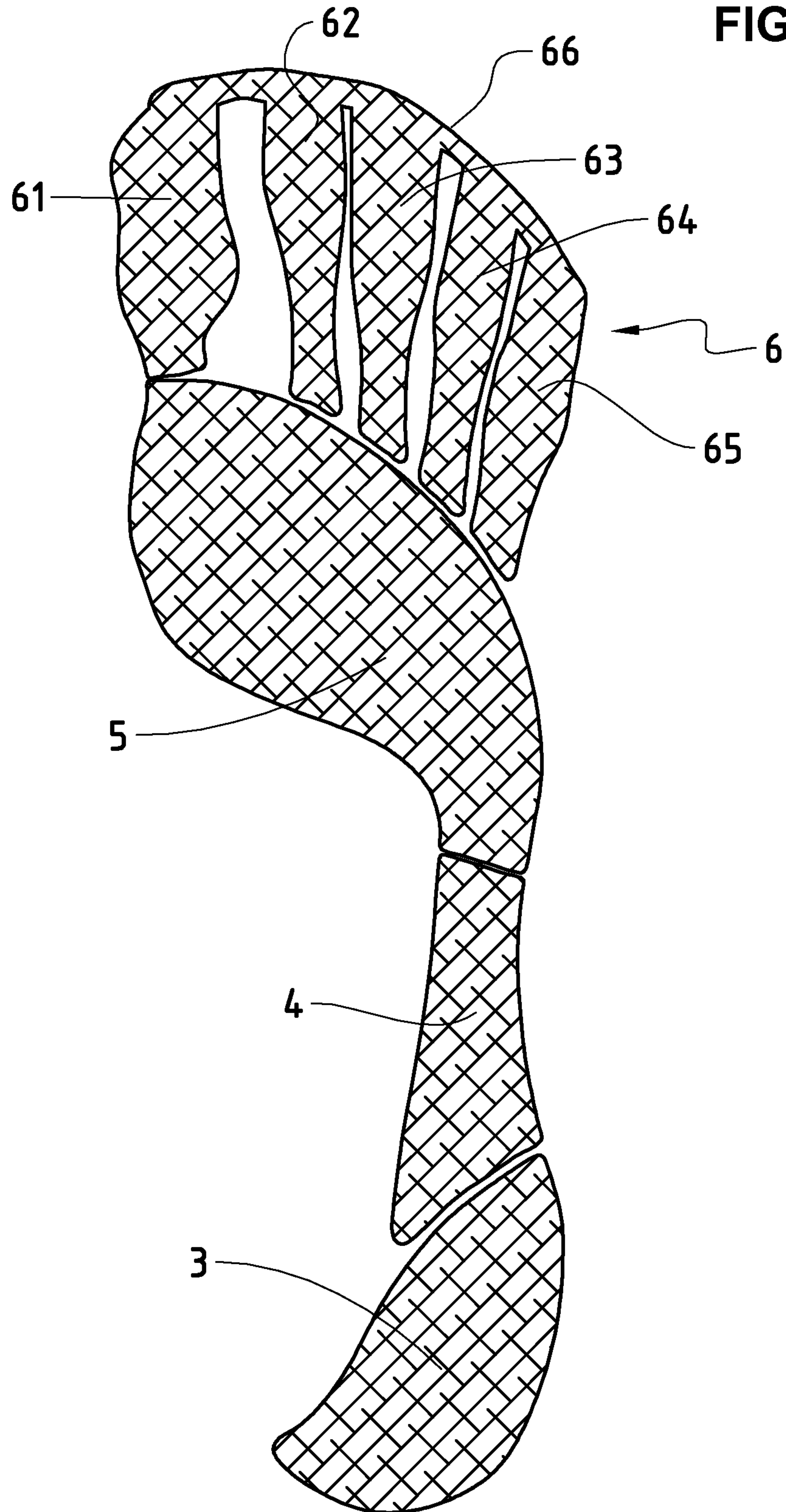


FIG. 5



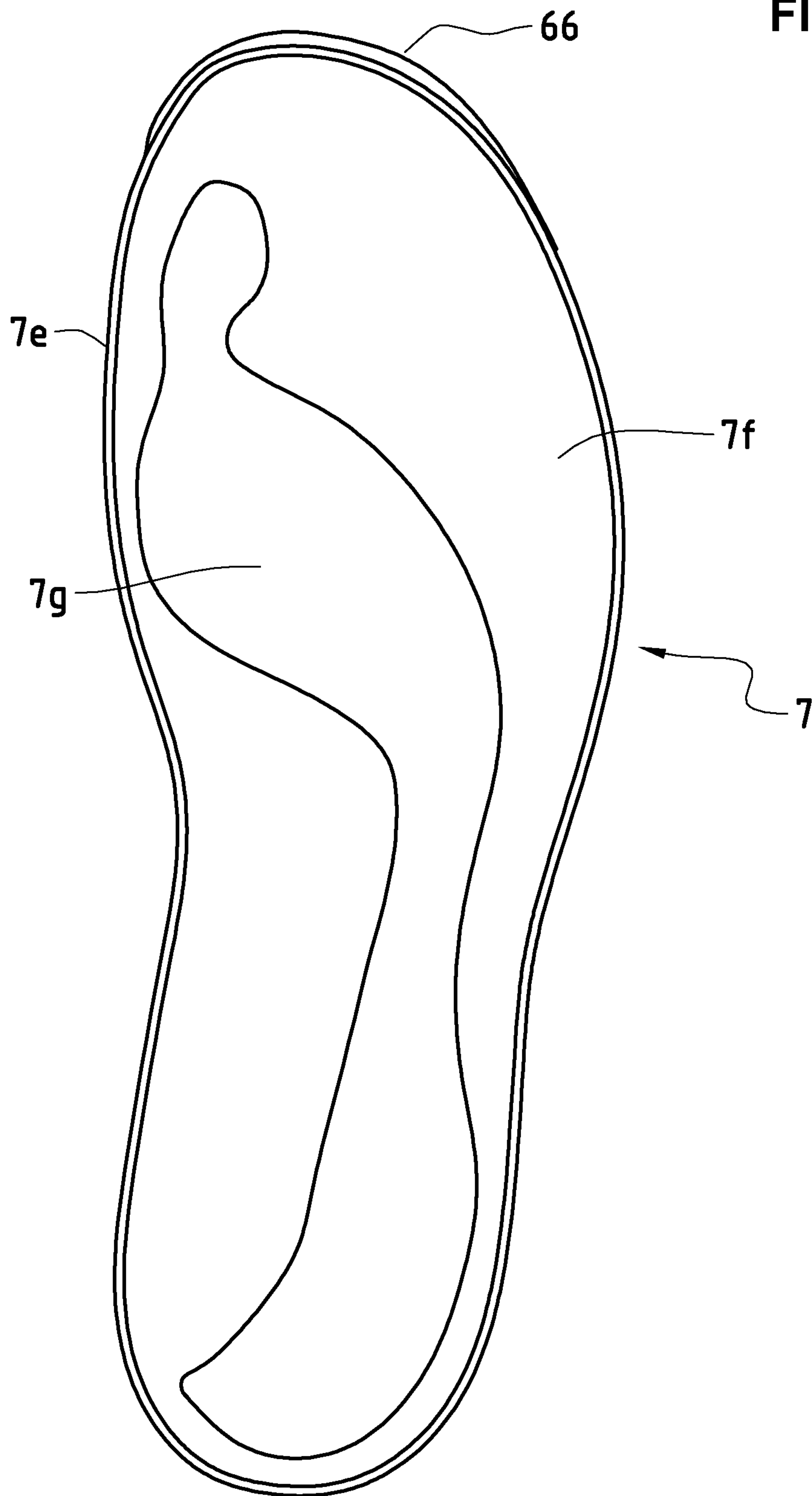
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FIG. 6



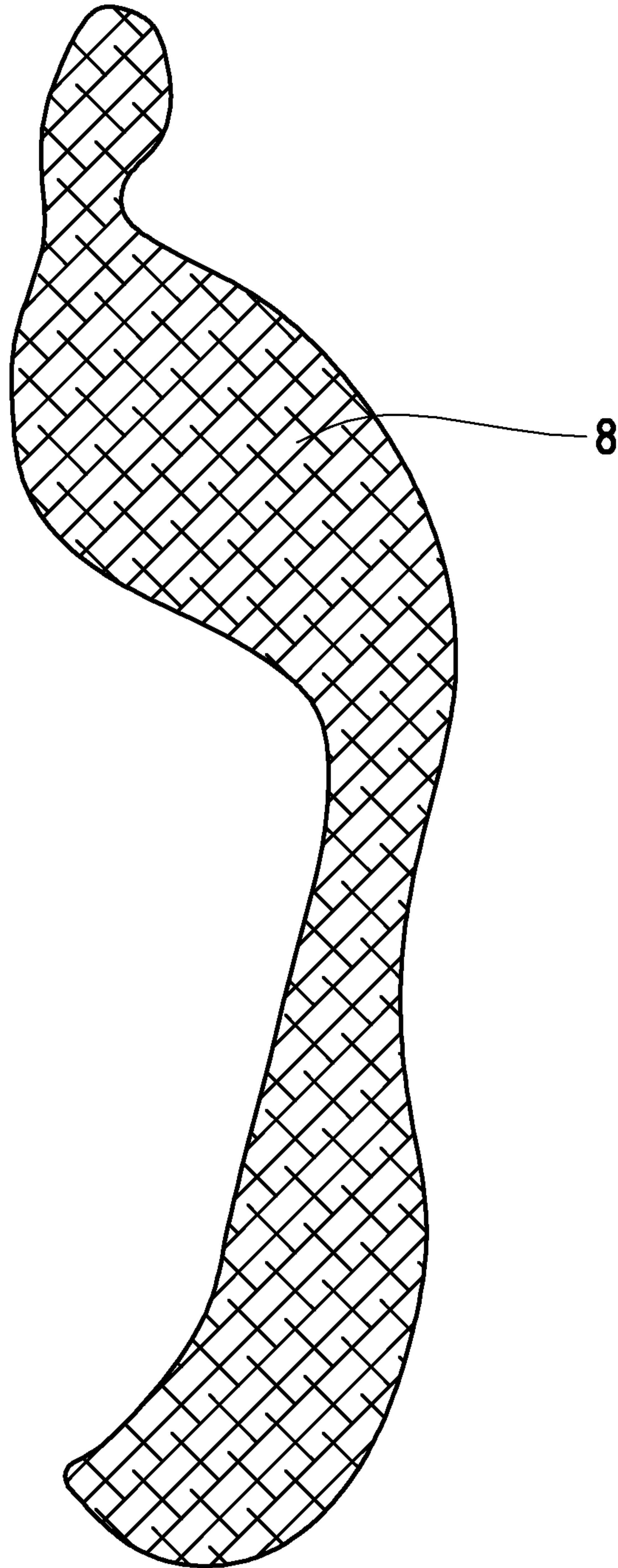
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FIG. 7

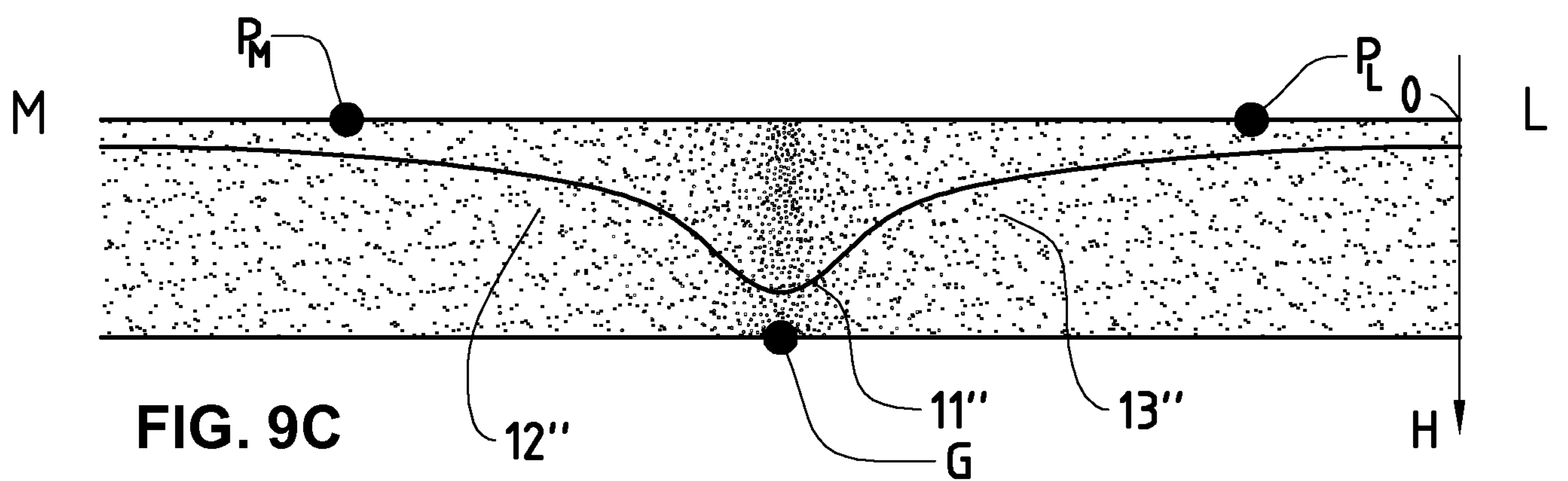
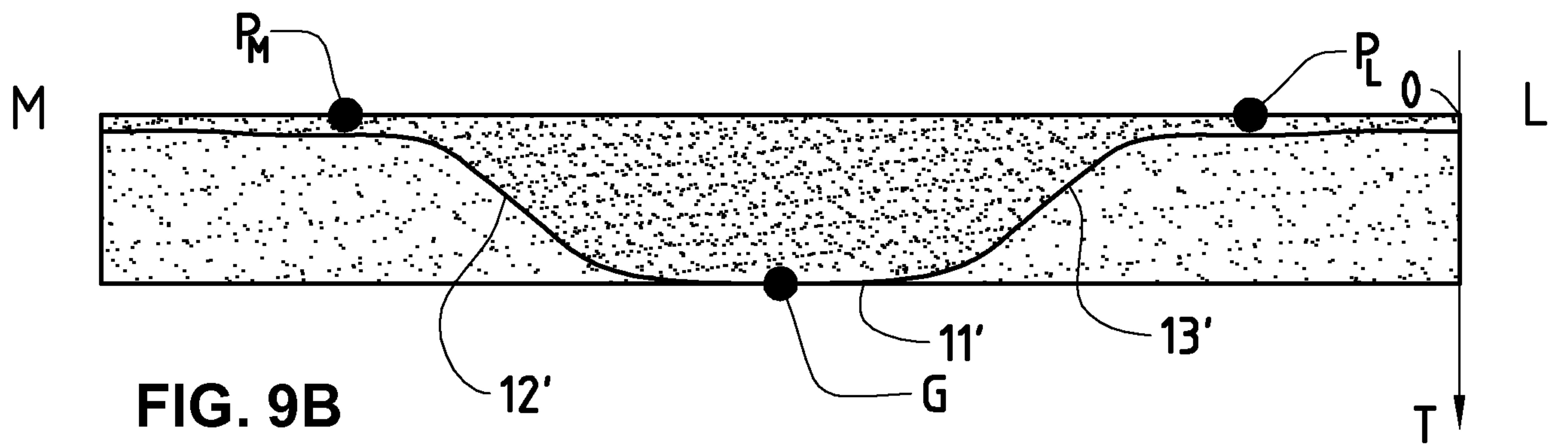
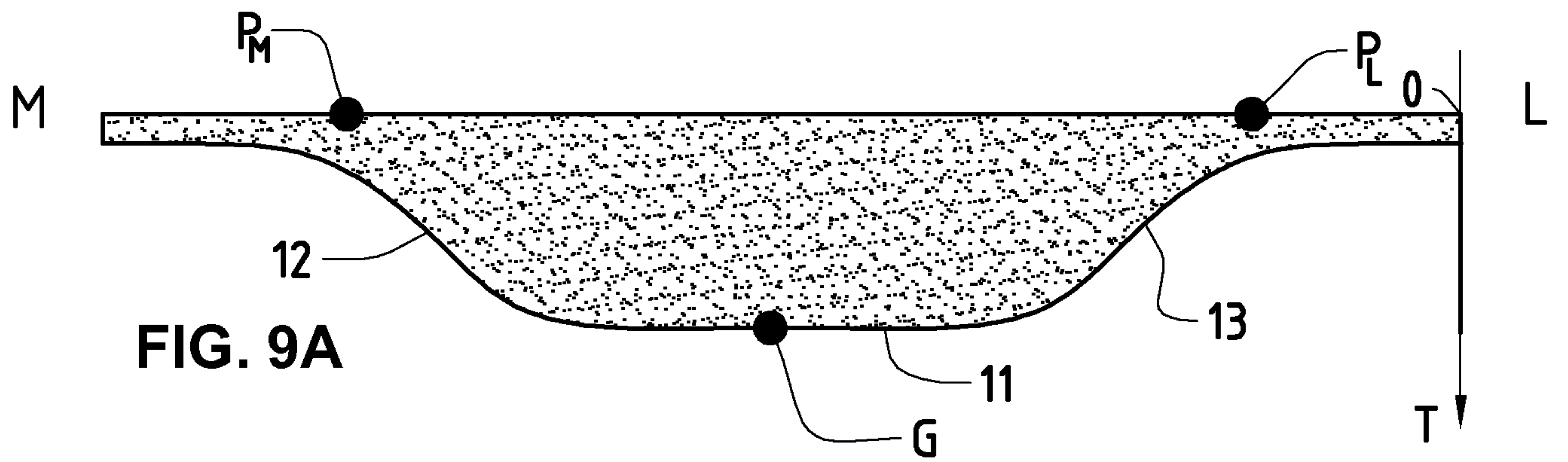


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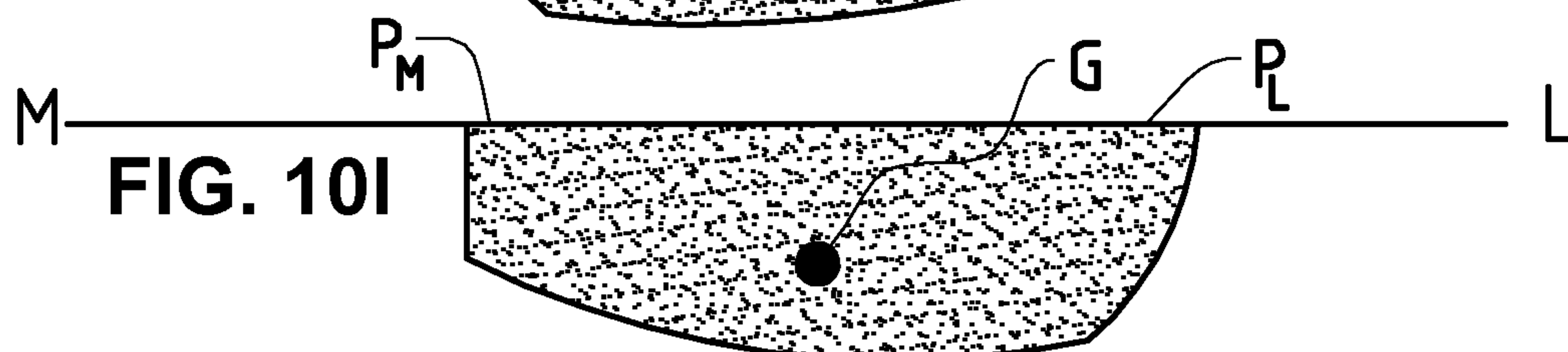
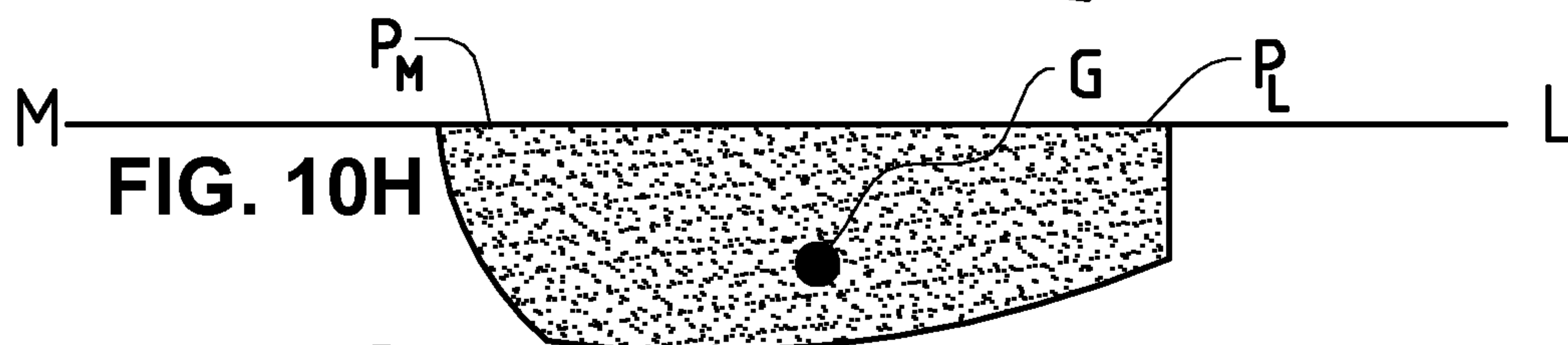
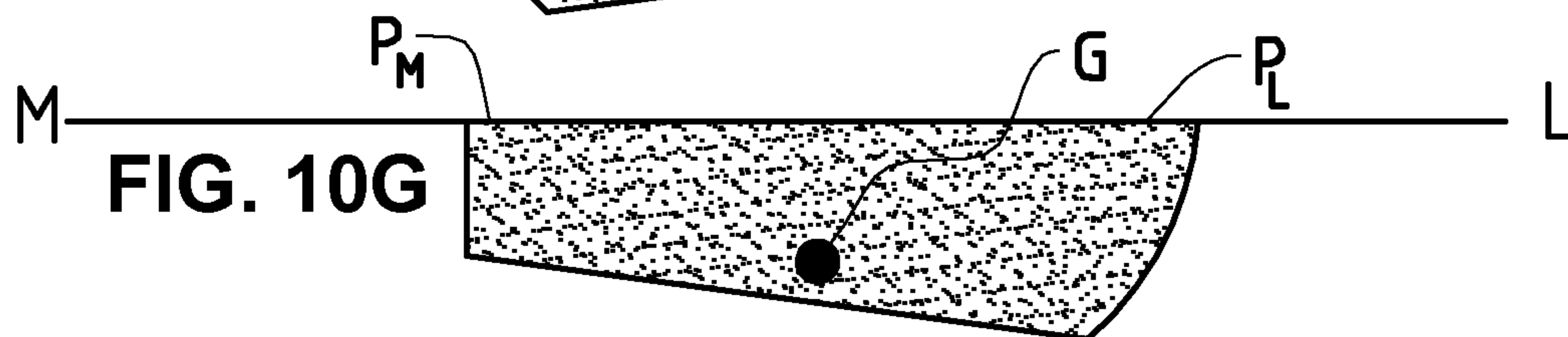
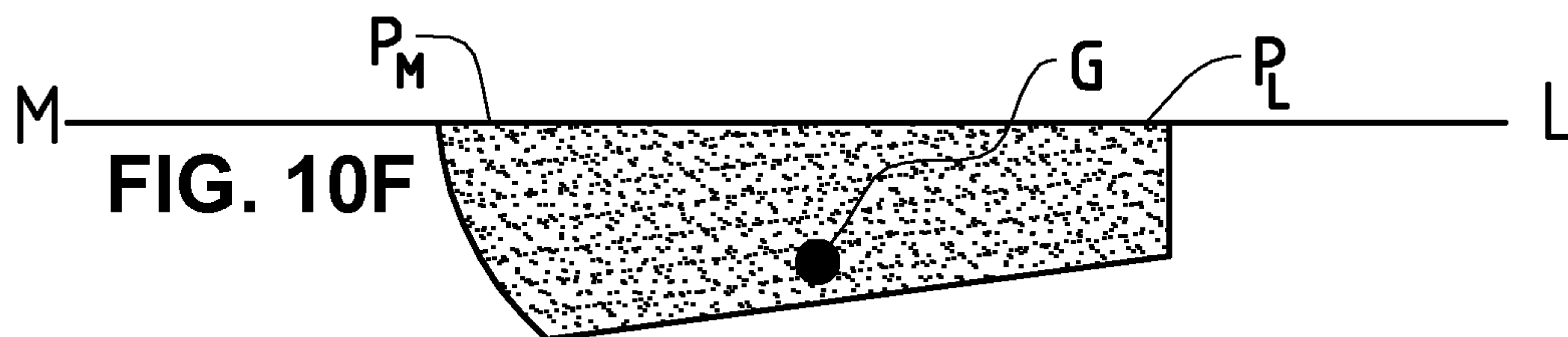
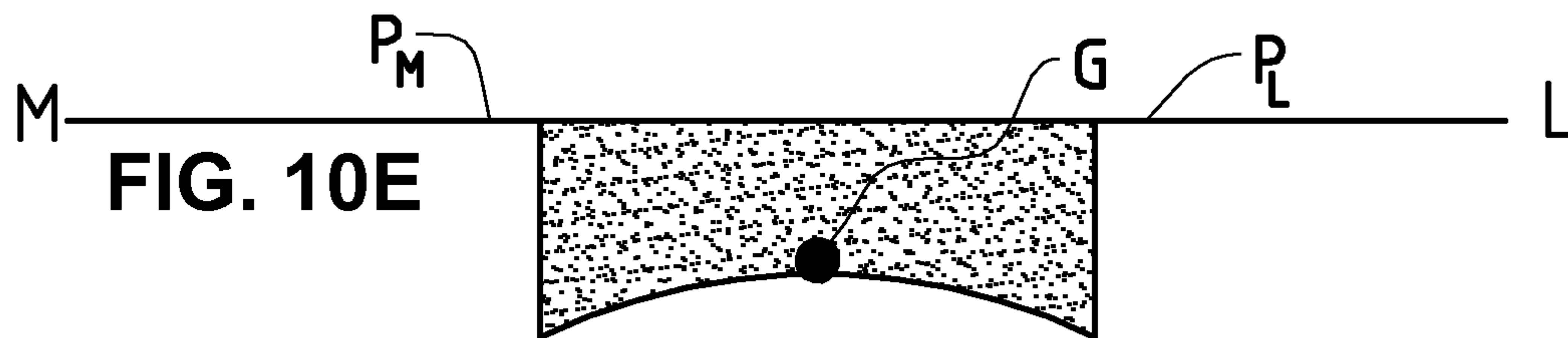
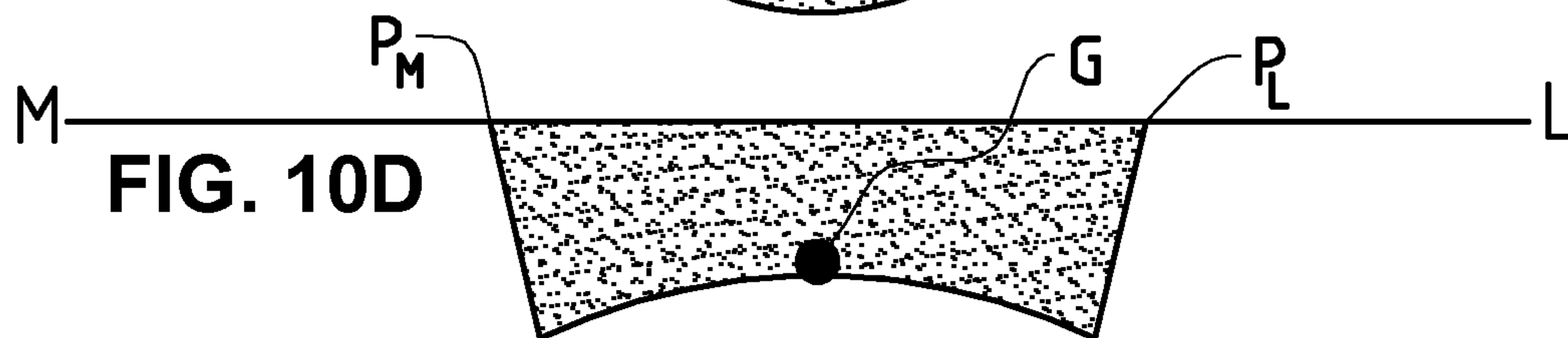
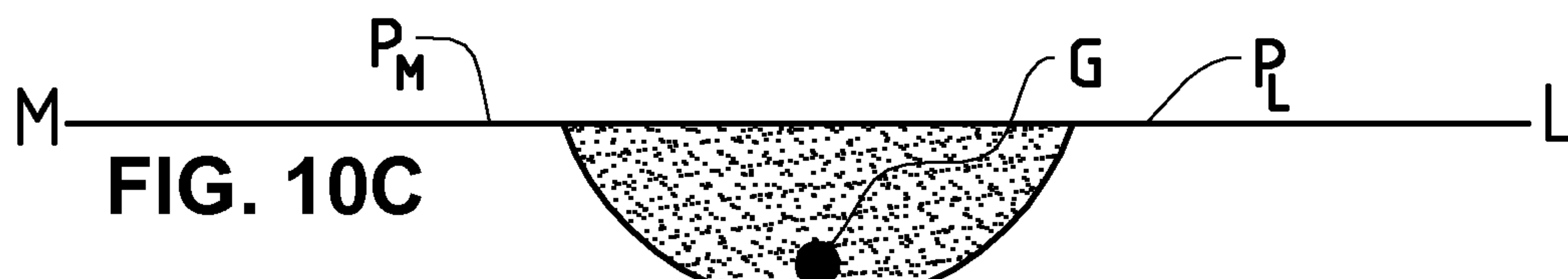
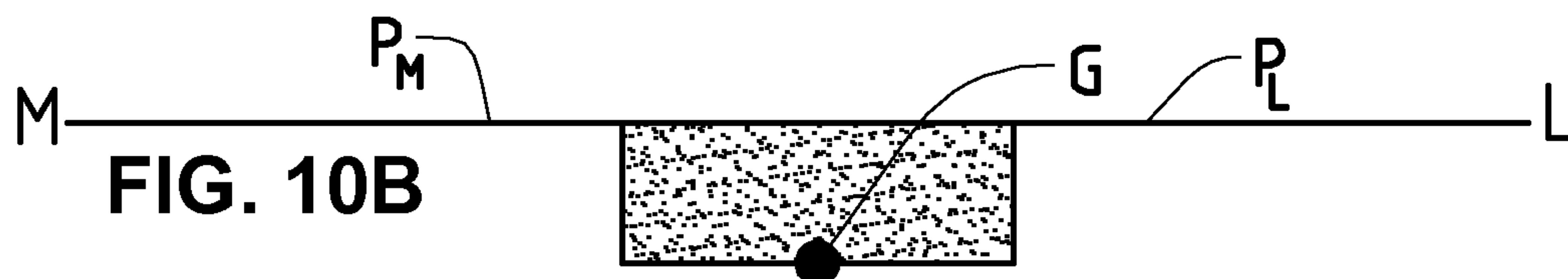
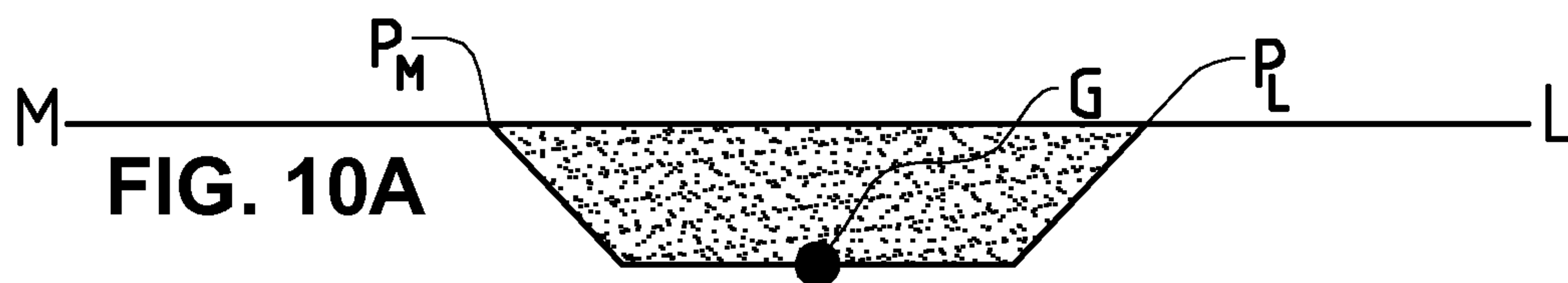
FIG. 8



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M

a)

al

7b

- 7b

7c

7c

4.

7d

G.

$$-W_4$$

W

-7

3-

W3