(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 056 105 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 153(4) EPC

(43) Date of publication:
17.08.2016 Bulletin 2016/33

(21) Application number: **13895363.3**

(22) Date of filing: **08.10.2013**

(51) Int Cl.:
A43B 13/38 *(2006.01)*

(86) International application number:
PCT/JP2013/077319

(87) International publication number:
WO 2015/052768 (16.04.2015 Gazette 2015/15)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **ASICS Corporation**
Kobe-shi, Hyogo 650-8555 (JP)

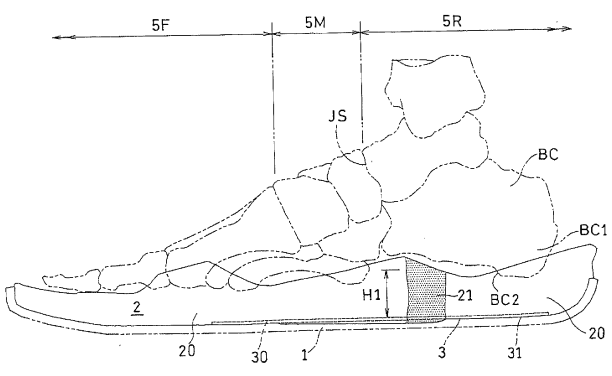
(72) Inventors:
- **SAKAMOTO, Kenji**
  Kobe-shi
  Hyogo 650-8555 (JP)
- **NAKATA, Mai**
  Kobe-shi
  Hyogo 650-8555 (JP)
- **NAKANISHI, Keizo**
  Kobe-shi
  Hyogo 650-8555 (JP)
- **KAMEUCHI, Takayuki**
  Kobe-shi
  Hyogo 650-8555 (JP)
- **TAKEI, Jun**
  Kobe-shi
  Hyogo 650-8555 (JP)

(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte Rechtsanwalt
Partnerschaft mbB
Joseph-Wild-Straße 20
81829 München (DE)

(54) EXERCISE SHOE SOLE

(57) A plate is provided located between an upper surface of the outsole and an upper surface of the mid sole and being continuous from a middle foot portion to a rear foot portion, the plate being formed by a material having a greater Young's modulus than the outsole and the mid sole, the mid sole includes: a low-hardness area provided in an area of a majority of the middle foot portion and a majority of the rear foot portion; and a high-hardness area arranged between a Chopart's joint and a rear end of a calcaneal bone, wherein where a medial side portion, a central portion and a lateral side portion are obtained by dividing the rear foot portion in three equal parts in a transverse direction perpendicular to a longitudinal axis of a foot, the high-hardness area is provided in at least a portion of the central portion and/or a portion of the lateral side portion, the high-hardness area having a greater hardness than that of the material forming the low-hardness area, wherein the plate is arranged continuously anterior to, directly below, and posterior to, the high-hardness area.

FIG 1



EP 3 056 105 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a shoe sole of an indoor shoe for handball, basketball, etc., and also to a shoe sole of an athletic shoe suitable for running outdoors or walking as an exercise.

BACKGROUND ART

[0002] For example, improvements to the cushioning property are being pursued for running, walking, etc..

[0003] In a shooting move in handball, one takes off on one foot. There is a demand for shoes allowing one to jump high on this one-foot takeoff.

CITATION LIST

PATENT LITERATURE

[0004]

First Patent Document: JP2000-083705A (Abstract)
Second Patent Document: JP2005-279020A (Abstract)
Third Patent Document: JP2003-009903A (Abstract)
Fourth Patent Document: JP2006-000311A (Abstract)
Fifth Patent Document: JP2010-538788W (Abstract)

SUMMARY OF INVENTION

[0005] FIG. **6A** is a side view schematically showing the movement of a conventional sole on the pivot foot during a jump shot in handball. Note that **1** denotes an outsole and **2** denotes a midsole.

[0006] For a one-foot jump, after the run (run-up), one transitions from heel contact **HC,** at which the rearfoot section of the pivot foot contacts the ground (the floor), to foot flat **FF,** at which the entire foot sole is in contact with the ground. In the transition from heel contact **HC** to foot flat **FF,** a brake is applied on the pivot foot, which cancels the inertia from the run.

[0007] However, the inertia from the run cannot be completely canceled out by the brake on the pivot foot, and the brake still acts on the pivot foot at heel rise, at which the heel comes off the floor from foot flat **FF.** This will result in a loss of the jumping ability.

[0008] Moreover, due to the inertia from the run, the center of gravity of the body (the gravity center of the body) will have moved anterior to the pivot foot, so that the jumping ability (power) will unlikely be fully exerted.

[0009] Another problem is that during the transition from heel contact **HC** to foot flat **FF,** one may feel an impact upon landing of the heel portion.

[0010] A first object of the present invention is to improve the cushioning property, and a second object thereof is to provide a structure of a shoe sole of an athletic shoe with which it is possible to increase the jump height in one-foot jump.

[0011] In one aspect, a shoe sole of the present invention includes:

an outsole **1** having a tread surface (a ground contact surface);
a mid sole **2** arranged above the outsole **1;** and
a plate **3** located between an upper surface of the outsole **1** and an upper surface of the mid sole **2** and being continuous from a middle foot portion **5M** to a rear foot portion **5R,** the plate **3** being formed by a material having a greater Young's modulus than Young's modulus of material of the outsole **1** and Young's modulus of material of the mid sole **2,** wherein:

the mid sole **2** includes:
a low-hardness (low hardness) area **20** provided in an area of a majority (more than half) of the middle foot portion **5M** and a majority (more than half) of the rear foot portion **5R;** and
a high-hardness (high hardness) area **21** arranged between a Chopart's joint (Chopart joint) JS and a rear end of a calcaneal bone **BC,** wherein where a medial side portion **2M,** a central portion **2C** and a lateral side portion **2L** are obtained by dividing the rear foot portion **5R** in three equal parts in a transverse direction **X** perpendicular to a longitudinal axis **CL** of a foot, the high-hardness area **21** is provided in at least a portion of the central portion **2C** and/or at least a portion of the lateral side portion **2L;**
a hardness of a foam body (foamed material) forming the high-hardness area **21** is greater than that of the low-hardness area **20;** and
the plate **3** is arranged continuously anterior to, directly below, and posterior to, the high-hardness area **21.** Herein, "between a Chopart's joint JS and a rear end of a calcaneal bone **BC"** means "between the frontmost (foremost) end of the Chopart's joint and the rear end of the calcaneal bone **BC".**

[0012] For example, in a jump shot in the game of handball, it is preferable to shoot from a position as close to the goal as possible while avoiding contact with the defense when shooting. That is, in the shot, it is preferable to brake with the pivot foot (with one foot) while running and make a one-foot jump from the takeoff position as vertically as possible. However, it is difficult to completely cancel out the inertia from the run by the brake on the pivot foot, and it is therefore inevitable that some of the inertia remains.

[0013] The deformation and the effect of the sole during a one-foot jump according to the present invention will be described with reference to drawings.

[0014] FIG. **6B** is a side view schematically showing the deformation of the sole in a one-foot jump.

[0015] In a one-foot jump, first, contact with the ground (the floor) is made starting from the lateral part of the rear end of the heel of the pivot foot. During this heel contact **HC,** the low-hardness area **20,** which is more flexible than the high-hardness area **21,** is compressed diagonally, while the high-hardness area **21** is less likely to be compressively deformed, and the rear portion of the plate **3** is inclined diagonally. The plate **3** extends from the rearfoot portion **5R,** passing under the high-hardness area **21,** which is hard, reaching the middle foot portion **5M.** Therefore, the plate **3** is bent (curved, flexurally deformed) so that the plate **3** as a whole protrudes downward to absorb the energy upon landing, and the impulse of the brake will increase. As used herein, "the impulse of the brake" means "the integral value of the force acting as the brake".

[0016] Subsequent to the heel contact **HC,** the cycle transitions to foot flat **FF** where the entire foot sole contacts the ground. During the heel contact **HC,** the plate **3** undergoes a flexural deformation, thereby compressively deforming the high-hardness area **21,** thus further increasing the apparent hardness of the high-hardness area **21.** Therefore, the plate **3** bends (curves) so as to protrude downward with the high-hardness area **21** serving as the fulcrum, but the heel portion side of the plate **3** is less likely to bend. As a result, when transitioning to the foot flat **FF,** after the exertion of the braking force in response to the heel portion contacting the ground, the entire surface of the foot sole will smoothly contact the ground.

[0017] During the foot flat **FF,** the bent plate **3** restores its original shape by being sandwiched between the foot sole and the floor surface. The restoration of the plate **3** increases the stepping force (vertical force) on the floor surface. The increase in the stepping force will contribute to the increase in the gripping force, and will increase the impulse of the brake.

[0018] The foot flat **FF** is followed by heel rise where the heel comes off the floor surface, and then the player jumps upward, with the entire foot sole coming off the floor surface.

[0019] Now, at the heel rise, if there remains a large portion of the inertia from the run, the center of gravity of the body will be located anterior to the foot, which makes it necessary to continue to apply the brake while exerting the upward jumping ability, thereby lowering the jump height.

[0020] On the other hand, at the heel rise, if the inertia from the run is small, the center of gravity of the body will be located generally directly above the foot, making it easier to exert the jumping ability. That is, according to the present invention, as described above, there is a large impulse of the brake, which will decrease the inertia from the run while transitioning from heel contact **HC** to foot flat **FF,** thereby increasing the jump height.

[0021] Another effect is that, as described above, while transitioning from heel contact **HC** to foot flat **FF,** the plate **3** is bent (curved) so as to protrude downward after the heel portion contacts the ground, bringing the outsole 1 into a rounded shape, so that the entire foot sole smoothly contacts the ground while the plate **3** functions like a leaf spring, thereby absorbing the impact at first strike by virtue of the deformation of the shoe sole including the plate **3.** Therefore, the cushioning property will also be improved when running or walking.

[0022] According to the present invention, if the high-hardness area **21** is arranged anterior to the frontmost end of the Chopart's joint or is arranged posterior to the rear end of the calcaneal bone **BC,** the amount of compressive deformation of the plate **3** or the low-hardness area **20** will likely be insufficient during heel contact **HC.**

[0023] The phrase "the plate **3** being continuous from the middle foot portion **5M** to the rear foot portion **5R"** means that the plate **3** needs to have such continuity that the deformation received by the plate **3** in the rearfoot portion **5R** is transmitted (transferred) to the middle foot portion **5M** of the plate **3.**

[0024] In another aspect of the present invention, a shoe sole includes:

an outsole **1** having a tread surface;
a mid sole **2** arranged above the outsole **1;** and
a plate **3** located between an upper surface of the outsole **1** and an upper surface of the mid sole **2** and being continuous from a middle foot portion **5M** to a rear foot portion **5R,** the plate **3** having a greater Young's modulus than those of the outsole **1** and the mid sole **2,** wherein:

the mid sole **2** includes:

an easy-to-compress area **20A** provided in an area of a majority (more than half) of the middle foot portion **5M** and a majority (more than half) of the rear foot portion **5R;** and
a hard-to-compress area **21A** arranged between a Chopart's joint JS and a rear end of a calcaneal bone **BC,** wherein where a medial side portion **2M,** a central portion **2C** and a lateral side portion **2L** are obtained by dividing the rear foot portion **5R** in three equal parts in a transverse direction **X** perpendicular to a longitudinal axis **CL** of a foot, the hard-to-compress area **21A** is provided in at least a portion of the central portion **2C** and/or at least a portion of the lateral side portion **2L,** the hard-to-compress area **21A** having a greater compressive rigidity than a material forming the easy-to-compress area **20A;** and
the plate **3** is arranged continuously anterior to, directly below, and posterior to, the hard-to-compress area **21A,** and a lower surface of the plate **3** is attached to an upper surface of the outsole **1** anterior to and posterior to the hard-to-compress area **21A.**

[0025] Also in this case, one may expect functions/ef-

fects similar to those of the first aspect described above. That is, similar effects may be obtained also when the easy-to-compress (easily compressible) area **20A** and the hard-to-compress area **21A** are formed by the plate **3,** for example, without providing different hardnesses in the midsole **2.**

[0026] However, when the low-hardness area **20** and the high-hardness area **21** are provided in the midsole **2,** it will be easier to estimate the behavior of the plate **3,** and the effects of improving the cushioning property and improving the jump height will be realized stably.

[0027] Note that the following preferred embodiments and combinations thereof can be employed also when the low-hardness area **20** is provided as the easy-to-compress area **20A** and the high-hardness area **21** as the hard-to-compress area **21A.**

BRIEF DESCRIPTION OF DRAWINGS

[0028]

FIG. **1** is a lateral side view of a shoe sole showing one embodiment of the present invention. Note that the medial side of the foot bone structure is shown in phantom line for ease of understanding of the invention.

FIG. **2** is a plan view showing a midsole according to the embodiment.

FIG. **3** is a bottom view of the midsole.

FIG. **4** is a perspective view showing the midsole as seen from a diagonally rear direction.

FIG. **5** is a perspective view showing the midsole as seen from the reverse side.

FIG. **6A** is a cycle diagram showing positions up to immediately before a jump with an ordinary athletic shoe, and FIG. **6B** is a cycle diagram showing positions up to immediately before a jump with an athletic shoe having the shoe sole of the embodiment.

FIG. **7A** and FIG. **7B** show test results.

FIG. **8** is a lateral side view of a shoe sole showing another example.

DESCRIPTION OF EMBODIMENTS

[0029] Preferably, the high-hardness area **21** is arranged between the Chopart's joint JS and a medial projection (a medial process) **BC2** of a calcaneal tuberosity **BC1;** and

the low-hardness area **20** is arranged to at least extend anterior to the Chopart's joint JS and posterior to the medial projection **BC2.**

[0030] In such a case, the high-hardness area **21** is arranged anterior to the medial projection **BC2** of the calcaneal tuberosity **BC1,** and therefore, the amount of compression of the low-hardness area **20 is** sufficiently large, and the plate **3** will be able to bend (curve) easily.

[0031] Therefore, it is possible to further increase the jump height and the cushioning property.

[0032] Preferably, the high-hardness area **21** is arranged between a front end of the calcaneal bone **BC** and a rear end of the calcaneal bone **BC;** and

the low-hardness area **20** is arranged to at least extend anterior to the front end of the calcaneal bone **BC** and posterior to the rear end of the calcaneal bone **BC.**

[0033] In such a case, the high-hardness area **21** is arranged posterior to the front end of the calcaneal bone **BC,** and awkwardness will unlikely be felt on the foot sole due to the high-hardness area **21,** which is hard.

[0034] Preferably, the high-hardness area **21** is arranged between a front end of the calcaneal bone **BC** and a medial projection **BC2** of a calcaneal tuberosity **BC1;** and

the low-hardness area **20** is arranged to at least extend anterior to the front end of the calcaneal bone **BC** and posterior to the medial projection **BC2.**

[0035] In such a case, the amount of compression of the low-hardness area **20** during heel contact **HC** is sufficiently large, and the plate **3** will be able to bend easily. Therefore, it is possible to further increase the jump height and the cushioning property.

[0036] Moreover, the high-hardness area **21** is arranged posterior to the front end of the calcaneal bone **BC,** and the awkwardness will unlikely be felt.

[0037] Preferably, an average value **W1** of a first width from a lateral end of the high-hardness area **21** to an opposite end of the high-hardness area **21** from the lateral end is set to 17% to 100% of a whole width **W** of the midsole **2** in an area where the high-hardness area **21** extends across.

[0038] If the first width **W1** is less than 17% of the whole width **W,** the jump height may not increase sufficiently. On the other hand, the first width **W1** will not be greater than the whole width **W,** and the maximum value of the first width **W1** is 100% of the whole width **W.**

[0039] However, if the high-hardness area **21,** which is hard, is provided extending over the whole width of the midsole **2,** awkwardness may be felt while running, for example.

[0040] For such reasons, the first width **W1** of the high-hardness area **21** is more preferably about 17% to 80% of the whole width **W.** Most preferably, the first width **W1** of the high-hardness area **21** is about 30% to 67% of the whole width **W.**

[0041] Preferably, an average value **H1** of a first height of the high-hardness area **21** is set to 25% to 150% of an average value **H** of a height over a whole width **W** of the midsole **2** in an area where the high-hardness area **21** is arranged.

[0042] If the average value **H1** of the first height is less than 25% of the average value **H** of height over the whole width of the midsole **2,** the jump height may not increase sufficiently.

[0043] Note that a large roll-up portion is normally provided in the rearfoot portion **5R** of the midsole **2,** and if the high-hardness area **21** is provided lopsided (positionally deviated) toward the roll-up portion, it may be about

150% of the average value **H** of height over the whole width.

[0044] Preferably, an average value of a flexural rigidity in dorsal flexion, of a front portion **30** of the plate **3** which is anterior to the high-hardness area **21** is greater than an average value of the flexural rigidity in dorsal flexion, of a rear portion **31** of the plate **3** which is posterior to the high-hardness area **21.**

[0045] In such a case, the average value of the flexural rigidity of the rear portion **31** is less than that of the front portion **30,** and the low-hardness area **20** of the midsole **2** in the rear portion **31** will easily be compressed substantially (greatly).

[0046] In such a case, the average value of the flexural rigidity of the front portion **30** is greater than that of the rear portion **31,** and it will be possible to have a larger energy absorbed by the front portion **30** of the plate **3** bent during heel contact **HC.**

[0047] Therefore, in such a case, one can expect a further increase in the jump height.

[0048] Preferably, a width of the plate **3** is greater than a width of the high-hardness area **21.**

[0049] In such a case, it will be possible to realize improvements to both a good wearability and a sufficient jump height. That is, it is preferred that the first width **W1** of the high-hardness area **21** is relatively smaller than the whole width **W** as described above. On the other hand, it is preferred that the width of the plate **3,** which functions like a leaf spring, is larger than the first width **W1** of the high-hardness area **21.**

[0050] Preferably, a front end of the plate **3** is arranged posterior to a front end of a ball **O1** of a big toe.

[0051] If the plate **3** extends anterior to the front end of the ball **O1** of the big toe, it may hinder the flexion of the MP joint, lowering the vertically kicking force, which may lower the jump height. For such reasons, the front end of the plate **3** is preferably set to be posterior to the MP (metatarsophalangeal) joints of the first to fifth toes.

[0052] Preferably, a front end of the plate **3** is set at a position posterior to a front end of a ball **O1** of a big toe and anterior to a base of a metatarsal bone **B14** of a big toe **B1.**

[0053] In such a case, the plate **3** is set at a position anterior to the base of the metatarsal bone **B14** of the big toe **B1,** and therefore, the long front portion **30** of the plate **3** bends substantially, so that one can expect a further increase in the jump height.

[0054] Note that the base refers to a portion of each bone that is close to the posterior joint and that is slightly expanding to a greater thickness, and it is referred to also as the proximal head.

[0055] Preferably, a rear end of the plate **3** is set at a position posterior to a medial projection **BC2** of a calcaneal tuberosity **BC1.**

[0056] In such a case, it is possible to ensure a sufficient amount of protrusion by which the plate **3** protrudes (projects) rearward from the rear end of the high-hardness area **21.**

[0057] Preferably, a length **L30** of a front portion **30** from a front end of the plate **3** to a front end of the high-hardness area **21** is greater than a length **L31** of a rear portion **31** from a rear end of the plate **3** to a rear end of the high-hardness area **21.**

[0058] In such a case, the impulse input from the short rear portion **31** during heel contact **HC** is accumulated in the long front portion **30.** Therefore, the function of the plate **3** to function like a leaf spring is increased, and the energy absorption efficiency will be high.

[0059] Preferably, a hardness of a foam body (foamed material) forming the high-hardness area **21** is set to a value that is 5° to 20° greater than a hardness of a foam body (foamed material) forming the low-hardness area **20** in terms of the JIS-C hardness.

[0060] If the hardness difference is less than 5° in terms of the JIS-C hardness, the jump height will not improve sufficiently. On the other hand, if the hardness difference is greater than 20°, one may feel an upthrust due to the high-hardness area **21,** or the hardness of the low-hardness area **20** will be too low.

[0061] Note that the hardness of the low-hardness area **20** is typically preferably about 50° to 60°. On the other hand, the hardness of the high-hardness area **21** is preferably about 60° to 75°, and most preferably about 65° to 70°.

EMBODIMENTS

[0062] The present invention will be understood more clearly from the following description of preferred embodiments taken in conjunction with the accompanying drawings. Note however that the embodiments and the drawings are merely illustrative and should not be taken to define the scope of the present invention. The scope of the present invention is defined only by the appended claims. In the accompanying drawings, like reference numerals denote like components throughout the plurality of figures.

[0063] One embodiment of the present invention will now be described with reference to FIG. **1** to FIG. **7.**

[0064] As shown in FIG. **1** to FIG. **5,** the shoe sole is a shoe sole suitable for an indoor sport such as handball, for example, and includes the outsole **1** having a tread surface to be in contact with the ground surface, the midsole **2** arranged on the outsole **1,** and the plate **3.**

[0065] The main body (majority) of the midsole **2** is made of a foam body (foamed material), it is for example formed by a material suitable for shock absorption such as a foam body containing a resin component such as EVA (ethylene-vinyl acetate copolymer). On the other hand, the outsole 1 is formed by a material having a good wear resistance such as a foam body or a non-foam body (non-foamed material) of a rubber, for example.

[0066] As shown in FIG. **2,** the midsole **2** includes the low-hardness area **20** and the high-hardness area **21.** Note that in FIG. **1** to FIG. **5,** the high-hardness area **21** is shaded with fine dots, and the plate **3** is shaded with

coarse dots.

[0067] The foamed material of the midsole **2** of FIG. **1** contains a thermoplastic resin component and another arbitrary suitable component. The thermoplastic resin component may be, for example, a thermoplastic elastomer and a thermoplastic resin. Note that a gel having a high shock-absorbing property may be embedded in the rearfoot portion **5R** of the midsole **2,** or a well-known reinforcement unit for reinforcing the middle foot portion **5M** may be provided on the upper surface of the midsole **2**.

[0068] An insole (not shown) is inserted on the midsole **2.** A sockliner is inserted on the insole inside the upper.

[0069] The forefoot portion **5F,** the middle foot portion **5M** and the rearfoot portion **5R** each mean an area covering the forefoot section, the middle foot section and the rearfoot section, respectively, of the foot of FIG. **3.**

[0070] As is well known in the art, the forefoot section includes five metatarsal bones and fourteen phalanges. The middle foot section includes a navicular bone, a cuboid bone, and three cuneiform bones. The rearfoot section includes a talus bone and a calcaneal bone **BC.**

[0071] As shown in FIG. **2,** the low-hardness area **20** is provided so as to extend continuously in an area of the majority of the forefoot portion **5F,** the majority of the middle foot portion **5M** and the majority of the rearfoot portion **5R.** The hardness of the foamed material of the low-hardness area **20** is preferably an ordinary hardness of the midsole member, and is set to about 50° to 60° in terms of the JIS-C hardness, for example.

[0072] As shown in FIG. **1,** the high-hardness area **21** is arranged between the Chopart's joint **JS** and the rear end of the calcaneal bone **BC,** and preferably arranged between the front end of the calcaneal bone **BC** and the medial projection **BC2** of the calcaneal tuberosity **BC1.** In this preferable embodiment, the low-hardness area **20** is at least arranged anterior to the front end of the calcaneal bone **BC** and posterior to the medial projection **BC2.**

[0073] The high-hardness area **21** of FIG. **2** is provided in a portion of the central portion **2C** and/or a portion of the lateral portion **2L** (of the medial portion **2M,** the central portion **2C** and the lateral portion **2L,** which are defined by equally dividing the rearfoot portion **5R** three ways along the transverse direction perpendicular to the longitudinal axis **CL** of the foot); in the present embodiment, it is provided only on the lateral side **L** of the longitudinal axis **CL.** Note that the low-hardness area **20** is provided right next to, on the medial side **M** of, the high-hardness area **21;** therefore, the low-hardness area **20** has such a shape that it is partially cut out (notched) or holed by the high-hardness area **21,** and the middle foot portion **5M** and the rearfoot portion **5R** are continuous with each other.

[0074] The foamed material of the high-hardness area **21** has a higher hardness than the foamed material forming the low-hardness area **20.** The hardness of the foamed material forming the high-hardness area **21** is set to a value that is preferably 5° to 20°, more preferably about 10° to 15°, greater than the hardness of the foamed material forming the low-hardness area **20** in terms of the JIS-C hardness. For example, the hardness of the foamed material of the high-hardness area **21** is set to 65° to 70° in terms of the JIS-C hardness.

[0075] The average value **W1** of the first width from the lateral end of the high-hardness area **21** to the opposite end thereof from the lateral end is set to 40% to 60% of the whole width **W** of the midsole **2** in the area where the high-hardness area **21** extends across. Note that the high-hardness area **21** does not need to extend at the right angle (directly horizontal) across the shoe, but may be inclined.

[0076] In FIG. **4** and FIG. **1,** the average value **H1** of the first height of the high-hardness area **21** is set to 80% to 100% of the average value **H** of the height over the whole width of the midsole **2** in the area where the high-hardness area **21** is arranged.

[0077] As shown in FIG. **1,** the plate **3** is located between the upper surface of the outsole **1** and the upper surface of the midsole **2** and is continuous from the middle foot portion **5M** to the rearfoot portion **5R.** The plate **3** has a greater Young's modulus than Young's moduli of materials of the outsole **1** and the midsole **2.**

[0078] The plate **3** is arranged between the upper surface of the outsole **1** and the lower surface of the midsole **2** in the present embodiment, but in a case where the midsole **2** is provided in the form of two, upper and lower, layers, for example, the plate **3** may be provided sandwiched between the upper and lower layers of the midsole **2.**

[0079] As clearly shown in FIG. **3,** the front end of the plate **3** is arranged at a position posterior to the front end of the ball **O1** of the big toe and anterior to the base of the metatarsal bone **B14** of the big toe **B1.** The plate **3** is arranged continuously anterior to, directly below and posterior to the high-hardness area **21** of FIG. **1.** The rear end of the plate **3** is set at a position posterior to the medial projection **BC2** of the calcaneal tuberosity **BC1** (FIG. **1**).

[0080] The length **L30** of the front portion **30** from the front end of the plate **3** to the front end of the high-hardness area **21** is greater than the length **L31** of the rear portion **31** from the rear end of the plate **3** to the rear end of the high-hardness area **21.**

[0081] The width of the plate **3** of FIG. **3** is greater than the first width **W1** of the high-hardness area **21** and is slightly smaller than the whole width **W** of the midsole **2.** The width of the plate **3** is preferably about 60% to 95% of the width of the midsole **2.** Note that where the width of the plate **3** is narrow, the plate **3** may be lopsided toward the lateral side of the midsole **2.**

[0082] The average value of the flexural rigidity in dorsal flexion of the front portion **30** of the plate **3** anterior to the high-hardness area **21** is greater than that of the rear portion **31** of the plate **3** posterior to the high-hardness area **21.**

[0083] Even if the average values are not in such a

relationship with each other, the spring effect will be realized to some extent. While a cutout (notch) **32** at the rear end of the plate **3** may be absent (not be provided), the cutout **32** makes it easier to lower the rigidity of the rear portion **31** of the plate **3** and to lower the rigidity of the low-hardness area **20.**

[0084] Ventilation holes may be provided in the plate **3.**

[0085] Moreover, the rear end of the plate **3** may extend to a point posterior to the rear end of the foot, as in squash shoes, for example.

[0086] Next, the results of a test on the effect of the athletic shoe having the shoe sole of the present embodiment, for the one-foot jump shot in handball, will be described.

[0087] In this test, handball shoes according to the embodiment of FIG. **1** to FIG. **5** were used as Test Example, and handball shoes sold on the market were used as Comparative Example. Handball players performed multiple jump shots wearing these shoes, while the jump height at the top of the jump was measured, shown in FIG. **7A,** and the distance jumped forward until reaching the top of the jump was measured, shown in FIG. **7B.**

[0088] As can be seen in FIG. **7A,** Test Example had a jump height greater than that of Comparative Example by about 15 mm (a few %). As can be seen in FIG. **7B,** the distance jumped forward of Test Example was shorter than that of Comparative Example by about 100 mm (10%).

[0089] The impulse of the braking force from heel contact **HC** to foot flat **FF** (FIG. **6B** and FIG. **6A**) during the jump shots was also measured, and the impulse for Test Example was higher than that for Comparative Example by about 10%. Moreover, the braking force at heel rise during the jump shot was also measured, and the braking force for Test Example was less than that for Comparative Example by about a few %.

[0090] The load at first strike when the impact is highest, i.e., at heel contact **HC** was also measured. As a result, the impact load for Test Example was smaller than that for Comparative Example by about 15%. Therefore, it can be seen that the structure of the present shoe sole is suitable not only for indoor sports, but also for running outdoors or walking as an exercise.

[0091] The effect of the shoe sole of the present invention was made clear from these test results.

[0092] Next, another embodiment will be described with reference to FIG. **8.**

[0093] In the present embodiment, the easy-to-compress area **20A** is provided instead of the low-hardness area **20,** while the hard-to-compress area **21A** is provided instead of the high-hardness area **21.**

[0094] The easy-to-compress area **20A** of FIG. **8** is provided in an area of the majority of the middle foot portion **5M** and the majority of the rearfoot portion **5R.** On the other hand, the hard-to-compress area **21A** is arranged in the same area as in the embodiment of FIG. **1,** and has a greater compressive rigidity than that of the material forming the easy-to-compress area **20A.**

[0095] The plate **3** is arranged continuously from anterior to the hard-to-compress area **21A** to posterior to the hard-to-compress area **21A,** and the lower surface of the plate **3** is attached to the upper surface of the outsole **1** anterior to and posterior to the hard-to-compress area **21A.**

[0096] In the present embodiment, the hard-to-compress area **21A** may be provided in the form of a ridge (rib) of the plate **3,** or one may employ a structure where the outsole **1** fills in a bent portion of the plate **3,** for example.

[0097] Other than this, the configuration is similar to that of the embodiment of FIG. 1 to FIG. **5,** and will not be further described below.

[0098] Next, a variation of the high-hardness area **21** and/or the hard-to-compress area **21A** in each embodiment will be described.

[0099] While the high-hardness area **21** of FIG. **4** has a levee-like shape that is generally a rectangular solid, the high-hardness area **21** may have a levee-like shape with a trapezoidal cross section as shown in FIG. **8,** or a levee-like shape with a triangular cross section as shown in FIG. **6B.**

[0100] Although the high-hardness area **21** of FIG. **1** is provided over the entire height of the midsole **2** from the lower surface to the upper surface thereof, it may be provided over a part of the midsole **2** in the vertical (up-and-down) direction. Where the high-hardness area **21** is thus provided partially, the high-hardness area **21** may be provided in an upper portion, a lower portion or an intermediate portion in the vertical direction of the midsole **2.**

[0101] The planar shape of the high-hardness area **21** of FIG. **2** does not need to be rectangular, but may be triangular, wave-shaped, trapezoidal, square, or a combination thereof.

[0102] For example, a plurality of square high-hardness portions may be arranged in the width direction of the foot while being spaced apart from one another, so that the high-hardness portions together form a single high-hardness area **21.** In such a case, the width of the high-hardness area **21** should be considered as being the distance from the lateral end of the most lateral **L** high-hardness portion to the medial end of the most medial **M** high-hardness portion.

[0103] Where the high-hardness area **21** is triangular or trapezoidal, for example, the length of the high-hardness area **21** along the foot-length (longitudinal) direction may gradually decrease as the high-hardness area **21** extends from the lateral portion **2L** toward the central portion **2C.**

[0104] The high-hardness area **21** may be formed by a high-hardness portion surrounding a part or whole of the perimeter of a low-hardness portion.

[0105] Regarding the arrangement of the high-hardness area **21** in the transverse direction **X,** although a part of the high-hardness area **21** is provided in a roll-up portion **22** on the lateral side **L** of the midsole **2,** the high-

hardness area **21** may be absent (not provided) in the roll-up portion **22.** The high-hardness area **21** may be provided only in the lateral portion **2L** or the central portion **2C.**

[0106] While preferred embodiments have been described above with reference to the drawings, various obvious changes and modifications will readily occur to those skilled in the art upon reading the present specification.

[0107] For example, an area where the hardness is higher than the low-hardness area **20** may be provided, on the medial side, in the middle foot portion **5M** or the rearfoot portion **5R** of the midsole **2,** in order to suppress overpronation.

[0108] An area where the hardness is higher than the low-hardness area **20** may be provided in the roll-up portion **22** in the forefoot portion **5F** or the middle foot portion **5M** of the midsole **2** to suppress lateral shifting (falling (down) to lateral-side) of the foot.

[0109] The structure of the present invention may be applied only to a shoe for the pivot foot, or the structure of the present invention may be applied to both feet.

[0110] Thus, such changes and modifications are deemed to fall within the scope of the present invention.

INDUSTRIAL APPLICABILITY

[0111] The present invention is applicable not only to indoor shoes for handball, basketball, etc., but also to athletic shoes for running or walking outdoors.

REFERENCE SIGNS LIST

[0112]

1: Outsole
2: Midsole, 2C: Central portion, 2L: Lateral portion, 2M: Medial portion, 22: Roll-up portion
20: Low-hardness area, 20A: Easy-to-compress area,
21: High-hardness area, 21A: Hard-to-compress area
3: Plate, 30: Front portion, 31: Rear portion
5F: Forefoot portion, 5M: Middle foot portion, 5R: Rearfoot portion
BC: Calcaneal bone, BC1: Calcaneal tuberosity, BC2: Medial projection
CL: Longitudinal axis
FF: Foot flat, HC: Heel contact
H: Average height value over whole width, H1: Average first height value
L: Lateral side, M: Medial side
O1: Ball of big toe
W: Whole width, W1: First width

Claims

1. A shoe sole of an athletic shoe, comprising:

an outsole **1** having a tread surface;
a mid sole **2** arranged above the outsole **1;** and
a plate **3** located between an upper surface of the outsole **1** and an upper surface of the mid sole **2** and being continuous from a middle foot portion **5M** to a rear foot portion **5R,** the plate **3** being formed by a material having a greater Young's modulus than Young's moduli of materials of the outsole **1** and the mid sole **2,** wherein:

the mid sole **2** includes:

a low-hardness area **20** provided in an area of a majority of the middle foot portion **5M** and a majority of the rear foot portion **5R;** and
a high-hardness area **21** arranged between a Chopart's joint JS and a rear end of a calcaneal bone **BC,** wherein where a medial side portion **2M,** a central portion **2C** and a lateral side portion **2L** are obtained by dividing the rear foot portion **5R** in three equal parts in a transverse direction **X** perpendicular to a longitudinal axis **CL** of a foot, the high-hardness area **21** is provided in at least a portion of the central portion **2C** and/or at least a portion of the lateral side portion **2L;**
a hardness of a foam body forming the high-hardness area **21** is greater than that of the low-hardness area **20;** and
the plate **3** is arranged continuously anterior to, directly below, and posterior to, the high-hardness area **21.**

2. The shoe sole according to claim 1, wherein:

the high-hardness area **21** is arranged between the Chopart's joint JS and a medial projection **BC2** of a calcaneal tuberosity **BC1;** and
the low-hardness area **20** is arranged to at least extend anterior to the Chopart's joint JS and posterior to the medial projection **BC2.**

3. The shoe sole according to claim 1, wherein:

the high-hardness area **21** is arranged between a front end of the calcaneal bone **BC** and a rear end of the calcaneal bone **BC;** and
the low-hardness area **20** is arranged to at least extend anterior to the front end of the calcaneal bone **BC** and posterior to the rear end of the calcaneal bone **BC.**

4. The shoe sole according to claim 1, wherein:

the high-hardness area **21** is arranged between

a front end of the calcaneal bone **BC** and a medial projection **BC2** of a calcaneal tuberosity **BC1;** and
the low-hardness area **20** is arranged to at least extend anterior to the front end of the calcaneal bone **BC** and posterior to the medial projection **BC2.**

5. The shoe sole according to any one of claims **1** to **4,** wherein:

an average value **W1** of a first width from a lateral end of the high-hardness area **21** to an opposite end thereof from the lateral end is set to 17% to 100% of a whole width **W** of the midsole **2 in** an area where the high-hardness area **21** extends across.

6. The shoe sole according to any one of claims 1 to 5, wherein:

an average value **H1** of a first height of the high-hardness area **21** is set to 25% to 150% of an average value **H** of a height over a whole width **W** of the midsole **2** in an area where the high-hardness area **21** is arranged.

7. The shoe sole according to any one of claims 1 to 6, wherein:

an average value of a flexural rigidity in dorsal flexion, of a front portion **30** of the plate **3** which is anterior to the high-hardness area **21** is greater than that of a rear portion **31** of the plate **3** which is posterior to the high-hardness area **21.**

8. The shoe sole according to any one of claims 1 to 7, wherein:

a width of the plate **3** is greater than a width of the high-hardness area **21.**

9. The shoe sole according to any one of claims 1 to 8, wherein:

a front end of the plate **3** is arranged posterior to a front end of a ball **O1** of a big toe.

10. The shoe sole according to any one of claims 1 to 8, wherein:

a front end of the plate **3** is set at a position posterior to a front end of a ball **O1** of a big toe and anterior to a base of a metatarsal bone **B14** of the big toe **B1.**

11. The shoe sole according to any one of claims 1 to 10, wherein:

a rear end of the plate **3** is set at a position posterior to a medial projection **BC2** of a calcaneal tuberosity **BC1.**

12. The shoe sole according to any one of claims 1 to 11, wherein:

a length **L30** of a front portion **30** from a front end of the plate **3** to a front end of the high-hardness area **21** is greater than a length **L31** of a rear portion **31** from a rear end of the plate **3** to a rear end of the high-hardness area **21.**

13. The shoe sole according to any one of claims 1 to 12, wherein:

a hardness of a foam body forming the high-hardness area **21** is set to a value that is 5° to 20° greater than a hardness of a foam body forming the low-hardness area **20** in terms of the JIS-C hardness.

14. The shoe sole according to any one of claims 1 to 13, wherein:

the low-hardness area **20** is arranged anterior to a front end of, and posterior to a rear end of, the high-hardness area **21.**

15. A shoe sole of an athletic shoe, comprising:

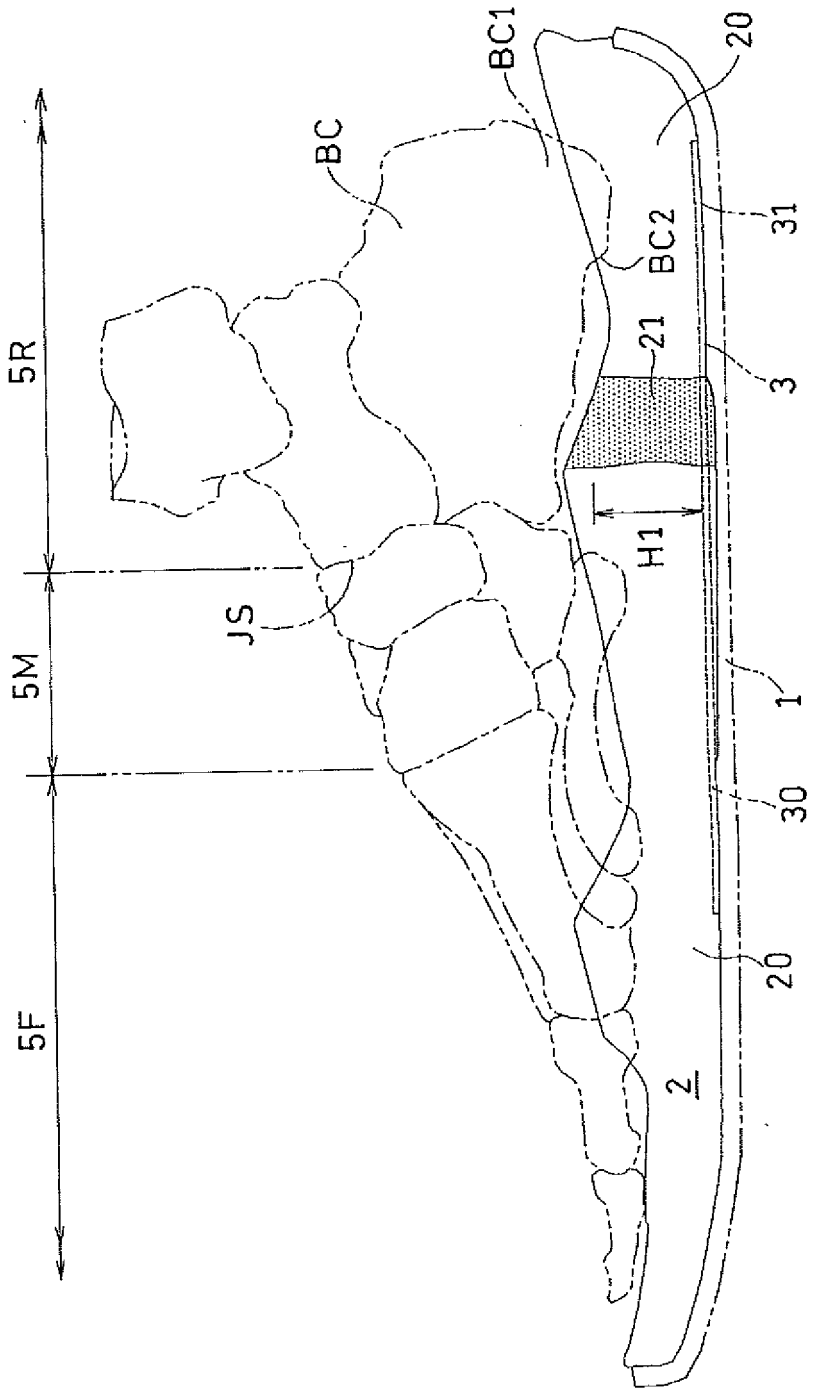
an outsole **1** having a tread surface;
a mid sole **2** arranged above the outsole 1; and
a plate **3** located between an upper surface of the outsole **1** and an upper surface of the mid sole **2** and being continuous from a middle foot portion **5M** to a rear foot portion **5R,** the plate **3** having a greater Young's modulus than Young's moduli of the outsole 1 and the mid sole **2,** wherein:

the mid sole **2** includes:

an easy-to-compress area **20A** provided in an area of a majority of the middle foot portion **5M** and a majority of the rear foot portion **5R;** and
a hard-to-compress area **21A** arranged between a Chopart's joint JS and a rear end of a calcaneal bone **BC,** wherein where a medial side portion **2M,** a central portion **2C** and a lateral side portion **2L** are obtained by dividing the rear foot portion **5R** in three equal parts in a transverse direction **X** perpendicular to a longitudinal axis **CL** of a foot, the hard-to-compress area **21A** is provided in at least a portion of the central portion **2C** and/or at least a portion of the lateral side portion **2L,** the hard-to-compress area **21A** having a greater compressive rigidity than a ma-

terial forming the easy-to-compress area **20A;** and
the plate **3** is arranged continuously anterior to, directly below, and posterior to, the hard-to-compress area **21A,** and a lower surface of the plate **3** is attached to an upper surface of the outsole 1 anterior to and posterior to the hard-to-compress area **21A.**

FIG 1



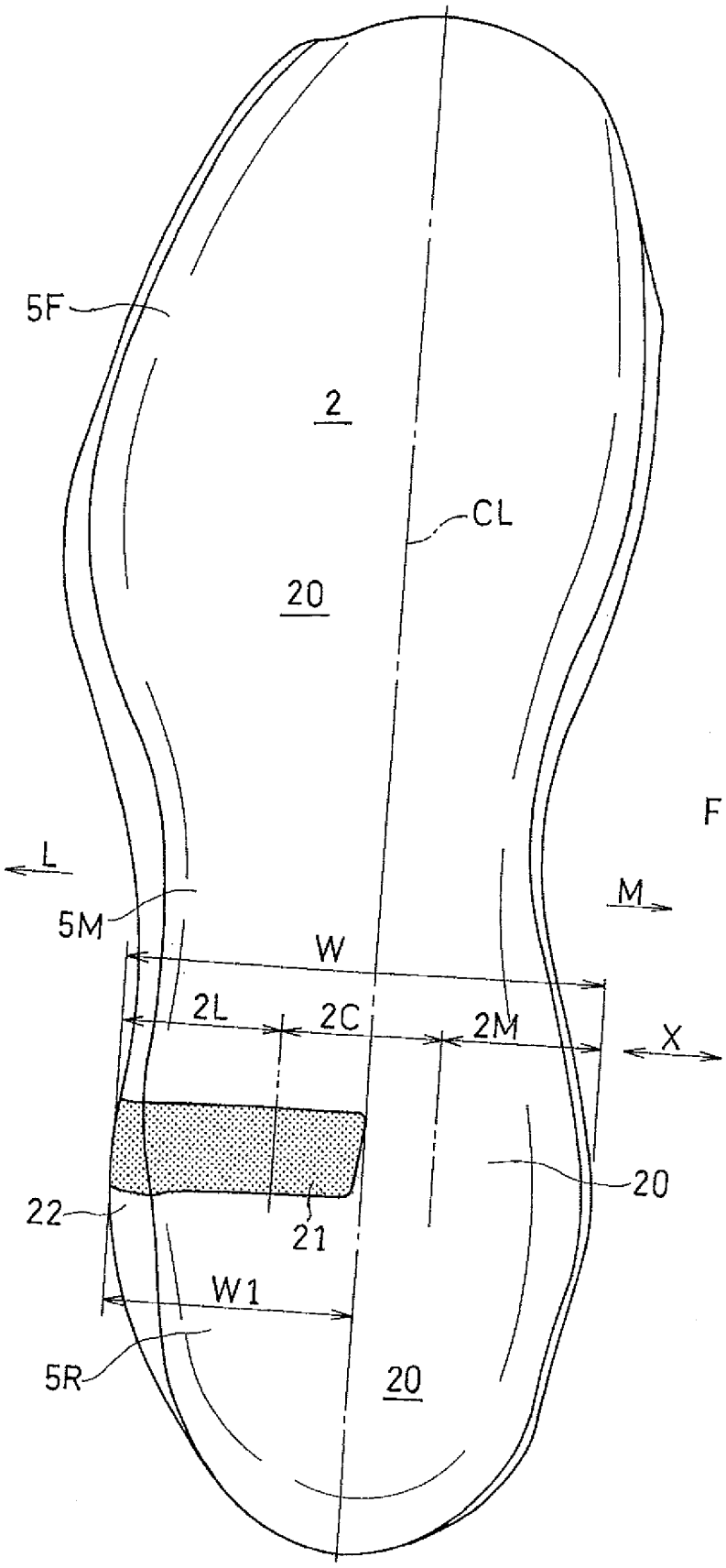


FIG 2

FIG 3

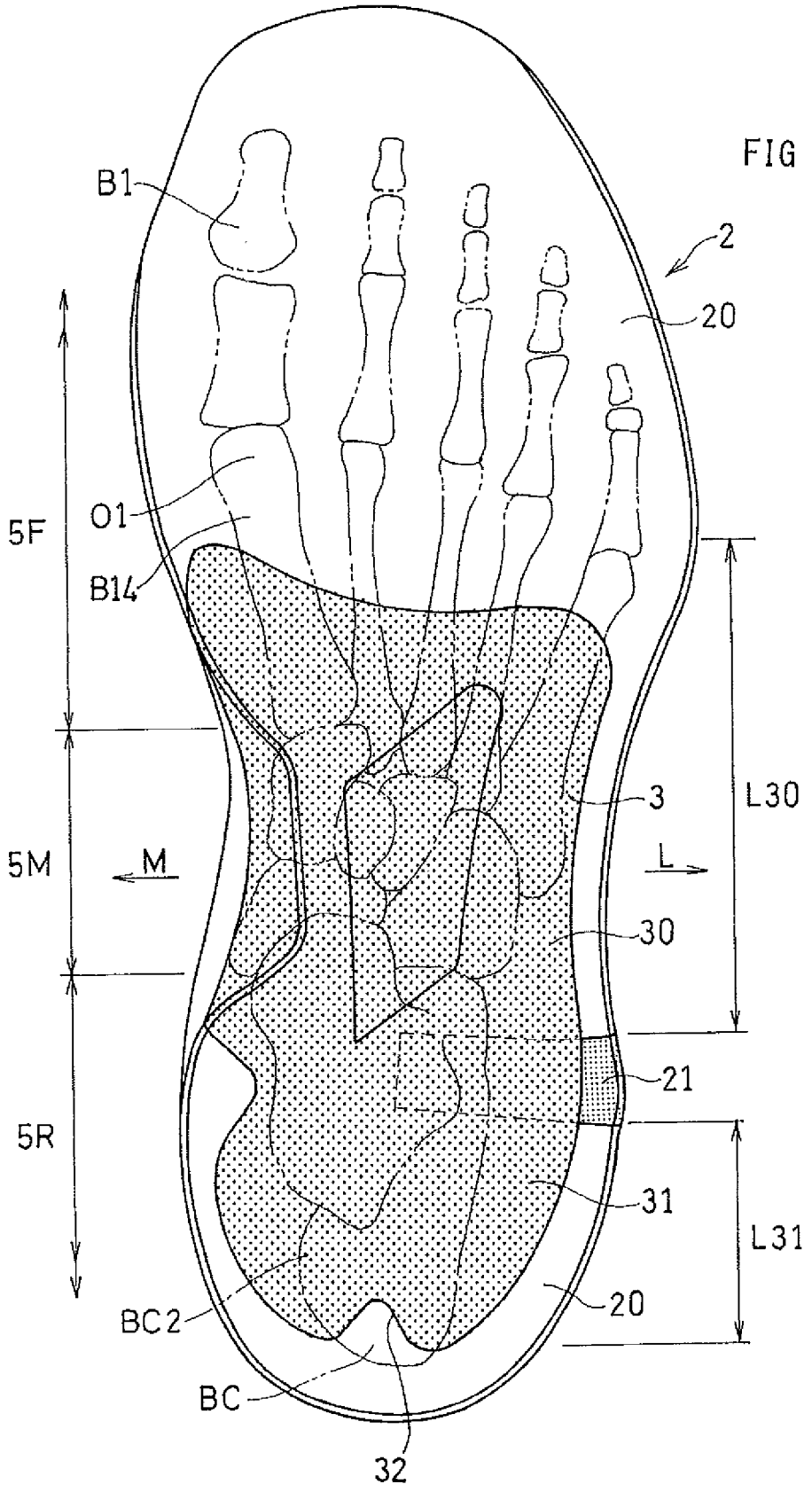


FIG 4

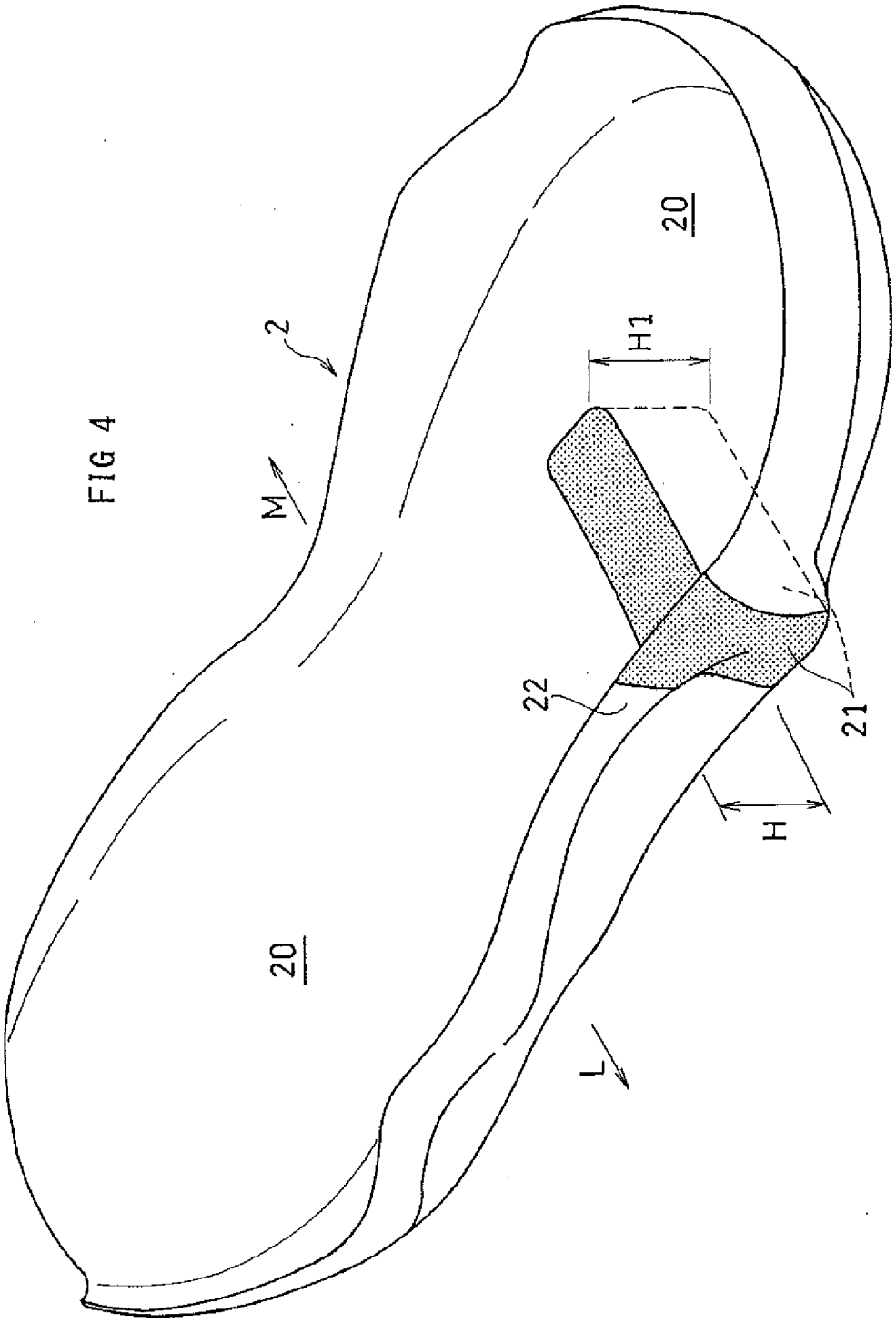
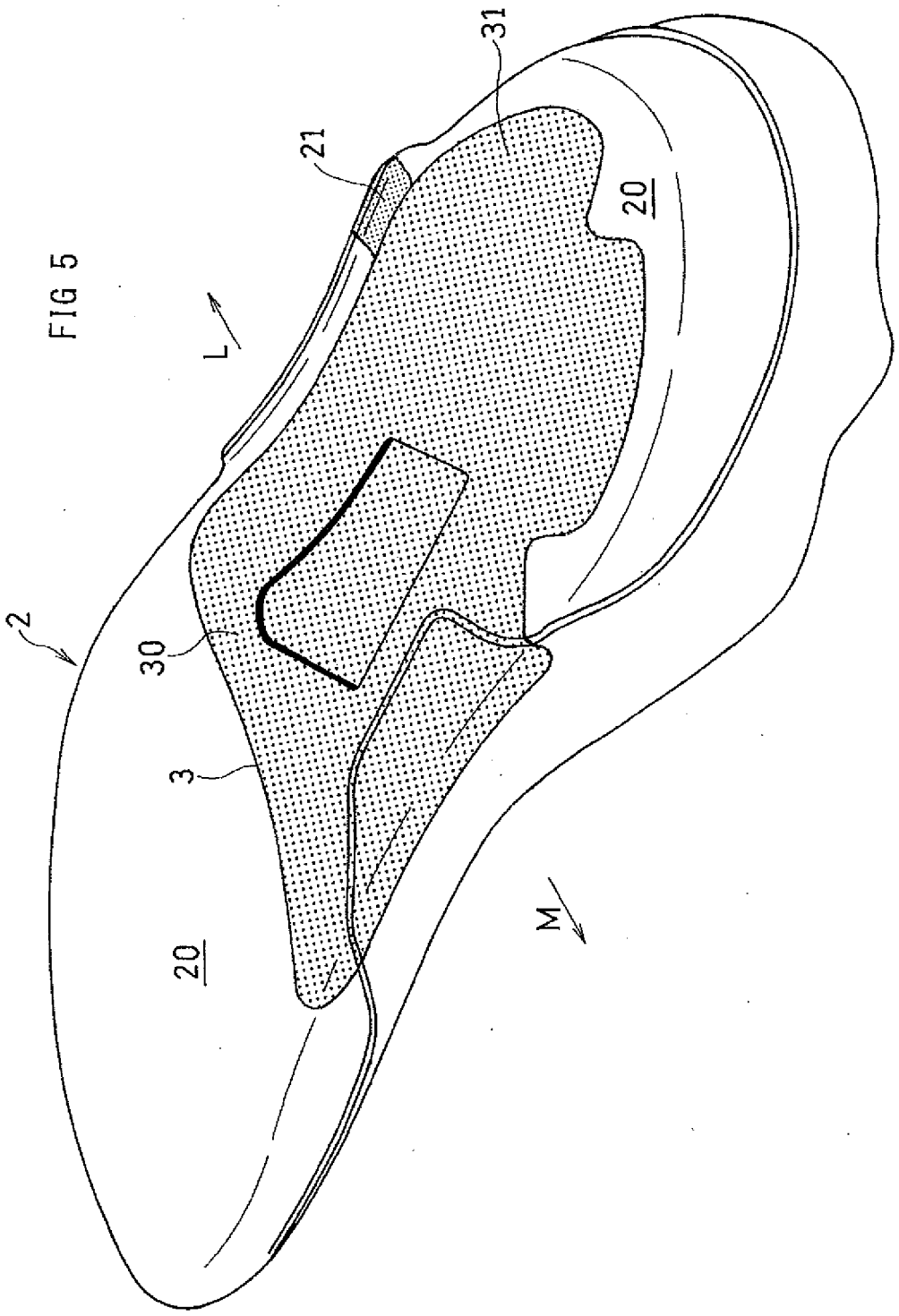


FIG 5



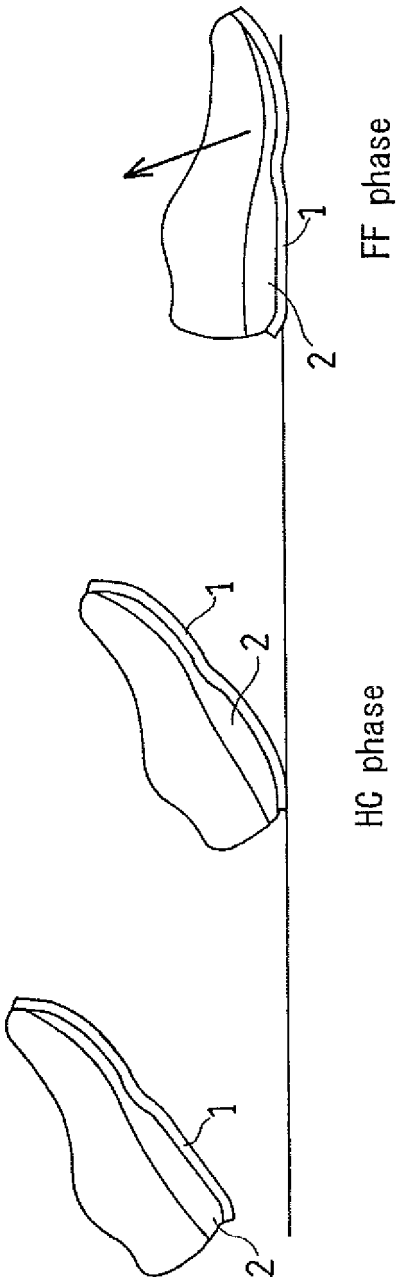


FIG 6A
PRIOR ART

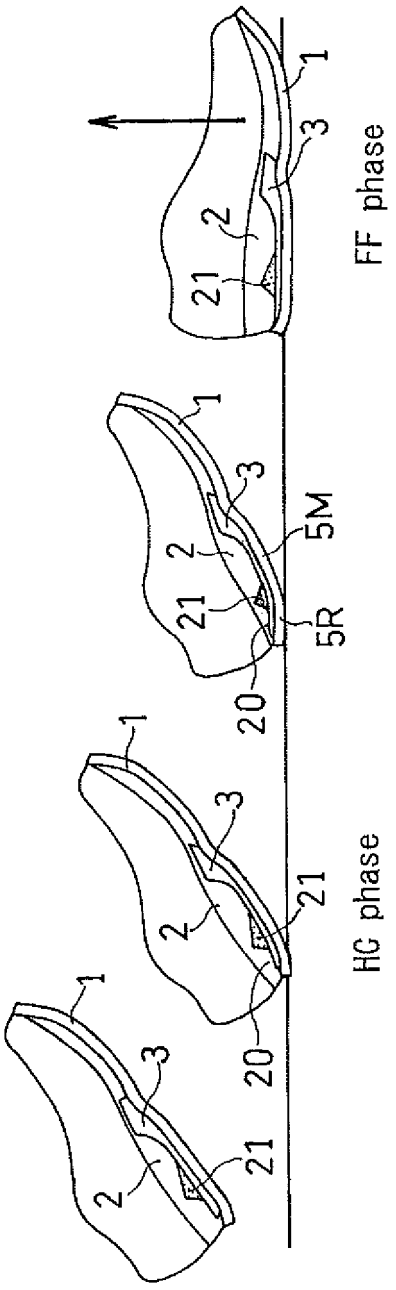


FIG 6B

FIG 7A

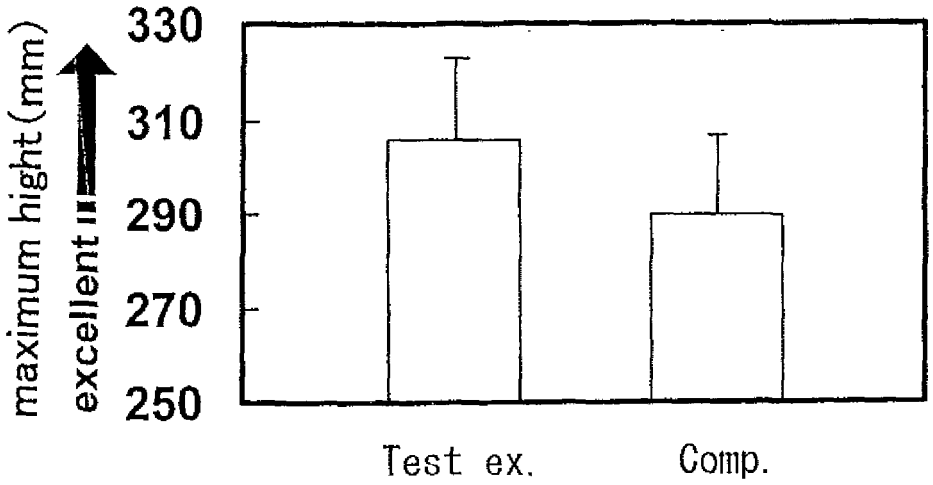

maximum hight (mm)
excellent
330
310
290
270
250
Test ex.
Comp.

FIG 7B

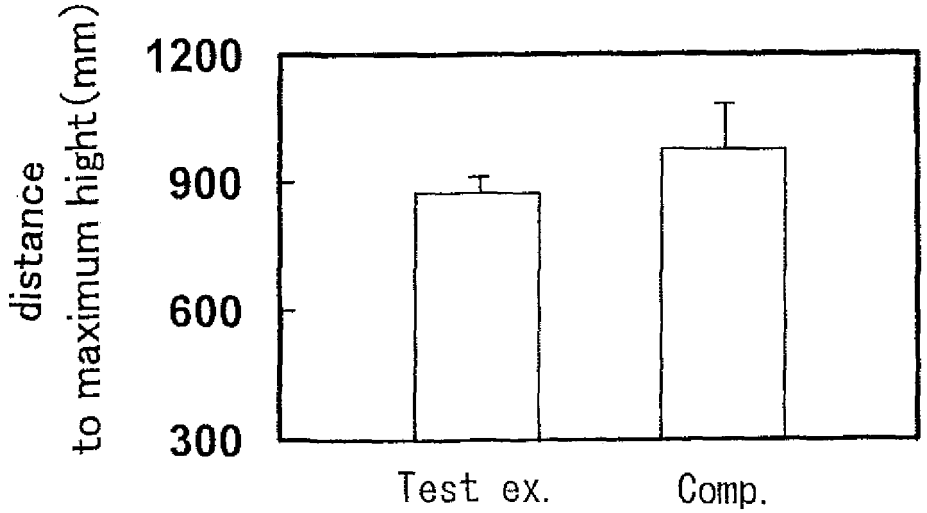
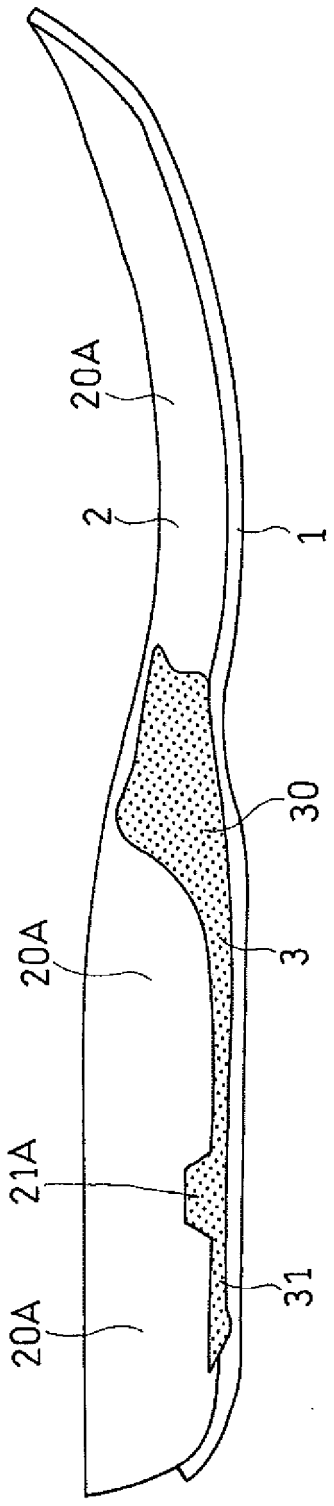

distance
to maximum hight (mm)
1200
900
600
300
Test ex.
Comp.

FIG 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/077319

A. CLASSIFICATION OF SUBJECT MATTER
A43B13/38(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A43B13/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2007/046133 A1 (Asics Corp.), 26 April 2007 (26.04.2007), (Family: none)	1-15
A	WO 2010/049983 A1 (Asics Corp.), 06 May 2010 (06.05.2010), & US 2011/0197469 A1 & EP 2342986 A1 & AU 2008363481 A	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 December, 2013 (03.12.13)	17 December, 2013 (17.12.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2000083705 A **[0004]**
- JP 2005279020 A **[0004]**
- JP 2003009903 A **[0004]**
- JP 2006000311 A **[0004]**
- JP 2010538788W B **[0004]**