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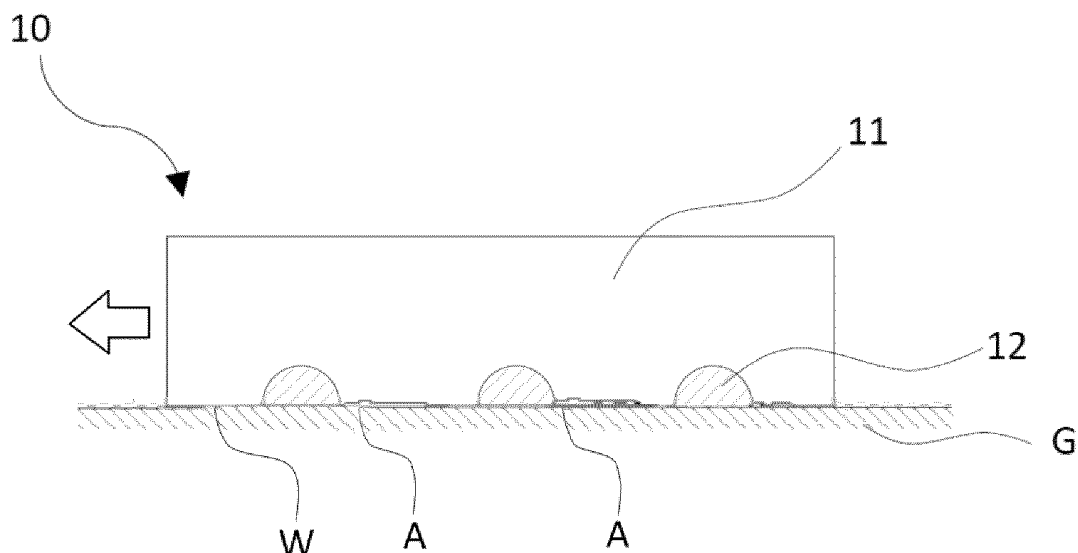
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(54) **SHOE SOLE, AND SHOE**

(57) Provided are a shoe sole composed of a rubber composition including rubber and activated carbon, and a shoe provided with the shoe sole.



**Fig. 3**

## Description

### FIELD

5 **[0001]** The present invention relates to a shoe sole and a shoe.

### BACKGROUND

10 **[0002]** Shoes are sometimes used on the ground wet by water during or after rain. The ground wet by water is likely to cause slippage and may cause the wearer of the shoes to slip on the ground when the wearer moves on the ground.  
**[0003]** In prior arts, it is conceived that rendering the shoe sole with high water absorbability is effective for the shoe to have high wet-grip performance (for example, Patent Literature 1, paragraph 0009). Therefore, a shoe sole of a shoe for which excellent wet-grip performance is required has conventionally been provided with a water-absorbing porous material.

### CITATION LIST

#### Patent Literature

20 **[0004]** Patent Literature 1: WO/2007-007412 A

### SUMMARY

#### Technical Problem

25 **[0005]** While the method as mentioned has been proposed in order to improve the wet-grip performance of the shoe, there are ongoing demands for a shoe that has more improved wet-grip performance.  
**[0006]** In view of the aforementioned problem, it is an object of the present invention to provide a shoe sole and a shoe that have improved wet-grip performance.

#### Solution to Problem

30 **[0007]** A shoe sole according to the present invention is composed of a rubber composition including rubber and activated carbon.  
**[0008]** A shoe according to the present invention includes the aforementioned shoe sole.

### BRIEF DESCRIPTION OF DRAWINGS

#### **[0009]**

40 Fig. 1 is a schematic view showing a surface of an elastic body forming a shoe sole according to one embodiment.  
 Fig. 2 is a schematic view showing the elastic body of Fig. 1 before it makes contact with an object wet by water.  
 Fig. 3 is a schematic view showing the elastic body of Fig. 1 after it makes contact with the object wet by water.  
 Fig. 4 is a schematic view showing a shoe as a wearable equipment of one embodiment, which has an anti-slip member provided at a ground engaging position of a shoe sole.  
 45 Fig. 5 is a schematic view showing an apparatus for observing and imaging a contact portion between rubber and a flat plate shaped glass by performing a friction test in a preliminary study of examples.  
 Fig. 6 is a photograph showing contact portions between the flat plate shaped glass and the rubber after the flat plate shaped glass is slid 5mm on the rubber having a smooth surface at an apex in contact with the glass, in the preliminary examination of examples.  
 50 Fig. 7 is a photograph showing contacting portions between the flat plate shaped glass and the rubber after the flat plate shaped glass is slid 5 mm on the rubber having pores of about 100  $\mu\text{m}^3$  formed at the apex in contact with the glass, in the preliminary study of examples.  
 Fig. 8 is a graph representing the areas of the contact portions between the flat plate shaped glass and the rubber after the flat plate shaped glass is slid 5mm on the rubber in the preliminary study of examples.  
 55 Fig. 9 is a graph showing the static friction coefficients between the flat plate shaped glass and the rubber after the flat plate shaped glass is slid 5mm on the rubber in the preliminary study of examples.

## DESCRIPTION OF EMBODIMENTS

**[0010]** Hereinafter, an embodiment of the present invention will be described with reference to the drawings. The following embodiments are shown merely as examples. The present invention is not limited to the following embodiment at all.

(Rubber composition)

**[0011]** First, a function of a rubber composition forming a shoe sole of the present invention will be described with reference to Figs. 1 to 3 using an elastic body composed of the rubber composition as a model. Fig. 1 is a schematic view showing a surface of an elastic body 10 of this embodiment. The elastic body 10 of this embodiment includes rubber 11 and activated carbon 12, and at least part of particles of the activated carbon 12 is exposed on the surface of the elastic body 10.

**[0012]** The present inventors have found that, in a shoe sole composed of a rubber composition, inclusion of particles having pores into which water hardly enters in the shoe sole can solve the above problem. And the present inventors have found that activated carbon is suitable as such particles.

**[0013]** Since activated carbon has high hydrophobicity and the size of the pores open to the surface is generally about 1  $\mu\text{m}$ , water hardly enters the pores even when water is in contact with the pores. The present inventors have found that when activated carbon having pores which have been considered unsuitable for the purpose of absorbing water is disposed on a shoe sole, air is released from the pores of activated carbon due to strain of the shoe sole at the time of the contact of the shoe sole with the ground via a water film, and a region in which the shoe sole and the ground are in direct contact with each other is formed, thereby have completed the present invention.

**[0014]** Fig. 2 is a schematic view showing the elastic body 10 composed of the same composition as the composition of the shoe sole of this embodiment before it makes contact with an object G wet by water W. Fig. 3 is a schematic view showing the elastic body 10 after it makes contact with the object G wet by the water W. The object G is herein represented as the ground wet by the water W. Further, Fig. 3 shows the state in which strain is being applied to the interface between the ground and the elastic body 10 by the strain applied to the elastic body 10 in the direction of the arrow.

**[0015]** The activated carbon 12 has a large number of pores. When the pore distribution is measured by the mercury intrusion method, the activated carbon 12 usually exhibits a peak in any portion of the ranges of 0.5  $\mu\text{m}$  or more and 3  $\mu\text{m}$  or less. In other words, the activated carbon 12 has a large number of pores having a diameter of 0.5  $\mu\text{m}$  to 3  $\mu\text{m}$  centered on a diameter of about 1  $\mu\text{m}$ . The activated carbon 12 is usually less hydrophilic (more hydrophobic) than porous particles such as silica or zeolite. For the activated carbon 12 having high hydrophobicity, water hardly enters the pores having a small diameter as described above because the contact angle increases.

**[0016]** As shown in Fig. 3, the activated carbon 12 exposed on the surface of the elastic body 10 in which strain is applied to the interface with the ground, releases air A from the pores. Although the amount of the air A released at this time is small, a gap is hardly formed between the elastic body 10 having low elasticity and the ground, so that the air A can be spread over a relatively wide range. When the air A is interposed between the elastic body 10 and the ground, a driving force that minimizes the sum of the surface free energies is exerted so that water is expelled between the elastic body 10 and the ground in the region where the air A is interposed, thereby allowing the surface of the elastic body 10 to be in direct contact with the ground. In this way, a large number of portions where the elastic body 10 and the ground come into direct contact with each other without water interposed therebetween are formed, so that the elastic body 10 exhibits high grip performance.

**[0017]** The elastic body 10 of this embodiment exhibits the above-described characteristics by including a specific component such as activated carbon in the rubber composition. It is preferable that the rubber composition have specific physical property value in order for the elastic body 10 to exhibit the above-described characteristics.

**[0018]** The content of the activated carbon in the rubber composition is preferably 0.1% by mass or more because excellent wet-grip performance can be imparted to the elastic body 10. The content of the activated carbon is more preferably 0.2% by mass or more, still more preferably 0.3% by mass or more. The content of the activated carbon is preferably 10% by mass or less because excellent strength can be imparted to the elastic body 10. The content of the activated carbon is more preferably 5% by mass or less, still more preferably 3% by mass or less.

**[0019]** The activated carbon can be made of a plant such as coconut shell, wood, or bamboo as a raw material, or can be made of peat, coal, plastic, or the like as a raw material. Preferably, the activated carbon is obtained from a plant raw material in that it has a large number of pores as described above.

**[0020]** The activated carbon is preferably powdered activated carbon. It is preferable that the powdered activated carbon have a particle diameter in which a passing ratio of 150  $\mu\text{m}$  mesh is 90% by mass or more. It is more preferable that the powdered activated carbon have a particle diameter in which a passing ratio of 75  $\mu\text{m}$  mesh is 90% by mass or more. However, the activated carbon is not limited to powdered activated carbon, and can be granular activated carbon.

**[0021]** As rubber in the rubber composition forming the elastic body 10, an elastomer generally used for forming a

shoe sole is used. Examples of the elastomer include a vulcanized rubber such as an isoprene rubber (IR), a natural rubber (NR), a butadiene rubber (BR), a styrene butadiene rubber (SBR), a chloroprene rubber (CR), an acrylonitrile butadiene rubber (NBR), a butyl rubber (IIR), or a silicone rubber (Si); and a thermoplastic elastomer such as a styrene-based elastomer (TPS), an olefin-based elastomer (TPO), a urethane-based elastomer (TPU), a polyester-based elastomer (TPEE), polyamide-based elastomer (TPA), polyvinyl chloride (PVC), or an ethylenevinyl acetate copolymer (EVA). IR, BR, SBR, and NR having excellent tensile strength, tear strength, and abrasion resistance are suitably selected.

**[0022]** The rubber composition can further include an inorganic filler such as silica, alumina, calcium carbonate, magnesium carbonate, carbon black, graphite, talc, or clay. When a portion other than activated carbon in the rubber composition is assumed as a matrix, it is preferable that the matrix itself have hydrophilicity. Therefore, an inorganic filler having excellent hydrophilicity is suitably included in the rubber composition. Silica having a large number of silanol groups (-Si-OH) which are hydrophilic functional groups on the particle surface is suitably selected for the inorganic filler included in the rubber composition.

**[0023]** The silica can be wet silica or dry silica. The wet silica can be precipitated silica, gel silica, or colloidal silica. The dry silica can be flame silica or arc method silica. It is preferable that the silica be wet silica. It is preferable that the wet silica include aggregated particles in which a plurality of primary particles of about 20  $\mu\text{m}$  are aggregated. Precipitated silica is suitable because it includes a large amount of aggregated particles which are easily decomposed into primary particles, is easy to handle, and is excellent in dispersibility of primary particles in rubber.

**[0024]** The content of the silica in the rubber composition is preferably 10 parts by mass or more based on 100 parts by mass of the rubber. The content of the silica is more preferably 20 parts by mass or more, still more preferably 30 parts by mass or more. The content of the silica in the rubber composition is preferably 100 parts by mass or less based on 100 parts by mass of the rubber. The content of the silica is more preferably 90 parts by mass or less, still more preferably 80 parts by mass or more.

**[0025]** It is preferable that the rubber composition include a silane coupling agent together with silica. The silane coupling agent in this embodiment has a hydrolyzable functional group at the end of the molecular chain, and can further have an organic functional group other than the hydrolyzable functional group. The hydrolyzable functional group can be an alkoxy group, a phenoxy group, a carboxyl group, an alkenyloxy group, or the like. The organic functional group can be an epoxy group, a vinyl group, an acryloyl group, a methacryloyl group, an amino group, a sulfide group, a mercapto group, or the like. The silane coupling agent in this embodiment preferably has a sulfide group. In other words, the silane coupling agent in this embodiment is preferably a sulfide-based silane coupling agent. The sulfide-based silane coupling agent can be a monosulfide-based silane coupling agent or a polysulfide-based silane coupling agent.

**[0026]** Examples of the sulfide-based silane coupling agent include bis (3-triethoxysilylpropyl) tetrasulfide, bis (3-trimethoxysilylpropyl) tetrasulfide, bis (3-triethoxysilylpropyl) disulfide, mercaptopropyltrimethoxysilane, mercaptopropyltriethoxysilane, 3-trimethoxysilylpropyl-N,N-dimethylthiocarbamoyl-tetrasulfide, trimethoxysilylpropyl-mercaptopbenzothiazole tetrasulfide, triethoxysilylpropyl-methacrylate-monosulfide, dimethoxymethylsilylpropyl-N, N-dimethylthiocarbamoyl-tetrasulfide, and 3-octanoylthio-1-propyltriethoxysilane. In this embodiment, a polysulfide-based silane coupling agent is preferred. The polysulfide-based silane coupling agent also works effectively in crosslinking of rubber. Among them, bis(3-triethoxysilylpropyl)tetrasulfide is preferred.

**[0027]** The silane coupling agent can be included in the rubber composition at a ratio of 1 part by mass or more when the content of silica in the rubber composition is set to 100 parts by mass. The content of the silane coupling agent is preferably 6 parts by mass or more, more preferably 7 parts by mass or more, based on 100 parts by mass of the silica. The content of the silane coupling agent is preferably 20 parts by mass or less, more preferably 15 parts by mass or less, based on 100 parts by mass of the silica.

**[0028]** The rubber composition can further include a compound having excellent hydrophilicity such as polyethylene glycol. The polyethylene glycol preferably has a mass average molecular weight of 2000 or more and 5000 or less. The mass average molecular weight is determined as a value in terms of polystyrene by the GPC method. The content of the polyethylene glycol in the rubber composition is preferably 0.1 parts by mass or more based on 100 parts by mass of the rubber. The content of the polyethylene glycol is more preferably 0.2 parts by mass or more, still more preferably 0.3 parts by mass or more. The content of the polyethylene glycol is more preferably 10 parts by mass or less, still more preferably 2 parts by mass or less.

**[0029]** The rubber composition can include a plasticizer such as paraffin oil (liquid paraffin). It is preferable that the content of a highly hydrophobic plasticizer such as paraffin oil be 30 parts by mass or less based on 100 parts by mass of the rubber.

**[0030]** In addition to the above components, the rubber composition of this embodiment can further include other optional components such as a vulcanizing agent, a vulcanization accelerator, a crosslinking accelerator, a filler, an antioxidant, or an ultraviolet absorber.

**[0031]** The hardness of the rubber composition is preferably set to 50 or more and 80 or less as measured by a Type A durometer based on JIS K 6253-3:2012.

**[0032]** The tensile elastic modulus of the rubber composition is preferably 12 MPa or less. The tensile elastic modulus

of the rubber composition is more preferably 10 MPa or less, still more preferably 8 MPa or less. The tensile elastic modulus is preferably 1 MPa or more. The tensile elastic modulus can be determined from the slope of the stress-strain curve in the low strain region in the tensile test of JIS K6251:2017 "Rubber, vulcanized or thermoplastic-Determination of tensile stress-strain properties" (e.g., the slope of the stress/strain curve corresponding to between 2 strain points of  $\varepsilon_1 = 0.05\%$ , and  $\varepsilon_2 = 0.25\%$ ).

**[0033]** It is preferable that the rubber composition have a tensile strength of 15 MPa or more measured on the basis of JIS K6251:2017 "Rubber, vulcanized or thermoplastic-Determination of tensile stress-strain properties" in terms of exhibiting properties required for a shoe sole. It is preferable that the rubber composition have a tensile elongation at break of 350% or more measured based on the same JIS. The tear strength determined on the basis of JIS K6252-1:2015 "Rubber, vulcanized or thermoplastic -- Determination of tear strength - Part 1: Trouser, angle and crescent test pieces" is preferably 40N/mm or more. The tear strength can be measured using an angle-shaped test piece (without notches).

**[0034]** The tensile strength of the rubber composition is more preferably 18 MPa or more, still more preferably 20 MPa or more. The tensile strength is usually 50 MPa or less.

**[0035]** The tensile elongation at break of the rubber composition is 400% or more, still more preferably 500% or more. The tensile elongation at break is usually 1000% or less.

**[0036]** The tear strength of the rubber composition is more preferably 50N/mm or more, still more preferably 60N/mm or more. The tensile strength is usually 120N/mm or less.

**[0037]** The rubber composition of this embodiment can be produced by kneading the above components, that is, the rubber, the activated carbon, and, optionally, silica, the silane coupling agent, polyethylene glycol, and the like by any method generally carried out by a person skilled in the art. For example, as the kneading method, a method of kneading the above components using an open roll or a kneader can be used.

**[0038]** The shoe sole of this embodiment exhibits high wet-grip performance by being composed of the rubber composition, as described above while exemplifying the aforementioned elastic body 10.

**[0039]** Fig. 4 is a schematic view showing a shoe 20 of one embodiment, which has the rubber composition (elastic body) provided at a ground engaging position of a shoe sole 23. The shoe 20 includes an upper member 21 covering the upper surface of the foot, a midsole 22 arranged on the lower side of the upper member 21, and an outer sole 23 in contact with the ground.

**[0040]** In this embodiment, the shoe 20 includes both the midsole 22 and the outer sole 23, but the shoe 20 does not necessarily include both of them. That is, the shoe 20 can be configured to include only the outer sole 23 as the shoe sole, and include no midsole 22.

**[0041]** As described above, since the shoe sole according to this embodiment is composed of a rubber composition including rubber and activated carbon, high wet-grip performance can be exhibited.

**[0042]** Preferably, the rubber composition of the shoe sole according to this embodiment has a tensile elastic modulus of 10 MPa or less. Therefore, the wet-grip performance of the shoe sole can be effectively enhanced in such a case.

**[0043]** Preferably, the shoe sole according to this embodiment has a content of the activated carbon in the rubber composition being 0.1% by mass or more and 5% by mass or less. In such a case, excellent wet-grip performance and excellent strength can be imparted to the rubber composition.

**[0044]** Preferably, in the shoe sole according to this embodiment, the rubber composition further includes silica, and the content of the silica in the rubber composition is 10 parts by mass or more and 100 parts by mass or less based on 100 parts by mass of the rubber. In such a case, the hydrophilicity of the rubber composition can be suitably enhanced.

**[0045]** Preferably, in the shoe sole according to this embodiment, the rubber composition further includes polyethylene glycol, and the content of the polyethylene glycol in the rubber composition is 0.1 parts by mass or more and 10 parts by mass or less based on 100 parts by mass of the rubber. In such a case, the hydrophilicity of the rubber composition can be suitably enhanced.

**[0046]** Further, since the shoe according to the present invention includes the above-described shoe sole, high wet-grip performance can be exhibited.

**[0047]** Although further detailed description will not be repeated here, even if there are any matters not described directly above, conventionally known technical matters for shoes and rubber compositions can be appropriately adopted in the present invention. In other words, the present invention is not limited to the above illustration in any way.

## EXAMPLES

**[0048]** Hereinafter, the present invention will be elucidated by way of specific examples and comparative examples of the present invention. However, the present invention is not limited to the following examples.

(Preliminary study)

**[0049]** First, in order to investigate the influence on wet-grip performance due to pores formed on the surface of the

rubber, a friction test of a rubber having pores formed on its surface and a rubber having no pores formed thereon with a flat plate shaped glass not wetted with water and a flat plate shaped glass wetted with water was performed.

#### Rubber

**[0050]** All of the rubbers used in the friction test were hemispherical silicone rubbers having a radius of curvature of 7.6 mm, one of which was a rubber SP1 having a smooth surface on which a recess or the like was not provided at an apex, and the other was a rubber SP2 having a recess (pore) of about  $100\ \mu\text{m}^3$  formed at an apex in contact with the glass. Fluorescent particles were kneaded into these rubbers in order to facilitate observation of the contact state with the flat plate shaped glass during the friction test.

#### Friction test

**[0051]** As shown on the left of Fig. 5, each rubber SP1, SP2 was placed on a dry (non-lubricated condition) or water-wetted (water-lubricated condition) flat plate shaped glass GL so as to have their apexes contacting the surface of the flat plate shaped glass GL. Thereafter, as shown on the right side of FIG. 5, with the normal load  $F=0.0981\text{N}$  of the apex of the rubber SP1, SP2, and at a sliding speed of  $0.10\text{ mm/s}$ , the flat plate shaped glass GL on the rubber SP1, SP2, was slid  $5.0\text{mm}$  in a direction parallel to the surface thereof.

**[0052]** During this time, in each of the non-lubricated conditions and the water-lubricated conditions, the true contact part of the rubber SP1, SP2 and the flat plate shaped glass GL was continued to be observed using the device shown in Fig. 5. After the flat plate shaped glass GL was slid  $5.0\text{mm}$ , the true contact part was imaged. The device includes a light source LS for illuminating the true contact part and a CCD device CD for imaging the true contact part. The true contact part was observed and imaged by combining the total reflection method and the optical interference method.

**[0053]** Fig. 6 and Fig. 7 show photographs of the real contact parts respectively imaged under the non-lubricated conditions and the water lubricated conditions. In Fig. 6 and Fig. 7, the black regions are the true contact parts, and the white regions are the regions where the flat plate shaped glass GL is not in contact with the rubber SP1, SP2. In Fig. 7, the gray region is a part where the flat plate shaped glass GL is in contact with water (is wet), and the white region is a part where the flat plate-shaped glass GL is not in contact with any of water and the rubber SP1, SP2 (air is present). Note that, although not shown, the presence of air remains only in the part where the pores are formed at the true contact part between the rubber SP2 and the flat plate shaped glass GL before sliding the flat plate shaped glass GL in the water lubricated conditions, and when the flat plate shaped glass GL is slid, a phenomenon in which bubbles diffuse over a wide range of the true contact part was observed. The area of the black region (true contact part) derived from the photographs of Fig. 6 and Fig. 7 (area of the true contact part) is derived, and a graph of the area is shown in Fig. 8.

**[0054]** Furthermore, the static friction coefficient between the rubber SP1, SP2 and the flat plate shaped glass GL was measured after the flat plate shaped glass GL was slid  $5.0\text{ mm}$ . Fig. 9 shows the measured static friction coefficient.

**[0055]** As can be understood from Fig. 6 to Fig. 9, in the non-lubricated conditions, although the area of the true contact part between the rubber SP2 and the flat plate shaped glass GL after the flat plate shaped glass GL is slid  $5.0\text{mm}$  was found to slightly decrease in comparison with the rubber SP1 due to the effect of pores formed on the surface, it can be seen that the friction coefficient is almost the same as the rubber SP1. Therefore, it can be seen that the grip performance in the non-lubricated conditions is hardly affected by the pores formed on the surface. On the other hand, in the water-lubricated conditions, the area of the true contact part between the rubber SP2 and the flat plate shaped glass GL after the flat plate shaped glass GL is slid  $5.0\text{mm}$  is increased by about 38% compared with the rubber SP1, and the friction coefficient is also increased by about 27%. In addition, for the rubber SP2 having pores formed on the surface, it can be seen that the friction coefficient is improved in the water-lubricated conditions compared with the non-lubricated conditions. From this result, it can be seen that in the rubber in which pores are formed on the surface, the wet-grip performance in the water lubricated conditions is greatly improved so as to be able to exceed the non-lubricated conditions.

(Study of rubber composition)

**[0056]** Next, in order to investigate the wet-grip performance for various rubber compositions according to the present invention, a friction test was performed on various rubber compositions according to the following Examples and Comparative Examples.

**[0057]** As a material of rubber to be blended into the rubber composition, the following materials were prepared.

IR: Isoprene rubber (high cis type, Mooney viscosity: approx. 82)

SiO<sub>2</sub>: Precipitated silica

CA: Silane coupling agent (bis(3-triethoxysilylpropyl)tetrasulfide)

PEG : Polyethylene glycol (mass average molecular weight: about 3000, melting point: about 60°C)

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PO: Liquid paraffin (kinematic viscosity: about 40 mm<sup>2</sup>/s, molecular weight: 430) St: Stearic acid

ZnO: Active zinc flour

AO: 2,6-di-tert-butyl-4-methylphenol

OA: Organic amine vulcanization accelerator

**[0058]** These materials were blended and kneaded in order by the blending ratios (mass ratios) shown in Table 1 below 3 separate times to prepare rubbers (a) to (d). Specifically, various IRs which are materials for primary kneading of the rubber raw material shown in Table 1 below were kneaded using a kneader (device name : DS3-10MWB, manufactured by Nippon Spindle Manufacturing Co., Ltd.) for 1 minute at 80 to 130°C, thereby obtaining a primary kneaded material. To the primary kneading material thus obtained, SiO<sub>2</sub>, PO, CA, St, and ZnO as materials for secondary kneading were blended by the blending ratios (mass ratios) shown in Table 1 below, and kneaded using a kneader (device name : DS3-10MWB, manufactured by Nippon Spindle Manufacturing Co., Ltd.) at 80 to 130°C for 10 minutes to obtain a secondary kneading material. To the secondary kneading material thus obtained, OA, PEG, and AO as materials for tertiary kneading were blended by the blending ratios (mass ratios) shown in Table 1 below, and kneaded using an open roll (device name : KD-M2-8, manufactured by KNEADER MACHINERY CO., LTD.) at 25 to 60°C for 10 minutes to obtain rubbers (a) to (d).

Table 1

	Material	(a)	(b)	(c)	(d)
Primary	IR	100	100	100	100
Secondary	SiO <sub>2</sub>	20	40	60	80
	PO	20	20	20	20
	CA	2.0	4.0	6.0	8.0
	St	2	2	2	2
	ZnO	5	5	5	5
Tertiary	OA	1	1	1	1
	PEG	1	1	1	1
	AO	1	1	1	1
	Total	152	174	196	218

**[0059]** As activated carbon to be blended into the rubber composition, the following materials were prepared.

Activated Carbon A: Activated carbon powder neutral (raw material: wood scrap) manufactured by Fujifilm Wako Pure Chemical Industries, Ltd.

Activated carbon B: YD32-1 (raw material: coconut shell charcoal) manufactured by Sanei Corporation

Activated carbon C: Takesumipowder-150 (raw material: bamboo charcoal) manufactured by Maeda Inc.

**[0060]** In addition to the rubber and the activated carbon described above, the following materials were prepared as other materials to be blended into the rubber composition.

S: Sulfur

DM: di-2-benzothiazolyl disulfide

D: 1,3-diphenylguanidine.

Comparative examples 1 to 4 and Examples 1 to 10

**[0061]** The rubber thus prepared, the activated carbon, and the other materials were blended in the blending ratios (mass ratios) shown in Table 2 below, and kneaded at 25 to 60 °C for 10 minutes using an open roll (device name: KD-M2-8, manufactured by KNEADER MACHINERY CO., LTD.). Thus, the rubber compositions were obtained.

Table 2

	C. Ex. 1	C. Ex. 2	C. Ex. 3	C. Ex. 4	Ex. 1	Ex. 2	Ex. 3
(a)	152						
(b)		174			174	174	174
(c)			196				
(d)				218			
S	2	2	2	2	2	2	2
DM	2	2	2	2	2	2	2
D	2	2	2	2	2	2	2
Activated Carbon A					0.1	0.5	1
Activated Carbon B							
Activated Carbon C							
Total	158	180	202	224	180.1	180.5	181

	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8	Ex. 9	Ex. 10
(a)			152				
(b)	174	174				174	174
(c)				196			
(d)					218		
S	2	2	2	2	2	2	2
DM	2	2	2	2	2	2	2
D	2	2	2	2	2	2	2
Activated Carbon A	5	10	5	5	5		
Activated Carbon B						5	
Activated Carbon C							5
Total	185	190	163	207	229	185	185

## Hardness measurement

**[0062]** The hardness of each of the rubber compositions of Comparative Examples 1 to 4 and Examples 1 to 10 was measured using "Asker Rubber Hardness Meter Type A" manufactured by Kobunshi Keiki Co., Ltd., as a Type A durometer based on JIS K 6253-3:2012. The results are shown in Table 3 below.

## Measurement of tensile strength and elongation at break

**[0063]** After the rubber compositions of Comparative Examples 1 to 4 and Examples 1 to 10 were each cut into a flat plate having a thickness of 4 mm, the flat plates were each cut using a dumbbell-shaped No. 2 punched mold based on JIS K 6251:2017 to obtain dumbbell-shaped test pieces for the respective resin compositions. For these test pieces, the tensile strength and the elongation at break of each of the test pieces were measured by performing a tensile test based on JIS K 6251:2017 using Autograph Precision Universal Testing Machine (Product name: "AG-50kNIS MS type" manufactured by Shimadzu Corporation) at 23°C and at a crosshead speed of 500 mm/min. The results are shown in Table 3 below.



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### Measurement of initial elastic modulus

**[0064]** After the rubber compositions of Comparative Examples 1 to 4 and Examples 1 to 10 were formed into a flat plate shape, they were cut into strips having a length of  $33 \pm 3$  mm, a width of  $5 \pm 1$  mm, and a thickness of  $2 \pm 1$  mm to obtain test pieces. The storage modulus [ $23^\circ\text{C}$ ] at  $23^\circ\text{C}$  of each of these test pieces was measured using a dynamic viscoelasticity measuring device "Rheogel-E4000" manufactured by UBE as a measuring device under the following conditions according to JIS K 7244-4:1999 (the same as in ISO 6721-4:1994), and it was set as an initial elastic modulus of each of the rubber compositions. The results are shown in Table 3.

Measuring mode: Tensile mode of sine wave distortion

Frequency: 10 Hz

Distance between chucks: 20 mm

Load: Automatic static load

Dynamic strain:  $5 \mu\text{m}$

Temperature rising rate:  $2^\circ\text{C}/\text{min}$

### Measurement of tear strength

**[0065]** The rubber compositions of Comparative Examples 1 to 4 and Examples 1 to 10 were heated at  $160^\circ\text{C}$  for 8 to 12 minutes using a mold for a flat plate having a thickness of 2 mm to obtain flat plate shaped test pieces having a thickness of 2 mm. For these test pieces, the tear strength of each of the test pieces was measured by performing the tear test based on JIS K 6252:2007 using a die cut in the form of a test piece of the standard shape. The results are shown in Table 3 below.

### Friction test

**[0066]** Test pieces each molded into a flat plate shape having a thickness of 2 mm were obtained by introducing the rubber composition of each of Comparative Examples 1 to 4 and Examples 1 to 10 into a flat plate shaped mold, followed by pressing at  $160^\circ\text{C}$  for 8 to 12 minutes (a predetermined appropriate vulcanization time  $T_{90} + 2$  minutes) using a device (name: Ram diameter of 12" 150 tons (manufactured by Nimei Koki Co., Ltd.)). The static friction coefficient and the dynamic friction coefficient in the water lubricated conditions were measured by wetting these test pieces with water and sliding the probe on the test pieces. Specifically, at an ambient temperature of  $24^\circ\text{C}$  and a relative humidity (RH) of 75%, the surface of each of the test pieces molded into a flat plate shape was wet with water, and an aluminum probe having a columnar shape (10 mm in diameter and 6.0 mm in length) was disposed on the water-wet surface of the test piece so that the surface of the test piece and the side face of the columnar body were in contact with each other. Thereafter, the columnar body was slid on the surface of the test piece in a direction orthogonal to the length direction of the probe at a vertical load of 0.981 N and a sliding speed of 10.0 mm/s, and the static friction coefficient and the dynamic friction coefficient at that time were measured. The results are shown in Table 3 below.

Table 3

	Rubber Type	Activated carbon phr/type	Hardness HA	Tensile strength MPa	Elongation at break %	Initial elastic modulus MPa	Tear strength N/mm	Static friction coefficient	Dynamic friction coefficient
C. Ex. 1	(a)	0	48	20.5	567.3	2.5	42.0	0.67	0.61
C. Ex. 2	(b)	0	60	24.8	558.6	5.6	68.3	0.57	0.50
C. Ex. 3	(c)	0	70	24.9	510.9	11.7	92.8	0.51	0.46
C. Ex. 4	(d)	0	79	22.9	426.6	18.6	90.2	0.39	0.34
C. Ex. 2	(b)	0	60	24.8	558.6	5.6	68.3	0.57	0.50
Ex. 1	(b)	0.1/A	59	24.7	503.5	5.7	63.3	0.58	0.52
Ex. 2	(b)	0.5/A	60	25.4	586.0	5.6	68.2	0.61	0.55
Ex. 3	(b)	1/A	59	25.2	608.1	5.3	68.6	0.62	0.62
Ex. 4	(b)	5/A	59	23.0	624.9	5.7	71.0	0.84	0.74
Ex. 5	(b)	10/A	60	20.4	593.2	5.8	65.1	0.74	0.68
Ex. 6	(a)	5/A	48	20.7	642.5	2.4	36.7	1.01	0.88
Ex. 4	(b)	5/A	59	23.0	624.9	5.7	71.0	0.84	0.74
Ex. 7	(c)	5/A	69	22.5	578.2	10.8	92.1	0.61	0.53
Ex. 8	(d)	5/A	77	21.5	514.0	17.2	96.2	0.45	0.43

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(continued)

	Rubber Type	Activated carbon phr/type	Hardness HA	Tensile strength MPa	Elongation at break %	Initial elastic modulus MPa	Tear strength N/mm	Static friction coefficient	Dynamic friction coefficient
C. Ex. 2	(b)	0	60	24.8	558.6	5.6	68.3	0.57	0.50
Ex. 4	(b)	5/A	59	23.0	624.9	5.7	71.0	0.84	0.74
Ex. 9	(b)	5/B	60	13.0	412.9	6.0	58.5	0.74	0.62
Ex. 10	(b)	5/C	61	23.2	566.5	6.2	55.3	0.81	0.75

## Evaluation

**[0067]** As is apparent from Table 3, it can be seen that the rubber compositions of Examples 1 to 10 including activated carbon are superior in the static friction coefficient and the dynamic friction coefficient in the water lubricated conditions compared with the rubber alone of Comparative Examples 1 to 4 including no activated carbon. For example, it can be seen that the rubber compositions of Examples 1 to 5 including the rubber (b) and activated carbon are superior in the static friction coefficient and the dynamic friction coefficient in the water lubricated conditions compared with the rubber (b) alone accompanied by no activated carbon according to Comparative Example 2.

**[0068]** Note that, although the rubber (a) alone according to Comparative Example 1 having a smaller content of the silane coupling agent than the rubber (b) is excellent in terms of the static friction coefficient and the dynamic friction coefficient, the mechanical strength such as hardness is greatly inferior to that of the rubber compositions of Examples 1 to 5. Therefore, it can be seen that the rubber compositions of Examples 1 to 5 have increased static friction coefficient and dynamic friction coefficient in the water lubricated conditions while maintaining sufficient mechanical strength. In this regard, it can be seen that the rubber compositions of Examples 1 to 3 in which the content of the activated carbon is 1 phr or less are excellent in terms of mechanical strength because the tensile strength is kept higher than that of the rubber compositions of Examples 4 and 5 in which the content of the activated carbon is 5 phr or more.

**[0069]** Note that, when the same test was performed using Shirasagi C M191, Shirasagi M M247, Carborafin M227, and Carborafin-6 M227 manufactured by Osaka Gas Chemical, which are other commercially available industrial activated carbons, respectively, in place of the activated carbon A of Examples 1 to 8, it was confirmed that almost the same effect as that of the activated carbon A was obtained. That is, it was also confirmed that the rubber compositions including these activated carbons have increased static friction coefficient and dynamic friction coefficient in the water lubricated conditions while keeping sufficient mechanical strength.

## REFERENCE SIGNS LIST

**[0070]**

- 10: Elastic body
- 11: Rubber
- 12: Activated carbon

**Claims**

1. A shoe sole composed of a rubber composition comprising rubber and activated carbon.
2. The shoe sole according to claim 1, wherein a tensile elastic modulus of the rubber composition is 10 MPa or less.
3. The shoe sole according to claim 1 or 2, wherein a content of the activated carbon in the rubber composition is 0.1% by mass or more and 5% by mass or less..
4. The shoe sole according to any one of claims 1 to 3, wherein the rubber composition further comprises silica, and a content of the silica in the rubber composition is 10 parts by mass or more and 100 parts by mass or less based on 100 parts by mass of the rubber.
5. The shoe sole according to any one of claims 1 to 4, wherein the rubber composition further comprises polyethylene glycol, and a content of the polyethylene glycol in the rubber composition is 0.1 parts by mass or more and 10 parts by mass or less based on 100 parts by mass of the rubber.
6. A shoe comprising the shoe sole according to any one of claims 1 to 5.

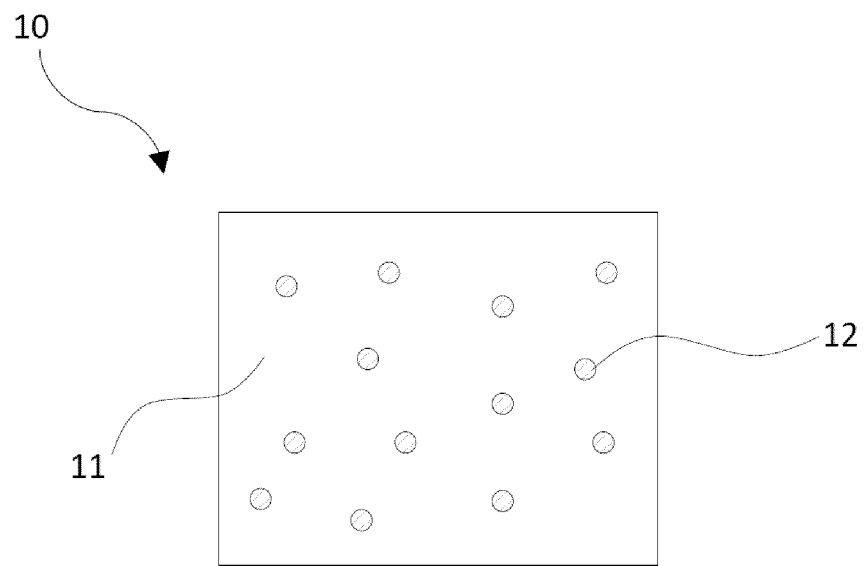


Fig. 1

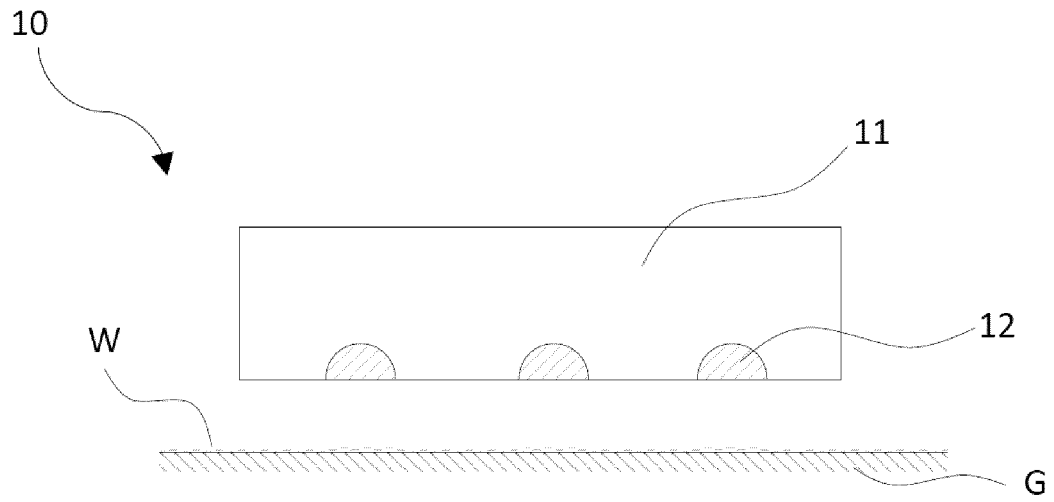


Fig. 2

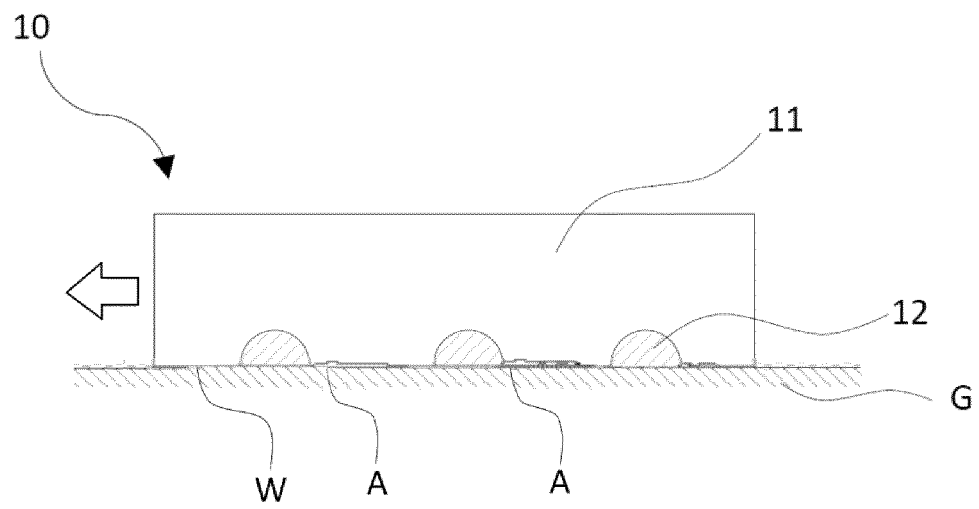


Fig. 3

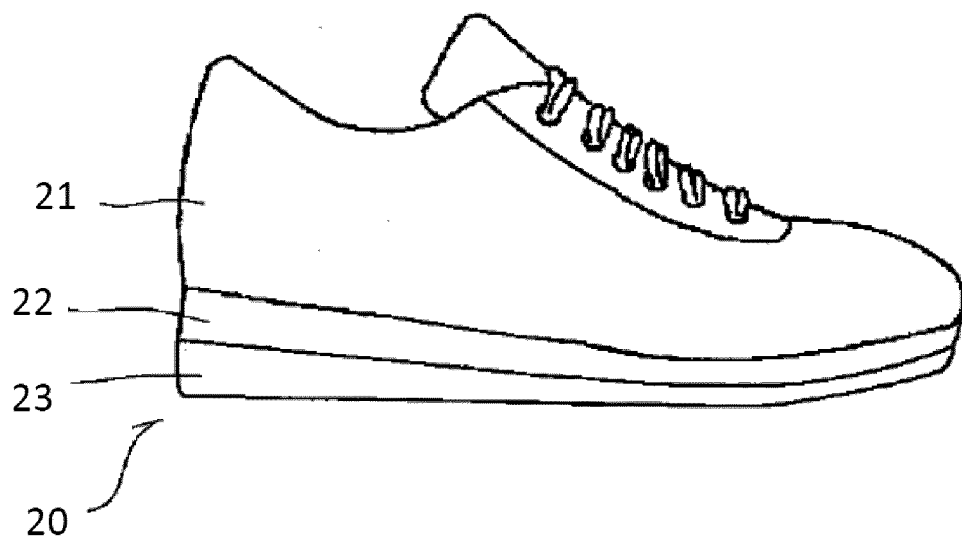


Fig. 4

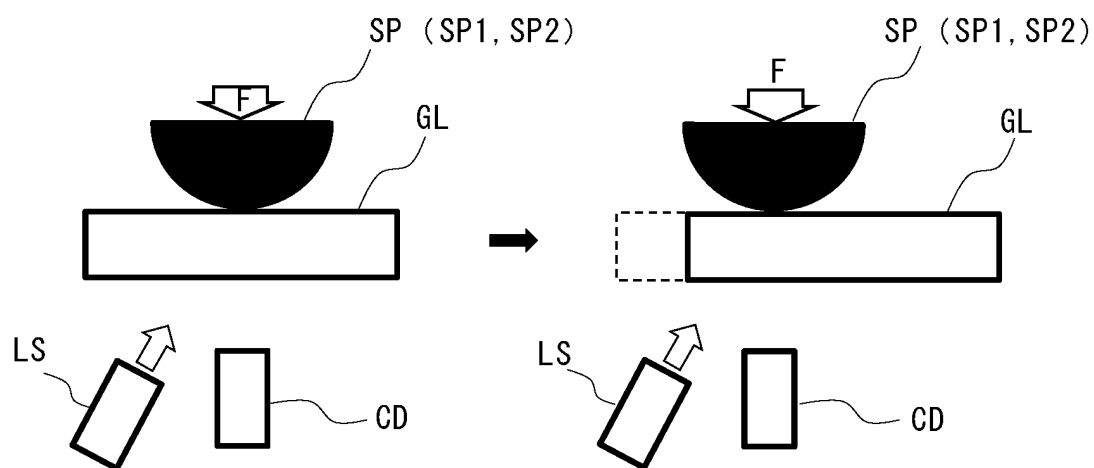


Fig. 5

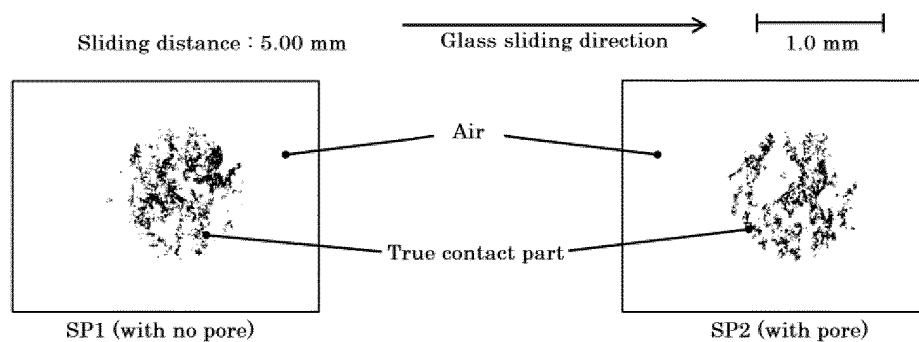


Fig. 6

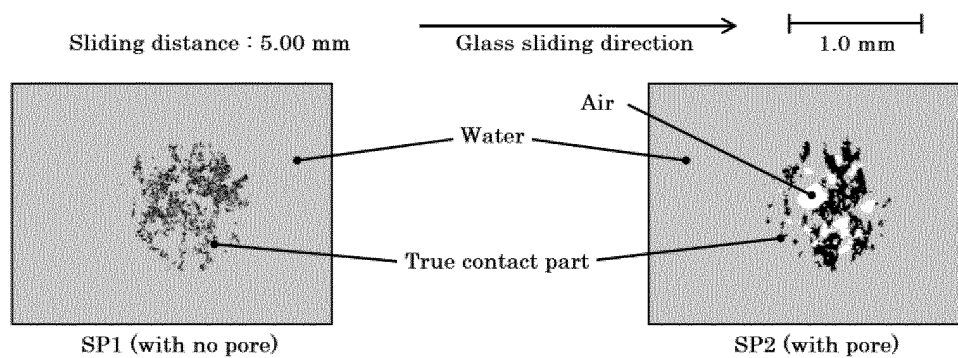


Fig. 7



True contact area during friction of hemispherical rubber/flat plate shaped glass

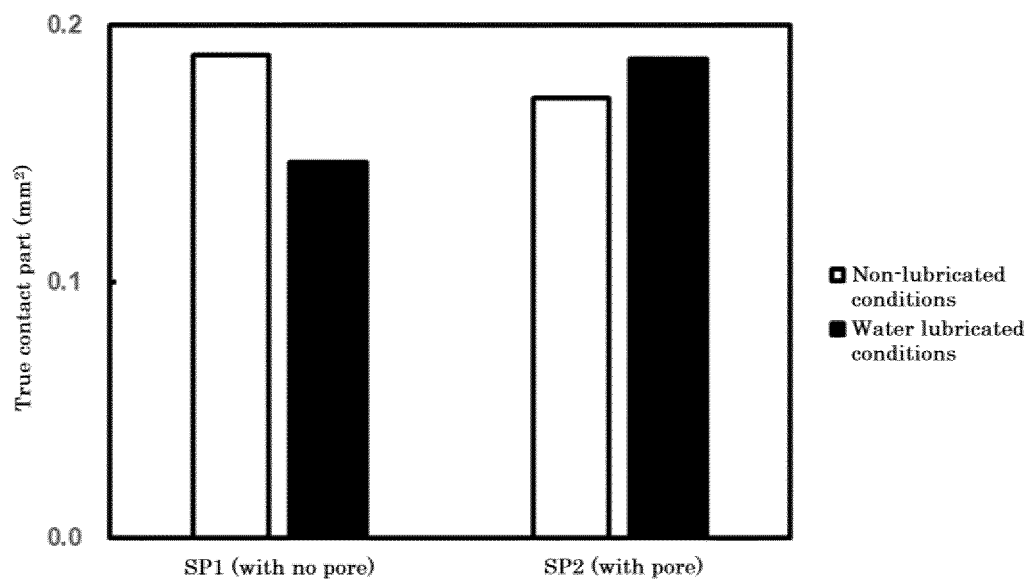


Fig. 8

Friction coefficient during friction of hemispherical rubber/flat plate

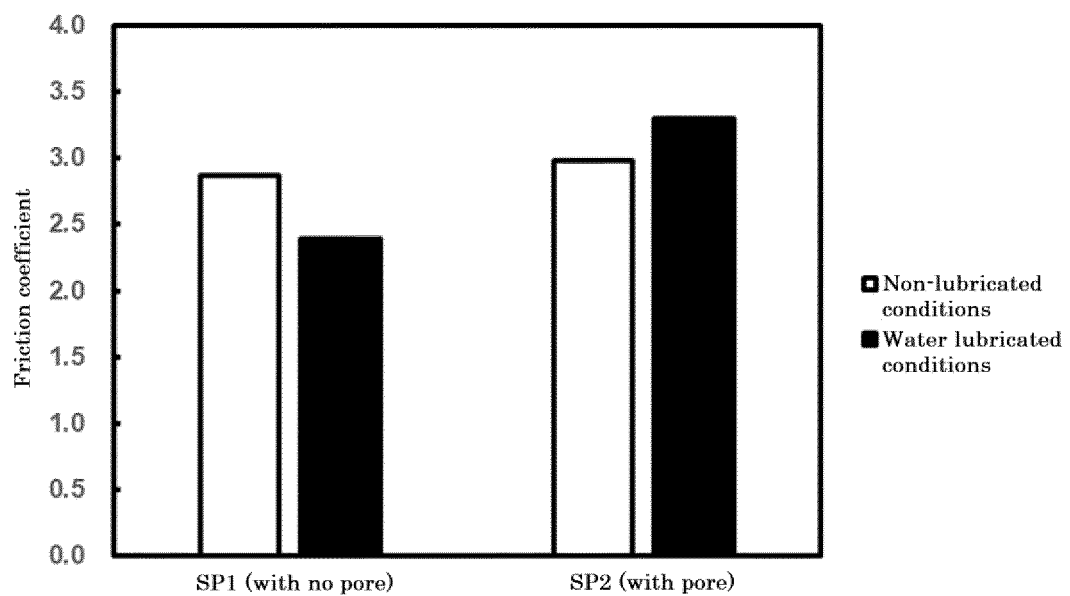


Fig. 9

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/009680

## A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. A43B13/02 (2006.01) i, A43B13/04 (2006.01) i  
 FI: A43B13/04 Z, A43B13/02 Z

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)

Int. Cl. A43B13/02, A43B13/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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.
Y	JP 2002-53700 A (AOKI ANZENGUTSU SEIZO KK) 19 February 2002, paragraphs [0001]-[0043]	1-6
Y	JP 10-231384 A (THE YOKOHAMA RUBBER CO., LTD.) 02 September 1998, claims 1-2, paragraphs [0001]- [0014]	1-6
Y	WO 2008/013060 A1 (UBE INDUSTRIES, LTD.) 31 January 2008, paragraphs [0064]-[0068], [0071]	2-6

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

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Date of the actual completion of the international search  
07.04.2020

Date of mailing of the international search report  
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## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/009680

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2002-53700 A	19.02.2002	(Family: none)	
JP 10-231384 A	02.09.1998	(Family: none)	
WO 2008/013060 A1	31.01.2008	US 2009/0239965 A1 paragraphs [0183]- [0202] EP 2045287 A1 CA 2635236 A CN 101365746 A KR 10-2009-0042752 A TW 200829654 A CA 2635236 A1	

Form PCT/ISA/210 (patent family annex) (January 2015)

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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