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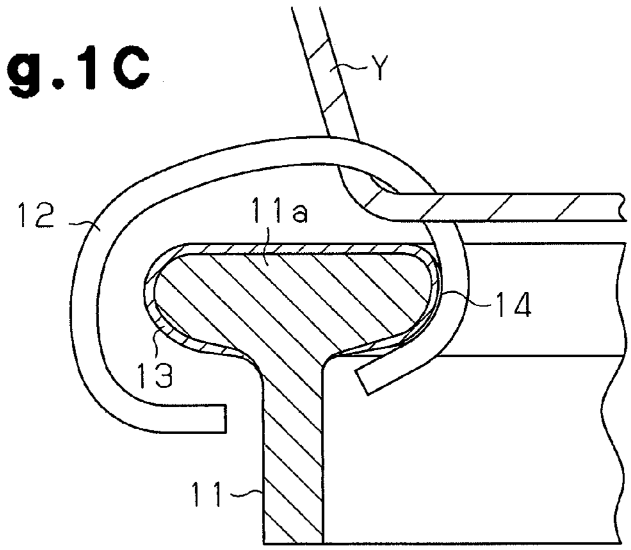
(54) **Ring-traveler system of ring spinning machine**

(57) A ring-traveler system of a ring spinning machine is of a non-liquid lubrication type. The ring-traveler system includes a ring and a traveler that travels along the ring. A plurality of recesses and a plurality of flat ridges are arranged alternately on a surface portion of one of the ring and the traveler. The other one of the ring and the traveler slides on the surface portion when the traveler travels. Each of the recesses has a depth of 0.1 to 20 μm. Each of the flat ridges has a width of 1 to 250 μm.

Fig.1C



EP 2 682 508 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a ring-traveler system of a ring spinning machine, and more particularly, to a ring-traveler system of a ring spinning machine that is free from liquid lubrication.

[0002] Various techniques have been proposed for ring-traveler systems of ring spinning frames to decrease frictional wear and seizing that affect the performance of the ring-traveler system, while increasing the speed and prolonging the life of the system. Such techniques include material variation, surface treatment, shape variation, and the use of liquid lubrication. In particular, the use of liquid lubrication is effective and relatively inexpensive. However, the passing yarn may be smeared with lubricating oil, and the use of oil leads to frequent maintenance. Thus, liquid lubrication is used for only limited applications such as spinning of woolen yarns.

[0003] Japanese National Phase Laid-Open Patent Publication No. 2002-510755 proposes the application of a surface treatment to the rings of a ring spinning frame or a ring twisting frame. The surface treatment reduces friction and is performed by plating hard chromium. The publication describes that the hard chromium plating preferably has a thickness of 1 to 60 μm and a maximum roughness Ra of 0.3 μm.

[0004] Although not directly related to ring spinning machines, International Publication No. WO2004/035255 describes a method for forming a microscopic periodic structure that reduces the friction resistance of a material surface. Specifically, a femtosecond pulsed laser beam is emitted to and scanned over the material surface so as to overlap irradiated portions. The interference between incident light and scattering light extending along the material surface causes ablation that forms a periodic structure. The periodic structure has submicron intervals and groove depths.

[0005] However, in the structure of Japanese National Phase Laid-Open Patent Publication No. 2002-510755, the reduction of friction is insufficient for the traveling, and wear may result in separation of the traveler. Further, the structure described in International Publication No. WO2004035255, in which a microscopic periodic structure is formed on the sliding surface, is designed for sliding under the presence of liquid lubrication. Thus, the application of this structure to a ring-traveler system that does not provide liquid lubrication causes early wear of the periodic structure that results in loss of the friction reduction effect.

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide a ring-traveler system of a ring spinning machine that obtains an improved, long-lasting friction reduction effect without using liquid lubrication.

[0007] To achieve the above object, one aspect of the present invention is a ring-traveler system of a ring spinning machine. The ring-traveler system is of a non-liquid lubrication type. The ring-traveler system includes a ring and a traveler that travels along the ring. A plurality of recesses and a plurality of flat ridges are arranged alternately on a surface portion of one of the ring and the traveler. The other one of the ring and the traveler slides on the surface portion when the traveler travels. Each of the recesses has a depth of 0.1 to 20 μm. Each of the flat ridges has a width of 1 to 250 μm.

[0008] The ring spinning machine includes a ring spinning frame and a ring twisting frame that wind a yarn through a traveler that slides along a ring, which is supported by a ring rail and lifted and lowered. The recess includes a groove and a dimple surround by a flat surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1A is a perspective view showing a ring of the first embodiment;
Fig. 1B is a partial enlarged view of the ring of Fig. 1A;
Fig. 1C is a schematic cross-sectional view showing the relationship between the ring and a traveler during spinning;
Figs. 2A to 2C are schematic cross-sectional views showing the relationships between grooves and flat ridges;
Figs. 3A to 3C are schematic views showing the directions of grooves;
Figs. 4A to 4C are schematic views showing relationships between grooves and flat ridges extending diagonally;
Fig. 5 is a graph showing the relationships between traveling resistance and traveling distance;
Fig. 6A is a schematic view showing wear of a traveler that is used with the ring of the first embodiment;
Fig. 6B is a schematic view showing wear of a traveler that is used with a commercial ring;
Fig. 7 is a schematic view showing recesses in a second embodiment;
Fig. 8 is a graph showing relationship between the traveling resistance and traveling distance;

Fig. 9A is a schematic view showing an abrasion of a traveler that is used with the ring of the second embodiment;
Fig. 9B is a schematic view showing an abrasion of a traveler that is used with a commercial ring;
Fig. 10 is a schematic cross-sectional view showing one embodiment that includes a solid lubrication coating on a recess wall;
Fig. 11A is a schematic cross-sectional view showing the shape of grooves in another embodiment;
Fig. 11 B is a schematic view showing the layout of grooves in another embodiment;
Fig. 11C is a partial cross-sectional view showing the shapes of the ring and traveler in another embodiment; and
Fig. 12 is a schematic view showing recesses in another embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[0010] Referring to Figs. 1A to 6B, a first embodiment of a ring-traveler system of a ring spinning frame will now be described.

[0011] Referring to Figs. 1A to 1C, a ring-traveler system includes a ring 11 and a traveler 12. The ring 11 includes a flange 11a having a T-shaped cross-section. The traveler 12 has a C-shaped cross-section. The ring 11 is made of a bearing steel. A plating layer 13 is applied to the flange 11a as shown in Figs. 1B and 1C. The plating layer 13 is chromium plating having a thickness of about 10 to 20 μm.

[0012] The plating layer 13 includes a periodic structure 14 (texture) in the surface portion on which the traveler 12 slides when the traveler 12 travels. In the present embodiment, the periodic structure 14 is formed on the inner circumference surface of the flange 11 a as shown in Fig. 1C. As shown in Figs. 2A to 4C, the periodic structure 14 includes grooves 15 and flat ridges 16 that are alternately arranged. The grooves 15 are also referred to as recesses. Each groove 15 has a depth of 0.1 to 20 μm. Preferably, each groove 15 has a depth of 5 μm or less. Each flat ridge 16 has a width of 1 to 250 μm. Preferably, each flat ridge 16 has a width of 10 to 50 μm.

[0013] The grooves 15 have a uniform width. As shown in Fig. 2A, each groove 15 may have a groove width W1 that is the same as a ridge width W2, which is the width of the flat ridge 16. Further, the groove width W1 may be wider as shown in Fig. 2B or narrower as shown in Fig. 2C than the ridge width W2. In addition, the grooves 15 may extend perpendicular to the circumferential direction of the ring 11 as shown in Fig. 3A, parallel to the circumferential direction of the ring 11 as shown in Fig. 3B, or diagonally to the circumferential direction of the ring 11 as shown in Fig. 3C. In Figs. 3A to 3C, the circumferential direction extends in the sideward direction.

[0014] The periodic structure 14 is formed, for example, by emitting a femtosecond pulsed laser to the portion of the ring 11 where the periodic structure 14 is to be formed.

[0015] The operation of the ring-traveler system will now be described. A yarn Y, which is fed from a draft part (not shown), passes through the traveler 12 as shown in Fig. 1C and is wound around a bobbin (not shown) that rotates at a high speed. The maximum rotation speed of the ring spinning frame during a normal spinning operation is about 25,000 rpm. The yarn Y applies tension, when being wound, to the traveler 12 so that the traveler 12 travels along the flange 11a. Although the orientation of the running traveler 12 slightly varies depending on the rotation speed, the traveler 12 travels in contact with the inner lower portion of the flange 11 a.

[0016] The ring-traveler system of the present embodiment includes the ring 11 with a surface portion provided with the periodic structure 14 on which the traveler 12 slides when the traveler 12 travels. The periodic structure 14 includes the grooves 15 and the flat ridges 16 that are alternately arranged. When the traveler 12 travels along the ring 11, the grooves 15 produce a wedge effect with the surrounding air and discharges foreign substances such as abrasion particles from the contact interface of the traveler 12 and the ring 11. Thus, a friction reduction effect is achieved without using liquid lubrication. In addition, the grooves 15 do not wear since the traveler 12 slides along the flat ridges 16. As a result, the present embodiment improves the friction reduction effect as compared to a conventional system, and the friction reduction effect continues for a long time. In addition, a conventional ring that has been used for a long time may be recycled by forming the periodic structure 14.

Example 1

[0017] First, rings 11 having periodic structures that do not include flat ridges were prepared to evaluate the effectiveness of the periodic structure 14. The periodic structures were formed by emitting a femtosecond pulsed laser to the designated portions of the rings 11. A ring-traveler system was prepared that included three different types of rings 11. The first ring 11 included periodic ridges and grooves arranged perpendicular to the circumferential direction of the ring 11. The second ring 11 included periodic ridges and grooves arranged parallel to the circumferential direction. The third ring 11 included periodic ridges and grooves arranged diagonally to the circumferential direction. As a comparative example, a ring-traveler system was prepared that included a commercial ring without a periodic structure. A spinning test was conducted without performing any preconditioning operations. The systems were tested until the traveling distance of each traveler 12 reached 6,600 km (33 doffing operations x 200 km of traveling distance of traveler 12 until doffing operations) to evaluate the relationship between the traveling resistance and the traveling distance. The traveling resistance was obtained by rotatably supporting the ring and measuring the drag force applied to the ring by the traveler.

[0018] The ring-traveler systems including the periodic structures 14 all had lower traveling resistances than the system including the commercial ring until the traveling distance reached 2,200 km. Then, between 2,600 and 4,200 km, the systems having the parallel and oblique periodic structures 14 had traveling resistances that were 30% lower than that of the system with commercial ring. However, the system with the perpendicular periodic structure 14 lost its superiority over the system with the commercial ring when reaching 13 doffing operations.

[0019] Then, the relationship between the traveling resistance and traveling distance was evaluated using the various types of rings 11 shown in Figs. 4A to 4C. The rings 11 each have the periodic structures 14 formed by periodic ridges and grooves arranged diagonally to the circumferential direction of the rings 11 (sideward direction as viewed in Fig. 4). As shown in Figs. 4A to 4C, the rings 11 vary in groove width W1 and ridge width W2 of the flat ridges 16. In Figs. 4A to 4C, the shaded portions are grooves 15, and the non-shaded portions are flat ridges 16.

[0020] Tests were conducted on rings 11 that include periodic structures 14 having grooves 15 extending at an angle of 45° relative to the circumferential direction of the ring 11. The rings 11 had different groove widths W1, ridge widths W2, and groove depths D as shown in Table 1 below. Spinning was performed by increasing the rotation speed in steps from 15,000 to 21,000 rpm in a preconditioning operation performed until the traveling distance reached 1,400 km. From the traveling distance of 1,600 km, spinning was performed at a high rotation speed of 22,000 rpm.

Table 1

Sample No.	Groove width (μm)	Ridge width (μm)	Groove depth (μm)
Sample 1	20	20	1
Sample 2	100	100	1
Sample 3	40	20	1
Sample 4	20	10	1
Sample 5	20	20	5
Sample 6	40	20	5
Sample 7	20	80	5

[0021] Fig. 5 shows the test results. As shown in Fig. 5, in the high-speed spinning after the preconditioning operation, all the rings 11 including the periodic structures 14 had lower traveling resistances than the commercial ring. The test verified the effectiveness of the periodic structure 14.

[0022] When comparing samples having the same groove width W1 and the same ridge width W2 but having different groove depths D, samples having a smaller groove depth have smaller traveling resistances. In samples having a groove width W1 of 20 μm and a ridge width W2 of 20 μm (samples 1 and 5) and samples having a groove width W1 of 40 μm and a ridge width W2 of 20 μm (samples 3 and 6), the samples with the lower groove depth (1 μm) had lower traveling resistances than the samples with the greater depth (5 μm). Thus, a groove depth of 1 μm is more preferable than a groove depth of 5 μm.

[0023] In addition, the travelers 12 were checked for abrasion. As shown in Fig. 6B, the traveler 12 used with the commercial ring had an abrasion 20 in the surface portion that was in contact with the ring. However, as shown in Fig. 6A, the traveler 12 that was used with the ring 11 having the periodic structure 14 had an abrasion 20' that was smaller than the abrasion 20.

[0024] The advantages of the present embodiment will now be described.

(1) The ring-traveler system of the ring spinning machine (ring spinning frame) includes the ring 11 that has the periodic structure 14 in the surface portion on which the traveler 12 slides when the traveler 12 travels. The periodic structure 14 includes recesses and flat ridges 16 that are alternately arranged. Each recess has a depth of 1 to 20 μm, and each flat ridge 16 has a width of 1 to 250 μm. The periodic structure 14 produces a wedge effect with the surrounding air when the traveler 12 slides along the ring 11. Thus, the present embodiment improves the friction reduction effect compared to the conventional system, and the friction reduction effect continues for a long time.

(2) The recesses are formed by grooves 15. The grooves 15 facilitate discharge of abrasion particles and enhances the friction reduction effect compared to when the recesses are formed by dimples.

(3) In view of the abrasion of the flat ridge 16 and the wedge effect of the periodic structure 14, the flat ridge 16

having a width in the range from 10 to 50 μm has a better friction reduction effect than when the width is outside this range.

(4) A recess (groove 15) having a depth of 5 μm or less improves the friction reduction effect.

(5) The periodic structure 14 includes the grooves 15 and the flat ridges 16 that form periodic projections and recesses arranged diagonally to the circumferential direction of the ring 11. This improves the friction reduction effect compared to when the periodic projections and depressions are arranged perpendicular to the circumferential direction.

Second Embodiment

[0025] Referring to Figs. 7 to 9, the second embodiment will now be described. The second embodiment differs from the first embodiment in that the recesses are formed by dimples 17 instead of grooves 15. Like or same reference numerals are given to those components that are the same as the corresponding components of the first embodiment. Such components will not be described in detail.

[0026] As shown in Fig. 7, each dimple 17 has a round opening. Each dimple 17 has a diameter of 5 to 50 μm and a depth of 1 to 10 μm. Adjacent dimples 17 are separated from each other by a distance of 10 to 100 μm. Thus, the dimples 17 satisfy the conditions in which the recesses having a depth of 0.1 to 20 μm and the flat ridges having a width of 1 to 250 μm are alternately arranged. The dimples 17 are formed by performing bead blasting on the portion of the ring 11 where a periodic structure is to be formed.

Example 2

[0027] A ring-traveler system was prepared that includes a ring 11. The portion of the ring 11 that requires a periodic structure included dimples 17 having a diameter of 10 μm and a depth of 2 μm. Adjacent dimples 17 were separated by a distance of 70 μm. As a comparison example, a ring-traveler system was prepared that includes a commercial ring that does not have dimples 17. A spinning test was conducted on the two systems. Spinning was performed by increasing the rotation speed in steps from 15,000 to 21,000 rpm in a preconditioning operation performed until the traveling distance reached 1,400 km. From the traveling distance of 1,600 km, spinning was performed at a high rotation speed of 22,000 rpm.

[0028] Fig. 8 shows the test results. As shown in Fig. 8, in the high-speed spinning after the preconditioning operation, the ring 11 with the dimples 17 had a lower traveling resistance than the commercial ring. The test verified the effectiveness of the dimples 17.

[0029] In addition, the traveler 12 was checked for abrasion. As shown in Fig. 9B, the traveler 12 used with the commercial ring had an abrasion 20 in the surface portion that was in contact with the ring. However, as shown in Fig. 9A, the traveler 12 used with the ring 11 including the dimples 17 had an abrasion 20' that was smaller than the abrasion 20.

[0030] Accordingly, the second embodiment has the following advantage in addition to advantage (1) of the first embodiment.

(6) Recesses are formed by round dimples 17 instead of grooves 15. This reduces the energy consumption required to form the recesses.

[0031] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

[0032] As shown in Fig. 10, a groove 15 or dimple 17, which serves as a recess, may have a wall surface to which a solid lubrication coating layer 18 is applied. The solid lubrication coating layer 18 is formed from a fluorine resin, for example. Here, the groove width W1, the groove depth D, the dimple diameter, and dimple depth are preferably set to be several micrometers or greater so that the groove 15 or the dimple 17 are not filled with the solid lubrication coating layer 18. Compared to a groove 15 or dimple 17 that does not include the solid lubrication coating layer 18, the groove 15 or dimple 17 including the solid lubrication coating layer 18 facilitates the discharge of fibers, abrasion particles, and other foreign matters from the groove 15 or the dimple 17. This avoids a decrease in the wedge effect of the recesses and the capability to discharge abrasion particles and other foreign matter from the contact surfaces of the traveler 12 and the ring 11.

[0033] The solid lubrication coating layers 18 only need to be formed in at least the recesses. Further, in addition to the wall surfaces of the grooves 15 or dimples 17, the solid lubrication coating layer 18 may be formed on the flat ridges 16. When forming the solid lubrication coating layer 18 on the flat ridge 16, after replacement of the traveler 12, cooperation is improved between the traveler 12 and the ring 11.

[0034] The groove 15 does not have to be symmetrical relative to a center line in the widthwise direction. For example, as shown in Fig. 11A, the groove 15 may have a deepest portion formed in one side located near a flat ridge 16, an arcuate surface extending from the deepest portion to the flat ridge 16, and an oblique surface extending from the deepest portion to a flat ridge 16 at the other side of the groove 15.

[0035] When forming the periodic structure 14 with grooves 15, the grooves 15 do not have to extend in one direction. For example, as shown in Fig. 11 B, the grooves 15 may include the grooves 15 extending parallel to the circumferential direction of the ring 11 and the grooves 15 extending diagonally to the circumferential direction of the ring 11. Furthermore, the grooves 15 may include two types of diagonal grooves 15 that form the same angle with the circumferential direction but extend in the opposite directions.

[0036] Each groove 15 extending diagonally to the circumferential direction of the ring 11 does not have to be arranged at an angle of 45° relative to the circumferential direction and may be arranged at any angle.

[0037] The dimple 17 does not have to have a round opening. For example, each dimple 17 may have an oval, elliptical rectangular, tetragonal, or polygonal opening. The dimples 17 having openings that are not round may be formed by emitting an extremely-short pulse laser such as a femtosecond pulsed laser instead of performing bead blasting. In addition, the dimples 17 are not required to have a uniform shape or size. As shown in Fig. 12, the dimples 17 may vary in shape and size. That is, the dimples 17 do not have to form a periodic structure.

[0038] The periodic structure 14 may be formed on the flange 11a without the plating layer 13. However, when the ring 11 is formed from the material used for present commercially available rings, the formation of plating layer 13 is desirable.

[0039] The flange 11 a of the ring 11 of the ring-traveler system is not required to have a T-shaped cross section. For example, the ring 11 may include a tilted flange 11a as shown in Fig. 11C. This structure requires a traveler 12 having a shape corresponding to the tilted flange 11a.

[0040] A method for forming the periodic structure 14 is not limited to the application of an extremely-short pulse laser such as a femtosecond pulsed laser to the portion that requires the periodic structure 14. For example, any chemical or physical process such as micro-etching may be performed.

[0041] The present invention is not applicable to a ring-traveler system that uses liquid lubrication since a yarn Y may be smeared with the liquid lubrication. However, the present invention is applicable to a ring-traveler system that uses solid lubrication such as polytetrafluoroethylene.

[0042] The periodic structure 14 may be formed on the traveler 12 of the ring-traveler system instead of the ring 11. However, the periodic structure 14 is preferably formed on the ring 11 since the periodic structure 14 on the traveler 12 has a significantly smaller area than the periodic structure 14 on the ring 11.

[0043] In addition to a ring spinning frame, the present invention may be embodied in other spinning machines having rings, such as a ring twisting frame.

[0044] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A ring-traveler system of a ring spinning machine, wherein the ring-traveler system is of a non-liquid lubrication type, the ring-traveler system comprising:

a ring (11); and
a traveler (12) that travels along the ring (11),
the ring-traveler system being **characterized in that**
a plurality of recesses (15, 17) and a plurality of flat ridges (16) are arranged alternately on a surface portion of one of the ring (11) and the traveler (12), the other one of the ring (11) and the traveler (12) sliding on the surface portion when the traveler (12) travels,
each of the recesses (15, 17) has a depth of 0.1 to 20 μm, and
each of the flat ridges has a width of 1 to 250 μm.

2. The ring-traveler system according to claim 1, wherein each of the flat ridges (16) has a width of 10 to 50 μm.

3. The ring-traveler system according to claim 1 or 2, wherein each of the recesses (15, 17) has a depth of 5 μm or less.

4. The ring-traveler system according to any one of claims 1 to 3, wherein the recesses are grooves (15).

5. The ring-traveler system according to claim 1, wherein
the recesses are round dimples (17), each having a diameter of 5 to 50 μm and a depth of 1 to 10 μm, and

adjacent ones of the dimples (17) are separated by a distance of 10 to 100 μm.

6. The ring-traveler system according to any one of claims 1 to 5, wherein among the recesses (15, 17) and the flat ridges (16), at least the recesses (15, 17) each include a solid lubrication coating layer (18).

7. A ring for a ring spinning machine, the ring (11) comprising a surface portion on which a traveler (12) slides when the traveler (12) travels, the ring (11) being **characterized in that**
a plurality of recesses (15, 17) and a plurality of flat ridges (16) are alternately arranged in the surface portion,
each of the recesses (15, 17) has a depth of 0.1 to 20 μm, and
each of the flat ridges (16) has a width of 1 to 250 μm.

8. A traveler for a ring spinning machine, the traveler (12) comprising a surface portion on which a ring (11) slides when the traveler (12) travels, the traveler (12) being **characterized in that**
a plurality of recesses (15, 17) and a plurality of flat ridges (16) are alternately arranged in the surface portion,
each of the recesses (15, 17) has a depth of 0.1 to 20 μm, and
each of the flat ridges (16) has a width of 1 to 250 μm.

Fig.1A

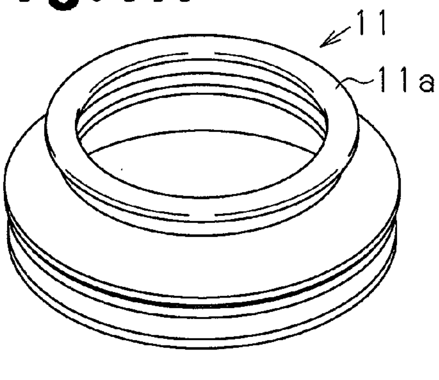


Fig.1B

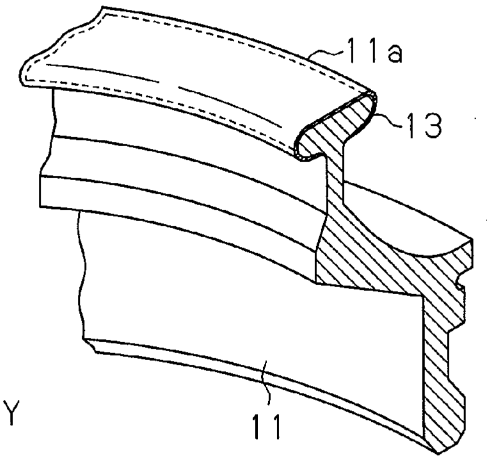


Fig.1C

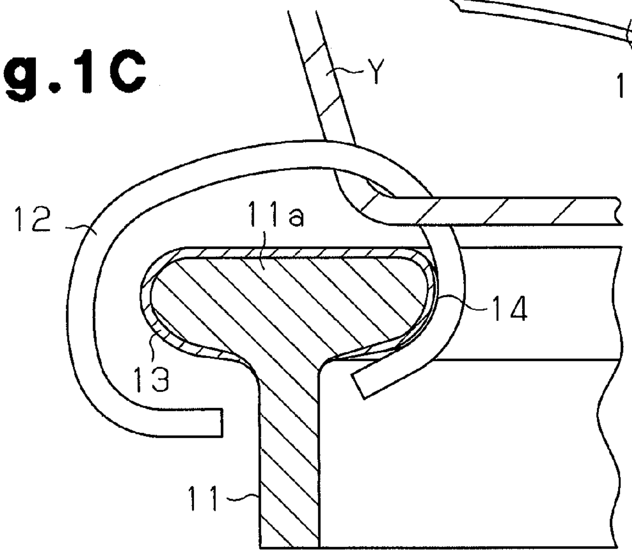


Fig.2A

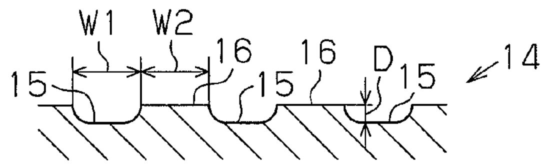


Fig.2B

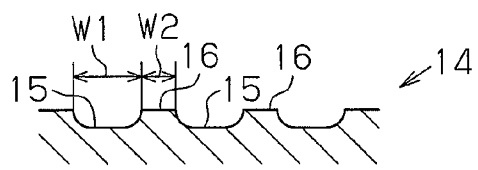


Fig.2C

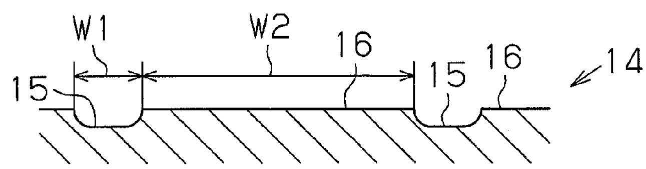


Fig.3A

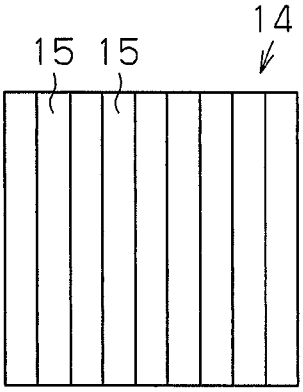


Fig.3B

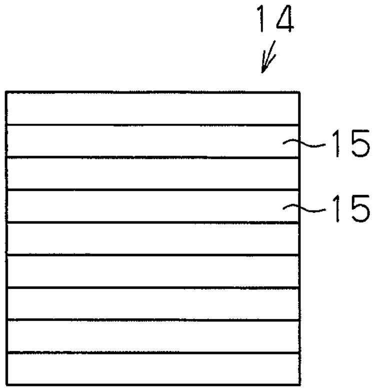


Fig.3C

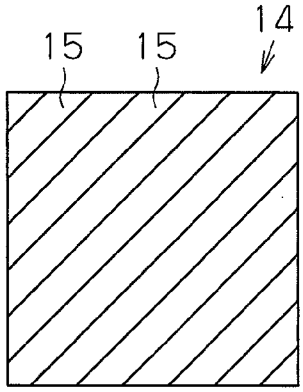


Fig.4A

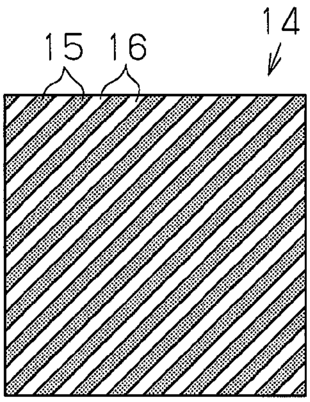


Fig.4B

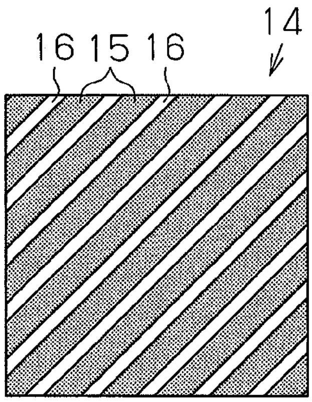


Fig.4C

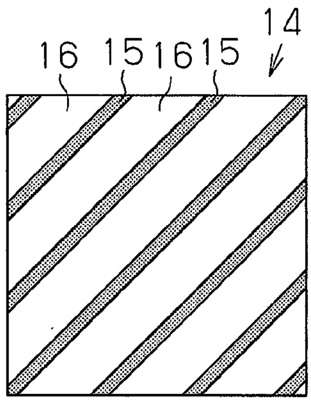
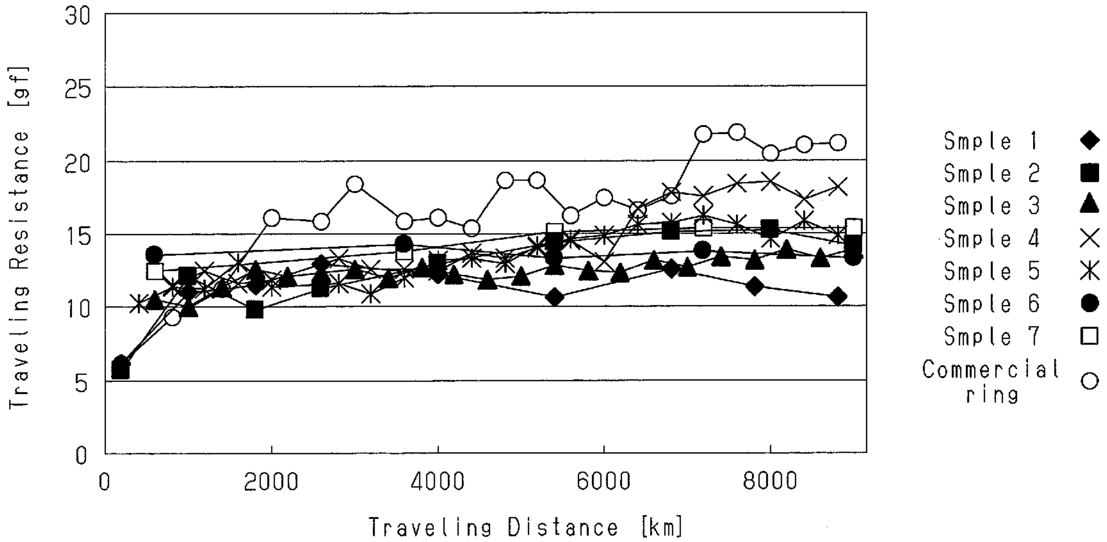


Fig.5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Traveling Resistance [gf]
0
2000
4000
6000
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Smple 2
Smple 3
Smple 4
Smple 5
Smple 6
Smple 7
Commercial ring

Fig.6A

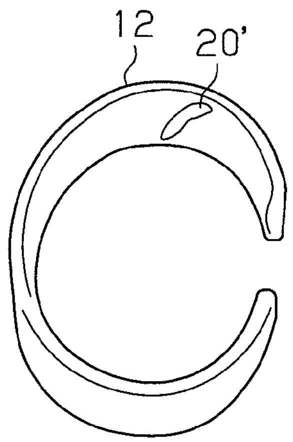


Fig.6B

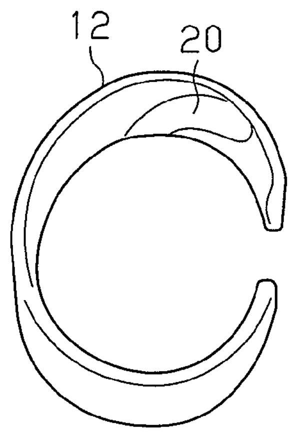


Fig.7

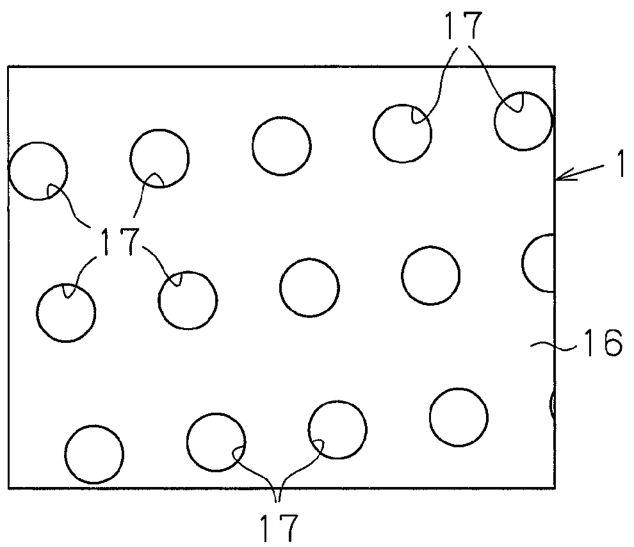


Fig.8

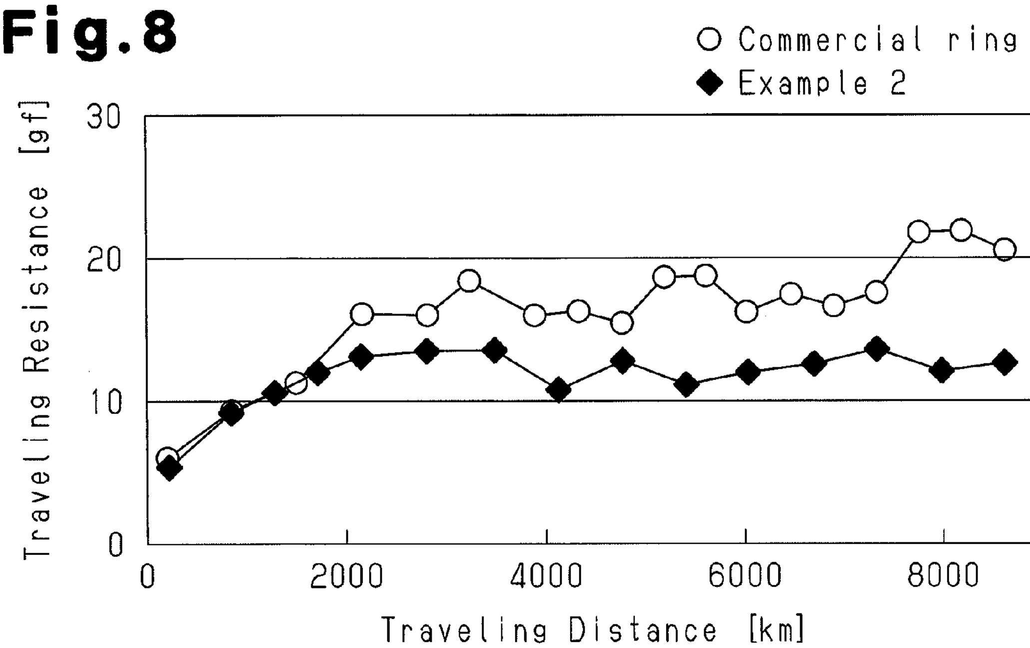


Fig.9A **Fig.9B**

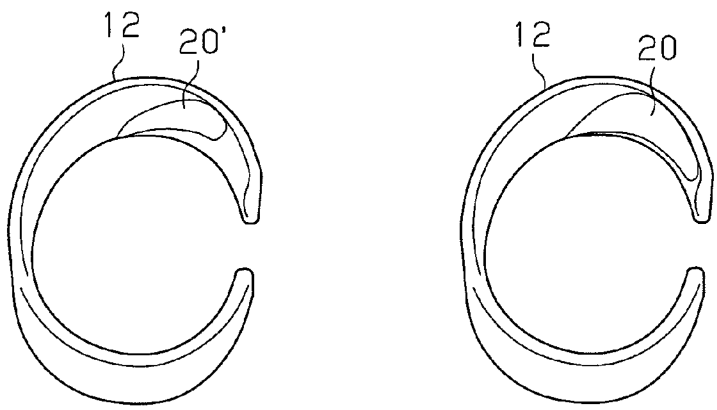


Fig.10

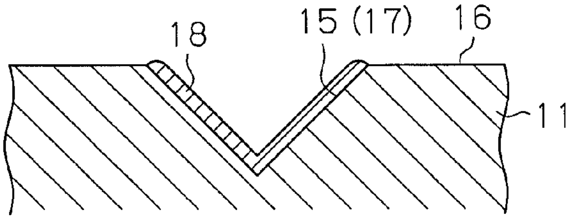


Fig.11A

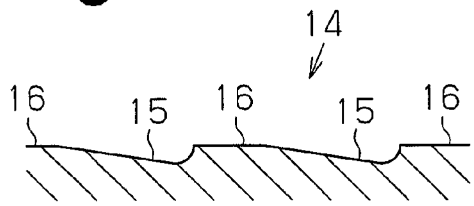


Fig.11B

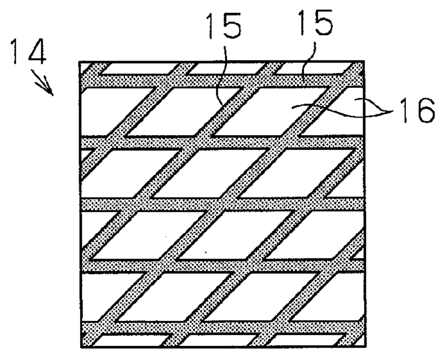


Fig.11C

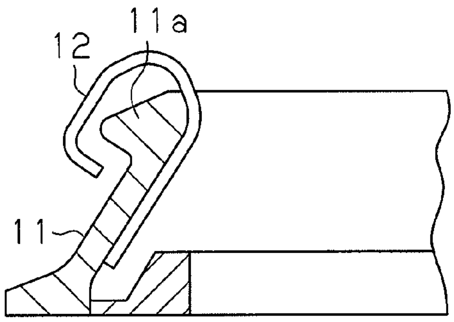
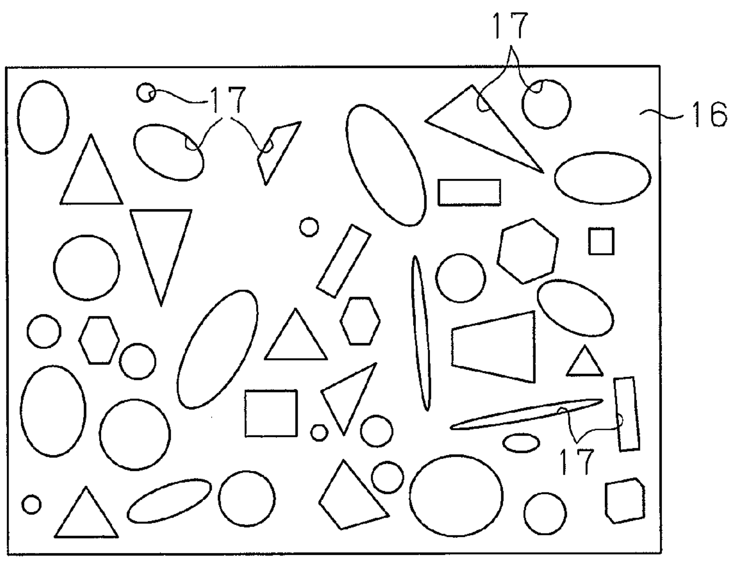


Fig.12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002510755 A **[0003] [0005]**
- WO 2004035255 A **[0004] [0005]**