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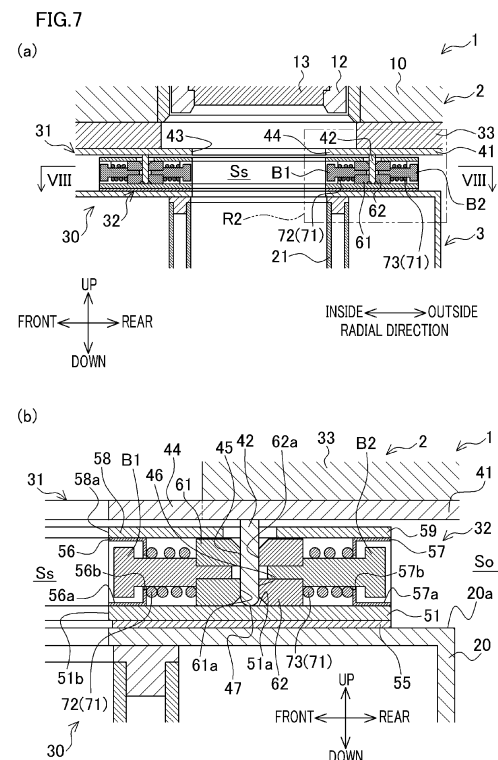
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(54) **YARN SPINNING SYSTEM**

(57) An unintentional change in length of a slow cooling space in an up-down direction is suppressed for a long time and required airtightness of the slow cooling space is maintained for a long time. A yarn spinning system 1 includes a spinning apparatus 2 and a cooler 3 movable between an operation position and a maintenance position. The yarn spinning system 1 further includes an air cylinder 28 which is configured to apply an upward force to the cooler 3, a cylindrical portion 42 which defines the length in an up-down direction of a slow cooling space Ss formed between a spinneret 13 of the spinning apparatus 2 and a cooling cylinder 21 of the cooler 3, and a seal 30 which seals a gap between the slow cooling space Ss and the outside space So. The seal 30 includes a contact portion 53, a biasing portion 54 configured to bias the contact portion 53 toward the cylindrical portion 42, and a first attaching portion 51 and an inner attaching plate 58 which seal a gap formed by the contact portion 53 and the biasing portion 54.



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a yarn spinning system.

[0002] Patent Literature 1 (Japanese Laid-Open Patent Publication No. 2008-138301) discloses a yarn spinning system configured to perform processes from spinning out of yarns made of synthetic fibers to winding of the yarns. To be more specific, the yarn spinning system includes a spinning apparatus and a cooler. The spinning apparatus has plural spinnerets and is configured to discharge liquid molten polymer from each spinneret, as a yarn material. The cooler includes plural cooling cylinders provided to correspond to the respective spinnerets and is configured to supply cooling air to the yarn material through the cooling cylinders. The yarn material is solidified by the cooling wind, with the result that a yarn formed of at least one filament is formed.

[0003] In the up-down direction, a space (slow cooling space) in which the descending yarn material is slowly cooled is formed between the spinning apparatus and the cooler. In order to suppress leakage of gas from the slow cooling space to the external space outside the slow cooling space, a sealing member (seal) is provided between the spinning apparatus and the cooler in the up-down direction. The seal is used as a regulating member (regulating portion) for regulating the length in the up-down direction of the slow cooling space, too. Hereinafter, the seal used as the regulating portion is termed a seal-cum-regulating portion.

[0004] Patent Literature 2 (Japanese Laid-Open Patent Publication No. 2016-108698) discloses a yarn spinning system including a seal and a regulating portion that are members different from each other. To be more specific, a cylindrical upper hood and an O-ring fitted to its side surface are provided as seals on the spinning apparatus side, whereas a cylindrical lower hood is provided as a seal on the cooler side. As the lower hood is provided inside the upper hood in the radial direction, the O-ring makes contact with the lower hood, with the result that the slow cooling space is sealed. An upper clamping stopper is provided as a regulating portion on the spinning apparatus side, whereas a slider plate is provided as a regulating portion on the cooler side.

SUMMARY OF THE INVENTION

[0005] Although not mentioned in Patent Literature 1, flexible rubber is typically used as a material of the seal-cum-regulating portion in order to improve the airtightness of the slow cooling space. Because the temperatures at around the spinning apparatus are high, i.e., about 260 to 300 degrees centigrade, the seal-cum-regulating portion tends to be deteriorated and deformed due to the heat, with the result that the length of the slow cooling space may be disadvantageously changed in the

up-down direction.

[0006] In this connection, as described in Patent Literature 2, it is possible to form the regulating portion by a material different from rubber, when the seal and the regulating portion are provided to be independent from each other. However, in the arrangement described in Patent Literature 2, the O-ring attached to the hot upper hood and making contact with the lower hood is typically an O-ring made of rubber. On this account, the O-ring may be deteriorated (i.e., the seal may be deteriorated) due to the heat, and the required airtightness may not be maintained for a long time.

[0007] An object of the present invention is to suppress an unintentional change in length of a slow cooling space in an up-down direction for a long time and to maintain required airtightness of the slow cooling space for a long time.

[0008] According to a first aspect of the invention, a yarn spinning system comprises: a spinning apparatus which includes spinnerets each of which is able to discharge a yarn material; and a cooler which includes cooling units capable of cooling the yarn material discharged from the spinnerets and is provided below the spinning apparatus, the yarn spinning system further comprising: a movement mechanism which is able to move the cooler between an operation position where the yarn material is spun out and a maintenance position below the operation position and which is configured to exert an upward force to the cooler when the cooler is at the operation position; regulating portions which are provided between the spinnerets and the cooling units in an up-down direction, respectively, and are arranged to define lengths in the up-down direction of slow cooling spaces formed between the spinnerets and the cooling units in the up-down direction, respectively, when the cooler is at the operation position; and seals which are arranged to seal gaps between the slow cooling spaces and an outside space outside the slow cooling spaces in a horizontal direction perpendicular to the up-down direction, when the cooler is at the operation position, each of the seals including: a contact portion which is attached to one of the spinning apparatus and the cooler, is provided to surround a corresponding one of the slow cooling spaces, and is arranged to make contact with the other of the spinning apparatus and the cooler; a biasing portion which is attached to the one of the spinning apparatus and the cooler, is independent from the movement mechanism, and is configured to bias the contact portion in a predetermined biasing direction toward the other of the spinning apparatus and the cooler; and a partition wall portion which is fixed to the one of the spinning apparatus and the cooler, is arranged to seal each of the gaps formed by the contact portion and the biasing portion, and separates a corresponding one of the slow cooling spaces from the outside space.

[0009] According to this aspect of the invention, in the seal, the biasing portion independent from the movement mechanism is able to press the contact portion onto the

other of the spinning apparatus and the cooler. Even if a gap is formed between the slow cooling space and the outside space by the contact portion and the biasing portion, the gap can be closed by the partition wall portion. Because the difference between the pressure of the slow cooling space and the pressure of the outside space is typically small, the required airtightness can be achieved by the seal. It is therefore possible to seal the gap formed between the slow cooling space and the outside space to some degree, without using members made of a rubber material as members forming the contact portion, the biasing portion, and the partition wall portion.

[0010] Because of the presence of the seal, the regulating portion may not be arranged to seal the gap between the slow cooling space and the outside space. It is therefore possible to use a member that is not made of a rubber material as a member constituting the regulating portion. On this account, deterioration and deformation of the regulating portion due to the heat generated by the spinning apparatus are suppressed. On this account, unintentional changes in length of the slow cooling space in the up-down direction are suppressed.

[0011] Due to this, it is possible to maintain the required airtightness of the slow cooling space for a long time, while suppressing unintentional changes in length of the slow cooling space in the up-down direction for a long time.

[0012] According to a second aspect of the invention, the yarn spinning system of the first aspect is arranged so that, when a temperature of the regulating portions is identical with a temperature when the spinning apparatus and the cooler are driven, the Young's modulus of a material of the regulating portions is equal to or higher than 10 GPa.

[0013] According to this aspect of the present invention, the Young's modulus of the material of which the regulating portion is made is high, i.e., 10 GPa, when the spinning apparatus and the cooler are driven. It is therefore possible to effectively suppress deformation of the regulating portion even if the regulating portion is pressurized as the cooler is pressed upward by the movement mechanism.

[0014] According to a third aspect of the invention, the yarn spinning system of the first or second aspect is arranged so that the regulating portions are made of a metal material.

[0015] Metal materials typically have characteristics such as a heat resisting property as compared to rubber materials, and hence deterioration and deformation are suppressed as compared to the rubber materials. According to the aspect of the invention, because the regulating portion is made of a metal material, it is possible to effectively suppress the need of early replacement of the regulating portion.

[0016] According to a fourth aspect of the invention, the yarn spinning system of any one of the first to third aspects is arranged so that, when a temperature of the contact portion is identical with a temperature when the

spinning apparatus and the cooler are driven, the Young's modulus of a material of the contact portion is equal to or higher than 10 GPa.

[0017] According to this aspect of the invention, because the contact portion is made of a hard material and distortion is suppressed, it is possible to effectively suppress the need of early replacement of the contact portion.

[0018] According to a fifth aspect of the invention, the yarn spinning system of any one of the first to fourth aspects is arranged so that the contact portion is made of a metal material.

[0019] In this aspect of the invention, because the contact portion is made of a metal material that is typically less likely to be deteriorated, it is possible to effectively suppress the need of early replacement of the contact portion.

[0020] According a sixth aspect of the invention, the yarn spinning system of any one of the first to fifth aspects is arranged so that the biasing portion includes a spring member.

[0021] The spring member is typically formed by a metal member that is less likely to be deteriorated. Therefore, the aspect of the invention makes it possible to effectively avoid the necessity of early replacement of the biasing portion.

[0022] According to a seventh aspect of the invention, the yarn spinning system of the sixth aspect is arranged so that the spring member is a compression coil spring.

[0023] In this aspect of the invention, because the compression coil spring is typically inexpensive, it is possible to suppress increase in the cost of components.

[0024] According to an eighth aspect of the invention, the yarn spinning system of any one of the first to seventh aspects is arranged so that the one of the spinning apparatus and the cooler is the cooler.

[0025] Members constituting the seal may be attached to the spinning apparatus. In this case, however, many members constituting the seal may be deteriorated due to the heat generated by the spinning apparatus. According to the aspect of the invention, it is possible to suppress excessive heating of these members because the members constituting the seal are attached to the cooler.

[0026] According to a ninth aspect of the invention, the yarn spinning system of any one of the first to eighth aspects is arranged so that the other of the spinning apparatus and the cooler includes extending portion which are provided to surround the respective slow cooling spaces when viewed in the up-down direction and which extend in the up-down direction, the contact portion is disposed to be in contact with a circumferential surface of a corresponding one of the extending portions, and the biasing direction intersects with the up-down direction.

[0027] The length in the up-down direction of the slow cooling space is typically required to be equal to or shorter than a predetermined length, in order to secure a good yarn quality. On this account, the size in the up-down

direction of the seal is severely restricted. Furthermore, because the biasing portion typically contracts and extends or moves in the biasing direction, an installation space having a sufficient size must be secured in the biasing direction. For this reason, when, for example, the biasing direction is substantially in parallel to the up-down direction, the degree of freedom in designing the biasing portion may be significantly lowered. In this regard, according to the aspect of the invention, the biasing direction intersects with the up-down direction (i.e., has a component in the horizontal direction). It is therefore possible to secure an installation space of the biasing portion in the horizontal direction, even if the size in the up-down direction of the seal is severely restricted. Due to this, the degree of freedom in designing the biasing portion is improved.

[0028] The length in the up-down direction of the slow cooling space must be particularly short when a narrow yarn is spun out. The slow cooling space is a relatively unstable region provided between the spinning apparatus and the cooler. On this account, when the slow cooling space is excessively long in the up-down direction, a narrow yarn particularly susceptible to external disturbance may be unstable in quality. In this regard, the present invention is particularly effective when a narrow yarn is produced, because the size of the seal is reduced in the up-down direction.

[0029] According to a tenth aspect of the invention, the yarn spinning system of the ninth aspect is arranged so that the regulating portions include the respective extending portions, and the extending portions define the lengths in the up-down direction of the respective slow cooling spaces.

[0030] In this aspect of the invention, the extending portions are each in contact with the contact portion and function as the regulating portions. It is therefore possible to reduce the number of components as compared to an arrangement in which a member in contact with the contact portion is different from a member constituting the regulating portion.

[0031] According to an eleventh aspect of the invention, the yarn spinning system of the tenth aspect further comprises a regulating surface which is positionally fixed in the up-down direction relative to the one of the spinning apparatus and the cooler and is arranged to be in contact with a leading end in the up-down direction of each of the extending portions when the cooler is at the operation position, the regulating surface being flat along the horizontal direction.

[0032] When the regulating surface in contact with the regulating portion is tilted relative to the horizontal direction, a change of the relative positions between the regulating portion and the regulating surface in the horizontal direction may result in a change of the relative positions between the regulating portion and the regulating surface in the up-down direction. Due to this, the length of the slow cooling space may be disadvantageously changed in the up-down direction. According to the aspect of the

invention, because the regulating surface is arranged to be flat along the horizontal direction, the disadvantage is suppressed.

[0033] According to a twelfth aspect of the invention, the yarn spinning system of any one of the ninth to eleventh aspects is arranged so that, when the cooler moves from the maintenance position to the operation position, the contact portion makes contact with the corresponding one of the extending portions so as to be movable at least in the horizontal direction against a biasing force of the biasing portion.

[0034] In this aspect of the invention, when the cooler moves from the maintenance position to the operation position, the contact portion is pressed by each of the extending portions and moved, even when the horizontal position of the contact portion is slightly deviated from the horizontal position of each of the extending portions. It is therefore possible to compensate a horizontal position deviation between each of the extending portions and the contact portion, while arranging each of the extending portions and the contact portion to be closely in contact with each other.

[0035] According to a thirteenth aspect of the invention, the yarn spinning system of any one of the ninth to twelfth aspects is arranged so that the circumferential surface of each of the extending portions includes an inner circumferential surface of each of the extending portions, the contact portion includes inner contact pieces which are aligned in a circumferential direction of the corresponding one of the extending portions and are provided to make contact with the inner circumferential surface of the corresponding one of the extending portions, the biasing portion includes inner biasing members which bias the inner contact pieces toward the inner circumferential surface, and when the corresponding one of the extending portions is in contact with the inner contact pieces, inner gaps that are gaps formed between the inner contact pieces in the circumferential direction are narrow in the circumferential direction as compared to a case where each of the extending portions is distanced from the inner contact pieces.

[0036] In an arrangement in which the contact portion makes contact with the circumferential surface of each of the extending portions, it is difficult to completely surround the slow cooling space by a member constituting the contact portion. In this regard, the aspect of the invention makes it possible to narrow the gap between the inner contact pieces in the circumferential direction, when each of the extending portions is in contact with the contact portion. It is therefore possible to minimize the decrease of the airtightness of the slow cooling space.

[0037] According to a fourteenth aspect of the invention, the yarn spinning system of the thirteenth aspect is arranged so that each of the inner contact pieces has an inner pressing surface that is provided at an outer end portion in a radial direction that is orthogonal to both the up-down direction and the circumferential direction, and when the corresponding one of the extending portions is

distanced from the inner contact pieces, the inner pressing surface at least partially overlaps each of the extending portions in the up-down direction and faces outward in the radial direction and toward the corresponding one of the extending portions in the up-down direction.

[0038] In this aspect of the invention, when each of the extending portions and the inner contact piece make contact with each other, the inner contact piece is pressed inward in the radial direction as each of the extending portions makes contact with the inner pressing surface. This allows each of the extending portions and the inner contact piece in contact with each other to smoothly move in the up-down direction relative to each other and allows the inner contact piece to move inward in the radial direction. It is therefore possible to cause the inner circumferential surface of each of the extending portions and the inner contact piece to make contact with each other simply by moving each of the extending portions and the inner contact piece in the up-down direction relative to each other.

[0039] According to a fifteenth aspect of the invention, the yarn spinning system of the thirteenth or fourteenth aspect is arranged so that the other of the spinning apparatus and the cooler includes disc-shaped portions which are adjacent to the respective extending portions in the up-down direction and are provided to be close to the other of the spinning apparatus and the cooler as compared to the extending portions, and a corresponding one of the disc-shaped portions at least partially overlaps the inner contact pieces in the up-down direction.

[0040] In this aspect of the invention, when each of the extending portions is in contact with inner contact pieces, the space in the vicinity of the inner contact pieces can be narrowed in the up-down direction by the disc-shaped portion. This arrangement further improves the airtightness of the slow cooling space.

[0041] According to a sixteenth aspect of the invention, the yarn spinning system of the fifteenth aspect is arranged so that the corresponding one of the disc-shaped portions opposes the partition wall portion in the up-down direction.

[0042] In this aspect of the invention, it is possible to narrow the space in the vicinity of the inner contact pieces in the up-down direction by the disc-shaped portion and the partition wall portion. This arrangement further improves the airtightness of the slow cooling space.

[0043] According to a seventeenth aspect of the invention, the yarn spinning system of any one of the thirteenth to sixteenth aspects is arranged so that the circumferential surface of each of the extending portions includes an outer circumferential surface of each of the extending portions, the contact portion includes outer contact pieces which are aligned in the circumferential direction of the corresponding one of the extending portions and are provided to make contact with the outer circumferential surface of the corresponding one of the extending portions, and the biasing portion includes outer biasing members which bias the respective outer contact pieces

toward the outer circumferential surface.

[0044] With this aspect of the invention, the outer contact pieces further improve the airtightness of the slow cooling space.

5 **[0045]** According to an eighteenth aspect of the invention, the yarn spinning system of the seventeenth aspect is arranged so that each of the outer contact pieces has an outer pressing surface that is provided at an inner end portion in the radial direction that is orthogonal to both the up-down direction and the circumferential direction, and when each of the extending portions is distanced from the outer contact pieces, the outer pressing surface at least partially overlaps the corresponding one of the extending portions in the up-down direction and faces inward in the radial direction and toward the corresponding one of the extending portions in the up-down direction.

10 **[0046]** In this aspect of the invention, it is possible to cause the outer circumference of each of the extending portions and the outer contact piece to make contact with each other simply by moving each of the extending portions and the outer contact piece in the up-down direction relative to each other.

15 **[0047]** According to a nineteenth aspect of the invention, the yarn spinning system of the seventeenth or eighteenth aspect is arranged so that outer gaps that are gaps formed between the outer contact pieces in the circumferential direction are positionally different from the inner gaps in the circumferential direction.

20 **[0048]** In this aspect of the invention, even if a passage of gas is unintentionally formed between the outer gaps and the inner gaps, it is possible to elongate the passage. This further suppresses gas from going in and out between the slow cooling space and the space outside the slow cooling space. On this account, the airtightness of the slow cooling space is further improved.

25 **[0049]** According to a 20th aspect of the invention, the yarn spinning system of any one of the ninth to nineteenth aspects is arranged so that each of the extending portions is ring-shaped when viewed in the up-down direction.

30 **[0050]** This aspect of the invention simplifies the shape of each of the extending portions.

35 **[0051]** According to a 21st aspect of the invention, the yarn spinning system of any one of the first to eighth aspects is arranged so that the contact portion includes a surrounding portion which surrounds a corresponding slow cooling space among the slow cooling spaces, the biasing portion is configured to bias the surrounding portion in the up-down direction, in a radial direction of the surrounding portion, the partition wall portion is provided (i) either inside the surrounding portion and the biasing portion or outside the surrounding portion and the biasing portion or (ii) both inside the surrounding portion and the biasing portion and outside the surrounding portion and the biasing portion, and the surrounding portion has an end face which faces the other of the spinning apparatus and the cooler in the up-down direction.

40 **[0052]** This aspect of the invention makes it possible to secure the airtightness of the slow cooling space by

causing the end face to make contact with the other of the spinning apparatus and the cooler. In this arrangement, the contact portion can be formed by a single component and the biasing direction can be set as a single direction. The structure of the seal is therefore simplified.

[0053] According to a 22nd aspect of the invention, the yarn spinning system of the 21st aspect is arranged so that the other of the spinning apparatus and the cooler has a contact surface which is provided to make contact with the end face of the surrounding portion, and when viewed in the up-down direction, one of the end face and the contact surface is inside the contour of the other of the end face and the contact surface.

[0054] In this aspect of the invention, even when the horizontal position of the contact portion is slightly deviated from the horizontal position of the other of the spinning apparatus and the cooler, the deviation does not hinder the achievement of the airtightness of the slow cooling space.

[0055] According to a 23rd aspect of the invention, the yarn spinning system of any one of the first to 22nd aspects is arranged so that, when the spinning apparatus and the cooler are driven, an absolute value of a difference between the pressure of each of the slow cooling spaces and the pressure of the outside space is less than 20 Pa.

[0056] In this aspect of the invention, because the difference between the pressure of the slow cooling space and the pressure of the outside space is small, gas leakage is easily suppressed when the contact portion is closely in contact with the other of the spinning apparatus and the cooler to some degree. On this account, the required airtightness of the slow cooling space can be easily achieved by the seal.

[0057] According to a 24th aspect of the invention, the yarn spinning system of any one of the first to 23rd aspects is arranged so that the regulating portions are formed by a single common member.

[0058] When plural regulating portions are formed by different members, the slow cooling spaces may be different in length in the up-down direction due to manufacturing variations between the regulating portions. The aspect of the invention makes it possible to suppress such variations in length in the up-down direction between the slow cooling spaces, because the regulating portions are formed of the common member.

[0059] According to a 25th aspect of the invention, the yarn spinning system of any one of the first to 24th aspects is arranged so that the contact portion is independent from the regulating portions.

[0060] This aspect of the invention makes it possible to maintain the length of the slow cooling space to be constant by the regulating portion, even if the contact portion is worn or deformed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0061]

FIG. 1 is a schematic representation of a yarn spinning system of an embodiment.

FIG. 2 illustrates a state in which a cooler is at a maintenance position.

FIG. 3 is a perspective view of the slow cooling unit and its surroundings.

FIG. 4(a) is a side cross sectional view of the slow cooling unit and its surroundings. FIG. 4(b) is a partial enlarged view of FIG. 4(a).

FIG. 5 is a cross section taken along a line V-V in FIG. 4(a).

Each of FIGs. 6(a) and 6(b) illustrates an operation of a sealing unit.

FIG. 7(a) is a side cross sectional view of the sealing unit and its surroundings when the cooler is at an operation position. FIG. 7(b) is a partial enlarged view of FIG. 7(a).

FIG. 8 is a cross section taken along a line VIII-VIII in FIG. 7(a).

Each of FIG. 9(a) and FIG. 9(b) is a side cross sectional view of a sealing unit of a modification and its surroundings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0062] The following will describe an embodiment of the present invention. Hereinafter, directions shown in FIG. 1 will be consistently used as an up-down direction and a front-rear direction, for convenience of explanation. The up-down direction (the up-down direction in the plane of FIG. 1) is a vertical direction in which the gravity acts. The front-rear direction (the left-right direction in the plane of FIG. 1) is a direction orthogonal to the up-down direction. A direction orthogonal to both the up-down direction and the front-rear direction (i.e., a direction perpendicular to the plane of FIG. 1) is set as a left-right direction.

(Yarn Spinning System)

[0063] The following will outline a yarn spinning system 1 of the present embodiment, with reference to the schematic representation of FIG. 1. The yarn spinning system 1 is a system configured to generate yarns Y formed of synthetic fibers. The yarn spinning system 1 includes a spinning apparatus 2, a cooler 3, a slow cooling unit 4, and an oil applicator 5.

[0064] The spinning apparatus 2 is a melt spinning device configured to be able to spin out yarns Y made of molten polymer. The spinning apparatus 2 includes a frame 10 that is substantially rectangular parallelepiped in shape, pack housings 11 formed in the frame 10, and spinning packs 12 attached to the respective pack housings 11. The spinning packs 12 are, for example, staggered to form two lines along the left-right direction. (The packs are not illustrated. As to the arrangement in the horizontal direction, see, e.g., later-described cooling cylinders 21 shown in FIG. 3.) To each spinning pack 12,

hot liquid molten polymer (yarn material) is supplied from an unillustrated pipe. At a lower end portion of each spinning pack 12, a spinneret 13 which is substantially disc-shaped is provided. The spinneret 13 has, for example, plural nozzles (not illustrated). The spinning pack 12 spins the yarn material out from the nozzles of the spinneret 13 (i.e., spins out a yarn Y). The yarn material spun out through the nozzles is cooled at the cooler 3 so that the yarn Y constituted by filaments f is formed. As such, one yarn Y is spun out from one spinneret 13. Alternatively, each spinneret 13 has only one nozzle. In such a case, the yarn Y is a mono-filament yarn. It is noted that the yarn material immediately after being discharged from the spinneret 13 (i.e., before cooled and solidified) is also equivalent to the yarn of the present invention. Furthermore, the spinning apparatus 2 is provided with an upper sealing member 31 (described later).

[0065] The cooler 3 is configured to cool and solidify the yarn material discharged from the spinnerets 13, by means of cooling wind. The cooler 3 is provided below the spinning apparatus 2. As shown in FIG. 1, the cooler 3 includes a box 20 and cooling cylinders 21 (cooling units of the present invention). FIG. 1 shows only one cooling cylinder 21.

[0066] The box 20 is a hollow member which is substantially rectangular parallelepiped in shape and to which plural cooling cylinders 21 are attached. At an upper end portion of the box 20, a top surface 20a that is substantially flat is formed to extend substantially horizontally. As shown in FIG. 1, for example, the internal space of the box 20 is partitioned into an upper space and a lower space by a flow adjustment plate 26 that is substantially horizontally provided. The flow adjustment plate 26 is made of a material having flow adjustment capability such as punching metal.

[0067] The cooling cylinders 21 are arranged to guide cooling wind to the yarn material. The cooling cylinders 21 are accommodated in the box 20 and fixed to the box 20. The cooling cylinders 21 extend in the up-down direction. The cooling cylinders 21 are provided immediately below the respective spinnerets 13. In other words, when viewed in the up-down direction, the cooling cylinder 21 is provided to surround the yarn material spun out from the spinneret 13. Each cooling cylinder 21 includes a punching filter 22 and a cooling filter 23. The punching filter 22 is a substantially cylindrical member. Being similar to the flow adjustment plate 26, the punching filter 22 is also formed of a material having flow adjustment capability such as punching metal. The punching filter 22 extends from the position of the lower end portion of the upper space (that is a space above the flow adjustment plate 26) of the box 20 to the position of the upper end portion of the box 20. The cooling filter 23 is substantially cylindrical in shape. A circumferential wall portion of the cooling filter 23 is, for example, made of a mesh material having flow adjustment capability. The cooling filter 23 is provided inside the punching filter 22 in the radial direction. Being similar to the punching filter 22, the cooling

filter 23 extends from the position of the lower end portion of the upper space of the box 20 to the position of the upper end portion of the box 20.

[0068] In the lower space of the box 20 (i.e., a space lower than the flow adjustment plate 26), partitioning cylinders 24 are provided directly below the cooling cylinders 21, respectively. Each partitioning cylinder 24 is arranged not to allow air to pass through in the radial direction of the partitioning cylinder 24. The yarn material which is discharged from a spinneret 13 and descends passes through the internal space of the cooling cylinder 21 directly below the spinneret 13 and the internal space of the partitioning cylinder 24 in this order.

[0069] To a rear part of a lower portion of the box 20, a duct 27 is connected. The duct 27 is connected to a compressed air source (not illustrated). The compressed air source supplies air for cooling the yarn material to the inside of the duct 27. The cooling air is supplied into the lower space of the box 20 through the duct 27. The flow of the air in the box 20 will be described below. (See the arrows in FIG. 1.) The air which flows into the lower space of the box 20 passes through the flow adjustment plate 26 to be adjusted to flow upward, and flows into the upper space of the box 20. In this regard, because the wall of the partitioning cylinder 24 does not allow air to pass through, air does not directly flow from the lower space of the box 20 into the partitioning cylinder 24. The air which flows into the upper space of the box 20 is adjusted while passing through the cooling cylinder 21. Subsequently, the air flows into the cooling cylinder 21 inward in the radial direction. As a result, the air is blown onto the yarn material from the entire outer circumference of the cooling cylinder 21, and the yarn material is cooled and made into the yarn Y.

[0070] The cooler 3 is arranged to be able to move in the up-down direction by an air cylinder 28 (movement mechanism of the present invention). To be more specific, the air cylinder 28 stands on the floor surface of a factory, for example. A piston rod 28a extends in the up-down direction. To the lower end of the box 20, a cover member 29 extending downward is fixed. To a side face of the cover member 29, a leading end portion of the piston rod 28a is fixed. With this arrangement, as the air cylinder 28 is driven, the entirety of the cooler 3 including the box 20 is movable between the operation position (see FIG. 1) where the yarn spinning system 1 operates and the maintenance position (see FIG. 2) below the operation position. When the cooler 3 is at the operation position, the yarns Y can be generated. When the cooler 3 is at the operation position, upward force (toward the spinning apparatus 2) is applied to the cooler 3 and the slow cooling unit 4 by the air cylinder 28. When the cooler 3 is at the maintenance position, a working space Sw is formed between the spinning apparatus 2 and the cooler 3 in the up-down direction. The working space Sw is a space where an operator performs tasks such as cleaning of the spinneret 13 while the yarns Y are not spun out from the spinning apparatus 2.

[0071] The slow cooling unit 4 is provided between the spinning apparatus 2 and the cooler 3 in the up-down direction. The slow cooling unit 4 is arranged to gradually cool the yarn material (i.e., perform slow cooling) until the yarn material discharged from the spinning apparatus 2 is cooled by the cooler 3. The slow cooling unit 4 has a slow cooling space Ss for slow cooling of the yarn material. When the yarn spinning system 1 is driven, a difference between the pressure in the slow cooling space Ss and the pressure in an outside space So (see FIG. 1) outside the slow cooling space Ss in the horizontal direction is small, i.e., about 0 Pa or more and 20 Pa or less. To put it differently, the slow cooling space Ss has a slightly positive pressure as compared to the outside space So. The slow cooling unit 4 will be detailed later.

[0072] The oil applicator 5 is configured to apply oil to the yarns Y. The oil applicator 5 is provided below the cooler 3. The oil applicator 5 includes oil guides (not illustrated) with which the yarns Y cooled by the cooler 3 make contact, respectively. At this stage, the oil guides discharge and apply oil to the respective yarns Y. The yarns Y to which the oil has been applied by the oil applicator 5 are taken up by a take-up roller (not illustrated). The yarns Y are then fed to a winding device (not illustrated). The yarns Y are wound onto bobbins (not illustrated) at the winding device.

(Details of Arrangement of Slow Cooling Unit)

[0073] The arrangement of the slow cooling unit 4 will be detailed with reference to FIG. 3 to FIG. 5. FIG. 3 is a perspective view of the slow cooling unit 4 and its surroundings when the cooler 3 is at the operation position. FIG. 3 does not show the spinning apparatus 2 in order to avoid the complexity. FIG. 4(a) is a side cross sectional view of the slow cooling unit 4 and its surroundings when the cooler 3 is at the maintenance position. FIG. 4(b) is an enlarged view of a part of FIG. 4(a) (i.e., a region R1 surrounded by a two-dot chain line). FIG. 5 is a cross section taken along a line V-V in FIG. 4(a). To suppress an unintentional change in length of the slow cooling space Ss in the up-down direction for a long time and to maintain the required airtightness of the slow cooling space Ss for a long time, the slow cooling unit 4 is arranged as described below.

[0074] The slow cooling unit 4 includes a seal 30 that is arranged to seal plural slow cooling spaces Ss. The seal 30 includes plural lower sealing mechanisms 32 (see FIG. 4(a) and FIG. 4(b)). The lower sealing mechanisms 32 are provided to seal the slow cooling spaces Ss together with the upper sealing member 31 (a common member of the present invention; see FIG. 3, FIG. 4 (a), and FIG. 4(b)). The upper sealing member 31 is provided in the spinning apparatus 2. The lower sealing mechanisms 32 are attached to the cooler 3. The spinning apparatus 2 is equivalent to "the other of the spinning apparatus and the cooler" in the present invention. The cooler 3 is equivalent to "one of the spinning apparatus and

the cooler" in the present invention. When the cooler 3 is at the maintenance position, the upper sealing member 31 is distanced from the lower sealing mechanisms 32 in the up-down direction (see FIG. 4(a) and FIG. 4(b)).

[0075] The upper sealing member 31 is commonly provided for sealing the slow cooling spaces Ss. The upper sealing member 31 is provided between the spinnerets 13 and the cooling cylinders 21 in the up-down direction. As shown in FIG. 3, the upper sealing member 31 extends along the horizontal direction. The upper sealing member 31 is fixed to the bottom surface of the spinning apparatus 2 by means of, for example, unillustrated bolts. In other words, the upper sealing member 31 is positionally fixed relative to the spinning apparatus 2 in the up-down direction. In the up-down direction, for example, a heat insulation member 33 is provided between the upper sealing member 31 and the spinning apparatus 2. The upper sealing member 31 is made of, for example, a metal material. The Young's modulus of the material of which the upper sealing member 31 is made is, for example, 10 GPa or higher when the temperature of the upper sealing member 31 is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. As shown in FIG. 4(a) and FIG. 4(b), the upper sealing member 31 includes a substantially flat plate portion 41 extending along the horizontal direction and plural cylindrical portions 42 each of which is integrated with the plate portion 41 and is substantially cylindrical in shape. The phrase "integrated with" indicates that the plate portion 41 and the cylindrical portions 42 are arranged in one of the following ways. The plate portion 41 and the cylindrical portions 42 may be formed of a single member. Alternatively, the plate portion 41 may be a member independent from the cylindrical portions 42, and they may be fixed to one another by, for example, welding or screwing. The cylindrical portion 42 is equivalent to an extending portion and a regulating portion of the present invention. To put it differently, the regulating portion is formed of the cylindrical portion 42 and is included in the extending portion.

[0076] In the plate portion 41, plural through holes 43 are formed to penetrate the plate portion 41 in the up-down direction (see FIG. 3 and FIG. 4(a)). The through holes 43 are provided to correspond to the respective spinnerets 13 and the respective cooling cylinders 21. Each of the through holes 43 is substantially circular when viewed in the up-down direction. Each through hole 43 is provided to overlap the corresponding spinneret 13 and the corresponding cooling cylinder 21 in the up-down direction. The cylindrical portions 42 are provided in the vicinity of the respective through holes 43. Each of the cylindrical portions 42 are provided outside the through hole 43 in the radial direction of the corresponding spinneret 13. That is to say, the plate portion 41 has plural substantially disc-shaped portions that are provided outside the through hole 43 and inside the cylindrical portion 42 in the radial direction of each through hole 43. Hereinafter, the substantially disc-shaped portions will be

termed disc-shaped portions 44. To be more specific, each of the disc-shaped portions 44 is a portion surrounded by each of two-dot chain lines in the plate portion 41 shown in FIG. 3. In the up-down direction, the disc-shaped portion 44 is provided in the vicinity of the corresponding cylindrical portion 42. Each cylindrical portion 42 protrudes downward from the bottom surface of the plate portion 41 and extends in the up-down direction. Each cylindrical portion 42 is provided to surround the entire circumference of the corresponding slow cooling space Ss. (In other words, each cylindrical portion 42 is provided around the corresponding slow cooling space Ss.) Each cylindrical portion 42 is substantially ring-shaped when viewed in the up-down direction. Each cylindrical portion 42 has an inner circumferential surface 45, an outer circumferential surface 46, and a bottom surface 47 (see FIG. 4(b)). The inner circumferential surface 45 is in contact with plural inner contact pieces 61 that will be described later. The outer circumferential surface 46 is in contact with plural outer contact pieces 62 that will be described later. Each of the inner circumferential surface 45 and the outer circumferential surface 46 is circular in shape when viewed in the up-down direction. The inner circumferential surface 45 and the outer circumferential surface 46 are encompassed in a circumferential surface of the present invention. The bottom surface 47 is provided at a lower end in the up-down direction of the cylindrical portion 42 (i.e., at the leading end in the up-down direction). The bottom surface 47 defines the length in the up-down direction of the slow cooling space Ss as the bottom surface 47 makes contact with a later-described first attaching portion 51. The bottom surface 47 is, for example, curved to be U-shaped in a cross section in parallel to the up-down direction (see FIG. 4(a) and FIG. 4(b)). It is noted that the shape of the bottom surface 47 is not limited to this arrangement.

[0077] The lower sealing mechanisms 32 are provided to correspond to the respective cylindrical portions 42 of the upper sealing member 31 (and the respective disc-shaped portions 44). The lower sealing mechanisms 32 are provided directly below the respective spinnerets 13. Each of the lower sealing mechanisms 32 includes the first attaching portion 51, a second attaching portion 52, a contact portion 53, and a biasing portion 54 as shown in FIG. 4(a) and FIG. 4(b). In summary, between the first attaching portion 51 and the second attaching portion 52 that are lined up in the up-down direction and extend substantially horizontally, the contact portion 53 and the biasing portion 54 are provided. The first attaching portion 51 and the second attaching portion 52 are arranged to seal a gap formed by the contact portion 53 and the biasing portion 54. The first attaching portion 51 and the second attaching portion 52 are equivalent to a partition wall portion of the present invention. The contact portion 53 is arranged to make contact with the corresponding cylindrical portion 42. The contact portion 53 is independent from the cylindrical portion 42. The biasing portion 54 is arranged to bias the contact portion 53 toward the

cylindrical portion 42.

[0078] The explanation will be continued with the focus on the lower sealing mechanism 32 shown in FIG. 4(a), FIG. 4(b), and FIG. 5. For convenience, the circumferential direction of the cylindrical portion 42 corresponding to the lower sealing mechanism 32 will be simply referred to as a circumferential direction (see FIG. 5). The radial direction of the cylindrical portion 42 will be simply referred to as a radial direction. The radial direction is a direction orthogonal to both the up-down direction and the circumferential direction.

[0079] The first attaching portion 51 is substantially horizontally provided. The first attaching portion 51 is made of, for example, a metal material. The Young's modulus of the material of which the first attaching portion 51 is made is, for example, 10 GPa or higher when the temperature of the first attaching portion 51 is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. The first attaching portion 51 is, for example, substantially disc-shaped. As shown in FIG. 4(b), the first attaching portion 51 includes a top surface 51a (regulating surface of the present invention). The top surface 51a defines the length in the up-down direction of the slow cooling space Ss as the top surface 51a makes contact with the bottom surface 47 of the cylindrical portion 42. The top surface 51a is substantially flat in shape and is arranged to be substantially planar along the horizontal direction. At a substantial center in the radial direction of the first attaching portion 51, a through hole 51b is formed to penetrate the first attaching portion 51 in the up-down direction (see FIG. 4(b)). The through hole 51b forms a part of the slow cooling space Ss in the up-down direction. The first attaching portion 51 is fixed to the upper end portion of the box 20 by means of, for example, unillustrated bolts. In other words, the first attaching portion 51 is positionally fixed relative to the cooler 3 in the up-down direction. In the up-down direction, for example, a plate-shaped sealing member 55 (see FIG. 4(b)) is provided between the first attaching portion 51 and the upper end portion of the box 20. The sealing member 55 is provided at a location relatively far from the spinning apparatus 2 in the up-down direction. On this account, the sealing member 55 may be made of a rubber material, for example.

[0080] In the first attaching portion 51, to a part which is in the vicinity of the through hole 51b, an inner fixing ring 56 (see FIG. 4(a), FIG. 4(b), and FIG. 5) that is substantially ring-shaped is attached. The inner fixing ring 56 is made of a metal material, for example. The inner fixing ring 56 is arranged to be substantially horizontal and is fixed to the top surface 51a (see FIG. 4(b)) of the first attaching portion 51 by, for example, unillustrated bolts. The inner fixing ring 56 has plural recesses 56a which are open inward in the radial direction. In the inner fixing ring 56, furthermore, a through hole 56b is formed at a position outside each recess 56a in the radial direction so as to penetrate the inner fixing ring 56 in a direction in parallel to the radial direction. Into the recesses 56a

and the through holes 56b, bolt members B1 are inserted, respectively. The bolt members B1 are fixed to the later-described inner contact pieces 61. Each of the bolt members B1 is, for example, a known half-threaded bolt (i.e., a male screw is formed only at a portion on the leading end side). The leading end portion of the bolt member B1 extends outward in the radial direction (see FIG. 4(a) and FIG. 4(b)). Outward movement of a head portion of the bolt member B1 in the radial direction is restricted by the periphery of the through hole 56b of the inner fixing ring 56.

[0081] On the outer side of the inner fixing ring 56 in the radial direction (to be more specific, at around the outer end portion of the first attaching portion 51 in the radial direction), an outer fixing ring 57 (see FIG. 4 (a), FIG. 4(b), and FIG. 5) that is substantially ring-shaped is provided. The outer fixing ring 57 is made of, for example, a metal material. The outer fixing ring 57 is arranged to be substantially horizontal and is fixed to the top surface 51a of the first attaching portion 51 by, for example, unillustrated bolts. The outer fixing ring 57 has plural recesses 57a which are open outward in the radial direction. In the outer fixing ring 57, furthermore, a through hole 57b is formed at a position inside each recess 57a in the radial direction so as to penetrate the outer fixing ring 57 in a direction in parallel to the radial direction. Into the recesses 57a and the through holes 57b, bolt members B2 are inserted, respectively. The bolt members B2 are fixed to the later-described outer contact pieces 62. Each of the bolt members B2 is, for example, a known half-threaded bolt in the same manner as the bolt member B1. The leading end portion of the bolt member B2 extends inward in the radial direction (see FIG. 4(a) and FIG. 4(b)). Inward movement of a head portion of the bolt member B2 in the radial direction is restricted by the periphery of the through hole 57b of the outer fixing ring 57.

[0082] The second attaching portion 52 includes an inner attaching plate 58 and an outer attaching plate 59 (see FIG. 4(a) and FIG. 4(b)). The second attaching portion 52 is made of, for example, a metal material. The inner attaching plate 58 is substantially disc-shaped. In the inner attaching plate 58, a through hole 58a is formed to penetrate the inner attaching plate 58 in the up-down direction (see FIG. 4(b)). The through hole 58a forms a part of the slow cooling space Ss in the up-down direction. When viewed in the up-down direction, the center of the through hole 58a is substantially identical with the center of the through hole 51b in term of position. The inner attaching plate 58 is fixed to the upper end face of the inner fixing ring 56 by means of, for example, unillustrated bolts. The inner attaching plate 58 at least partially overlaps the disc-shaped portion 44 in the up-down direction (see FIG. 4(a)). In other words, the inner attaching plate 58 opposes the disc-shaped portion 44 in the up-down direction. The outer attaching plate 59 is substantially disc-shaped. The outer attaching plate 59 is fixed to the upper end face of the outer fixing ring 57 by means of, for example, unillustrated bolts. The outer attaching plate

59 is provided outside the inner attaching plate 58 in the radial direction. The position in the up-down direction of the outer attaching plate 59 is substantially identical with the position in the up-down direction of the inner attaching plate 58. In the radial direction, a gap G is formed between the outer attaching plate 59 and the inner attaching plate 58 (see FIG. 4(a) and FIG. 4(b)).

[0083] The contact portion 53 is provided between the first attaching portion 51 and the second attaching portion 52 in the up-down direction. The contact portion 53 includes plural inner contact pieces 61 and plural outer contact pieces 62 (see FIG. 4(a), FIG. 4(b), and FIG. 5). When the cooler 3 is at the maintenance position, the cylindrical portion 42 is distanced from the contact portion 53 in the up-down direction. (Hereinafter, this state will be termed a distanced state.) The contact portion 53 is movable in the up-down direction relative to the cylindrical portion 42, in accordance with the movement of the cooler 3 in the up-down direction. In other words, the cylindrical portion 42 and the contact portion 53 are movable relative to each other in the up-down direction. The cylindrical portion 42 and the contact portion 53 are therefore switchable between the distanced state and a contact state (detailed later) in which these portions are in contact with each other.

[0084] The inner contact pieces 61 are arranged to make contact with the inner circumferential surface 45 of the cylindrical portion 42 (as detailed later). Each of the inner contact piece 61 is made of, for example, a metal material. The Young's modulus of the material of which each inner contact piece 61 is made is, for example, 10 GPa or higher when the temperature of each inner contact piece 61 is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. As shown in FIG. 4(a) to FIG. 5, the inner contact pieces 61 are provided outside the inner fixing ring 56 in the radial direction. Each of the inner contact pieces 61 is shaped as a piece of a substantially ring-shaped ring member (not illustrated) divided in the circumferential direction. In the present embodiment, the contact portion 53 includes three inner contact pieces 61. To be more specific, when viewed in the up-down direction, the shape of a surface (outer circumferential surface 61a) on the outer side in the radial direction of each inner contact piece 61 is an arc formed by equally dividing a circle into three (see FIG. 5). The curvature radius of the outer circumferential surface 61a is substantially identical with the radius of the inner circumferential surface 45 of the cylindrical portion 42. In the inner circumferential surface of each inner contact piece 61, female screws (not illustrated) are formed to be separated from one another in the circumferential direction. The above-described male screw of the bolt member B1 is screwed into the female screw. The inner contact pieces 61 at least partially overlap the disc-shaped portion 44 in the up-down direction. The inner contact pieces 61 are arranged to be movable in the radial direction. To be more specific, each inner contact piece 61 is slidable in the radial direction relative

to the first attaching portion 51 and the second attaching portion 52. The bottom surface of each inner contact piece 61 is in contact with, for example, the top surface 51a of the first attaching portion 51. The distance between the top surface of each inner contact piece 61 and the bottom surface of the second attaching portion 52 in the up-down direction is about 0.2 mm. Surfaces (end faces 61b) formed at the respective ends in the circumferential direction of each inner contact piece 61 are provided to be able to make contact with the end faces 61b of the neighboring inner contact piece 61 in the circumferential direction (as detailed later). Between the two opposing end faces 61b, an inner gap G1 is formed.

[0085] At an outer end portion in the radial direction of each inner contact piece 61, an inner pressing surface 61c (see FIG. 4(b)) is formed. When the cylindrical portion 42 and the contact portion 53 are in the above-described distanced state, the inner pressing surface 61c at least partially overlaps the cylindrical portion 42 in the up-down direction. When the cylindrical portion 42 and the contact portion 53 are in the above-described distanced state, the inner pressing surface 61c faces outward in the radial direction and toward the cylindrical portion 42 side in the up-down direction (i.e., upward in the present embodiment).

[0086] The outer contact pieces 62 are arranged to make contact with the outer circumferential surface 46 of the cylindrical portion 42 (as detailed later). Each of the outer contact pieces 62 is made of, for example, a metal material. The Young's modulus of the material of which each outer contact piece 62 is made is, for example, 10 GPa or higher when the temperature of each outer contact piece 62 is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. The outer contact pieces 62 are provided outside the inner contact pieces 61 in the radial direction and inside the outer fixing ring 57 in the radial direction. Each of the outer contact pieces 62 is shaped as a piece of a substantially ring-shaped ring member (not illustrated) divided in the circumferential direction. In the present embodiment, the contact portion 53 includes three outer contact pieces 62. To be more specific, when viewed in the up-down direction, the shape of a surface (inner circumferential surface 62a) on the inner side in the radial direction of each outer contact piece 62 is, for example, an arc formed by equally dividing a circle into three (see FIG. 5). The curvature radius of the inner circumferential surface 62a is substantially identical with the radius of the outer circumferential surface 46 of the cylindrical portion 42. In the outer circumference of each outer contact piece 62, female screws (not illustrated) are formed to be separated from one another in the circumferential direction. The above-described male screw of the bolt member B2 is screwed into the female screw. The outer contact pieces 62 are arranged to be movable in the radial direction. To be more specific, each outer contact piece 62 is slidable in the radial direction relative to the first attaching portion 51 and the second attaching portion 52. The bot-

tom surface of each outer contact piece 62 is in contact with, for example, the top surface 51a of the first attaching portion 51. The distance between the top surface of each outer contact piece 62 and the bottom surface of the second attaching portion 52 in the up-down direction is about 0.2 mm. Surfaces (end faces 62b) formed at the respective ends in the circumferential direction of each outer contact piece 62 are provided to be positionally different from the end faces 61b in the circumferential direction. In other words, an outer gap G2 formed between two opposing end faces 62b is positionally different from the inner gap G1 in the circumferential direction.

[0087] At an inner end portion in the radial direction of each outer contact piece 62, an outer pressing surface 62c (see FIG. 4(b)) is formed. When the cylindrical portion 42 and the contact portion 53 are in the distanced state, the outer pressing surface 62c at least partially overlaps the cylindrical portion 42 in the up-down direction. When the cylindrical portion 42 and the contact portion 53 are in the distanced state, the outer pressing surface 62c faces inward in the radial direction and toward the cylindrical portion 42 side in the up-down direction (i.e., upward in the present embodiment).

[0088] The biasing portion 54 is provided with spring members 71 (biasing members). Each spring member 71 is, for example, a compression coil spring made of a metal material. As shown in FIG. 4(a) to FIG. 5, the spring members 71 include inner spring members 72 (inner biasing members of the present invention) and outer spring members 73 (outer biasing members of the present invention). The inner spring members 72 are provided outside the inner fixing ring 56 and inside the inner contact pieces 61 in the radial direction. In the present embodiment, for example, six inner spring members 72 are provided as the inner spring members 72 (see FIG. 5). Two inner spring members 72 are provided to correspond to one inner contact piece 61. Into each inner spring member 72, a part of the bolt member B1, which is between the head portion and the male screw, is inserted. One end of the inner spring member 72 is in contact with the outer circumferential surface of the inner fixing ring 56. The other end of the inner spring member 72 is in contact with the inner circumferential surface of the corresponding inner contact piece 61. With this arrangement, each inner spring member 72 biases the corresponding inner contact piece 61 outward in the radial direction.

[0089] The outer spring members 73 are provided outside the outer contact pieces 62 and inside the outer fixing ring 57 in the radial direction. In the present embodiment, for example, six inner spring member 72 are provided as the outer spring members 73 (see FIG. 5). Two outer spring members 73 are provided to correspond to one outer contact piece 62. Into each outer spring member 73, a part of the bolt member B2, which is between the head portion and the male screw, is inserted. One end of the outer spring member 73 is in contact with the inner circumferential surface of the outer fixing ring 57. The other end of the outer spring member 73 is in contact

with the outer circumference of the corresponding outer contact piece 62. With this arrangement, each outer spring member 73 biases the corresponding outer contact piece 62 inward in the radial direction. When the cylindrical portion 42 and the contact portion 53 are in the distanced state, the outer circumferential surface 61a of the inner contact piece 61 is in contact with the inner circumferential surface 62a of the outer contact piece 62.

[0090] When the cylindrical portion 42 and the contact portion 53 are in the distanced state, the operator is allowed to reach members such as the spinneret 13 by a cleaning tool (not illustrated), through the gap formed between the cylindrical portion 42 and the contact portion 53. The operator is therefore able to perform maintenance operations including cleaning of members such as the spinneret 13.

(Operations of Sealing Mechanism)

[0091] Now, the following will describe operations of the seal 30 when the cooler 3 is moved up from the maintenance position to the operation position, with reference to FIG. 6(a) to FIG. 8. FIG. 6(a) illustrates the operations of the lower sealing mechanism 32 when the contact portion 53 starts to make contact with the cylindrical portion 42. FIG. 6(b) illustrates a state in which the lower sealing mechanism 32 is further moved up from the state shown in FIG. 6(a). FIG. 7(a) is a side cross sectional view of the slow cooling unit 4 and its surroundings when the cooler 3 is at the operation position. FIG. 7(b) is an enlarged view of a part of FIG. 7(a) (i.e., a region R2 surrounded by a two-dot chain line). FIG. 8 is a cross section taken along a line VIII-VIII in FIG. 7(a).

[0092] As the cooler 3 at the maintenance position is moved upward by the air cylinder 28, the cooler 3 is ascended to the operation position. Accordingly, the lower sealing mechanism 32 attached to the cooler 3 is ascended, too (see an arrow in FIG. 6(a)). In the ascending process of the lower sealing mechanism 32, as shown in FIG. 6(a), a lower part of the cylindrical portion 42 relatively passes through the gap between the inner attaching plate 58 and the outer attaching plate 59, and the inner contact piece 61 and the outer contact piece 62 of the contact portion 53 make contact with the cylindrical portion 42. To be more specific, the inner pressing surface 61c of the inner contact piece 61 and the outer pressing surface 62c of the outer contact piece 62 make contact with the bottom surface 47 of the cylindrical portion 42. At this stage, an upward force is exerted to the inner contact piece 61 and the outer contact piece 62 by the air cylinder 28. Due to the law of action and reaction, a downward force is exerted to the inner contact piece 61 and the outer contact piece 62 by the cylindrical portion 42. Because the inner pressing surface 61c faces upward and outward in the radial direction, a force that is downward and inward in the radial direction is exerted to the inner pressing surface 61c (see an arrow in FIG. 6(a)). As a result of this, the inner contact piece 61 is moved inward

in the radial direction by the cylindrical portion 42. Because the outer pressing surface 62c faces upward and inward in the radial direction, a force that is downward and outward in the radial direction is exerted to the outer pressing surface 62c (see an arrow in FIG. 6(a)). As a result of this, the outer pressing surface 62c is moved outward in the radial direction by the cylindrical portion 42. As the lower sealing mechanism 32 is further ascended, the inner contact piece 61 and the bolt member B1 move further inward in the radial direction, whereas the outer contact piece 62 and the bolt member B2 move further outward in the radial direction (see an arrow in FIG. 6(b)). At this stage, the inner spring member 72 and the outer spring member 73 are pressed in the radial direction by the cylindrical portion 42 and are elastically deformed.

[0093] In this way, when the cooler 3 moves from the maintenance position to the operation position, the contact portion 53 makes contact with the cylindrical portion 42 and is therefore movable at least in the horizontal direction against the biasing force of the biasing portion 54.

[0094] When the movement of the cooler 3 to the operation position is completed, as shown in FIG. 7(a) and FIG. 7(b), the outer circumferential surface 61a of the inner contact piece 61 makes contact with the inner circumferential surface 45 of the cylindrical portion 42 and the inner circumferential surface 62a of the outer contact piece 62 makes contact with the outer circumferential surface 46 of the cylindrical portion 42 (contact state). The inner contact piece 61 is biased outward in the radial direction (i.e., toward the cylindrical portion 42) by the elastic restoring force of the inner spring member 72. The outer contact piece 62 is biased inward in the radial direction (i.e., toward the cylindrical portion 42) by the elastic restoring force of the outer spring member 73. To put it differently, the inner contact piece 61 and the outer contact piece 62 are biased in directions substantially orthogonal to the up-down direction (i.e., biased in intersecting directions). The radial direction is equivalent to a biasing direction of the present invention. The gap formed by the contact portion 53 and the biasing portion 54 is sealed by the first attaching portion 51 and the second attaching portion 52.

[0095] When the cooler 3 is at the operation position, as shown in FIG. 7(a) and FIG. 7(b), the bottom surface 47 of the cylindrical portion 42 is in contact with the top surface 51a of the first attaching portion 51. This restricts the movement of the cylindrical portion 42 and the first attaching portion 51 in the up-down direction. On this account, the length in the up-down direction of the slow cooling space Ss is defined by the cylindrical portion 42 and the first attaching portion 51 that are in contact with each other. When the cooler 3 is at the operation position, the distance between the bottom surface of the disc-shaped portion 44 of the plate portion 41 and the top surface of the inner attaching plate 58 in the up-down direction is, for example, about 1.1 mm. In this way, the

gap between the disc-shaped portion 44 and the inner attaching plate 58 is narrow. However, the size of the gap is not limited to the specific value described above.

[0096] As described above, the curvature radius of the outer circumferential surface 61a of the inner contact piece 61 is substantially identical with the radius of the inner circumferential surface 45 of the cylindrical portion 42. On this account, when the cooler 3 is at the operation position (i.e., when the cylindrical portion 42 and the contact portion 53 are in the contact state), the outer circumferential surface 61a is closely in contact with the inner circumferential surface 45 as shown in FIG. 8.

[0097] When the cylindrical portion 42 and the contact portion 53 are in the contact state, the inner contact piece 61 is at an inner position in the radial direction as compared to a case where the cylindrical portion 42 and the contact portion 53 are in the distanced state. At this stage, two neighboring end faces 61b oppose each other within a short distance or are in contact with each other. When the cylindrical portion 42 and the contact portion 53 are in the contact state, the inner gap G1 is narrow in the circumferential direction as compared to a case where the cylindrical portion 42 and the contact portion 53 are in the distanced state. This makes it possible to improve the airtightness of the slow cooling space Ss.

[0098] As described above, the curvature radius of the inner circumferential surface 62a of the outer contact piece 62 is substantially identical with the radius of the outer circumferential surface 46 of the cylindrical portion 42. With this arrangement, when the cylindrical portion 42 and the contact portion 53 are in the contact state, the inner circumferential surface 62a is closely in contact with the outer circumferential surface 46 as shown in FIG. 8.

[0099] The inner gap G1 and the outer gap G2 are positionally different from each other in the circumferential direction. On this account, movement of gas between the slow cooling space Ss and the space outside the slow cooling space Ss in the radial direction is suppressed.

(Evaluation of Sealing Property)

[0100] Now, the following will describe evaluation of a sealing property of the seal 30 arranged as described above and a result of the evaluation. The inventor of the subject application prepared a test chamber (not illustrated) having substantially the same structure as the seal 30. To be more specific, the inventor of the subject application prepared a box-shaped member (hereinafter, a box member) that was slightly larger than the contact portion 53 when viewed in the up-down direction. The box member was a substantially cube-shaped, was made of metal, and was hollow. The inventor of the subject application sealed the bottom surface of the box member by an unillustrated plate member. The inventor of the subject application formed an air inlet in one (first side surface) of four side surfaces of the box member. The inventor of the subject application formed an air outlet

(first outlet) in a side surface (second side surface) opposing the first side surface. The inventor of the subject application formed the other air outlet (second outlet) in one of the remaining two side surfaces, and attached a differential pressure gauge to the other of the two side surfaces. The differential pressure gauge is a known gauge for measuring a differential pressure between the internal space of the test chamber and the outside space. The inventor of the subject application provided, at the top surface of the box member, a seal having the same structure as the contact portion 53, and attached a below-described lid member to the seal. The lid member includes a cylinder identical in shape with the above-described cylindrical portion 42 and a disc identical in shape with the above-described disc-shaped portion 44. The inventor of the subject application sealed the through hole (identical in shape with the above-described through hole 43) of the disc by means of a tape.

[0101] In the test chamber arranged as described above, air injected through the inlet is basically discharged through the first outlet and the second outlet. Based on this, the inventor of the subject application checked whether the sealing property between the seal and the lid member was sufficient, by visually observing a flow of air by means of a known smoke tester. When the pressure of the internal space was higher by about 50 Pa than the pressure of the outside space (i.e., when the differential pressure was higher by about 50 Pa), air leakage from between the seal and the lid member was not observed. As described above, when the yarn spinning system 1 is driven, the difference between the pressure of the slow cooling space Ss and the pressure of the outside space is less than 20 Pa. It was therefore confirmed that the test chamber had a sufficient sealing property.

[0102] As described above, in the seal 30, the contact portion 53 is pressed onto the spinning apparatus 2 (cylindrical portion 42) by the biasing portion 54 independent from the air cylinder 28. Even if a gap is formed between the slow cooling space Ss and the outside space So by the contact portion 53 and the biasing portion 54, the gap can be closed by the first attaching portion 51 and the second attaching portion 52. Because the difference between the pressure of the slow cooling space Ss and the pressure of the outside space So is typically small, the required airtightness can be achieved by the seal 30. It is therefore possible to seal the gap formed between the slow cooling space Ss and the outside space So to some degree, without using members made of a rubber material as members forming the contact portion 53, the biasing portion 54, the first attaching portion 51, and the second attaching portion 52.

[0103] In addition to the above, even if the contact portion 53 is worn or deformed, the required airtightness can be achieved because the contact portion 53 is firmly in contact with the cylindrical portion 42 thanks to the biasing portion 54.

[0104] In addition to the above, design errors between

the spinnerets 13 (e.g., errors in size and/or positional relationship between the spinnerets 13) can be easily absorbed by the biasing portion 54.

[0105] Because of the presence of the seal 30, the cylindrical portion 42 may not be arranged to seal the gap between the slow cooling space Ss and the outside space So. It is therefore possible to use a member that is not made of a rubber material as a member constituting the cylindrical portion 42. On this account, deterioration and deformation of the cylindrical portion 42 due to the heat generated by the spinning apparatus 2 are suppressed. On this account, unintentional changes in length of the slow cooling space Ss in the up-down direction are suppressed. Due to this, it is possible to maintain the required airtightness of the slow cooling space Ss for a long time, while suppressing unintentional changes in length of the slow cooling space Ss in the up-down direction for a long time.

[0106] In addition to the above, the Young's modulus of the material of which the cylindrical portion 42 is made is high, i.e., 10 GPa, when the spinning apparatus 2 and the cooler 3 are driven. It is therefore possible to effectively suppress deformation of the cylindrical portion 42 even if the cylindrical portion 42 is pressurized as the cooler 3 is pressed upward by the air cylinder 28.

[0107] In addition to the above, because the cylindrical portion 42 is made of a metal material, it is possible to effectively suppress the need of early replacement of the cylindrical portion 42.

[0108] In addition to the above, the Young's modulus of the material of which the contact portion 53 is made is high, i.e., 10 GPa, when the spinning apparatus 2 and the cooler 3 are driven. Because the contact portion 53 is made of a hard material and distortion is suppressed, it is possible to effectively suppress the need of early replacement of the contact portion 53.

[0109] In addition to the above, because the contact portion 53 is made of a metal material that is less likely to be deteriorated, it is possible to effectively suppress the need of early replacement of the contact portion 53.

[0110] The biasing portion 54 is provided with the spring members 71. The spring members 71 are typically formed by metal members that are less likely to be deteriorated. Therefore, it is possible to effectively avoid the necessity of early replacement of the biasing portion 54.

[0111] Each spring member 71 is a compression coil spring. Because the compression coil spring is typically inexpensive, it is possible to suppress increase in the cost of components.

[0112] In addition to the above, members constituting the seal 30 are attached to the cooler 3. It is therefore possible to suppress excessive heating of these members as compared to a case where the members constituting the seal 30 are attached to the spinning apparatus 2.

[0113] In addition to the above, the biasing directions in which the spring members 71 bias the contact portion

53 intersect with the up-down direction (i.e., have a component in the horizontal direction). It is therefore possible to secure an installation space of the biasing portion 54 in the horizontal direction, even if the size in the up-down direction of the seal 30 is severely restricted. Due to this, the degree of freedom in designing the biasing portion 54 is improved.

[0114] The length in the up-down direction of the slow cooling space Ss must be particularly short when a narrow yarn Y is spun out. The slow cooling space Ss is a relatively unstable region provided between the spinning apparatus 2 and the cooler 3. On this account, when the slow cooling space Ss is excessively long in the up-down direction, a narrow yarn Y particularly susceptible to external disturbance may be unstable in quality. In this regard, the present embodiment is particularly effective when a narrow yarn Y is produced, because the size of the seal 30 is reduced in the up-down direction.

[0115] In addition to the above, the cylindrical portion 42 is in contact with the contact portion 53 and functions as the regulating portion of the present invention. It is therefore possible to reduce the number of components as compared to an arrangement in which a member in contact with the contact portion 53 is different from a member constituting the regulating portion.

[0116] When the top surface 51a in contact with the cylindrical portion 42 is tilted relative to the horizontal direction, a change of the relative positions between the cylindrical portion 42 and the top surface 51a in the horizontal direction may result in a change of the relative positions between the cylindrical portion 42 and the top surface 51a in the up-down direction. Due to this, the length of the slow cooling space Ss may be disadvantageously changed in the up-down direction. Because the top surface 51a is arranged to be flat along the horizontal direction in the present embodiment, the disadvantage is suppressed.

[0117] In addition to the above, when the cooler 3 moves from the maintenance position to the operation position, the contact portion 53 makes contact with the cylindrical portion 42 and is therefore movable at least in the horizontal direction against the biasing force of the biasing portion 54. On this account, the contact portion 53 is pressed by the cylindrical portion 42 and moved, even when the horizontal position of the contact portion 53 is slightly deviated from the horizontal position of the cylindrical portion 42. It is therefore possible to compensate a horizontal position deviation between the cylindrical portion 42 and the contact portion 53, while arranging the cylindrical portion 42 and the contact portion 53 to be closely in contact with each other.

[0118] In addition to the above, when the cylindrical portion 42 and the contact portion 53 are in the contact state, the inner gap G1 formed between the inner contact pieces 61 in the circumferential direction is narrow in the circumferential direction as compared to a case where the cylindrical portion 42 and the contact portion 53 are in the distanced state. It is therefore possible to minimize

the decrease of the airtightness of the slow cooling space Ss.

[0119] The inner contact piece 61 includes the inner pressing surface 61c. With this arrangement, when the cylindrical portion 42 and the contact portion 53 are switched from the distanced state to the contact state, the bottom surface 47 of the cylindrical portion 42 makes contact with the inner pressing surface 61c, with the result that the inner contact piece 61 is pressed inward in the radial direction. This allows the cylindrical portion 42 and the inner contact piece 61 in contact with each other to smoothly move in the up-down direction relative to each other and allows the inner contact piece 61 to move inward in the radial direction. It is therefore possible to cause the inner circumferential surface 45 of the cylindrical portion 42 and the inner contact piece 61 to make contact with each other simply by moving the cylindrical portion 42 and the contact portion 53 in the up-down direction relative to each other.

[0120] The disc-shaped portion 44 at least partially overlaps the inner contact pieces 61 (and the inner attaching plate 58) in the up-down direction. It is therefore possible to narrow the space in the vicinity of the inner contact pieces 61 in the up-down direction by the disc-shaped portion 44, when the cylindrical portion 42 and the contact portion 53 are in the contact state. This arrangement further improves the airtightness of the slow cooling space Ss.

[0121] The disc-shaped portion 44 and the partition wall portion (specifically, the inner attaching plate 58 of the second attaching portion 52) oppose each other in the up-down direction. It is therefore possible to narrow the space in the vicinity of the inner contact pieces in the up-down direction by the disc-shaped portion 44 and the inner attaching plate 58. This arrangement further improves the airtightness of the slow cooling space.

[0122] The spring members 71 include the outer spring members 73 which are configured to bias the outer contact pieces 62 toward the outer circumferential surface 46 of the cylindrical portion 42. On this account, the outer contact pieces 62 further improve the airtightness of the slow cooling space Ss.

[0123] The outer contact piece 62 includes the outer pressing surface 62c. With this arrangement, when the cylindrical portion 42 and the contact portion 53 are switched from the distanced state to the contact state, the bottom surface 47 of the cylindrical portion 42 makes contact with the outer pressing surface 62c, with the result that the outer contact piece 62 is pressed outward in the radial direction. It is therefore possible to cause the outer circumferential surface 46 of the cylindrical portion 42 and the outer contact piece 62 to make contact with each other simply by moving the cylindrical portion 42 and the contact portion 53 in the up-down direction relative to each other.

[0124] Even if a passage of gas is unintentionally formed between the outer gaps G2 and the inner gaps G1, it is possible to elongate the passage. This further

suppresses gas from going in and out between the slow cooling space Ss and the space outside the slow cooling space Ss. This arrangement further improves the airtightness of the slow cooling space Ss.

[0125] Each cylindrical portion 42 is substantially ring-shaped when viewed in the up-down direction. The shape of the extending portion is therefore simple.

[0126] When the spinning apparatus 2 and the cooler 3 are driven, the difference between the pressure of the slow cooling space Ss and the pressure of the outside space So is less than 20 Pa. With this arrangement, the required airtightness of the slow cooling space Ss can be easily achieved by the seal 30.

[0127] The plural cylindrical portions 42 are included in one upper sealing member 31. The plate portion 41 and the cylindrical portions 42 are preferably formed of a single member. This arrangement makes it possible to suppress variations in length in the up-down direction between the slow cooling spaces Ss, as compared to a case where the cylindrical portions 42 are formed of different members.

[0128] The contact portion 53 is independent from the cylindrical portion 42 (regulating portion). It is therefore possible to maintain the length of the slow cooling space Ss to be constant by the cylindrical portion 42, even if the contact portion 53 is worn or deformed.

[0129] The following will describe modifications of the above-described embodiment. The members identical with those in the embodiment above will be denoted by the same reference numerals and the explanations thereof are not repeated.

(1) In the embodiment above, the cylindrical portion 42 is substantially ring-shaped when viewed in the up-down direction. That is to say, each of the inner circumferential surface 45 and the outer circumferential surface 46 of the cylindrical portion 42 is circular in shape when viewed in the up-down direction. However, the disclosure is not limited to this arrangement. The cylindrical portion 42 may not be substantially ring-shaped when viewed in the up-down direction. Although not illustrated, at least one of the inner circumferential surface 45 or the outer circumferential surface 46 may be, for example, polygonal in shape and has plural straight lines when viewed in the up-down direction. Accordingly, the outer circumferential surface 61a of each of the inner contact pieces 61 and/or the inner circumferential surface 62a of the outer contact piece 62 may be linear in shape when viewed in the up-down direction.

(2) In the embodiment above, the outer gap G2 is positionally different from the inner gap G1 in the circumferential direction. However, the disclosure is not limited to this arrangement. The outer gap G2 may be substantially positionally identical with the inner gap G1 in the circumferential direction.

(3) In the embodiment above, the outer pressing surface 62c is formed on the outer contact piece 62.

However, the disclosure is not limited to this arrangement. The outer pressing surface 62c may not be formed. For example, at a portion that is an upper end portion and an inner end portion in the radial direction of the outer contact piece 62, a corner may be formed. In such a case, for example, a cross section along the up-down direction of the lower end portion of the cylindrical portion 42 may be arranged to be thin. When the cooling mechanism ascends from the maintenance position to the operation position, the lower end portion of the cylindrical portion 42 may relatively move and enter a gap between the inner contact piece 61 and the outer contact piece 62 in the radial direction. In this way, the cylindrical portion 42 may move the inner contact piece 61 and the outer contact piece 62 in the radial direction. Likewise, the inner pressing surface 61c may not be formed on the inner contact piece 61.

(4) In the embodiment above, the contact portion 53 includes the outer contact piece 62. However, the disclosure is not limited to this arrangement. The contact portion 53 may not include the outer contact piece 62.

(5) In the embodiment above, the inner attaching plate 58 is provided above the inner contact piece 61. Due to this, the disc-shaped portion 44 and the inner attaching plate 58 overlap each other in the up-down direction and the space in the vicinity of the inner contact pieces 61 is narrow in the up-down direction. However, the disclosure is not limited to this arrangement. The inner attaching plate 58 may not be provided to overlap the disc-shaped portion 44 in the up-down direction.

(6) In the embodiment above, the upper sealing member 31 includes plural disc-shaped portions 44. Due to this, the space in the vicinity of the inner contact pieces 61 is narrow in the up-down direction. However, the disclosure is not limited to this arrangement. The upper sealing member 31 may not include the disc-shaped portion 44.

(7) In the embodiment above, when the cylindrical portion 42 and the contact portion 53 are in the contact state, the inner gaps G1 are narrow in the circumferential direction as compared to a case where the cylindrical portion 42 and the contact portion 53 are in the distanced state. However, the disclosure is not limited to this arrangement. The contact portion 53 may be arranged such that the sizes of the inner gaps G1 when the cylindrical portion 42 and the contact portion 53 are in the contact state are identical with the sizes of the inner gaps G1 when the cylindrical portion 42 and the contact portion 53 are in the distanced state.

(8) In the embodiment above, the contact portion 53 includes the inner contact piece 61. However, the disclosure is not limited to this arrangement. The contact portion 53 may not include the inner contact piece 61. The contact portion 53 may include only

the outer contact piece 62.

(9) In the embodiment above, the spring members 71 bias the contact portion 53 in the radial directions. However, the disclosure is not limited to this arrangement. The spring members 71 may be provided to bias the contact portion 53 in directions having, for example, components in the radial direction and the up-down direction. Alternatively, for example, another seal 81 (see FIG. 9(a) and FIG. 9(b)) different from the seal 30 may be provided in the yarn spinning system 1. This arrangement will be specifically described below.

[0130] As shown in FIG. 9(a) and FIG. 9(b), the seal 81 includes the above-described upper sealing member 31 and a lower sealing mechanism 82 attached to the cooler 3. The lower sealing mechanism 82 includes a first attaching portion 83, a second attaching portion 84, a fixing ring 85, a contact portion 86 (surrounding portion of the present invention), and a biasing portion 87. The first attaching portion 83 is a cylindrical member extending in the up-down direction. The first attaching portion 83 is provided directly above the cooling cylinder 21 and is fixed to the top surface 20a of the box 20. The first attaching portion 83 is provided outside the contact portion 86 and the biasing portion 87 in the radial direction and is arranged to seal a gap formed by the contact portion 86 and the biasing portion 87. The second attaching portion 84 is a cylindrical member extending in the up-down direction. The second attaching portion 84 is provided outside the first attaching portion 83 in the radial direction and is fixed to the top surface 20a of the box 20. The second attaching portion 84 is provided inside the contact portion 86 and the biasing portion 87 in the radial direction and is arranged to seal a gap formed by the contact portion 86 and the biasing portion 87. At least one of the first attaching portion 83 or the second attaching portion 84 is equivalent to the partition wall portion of the present invention. In the radial direction, there is a gap between the first attaching portion 83 and the second attaching portion 84. The fixing ring 85 is a substantially ring-shaped member provided substantially horizontally, and is provided in the gap. The fixing ring 85 is fixed to the top surface 20a of the box 20. The fixing ring 85 is shorter than the first attaching portion 83 and the second attaching portion 84 in the up-down direction. In the fixing ring 85, recesses (not illustrated) that are open downward are formed. On the upper side of each recess, a through hole (not illustrated) is formed to penetrate the fixing ring 85 in the up-down direction. Into the recesses and the through holes, bolt members B3 that are structurally identical with the bolt members B1 and B2 are inserted, respectively. The leading end portion of the bolt member B3 extends upward. Upward movement of a head portion of the bolt member B3 is restricted by the periphery of the through hole of the fixing ring 85.

[0131] The contact portion 86 is, for example, substantially ring-shaped. The contact portion 86 is made of, for

example, a metal material. The Young's modulus of the material of the contact portion 86 is, for example, 10 GPa or higher when the temperature of the contact portion 86 is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. The contact portion 86 is provided directly below the disc-shaped portion 44 of the upper sealing member 31. The contact portion 86 has a top surface 86a (end face of the present invention) that faces up. The disc-shaped portion 44 has a bottom surface 44a (contact surface of the present invention) that faces down. The top surface 86a is disposed to oppose the bottom surface 44a in the up-down direction. When viewed in the up-down direction, the top surface 86a (one of the end face and the contact surface of the present invention) may be inside the contour of the bottom surface 44a (the other of the end face and the contact surface of the present invention). The contact portion 86 is provided directly above the fixing ring 85. In the same manner as the fixing ring 85, the contact portion 86 is provided in the gap between the first attaching portion 83 and the second attaching portion 84. In the bottom surface of the contact portion 86, a female screw is formed. The male screw of the bolt member B3 is screwed into the female screw. The biasing portion 87 is provided with, for example, spring members 88. Each spring member 88 is a compression coil spring similar to, for example, the inner spring member 72 and the outer spring member 73. The spring member 88 is provide to be extendable and contractible in the up-down direction. Into the outer spring member 88, a part of the bolt member B3, which is between the head portion and the male screw, is inserted. Because of this, each spring member 88 biases the contact portion 86 upward. The contact portion 86 is slidable in the up-down direction relative to the first attaching portion 83 and the second attaching portion 84. In this modification, the cylindrical portion 42 is equivalent to the regulating portion of the present invention.

[0132] The disc-shaped portion 44 and the contact portion 86 are switchable between the distanced state (see FIG. 9(a)) in which the bottom surface 44a of the disc-shaped portion 44 and the top surface 86a of the contact portion 86 are distanced from each other and the contact state (see FIG. 9(b)) in which the bottom surface 44a and the top surface 86a are in contact with each other. When the disc-shaped portion 44 and the contact portion 86 are in the contact state, the bottom surface 47 of the cylindrical portion 42 of the upper sealing member 31 is in contact with the top surface 20a of the box 20. The top surface 20a is equivalent to the regulating surface of the present invention. This arrangement of the present invention also makes it possible to achieve the airtightness of the slow cooling space Ss. Furthermore, even when the horizontal position of the contact portion 86 is slightly deviated from the horizontal position of the disc-shaped portion 44, the deviation does not hinder the achievement of the airtightness of the slow cooling space Ss. However, an idea for successfully arranging the length in the up-down direction of the slow cooling space Ss to be equal

to or shorter than a predetermined length is required. In the seal 81, for example, plural pole-shaped members (not illustrated) extending in the up-down direction may be aligned in the circumferential direction in place of the cylindrical portions 42. In this case, each pole-shaped member is equivalent to the regulating portion of the present invention.

(10) In the embodiment above, all of the cylindrical portions 42 and the disc-shaped portions 44 are included in one upper sealing member 31. However, the disclosure is not limited to this arrangement. The upper sealing member 31 may be divided into plural members.

(11) In the embodiment above, the top surface 51a of the first attaching portion 51 is flat. Alternatively, the top surface 20a of the box 20 is flat. However, the disclosure is not limited to these arrangements. A part of the top surface 51a where the top surface 51a is in contact with the cylindrical portion 42 may be tilted or curved. A part of the top surface 20a where the top surface 20a is in contact with the cylindrical portion 42 may be tilted or curved.

(12) As a movement mechanism for moving the cooler 3 in the up-down direction, for example, a hydraulic cylinder (not illustrated) may be provided in place of the air cylinder 28. Alternatively, for example, an unillustrated hydraulic jack may be provided as the movement mechanism.

(13) In the embodiment above, the lower sealing mechanism 32 and the biasing portion 54 are attached to the cooler 3 whereas the upper sealing member 31 is attached to the spinning apparatus 2. However, the disclosure is not limited to this arrangement. For example, a member that is substantially symmetrical with the upper sealing member 31 in the up-down direction may be attached to the cooler 3. In addition to this, a structure that is substantially symmetrical with the lower sealing mechanism 32 and the biasing portion 54 in the up-down direction may be attached to the spinning apparatus 2.

(14) In the embodiment above, the contact portion is made of a metal material. However, the disclosure is not limited to this arrangement. The contact portion may be made of, for example, a non-metal material such as ceramic. Likewise, the regulating portion may be made of a non-metal material.

(15) In the embodiment above, the Young's modulus of the material of the contact portion is 10 GPa or higher when the temperature of the contact portion is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. However, the disclosure is not limited to this arrangement. The Young's modulus of the material of which the contact portion is made may be lower than 10 GPa when the temperature of the contact portion is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven. Likewise, the Young's modulus

of the material of which the regulating portion is made may be lower than 10 GPa when the temperature of the regulating portion is equal to a temperature at which the spinning apparatus 2 and the cooler 3 are driven.

(16) While in the embodiment above each of the spring members 71 and 88 is a compression coil spring, the disclosure is not limited to this arrangement. Each of these spring members may be a spring member different from the compression coil spring, such as a plate spring (not illustrated) or a torsion spring (not illustrated).

(17) The biasing portion of the present invention may include an elastic body different from the spring member. For example, in the above-described seal 81, a heat insulation member (not illustrated) and a rubber member (not illustrated) may be provided in place of the bolt member B3 and the spring member 88. In other words, for example, the heat insulation member may be provided below the contact portion 86 and the rubber member may be provided below the heat insulation member and above the box 20. This arrangement makes it possible to bias the contact portion 86 upward while minimizing heat transfer from the spinning apparatus 2 to the rubber member.

(18) In the embodiment above, the spinning apparatus 2 has plural spinnerets 13. Furthermore, the cooler 3 has plural cooling cylinders 21. These components form plural slow cooling spaces Ss. However, the disclosure is not limited to this arrangement. Each of the number of spinnerets 13, the number of cooling cylinders 21, and the number of slow cooling spaces Ss may be one. In the seal 30 or the seal 81, each of the number of contact portions and the number of biasing portions may be one. In this arrangement, the number of regulating portions may be one.

(19) In the embodiment above, the slow cooling space Ss has a positive pressure as compared to the outside space So. To be more specific, the difference between the pressure of the slow cooling space Ss and the pressure of the outside space So is more than 0 Pa and less than 20 Pa. However, the disclosure is not limited to this arrangement. For example, the pressure difference may be equal to or more than 20 Pa, or may be equal to or less than 50 Pa described above. Alternatively, the pressure difference may be substantially zero, or the slow cooling space Ss may have a negative pressure as compared to the outside space So. In these cases, the absolute value of the pressure difference may be less than 20 Pa or may be equal to or more than 20 Pa, for example.

(20) In the embodiment above, the contact portion 53 of the seal 30 is provided to be independent from the cylindrical portion 42 (regulating portion). However, the disclosure is not limited to this arrangement. A single member may be arranged to function

both the contact portion and the regulating portion of the present invention. For example, in the above-described seal 81, the length in the up-down direction of the contact portion 86 may be substantially identical with the length in the up-down direction of the cylindrical portion 42. In this case, the contact portion 86 is able to function as a regulating portion. In the case above, furthermore, the cylindrical portion 42 may not be provided as long as the required airtightness of the slow cooling space can be maintained for a long time.

Claims

1. A yarn spinning system (1) comprising:

a spinning apparatus (2) which includes spinnerets (13) each of which is able to discharge a yarn material; and
a cooler (3) which includes cooling units (21) capable of cooling the yarn material discharged from the spinnerets (13) and is provided below the spinning apparatus (2), the yarn spinning system (1) further comprising:

a movement mechanism (28) which is able to move the cooler (3) between an operation position where the yarn material is spun out and a maintenance position below the operation position and which is configured to exert an upward force to the cooler (3) when the cooler (3) is at the operation position; regulating portions (42) which are provided between the spinnerets (13) and the cooling units (21) in an up-down direction, respectively, and are arranged to define lengths in the up-down direction of slow cooling spaces (Ss) formed between the spinnerets (13) and the cooling units (21) in the up-down direction, respectively, when the cooler (3) is at the operation position; and seals (30, 81) which are arranged to seal gaps between the slow cooling spaces (Ss) and an outside space (So) outside the slow cooling spaces (Ss) in a horizontal direction perpendicular to the up-down direction, when the cooler (3) is at the operation position, each of the seals (30, 81) including:

a contact portion (53, 86) which is attached to one of the spinning apparatus (2) and the cooler (3), is provided to surround a corresponding one of the slow cooling spaces (Ss), and is arranged to make contact with the other of the spinning apparatus (2) and the cooler (3);

- a biasing portion (54, 87) which is attached to the one of the spinning apparatus (2) and the cooler (3), is independent from the movement mechanism (28), and is configured to bias the contact portion (53, 86) in a predetermined biasing direction toward the other of the spinning apparatus (2) and the cooler (3); and
a partition wall portion (51, 52, 83, 84) which is fixed to the one of the spinning apparatus (2) and the cooler (3), is arranged to seal each of the gaps formed by the contact portion (53, 86) and the biasing portion (54, 87), and separates a corresponding one of the slow cooling spaces (Ss) from the outside space (So).
2. The yarn spinning system (1) according to claim 1, wherein, when a temperature of the regulating portions (42) is identical with a temperature when the spinning apparatus (2) and the cooler (3) are driven, the Young's modulus of a material of the regulating portions (42) is equal to or higher than 10 GPa.
 3. The yarn spinning system (1) according to claim 1 or 2, wherein, the regulating portions (42) are made of a metal material.
 4. The yarn spinning system (1) according to any one of claims 1 to 3, wherein, when a temperature of the contact portion (53, 86) is identical with a temperature when the spinning apparatus (2) and the cooler (3) are driven, the Young's modulus of a material of the contact portion (53, 86) is equal to or higher than 10 GPa.
 5. The yarn spinning system (1) according to any one of claims 1 to 4, wherein, the contact portion (53, 86) is made of a metal material.
 6. The yarn spinning system (1) according to any one of claims 1 to 5, wherein, the biasing portion (54, 87) includes a spring member (71, 88).
 7. The yarn spinning system (1) according to claim 6, wherein, the spring member (71, 88) is a compression coil spring.
 8. The yarn spinning system (1) according to any one of claims 1 to 7, wherein, the one of the spinning apparatus (2) and the cooler (3) is the cooler (3).
 9. The yarn spinning system (1) according to any one of claims 1 to 8, wherein,
the other of the spinning apparatus (2) and the cooler (3) includes extending portions (42) which are provided to surround the respective slow cooling spaces (Ss) when viewed in the up-down direction and which extend in the up-down direction,
the contact portion (53) is disposed to be in contact with a circumferential surface (45, 46) of a corresponding one of the extending portions (42), and
the biasing direction intersects with the up-down direction.
 10. The yarn spinning system (1) according to claim 9, wherein,
the regulating portions (42) include the respective extending portions (42), and
the extending portions (42) define the lengths in the up-down direction of the respective slow cooling spaces (Ss).
 11. The yarn spinning system (1) according to claim 10, further comprising:
a regulating surface (51a) which is positionally fixed in the up-down direction relative to the one of the spinning apparatus (2) and the cooler (3) and is arranged to be in contact with a leading end in the up-down direction of each of the extending portions (42) when the cooler (3) is at the operation position,
the regulating surface (51a) being flat along the horizontal direction.
 12. The yarn spinning system (1) according to any one of claims 9 to 11, wherein, when the cooler (3) moves from the maintenance position to the operation position, the contact portion (53) makes contact with the corresponding one of the extending portions (42) so as to be movable at least in the horizontal direction against a biasing force of the biasing portion (54).
 13. The yarn spinning system (1) according to any one of claims 9 to 12, wherein,
the circumferential surface (45, 46) of each of the extending portions (42) includes an inner circumferential surface (45) of each of the extending portions (42),
the contact portion (53) includes inner contact pieces (61) which are aligned in a circumferential direction of the corresponding one of the extending portions (42) and are provided to make contact with the inner circumferential surface (45) of the corresponding one of the extending portions (42),
the biasing portion (54) includes inner biasing members (72) which bias the inner contact pieces

- es (61) toward the inner circumferential surface (45), and
 when the corresponding one of the extending portions (42) is in contact with the inner contact pieces (61), inner gaps (G1) that are gaps
 5 formed between the inner contact pieces (61) in the circumferential direction are narrow in the circumferential direction as compared to a case where each of the extending portions (42) is distanced from the inner contact pieces (61). 10
- 14.** The yarn spinning system (1) according to claim 13, wherein,
- each of the inner contact pieces (61) has an inner pressing surface (61c) that is provided at an inner end portion in a radial direction that is orthogonal to both the up-down direction and the circumferential direction, and
 15 when each of the extending portions (42) is distanced from the inner contact pieces (61), the inner pressing surface (61c) at least partially overlaps the corresponding one of the extending portions (42) in the up-down direction and faces outward in the radial direction and toward the corresponding one of the extending portions (42) in the up-down direction. 20 25
- 15.** The yarn spinning system (1) according to claim 13 or 14, wherein, 30
- the other of the spinning apparatus (2) and the cooler (3) includes disc-shaped portions (44) which are adjacent to the respective extending portions (42) in the up-down direction and are provided to be close to the other of the spinning apparatus (2) and the cooler (3) as compared to the extending portions (42), and
 35 a corresponding one of the disc-shaped portions (44) at least partially overlaps the inner contact pieces (61) in the up-down direction. 40
- 16.** The yarn spinning system (1) according to claim 15, wherein, the corresponding one of the disc-shaped portions (44) opposes the partition wall portion (51, 52) in the up-down direction. 45
- 17.** The yarn spinning system (1) according to any one of claims 13 to 16, wherein, 50
- the circumferential surface (45, 46) of each of the extending portions (42) includes an outer circumferential surface (46) of each of the extending portions (42),
 55 the contact portion (53) includes outer contact pieces (62) which are aligned in the circumferential direction of the corresponding one of the extending portions (42) and are provided to make contact with the outer circumferential surface (46) of the corresponding one of the extending portions (42), and
 the biasing portion (54) includes outer biasing members (73) which bias the respective outer contact pieces (62) toward the outer circumferential surface (46).
- 18.** The yarn spinning system (1) according to claim 17, wherein,
- each of the outer contact pieces (62) has an outer pressing surface (62c) that is provided at an inner end portion in the radial direction that is orthogonal to both the up-down direction and the circumferential direction, and
 when each of the extending portions (42) is distanced from the outer contact pieces (62), the outer pressing surface (62c) at least partially overlaps the corresponding one of the extending portions (42) in the up-down direction and faces inward in the radial direction and toward the corresponding one of the extending portions (42) in the up-down direction.
- 19.** The yarn spinning system (1) according to claim 17 or 18, wherein, outer gaps (G2) that are gaps formed between the outer contact pieces (62) in the circumferential direction are positionally different from the inner gaps (G1) in the circumferential direction.
- 20.** The yarn spinning system (1) according to any one of claims 9 to 19, wherein, each of the extending portions (42) is ring-shaped when viewed in the up-down direction.
- 21.** The yarn spinning system (1) according to any one of claims 1 to 8, wherein,
- the contact portion (86) includes a surrounding portion (86) which surrounds a corresponding slow cooling space (Ss) among the slow cooling spaces (Ss),
 the biasing portion (87) is configured to bias the surrounding portion in the up-down direction, in a radial direction of the surrounding portion (86), the partition wall portion (83, 84) is provided (i) either inside the surrounding portion (86) and the biasing portion (87) or outside the surrounding portion (86) and the biasing portion (87) or (ii) both inside the surrounding portion (86) and the biasing portion (87) and outside the surrounding portion (86) and the biasing portion (87), and
 the surrounding portion (86) has an end face (86a) which faces the other of the spinning apparatus (2) and the cooler (3) in the up-down direction.

22. The yarn spinning system (1) according to claim 21, wherein,

the other of the spinning apparatus (2) and the cooler (3) has a contact surface (44a) which is provided to make contact with the end face (86a) of the surrounding portion (86), and when viewed in the up-down direction, one of the end face (86a) and the contact surface (44a) is inside the contour of the other of the end face (86a) and the contact surface (44a).

23. The yarn spinning system (1) according to any one of claims 1 to 22, wherein, when the spinning apparatus (2) and the cooler (3) are driven, an absolute value of a difference between the pressure of each of the slow cooling spaces (Ss) and the pressure of the outside space (So) is less than 20 Pa.

24. The yarn spinning system (1) according to any one of claims 1 to 23, wherein, the regulating portions (42) are formed by a single common member (31).

25. The yarn spinning system (1) according to any one of claims 1 to 24, wherein, the contact portion (53, 86) is independent from the regulating portions (42).

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FIG.1

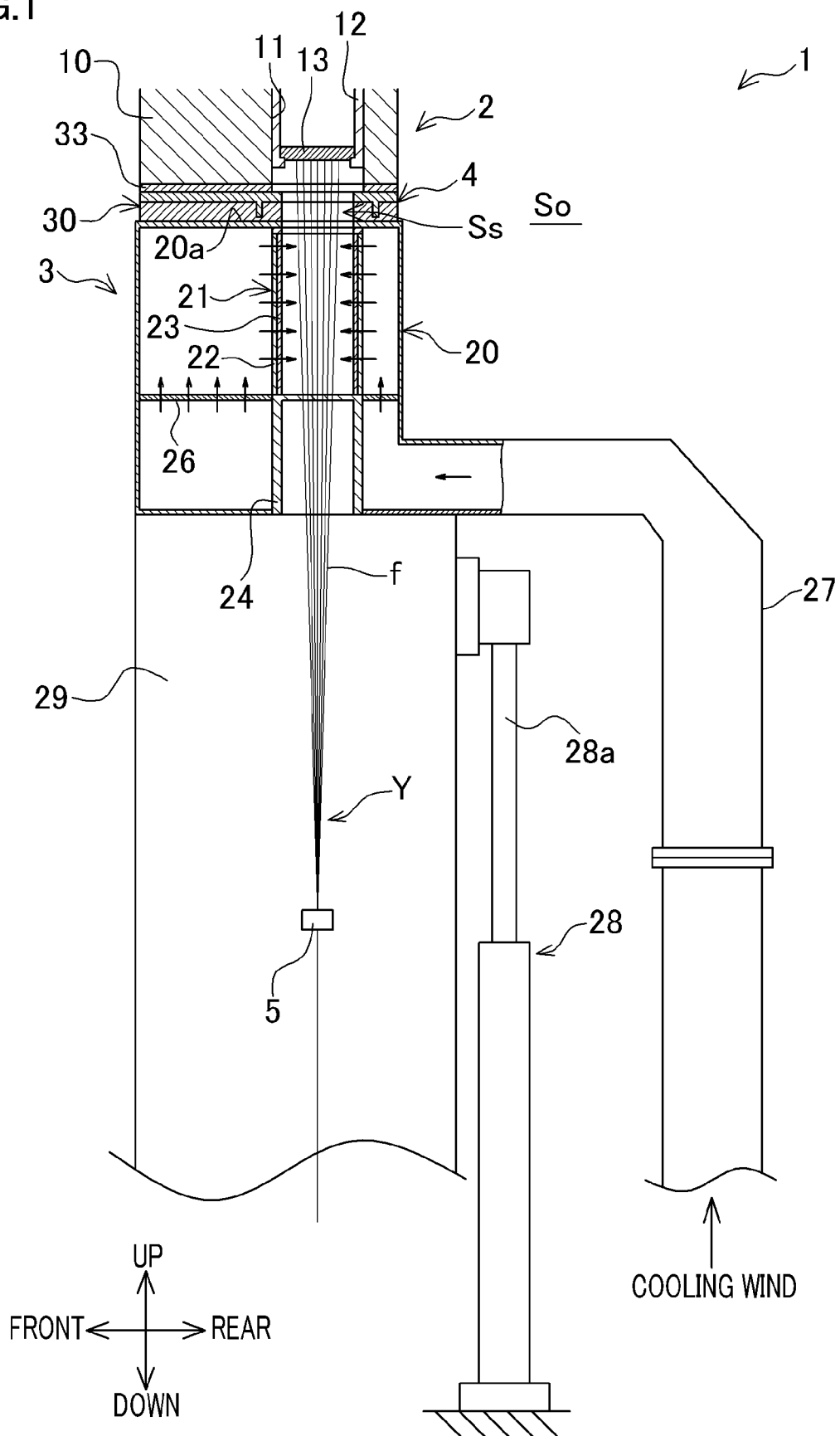


FIG.2

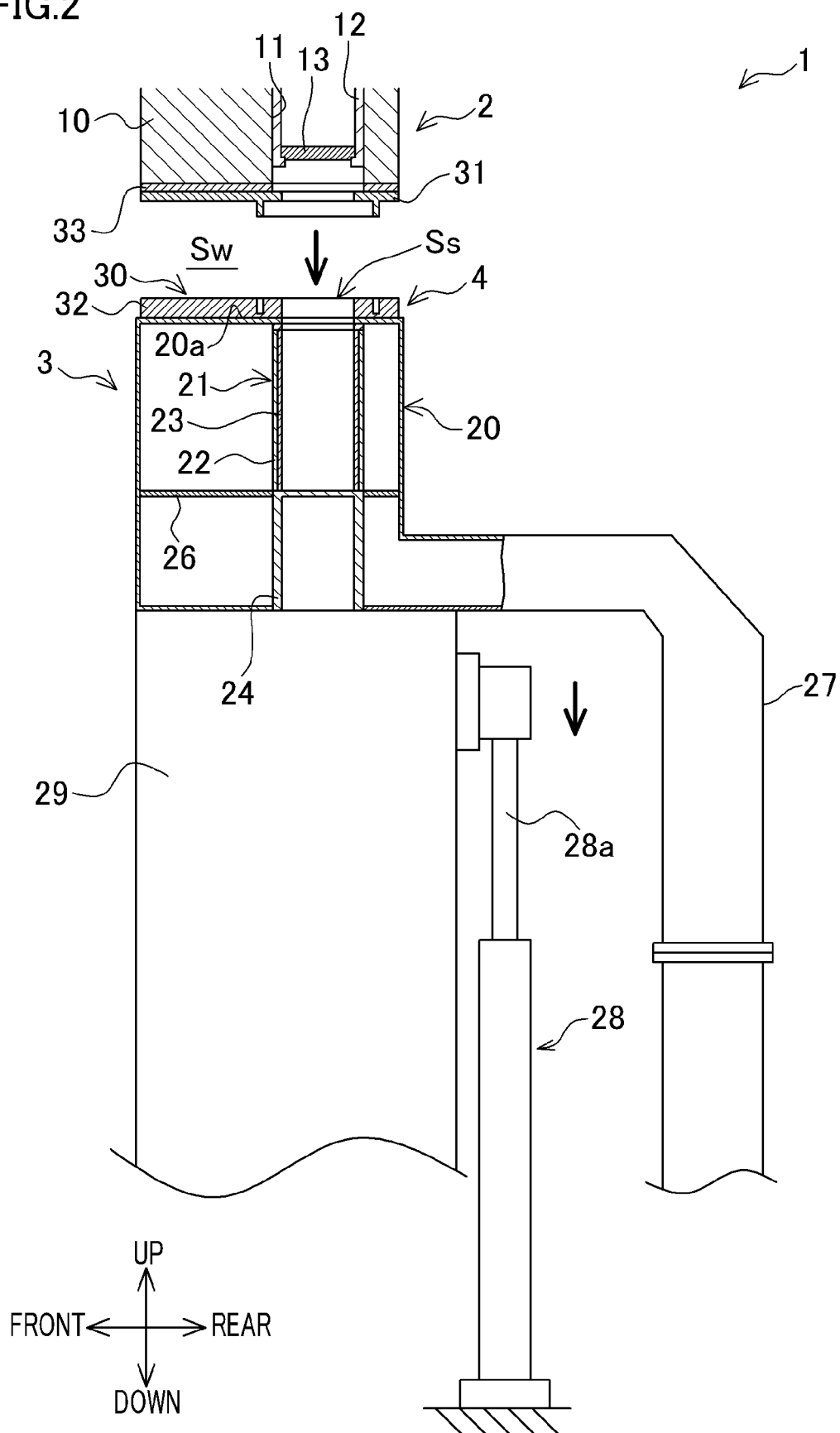


FIG.3

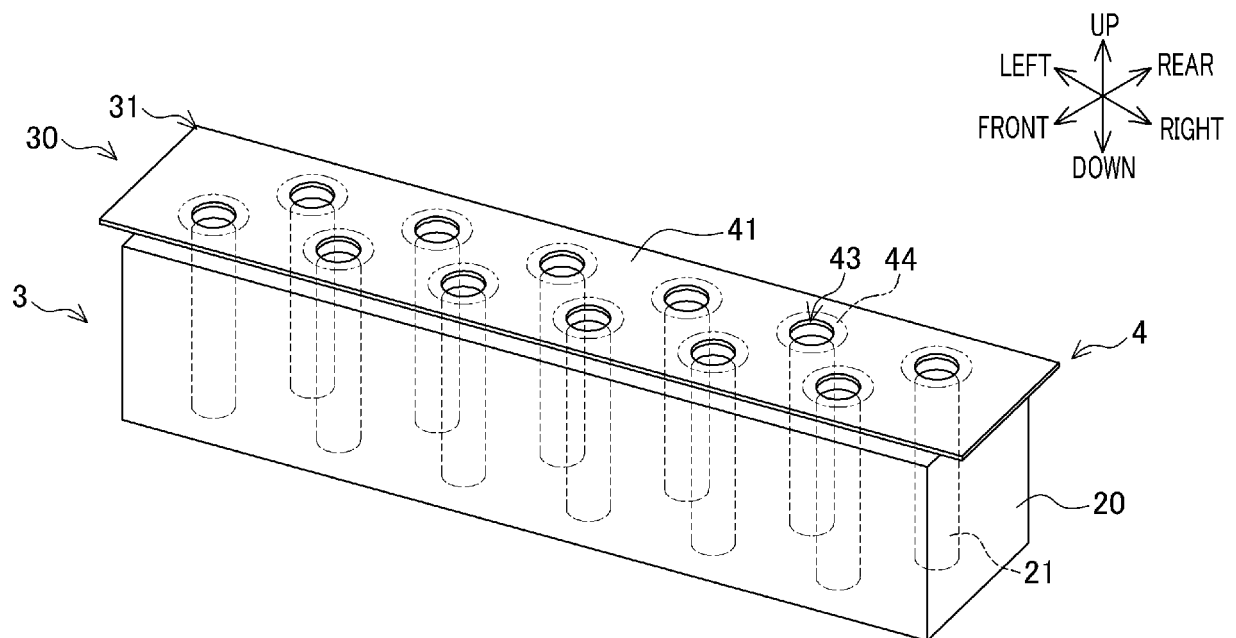


FIG.4

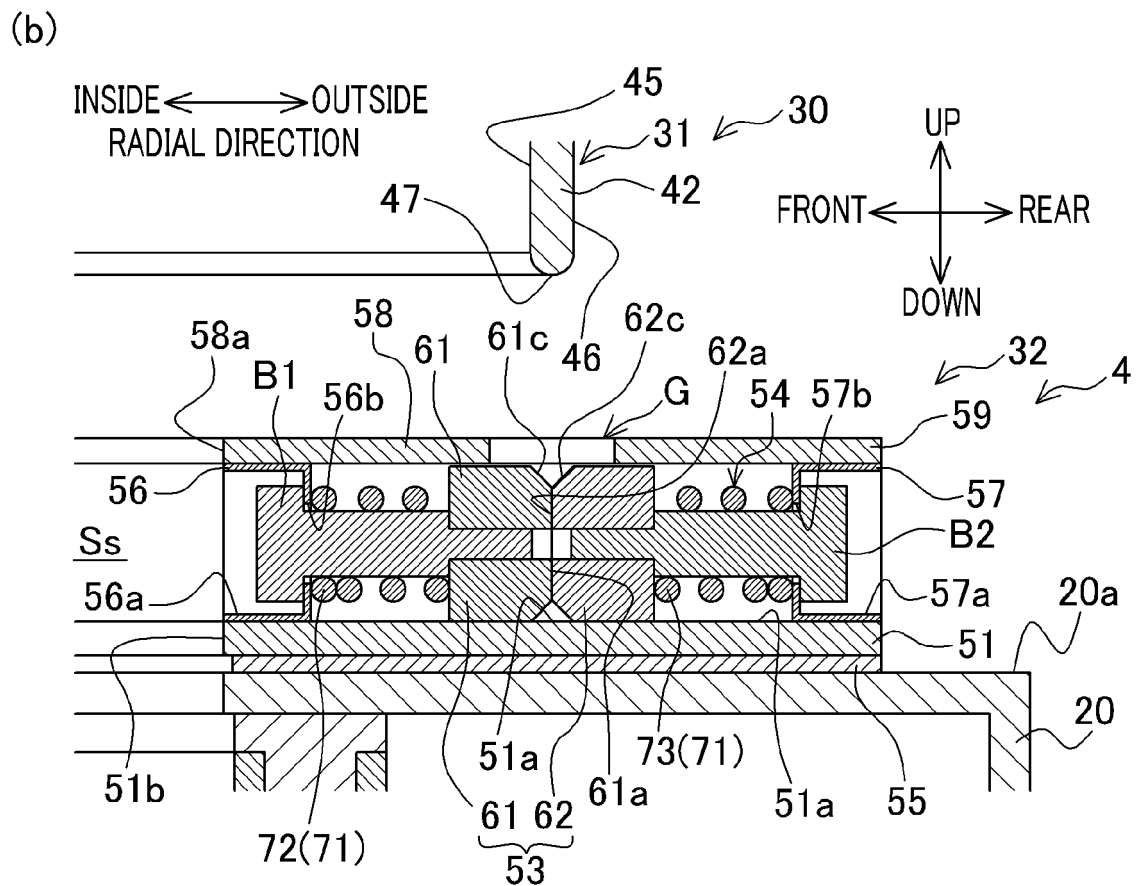
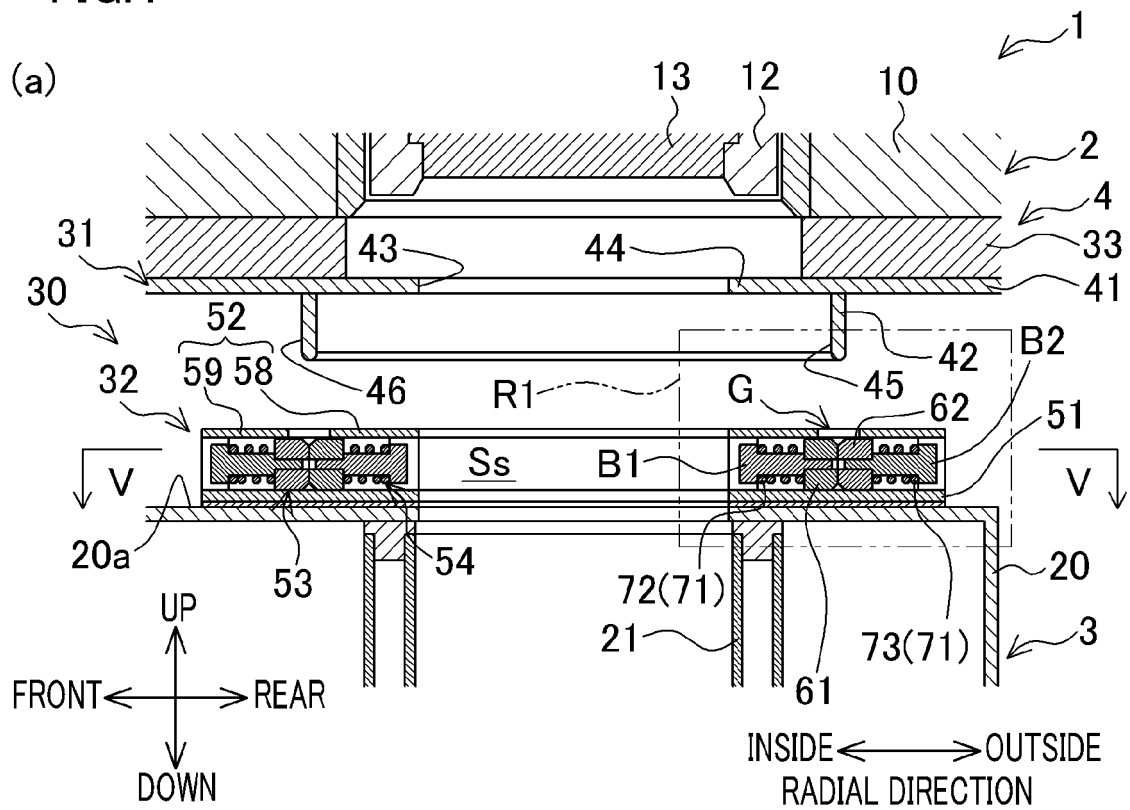


FIG.5

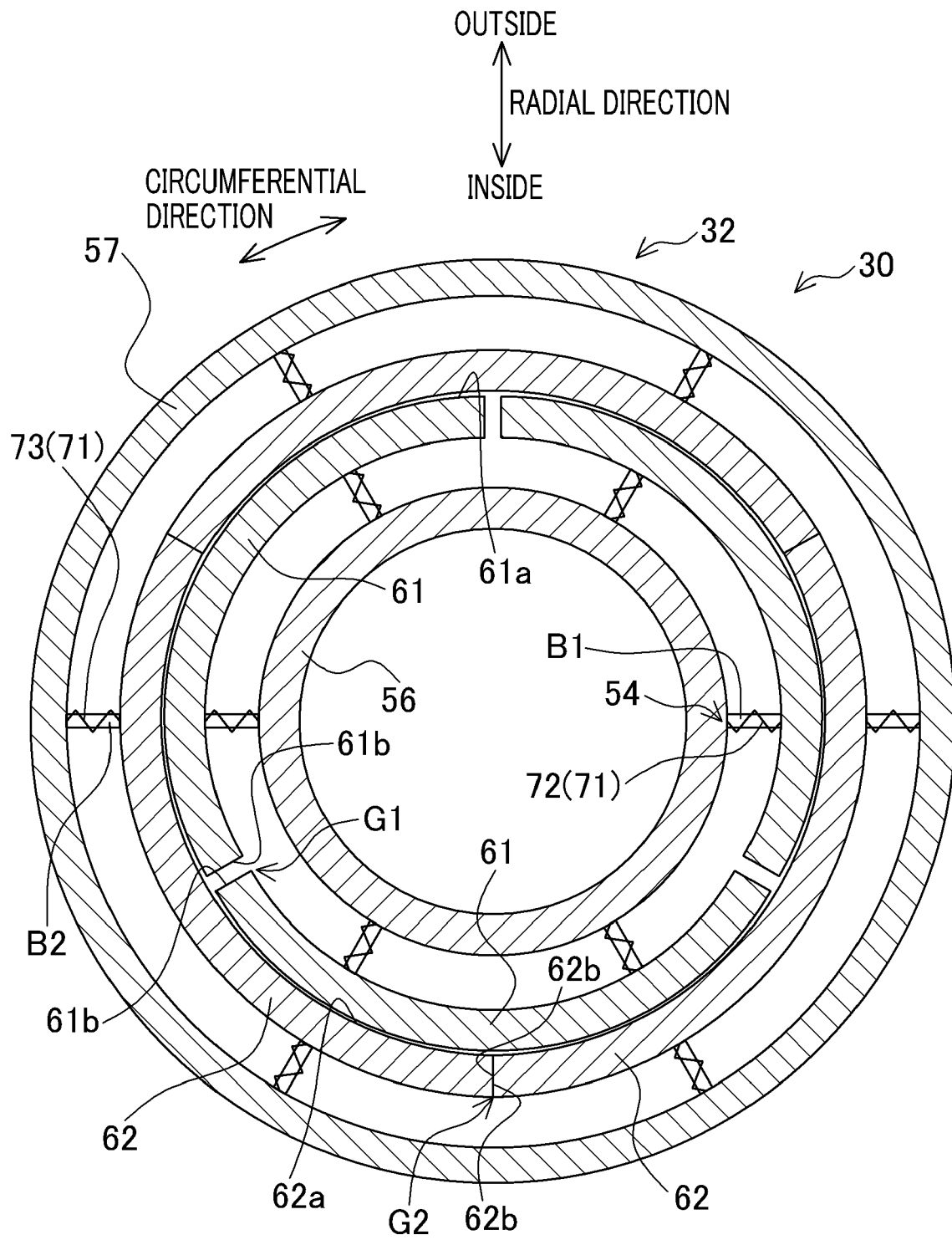


FIG.6

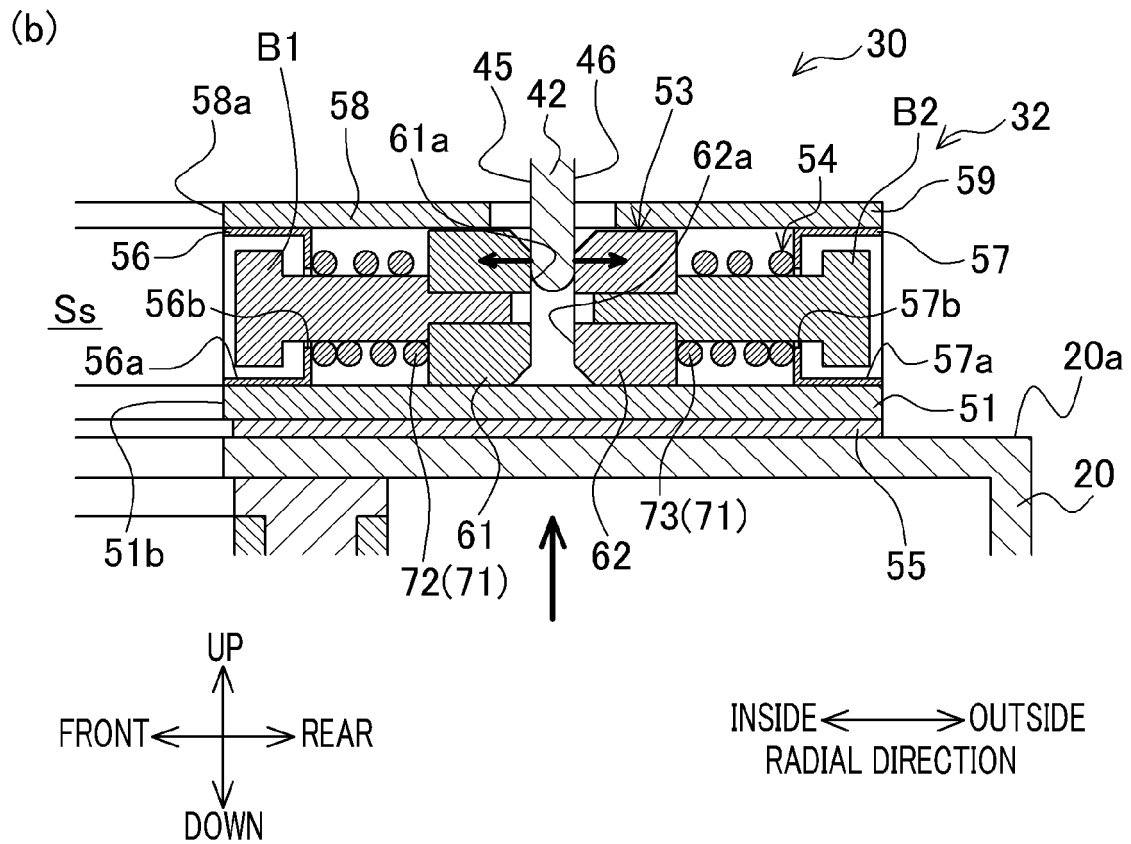
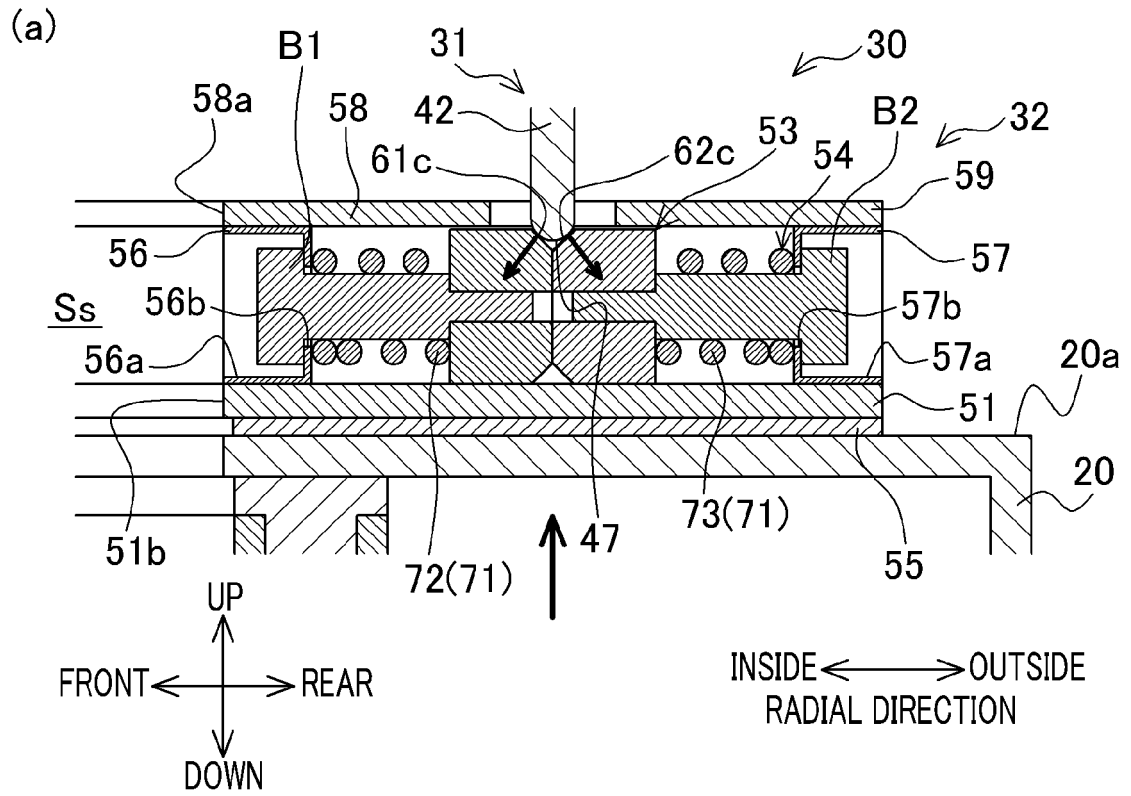


FIG.7

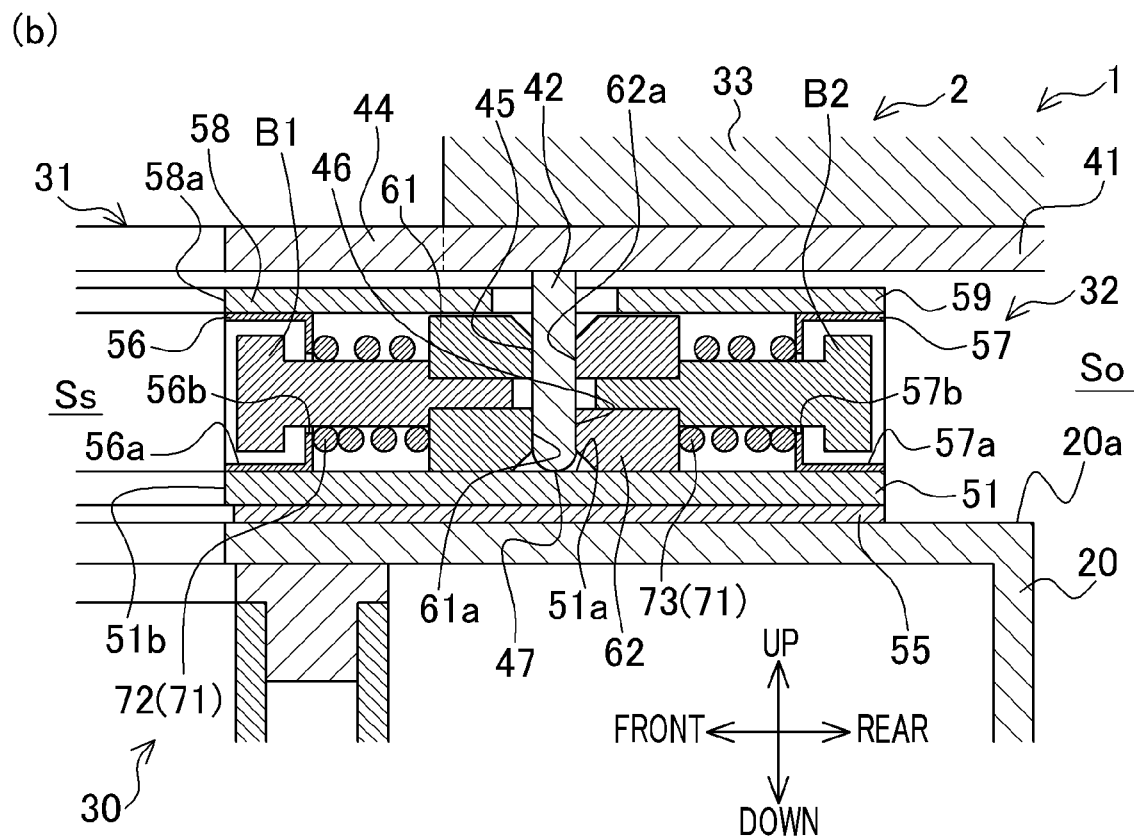
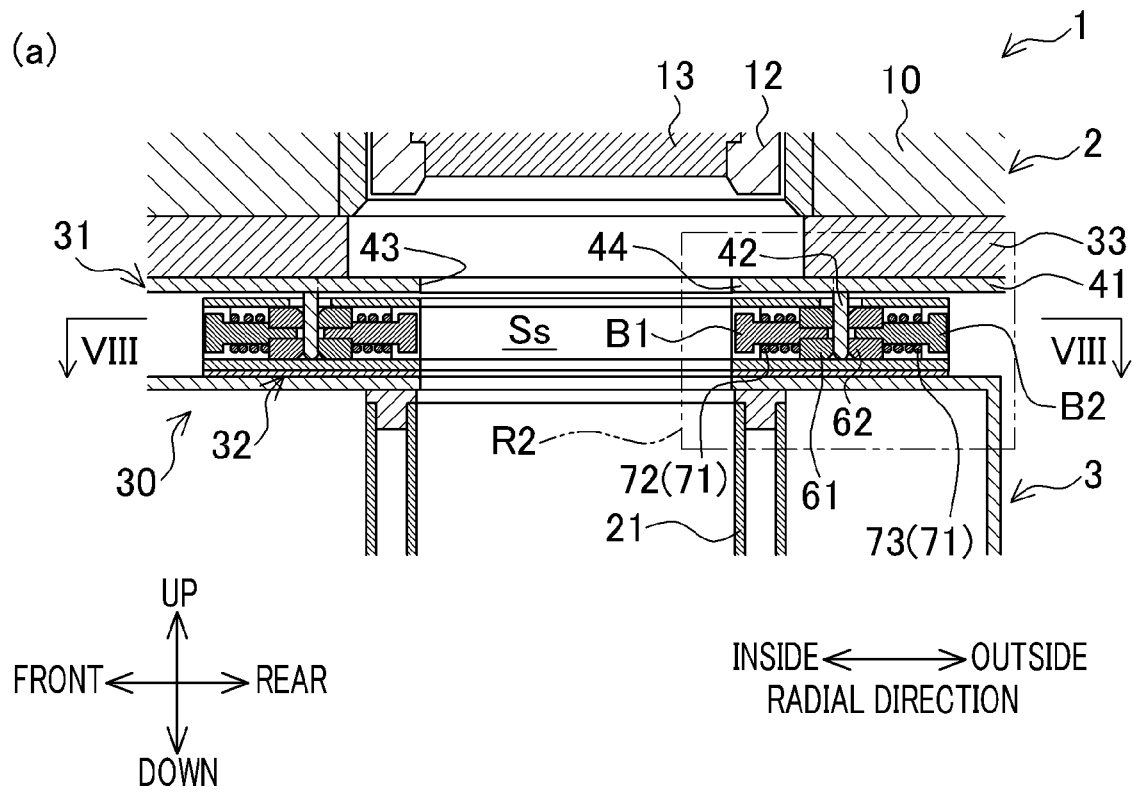


FIG.8

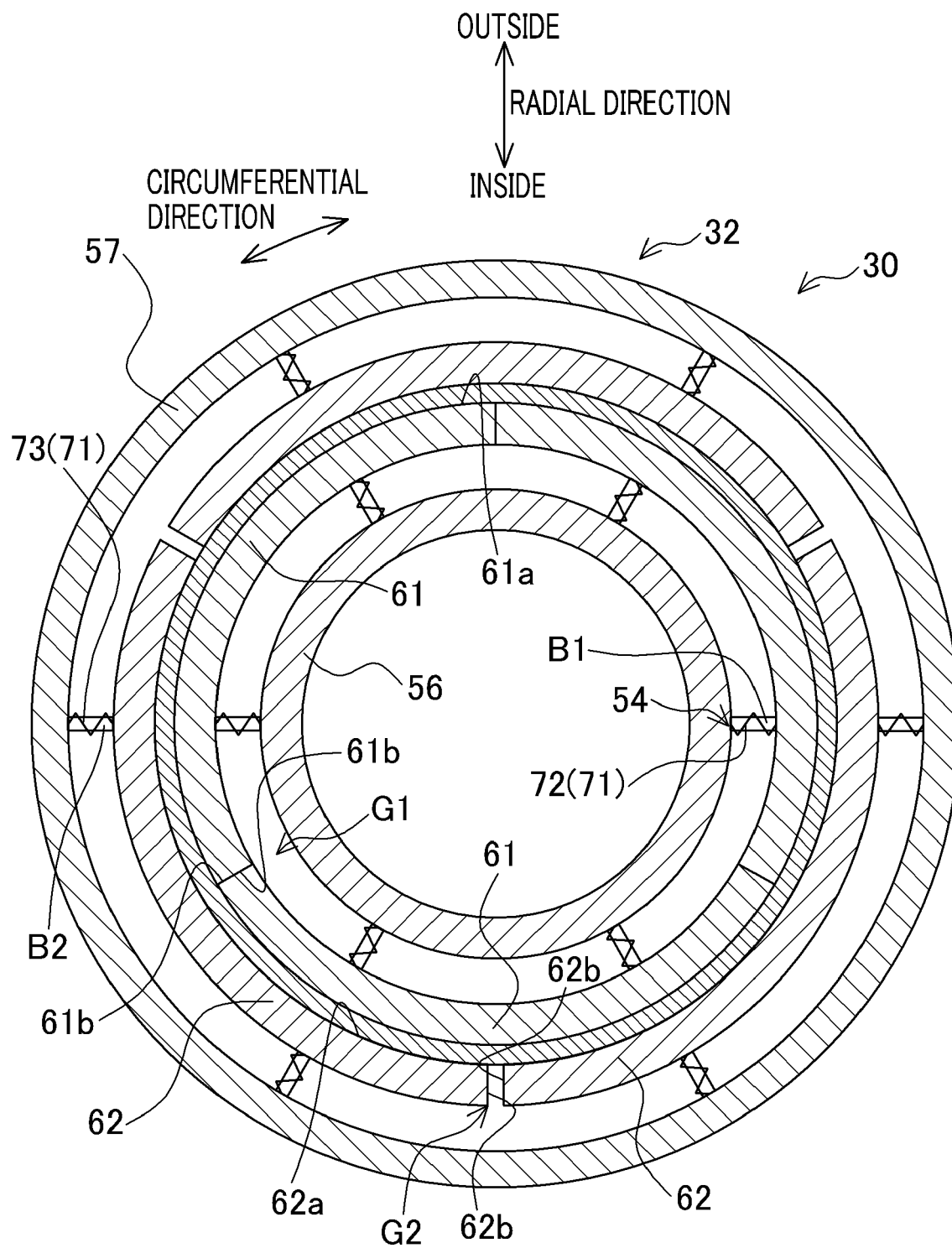
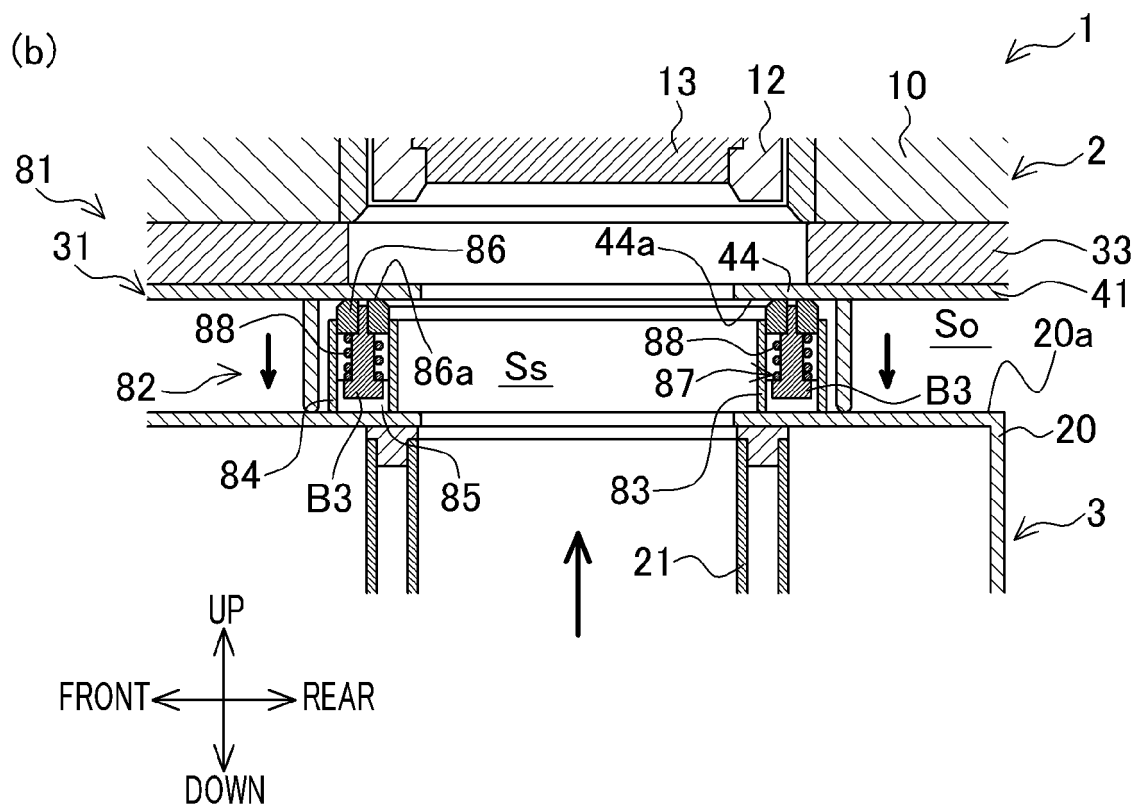
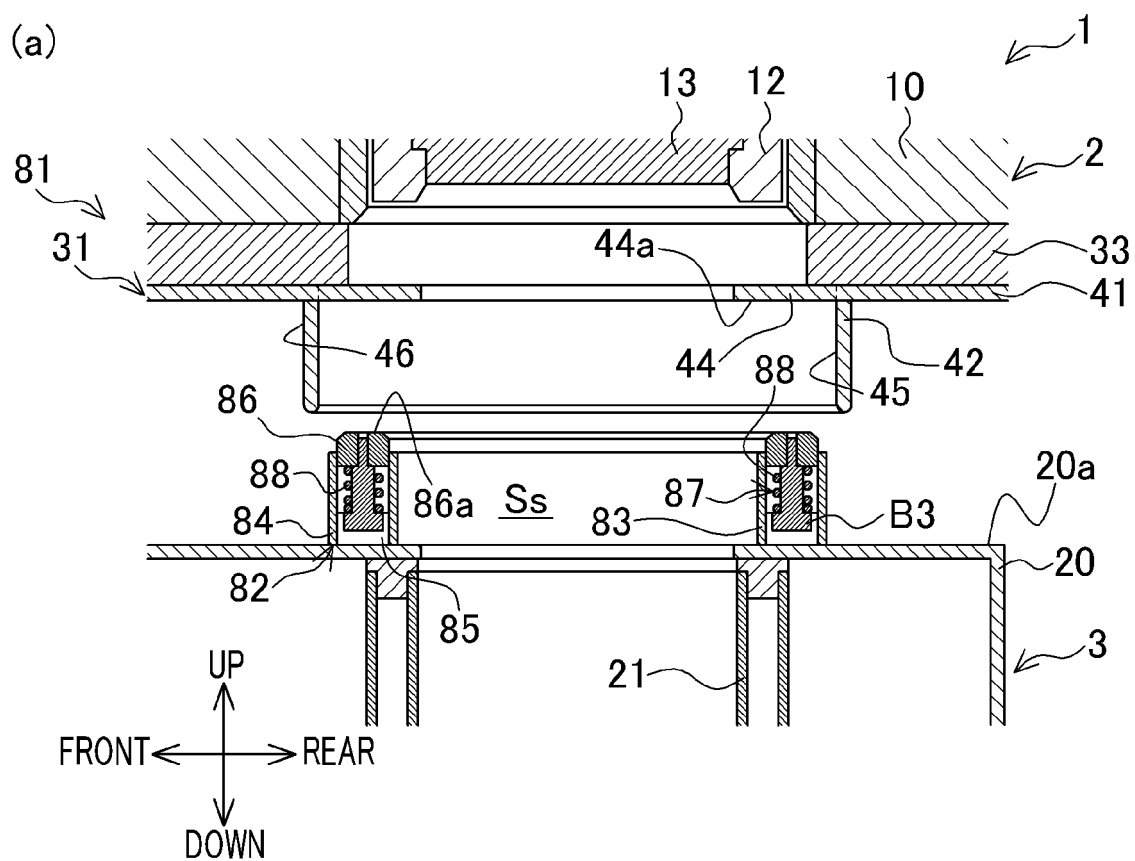


FIG.9





EUROPEAN SEARCH REPORT

Application Number

EP 23 19 5979

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EPO FORM 1503 03.82 (P04C01)

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X	EP 4 063 542 A2 (TMT MACHINERY INC [JP]) 28 September 2022 (2022-09-28)	1-12, 24, 25	INV. D01D5/088
A	* paragraphs [0008], [0040], [0050], [0051], [0054], [5561] - [0064], [0082]; figures 1, 5 *	13-23	D01D5/092 D01D13/02
A	EP 3 147 392 A1 (TMT MACHINERY INC [JP]) 29 March 2017 (2017-03-29) * paragraphs [0034], [0035], [0036], [0059], [0063]; figures 1-4 *	1-25	
A	JP 2016 108698 A (TORAY INDUSTRIES) 20 June 2016 (2016-06-20) * paragraphs [0040], [0041], [0050]; claim 1 *	1-25	
			TECHNICAL FIELDS SEARCHED (IPC)
			D01D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 February 2024	Examiner Van Beurden-Hopkins
CATEGORY OF CITED DOCUMENTS			
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The members are as contained in the European Patent Office EDP file on
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22-02-2024

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