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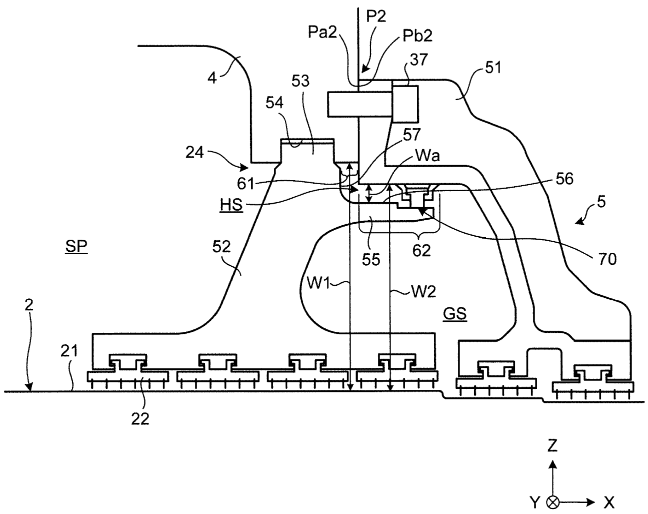
(54) Steam turbine sealing mechanism

(57) A steam turbine (1) includes a turbine rotor (2) including a shaft member and seals connected to the shaft member, a turbine casing (4) disposed around the turbine rotor with a turbine casing space (SP) formed between the turbine casing and the turbine rotor, a gland member (51) and a space-forming member provided with a sealing mechanism (70). The gland member includes a first section having a first joint surface and a second section having a second joint surface joined to the first joint surface, the first section being disposed around a part of the turbine rotor, the second section being disposed around another part of the turbine rotor. The gland member is connected to the turbine casing so as to close an opening (GS) of the turbine casing space that is located at an end thereof. The space-forming member forms a heat insulation space (HS) in which gas flow is inhibited, the heat insulation space being formed between the space-forming member, a first region of the inner surface of the turbine casing, and a second region of the inner surface of the gland member. The first region includes a first end portion of the turbine casing with respect to a direction parallel to a shaft of the turbine rotor and the second region includes a second end portion of the gland member that is adjacent to the first end portion.

FIG.2



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Description

Field

[0001] The present invention relates to a steam turbine.

Background

[0002] One known steam turbine includes a casing for containing a turbine rotor and a gland packing for sealing the gap between the casing and the turbine rotor, as disclosed in, for example, Patent Literature 1. In this steam turbine, the gland packing includes two separate parts, and the first half and second half of the gland packing are connected with bolts with the joint surface of the first half of the gland packing and the joint surface of the second half mating with each other. In addition, the casing and the gland packing are connected with bolts with the joint surface of the casing and the joint surface of the gland packing mating with each other. Seal steam (gland steam) is supplied to the first half of the gland packing, and heat insulation members are disposed in the second half of the gland packing. In this manner, leakage of the steam from the gap between the casing and the gland packing when the casing is thermally deformed is prevented.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent Application Laid-open No. 2003-13704

Summary

Technical Problem

[0004] When the difference in temperature between the casing and the gland packing becomes large and the difference in the amount of thermal deformation thereby becomes large, sufficient pressure (contact pressure) may not be ensured on, for example, the mating surface at which the joint surface of the first half of the gland packing and the joint surface of the second half mate with each other. Therefore, the steam may leak from the gap between the first half and second half of the gland packing.

[0005] It is an object of the present invention to provide a steam turbine in which leakage of steam can be prevented.

Solution to Problem

[0006] According to the present invention, there is provided a steam turbine including: a turbine rotor including a shaft member and a seal connected to the shaft member; a turbine casing disposed around the turbine rotor with a turbine casing space formed between the turbine casing and the turbine rotor; a gland member including a first section having a first joint surface and a second section having a second joint surface joined to the first joint surface, the first section being disposed around a part of the turbine rotor, the second section being disposed around another part of the turbine rotor, the gland member being connected to the turbine casing so as to close an opening of the turbine casing space that is located at an end thereof; and a space-forming member for forming a heat insulation space in which gas flow is inhibited, the heat insulation space being formed between the space-forming member, a first region of an inner surface of the turbine casing, and a second region of an inner surface of the gland member, the first region including a first end portion of the turbine casing with respect to a direction parallel to a shaft of the turbine rotor, the second region including a second end portion of the gland member that is adjacent to the first end portion with respect to the direction parallel to the shaft of the turbine rotor.

[0007] In the present invention, the heat insulation space in which gas flow is inhibited is formed in the boundary region between the first end portion of the turbine casing and the second end portion of the gland member adjacent to the first end portion of the turbine casing. This prevents the difference in temperature between the turbine casing and the gland member from increasing in the boundary region (a joint portion, a connection portion) between the turbine casing and the gland member. Therefore, the difference in the amount of thermal deformation between the turbine casing and the gland member is prevented from increasing in the vicinity of the boundary region. Leakage of steam from the mating surface at which the first joint surface of the first section of the gland member mates with the second joint surface of the second section is thereby prevented.

[0008] In the steam turbine according to the present invention, the heat insulation space is formed so as to surround the shaft. In this case, the difference in temperature between the turbine casing and the gland member is prevented from increasing.

[0009] In the steam turbine according to the present invention, a dimension of the heat insulation space in a radial direction of the shaft of the turbine rotor is smaller than a distance from an outer surface of the shaft member to the first region and a distance from the outer surface of the shaft member to the second region. In this case, while the space to which the gland steam is supplied is ensured, a very small heat insulation space can be formed in the boundary region between the first end portion of the turbine casing and the second end portion of the gland member.

[0010] In the steam turbine according to the present invention, the heat insulation space is a hermetically sealed space. In this case, the gas flow is sufficiently inhibited in the heat insulation space, and a high heat insulation effect can be obtained.

[0011] In the steam turbine according to the present invention, the space-forming member includes: an inner member disposed around the turbine rotor at a position closer to the center of the turbine casing space than the gland member with respect to the direction parallel to the shaft, the inner member including a connection section connected to the inner surface of the turbine casing and a facing surface facing the first region and the second region; and a sealing mechanism that seals a gap between the facing surface and the inner surface of the gland member. In this case, a heat insulation space that can provide a high heat insulation effect can be formed between the inner member, the sealing mechanism, the first region of the turbine casing, and the second region of the gland member.

[0012] In the steam turbine according to the present invention, the turbine casing may include: a third section disposed around a part of the turbine rotor and having a third joint surface; and a fourth section disposed around another part of the turbine rotor and having a fourth joint surface to be joined to the third joint surface. When the turbine casing, as well as the gland member, is separable, maintenance, for example, is facilitated.

Advantageous Effects of Invention

[0013] According to the present invention, leakage of steam can be prevented.

Brief Description of Drawings

[0014]

FIG. 1 is a schematic configuration diagram illustrating an example of a steam turbine according to an embodiment.

FIG. 2 is a side cross-sectional view illustrating the vicinity of a boundary region between a turbine casing and a gland member according to the embodiment.

FIG. 3 is a front view illustrating an example of a casing according to the embodiment.

FIG. 4 is a perspective view illustrating an example of the gland member according to the embodiment.

FIG. 5 is a diagram illustrating an example of a sealing mechanism according to the embodiment.

FIG. 6 is a diagram illustrating an example of a steam turbine according to a comparative example.

FIG. 7 is a diagram illustrating the distribution of temperature in a turbine casing and a gland member in the comparative example.

FIG. 8 is a diagram illustrating the distribution of temperature in the turbine casing and the gland member according to the embodiment.

Description of Embodiments

[0015] Embodiments of the present invention will next be described with reference to the drawings, but the present invention is not limited thereto. The requirements in the respective embodiments described below may be appropriately combined. Some components may not be used. The components in the following embodiments include those which can be easily replaced by persons skilled in the art and also include those substantially equivalent to these components.

[0016] In the following description, an XYZ orthogonal coordinate system is set, and the positional relations between components will be described with reference to the XYZ orthogonal coordinate system. One direction in a prescribed plane is defined as an X axis direction. A direction orthogonal to the X axis direction in the prescribed plane is defined as a Y axis direction, and a direction orthogonal to (i.e., a direction normal to) the X axis direction and to the Y axis direction is defined as a Z axis direction. The directions of rotation (inclination) about the X, Y, and Z axes are defined as θX, θY, and θZ directions, respectively. The X axis is perpendicular to a YZ plane. The Y axis is perpendicular to an XZ plane. The Z axis is perpendicular to an XY plane. The XY plane includes the X axis and the Y axis. The XZ plane includes the X axis and the Z axis. The YZ plane includes the Y axis and the Z axis.

[0017] FIG. 1 is a schematic configuration diagram illustrating an example of a steam turbine 1 according to this embodiment. In FIG. 1, the steam turbine 1 includes a low-pressure turbine casing 100 and a high-pressure turbine casing 200. The high-pressure turbine casing 200 includes a casing 3 disposed around a turbine rotor 2. In this embodiment, the shaft (rotating shaft) of the turbine rotor 2 is parallel to the X axis.

[0018] The casing 3 includes: a turbine casing 4 disposed around the turbine rotor 2 and having a turbine casing space SP formed between the turbine casing 4 and the turbine rotor 2; and gland casings 5 disposed around the turbine rotor 2 and connected to the turbine casing 4 so as to close openings 24 at the ends of the turbine casing space SP. The openings 24 and the gland casings 5 are disposed at respective opposite ends, with respect to X axis direction, of the turbine casing 4.

[0019] FIG. 2 is an enlarged diagram showing part of FIG. 1 and is a side cross-sectional view illustrating the vicinity of a boundary region between the turbine casing 4 and one of the gland casings 5. FIG. 2 is a cross-sectional view showing the vicinity of the gland casing 5 disposed on the +X side of the center of the turbine casing space SP. FIG. 3 is a front view illustrating an example of the casing 3 of the steam turbine 1.

[0020] As shown in FIGS. 1, 2, and 3, the turbine rotor 2 includes a rotatable shaft member 21 and a plurality of seals 22 connected to the shaft member 21. As shown in FIG. 1, the turbine rotor 2 is rotatably supported by bearings 32. The bearings 32 are disposed outside of the turbine casing 4. The bearings 32 are supported by bearing stands provided on a base 35 formed from, for example, concrete.

[0021] The turbine casing 4 is disposed around the turbine rotor 2. The turbine casing 4 has the openings 24 which connect the outer space of the turbine casing 4 to the turbine casing space SP, i.e., the inner space of the turbine casing 4, and in which at least part of the turbine rotor 2 is disposed. The openings 24 are formed on the opposite sides, with respect to the X axis direction, of the turbine casing 4 and disposed at the opposite ends of the turbine casing space SP. The central portion, with respect to the X axis direction, of the turbine rotor 2 is disposed inside of the turbine casing 4, and the opposite ends of the turbine rotor 2 are disposed outside of the turbine casing 4. A steam supply port is provided in an upper portion of the turbine casing 4. Steam (main steam) is supplied to the turbine casing space SP of the turbine casing 4 through the steam supply port.

[0022] The turbine casing 4 is separated into an upper turbine casing 4A and a lower turbine casing 4B. The upper turbine casing 4A is disposed around a part of the turbine rotor 2, and the lower turbine casing 4B is disposed around another part of the turbine rotor 2. The upper turbine casing 4A has a joint surface Pa1. The lower turbine casing 4B has a joint surface Pb1 joined to the joint surface Pa1. Each of the joint surface Pa1 and the joint surface Pb1 is parallel to the XY plane.

[0023] The upper turbine casing 4A includes an upper flange 41 including the joint surface Pa1. The lower turbine casing 4B includes a lower flange 42 including the joint surface Pb1. With the joint surface Pa1 and the joint surface Pb1 mating with each other, the upper turbine casing 4A and the lower turbine casing 4B are fastened with bolts and thereby connected to each other, whereby the turbine casing 4 is formed. The openings 24 are formed between the upper turbine casing 4A and the lower turbine casing 4B.

[0024] As shown in FIG. 2, each of the gland casings 5 includes: an outer gland (gland member) 51 disposed so as to close the opening 24 at an end of the turbine casing space SP from the outside; and an inner gland (inner member) 52 disposed at a position closer to the center, with respect to the X axis direction, of the turbine casing space SP than the outer gland 51 so as to close the opening 24 at the end of the turbine casing space SP. The outer gland 51 and the inner gland 52 are disposed around the turbine rotor 2.

[0025] As shown in FIG. 2, the turbine casing 4 has a joint surface Pb2 joined to a joint surface Pa2 of the outer gland 51. The joint surface Pb2 of the turbine casing 4 is an attachment surface to which the outer gland 51 is attached. The joint surface Pb2 of the turbine casing 4 is an annular surface disposed around the opening 24 and facing outward with respect to the center of the turbine casing space SP. Each of the joint surface Pa2 and the joint surface Pb2 is parallel to the YZ plane perpendicular to the shaft of the turbine rotor 2. A mating surface P2 at which the joint surface Pa2 and the joint surface Pb2 mate with each other is perpendicular to a mating surface P1 at which the joint surface Pa1 and the joint surface Pb1 mate with each other.

[0026] FIG. 4 is a perspective view of one of the outer glands 51. Each outer gland 51 is disposed so as to cover a gap between the turbine casing 4 and the turbine rotor 2 disposed in the opening 24 of the turbine casing 4 and prevents leakage of steam from the opening 24. In this embodiment, gland steam (seal steam) is supplied to a gland space GS between the outer gland 51 and the inner gland 52 through supply ports 81 provided in the outer gland 51. At least part of the gland steam supplied to the gland space GS is discharged from discharge ports 82 provided in the outer gland 51.

[0027] As shown in FIGS. 3 and 4, each outer gland 51 has an annular shape in the YZ plane. At least part of the outer gland 51 is connected to the turbine casing 4. With the joint surface Pa2 of the turbine casing 4 and the joint surface Pb2 of the outer gland 51 mating with each other, the outer gland 51 and the turbine casing 4 are fastened with bolts 37, and the outer gland 51 is thereby connected to the turbine casing 4.

[0028] Each outer gland 51 is separated into an upper outer gland 51A and a lower outer gland 51B. The upper outer gland 51A is disposed around a part of the turbine rotor 2, and the lower outer gland 51B is disposed around another part of the turbine rotor 2. The upper outer gland 51A has a joint surface Pa3. The lower outer gland 51B has a joint surface Pb3 joined to the joint surface Pa3. The joint surface Pa3 and the joint surface Pb3 are parallel to the XY plane. In this embodiment, the mating surface P1 at which the joint surface Pa1 and the joint surface Pb1 mate with each other and a mating surface P3 at which the joint surface Pa3 and the joint surface Pb3 mate with each other are disposed in the same plane.

[0029] The upper outer gland 51A includes an upper flange 27 including the joint surface Pa3. The lower outer gland 51B includes a lower flange 28 including the joint surface Pb3. With the joint surface Pa3 and the joint surface Pb3 mating with each other, the upper outer gland 51A and the lower outer gland 51B are fastened with bolts 38 and thereby connected to each other, whereby the outer gland 51 is formed.

[0030] Each inner gland 52 is disposed so as to cover a gap between the turbine casing 4 and the turbine rotor 2 disposed in the opening 24 of the turbine casing 4 and prevents leakage of steam from the opening 24. At least part of the inner gland 52 is connected to the turbine casing 4. The inner gland 52 has an annular shape in the YZ plane. As is the outer gland 51, the inner gland 52 may be separated into an upper inner gland and a lower inner gland. The inner gland 52 may be formed by connecting the upper inner gland and the lower inner gland with, for example, bolts. The inner gland 52 may not be separated.

[0031] As shown in FIG. 2, the inner gland 52 has a connection section 53 connected to the inner surface of the turbine casing 4. In this embodiment, a recess 54 is formed on the inner surface of the turbine casing 4. The connection section 53 includes a protrusion fitted into the recess 54. The inner gland 52 includes a protrusion 55 extending toward the outer side of the center, with respect to the X axis direction, of the turbine casing space SP. The protrusion 55 is disposed so as to surround the shaft of the turbine rotor 2.

[0032] A heat insulation space HS is defined by a first region 61 of the inner surface of the turbine casing 4 and a second region 62 of the outer gland 51 with respect to the X axis direction. The first region 61 of the inner surface of the turbine casing 4 includes a first end portion, with respect to the X axis direction, of the inner surface of the turbine casing 4 (the end portion on the +X side in the example shown in FIG. 2). The second region 62 of the outer gland 51 includes a second end portion of the inner surface of the outer gland 51 that is adjacent to the first end portion of the inner surface of the turbine casing 4 (the second end portion is the end portion of the outer gland 51 on the -X side in the example shown in FIG. 2). The heat insulation space HS is formed between the first region 61 of the turbine casing 4, the second region 62 of the outer gland 51, the inner gland 52, and a sealing mechanism 70. In this embodiment, the inner gland 52 and the sealing mechanism 70 serve as space-forming members that form the heat insulation space HS between the inner gland 52, the sealing mechanism 70, the first region 61, and the second region 62.

[0033] The inner gland 52 includes: a facing surface 56 that is disposed in the protrusion 55 and faces the first region 61 and the second region 62 through a gap; and a side surface 57 that is disposed between the connection section 53 and the facing surface 56 and faces the outer side with respect to the center of the turbine casing space SP. The side surface 57 faces the sealing mechanism 70 through a gap. In this embodiment, each of the first region 61, the second region 62, and the facing surface 56 is substantially parallel to the X axis.

[0034] The sealing mechanism 70 seals the gap between the facing surface 56 and the inner surface of the outer gland 51. In this embodiment, the heat insulation space HS is formed between the first region 61 of the turbine casing 4, the second region 62 of the outer gland 51, the facing surface 56 of the inner gland 52, the side surface 57 of the inner gland 52, and the sealing mechanism 70.

[0035] The heat insulation space HS is a closed space. In this embodiment, the heat insulation space HS is a hermetically sealed space. The heat insulation space HS is formed so as to surround the shaft of the turbine rotor 2. The gland space GS is disposed so as to be adjacent to the heat insulation space HS. The space-forming members including the inner gland 52 (the protrusion 55) and the sealing mechanism 70 are disposed at the boundary between the heat insulation space HS and the gland space GS. The first region 61 and the second region 62 form the boundary region between the turbine casing 4 and the outer gland 51. The heat insulation space HS is disposed between the gland space GS and the first and second regions 61 and 62.

[0036] In the heat insulation space HS, the flow of gas is inhibited. In this embodiment, the flow of gas (the velocity of the airflow) in the heat insulation space HS is smaller (lower) than the flow of gas (the velocity of the airflow) in the gland space GS. Gland steam is supplied from the outside of the gland space GS to the gland space GS through the supply ports 81. No gas (such as gland steam) is supplied from the outside of the heat insulation space HS to the heat insulation space HS. The sealing mechanism 70 is disposed between the heat insulation space HS and the gland space GS to thereby prevent the gland steam in the gland space GS from flowing into the heat insulation space HS. Specifically, in this embodiment, the amount of gas flowing into the heat insulation space HS from the outside per unit time is smaller than the amount of gas (gland steam) flowing into the gland space GS from the outside per unit time.

[0037] The dimension Wa of the heat insulation space HS in the radial direction of the shaft of the turbine rotor 2 is smaller than the distance W1 between the outer surface of the shaft member 21 and the first region 61 and the distance W2 between the outer surface of the shaft member 21 and the second region 62. The heat insulation space HS is a very small space formed in the boundary region between the turbine casing 4 and the outer gland 51.

[0038] FIG. 5 is a diagram illustrating an example of the sealing mechanism 70 according to this embodiment. The sealing mechanism 70 includes a secured member 71 secured to the inner surface of the outer gland 52 and having an inner space, an elastic member 72, such as a flat spring, disposed in the inner space of the secured member 71, and a sealing member 73, at least part of which is disposed in the inner space of the secured member 71. The secured member 71 has an opening 74 that connects the inner space of the secured member 71 to its outer space. At least part of the sealing member 73 is disposed in the opening 74. A part of the sealing member 73 is disposed in the inner space of the secured member 71, and another part of the sealing member 73 is disposed in the outer space of the secured member 71 through the opening 74. In the inner space of the secured member 71, the elastic member 72 is disposed between the outer gland 51 and the sealing member 73. The elastic member 72 generates a force (urging force) that causes the sealing member 73 to be pressed against the inner gland 52 (the protrusion 55). Sufficient contact between the sealing member 73 and the inner gland 52 is thereby obtained. Therefore, the outflow of gas in the heat insulation space HS and the flow of gas in the gland space GS into the heat insulation space HS are prevented.

[0039] The heat insulation space HS described with reference to FIG. 2 etc. is formed on a first side (+X side), with respect to the X axis direction, of the turbine casing space SP. As shown in FIG. 1, another gland casing 5 including the outer gland 51 and the inner gland 52 is disposed on a second side (-X side), with respect to the X axis direction, of the turbine casing space SP, and another heat insulation space HS is formed. In the gland casing 5 disposed on the second side (-X side) of the turbine casing space SP, the heat insulation space HS is defined by the first region 61 of the inner surface of the turbine casing 4 and the second region 62 of the outer gland 51. The first region 61 of the inner surface of the turbine casing 4 includes a second end portion, with respect to the X axis direction, of the inner surface of the turbine casing 4 (the end portion on the -X side). The second region 62 of the outer gland 51 includes a first end portion of the inner surface of the outer gland 51 that is adjacent to the second end portion of the inner surface of the turbine casing 4 (the first end portion of the outer gland 51 is the end portion on the +X side). The first region 61 and the second region 62 form a boundary region between the turbine casing 4 and the outer gland 51 on the second side (-X side) of the turbine casing space SP with respect to the X axis direction. The heat insulation space HS is formed between the first region 61 of the turbine casing 4, the second region 62 of the outer gland 51, the inner gland 52, and the sealing mechanism 70, the inner gland 52 and the sealing mechanism 70 being disposed on the second side (-X side) of the turbine casing space SP with respect to the X axis direction.

[0040] Next, the operation of the steam turbine 1 according to this embodiment will be described. High-temperature high-pressure steam (main steam) is supplied to the turbine casing space SP through a steam supply port 23. The steam supplied to the turbine casing space SP rotates the turbine rotor 2. In addition, gland steam is supplied to the gland spaces GS through the supply ports 81.

[0041] Since the main steam is supplied to the turbine casing space SP and the gland steam is supplied to the gland spaces GS, the difference in temperature between the turbine casing 4 and each of the outer glands 51 may become large. When the difference in temperature between the turbine casing 4 and an outer gland 51 becomes large with the turbine casing 4 connected to the outer gland 51, the difference in the amount of thermal deformation between the turbine casing 4 and the outer gland 51 may become large. In this case, sufficient pressure (contact pressure) may not be ensured on the mating surface P3 at which the joint surface Pa3 of the upper outer gland 51A mates with the joint surface Pb3 of the lower outer gland 51B. For example, even when the temperature of the turbine casing 4 becomes high and the amount of thermal deformation of the turbine casing 4 becomes large, the temperature of the outer gland 51 may not become as high as the temperature of the turbine casing 4, and the amount of thermal deformation of the outer gland 51 may be small. In this case, a force may act on the outer gland 51 as the turbine casing 4 is thermally deformed. For example, a force may act on at least one of the upper outer gland 51A and the lower outer gland 51B such that the joint surface Pa3 and the joint surface Pb3 are separated from each other. Therefore, steam (gland steam) may leak from the gap between the joint surface Pa3 of the upper outer gland 51A and the joint surface Pb3 of the lower outer gland 51B.

[0042] In this embodiment, the heat insulation spaces HS disposed in the boundary regions between the turbine casing 4 and the outer glands 51 can prevent the difference in temperature between the turbine casing 4 and the outer glands 51 from increasing in the vicinities of the boundary regions between the turbine casing 4 and the outer glands 51.

[0043] FIG. 6 is a diagram illustrating an example of a steam turbine 1J according to a comparative example. The steam turbine 1J according to the comparative example has no heat insulation space HS.

[0044] FIG. 7 is a schematic diagram illustrating the distribution of temperature in the turbine casing 4 and an outer gland 51 in the steam turbine 1J according to the comparative example when main steam is supplied to the turbine casing space SP and gland steam is supplied to the gland spaces GS. FIG. 7 shows the temperature distribution in a cross section parallel to the XY plane and near the boundary region between the turbine casing 4 and the outer gland 51. As shown in FIG. 7, in the steam turbine 1J according to the comparative example, it can be seen that the difference in temperature between the turbine casing 4 and the outer gland 51 is large in the vicinity of the boundary region between the turbine casing 4 and the outer gland 51.

[0045] FIG. 8 is a diagram illustrating the distribution of temperature in the turbine casing 4 and the outer gland 51 in the steam turbine 1 according to the embodiment when main steam is supplied to the turbine casing space SP of the steam turbine 1 and gland steam is supplied to the gland spaces GS. FIG. 8 shows the temperature distribution in a cross section parallel to the XY plane and near the boundary region between the turbine casing 4 and the outer gland 51. As shown in FIG. 8, in the steam turbine 1 according to this embodiment, since the heat insulation space HS for inhibiting the flow of gas is disposed in the boundary region between the turbine casing 4 and the outer gland 51, the difference in temperature between the turbine casing 4 and the outer gland 51 is prevented from increasing in the vicinity of the boundary region between the turbine casing 4 and the outer gland 51.

[0046] Leakage of the steam from the mating surfaces P3 in the steam turbine 1 according to this embodiment is smaller than leakage of the steam from the mating surfaces P3 in the steam turbine 1J according to the comparative example.

[0047] This may be because the gland steam supplied to the gland spaces GS is not supplied to the boundary regions between the turbine casing 4 and the outer glands 51 (the first regions 61 and the second regions 62) and therefore the difference in temperature between the turbine casing 4 and the outer glands 51 is prevented from increasing. Specifically, when the gland steam in the gland spaces GS flows near the boundary regions between the turbine casing 4 and the outer glands 51, an increase in the temperature of the outer glands 51 that is caused by the gland steam in the gland spaces GS may be prevented. More specifically, when the gland steam flows so as to come into contact with the first regions 61 and the second regions 62, the gland steam may cause a phenomenon in which the temperature of the outer glands 51 near the boundary regions is not as high as the temperature of the turbine casing 4.

[0048] In this embodiment, the heat insulation spaces HS prevent the gland steam in the gland spaces GS from flowing in the vicinities of the boundary regions between the turbine casing 4 and the outer glands 51. In other words, since the first regions 61 and the second regions 62 forming the boundary regions between the turbine casing 4 and the outer glands 51 are protected by the heat insulation spaces HS, the gland steam in the gland spaces GS is prevented from flowing in contact with the first regions 61 and the second regions 62. Therefore, the occurrence of the phenomenon in which the temperature of the outer glands 51 is prevented from increasing in the vicinities of the boundary regions is suppressed. The heat of the turbine casing 4 is transferred to the outer glands 51 through the mating surfaces P3 etc., and the temperature of the outer glands 51 thereby increases. This may prevent the difference in temperature between the turbine casing 4 and the outer glands 51 from increasing in the vicinities of the boundary regions.

[0049] Since the difference in temperature between the turbine casing 4 and the outer glands 51 is prevented from increasing in the vicinities of the boundary regions between the turbine casing 4 and the outer glands 51, a force that causes separation of the joint surfaces Pa3 from the joint surfaces Pb3 when the turbine casing 4 is thermally deformed is prevented from acting on the outer glands 51. Specifically, the difference in temperature between the turbine casing 4 and the outer glands 51 is small. Therefore, when the turbine casing 4 is thermally deformed, the outer glands 51 are also thermally deformed with the amount of thermal deformation of the outer glands 51 being substantially the same as the amount of thermal deformation of the turbine casing 4. This prevents a force causing separation of the joint surfaces Pa3 from the joint surfaces Pb3 from acting on the outer glands 51. Therefore, leakage of the steam (gland steam) from gaps between the joint surfaces Pa3 of the upper outer glands 51A and the joint surfaces Pb3 of the lower outer glands 51B is prevented.

[0050] As described above, in this embodiment, the heat insulation spaces HS in which the flow of gas is inhibited are formed in the boundary regions between the turbine casing 4 and the outer glands 51, so that the difference in temperature between the turbine casing 4 and the outer glands 51 is prevented from increasing in the boundary regions (joint portions, connection portions) between the turbine casing 4 and the outer glands 51. Therefore, the difference in the amount of thermal deformation between the turbine casing 4 and the outer gland 51 is prevented from increasing in the vicinities of the boundary regions. This can prevent leakage of the steam from the mating surfaces P3 at which the joint surfaces Pa3 of the upper outer glands 51A of the outer glands 51 mate with the joint surfaces Pb3 of the lower outer glands 51B.

[0051] In this embodiment, the outer gland 51 can be separated into the joint surface Pa3 of the upper outer gland 51A and the lower outer gland 51B, and this can facilitate, for example, maintenance of the steam turbine 1.

[0052] In this embodiment, the heat insulation spaces HS are formed so as to surround the shaft of the turbine rotor 2. This can prevent the difference in temperature between the turbine casing 4 and the outer glands 51 from increasing in the vicinities of the boundary regions between the turbine casing 4 and the outer glands 51.

[0053] In this embodiment, the dimension Wa of the heat insulation spaces HS in the radial direction of the shaft of the turbine rotor 2 is smaller than the distance W1 from the outer surface of the shaft member 21 to the first regions 61 and is also smaller than the distance W2 from the outer surface of the shaft member 21 to the second regions 62. Therefore, while the gland spaces GS to which the gland steam is supplied are ensured, very small heat insulation spaces HS can be formed in the boundary regions between the turbine casing 4 and the outer glands 5.

[0054] In this embodiment, the heat insulation spaces HS are hermetically sealed spaces. Therefore, the flow of gas is sufficiently inhibited in the heat insulation spaces HS, and a high heat insulation effect can thereby be obtained.

[0055] In this embodiment, the turbine casing 4 is separated into the upper turbine casing 4A and the lower turbine casing 4B. Since the turbine casing 4, as well as the outer glands 51, is separable, for example, maintenance of the steam turbine 1 can be smoothly performed.

[0056] In this embodiment, a plurality of heat insulation spaces HS may be formed around the shaft of the turbine rotor 2, or a heat insulation space HS may be formed only in the vicinity of each mating surface P3.

[0057] In this embodiment, each heat insulation space HS may be completely sealed hermetically or may not be sealed hermetically. Each heat insulation space HS may be a closed space or a semi-closed space. For example, the sealing mechanism 70 may completely seal the gap between the facing surface 56 and the inner surface of the outer gland 51, or a gap may be formed between the sealing mechanism 70 and one or both of the facing surface 56 and the outer gland 51. Specifically, it is only necessary that the flow of gas be more inhibited in the heat insulation spaces HS than in the gland spaces GS. Therefore, the sealing mechanisms 70 may be omitted.

[0058] In this embodiment, the facing surfaces 56 are disposed in the protrusions 55 provided in the inner glands 52. However, the facing surfaces 56 may be disposed in, for example, the outer glands 51. For example, each outer gland 51 may include a protrusion protruding toward the center, with respect to the X axis direction, of the turbine casing space SP, and the protrusion may have a facing surface 56. The space-forming members for forming the heat insulation spaces HS between the space-forming members, the first regions 61, and the second regions 62 may be members different from the outer glands 51 and the inner glands 52. For example, members different from the outer glands 51 and the inner glands 52 may be disposed in the gland spaces GS so as to face the first regions 61 and the second regions 62.

Reference Signs List

[0059]

1	steam turbine
2	turbine rotor
3	casing
4	turbine casing
4A	upper turbine casing
4B	lower turbine casing
5	gland casing
21	shaft member
22	seal
24	opening
51	outer gland
51A	upper outer gland
51B	lower outer gland
52	inner gland
53	connection section
56	facing surface
61	first region
62	second region
70	sealing mechanism
GS	gland space
HS	heat insulation space
SP	turbine casing space

Claims

1. A steam turbine comprising:

a turbine rotor including a shaft member and a seal connected to the shaft member;
a turbine casing disposed around the turbine rotor with a turbine casing space formed between the turbine casing and the turbine rotor;
a gland member including a first section having a first joint surface and a second section having a second joint surface joined to the first joint surface, the first section being disposed around a part of the turbine rotor, the second section being disposed around another part of the turbine rotor, the gland member being connected to the turbine casing so as to close an opening of the turbine casing space that is located at an end thereof; and
a space-forming member for forming a heat insulation space in which gas flow is inhibited, the heat insulation space being formed between the space-forming member, a first region of an inner surface of the turbine casing, and a second region of an inner surface of the gland member, the first region including a first end portion of the turbine casing with respect to a direction parallel to a shaft of the turbine rotor, the second region including a second end portion of the gland member that is adjacent to the first end portion with respect to the direction parallel to the shaft of the turbine rotor.

2. The steam turbine according to claim 1, wherein the heat insulation space is formed so as to surround the shaft.

3. The steam turbine according to claim 1 or 2, wherein a dimension of the heat insulation space in a radial direction of the shaft of the turbine rotor is smaller than a distance from an outer surface of the shaft member to the first region and a distance from the outer surface of the shaft member to the second region.

4. The steam turbine according to any one of claims 1 to 3, wherein the heat insulation space is a hermetically sealed space.

5. The steam turbine according to any one of claims 1 to 4, wherein
the space-forming member includes:

an inner member disposed around the turbine rotor at a position closer to the center of the turbine casing space than the gland member with respect to the direction parallel to the shaft, the inner member including a connection section connected to the inner surface of the turbine casing and a facing surface facing the first region and the second region; and
a sealing mechanism that seals a gap between the facing surface and the inner surface of the gland member.

6. The steam turbine according to any one of claims 1 to 5, wherein the turbine casing includes: a third section disposed around a part of the turbine rotor and having a third joint surface; and a fourth section disposed around another part of the turbine rotor and having a fourth joint surface joined to the third joint surface.

FIG.1

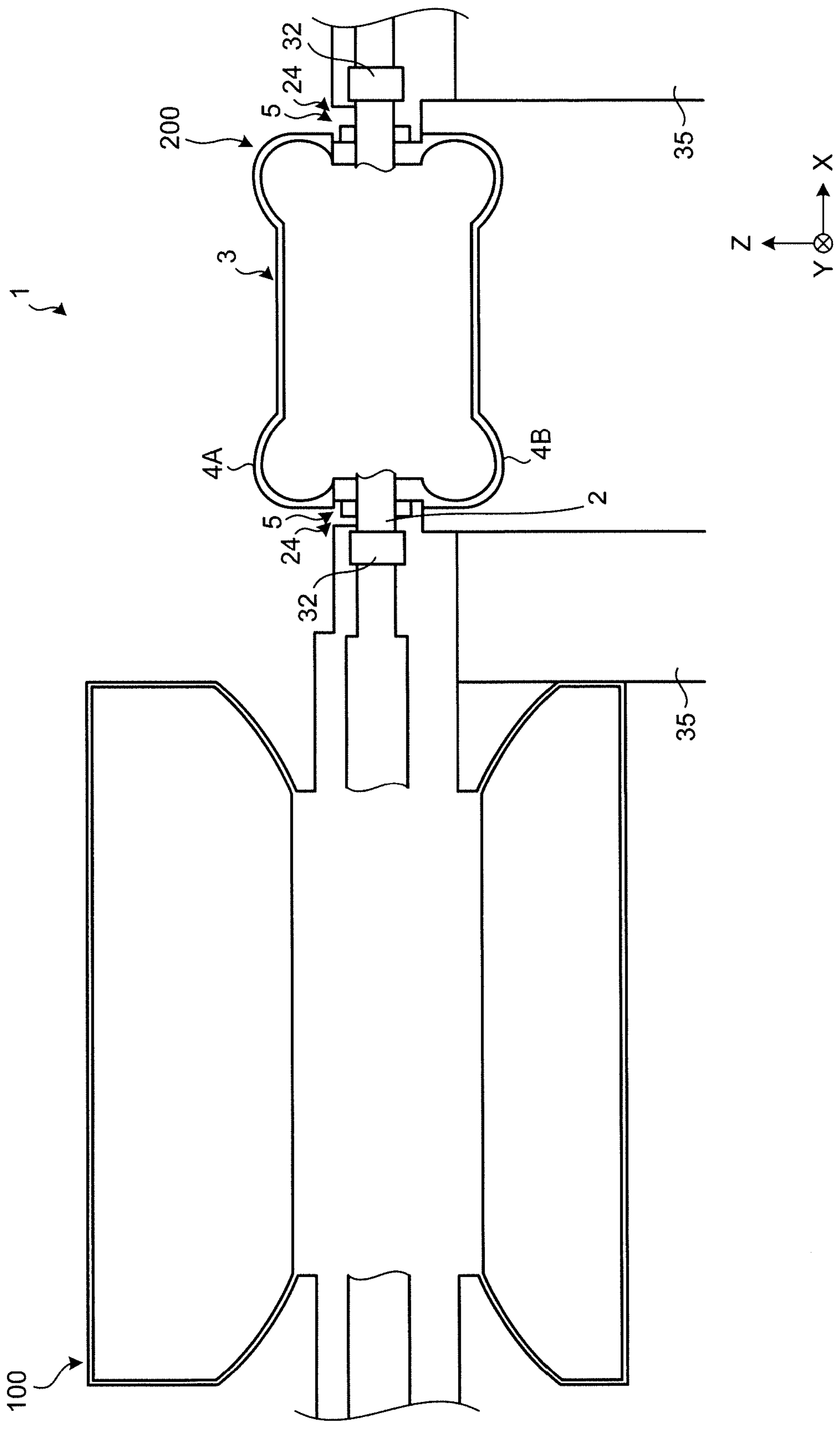
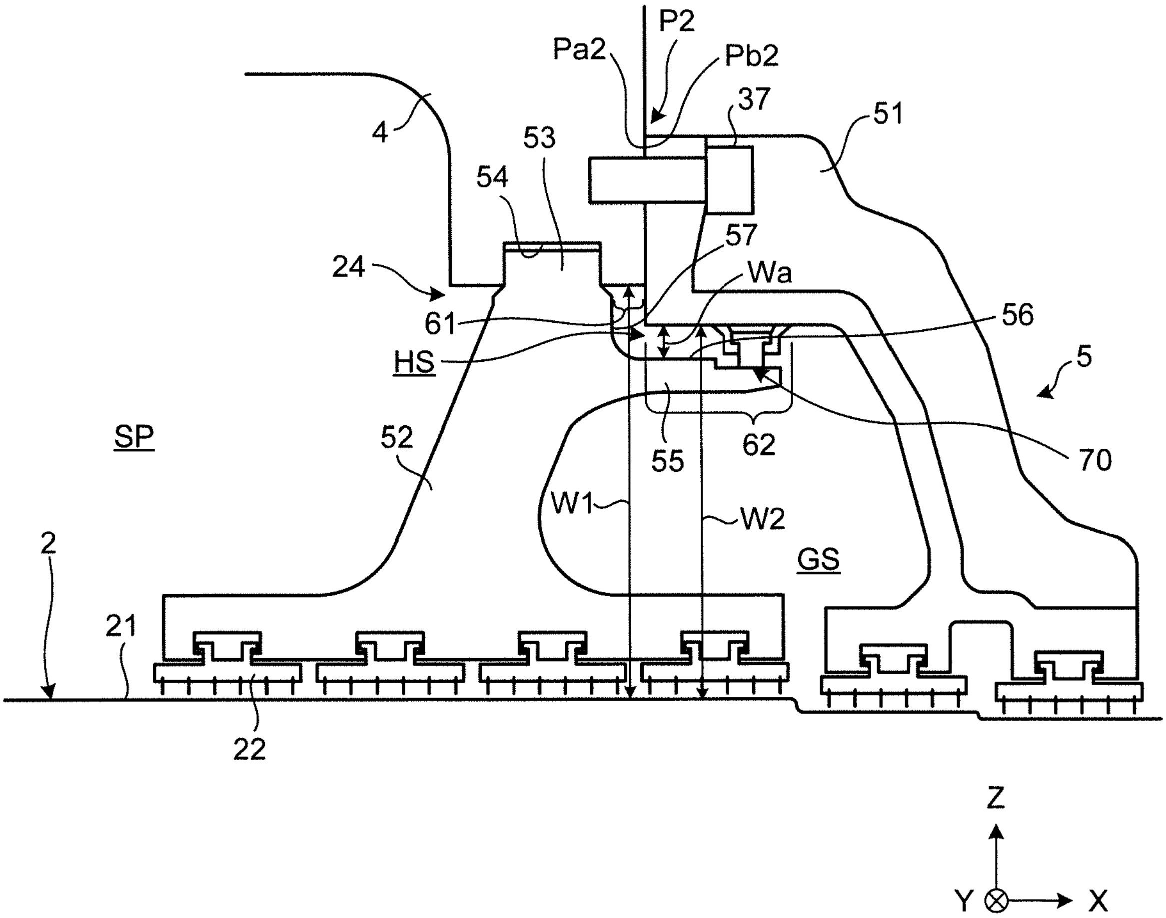


FIG.2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4
53
54
57
Wa
24
56
61
5
HS
SP
52
55
62
70
W1
W2
GS
2
21
22
Z
Y
X

FIG.3

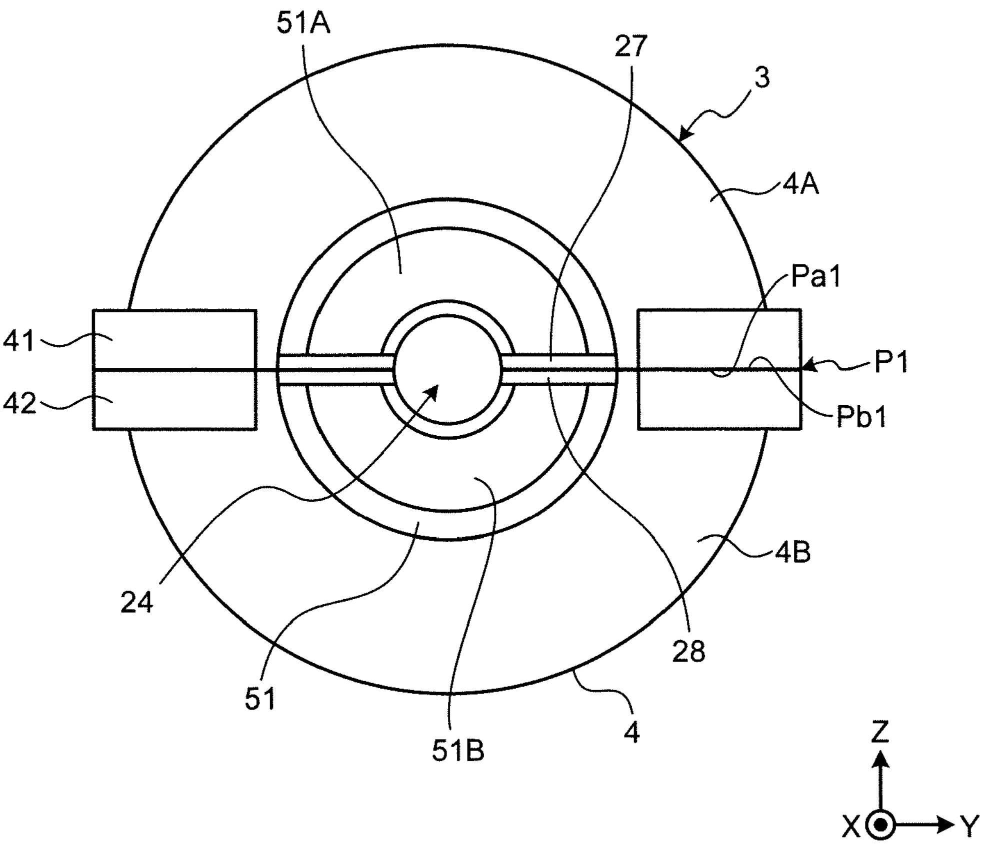


FIG.4

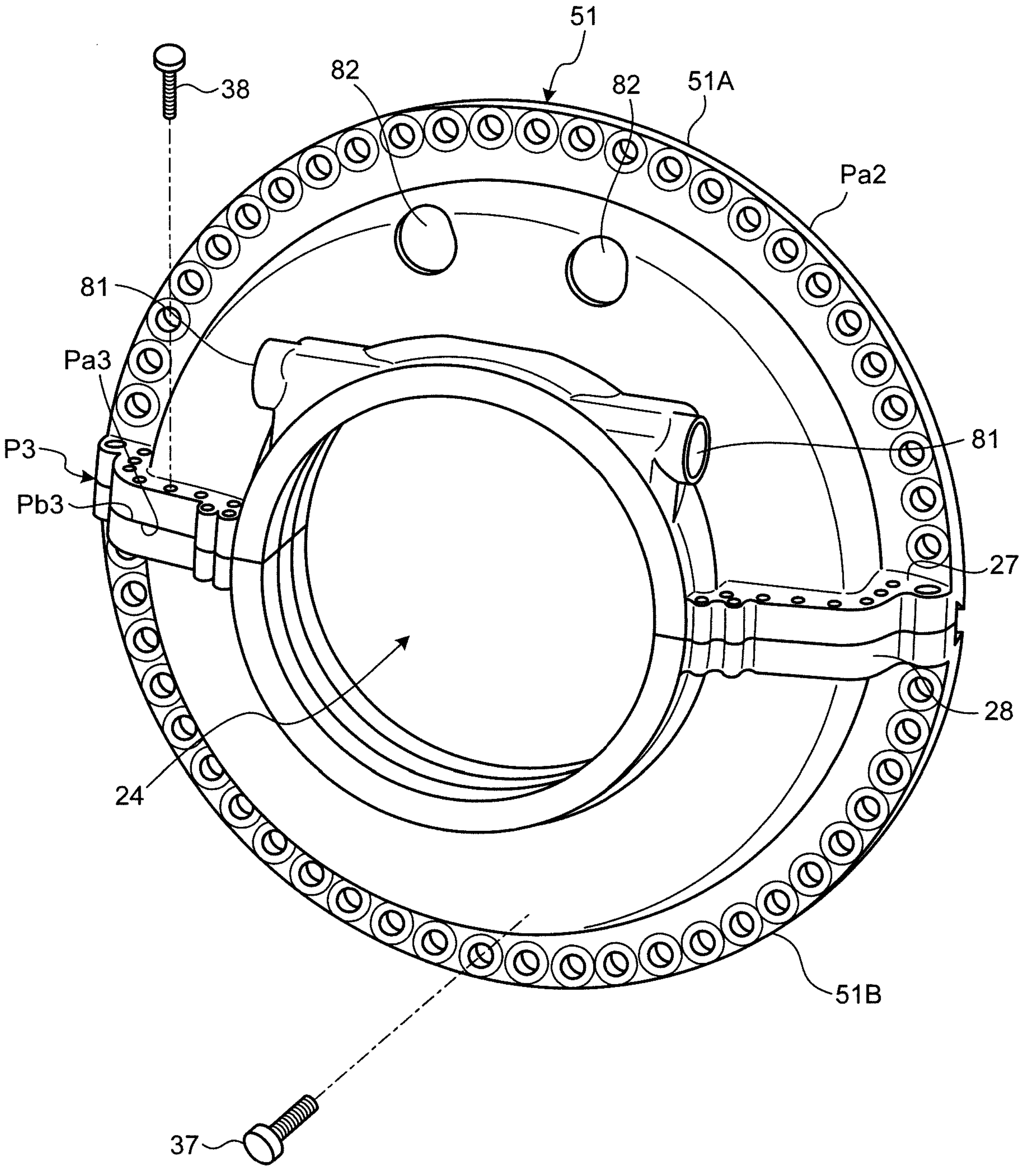


FIG.5

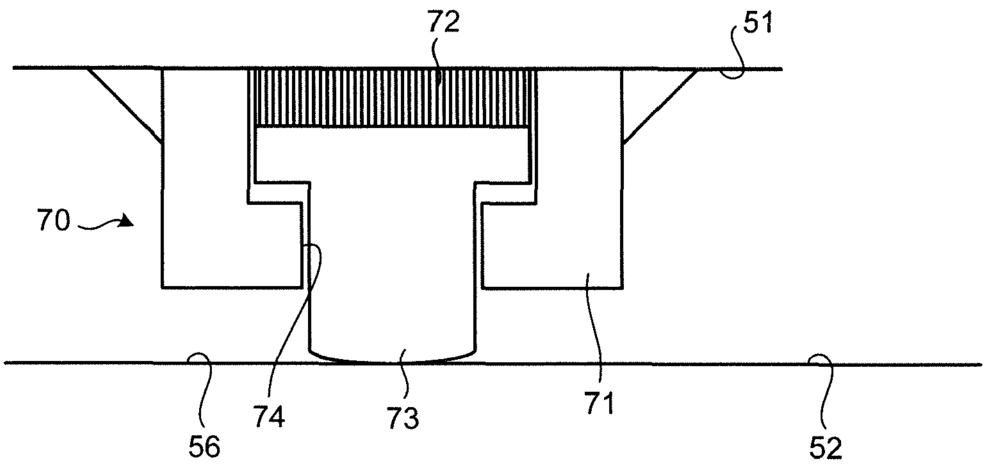


FIG.6

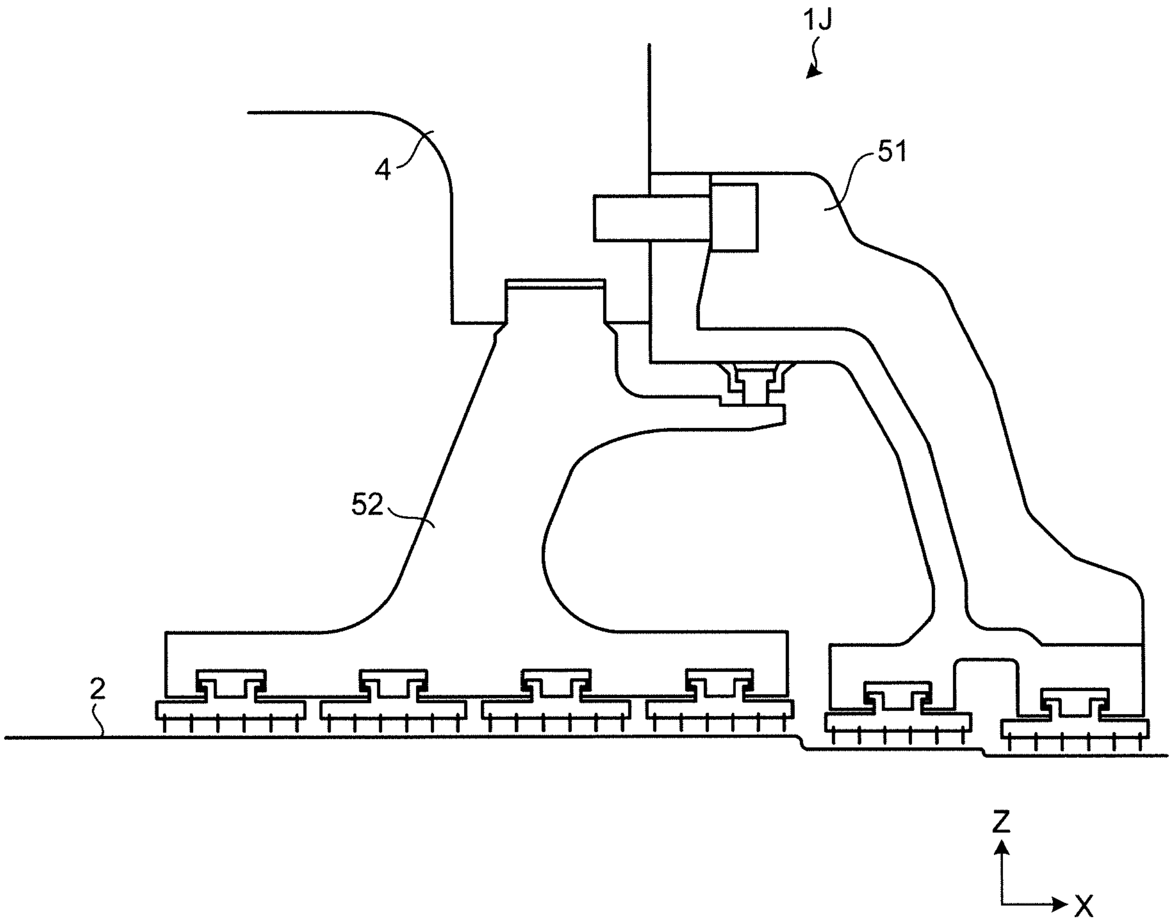
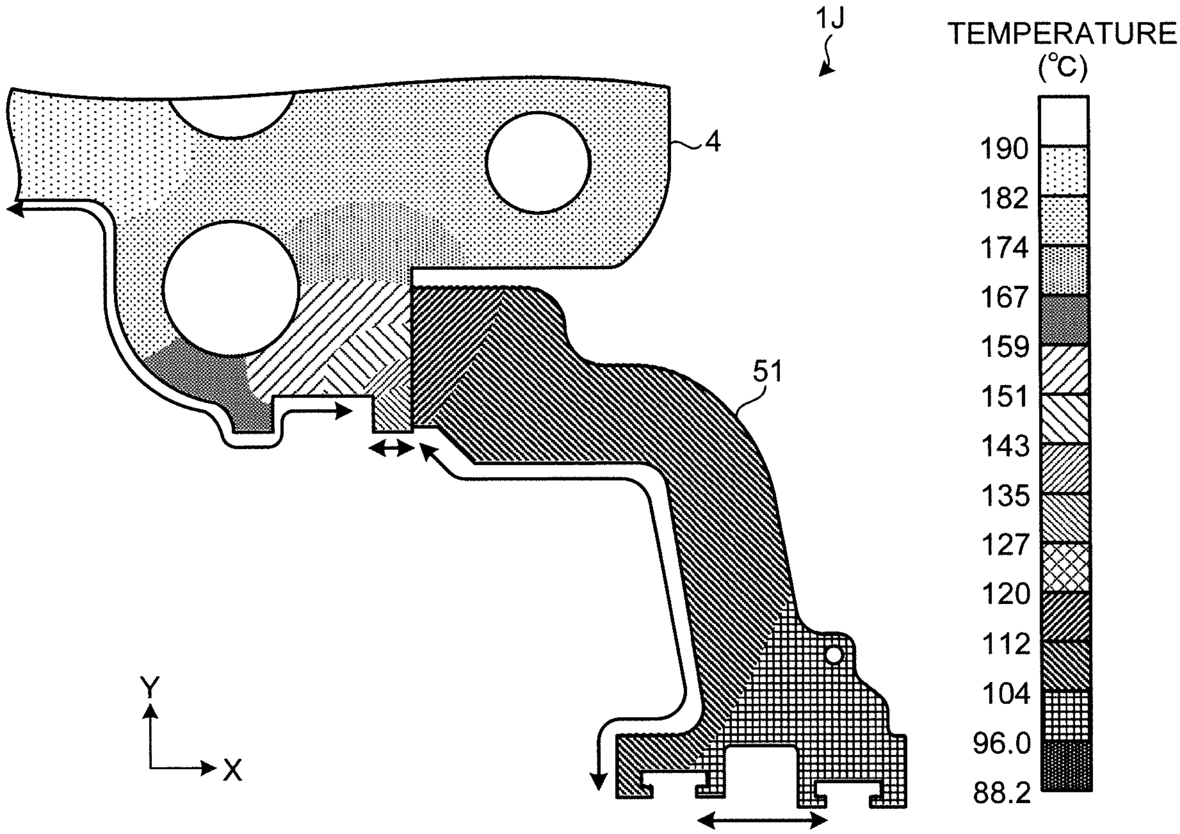


FIG.7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88.2
4
51
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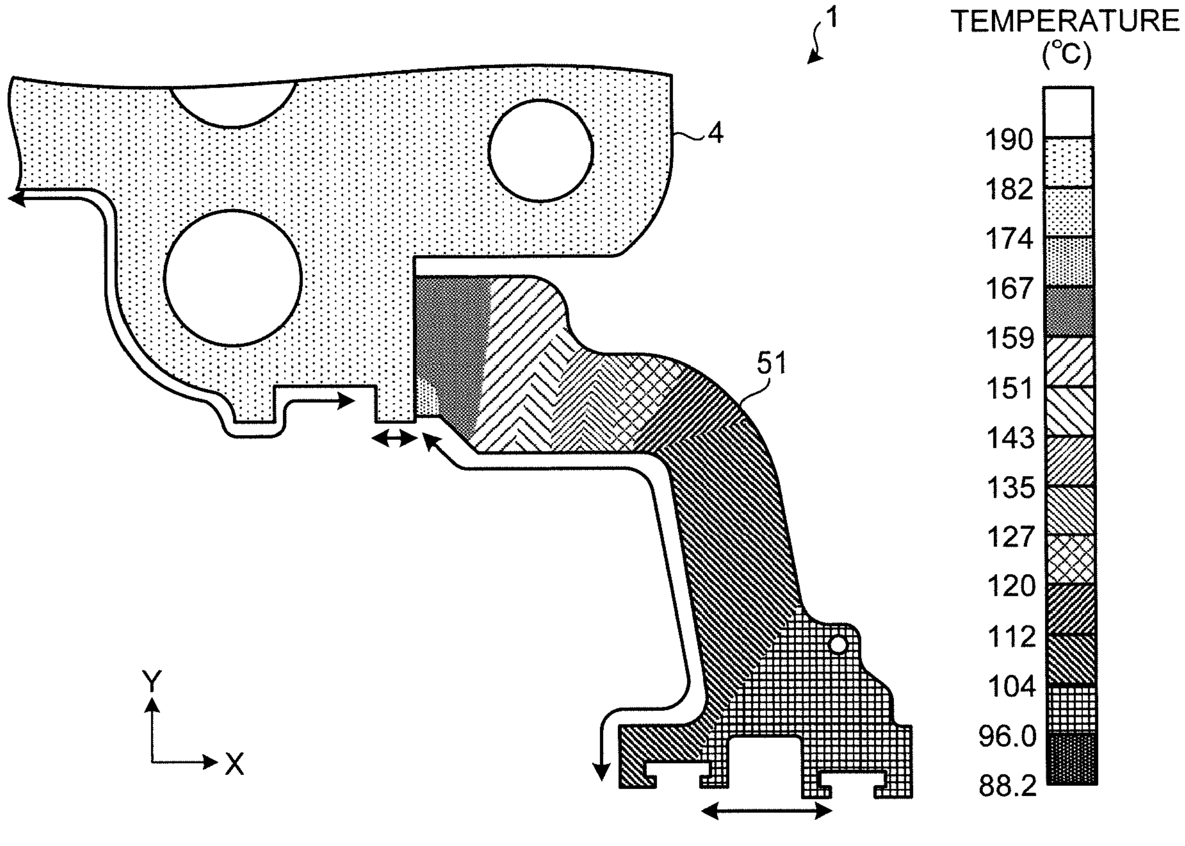
X

FIG.8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X

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 8288

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F01D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 February 2015	Koch, Rafael

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