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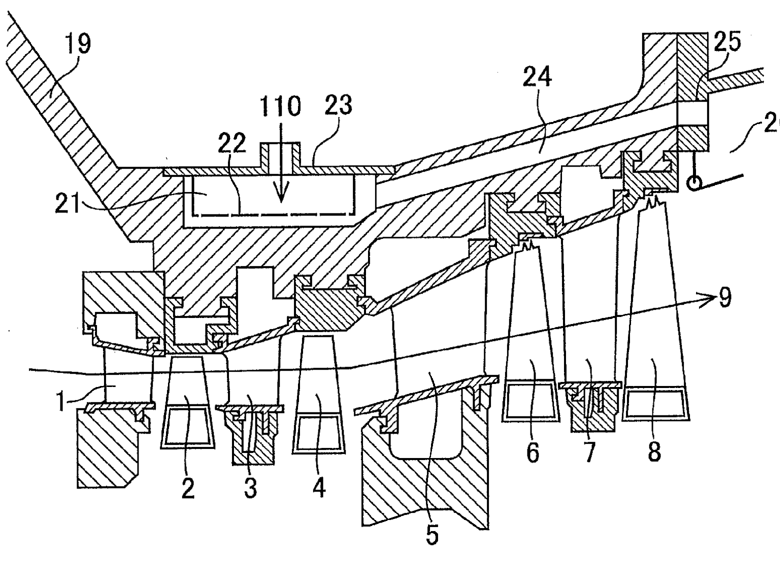
(54) Gas turbine

(57) A gas turbine is provided that can suppress an increase in the supplied amount of cooling air in clearance adjustment through casing cooling.

The gas turbine 101 includes a turbine casing 19 enclosing a turbine shaft 105, the turbine casing 19 including a cooling air header 21 and a cooling passage 24; and an exhaust diffuser 113 connected to the exhaust side of the casing 19, the exhaust diffuser 113 including an exhaust diffuser cooling passage 26. A plate 22 formed with a plurality of impingement cooling holes 28 is installed inside the cooling air header, and a route is formed which allows cooling air introduced from the impingement cooling holes to flow from the casing cooling passage to the diffuser cooling passage.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a gas turbine in which are adjusted clearances between a casing enclosing a turbine shaft, turbine rotor blades, etc., and the turbine rotor blades.

2. Description of the Related Art

[0002] Gas turbines are configured such that a rotor (a rotating body) is enclosed inside a casing (a stationary body). Turbine rotor blades are installed on the outer circumferential portion of the rotor. A clearance exists between the tip (the outermost circumferential side) of the turbine rotor blade and a shroud mounted on the inner circumference of the casing. When high temperature and high pressure mainstream gas passes through the clearance, a leakage loss occurs, which results in performance degradation. Thus, it is desirable that the clearance between the turbine rotor blade and the shroud be small in terms of improvement in turbine performance.

[0003] On the other hand, too a small clearance between the tip of the rotor blade and the shroud may cause the tip of the rotor blade and the shroud to come into contact with each other and they may be broken. The clearance is varied during the operation of the turbine due to the thermal expansion and centrifugal expansion of the rotor, the casing and the like. The clearance is determined at the time of assembly of the casing (at the time of start-up) in order to prevent breakage attributable to the contact under the entire operating conditions.

[0004] In general, this minimum clearance appears in the process of the start-up in industrial gas turbines. This is because the casing is harder to be heated up than the rotor due to a difference in heat capacity therebetween. If the clearance is minimized at times other than during steady operation, the clearance has to be designed so that contact may not occur at times other than during the steady operation. The clearance during rated operation is larger than that in the middle of start-up. Thus, the turbine is operated while having an undesirable excessively large clearance.

[0005] To avoid the undesirable excessively large clearance, some gas turbines shown in e.g. JP-2008-196490-A have manifolds installed on the outer circumference of the casing to cool the outer circumference of the casing by use of air flow. Thus, the thermal expansion of the casing is suppressed to adjust the clearance.

SUMMARY OF THE INVENTION

[0006] High-temperature components of a gas turbine are subjected to temperature control by supplying thereto air extracted from a compressor or cooling air from a separate-placement blower in view of high-temperature strength, thermal deformation and material costs. The high-temperature components to be cooled include a combustor, turbine blades and an exhaust diffuser.

[0007] Also casing cooling for improving the gas turbine performance needs the supply of cooling air, for which a blower is generally used. Since the temperature of the casing reaches as high as several hundred degrees centigrade, it is possible to use the compressor extraction air having temperature lower than such casing temperature.

[0008] Power is needed to supply the compressor extraction air or the cooling air from the blower or the like. If a casing cooing system is simply added, the consumption of cooling air is increased and also the power for supplying the cooling air is increased. Thus, an improvement in performance resulting from clearance adjustment is partially offset by the increased power.

[0009] It is an object of the present invention to provide such a gas turbine that an increase in the amount of cooling air to supply is suppressed upon clearance adjustment through casing cooling.

[0010] According to an aspect of the present invention, there is provided a gas turbine including a casing enclosing a turbine shaft, the casing including a cooling air header and a casing cooling passage; and an exhaust diffuser connected to an exhaust side of the casing, the exhaust diffuser including an exhaust diffuser cooling passage. A plate formed with a plurality of impingement cooling holes is installed inside the cooling air header, and a route is formed which allows cooling air introduced from the impingement cooling holes to flow from the casing cooling passage to the diffuser cooling passage.

[0011] The present invention provides a gas turbine in which a turbine casing can be cooled by use of a slightly increased amount of cooling air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a partial cross-sectional view of a gas turbine according to an embodiment of the present invention.

Fig. 2 is a conceptual diagram showing a gas turbine embodying the present invention.

Fig. 3 is a partial cross-sectional view of the gas turbine according to the embodiment of the present invention.

Fig. 4 is a characteristic diagram of a rotor blade tip clearance of a conventional gas turbine.

Fig. 5 is a characteristic diagram of a rotor blade tip clearance of the gas turbine according to the embodiment of the present invention.

Fig. 6 is an enlarged view of an impingement cooling plate shown in Fig. 1.

Fig. 7 is a conceptual view showing a thermal deformation state of a casing.

Fig. 8 is a diagram of a gas turbine cooling system according to an embodiment of the present invention.

Fig. 9 is a conceptual view showing a state where the center of the casing is not coincident with the center of a turbine shaft.

Fig. 10 is a diagram of a gas turbine cooling system according to another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] In the invention described in JP-2008-196490-A, the impingement manifolds are installed on the outer surface of the casing so as to impingement-cool the casing. Cooling air used for the impingement cooling is led from a blower, impingement-cools the casing, and then is discharged to the atmosphere. Thus, the total used amount of the cooling air for the gas turbine is increased by the amount of cooling air used for cooling the casing.

[0014] High-temperature components including an exhaust diffuser in a gas turbine are usually cooled by air extracted from a compressor or air from a separate-placement blower. Power is needed to supply cooling air by use of a compressor or a blower. If a casing is cooled for clearance adjustment and an amount of cooling air is increased, also power used to supply cooling air is increased. Therefore, an improvement in performance resulting from clearance adjustment is partially offset by the increased power. Thus, if the addition of a casing cooling system is assumed, it is desired that the casing can be cooled by the less increased amount of cooling air.

[0015] Additionally, it is desired that a clearance between a turbine rotor blade and a shroud be small as much as possible. However, if the clearance is too small, breakage may be likely to occur when the rotor blade and the shroud come into contact with each other. For this reason, for example, a combination of a honeycomb seal and a shroud fin is used on a rear stage side to permit the contact. This absorbs the influence of manufacturing tolerance and an influence of the deformation of the casing, thereby keeping the clearance small. A turbine front stage side where the temperature of mainstream gas is high cannot use the honeycomb seal because of a heat resistance problem. Therefore, a margin is provided at the clearance located at the tip of the rotor blade to avoid the contact due to the influence of the manufacturing tolerance or of the deformation of the casing.

[0016] As described above, the front stage side of the gas turbine is likely to increase the clearance according to the provision of the margin compared with the rear stage side. Therefore, it is desired that a clearance adjustment amount of the front stage side can be more enlarged.

[0017] Air extracted from a compressor is led as cooling air for high-temperature components toward a turbine side via extraction pipes installed on the outside of the gas turbine. An increase in the number of the extraction pipes leads to an increased cost. Therefore, the number of the extraction stages is limited to several stages such as, for example, the intermediate stages and rear stages of the turbine. The number of the extraction stages is generally smaller than the number of the turbine stages to be cooled. The use of excessive high-pressure air leads to an increased loss. However, the number of the extraction stages is limited; therefore, a portion exists to which cooling air is supplied at a slightly excessive pressure. This excessive pressure is regulated to an appropriate pressure; therefore, an orifice or the like causes a pressure loss. However, it is desired to avoid pressure regulation performed by such an orifice because of a pressure waste.

[0018] The present invention will be described using embodiments hereinafter. The present invention provides a gas turbine in which a turbine casing can be cooled by the slightly increased flow of cooling air and preferable clearance control is executable. In addition, the present invention provides a gas turbine that allows a reduction in the distortion of an exhaust diffuser. First, the overall system configuration of the gas turbine will be described with reference to Fig. 2.

[0019] Fig. 2 is a configurational diagram of an overall system of a gas turbine embodying the present invention.

[0020] The gas turbine 101 mainly includes a compressor 102, a combustor 103 and a turbine 104. The compressor 102 compresses ambient air 111 to generate compressed air 106 and supplies the compressed air 106 thus generated to the combustor 103. The combustor 103 mixes fuel with the compressed air 106 generated by the compressor 102 for combustion to generate combustion gas 107 and discharges it to the turbine 104.

[0021] The turbine 104 uses the combustion gas 107 increased in the energy of the compressed air and discharged from the combustor 103 to allow a turbine shaft 105 to generate rotational force. The rotational force of the turbine shaft 105 drives equipment 109 (driven machines such as a generator, a pump, and a screw) connected to the gas turbine 101. The energy of the combustion gas 107 is recovered by the turbine 104 and then the combustion gas 107 is discharged as exhaust gas 112 from the turbine 104 via the exhaust diffuser 113.

[0022] Air extracted from the compressor 102 or air from a blower (not shown) is supplied as cooling air 110 to the turbine 104 or the exhaust diffuser 113 not via the combustor 103.

[0023] Fig. 3 is a partial cross-sectional view of the gas turbine. There are shown a first-stage stator blade 1, a first-stage rotor blade 2, a second-stage stator blade 3, a second-stage rotor blade 4, a third-stage stator blade 5, a third-stage rotor blade 6, a fourth-stage stator blade 7 and a fourth-stage rotor blade 8. Reference numeral 9 denotes a flow direction of the combustion gas 107 in the turbine.

[0024] The first-stage rotor blade 2 is connected to the outer circumference of a first-stage wheel 10. In addition, the first-stage wheel 10, a second-stage wheel 11 to which a second-stage rotor blade 4 is connected, a compressor rotor 20, which is a constituent element of the compressor 102, and a spacer 14 are stacked by means of stacking bolts. In this way, a high-pressure side turbine shaft 105 is configured. The third-stage rotor blade 6 is connected to the outer circumference of a third-stage wheel 12. The third-stage wheel 12, a four-stage wheel 13 to which the fourth-stage rotor blade 8 is connected, a rotor connected to the equipment 109 such as a generator, and a spacer 14 are stacked by means of stacking bolts. In this way, a low-pressure side turbine shaft 105 is configured. The turbine shaft 105 recovers the energy of the combustion gas 107 discharged from the combustor 103 by use of the first-stage rotor blade 2, the second-stage rotor blade 4, the third-stage rotor blade 6 and the fourth-stage rotor blade 8. In addition, the turbine shaft 105 drives the compressor 102 and the equipment 109 connected to an end portion of the turbine shaft.

[0025] The turbine shaft 105 is enclosed by a turbine casing 19. The first-stage stator blade 1, the second-stage stator blade 3, the third-stage stator blade 5, the fourth-stage stator blade 7, a first-stage shroud 15, a second-stage shroud 16, a third-stage shroud 17 and a fourth-stage shroud 18 are connected to the inner circumferential side of the turbine casing 19. Further, diaphragms 27 are connected to the inner circumferential side of the second-stage stator blade 3 and of the forth-stage stator blade 7.

[0026] Clearances are provided between the first-stage rotor blade 2 and the first-stage shroud 15, between the second-stage rotor blade 4 and the second-stage shroud 16, between the third-stage rotor blade 6 and the third-stage shroud 17, between the fourth-stage rotor blade 8 and the fourth-stage shroud 18, and between the spacers 14 and the corresponding diaphragms 27. The clearances serve as an interface between a stationary body and a rotating body.

[0027] The clearances are each varied depending on the operating conditions of the gas turbine. Fig. 4 shows a variation trend of a clearance in a conventional gas turbine. Immediately after start-up, the turbine shaft 105 is first increased in rotation rate so that it is radially expanded by centrifugal force to reduce the clearance. Thereafter, the mainstream gas is increased in temperature so that the turbine shaft 105, the shrouds 15, 16, 17, 18, and the turbine casing 19 are thermally expanded. The turbine shaft 105 is expanded radially outwardly and the shrouds 15, 16, 17, 18 are expanded radially inwardly. Thus, the clearance is reduced. The turbine casing 19 is expanded radially outwardly to enlarge the clearance. In general, the turbine shaft 105 and the shrouds 15, 16, 17, 18 are likely to increase in temperature compared with the turbine casing 19. Therefore, the clearance is minimized before the turbine is thermally stabilized, specifically, approximately at the time of reaching a rated load. Thus, the clearance during steady operation is greater than the minimum clearance.

(Embodiment)

[0028] A casing cooling structure is described with reference to Fig. 1. Fig. 1 is an enlarged view of the turbine casing 19. A cooling air header 21 is installed on a front-stage side outer circumferential portion of the turbine casing 19 so as to form an annular space. Impingement cooling plates 22 having a division structure are annularly installed inside the cooling air header 21. Further, the cooling air header 21 is isolated from space outside the cooling air header 21 by cooling air header covers 23 to form the annular space. The impingement cooling plates 22 and the cooling air header covers 23 are plurally installed along the circumferential direction of the casing 19. A cooling air pipe is connected to each of the cooling air header covers 23. Cooling passages 24 are connected to an end face of the cooling air header 21. The cooling passages 24 extend inside the turbine casing 19 toward an axially rear stage side. The cooling passages 24 each have a generally circular cross-section and are intermittently arranged in a circumferential direction.

[0029] Cooling air 110 used to cool the exhaust diffuser 113 is generally led from the cooling air pipe to the cooling air header 21. The cooling air 110 is jetted as jet flows from impingement holes 28 formed in the impingement cooling plate 22 installed in the annular cooling air header 21, and impingement-cools the turbine casing 19. Thereafter, the cooling air 110 flows in the cooling passage 24 toward the rear stage side in the axial direction of the turbine shaft. The cooling passages 24 are connected to respective diffuser cooling passages 26 via corresponding connection holes 25. The cooling air flowing inside the cooling passages 24 is supplied to the exhaust diffuser cooling passages 26 to cool the exhaust diffuser 113.

[0030] Fig. 6 is an enlarged view of the impingement cooling plate 22 shown in Fig. 1. The annular impingement cooling plate 22 is formed with a plurality of impingement holes 28. The impingement holes 28 are formed at least in a surface opposed to the outer circumferential surface of the casing. Cooling air 110 fed from the cooling air header cover 23 is jetted from the plurality of impingement holes 28. The impingement cooling air 110a having been jetted from the impingement holes 28 impinges the outer surface of the casing opposed to the impingement cooling plate 22. This impingement jet cools the casing from the outer circumferential side thereof.

[0031] Fig. 5 shows clearance characteristics of the gas turbine according to the present embodiment. The execution of casing cooling can reduce the deformation amount of the turbine casing 19 which expands radially outwardly. Consequently, a difference between the minimum clearance during the process from the start-up to the steady state and the clearance in the steady state is reduced compared with the case where the casing is not cooled. Thus, the clearance in the steady state can be kept small compared with the conventional clearance. In this case, the minimum clearance can be made nearly equal to the conventional clearance; therefore, it is possible to improve performance without impairing the reliability of the gas turbine.

[0032] It is difficult to use, on the front-stage side of the gas turbine, a seal structure capable of following clearance variations. This is because of the following reasons. To apply a labyrinth seal to the front-stage side of the gas turbine, a shroud is needed to be formed at a blade tip. However, the formation of the shroud increases the weight of a blade end face, which excessively increases the stress of the blade. Further, it is difficult to use a seal structure permitting contact with a honeycomb seal or the like because of a problem with heat resistance. To suppress a leakage loss, it is necessary to keep the clearance small. For breakage prevention, however, design with a margin has to be done to some extent. By contrast, since the mainstream gas on the rear-stage side has low temperature, a honeycomb seal capable of permitting such contact can be applied to the rear-stage side. Thus, design with a small margin can be done, that is, the clearance can be designed to be small in size. As described above, since the clearance on the front-stage side tends to increase excessively, it is desirable that the clearance adjustment amount on the front-stage side can be increased, that is, the casing cooling effect on the front-stage side can be enhanced.

[0033] The present embodiment has no large limitations, in the axial direction, on the installation of the cooling air header 21. The impingement cooling plate 22 is attached to the inside of the cooling air header cover 23. Therefore, the cooling air header cover 23 can be attached to and detached from the turbine casing 19 integrally with the impingement cooling plate 22. With the configuration as above, it becomes easy to dispose the impingement cooling plate 22 with respect to the cooling air header 21. Thus, it is possible to keep small the front-stage side clearance that would otherwise have to be increased during non-cooling of the casing.

[0034] The configuration of the present embodiment is such that the cooling passages 24 and the exhaust diffuser cooling passages 26 are connected to each other via the corresponding communication holes 25. The cooling air 110 having cooled the casing is led via the communication holes 25 to the exhaust diffuser cooling passages 26 to cool the exhaust diffuser 113. A conventional gas turbine is such that the exhaust diffuser 113 and the casing 19 are cooled by different air. However, when cooling air for the casing is reused as cooling air for the exhaust diffuser in the present embodiment, it is possible to suppress an additional increase in the amount of cooling air resulting from the application of casing cooling.

[0035] Further, since the cooling air 110 flows in the cooling passages 24, the rear side of the casing is cooled by convection cooling, which makes it possible to reduce the clearance on the rear-stage side of the turbine.

[0036] Another embodiment of the present invention is next described with reference to Figs. 7 and 8. Fig. 7 is a conceptual diagram showing a state where thermal deformation occurs in a casing. Fig. 8 is a diagram of a gas turbine cooling system. As shown in Fig. 7, a casing 19 includes an upper-half casing 19a and a lower-half casing 19b separated from each other, which are joined to each other via respective flanges 35 thereof. During the start-up of a plant, if thermal expansion occurs in the casing 19 having the flanges 35 as described above, the upper-half casing 19a and the lower-half casing 19b each have a larger amount of thermal expansion on the top side than that on the flange side. More specifically, the top side portion is thermally expanded large in a horizontal direction, whereas the flange side portion is thermally expanded small in a vertical direction. This is because the flanges 35 formed at the division surface of the casing 19 exist, so that the flange side portion has larger thermal capacity than the top side portion. Consequently, as shown by a solid line in Fig. 7, non-uniform thermal expansion (deformation) occurs in the overall casing, that is, the flange side portion is displaced large leftward and rightward outwardly.

[0037] Therefore, the present embodiment is configured such that a flow rate of cooling air supplied to the top side of the casing which has relatively large thermal expansion is made greater than that supplied to the flange side which has relatively small thermal expansion. A description is given of the configuration of the present embodiment that achieves control for uniform clearance with reference to Fig. 8.

[0038] A plurality of impingement cooling plates 22 are installed inside cooling air headers of the upper-half casing 19a and the lower-half casing 19b along the circumferential direction of the casing 19. Fig. 8 shows an example in which eight impingement cooling plates 22 are installed. For convenience sake, impingement cooling plates disposed on the top side (on the vertical side) of the upper-half casing 19a and the lower-half casing 19b are referred to as the top side impingement cooling plates 22a. In addition, impingement cooling plates disposed on the flange 35 side are referred to as the flange side impingement cooling plates 22b. A plurality of cooling air supply systems 38 are connected via cooling air header covers 23 (not shown for convenience sake in fig.8) to spaces each defined by each impingement cooling plate 22 (the spaces each defined by the impingement cooling plate 22 and the cooling air header cover 23 shown in Fig. 6). The cooling air supply system 38 supplies a cooling air (a cooling medium) for impingement cooling. The cooling air supply system 38 includes a common system 38a and a plurality of systems 38b, 38c bifurcated from the common system 38a. The system 38b supplies cooling air to a space defined by the top side impingement cooling plate 22a. The system 38c supplies cooling air to a space defined by the flange side impingement cooling plate 22b. An orifice 30 is installed in the system 38c, of the bifurcate systems 38b, 38c, which is connected to the space defined by the flange side impingement cooling plate 22b. The orifice 30 serves as a flow control device which regulates the flow rate of cooling air.

[0039] With the present embodiment described above, the flow rate of cooling air flowing from the common system 38a to the system 38c toward the flange side impingement cooling plate 22b, is regulated by the orifice 30 so as not to exceed a predetermined flow rate. As a result, the circumferential distributions in thermal expansion on the top side and flange side of the casing are made uniform. This makes it possible to uniformly reduce the clearances at the tips of the turbine blades on the front-stage side of the gas turbine.

[0040] Another embodiment of the present invention is described with reference to Figs. 9 and 10. Fig. 9 is a conceptual view showing a state where the center of a casing is not coincident with the center of a turbine shaft. Fig. 10 is a diagram of a gas turbine cooling system according to the present embodiment. As shown in Fig. 9, the center of a casing 19 is not completely coincident with the center of a turbine shaft 105 due to manufacturing tolerance and a temporal change of the casing. Therefore, the size of a clearance between a turbine rotor blade and a shroud has circumferential deviation. If the casing is to uniformly be cooled over the whole circumference thereof, the thermal expansion of the casing will be reduced uniformly in the whole circumference thereof. Thus, the non-uniformity of the clearance cannot be eliminated.

[0041] The present embodiment is adapted to eliminate the non-uniformity of the clearance mentioned above by installing a device for regulating a circumferential cooling amount for the casing and controlling radial and circumferential deformations of the casing.

[0042] As shown in Fig. 10, impingement cooling plates 22 installed in the casing 19 are sectioned in a circumferential direction. A plurality of cooling air supply systems 38 are connected via cooling air header covers 23 (not shown for convenience sake in fig.10) to spaces each defined by each impingement cooling plate 22. The cooling air supply system 38 includes a common system 38a and a plurality of systems 38d branched from the common system 38a. The each system 38d supplies cooling air to each space defined by each impingement cooling plate 22. An orifice 30 as a flow control device for regulating a flow rate of cooling air is installed in the each system 38d. A description is below given of an orifice-diameter setting method.

[0043] After a gas turbine is assembled, it is confirmed that setting clearances fall within tolerance, wherein a clearance between the tip of a turbine rotor blade (a rotating body) and a shroud (a stationary body) in a stationary state is circumferentially measured at plural points. A deviation δ between the rotor center and the casing center is obtained from this clearance measurement record. How much the clearance is to be reduced in which direction during the operation of the gas turbine is estimated to eliminate the non-uniformity of the clearance. Thus, a clearance reduction amount to be targeted is determined.

[0044] A relationship between the size of an orifice diameter and a casing deformation amount at each position is previously evaluated based on analysis using a finite element method and/or clearance measurement results obtained by a real machine test. If a casing deformation amount encountered when each orifice diameter is independently changed is found, a casing deformation amount encountered when a plurality of orifice diameters are simultaneously changed can be estimated by synthesizing the deformation amounts.

[0045] A target clearance reduction amount is determined based on the clearance measurement record. An orifice diameter and arrangement appropriate for achievement of the target clearance reduction amount are determined based on the relationship between the orifice diameter and the casing deformation amount. When the gas turbine is assembled, several different types of orifices are previously prepared. After clearance measurement, the orifice diameter is determined and an original orifice is replaced with an appropriate orifice in a short time.

[0046] Further, clearances are measured in the stationary state of the turbine every disassembly and reassembly for periodic inspections. Thus, also the temporal deformation of the casing can be coped with when the orifice diameter is set again on the basis of the clearance measurement record.

[0047] Features, components and specific details of the structures of the above-described embodiments may be exchanged or combined to form further embodiments optimized for the respective application. As far as those modifications are apparent for an expert skilled in the art they shall be disclosed implicitly by the above description without specifying explicitly every possible combination.

Claims

1. A gas turbine comprising:

a casing (19) enclosing a turbine shaft (105), the casing (19) including a cooling air header (21) and a casing cooling passage (24); and
an exhaust diffuser (113) connected to an exhaust side of the casing (19), the exhaust diffuser (113) including an exhaust diffuser cooling passage (26);
wherein a plate (22) formed with a plurality of impingement cooling holes (28) is installed inside the cooling air header (21), and a route is formed which allows cooling air introduced from the impingement cooling holes (28) to flow from the casing cooling passage (24) to the diffuser cooling passage (26).

2. The gas turbine according to claim 1, wherein the plate (22) is disposed to impingement-cool a casing located at a position corresponding to a front-stage side of turbine stages composed of a plurality of stages.

3. The gas turbine according to claim 1 or 2, wherein the casing (19) has a cover isolating the cooling air header (21) from outside space.

4. The gas turbine according to at least one of claims 1 to 3, wherein the plate is attached inside the cover and the cover is configured to be attachable to and detachable from the casing (19) integrally with the plate (22).

5. The gas turbine according to at least one of claims 1 to 4 wherein the casing (19) includes an upper-half casing (19a) and a lower-half casing (19b) separated from each other, the upper-half casing (19a) and the lower-half casing (19b) being joined to each other via respective flanges (35) thereof, a plurality of the plates (22) are installed along a circumferential direction of the casing (19), a plurality of systems are provided which each supply cooling air to each of spaces defined by the plates (22), and a flow rate control device for regulating a flow rate of cooling air is mounted in the system connected to a space defined by a plate (22) located on the flange side among the plurality of plates (22).

6. The gas turbine according to at least one of claims 1 to 4, wherein the casing (19) includes an upper-half casing (19a) and a lower-half casing (19b) separated from each other, the upper-half casing (19a) and the lower-half casing (19b) being joined to each other via respective flanges (35) thereof, a plurality of the plates (22) are installed along a circumferential direction of the casing (19), a plurality of systems are provided which each supply cooling air to each of spaces defined by the plates (22), an orifice (30) is attached to each of the systems, and respective diameters of the orifices (30) are set based on, at circumferential positions of the gas turbine, a clearance value between a rotating body and a stationary body in a stationary state of the gas turbine, and a relationship between the size of a diameter of the orifice (30) and an amount of deformation of the casing (19).

FIG. 1

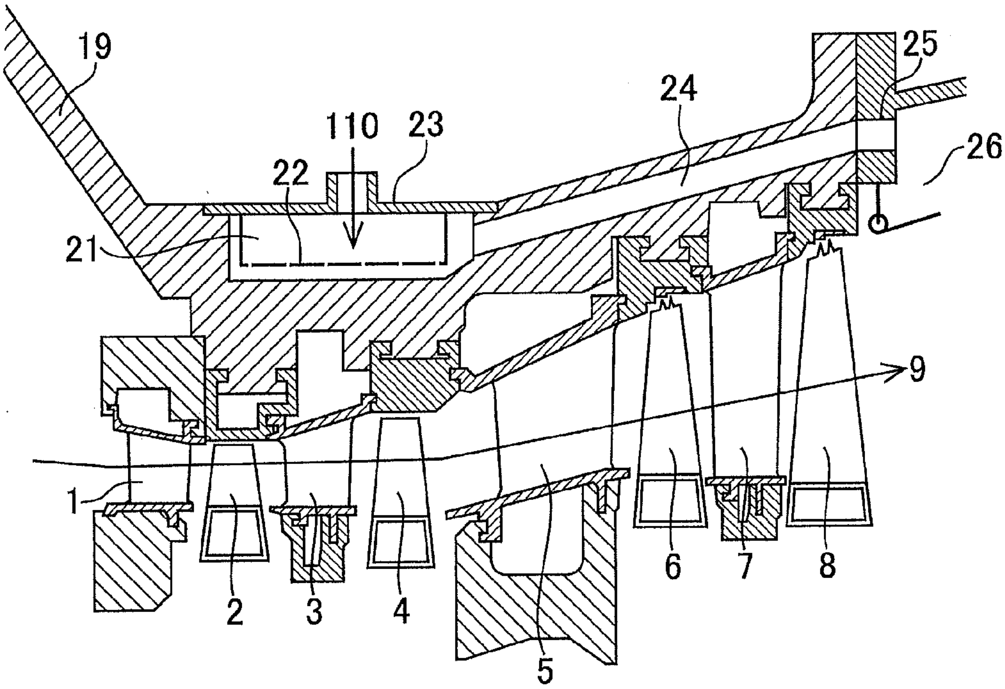
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FIG. 2

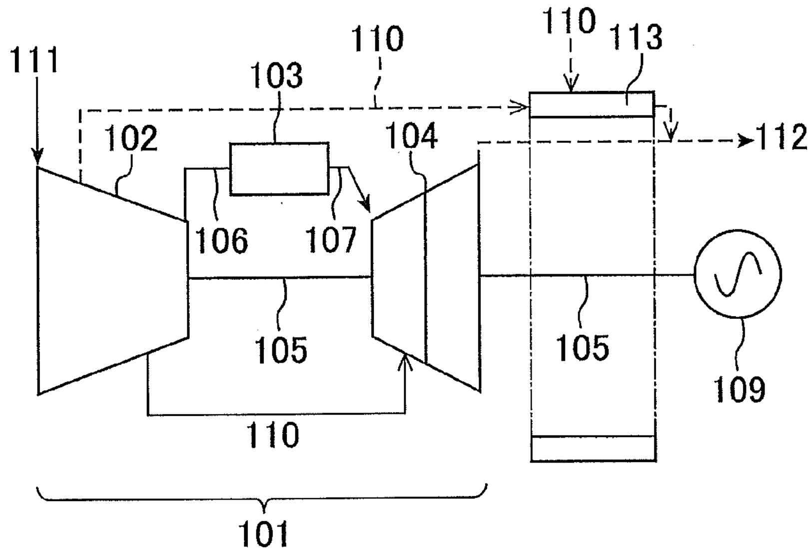
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FIG. 3

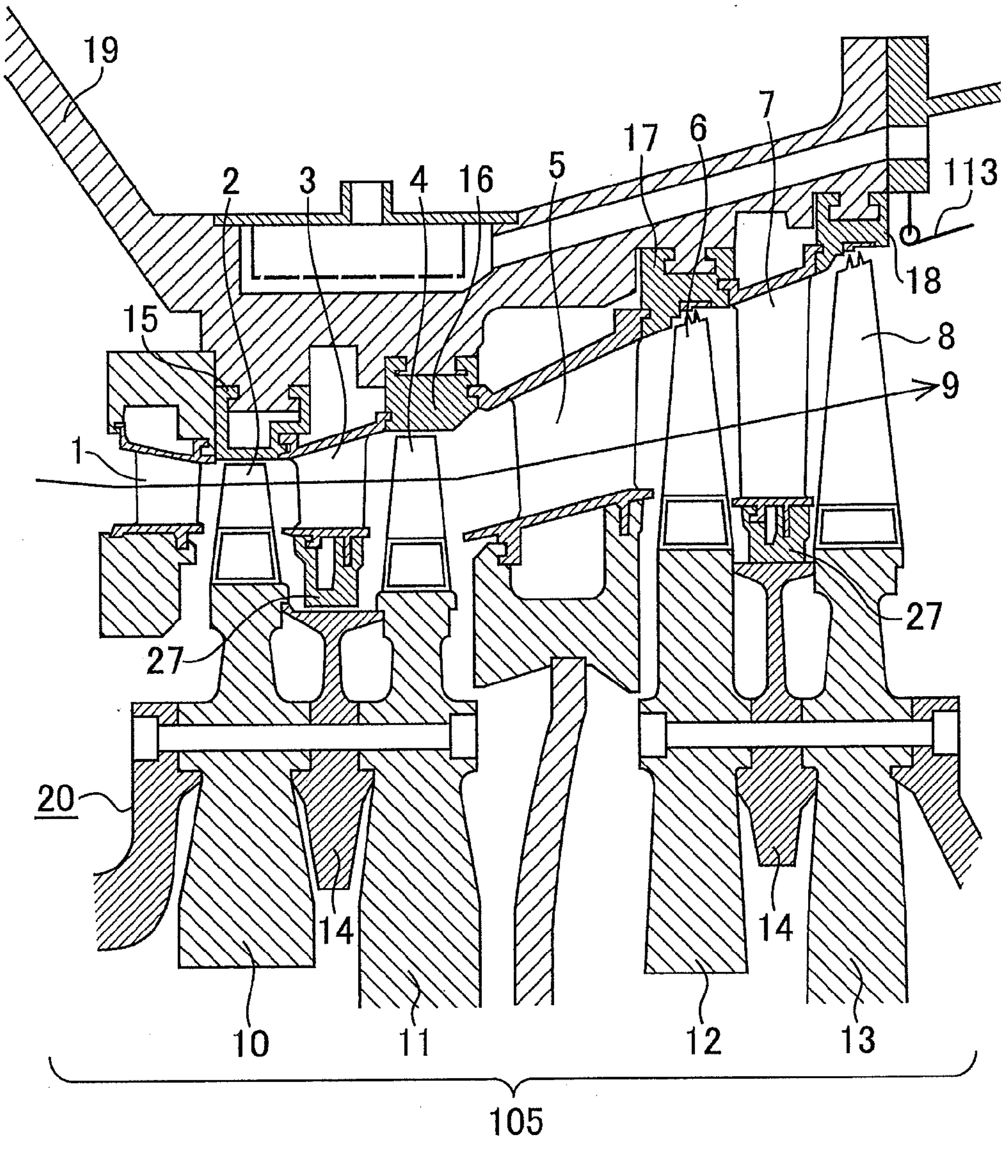
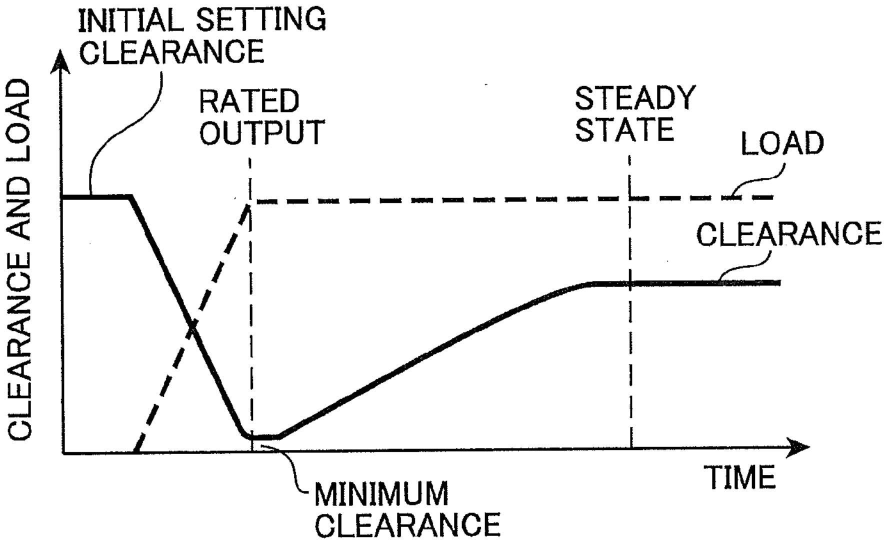


FIG. 4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CLEARANCE
TIME
MINIMUM CLEARANCE

FIG. 5

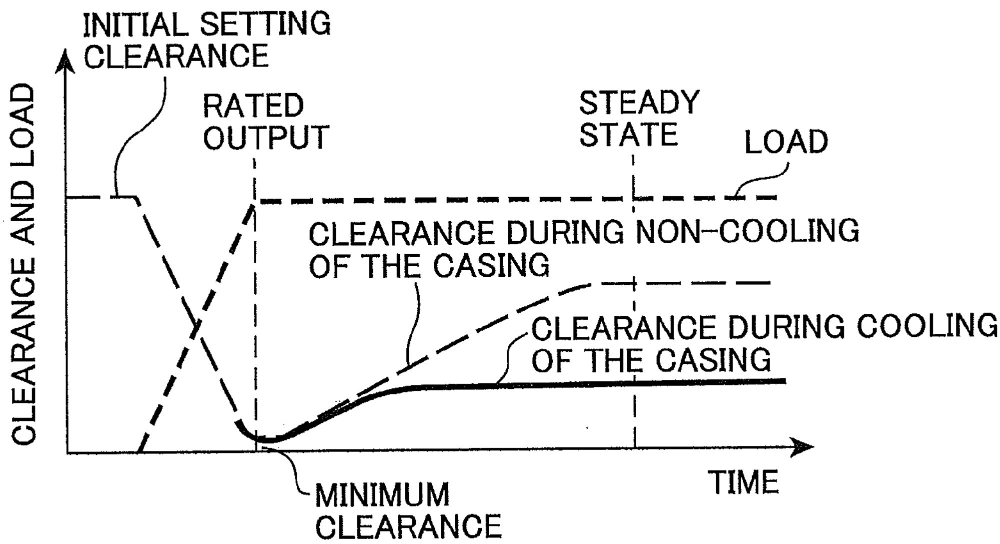
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FIG. 6

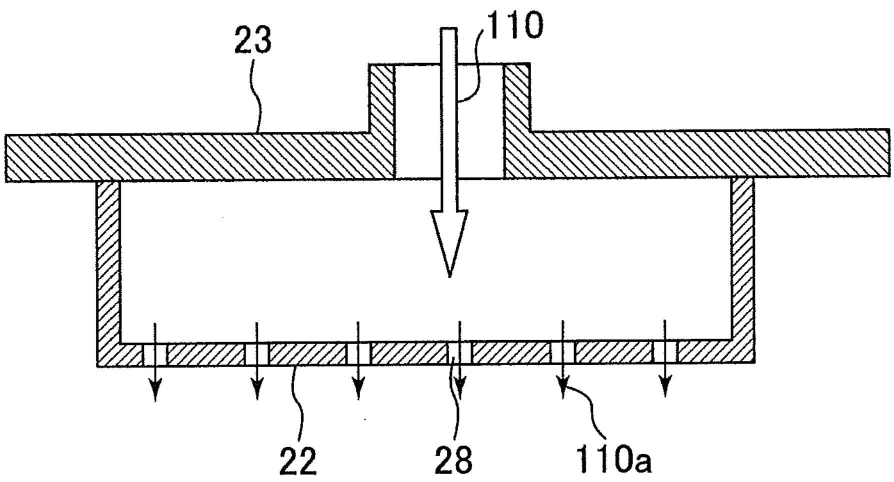


FIG. 7

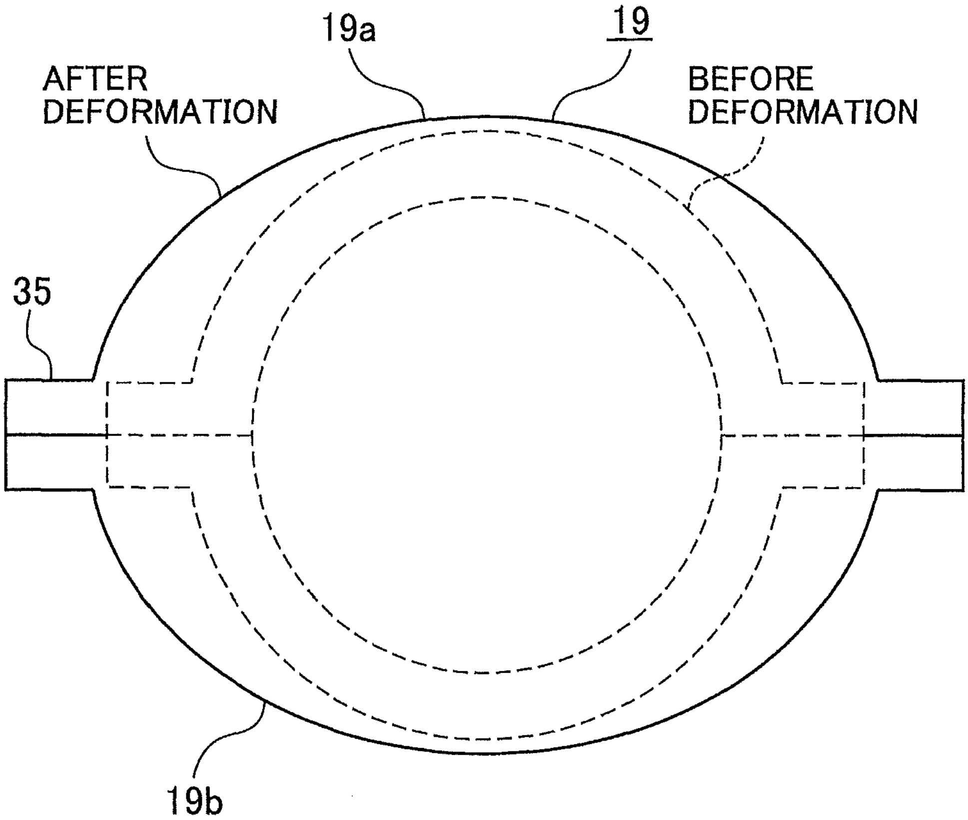


FIG. 8

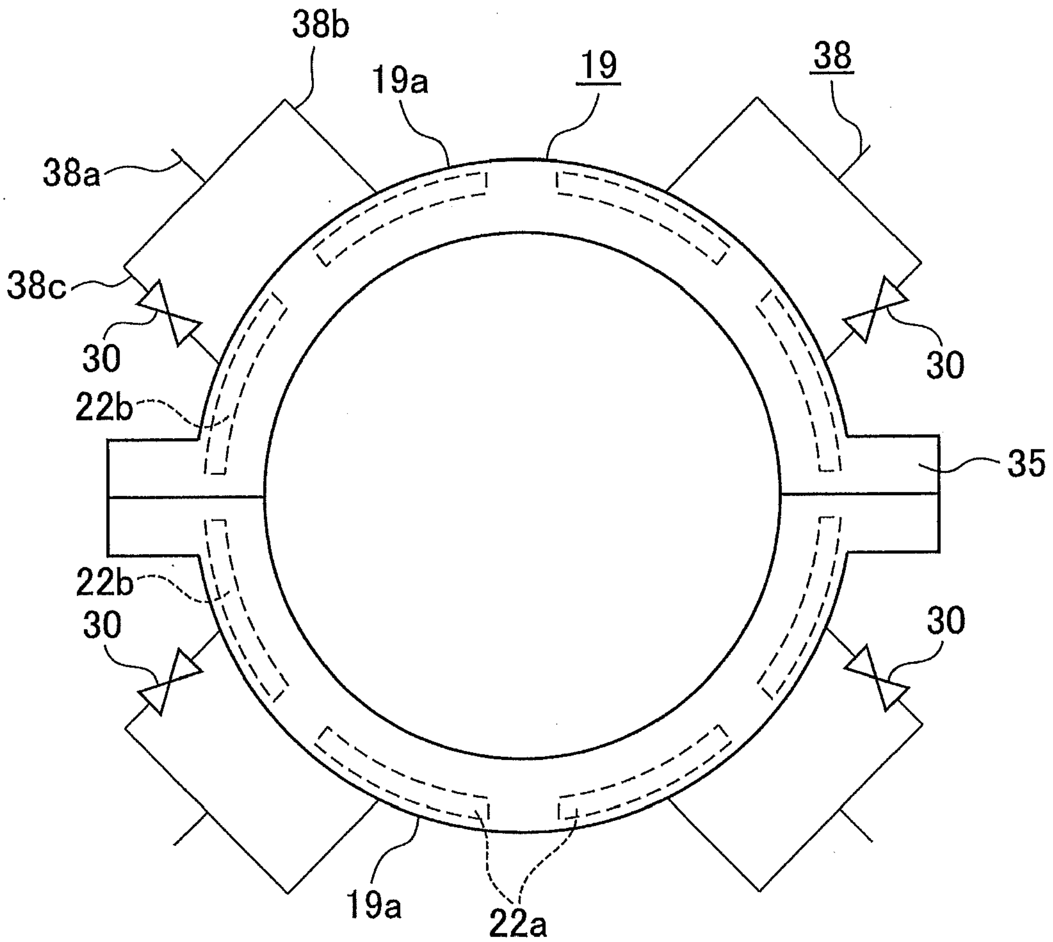


FIG. 9

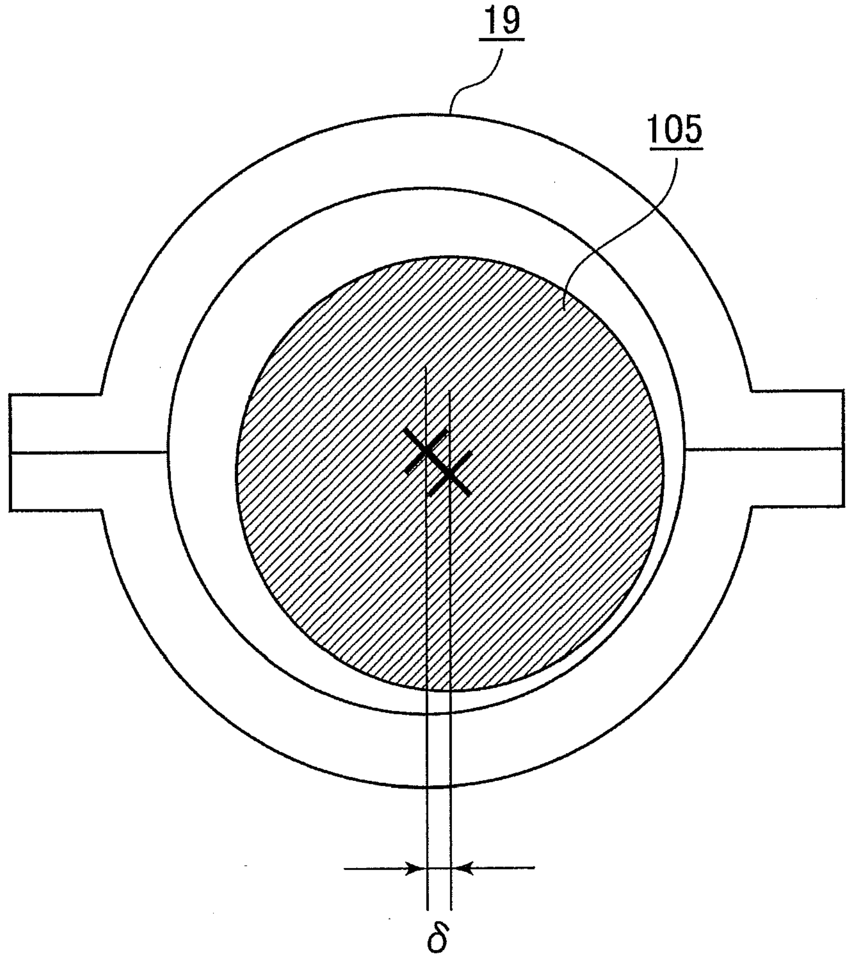
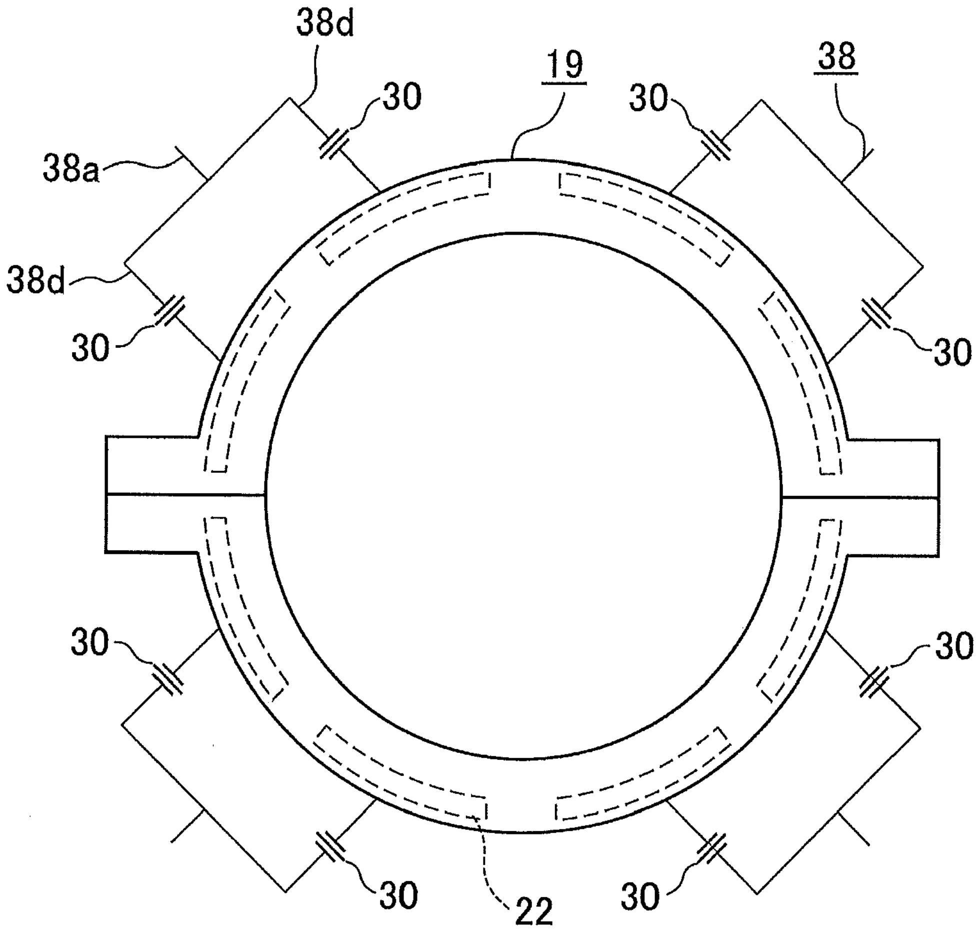


FIG. 10



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Patent documents cited in the description

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