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(54) RADIAL FLOW STEAM TURBINE

(57) Provided is a high-efficiency, realistic, radial flow steam turbine such that the steam supply method is simplified, and that a sufficient amount of steam is supplied to the interior of a turbine unit which is additionally provided in the axial direction. The radial flow steam turbine is equipped with a rotation shaft; a rotor disk connected to the rotation shaft; rotor blades are mounted on the rotor disk; stator disks which face the rotor disk are supported by a casing by being fixed thereto; stator blades are mounted on the stator disk; and an operating steam circulation path is formed wherein the rotor blades on the rotor disk and the stator blades on the stator disk are alternately disposed in the radial direction, and wherein the flow direction of operating steam is in a radial direction which is outward with respect to the rotation shaft. Also, the radial flow steam turbine is configured in such a way that the steam supplied by a steam supply source is circulated as operating steam in the operating steam path, and that thereby the rotor disk and the rotation shaft are rotated. In this radial flow steam turbine, openings are provided in those areas of the rotor disk in the vicinity of the rotation shaft, with the result that an axial steam supply passage is secured.

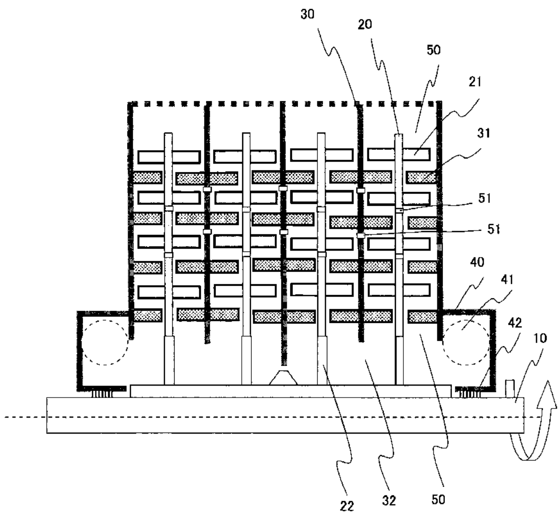

FIG.1

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Description

Technical Field

[0001] This invention relates to a steam turbine, and particularly relates to a radial flow steam turbine in which the operating steam travels in an outflow direction, that is the radial direction perpendicular to the rotation shaft.

Background Art

[0002] A steam turbine operated by the dilatational energy of the expanding steam is commonly used for supplying electric power all over the world. For enhancing the turbine efficiency, the operation steam temperature and the operating steam pressure become higher and the scale of the plant becomes larger. In some cases, the steam turbine is combined with a gas turbine for achieving the combined steam circle. On the other hand, the recycling of the wasted heat is required for reducing the carbon-dioxide. Examples of the wasted heat are the wasted heat from the diesel engine in ships, the wasted heat from the process operation in factories, and the wasted heat from garbage disposal facilities. It is desired to convert those wasted heat energy into available electric energy. However, it is not achieved simply by scaling down the large scale steam turbine such as for the power plant, since the efficiency will be deteriorated. Therefore the appropriate small scale steam turbine is required corresponding to the demand for small scale electricity generation.

[0003] The prior steam turbine in general converts the dilatational energy of the expanding steam into the rotary motion by utilizing the pressure difference along to the rotation shaft by supplying the steam so as to keep the steam pressure at the turbine input terminal high and the steam pressure at the turbine output terminal low. For this reason, the axial flow turbine in which the direction of the steam flow is parallel to the rotation shaft has been developed and has been up-scaled corresponding to the demand for large scale power plants. Besides the axial flow turbine, the radial flow turbine utilizing the steam pressure difference along the radial direction perpendicular to the rotation shaft, in other words, the outflow direction, is known in the prior art. The radial flow steam turbine is suitable for the small scale type turbine and is a relatively high efficiency turbine. However it is not suitable for the large scale type turbine, so it had faded away from the market use. However, it is being reconsidered once again from the necessity of the demand for re-use of the small scale industrial wasted heat energy. The typical example of the radial flow steam turbine is a Ljungstrom turbine (prior art 1, 2 and 3).

[0004] The characteristic of the Ljungstrom turbine (Fig.3 shown in the prior art 1) representing the conventional radial flow steam turbine, which is the common base technology of the listed prior art, is that two facing rotor disks are attached respectively to the front edge of two facing rotation shafts, and the steam flow passes from the center part to the outer part in the outflow radial direction formed between these facing two rotor disks. The cluster of the rotor blades are mounted on each surface of the facing two rotor disks respectively. The rotor blades are arrayed annularly on concentric paths, each set of the rotor blades is arrayed on the surface of the facing two rotor disks respectively in the radial direction in order to rotate the one disk in the clockwise direction and the other disk in the counterclockwise direction by utilizing the aerial bounce generated between the rotor blades attached to the one rotor disk and the rotor blades attached to the other rotor disk (see Fig.7 of this application)

Prior art 1: Tokkai 2005-105854 JP
Prior art 2: Tokkai 2006-144758 JP
Prior art 3: Tokkai 2005-042567 JP
Prior art 4: US Patent 5071312
Prior art 5: US Patent 7244095

Disclosure of the invention

The problems to be solved

[0005] The above conventional Ljungstrom turbine as the conventional radial flow steam turbine includes the two facing rotor disks rotating in the clockwise and the counterclockwise respectively by utilizing the aerial bounce, and the two facing rotation shafts having the rotor disk at the front edge (Prior art 1 and 2). There is another type of the conventional radial flow steam turbine that includes a stator disk on which a cluster of stator blades are mounted, a rotor disk on which a cluster of rotor blades are mounted, and a rotation shaft on which the rotor disk is fixed (Prior art 4 and 5). The basic structure of the radial flow steam turbine in these prior art 1 and 2 can employ only one rotor disk fixed to the rotation shaft. By this reason, there is a limitation on obtaining large power output.

[0006] The prior art 3 and 4, in order to solve the above-mentioned problem, includes rotor blades mounted on the both side surface of the rotor disk, the steam passages along to the radial flow direction are formed on the both side surfaces of the rotor disk, and the plural rotor disks are installed to the rotation shaft.

[0007] However, there is a problem of how to secure the steam supply to each steam passage formed in the radial outflow direction among plural disks in those prior art 1 to 4. In order to solve this problem, steam is supplied by the axial steam passage formed through the rotation shaft, the steam goes through the rotation shaft and bent to the steam passage formed on the both sides of rotor disks in the radial outflow direction via small holes opened formed in the pipe wall of the rotation shaft. However, by this method, another problem occurs with the rotation shaft due to its heat expansion because of the hot and high pressure steam. Moreover, there is a serious actual problem that the amount of the supplied steam is limited by the small size holes, so the amount of the supplied steam is not enough for the steam passage to be reach to the radial outflow via the small holes on the limited diameter and the limited surface of the rotation shaft. As a result, a sufficient amount of output cannot be obtained. In addition, it is difficult to manufacture such a turbine, and the manufacturing cost will be high, so it has not become popular in the actual industrial use.

[0008] Moreover, the amount of the surface area for steam flow through the gap between the rotor disk and stator disk is almost the same even if the amount of the surface area of the rotor blades is increased or decreased. Regarding the ratio of the amount of the surface area of the rotor blades and the amount of the surface area of the gap for the steam to be flowed, the amount of the surface area of the rotor blades should be relatively large enough. In the prior art 3, the small rotor blades are employed, so the steam leakage loss will be large. As a result, it is not suitable for the actual use even if the number of the rotor disks is increased.

[0009] Therefore, in order to increase the output of the radial flow steam turbine, the rotor blades and the stator blades are arrayed in multistage manner. The steam to have been decompressed and to have expanded in the steam passage to the radial outflow becomes faster and gives the rotating motion energy to the rotor blades. However, the rapid expansion of the steam occurrs, the volume of the operating steam is expanded rapidly, it is difficult for steam to run through the gap between the rotor blades and the stator blades. As a result, the steam flow may be blocked and stuffed, so the speed of the steam flow may be decreased.

[0010] It is an object of the present invention to provide a high efficiency radial flow steam turbine by simplifying the steam supply method and supplying a sufficient amount of steam in the multiplied turbine unit installed on the rotation shaft.

Means for solving the problems

[0011] In order to achieve the above-mentioned object, the present invention of a radial flow steam turbine comprises; a rotation shaft; a rotor disk connected to the rotation shaft; rotor blades mounted on the rotor disk; a stator disk facing to the rotor disk fixed and supported by a casing; stator blades mounted on the stator disk; wherein the rotor blades mounted on the rotor disk and the stator blades mounted on the stator disk are arrayed alternately in the radial direction; an operating steam flow passage in which the operating steam flows from in the vicinity of the rotation shaft to the outflow radial direction, wherein a steam supplied from the steam supply source flows to the steam flow passage as an operating steam for rotating the rotor disk and the rotation shaft; and a steam supply route along to the axial direction is formed and secured by forming a through opening on the rotor disk in the vicinity of the rotation shaft.

[0012] According to the above-mentioned configuration, the radial flow steam turbine can improve the steam supply that was difficult in the prior art, and sufficient amount of the steam can be supplied to every turbine unit arrayed in the axial direction.

[0013] It is preferable that the set of the rotor disk and the stator disk is provided for at least one unit. Therefore, the number of the rotor disk is at least one, the rotor blades are mounted on the both sides of each rotor disk respectively, and the stator disks face to both sides of each rotor disk respectively. The operating steam flow passages are formed to be at least two, and the steam is led from the steam supply source to each operating steam flow passage via the steam supply route.

[0014] The combination of the shape of the rotor disk and the shape of the through opening in the vicinity of the rotation shaft of the rotor disk are as follows.

[0015] The first combination is that the rotor disk is installed on the rotation shaft directly, and the through opening of the rotor disk is through hole in the vicinity of the rotation shaft of the rotor disk.

[0016] The second combination is that the rotor disk is a doughnut-shape hollow circular disk having a center hole larger than the diameter of the rotation shaft, wherein the rotor disk is supported by the plural rotor disk supporters fixed to the rotation shaft, and the through opening of the rotor disk in the vicinity of the rotation shaft of the rotor disk is the inter-gap between the rotor disk supporters.

[0017] In those combinations, if the stator disk is fixed to the casing by securing the gap between stator disk edge and the rotation shaft, the gap between the stator disk edge and the rotation shaft forms a part of the steam supply route.

[0018] It is preferable that the rotor blades mounted on the rotor disk and the stator blades mounted on the stator disk are formed outside of the steam supply route. Because as a part of the steam supply route, the through opening is formed in the vicinity of the rotation shaft in the rotor disk, and the gap between the stator disk edge and the rotation shaft is formed in the vicinity of the rotation shaft. Therefore the rotor blades and the stator blades do not cover this area and secure the through opening.

[0019] It is preferable that the steam supply directions from the steam supply source to the operating steam flow passage via the steam supply route are two directions, the one is the direction from the one terminal of the rotation shaft, and the other is the direction from the other terminal of the rotation shaft.

[0020] Next, if there are plural sets of the rotor disk and stator disk along the axial direction, it is preferable that the operating steam pressure adjusting through holes for adjusting the air pressure gap among the steam flow passages by connecting through the operating steam flow passages are formed appropriately on the rotor disk and the stator disk besides the steam supply route.

[0021] According to the above-mentioned configuration, if the radial flow steam turbine employs plural sets of the rotor disk and stator disk along to the axial direction, the air pressure difference can be adjusted among the steam supply routes, and the operation of the radial flow steam turbine will be stable.

[0022] Next, the stage number of the rotor blades and stator blades in the radial flow steam turbine can be adjusted. A stage of the rotor blades comprises the rotor blades arrayed annularly on concentric paths, and the multi-stage rotor blades comprises plural stages mounted on the rotor disk along the radial direction. The stator blades are mounted on the stator disk corresponding to the rotor blades on the rotor disk.

Effect of the present invention

[0023] In the conventional radial flow steam turbine in the prior art, the output can be increased only by the method in which the number of the stages in the multi-stage of the rotor blades is increased because there is only one rotor disk on the rotation shaft, but this method requires very high skill and high cost. If the conventional radial flow steam turbine in the prior art employs the rotor blades on both sides of the rotor disk and plural rotor disk are added to the rotary axial disk in order to form the plural steam passages in the radial outflow direction, the only method for supplying the steam in the prior art is limited to the method forming the steam passage in the rotation shaft. Therefore, the steam will be supplied through the rotating rotation shaft, and a sufficient amount of steam cannot be supplied. The conventional radial flow steam turbine is not in actual use. On the contrary, the radial flow steam turbine in the present invention can employ the plural sets of the turbine units including the rotor disk and the stator disk installed on the rotation shaft, and the steam can be supplied to every turbine unit via the through opening formed in the vicinity of the rotation shaft. In result, a sufficient amount of the steam can be supplied to every steam passage.

[0024] The radial flow steam turbine of the present invention can add an arbitrary number of the turbine unit including the rotor disk and the stator disk onto the rotation shaft according to the steam supply ability and condition. Therefore, the radial flow steam turbine of the present invention can be modified according to the various needs of the facility and the steam supply condition. According to the radial flow steam turbine of the present invention, the wasted heat from the diesel engine in ships, and the wasted heat from garbage disposal facilities turn into re-useable energy by converting the wasted heat energy to electric energy. Carbon oxides can be reduced by utilizing the wasted heat energy emitted from the various processes in the facilities as available electric energy with high efficiency.

Brief description of the drawings

[0025]

Fig.1 is a concept figure of the first radial flow steam turbine 100 in Embodiment 1.

Fig.2 is a concept figure showing a part of the doughnut-shape hollow circular disk fixed to the rotation shaft connected by the plural rotor disk supporters.

Fig. 3 is a concept figure showing the steam passage by forming the through hole as a through opening onto the rotor disk.

Fig. 4 is a concept figure showing the radial flow steam turbine wherein the unit addition of the turbine unit including the rotor disk and the stator disk along to the rotation shaft.

Fig.5 is a concept figure showing the radial flow steam turbine employing a single stage of the rotor blades and stator blades.

Fig.6 is a concept figure of the radial flow steam turbine wherein the steam is supplied from single side direction.

Fig.7 is a concept figure showing the conventional Ljungstrom turbine employing the different rotating direction of the rotor blades.

Detailed description of the preferred embodiment

[0026] Some embodiments of a radial flow steam turbine according to the present invention are described below with reference to the relevant drawing. Needless to add, the claims of the present invention include but are not limited to the embodiments. In each figure, the same number is used for the same component, and the same explanation is omitted appropriately. The drawing is always displaying minute details in a reduced scale, and sometimes features are emphasized to help to understand this invention easily.

(Embodiment 1)

[0027] The first radial flow steam turbine 100 in embodiment 1 according to the present invention is described.

[0028] Fig.1 is a concept figure of the first radial flow steam turbine 100 in Embodiment 1. Fig.1 is a drawing displaying the inside configuration from the side view.

[0029] As shown in Fig.1, the first radial flow steam turbine 100 comprises a rotation shaft 10, a rotor disk 20, a stator disk 30 and a casing 40 as basic parts. Fig. 1 only shows the basic parts, so other parts such as peripheral parts and pipes are omitted here in order to explain simply and focus on the operation principle.

[0030] The rotation shaft 10 is supported for free rotation by a bearing not shown in the figure. The material of rotation shaft 10 is not especially limited, but for example it is a stiff-high strength material in order to secure its stiffness for tolerating dangerous rotation speed higher than the maximum speed of rotations in the operation range for the radial flow steam turbine. There is no danger that the rotor blades crash into each other by adopting a stiff enough axis in order to suppress the occurrence of the resonance oscillation.

[0031] The rotor disk 20 is connected to the rotation shaft 10, and it rotates by the force which is given to the rotor blade 21 by the operating steam flowing from the center portion to the outside in the radial direction as shown below. The rotor disk 20 rotates together with the rotation shaft 10.

[0032] The rotor blade 21 is mounted in the rotor disk 20. The rotor blade 21 may be an impulse blade type or a reaction blade type. Hybrid composition may be possible. For example, the blade mounted on the peripheral part may be the impulse blade type and the blade mounted on the inner part the reaction blade type. For example, the rotational speed of the inner part is slow, and the steam pressed by the stator blade 31 can hit the rotor blade 21, so it is preferable that the impulse blade type be adopted to this portion. On the other hand, the rotational speed of the peripheral part is fast, and the steam pressed by the stator blade 31 cannot hit the rotor blade 21 sufficiently, so it is preferable that the reaction blade type be adopted to this portion. Regarding the steam flow width, the more the steam flows to the outer portion, the narrower the width becomes. Therefore, the more the steam flows to the outer portion, the lower the pressure of the steam becomes and the faster the speed of the steam becomes. In this condition, the rotation force is generated on the rotor blades by converting the heat energy into the rotation energy. The rotor blades 21 can be mounted on either one surface or both surfaces of the rotor disk 20. For improving the output efficiency, the rotor blades 21 are mounted onto both surfaces of the rotor disk 20 in this Embodiment.

[0033] In the radial flow steam turbine 100, the number of blades 21 is not limited. In this configuration, one stage of the rotor blades comprises plural rotor blades arrayed annularly on concentric paths, and the multi-stage rotor blades comprises plural stages mounted on the rotor disk arrayed annularly on concentric paths. The configuration shown in Fig.1 uses the four stages of the multi-stage rotor blades. The installation position of the rotor blades 21 on the rotor disk 20 are on the outer part of the through opening 22 because the through opening 22 exists in the vicinity of the rotation shaft. The example configuration using a single stage rotor blade 21 is described in Embodiment 2 later on.

[0034] The through opening 22 is an opening existing in the vicinity of the rotation shaft on the rotor disk 20, it works as a part for securing the steam supply route passing the steam flow through the axial direction. Regarding the radial flow steam turbine 100 of the present invention, the steam should be introduced from the steam supply source (it is not shown in figure) up to the operating steam flow passages in which the steam travels in the outflow direction along the radial (in a perpendicular direction relative to the rotation shaft) formed between the rotor disk 20 and the stator disk 30. The through opening 22 in the vicinity of the rotation shaft works as a part of the steam supply route. As shown above, the steam flows along the axial direction via the through opening 22 on the rotor disk 20, so even if the sets of rotor disk 20 and stator disk 30 are added to the rotation shaft 10, sufficient amount of operating steam can be supplied to every turbine unit and high output can be obtained. Details of the steam flow are described later on.

[0035] The shape and structure of the through opening 22 are not limited, two patterns are described below.

[0036] Fig.2 is a concept figure showing an example of the rotor disk 20a and the through opening 22a. Fig.2 shows a part of the rotor disk and rotor blades for two stages. In Fig.2, the rotor disk 20a is a doughnut-shape hollow circular disk having a large center hole larger than the diameter of the rotation shaft 10, and the rotor disk 20a is supported by plural rotor disk supporters 11. The through opening 22a is formed in the vicinity of the rotor axial shaft on the rotor disk 20a. The through opening 22a shown in Fig.2 is an inter-gap passage between the rotor disk supporters 11. The steam flow passes through the rotor disk 20a in the axial direction via the through opening 22a. The pillars shown in Fig.2 are straight pillars and the shape of the through opening 22a is a roughly quadrilateral shape, but the shape of the through opening 22a can be modified appropriately according to the condition such as the steam supply condition.

[0037] Fig. 3 is a concept figure showing another example of the rotor disk 20b and the through opening 22b. Fig.3 shows a part of the rotor disk and rotor blades for two stages. In Fig.3, the rotor disk 20b is a circular disk installed directly on the rotor axial shaft 10. The through opening 22b is formed as a through hole on the rotor disk 20b in the vicinity of the rotation shaft 10. Steam can pass through the rotor disk 20b in the axial direction via the through opening 22b. The through opening 22b shown in Fig.3 is an oval shape. However, the shape of the through opening 22b can be modified appropriately according to the condition such as the steam supply condition.

[0038] Next, the stator disk 30 is described below.

[0039] The stator disk 30 is fixed to the casing 40. The stator disk 30 is extended from the casing 40 for facing the rotor disk 20. In the configuration shown in Fig.1, five stator disks 30 and four rotor disks 20 are arrayed alternately. The stator disk 30 is extended from the casing and the gap between the edge of the stator disk 30 and the rotation shaft 10 is formed. This gap works as a part of the steam passage portion 32 as described later.

[0040] The stator blades 31 are mounted on the stator disk 30. The stator blades 31 are mounted corresponding to each rotor blade 21 for assisting the rotor blades 21 to catch the force given by the operating steam flowing from the center portion to the outer radial direction. The stator blades 31 are arrayed from the center portion to the peripheral portion along to the radial direction. These stator blades 31 on the stator disk 30 and these rotor blades 21 on the rotor disk 20 are facing each other alternately in the radial direction. The stator disk 30 does not rotate because it is fixed to the casing 40.

[0041] The stator blades 31 can be mounted on either a single surface or both surfaces of the stator disk 30. In the configuration shown in Fig.1, regarding the stator disk 30 fixed on the right end and the left end, the stator blades 31 are mounted on only the inside surface, and regarding the stator disk 30 in the middle, the stator blades 31 are mounted on both sides. The installation position of the stator blades 31 on the stator disk 30 is on the outer part of the steam passage portion 32 because the steam passage portion 32 exists in the vicinity of the rotation shaft.

[0042] The number of the stator blade 31 is not limited, in this configuration, one stage of the stator blades comprises the plural stator blades arrayed in annularly on the stator disk 30, and the multi-stage stator blades comprise plural stages mounted on the stator disk 30 arrayed annularly on concentric paths. The configuration shown in Fig.1 is the multi-stage stator blades comprising four stages corresponding to the four multi-stage rotor blades. The example configuration using the single stage stator blades 31 is described in Embodiment 2 later on.

[0043] The steam passage portion 32 is a through opening existing in the vicinity of the rotation shaft on the stator disk 30, and it works as a part of the steam supply route passing the steam flow in the axial direction. In this configuration, the stator disk 30 is fixed to the casing by securing the gap between stator disk edge and the rotation shaft, the gap between the edge of the stator disk 30 and the rotation shaft 10 forms the steam passage portion 32. The steam passage portion 32 works as a part of the steam supply route.

[0044] Next, the casing 40 is described. The casing 40 is not limited especially. It is supplied as the housing for the rotation shaft 10, the bearing (not shown in figures), the rotor disk 20, and the stator disk 30. The casing 40 is supported by a stand (not shown in figures). As inner casing and an outer casing may be included in the casing 40.

[0045] It is preferable that the casing 40 is sealed appropriately for blocking the steam leakage. The steam leakage countermeasures is important, so the steam leakage mitigation system such as fins, shrouds or labyrinths 42 is appropriately installed to the portions such as the gap between the rotor disk 20 and the stator blades 31, the gap between the stator disk 30 and the rotor blades 21, the gap between the rotation shaft 10 and the casing 40, and the surrounding area of the steam input opening 41.

[0046] There are the steam input openings 41 in the casing 40. The steam is supplied from the steam supply source (it is not shown in figures) to the inside of the casing 40 via the steam input openings 41. The steam input openings 41 may be formed on one side of the casing 40 and the steam supplied from the one side only, and the steam input openings 41 may be formed on both sides of the casing 40 and the steam supplied from both sides.

[0047] Next, the operating steam flow passage portion 50 is described.

[0048] The operating steam flow passage portion 50 is an operating steam passage formed between facing the rotor disk 20 and the stator disk 30. The flow direction of the operating steam flow is the radial direction from the center portion to the outer portion. The operating steam flow passage portion 50 passes the supplied steam from the steam supply source (it is not shown in figures) and makes the rotor disk 20 and the rotation shaft rotate.

[0049] In the configuration shown in Fig.1, both the rotor disk 20 and the stator disk 30 are installed to the rotation shaft 10 perpendicularly, so these are facing each other in parallel, and the width of the operating steam flow passage portion 50 is constant in the radial direction. Other configurations are possible. Either the rotor disk 20 or the stator disk 30, or both of them can have a skew against the rotation shaft in order to modify the operating steam flow passage portion 50 as follows; the more the steam flows to the outer side, the larger the width of the operating steam flow passage portion 50 becomes. As described later, the operating steam flowing in the radial direction from center portion outward through the operating steam flow passage portion 50 becomes high speed by expansion and running through the stator blades 31 and the rotor blades 21, so the larger the width of the operating steam flow passage portion 50 becomes, the more the operating steam flows to the outer side in the radial direction.

[0050] The radial flow steam turbine 100 of the present invention may employ plural steam flow passages 50. The radial flow steam turbine 100 of the present invention includes at least one rotor disk, rotor blades mounted on both side surfaces of the rotor disk respectively, the stator disks installed corresponding to both sides of each rotor disk respectively, so that at least two operating steam flow passage portions are formed. In the configuration shown in Fig.1, there are four rotor disks 20, five stator disks 30, and eight operating steam flow passage portions 50.

[0051] Next, the operating steam pressure adjusting holes 51 is described.

[0052] In the configuration shown in Fig.1, there are four rotor disks 20, five stator disks 30, and eight operating steam flow passage portions 50. In this configuration, there is no air pressure difference among the steam flow passages 50 because there are steam supply routes in the vicinity of the rotation shaft on each rotor disks 20 respectively through the axis direction. However, when the number of the stages of the operating steam flow passage portions 50 become larges, uneven steam expansion may occur in the stages according to the condition such as the amount of the steam volume supplied from the steam supply source being unstable. If the operating steam volume becomes large quickly by the rapid expansion of the supplied steam, not all the supplied steam passes through the gap between the rotor blades 21 and the stator blades 31 smoothly. In this case, the steam flow to the outflow direction is blocked and the steam flow decelerates. As shown above, the air pressure difference occurs among the steam flow passages portions 50, which deteriorates the safe operation.

[0053] In this configuration, the operating steam pressure adjusting holes 51 are formed on the rotor disk 20 and the stator disk 30 appropriately in order to adjust the air pressure difference among the steam flow passages portions 50 by connecting these steam flow passages portions 50 in addition to the steam supply route. When the air pressure difference occurs among the steam flow passages portions 50, the steam pressure can be adjusted among the steam flow passages portions 50 via the operating steam pressure adjusting holes 51. Therefore the radial flow steam turbine 100 can ease the rapid increase or decrease of the steam flow volume appropriately, and the steam stuffing problem can be avoided.

[0054] Next, the steam flow is described.

[0055] Fig. 4 is a figure showing the steam flow superimposed onto the configuration shown in the Fig.1.

[0056] The steam generated in the steam supply source (it is not shown in figures) is introduced from the steam flow input openings 41. In this configuration, the steam flow input openings 41 are formed on both sides of the casing 40, the steam is supplied from both sides into the casing 40.

[0057] The introduced steam goes to the rotor disk 20 along to the rotation shaft 10, then the steam goes through the through opening 22 on the rotor disk 20, and passes through the steam supply route formed by the steam passage portion 31 on the stator disk 30. Then the steam flows in the axial direction in the vicinity of the rotor disk 10 along to the rotation shaft 10. The steam flowing in the steam supply route flows in the axis direction, then reaches each operating steam flow passage portion 50 and bend and flows into each operating steam flow passage portion 50.

[0058] The operating steam flowing into each operating steam flow passage portion 50 in the outflow radial direction expands and runs through each stator blade 31 and each rotor blade 21 at high speed. The steam gives the rotation energy to each rotor blade 21, and the rotor blades 20 and the rotation shaft 10 rotate together. In this configuration, the steam goes through both side surfaces of the rotor disk 20, the steam passes through each stage of the stator blades 31 and the rotor blades 21 according to the air pressure difference along the radial direction, and the steam gives the rotation energy to each rotor blade 21 while passing through the operating steam flow passage portion 50.

[0059] In this configuration, the rotor blades 21 are mounted on both side surfaces of the rotor disk 20 and the operating steam flow passage portions 50 are formed on both side surface of the rotor disk 20. Thus, about twice the rotation torque can be obtained compared with the case of the configuration in which the rotor blades 21 are mounted on single side surface.

[0060] In the conventional radial flow steam turbine shown in Fig.7, the corresponding operating steam flow passage portion running through the stages of the stator blades and the rotor blades can be formed as only one, so the utilized operating steam flow passage portion is only one. On the other hand, regarding the radial flow steam turbine of the present invention, the configuration shown in Fig.4 can form and utilized eight operating steam flow passage portions in the outflow direction, and the output can be enhanced.

(Embodiment 2)

[0061] Embodiment 2 describes the example of the radial flow steam turbine in which there is a single stage of the rotor blades 21 arrayed annularly and a single stage of the stator blades 31 arrayed annularly. The merit of the single stage is that the safe operation is possible when the steam pressure supplied from the steam supply source is not large enough.

[0062] Fig.5 (a) shows the example in which two rotor disks 20 are installed on the rotation shaft 10 and three stator disks 30 are installed. The single stage of the rotor blades 21 is mounted on the rotor disk 20, and the single stage of the stator blades 31 is mounted on the stator disk 30, so the unit is formed as a single stage. The number of the rotor disk 20 and the stator disk 30 can be modified corresponding to the amount of steam supplied from the steam supply source.

[0063] As shown in Fig.5 (b), in the operation of the single stage of the radial flow steam turbine, the same as Embodiment 1, the steam generated in the steam supply source (it is not shown in figures) is introduced from the steam flow input openings 41. The introduced steam goes to the rotor disk 20 along to the rotation shaft 10, then the steam goes through the opening portion 21 on the rotor disk 20, and passes through the steam supply route formed by the steam passage portion 32 on the stator disk 30, then the steam flows in the axial direction in the vicinity of the rotor disk 20 along the rotation shaft 10. The steam flowing in the steam supply route flows in the axis direction, then reaches each operating steam flow passage portion 50 and bends and flows into each operating steam flow passage portion 50. In this configuration, the rotor blade 21 and stator blade 31 compose a single stage, the supplied steam is not required to be high temperature and high pressure. If the amount of the supplied steam is large enough, the rotor disk 20 and the stator disk 30 are provided in multi-stage. The same as Embodiment 1, a large amount of steam can be supplied enough via the through opening 22 formed on the rotor disk 20 and the steam flow portion 32 formed on the stator disk 30.

[0064] As shown this Embodiment 2, if the steam supplied from the steam supply source such as a boiler is not enough high temperature and high pressure, the radial flow steam turbine in which there is a single stage of the rotor blades 21 arrayed annularly and a single stage of the stator blades 31 arrayed annularly can be applied. The cost for the facility can be restrained and the wasted heat energy from the various industries can be re-used.

(Embodiment 3)

[0065] Embodiment 3 describes the example of the radial flow steam turbine in which the steam flow opening 41 is formed in a single side of the casing 40, and the steam is supplied from the steam supply source (it is not shown in figures) to this single side direction.

[0066] Fig.6 is a concept figure of the radial flow steam turbine wherein the steam is supplied from single side direction.

[0067] In the prior art, most conventional radial flow steam turbines in which the rotor blades are mounted onto the single side of the rotor disk supply the steam from a single direction to the single side surface of the rotor disk. Therefore, the thrust force along to the rotation shaft acts on the rotor disk from a single direction. For example, in order to reduce the axis direction thrust force impressed to the rotor disk, the prior art 5 employs a small hole formed on the rotor disk. However, the steam passing through this small hole is not utilized. It is regarded as the loss of the leaked steam.

[0068] On the other hand, the radial flow steam turbine of the present invention comprises the rotor blades 21 arrayed both side of the rotor disk 20, the through opening 22 in the vicinity of the rotor disk 20 for securing the steam supply route in the axis direction. Therefore, even if the steam flow opening 41 is formed on the single side, the thrust force along the rotation shaft acting on the rotor disk from a single direction becomes very small, so the steam flowing on both sides of the rotor disk can provide enough force on the rotor blades.

[0069] In the configuration shown in Fig.6, the more the operating steam flows to the outer direction, the larger the width of the operating steam flow passage portion 50 becomes. Therefore the operating steam flowing through the operating steam flow passage portion 50 in the outflow radial direction flows and expands according to the width of the operating steam flow passage portion 50.

[0070] Fig.6 (b) shows a modified model of the steam supplying method for supplying the steam to the radial flow steam turbine. The configuration shown in Fig.6 (a) employs one steam flow opening 41 formed in the single side of the casing 40 as the steam supplying method for supplying the steam to the radial flow steam turbine. This Fig.6 (b) also employs one steam flow opening 41 but the supplied steam is divided into the left route and the right route for securing the two steam supply routes along the axis direction.

[0071] As shown above, the radial flow steam turbine of the present invention secures the steam supply route along to the axis direction by forming the through opening 22 in the vicinity of the rotation shaft on the rotor disk 20, so the plural sets of the turbine units can be added along to the rotation shaft 10 easily, and the sufficient amount of the steam can be supplied to the steam flow route along to the radial direction. The required output can be obtained corresponding to the condition such as the performance of the steam supply source.

[0072] While some preferable embodiments of the radial flow steam turbine according to the present invention are described above, it should be understood that various changes are possible, without deviating from the technical scope according to the present invention.

Industrial applicability

[0073] A radial flow steam turbine according to the present invention can be used as a steam turbine used for various industrial facilities because the turbine unit including the rotor disk and the stator disk can be added according to the steam supply condition at the spot. For example, it can be applicable to a steam turbine for ships utilizing the wasted heat from the engine, and it can be applicable to a steam turbine for garbage processing facilities as utilizing the wasted heat from the garbage processing facilities.

Claims

1. A radial flow steam turbine comprising;

a rotation shaft;
a rotor disk connected to the rotation shaft;
a rotor blade mounted on the rotor disk;
a stator disk facing to the rotor disk fixed and supported by a casing;
a stator blade mounted on the stator disk;
wherein, the rotor blade mounted on the rotor disk and the stator blade mounted on the stator disk are arrayed alternately in the radial direction,
an operating steam flow passage in which the operating steam flows from around the rotation shaft in an outflow radial direction,
wherein, the steam supplied from the steam supply source flows to the operating steam flow passage as an operating steam for rotating the rotor disk and the rotation shaft,
an operating steam supply route along to the axial direction is formed and secured by a through opening formed on the rotor disk in the vicinity of the rotation shaft.

2. A radial flow steam turbine according to claim 1, wherein the number of the rotor disk is at least one, a plurality of the rotor blades are mounted on both sides of each rotor disk respectively, the stator disks face both sides of each rotor disk respectively, at least two of the operating steam flow passages are formed, and the steam is led from the steam supply source to each operating steam flow passage via the steam supply route.

3. A radial flow steam turbine according to claim 1 or 2, wherein the rotor disk is installed on the rotation shaft directly, and the through opening of the rotor disk is a through hole in the vicinity of the rotation shaft of the rotor disk.

4. A radial flow steam turbine according to claim 1 or 2, wherein the rotor disk is a doughnut-shape hollow circular disk having a center hole larger than the diameter of the rotation shaft, the rotor disk is supported by plural rotor disk supporters fixed to the rotation shaft, and the through opening of the rotor disk in the vicinity of the rotation shaft of the rotor disk is an inter-gap between the rotor disk supporters.

5. A radial flow steam turbine according to any one of claims 1 to 4, wherein the stator disk is fixed to the casing by securing the gap between stator disk edge and the rotation shaft, and the gap between the stator disk edge and the rotation shaft forms a part of the steam supply route.

6. A radial flow steam turbine according to any one of claims 1 to 5, wherein the rotor blades mounted on the rotor disk and the stator blades mounted on the stator disk are formed outside of the steam supply route.

7. A radial flow steam turbine according to any one of claims 1 to 6, wherein the steam supply directions from the steam supply source to the operating steam flow passage via the steam supply route are two directions, the one is the direction from the one end of the rotation shaft, the other is the direction from the other end of the rotation shaft.

8. A radial flow steam turbine according to any one of claims 1 to 7, wherein operating steam pressure adjusting holes for adjusting the air pressure gap among the operating steam flow passages by connecting among the operating steam flow passages are formed on the rotor disk and the stator disk besides the steam supply route.

9. A radial flow steam turbine according to any one of claims 1 to 8, wherein multi-stage rotor blades are mounted on the rotor disk arrayed along the radial direction, wherein a single-stage of the rotor blades is formed by mounting the rotor blades arrayed annularly on concentric paths.

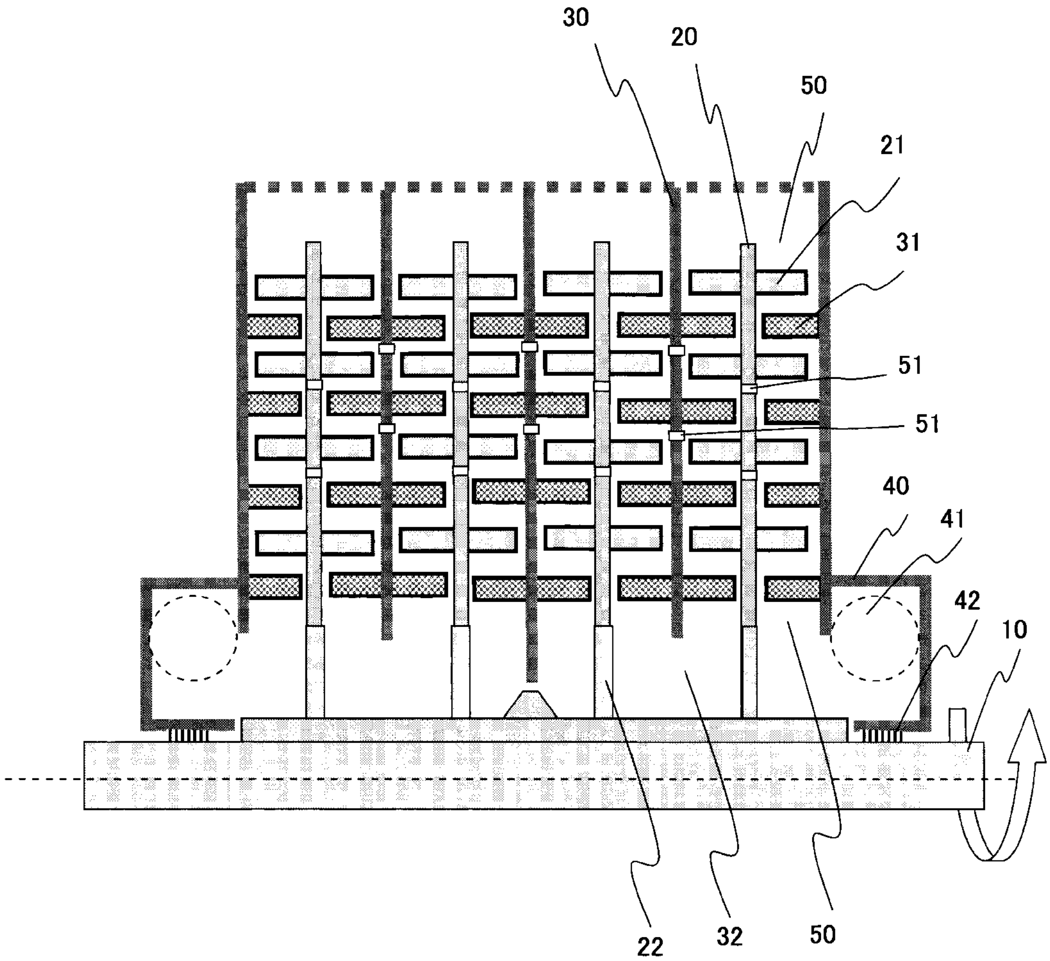


FIG.1

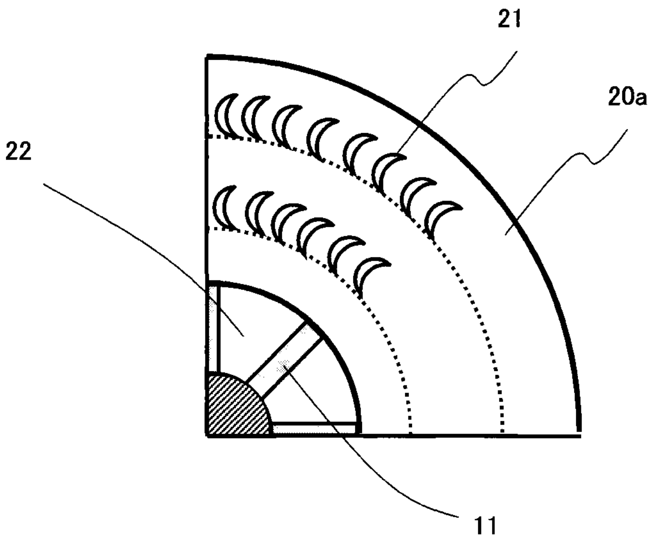


FIG.2

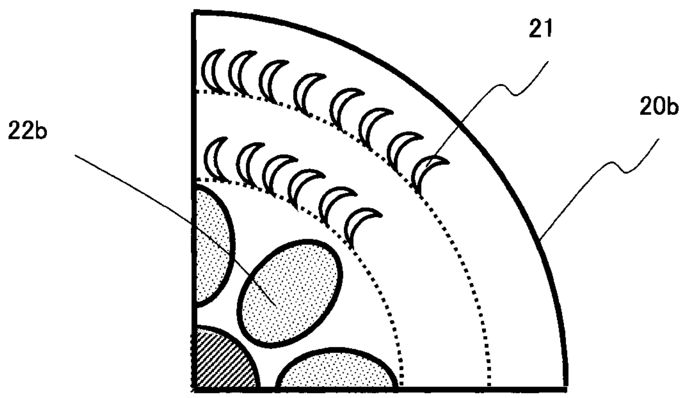


FIG.3

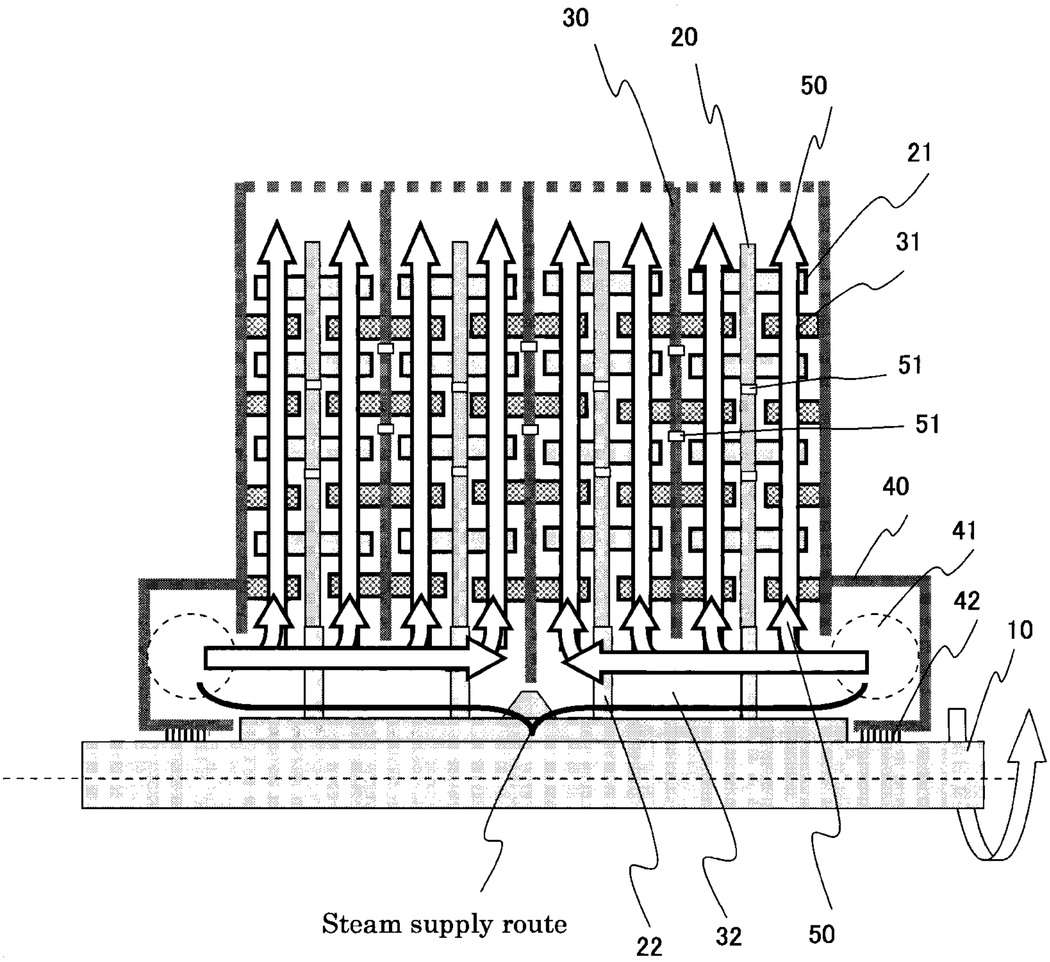
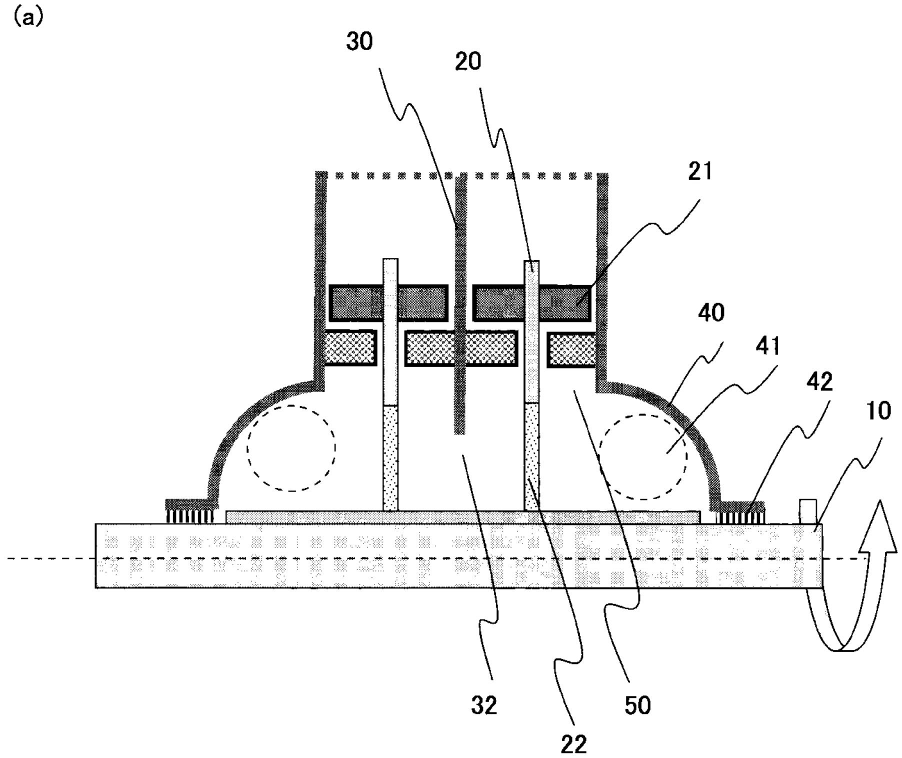


FIG.4

(a)



(b)

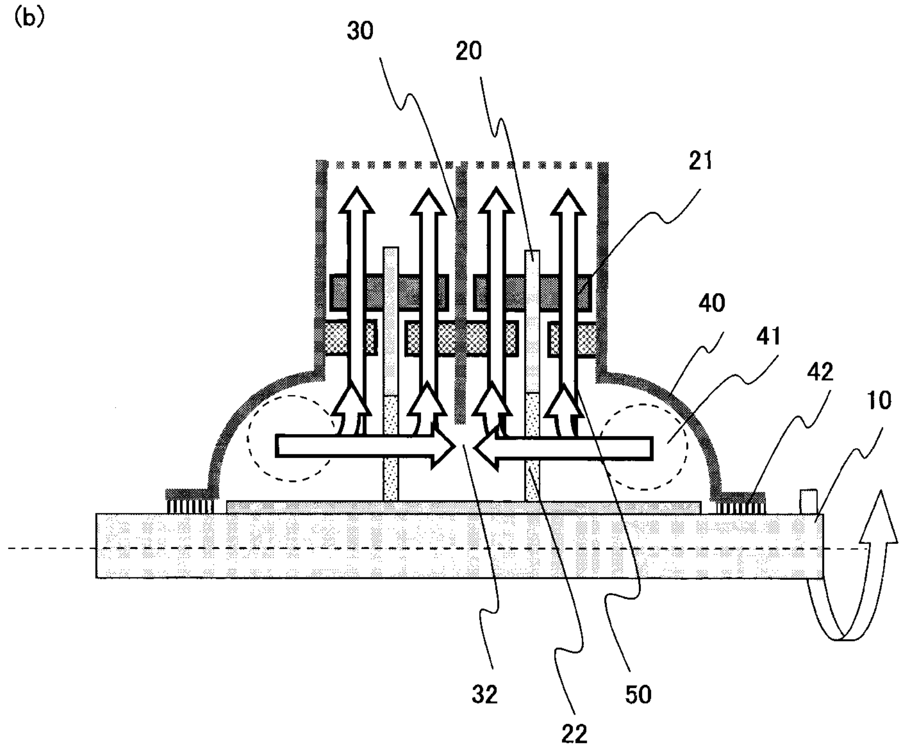
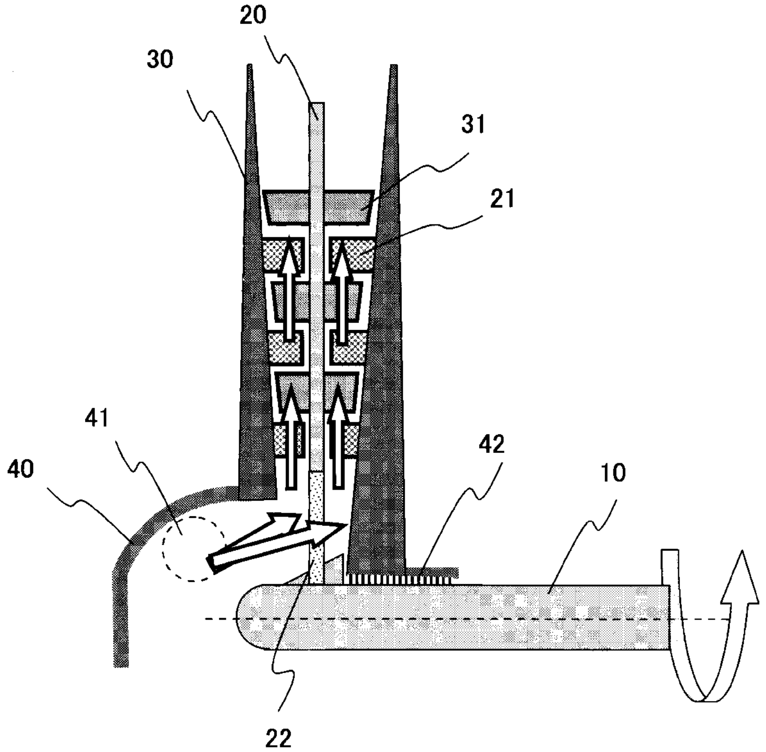


FIG.5

(a)



(b)

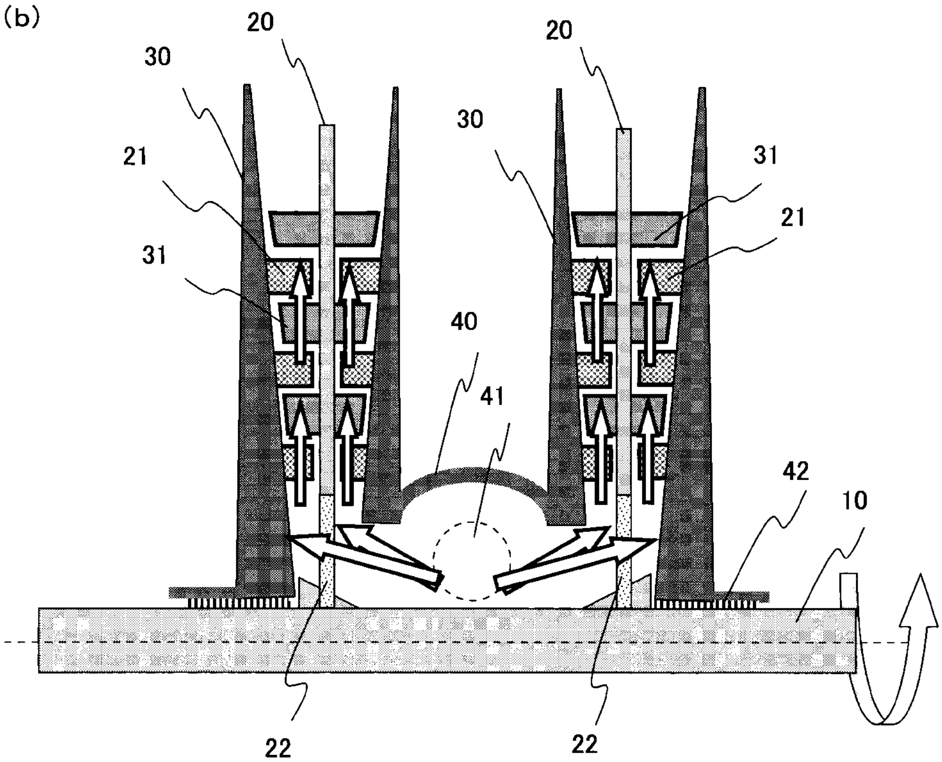
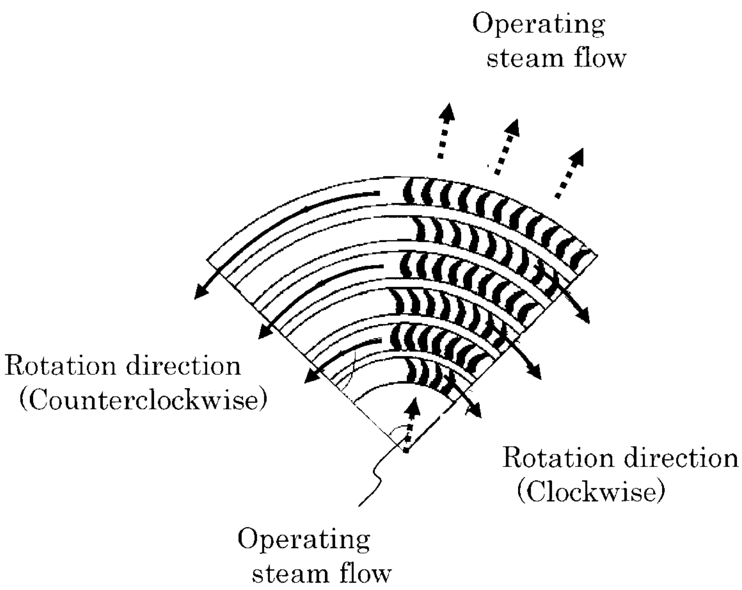


FIG.6



(Conceptual figure of the rotor blades in the Ljungstrom turbine)

FIG.7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/062745

A. CLASSIFICATION OF SUBJECT MATTER
F01D1/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01D1/06

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2021078 A (Andrew S. MILLER), 12 November 1935 (12.11.1935), fig. 1 to 3 (Family: none)	1-6,9 7 8
Y A	US 1910845 A (Alf LYSHOLM), 23 May 1933 (23.05.1933), fig. 1 (Family: none)	7 1-6,8,9
A	JP 2005-42567 A (Takeo SAITO), 17 February 2005 (17.02.2005), entire text (Family: none)	1-9

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

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Date of the actual completion of the international search 20 June, 2011 (20.06.11)	Date of mailing of the international search report 28 June, 2011 (28.06.11)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/062745

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2-70903 A (John Kirby), 09 March 1990 (09.03.1990), fig. 11 & US 5071312 A & GB 2221259 A & EP 353856 A1 & DK 374589 A & PT 91317 A	1-9
A	FR 372797 A (Karl KLASS), 18 April 1907 (18.04.1907), fig. 2 to 4 (Family: none)	1-9
A	FR 375623 A (Edwin FITZ GERALD), 13 July 1907 (13.07.1907), fig. 1 (Family: none)	1-9
A	JP 2003-3859 A (Shigeru SATO), 08 January 2003 (08.01.2003), paragraph [0006]; fig. 2 (Family: none)	8
A	JP 2009-203984 A (General Electric Co.), 10 September 2009 (10.09.2009), fig. 1 to 3 & US 2009/0217673 A1 & DE 102009003526 A & FR 2928179 A & RU 2009107292 A	8

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- JP 2005042567 A **[0004]**
- US 5071312 A **[0004]**
- US 7244095 B **[0004]**