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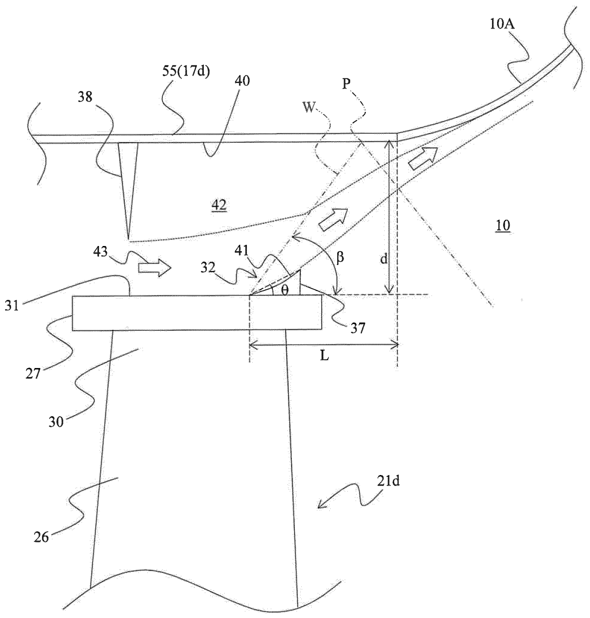
(54) **MOVING BLADE AND TURBINE USING MOVING BLADE**

(57) A moving blade 21d is disposed in a last stage closest to a diffuser 10 among a plurality of stages of a turbine 9 including a turbine rotor 12 and a stationary body 14. The diffuser 10 is connected to an outlet side of the stationary body 14. A distal end of the moving blade 21d is opposed to a seal fin 38 provided in the stationary body 14. The moving blade 21d includes a blade section 26, a cover 27 and a guide 32 provided on a moving blade distal end face 31, which is a surface of the cover 27. The moving blade distal end face 31 extends in a rotation axis direction of the turbine rotor 12, and the guide 32 includes a guide surface 41 located on a side close to the diffuser 10 with respect to the seal fin 38 and formed to incline upward in a direction from the seal fin 38 toward the diffuser 10.

FIG. 6



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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a moving blade and a turbine using the moving blade.

[Background Art]

[0002] A moving blade at a last stage (hereinafter, last-stage moving blade) of a low-pressure turbine tends to be elongated in order to meet requests for a high output and high efficiency of turbines in recent years (see JP-A-2003-65002 and the like).

SUMMARY OF THE INVENTION

[0003] When the last-stage moving blade is elongated, the circumferential speed of the last-stage moving blade increases. In order to obtain a large stage heat drop proportionate to the increased circumferential speed, it is necessary to raise the pressure of working fluid on an upstream side in a flowing direction (hereinafter, upstream side) of the working fluid of the last-stage moving blade. On the other hand, the pressure of the working fluid on a downstream side in the flowing direction (hereinafter, downstream side) of the working fluid of the last-stage moving blade is generally determined by the pressure in a condenser disposed on the downstream side of the turbine. Therefore, when the pressure of the working fluid present on the upstream side of the last-stage moving blade is raised, a ratio of an upstream pressure with respect to a downstream pressure of the working fluid of the last-stage moving blade increases.

[0004] Incidentally, in the turbine, there is a gap between a moving blade of a turbine rotor, which is a rotating body, and a stationary body that covers the turbine rotor. A part of the working fluid present on the upstream side of the last-stage moving blade can pass the gap. A flow passing the gap between a moving blade distal end and the stationary body opposed to the moving blade distal end without passing a blade section (a profile section) of the moving blade in this way is described as leak flow in this specification. The leak flow is sometimes suppressed by providing a seal fin on opposed surfaces of the moving blade distal end and the stationary body. However, even in this case, a very small gap remains between a seal fin distal end and a section opposed to the seal fin distal end. The leak flow cannot be completely suppressed.

[0005] When the ratio of the upstream pressure with respect to the downstream pressure of the last-stage moving blade increases as explained above and a ratio of pressures of the leak flow in front of and behind the seal fin exceeds a critical pressure ratio, the leak flow flows out from the very small gap at supersonic speed. In general, in a supersonic flow, contrary to a subsonic flow, flow velocity increases and pressure drops according to an increase in a sectional area of the flow. Therefore, in the supersonic leak flow, flow velocity increases in the portion of a diffuser provided such that the sectional area of the flow increases in order to reduce the subsonic flow of a main flow. A shock wave occurs and the supersonic leak flow changes to the subsonic flow further downstream of the diffuser. At this point, the pressure of the leak flow dropped according to the seal fin passage suddenly rises with the shock wave (a discontinuous change in pressure) in the diffuser. When a wall surface boundary layer flow with low flow velocity flowing near a diffuser wall surface passes through the shock wave, the leak flow separates from the diffuser wall surface. It is likely that a channel area enlargement effect of the diffuser decreases, pressure recovery performance is deteriorated, and a pressure loss increases.

[0006] The present invention has been devised in view of the above and an object of the present invention is to provide a moving blade that can suppress an increase in a pressure loss due to separation of a leak flow from a diffuser wall surface.

[0007] In order to achieve the object, the present invention is a moving blade disposed in a last stage closest to a diffuser among a plurality of stages of a turbine including a turbine rotor and a stationary body that covers the turbine rotor, the diffuser being connected to an outlet side of working fluid of the stationary body, a distal end of the moving blade being opposed to a seal fin provided in the stationary body, the moving blade including: a blade section; a cover provided at a distal end portion of the blade section; and a guide provided on a moving blade distal end face, which is a surface of the cover opposed to the stationary body. When the moving blade is assembled to the turbine, when viewed on a cross section cut along a plane including a rotation axis of the turbine rotor, the moving blade distal end face extends in a rotation axis direction of the turbine rotor, and the guide includes a guide surface located on a side close to the diffuser with respect to the seal fin and formed to incline upward in a direction from the seal fin toward the diffuser.

[0008] According to the present invention, it is possible to suppress an increase in a pressure loss due to separation of a leak flow from a diffuser wall surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic diagram showing the overall configuration of a configuration example of a steam turbine power generation facility applied with a moving blade according to a first embodiment of the present invention;

Fig. 2 is a sectional view showing the internal structure of a main part of a low-pressure turbine applied with the moving blade according to the first embodiment of the present invention;

Fig. 3 is a perspective view showing the schematic configuration of a last-stage moving blade according to the first embodiment of the present invention;

Fig. 4 is a perspective view showing a state in which the last-stage moving blade according to the first embodiment of the present invention is fixed to a rotor disk;

Fig. 5 is a diagram in which Fig. 4 is viewed from a radial direction outer side;

Fig. 6 is a partially enlarged view showing the distal end portion of the last-stage moving blade according to the first embodiment of the present invention;

Fig. 7 is a partially enlarged view showing the distal end portion of a last-stage moving blade according to a comparative example;

Fig. 8 is a partially enlarged view showing the distal end portion of a last-stage moving blade according to a second embodiment of the present invention;

Fig. 9 is a diagram of a last-stage moving blade according to a third embodiment of the present invention viewed from a radial direction outer side;

Fig. 10 is a diagram of a last-stage moving blade according to a fourth embodiment of the present invention viewed from a radial direction outer side; and

Fig. 11 is a partially enlarged view showing the distal end portion of a last-stage moving blade according to a fifth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

<First embodiment>

(Configuration)

1. Steam turbine power generation facility

[0010] Fig. 1 is a schematic diagram showing the overall configuration of a configuration example of a steam turbine power generation facility applied with a moving blade according to this embodiment. In the following explanation, the moving blade according to this embodiment is applied to the steam turbine power generation facility. However, an application target of the moving blade according to this embodiment is not limited to the steam turbine power generation facility. The moving blade according to this embodiment can also be applied to, for example, a gas turbine power generation facility.

[0011] As shown in Fig. 1, a steam turbine power generation facility 100 includes a steam generation source 1, a high-pressure turbine 3, an intermediate-pressure turbine 6, a low-pressure turbine 9, a condenser 11, and a load apparatus 13.

[0012] The steam generation source (a boiler) 1 heats feed water supplied from the condenser 11 and generates high-temperature/high-pressure steam. The steam generated by the boiler 1 is guided to the high-pressure turbine 3 via a main steam pipe 2 and drives the high-pressure turbine 3. The steam that has driven the high-pressure turbine 3 and has been decompressed flows down in a high-pressure turbine exhaust pipe 4 and is guided to the boiler 1 and heated again to be reheated steam.

[0013] The reheated steam heated by the boiler 1 is guided to the intermediate-pressure turbine 6 via a reheating steam pipe 5 and drives the intermediate-pressure turbine 6. The steam that has driven the intermediate-pressure turbine 6 and has been decompressed is guided to the low-pressure turbine 9 via an intermediate-pressure turbine exhaust pipe 7 and drives the low-pressure turbine 9. The steam that has driven the low-pressure turbine 9 and has been decompressed flows in a diffuser 10 and is guided to the condenser 11. The condenser 11 includes a cooling water pipe (not shown in the figure). The condenser 11 causes the steam guided to the condenser 11 and cooling water flowing in the cooling water pipe to perform heat exchange and condenses the steam. The condensed water generated by the condenser 11 is sent to the boiler 1 again as feed water by a feed water pump 56.

[0014] The high-pressure turbine 3, the intermediate-pressure turbine 6, and the low-pressure turbine 9 are coupled on the same axis by a turbine rotor 12. The load apparatus (in this embodiment, a generator) 13 is coupled to the turbine rotor 12. The generator 13 is driven by rotation power of the high-pressure turbine 3, the intermediate-pressure turbine 6, and the low-pressure turbine 9. The rotation power of the high-pressure turbine 3, the intermediate-pressure turbine 6, and the low-pressure turbine 9 is converted into electric power.

[0015] In this embodiment, the configuration is illustrated in which the coupled high-pressure turbine 3, intermediate-pressure turbine 6, and low-pressure turbine 9 drive the generator 13. However, a configuration may be adopted in which the high-pressure turbine 3, the intermediate-pressure turbine 6, and the low-pressure turbine 9 respectively drive generators and individually convert rotation power into electric power or a configuration may be adopted in which a turbine obtained by coupling any two of the high-pressure turbine 3, the intermediate-pressure turbine 6, and the low-pressure turbine 9 drives a generator and converts rotation power into electric power. The configuration including the high-pressure turbine 3, the intermediate-pressure turbine 6, and the low-pressure turbine 9 is illustrated. However, a configuration excluding the intermediate-pressure turbine 6 and including the high-pressure turbine 3 and the low-pressure turbine 9 may be adopted. Further, the configuration including the boiler as the steam generation source 1 is illustrated. However, a configuration including, as the steam generation source 1, a heat recovery steam generator (HRSG) that uses exhaust heat of a gas turbine may be adopted. That is, the steam turbine power generation facility may be a combined cycle power generation facility. The steam generation source 1 may be an atomic power generation facility including an atomic reactor.

2. Steam turbine

[0016] Fig. 2 is a sectional view showing the internal structure of a main part of the low-pressure turbine 9 applied with the moving blade according to this embodiment. As shown in Fig. 2, the low-pressure turbine 9 includes the turbine rotor 12 and a stationary body 14 that covers the turbine rotor 12. The diffuser 10 is connected to an outlet side (a most downstream side) of working fluid 22 of the stationary body 14. Note that, in this specification, a rotating direction and a rotation axis direction of the turbine rotor 12 are simply referred to as "rotating direction" and "rotation axis direction" and a radial direction inner side and a radial direction outer side of the turbine rotor 12 are simply referred to as "radial direction inner side" and "radial direction outer side".

[0017] The stationary body 14 includes a casing 16, outer diaphragms 17a to 17d, stationary blades 18a to 18d, and inner diaphragms 19a to 19d.

[0018] The casing 16 is a cylindrical member that forms the outer circumferential wall of the low-pressure turbine 9. The outer diaphragms 17a to 17d, the stationary blades 18a to 18d, the inner diaphragms 19a to 19d, and the turbine rotor 12 are housed in the casing 16.

[0019] The outer diaphragms 17a to 17d are supported on the inner circumferential surface of the casing 16. The outer diaphragms 17a to 17d are cylindrical members extending in the rotating direction. In this embodiment, the outer diaphragms 17a to 17d are configured by combining members formed in a semicircular shape. The outer diaphragms 17a to 17d are formed such that the inner circumferential surfaces thereof spread to the radial direction outer side toward a downstream side. An outer circumferential wall 10A of the diffuser 10 is connected to the end portion on the downstream side of a projecting section 55 of the outer diaphragm 17d provided on the most downstream side among the outer diaphragms 17a to 17d. Note that, in this embodiment, the configuration is illustrated in which the outer diaphragms 17a to 17d are respectively supported on the inner circumferential surface of the casing 16. However, a configuration may be adopted in which the outer diaphragms 17a to 17d are integrally formed and supported on the inner circumferential surface of the casing 16.

[0020] The stationary blades 18a to 18d are provided in plurality along the rotating direction on the inner circumferential surfaces of the outer diaphragms 17a to 17d. The stationary blades 18a to 18d are provided to extend from the inner circumferential surfaces of the outer diaphragms 17a to 17d toward the radial direction inner side.

[0021] The inner diaphragms 19a to 19d are provided on the radial direction inner side of the outer diaphragms 17a to 17d. The inner diaphragms 19a to 19d are cylindrical members extending in the rotating direction. In this embodiment, the inner diaphragms 19a to 19d are configured by combining members formed in a semicircular shape. The stationary blades 18a to 18d are connected to the outer circumferential surfaces of the inner diaphragms 19a to 19d. That is, the stationary blades 18a to 18d are fixed between the outer diaphragms 17a to 17d and the inner diaphragms 19a to 19d.

[0022] In this embodiment, the outer diaphragm 17a, the stationary blade 18a, and the inner diaphragm 19a configure a stationary blade row 15a at a first stage, the outer diaphragm 17b, the stationary blade 18b, and the inner diaphragm 19b configure a stationary blade row 15b at a second stage, the outer diaphragm 17c, the stationary blade 18c, and the inner diaphragm 19c configure a stationary blade row 15c at a third stage, and the outer diaphragm 17d, the stationary blade 18d, and the inner diaphragm 19d configure a stationary blade row 15d at a fourth stage (a last stage).

[0023] An annular space formed between the inner diaphragms 19a to 19d and platforms (explained below) of moving blades 21a to 21d and the outer diaphragms 17a to 17d and covers (explained below) configures a channel (an annular channel) 23 in which the working fluid 22 flows. The inner circumferential wall of the annular channel 23 is formed by the outer circumferential surfaces of the inner diaphragms 19a to 19d and the outer circumferential surfaces of the platforms of the moving blades 21a to 21d. The outer circumferential wall of the annular channel 23 is formed by the inner circumferential surfaces of the outer diaphragms 17a to 17d and surfaces facing the radial direction inner side of the covers.

[0024] The turbine rotor 12 includes rotor disks 20a to 20d and the moving blades 21a to 21d.

[0025] The rotor disks 20a to 20d are disk-like members disposed side by side in the rotation axis direction. The rotor disks 20a to 20d are sometimes alternately superimposed with spacers (not shown in the figure).

[0026] The moving blades 21a to 21d are respectively provided on the outer circumferential surfaces of the rotor disks 20a to 20d in plurality at equal intervals along the rotating direction. The moving blades 21a to 21d are provided to extend from the outer circumferential surfaces of the rotor disks 20a to 20d toward the radial direction outer side. The moving blades 21a to 21d are rotated round a rotation axis R together with the rotor disks 20a to 20d by the working fluid 22 flowing in the annular channel 23.

[0027] In this embodiment, the rotor disk 20a and the moving blade 21a configure a moving blade row 53a at the first stage, the rotor disk 20b and the moving blade 21b configure a moving blade row 53b at the second stage, the rotor disk 20c and the moving blade 21c configure a moving blade row 53c at the third stage, and the rotor disk 20d and the moving blade 21d configure a moving blade row 53d at the fourth stage (the last stage).

[0028] The stationary blades 18a to 18d and the moving blades 21a to 21d are alternately provided in the rotation axis direction in the order of the stationary blade 18a, the moving blade 21a, the stationary blade 18b, the moving blade 21b, and the like from an inlet side (a most upstream side) of the working fluid 22 of the stationary body 14 toward the downstream side. The stationary blades 18a to 18d are disposed to be opposed to the moving blades 21a to 21d in the rotation axis direction.

[0029] From the inlet side of the working fluid 22 of the stationary body 14, one set of a stationary blade row and a moving blade row adjacent to each other in the rotation axis direction configures a blade stage. In this embodiment, the stationary blade row 15a at the first stage and the moving blade row 53a at the first stage configure a first blade stage 24a, the stationary blade row 15b at the second stage and the moving blade row 53b at the second stage configure a second blade stage 24b, the stationary blade row 15c at the third stage and the moving blade row 53c at the third stage configure a third blade stage 24c, and the stationary blade row 15d at the fourth stage and the moving blade row 53d at the fourth stage configure a fourth blade stage 24d. The fourth blade stage 24d is a last stage disposed on the outlet side of the working fluid 22 of the stationary body 14. The fourth blade stage 24d is disposed in a position closest to the diffuser 10. Blade lengths (lengths in the radial direction) of the moving blades 21a to 21d disposed in the first to fourth blade stages are formed to be larger in the moving blades located further on the downstream side. The blade length of the moving blade (the last-stage moving blade) 21d disposed in the fourth blade stage 24d is formed largest among the moving blades 21a to 21d. Specifically, the last-stage moving blade 21d has the blade length at which a moving blade distal end circumferential speed Mach number obtained by dividing the rotation circumferential speed of the distal end portion of a blade section 26 (explained below) by the sonic speed of the working fluid 22 flowing at the distal end portion of the blade section 26 exceeds 1.0 during the rotation of the turbine rotor 12.

[0030] Fig. 3 is a perspective view showing the schematic configuration of the last-stage moving blade 21d. As shown in Fig. 3, the last-stage moving blade 21d includes a platform 25, the blade section 26, an integral cover 27, and a tie boss 28.

[0031] The platform 25 has size for covering the entire end face of a root portion (a portion on the radial direction inner side) 29 of the blade section 26. In this embodiment, the platform 25 is formed in a lozenge shape when viewed from the radial direction outer side. A blade root attachment (not shown in the figure) projecting to the opposite side of the blade section 26 is provided on the lower surface (a surface on the radial direction inner side) of the platform 25. The blade root attachment is formed in, for example, a reverse Christmas tree shape. The blade root attachment is fit with a groove section (not shown in the figure) formed on the outer circumferential surface of the rotor disk 20d (see Fig. 2), whereby the last-stage moving blade 21d is fixed to the rotor disk 20d. Note that, in the illustration in this embodiment, the blade root attachment is formed in the reverse Christmas tree shape. However, the shape of the blade root attachment is not limited to the reverse Christmas tree shape as long as the blade root attachment can be fit with the groove section formed on the outer circumferential surface of the rotor disk 20d and can fix the last-stage moving blade 21d to the rotor disk 20d resisting a centrifugal force generated during the rotation of the turbine rotor 12.

[0032] The blade section 26 is attached to the outer circumferential surface of the platform 25 and extends from the outer circumferential surface of the platform 25 to the radial direction outer side. The blade section 26 is formed to be twisted.

[0033] The integral cover (the cover) 27 is provided at a distal end portion (an end portion in the radial direction outer side) 30 of the blade section 26. The cover 27 includes a suction side integral cover (a first cover) 27A extending in the rotating direction in a suction side section of the last-stage moving blade 21d and a pressure side integral cover (a second cover) 27B extending in the rotating direction in a pressure side section of the last-stage moving blade 21d. As explained above, the surface of the cover 27 facing the radial direction inner side configures a part of the outer circumferential wall of the annular channel 23 and defines the annular channel 23. The cover 27 comes into contact with covers of last-stage moving blades (adjacent blades) adjacent to each other on both sides in the rotating direction of the last-stage moving blade 21d during the rotation of the turbine rotor 12 and couples the last-stage moving blade 21d and the adjacent blades. Action of the cover 27 during the rotation of the turbine rotor 12 is explained below.

[0034] When the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed on a cross section cut along a plane including the rotation axis R of the turbine rotor 12 (hereinafter referred to as meridional plane cross section), the cover 27 includes a surface opposed to the inner circumferential surface of the outer diaphragm 17d (the stationary body 14) and extending in the rotation axis direction. In this specification, the surface facing the radial direction outer side of the cover 27 and opposed to the inner circumferential surface of the outer diaphragm 17d is described as a moving blade distal end face 31 for convenience. In this embodiment, the moving blade distal end face 31 is formed in size for covering the entire end face of the distal end portion 30 of the last-stage moving blade 21d. That is, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed on the meridional plane cross section, the length in the rotation axis direction of the moving blade distal end face 31 is set larger than the length in the rotation axis direction of the blade section 26 at the distal end portion 30 of the last-stage moving blade 21d. A gap 42 that causes spaces on upstream and downstream sides of the last-stage moving blade 21d to communicate is present between the moving blade distal end face 31 and the inner circumferential surface of the outer diaphragm 17d (see Fig. 2). A guide 32 is provided on the moving blade distal end face 31. The guide 32 is explained below.

[0035] The tie boss 28 is provided between the root portion 29 and the distal end portion 30 of the blade section 26. In this embodiment, the tie boss 28 is provided in an intermediate portion in the radial direction of the blade section 26. The tie boss 28 includes a suction side tie boss (a first tie boss) 28A provided on the suction side of the last-stage moving blade 21d and a pressure side tie boss (a second tie boss) 28B provided on the pressure side of the last-stage moving blade 21d. The tie boss 28 comes into contact with a tie boss of an adjacent blade during the rotation of the turbine rotor 12 and couples the last-stage moving blade 21d and the adjacent blade. Action of the tie boss 28 during the rotation of the turbine rotor 12 is explained below. Note that, in the illustration in this embodiment, the tie boss 28 is provided in the intermediate portion in the radial direction of the blade section 26. However, the tie boss 28 may be shifted to the radial direction inner side or the radial direction outer side from the intermediate portion of the blade section 26 according to, for example, torsional rigidity of the blade section 26.

[0036] Fig. 4 is a perspective view showing a state in which the last-stage moving blade 21d is fixed to the rotor disk 20d. Fig. 5 is a diagram in which Fig. 4 is viewed from the radial direction outer side. Note that, in Fig. 4, the rotor disk 20d is omitted.

[0037] According to an increase of the rotating speed of the turbine rotor 12, a centrifugal force acts on the blade section 26 of the last-stage moving blade 21d from the root portion 29 toward the distal end portion 30. Since the blade section 26 is twisted as explained above, untwist is caused in the blade section 26 by the centrifugal force. Consequently, as shown in Fig. 4, an untwist moment 33 acts on the distal end portion 30 of the blade section 26, an untwist moment 34 acts on the intermediate portion of the blade section 26, and an untwist moment 35 acts on the root portion 29 of the blade section 26 respectively in directions indicated by arrows. Similarly, an untwist moment 33’ acts on a distal end portion 30’ of a blade section 26’ of a last-stage moving blade 21d’ adjacent to the last-stage moving blade 21d in the rotating direction, an untwist moment 34’ acts on the intermediate portion of the blade section 26’, and an untwist moment 35’ acts on a root portion 29’ of the blade section 26’ respectively in directions indicated by arrows.

[0038] As shown in Fig. 5, in this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed from the radial direction outer side, an end face 36 on the downstream side in the rotating direction of the first cover 27A of the last-stage moving blade 21d and an end face 36’ on the upstream side in the rotating direction of a second cover 27B’ of the last-stage moving blade 21d’ restrict the untwist moments 33 and 33’ during the rotation of the turbine rotor 12. The second tie boss 28B of the last-stage moving blade 21d and a first tie boss 28A’ of the last-stage moving blade 21d’ restrict the untwist moments 34 and 34’. Consequently, during the rotation of the turbine rotor 12, the end face 36 and the end face 36’ come into surface contact with each other, the second tie boss 28B and the first tie boss 28A’ come into surface contact with each other, and the last-stage moving blades 21d and 21d’ are coupled in the rotating direction.

[0039] Fig. 6 is a partially enlarged view showing the distal end portion 30 of the last-stage moving blade 21d.

[0040] In this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, as shown in Fig. 6, when viewed on the meridional plane cross section, a seal fin 38 is provided on a surface of the projecting section 55 of the outer diaphragm 17d opposed to the last-stage moving blade 21d (a seal fin is not provided on the moving-blade distal end face 31 of the cover 27). In this specification, a portion extending in the rotation axis direction and opposed to the last-stage moving blade 21d on the inner circumferential surface of the projecting section 55 of the outer diaphragm 17d is described as a moving blade opposed surface 40 for convenience. Note that, in this embodiment, the configuration is illustrated in which the outer diaphragm 17d and the projecting section 55 are integrally formed. However, a configuration may be adopted in which the projecting section 55 is attached to the outer diaphragm 17d by welding or the like as an inner casing on the outer side of the last-stage moving blade 21d. When the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed on the meridional plane cross section, the seal fin 38 extends from the moving blade opposed surface 40 toward the last-stage moving blade 21d to suppress a leak flow 43 flowing in the gap 42 between the cover 27 and the moving blade opposed surface 40. In other words, the last-stage moving blade 21d is disposed such that the distal end (the cover 27) of the last-stage moving blade 21d is opposed to the seal fin 38. In this embodiment, one seal fin 38 is provided in the rotation axis direction on the moving blade opposed surface 40. A very small gap is present between the distal end portion (the end portion on the radial direction inner side) of the seal fin 38 and the moving blade distal end face 31 in order to avoid contact of the stationary body 14 and the turbine rotor 12.

[0041] As shown in Fig. 6, the guide 32 is provided on the moving blade distal end face 31 of the cover 27 to be located on a side close to the diffuser 10 with respect to the seal fin 38. Note that, in an illustration in Fig. 6, one seal fin 38 is provided in the rotation axis direction on the moving blade opposed surface 40 of the outer diaphragm 17d. However, when a plurality of seal fins are provided in the rotation axis direction, the guide 32 only has to be provided to be located on a side close to the diffuser 10 with respect to the seal fin present closest to the diffuser 10 side among the plurality of seal fins.

[0042] As shown in Fig. 5, in this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed from the radial direction outer side, the guide 32 extends in the rotating direction and is provided such that both ends thereof are opposed to the end portions of guides of last-stage moving blades adjacent to each other on both sides in the rotating direction. That is, the end portion on the downstream side in the rotating direction of the guide 32 of the last-stage moving blade 21d is opposed to the end portion on the upstream side in the rotating direction of a guide 32' of the last-stage moving blade 21d' adjacent to the last-stage moving blade 21d in the rotating direction. In this embodiment, the guide 32 is provided on the moving blade distal end face 31 of the cover 27 to extend from an end portion on the upstream side to an end portion on the downstream side in the rotating direction. With such a configuration, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed from the upstream side, the guide 32 is formed in a ring shape to cover the exterior of a plurality of last-stage moving blades arranged in the rotating direction.

[0043] As shown in Fig. 6, in this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, the guide 32 is provided as a projecting section that projects from the moving blade distal end face 31 to the moving blade opposed surface 40 side when viewed on the meridional plane cross section. The guide 32 includes a wall surface 37 and a guide surface 41.

[0044] The wall surface 37 extends from the moving blade distal end face 31 of the cover 27 toward the moving blade opposed surface 40 of the outer diaphragm 17d. The height (the length in the radial direction from the moving blade distal end face 31) of the wall surface 37 is set smaller than the length in the radial direction from the moving blade distal end face 31 to the distal end portion of the seal fin 38 during the rotation. Consequently, even if relative positions in the rotation axis direction of the last-stage moving blade 21d and the seal fin 38 change because of a hot stretching difference between a rotating section such as the rotor and a stationary section such as the casing, it is possible to prevent the guide 32 from coming into contact with the seal fin 38. It is possible to secure reliability of the low-pressure turbine 9.

[0045] When the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed on the meridional plane cross section, the guide surface 41 is formed to incline upward in a direction from the seal fin 38 toward the diffuser 10. In this embodiment, the guide surface 41 is formed in a convex shape toward the rotation axis from an end portion (an upstream edge portion) on the seal fin 38 side to an end portion (a downstream edge portion) on the diffuser 10 side.

[0046] A method of designing and manufacturing the guide 32 and a method of application to the last-stage moving blade 21d are explained.

[0047] As shown in Fig. 6, in this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed on the meridional plane cross section, an incident point (a point where an oblique shock wave hits another medium) P of a shock wave inclining to the radial direction outer side (an oblique shock wave) W generated at the upstream edge portion of the guide surface 41 because the supersonic leak flow 43 flowing on the downstream side of the seal fin 38 in the gap 42 collides with the guide surface 41 when passing the upstream edge portion of the guide surface 41 is located on the moving blade opposed surface 40 of the outer diaphragm 17d present further on the upstream side than the outer circumferential wall 10A of the diffuser 10. In this case, when an inclination angle of the oblique shock wave W with respect to the moving blade distal end face 31 (the rotation axis R) is represented as β, length in the rotation axis direction from the upstream edge portion of the guide surface 41 to a connecting section of the outer diaphragm 17d and the outer circumferential wall 10A of the diffuser 10 is represented as L, and length in the radial direction from the moving blade distal end face 31 to the moving blade opposed surface 40 is represented as d, the inclination angle β needs to satisfy the following Expression (1).

$$\tan\beta \geq d/L \quad (1)$$

[0048] On the other hand, when an inclination angle of a line segment connecting the upstream edge portion and the downstream edge portion of the guide surface 41 with respect to the moving blade distal end face 31 (the rotation axis R) is represented as θ, the inclination angle θ can be represented as the following Expression (2).

$$\tan\theta = \{2\cos\beta(M1^2\sin^2\beta - 1)\}/M1^2(\kappa + \cos2\beta) + 2\} \quad (2)$$

[0049] In the expression, κ is a ratio of specific heat of working fluid. In the case of working fluid (wet steam) flowing in the last-stage moving blade, κ is, for example, 1.1 to 1.14. In this embodiment, κ is set to 1.135. M1 is a Mach number of the supersonic leak flow 43 flowing into the gap 42.

[0050] The inclination angle θ is determined using Expression (2) such that the inclination angle β satisfies Expression (1), the height of the wall surface 37 is determined, and the guide 32 is designed and manufactured. When the last-stage moving blade 21d is assembled to the low-pressure turbine 9, the manufactured guide 32 is attached to the moving blade distal end face 31 of the cover 27 by welding or the like to be located on a side close to the diffuser 10 with respect to the seal fin 38 provided on the moving blade opposed surface 40 when viewed on the meridional plane cross section.

(Operation)

Concerning a main flow (a flow passing the blade section of the moving blade)

[0051] A main flow of the working fluid 22 flows into spaces among the stationary blades 18a of the stationary blade row 15a at the first stage, accelerates while turning along the shape of the stationary blades 18a, and flows out from the spaces among the stationary blades 18a. The main flow flowing out from the spaces among the stationary blades 18a flows into spaces among the moving blades 21a of the moving blade row 53a at the first stage disposed on the downstream side of the stationary blade row 15a at the first stage and drives to rotate the turbine rotor 12. The main flow flowing out from the spaces among the moving blades 21a flows into spaces among the stationary blades 18b of the stationary blade row 15b at the second stage disposed on the downstream side of the moving blade row 53a at the first stage. Thereafter, the main flow flows into the diffuser 10 provided on the downstream side of the last-stage moving blade 21d while repeating the turning by the stationary blades, imparting of an acceleration component, and the rotation driving of the moving blades.

Concerning the leak flow

[0052] As shown in Fig. 6, a part of the working fluid 22 passes a very small gap present between the distal end portion of the seal fin 38 and the cover 27 and flows into the gap 42 as the leak flow 43.

[0053] When the pressure of the working fluid 22 on the upstream side of the last-stage moving blade 21d is raised, the rotating speed of the last-stage moving blade 21d increases and the rotation circumferential speed of the distal end portion of the blade section 26 increases. For the working fluid to impart a rotation driving force to the moving blade, a stagnation pressure of a moving blade inlet needs to be larger as circumferential speed is larger. Therefore, when a ratio of pressures in front of and behind the seal fin 38 increases and a moving blade distal end circumferential speed Mach number obtained by dividing the rotation circumferential speed of the distal end portion of the blade section 26 by the sonic speed of the working fluid 22 flowing into the blade section 26 increases to exceed 1.0, it is highly likely that the ratio of pressures in front of and behind the seal fin 38 exceeds a critical pressure ratio at which the speed of the working fluid 22 increases to supersonic speed downstream of passage of the seal fin 38.

[0054] The supersonic leak flow 43 flowing on the downstream side of the seal fin 38 in the gap 42 collides with the guide surface 41 when passing the upstream edge portion of the guide surface 41 of the guide 32 provided on the moving blade distal end face 31. At this point, the oblique shock wave W is generated from the upstream edge portion of the guide surface 41 toward the incident point P on the moving blade opposed surface 40. The supersonic leak flow 43 passing the upstream edge portion of the guide surface 41 and flowing along the guide surface 41 interferes with the oblique shock wave W to be decelerated and is turned to the radial direction outer side by the oblique shock wave W. Thereafter, the leak flow 43 flows into the diffuser 10 from the gap 42. However, since the leak flow 43 is turned to the outer side, a channel area is reduced rather than being expanded as shown in Fig. 6. The leak flow 43 is gradually decelerated and is decelerated to be a subsonic flow without involving a large pressure loss.

(Effect)

[0055]

(1) Fig. 7 is a partially enlarged view showing the distal end portion of a last-stage moving blade A according to a comparative example. As shown in Fig. 7, a guide is not provided in a cover B of the last-stage moving blade A according to the comparative example. Therefore, a supersonic leak flow D passing a very small gap F present between the distal end portion of a seal fin G and the cover B and flowing in a gap present between the cover B and an outer diaphragm C increases in flow velocity and flows into a diffuser E and is thereafter changed to a subsonic flow while involving a total pressure loss by a shock wave. At this point, the pressure of the leak flow D dropped according to the seal fin passage suddenly rises because the leak flow D passes through a shock wave H in the diffuser E and has subsonic speed. When a wall surface boundary layer flow with low flow velocity flowing near a diffuser wall surface passes through the shock wave, the wall surface boundary layer flow separates from the wall surface of the diffuser E. It is likely that a channel area enlargement effect of the diffuser decreases, pressure recovery performance is deteriorated, and a pressure loss increases.
On the other hand, in this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, as shown in Fig. 6, when viewed on the meridional plane cross section, the guide 32 including the guide surface 41 formed to incline upward in the direction from the seal fin 38 toward the diffuser 10 is provided on the moving blade distal end face 31 of the cover 27. Therefore, it is possible to turn, along the guide surface 41, the supersonic leak flow 43 flowing on the downstream side of the seal fin 38 in the gap 42, generate the oblique shock wave W, and decelerate the supersonic leak flow 43. Since the leak flow passes through the oblique shock wave W, it is possible to turn the flow of the supersonic leak flow 43 to the radial direction outer side and reduce the sectional area of the flow. It is possible to further decelerate the supersonic leak flow 43. Consequently, it is possible to suppress a sudden rise in pressure due to a shock wave at the time when the supersonic leak flow 43 flows into the diffuser 10 and changes to a subsonic flow and reduce the strength of a shock wave generated in the diffuser 10. Therefore, when the leak flow 43 passes through the shock wave generated in the diffuser 10, it is possible to prevent a wall surface boundary layer flow with low flow velocity flowing near the outer circumferential wall 10A of the diffuser 10 from separating from the outer circumferential wall 10A of the diffuser 10. It is possible to suppress an increase in a pressure loss.

(2) In this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed on the meridional plane cross section, the guide surface 41 is formed to incline upward from the moving blade distal end face 31 in the direction from the seal fin 38 toward the diffuser 10. Therefore, it is possible to reduce, from the upstream edge portion toward the downstream edge portion of the guide surface 41, the sectional area of the leak flow 43 flowing on the downstream side of the seal fin 38 in the gap 42. Therefore, it is possible to reduce the sectional area of the flow of the supersonic leak flow 43. It is possible to further decelerate the supersonic leak flow 43. This also contributes to preventing the wall surface boundary layer flow with low flow velocity from separating from the outer circumferential wall 10A of the diffuser 10 and suppressing an increase in a pressure loss.

(3) As shown in Fig. 7, in the last-stage moving blade A according to the comparative example, a part of the supersonic leak flow D flowing in the diffuser E interferes with a main flow L flowing into the diffuser E passing through a blade section K of the last-stage moving blade A. An interference loss due to mixing of fluids having different velocities could occur. On the other hand, in this embodiment, as explained above, it is possible to turn the flow of the supersonic leak flow 43 to the radial direction outer side. Therefore, it is possible to prevent the supersonic leak flow 43 from interfering with the main flow flowing into the diffuser 10 passing through the blade section 26 of the last-stage moving blade 21d.

(4) In this embodiment, when the last-stage moving blade 21d is assembled to the low-pressure turbine 9, when viewed from the radial direction outer side, the guide 32 is provided on the moving blade distal end face 31 to extend from the end portion on the upstream side to the end portion on the downstream side in the rotating direction. Both the ends of the guide 32 are opposed to the end portions of the guides of the last-stage moving blades adjacent to each other on both the sides in the rotating direction. Consequently, when viewed from the upstream side, it is

possible to form the guide 32 in a ring shape to cover the exterior of the plurality of last-stage moving blades. It is possible to decelerate, over the entire circumference in the rotating direction, the supersonic leak flow 43 flowing in the gap 42 and surely suppress an increase in a pressure loss.

<Second Embodiment>

(Configuration)

[0056] Fig. 8 is a partially enlarged view showing the distal end portion 30 of a last-stage moving blade 44d according to this embodiment. In Fig. 8, portions equivalent to the portions in the first embodiment are denoted by the same reference numerals and signs and explanation of the portions is omitted as appropriate.

[0057] The last-stage moving blade 44d according to this embodiment is different from the last-stage moving blade 21d according to the first embodiment in that the shape of a guide 45 is different. The other components are the same as the components of the last-stage moving blade 21d according to the first embodiment.

[0058] In this embodiment, when the last-stage moving blade 44d is assembled to the low-pressure turbine 9, as shown in Fig. 8, when viewed on the meridional plane cross section, the guide 45 is provided as a concave section recessed from the moving blade distal end face 31 of the cover 27 to the rotation axis side (the blade section 26 side of the last-stage moving blade 44d). The guide 45 includes a wall surface 46 and a guide surface 47.

[0059] The wall surface 46 is formed to extend from the moving blade distal end face 31 of the cover 27 to the rotation axis side. The depth (length from the moving blade distal end face 31 toward the radial direction inner side) of the wall surface 46 is set smaller than the thickness (length in the radial direction) of the cover 27. The guide surface 47 is formed to incline upward in the direction from the seal fin 38 toward the diffuser 10 and connects the end portion on the radial direction inner side of the wall surface 46 and the moving blade distal end face 31.

[0060] A method of designing and manufacturing the guide 45 and a method of application to the last-stage moving blade 44d are explained.

[0061] In this embodiment, when the last-stage moving blade 44d is assembled to the low-pressure turbine 9, as shown in Fig. 8, a line extending in the rotation axis direction passing the upstream edge portion of the guide surface 47 is represented as a reference line X, an inclination angle of the oblique shock wave W with respect to the reference line X is represented as β, and length in the radial direction from the moving blade opposed surface 40 to the reference line X is represented as d when viewed on the meridional plane cross section, the inclination angle θ is determined from Expressions (1) and (2), the depth of the wall surface 46 is determined, and the guide 45 is designed and manufactured. When the last-stage moving blade 44d is assembled to the low-pressure turbine 9, the moving blade distal end face 31 of the cover 27 is, for example, cut and formed to locate the manufactured guide 45 on a side close to the diffuser 10 with respect to the seal fin 38 provided on the moving blade opposed surface 40 when viewed on the meridional plane cross section.

(Effect)

[0062] In this embodiment, when the last-stage moving blade 44d is assembled to the low-pressure turbine 9, as shown in Fig. 8, when viewed on the meridional plane cross section, the guide 45 including the guide surface 47 formed to incline upward in the direction from the seal fin 38 toward the diffuser 10 is provided on the moving blade distal end face 31. Therefore, as in the first embodiment, it is possible to prevent the wall surface boundary layer flow with low flow velocity flowing near the outer circumferential wall 10A of the diffuser 10 from separating from the outer circumferential wall 10A of the diffuser 10 and suppress an increase in a pressure loss. In addition, in this embodiment, an effect explained below is obtained.

[0063] In this embodiment, the guide 45 is provided as the concave section recessed from the moving blade distal end face 31 to the rotation axis side. Therefore, it is possible to more surely prevent interference of the guide 45 and the seal fin 38. It is possible to improve reliability of the low-pressure turbine 9.

<Third Embodiment>

(Configuration)

[0064] Fig. 9 is a diagram of a last-stage moving blade 48d according to this embodiment viewed from the radial direction outer side. In Fig. 9, portions equivalent to the portions in the first embodiment are denoted by the same reference numerals and signs and explanation of the portions is omitted as appropriate.

[0065] The last-stage moving blade 48d according to this embodiment is different from the last-stage moving blade 21d according to the first embodiment in that the shape and the position of a guide 49 are different. The other components are the same as the components of the last-stage moving blade 21d according to the first embodiment.

[0066] As shown in Fig. 9, in this embodiment, when viewed from the radial direction outer side (the stationary body side), the guide 49 is provided along the rear edge portion (the edge portion on the diffuser 10 side) of the moving blade distal end face 31 of the cover 27. The other components are the same as the components of the guide 32 according to the first embodiment.

[0067] In a configuration illustrated in Fig. 9, the rear edge portion of the moving blade distal end face 31 of the cover 27 extends in the rotating direction while meandering. The guide 49 is provided to meander along the rear edge portion of the moving blade distal end face 31 of the cover 27. Note that, in the illustration in this embodiment, the guide 49 is a projecting section. However, as in the second embodiment, the guide 49 may be a concave section recessed from the moving blade distal end face 31 to the rotation axis side.

(Effect)

[0068] In this embodiment, an effect same as the effect in the first embodiment can be obtained. In addition, in this embodiment, an effect explained below is obtained.

[0069] In this embodiment, since the guide 49 is provided along the rear edge portion of the moving blade distal end face 31 of the cover 27, the guide 49 can be provided in a position separated to the diffuser 10 side from the seal fin 38 (see Fig. 6) provided on the moving blade opposed surface 40. Therefore, it is possible to more surely avoid the interference of the guide 49 and the seal fin 38. It is possible to further improve the reliability of the low-pressure turbine 9.

<Fourth Embodiment>

(Configuration)

[0070] Fig. 10 is a diagram of a last-stage moving blade 50d according to this embodiment viewed from the radial direction outer side. In Fig. 10, portions equivalent to the portions in the first embodiment are denoted by the same reference numerals and signs and explanation of the portions is omitted as appropriate.

[0071] The last-stage moving blade 50d according to this embodiment is different from the last-stage moving blade 21d according to the first embodiment in that the shape and the position of a guide 51 are different. The other components are the same as the components of the last-stage moving blade 21d according to the first embodiment.

[0072] In this embodiment, when viewed from the radial direction outer side, the guide 51 is provided to close a channel 52 in a region (the first cover 27A) on the rear surface side of the blade section 26 on the moving blade distal end face 31 of the cover 27 of the last-stage moving blade 50d. Note that, in the illustration in this embodiment, as in the first embodiment, the guide 51 is a projecting section. However, as in the second embodiment, the guide 51 may be a concave section recessed from the moving blade distal end face 31 to the rotation axis side.

(Effect)

[0073] As shown in Fig. 10, when working fluid flowing out from a stationary blade (not shown in the figure) provided on the upstream side of the last-stage moving blade 50d flows into the last-stage moving blade 50d in a direction indicated by a vector V and the last-stage moving blade 50d is rotating in a direction indicated by a vector U around a rotation axis, when viewed in a relative coordinate system rotating together with the last-stage moving blade 50d, the working fluid flowing in the direction indicated by the vector V flows in a direction indicated by a vector W according to combination of the vector V and the vector U and flows into the channel 52 between the blade section 26 of the last-stage moving blade 50d and the blade section 26' of a last-stage moving blade 50d' adjacent to the rear surface side of the blade section 26.

[0074] In this embodiment, when viewed from the radial direction outer side, the guide 51 is provided to close the channel 52 in the region on the rear surface side of the blade section 26 on the moving blade distal end face 31 of the cover 27. Therefore, when the last-stage moving blade 50d is viewed from the direction indicated by the vector W, the guide 51 is formed in a ring shape to cover the exterior of a plurality of last-stage moving blades that rotate around the rotation axis. Therefore, in this embodiment, an effect same as the effect in the first embodiment can be obtained. In addition, in this embodiment, an effect explained below is obtained.

[0075] In this embodiment, the guide 51 only has to be provided in the region on the rear surface side of the blade section 26 on the moving blade distal end face 31 of the cover 27. Therefore, it is unnecessary to provide the guide 32 on the moving blade distal end face 31 of the cover 27 from the end portion on the upstream side to the end portion on the downstream side in the rotating direction. Accordingly, it is possible to suppress an increase in manufacturing cost of the guide.

<Fifth Embodiment>

(Configuration)

[0076] Fig. 11 is a partially enlarged view showing the distal end portion 30 of a last-stage moving blade 54d according to this embodiment. In Fig. 11, portions equivalent to the portions in the first embodiment are denoted by the same reference numerals and signs and explanation of the portions is omitted.

[0077] The last-stage moving blade 54d according to this embodiment is different from the last-stage moving blade 21d according to the first embodiment in that the positions of the guide 32 and the seal fin 38 are interchanged. The other components are the same as the components of the last-stage moving blade 21d according to the first embodiment.

[0078] As shown in Fig. 11, in this embodiment, the seal fin 38 is provided on the moving blade distal end face 31 of the cover 27 instead of being provided on the moving blade opposed surface 40 of the outer diaphragm 17d. The guide 32 is provided on the moving blade opposed surface 40 instead of being provided on the moving blade distal end face 31. In this embodiment, when the last-stage moving blade 54d is assembled to the low-pressure turbine 9, when viewed on the meridional plane cross section, the guide surface 41 of the guide 32 is formed to incline downward in the direction from the seal fin 38 to the diffuser 10. The guide surface 41 is formed in a concave shape toward the rotation axis from the upstream edge portion to the downstream edge portion.

(Effect)

[0079] As in this embodiment, even when the seal fin 38 is provided on the moving blade distal end face 31 instead of being provided on the moving blade opposed surface 40 and the guide 32 is provided on the moving blade opposed surface 40 instead of being provided on the moving blade distal end face 31, it is possible to cause the supersonic leak flow 43 flowing on the downstream side of the seal fin 38 in the gap 42 to collide with the guide surface 41 to cause the oblique shock wave W and decelerate the leak flow 43. Therefore, as in the first embodiment, it is possible to prevent the wall surface boundary layer flow with low flow velocity flowing near the outer circumferential wall 10A of the diffuser 10 from separating from the outer circumferential wall 10A of the diffuser 10 and suppress an increase in a pressure loss.

<Others>

[0080] The present invention is not limited to the embodiments explained above and includes various modifications. For example, the embodiments are explained in detail in order to clearly explain the present invention. The embodiments are not always limited to embodiments including all the components explained above. For example, a part of the components of a certain embodiment can be replaced with the components of another embodiment. The components of another embodiment can be added to the components of a certain embodiment.

[0081] In the illustrations in the embodiments explained above, the guide surface is formed in the convex shape or the concave shape toward the rotation axis from the upstream edge portion to the downstream edge portion. However, the essential effect of the present invention is to provide a moving blade that can suppress an increase in a pressure loss due to separation of a leak flow from a diffuser wall surface. The present invention is not always limited to the configuration explained above as long as the essential effect is obtained. For example, the guide surface may be linearly formed from the upstream edge portion to the downstream edge portion.

[0082] In the embodiments explained above, the configuration is illustrated in which the outer diaphragm 17d is opposed to the cover 27. However, the present invention is not always limited to the configuration as long as the essential effect of the present invention is obtained. A configuration may be adopted in which the member opposed to the cover 27 is the stationary body 14 and, for example, the casing 16 is opposed to the cover 27.

[0083] In the embodiments explained above, the moving blade according to the present invention is applied to the last stage of the low-pressure turbine 9. However, an application target of the moving blade according to the present invention is not limited to the last stage of the low-pressure turbine. For example, the present invention can also be applied to the last stages of the high-pressure turbine 3 and the intermediate-pressure turbine 6.

Claims

1. A moving blade disposed in a last stage closest to a diffuser (10) among a plurality of stages of a turbine (9) including a turbine rotor (12) and a stationary body (14) that covers the turbine rotor (12), the diffuser (10) being connected to an outlet side of working fluid (22) of the stationary body (14), a distal end of the moving blade being opposed to a seal fin (38) provided in the stationary body (14),
the moving blade comprising:

a blade section (26);
a cover (27) provided at a distal end portion of the blade section (26); and
a guide (32) provided on a moving blade distal end face (31), which is a surface of the cover (27) opposed to the stationary body (14), **characterized in that**
when the moving blade is assembled to the turbine (9), when viewed on a cross section cut along a plane including a rotation axis of the turbine rotor (12), the moving blade distal end face (31) extends in a rotation axis direction of the turbine rotor (12), and the guide (32) includes a guide surface (41) located on a side close to the diffuser (10) with respect to the seal fin (38) and formed to incline upward in a direction from the seal fin (38) toward the diffuser (10).

2. The moving blade according to claim 1, wherein the guide (32) is a projecting section projecting from the moving blade distal end face (31) to the stationary body (14) side or a concave section recessed from the moving blade distal end face (31) to the rotation axis side.

3. The moving blade according to claim 1 or 2, wherein a moving blade distal end circumferential speed Mach number obtained by dividing rotation circumferential speed of the distal end portion of the blade section (26) by sonic speed of the working fluid (22) flowing at the distal end portion of the blade section (26) exceeds 1.0.

4. The moving blade according to one of the preceding claims, wherein the guide surface (41) is a curved surface having a convex shape toward the rotation axis.

5. The moving blade according to claim 2, wherein the guide (32) extends in a rotating direction of the turbine rotor (12) and is provided such that both ends thereof are opposed to end portions of guides of moving blades adjacent to each other on both sides in the rotating direction.

6. The moving blade according to claim 2, wherein the guide (32) is provided along a rear edge portion of the moving blade distal end face (31).

7. The moving blade according to claim 2, wherein, when viewed from the stationary body (14) side, the guide (32) is provided in a region on a rear surface side of the blade section (26) on the moving blade distal end face (31) and provided to close a channel (52) between the blade section (26) and a blade section of a moving blade adjacent to the rear surface side.

8. A turbine (9) comprising:

a turbine rotor (12) including the moving blade according to one of claims 1 to 7; and
a stationary body (14) including a stationary blade disposed to be opposed to the moving blade in the rotation axis direction.

9. The turbine (9) according to claim 8, wherein
the seal fin (38) is provided on the moving blade distal end face (31) instead of being provided on the stationary body (14),
the guide (32) is provided on a moving blade opposed surface (40), which is a surface of the stationary body (14) opposed to the moving blade distal end face (31), instead of being provided on the moving blade distal end face (31), and
when the moving blade is assembled to the turbine (9), when viewed on a cross section cut along a plane including a rotation axis of the turbine rotor (12), the moving blade opposed surface (40) extends in a rotation axis direction of the turbine rotor (12), and the guide (32) includes a guide surface (41) formed to incline downward in a direction from the seal fin (38) toward the diffuser (10).

FIG. 1

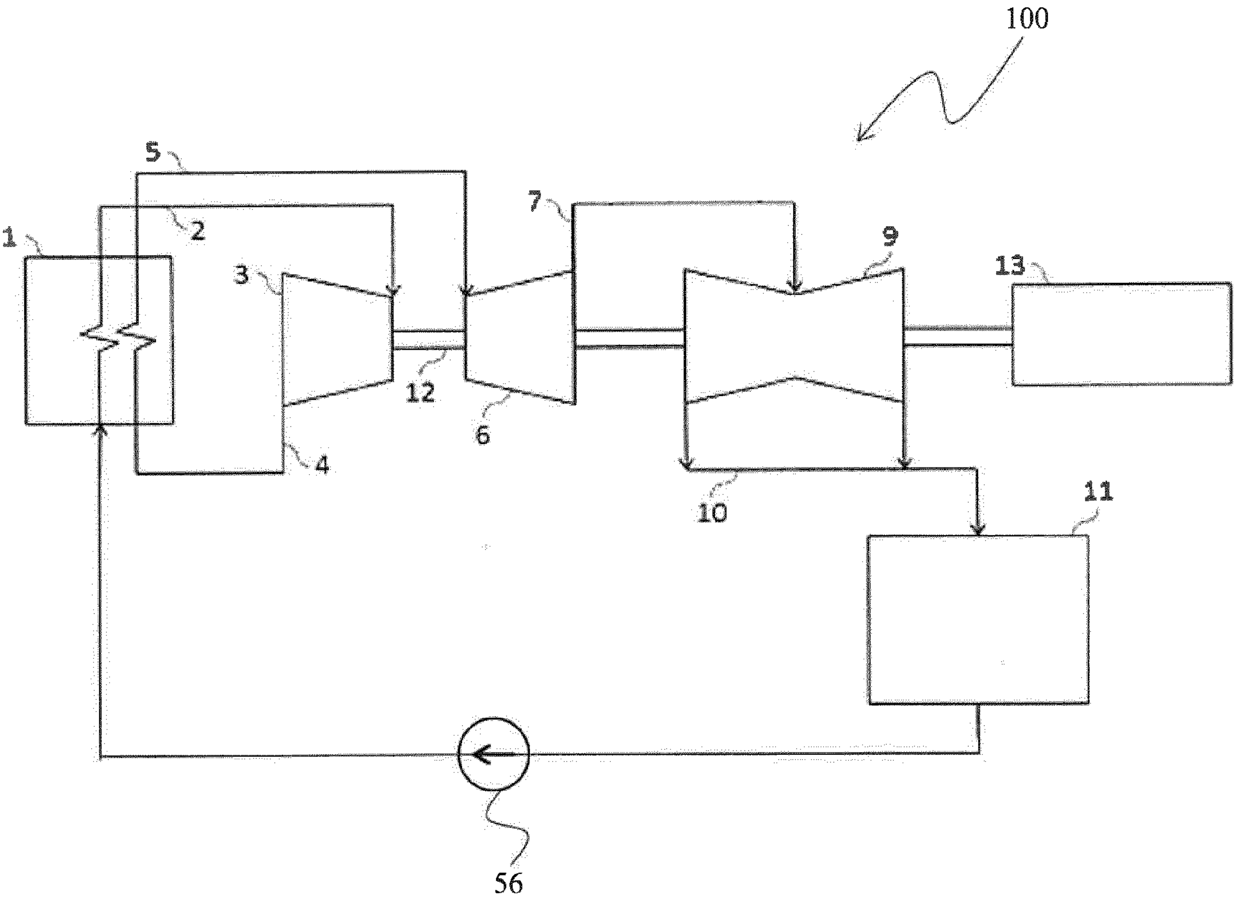
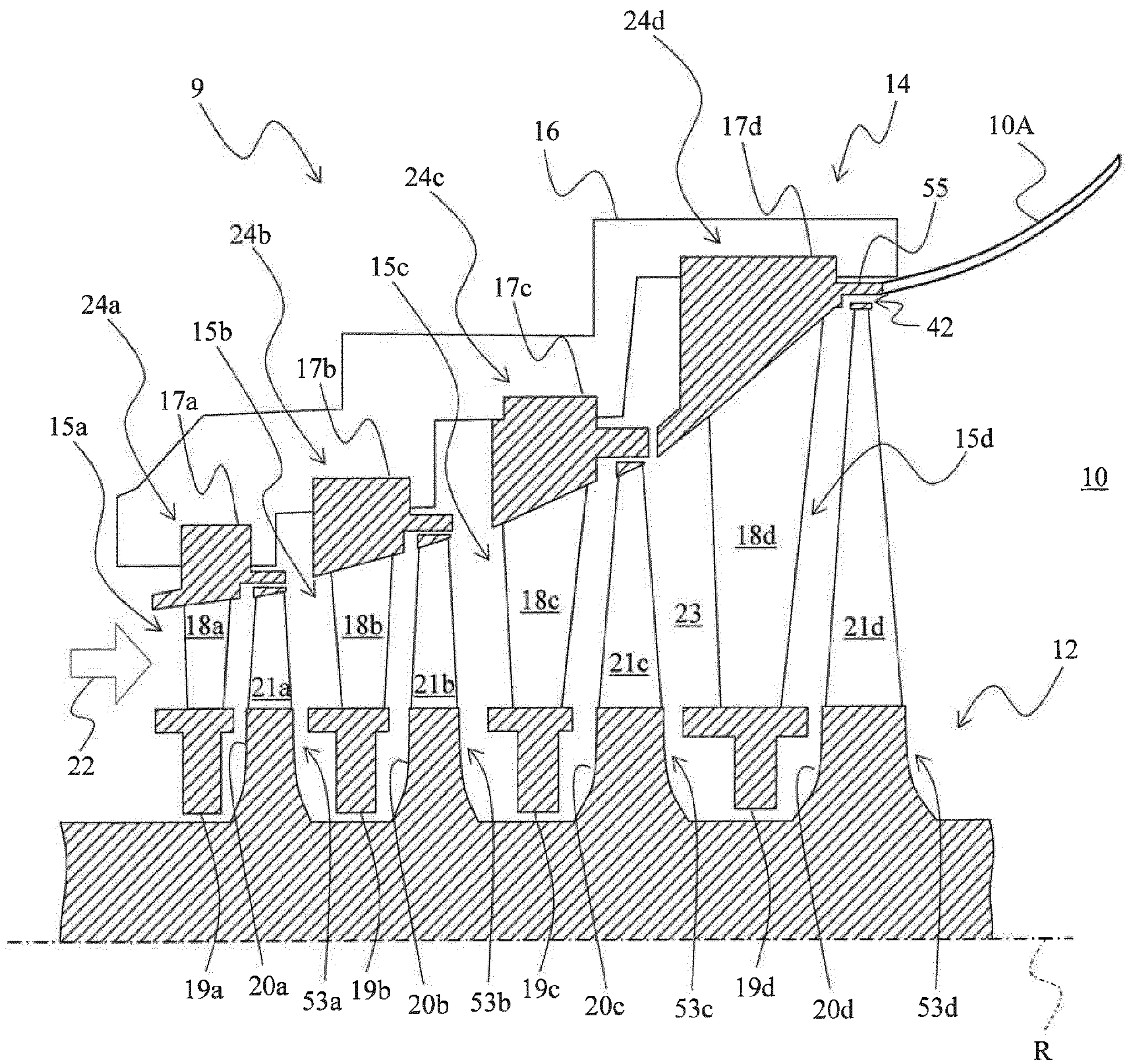


FIG. 2



24d
9
14
16
17d
10A
24c
55
24b
15c
17c
24a
15b
42
17b
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15a
15d
10
18d
18c
23
18a
18b
21d
21c
21a
21b
12
22
19a
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53a
19b
20b
53b
19c
20c
53c
19d
20d
53d
R

FIG. 3

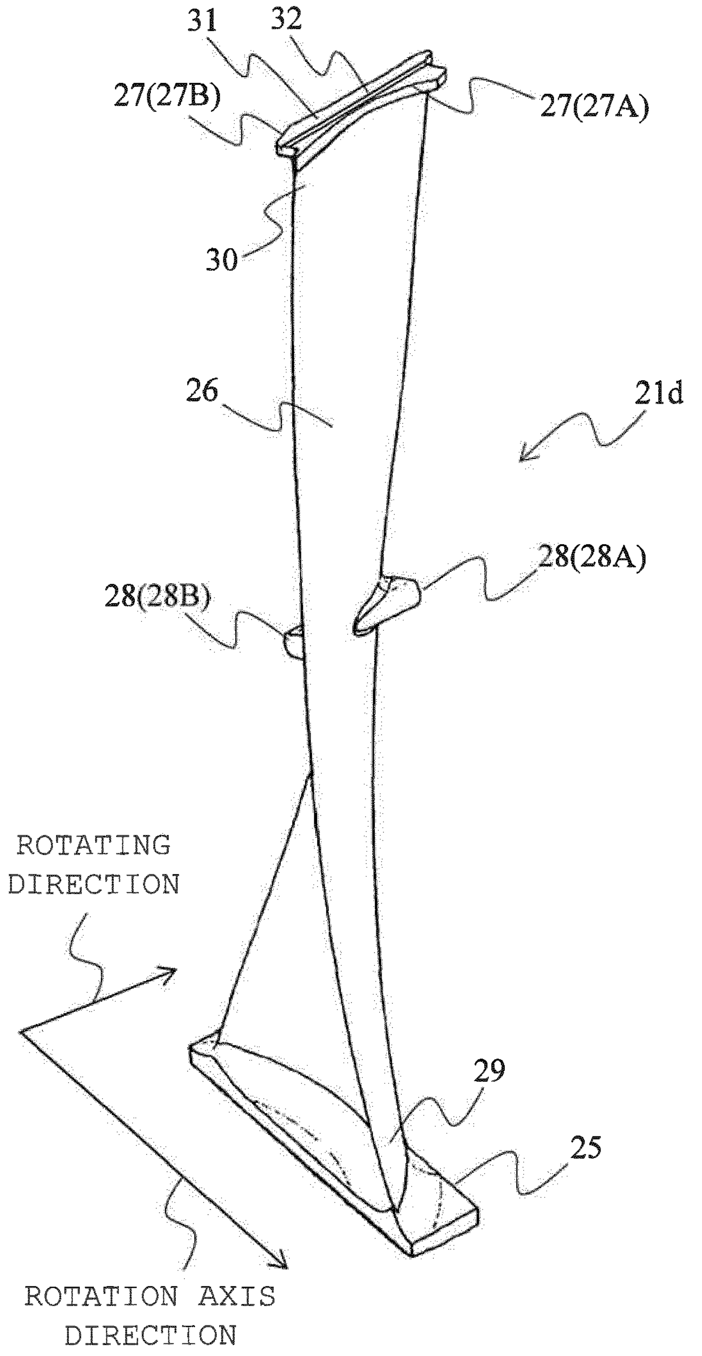

31
32
27(27B)
27(27A)
30
26
21d
28(28A)
28(28B)
ROTATING
DIRECTION
29
25
ROTATION AXIS
DIRECTION

FIG. 4

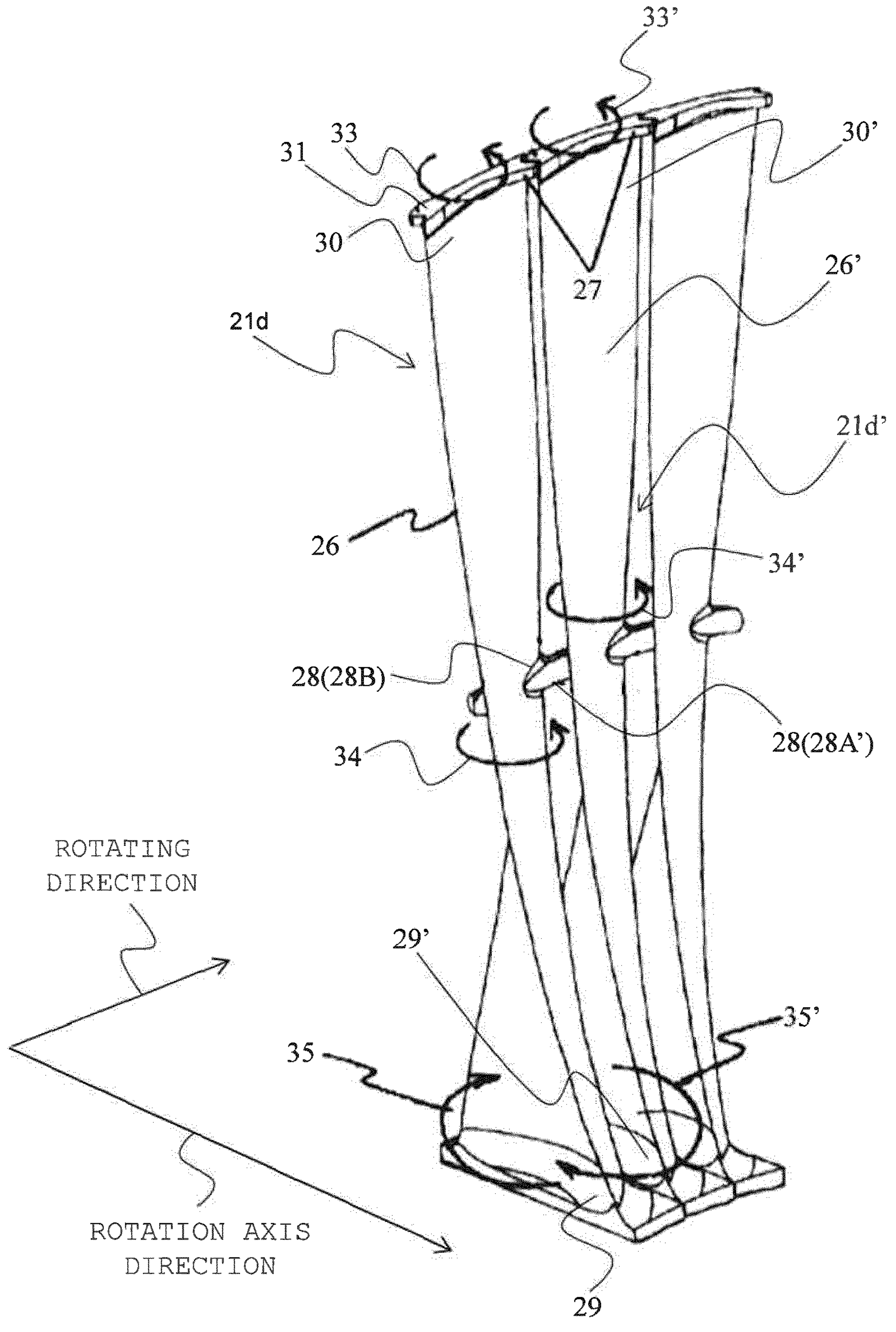
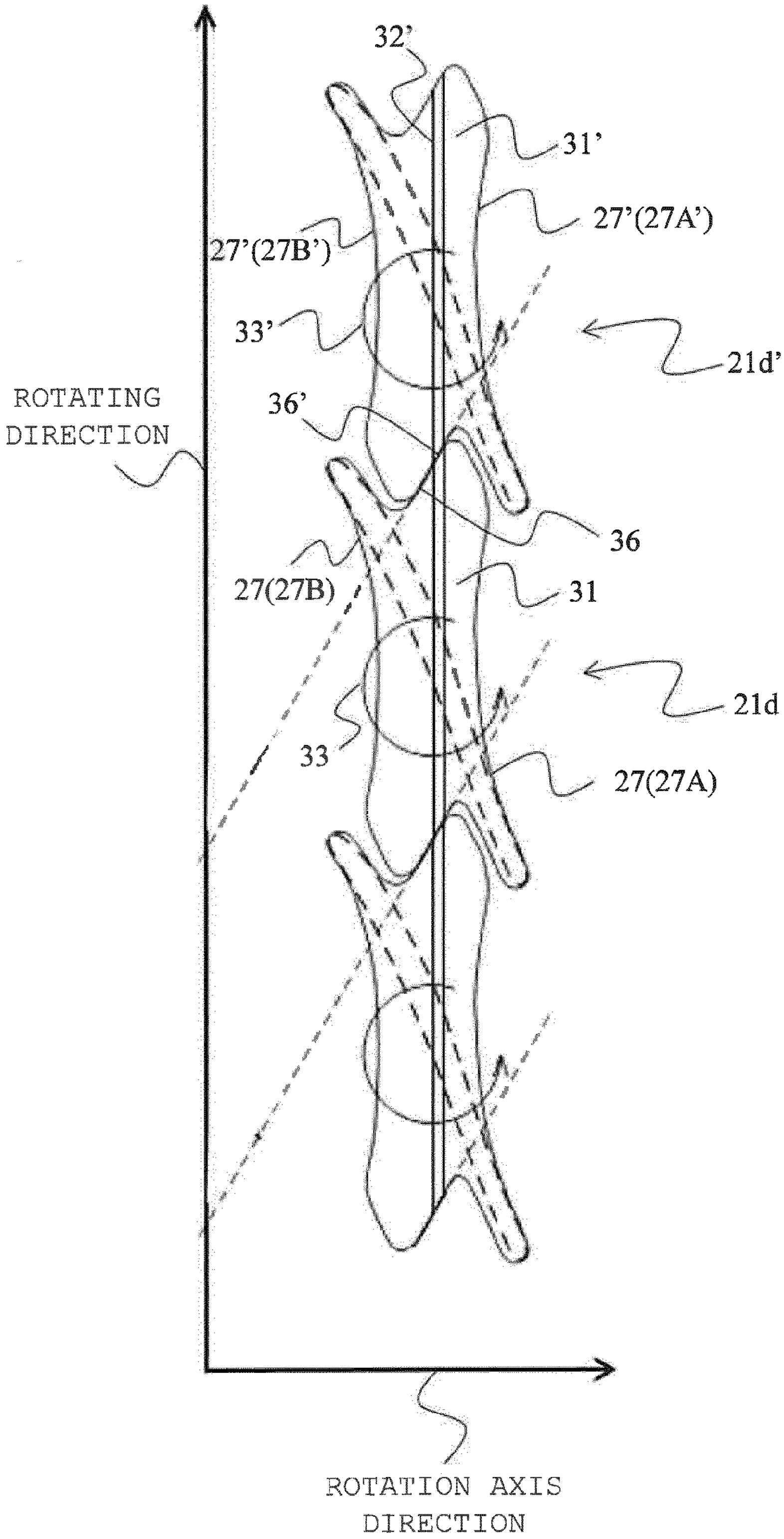

33'
33
31
30'
30
27
26'
21d
21d'
26
34'
28(28B)
28(28A')
34
ROTATING
DIRECTION
29'
35'
35
ROTATION AXIS
DIRECTION
29

FIG. 5


32'
31'
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27'(27B')
33'
21d'
ROTATING
DIRECTION
36'
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31
21d
33
27(27A)
ROTATION AXIS
DIRECTION

FIG. 6

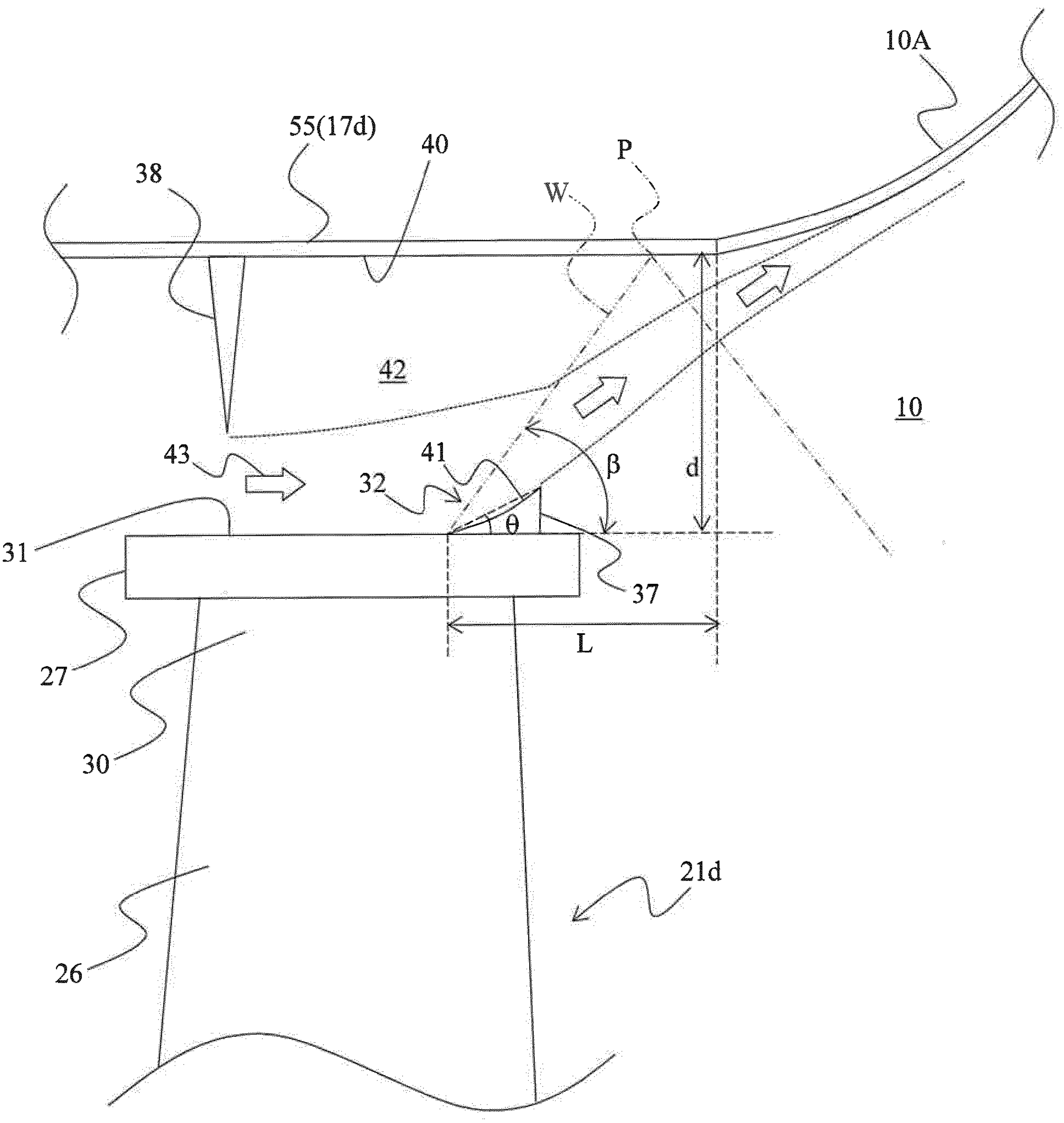


FIG. 7

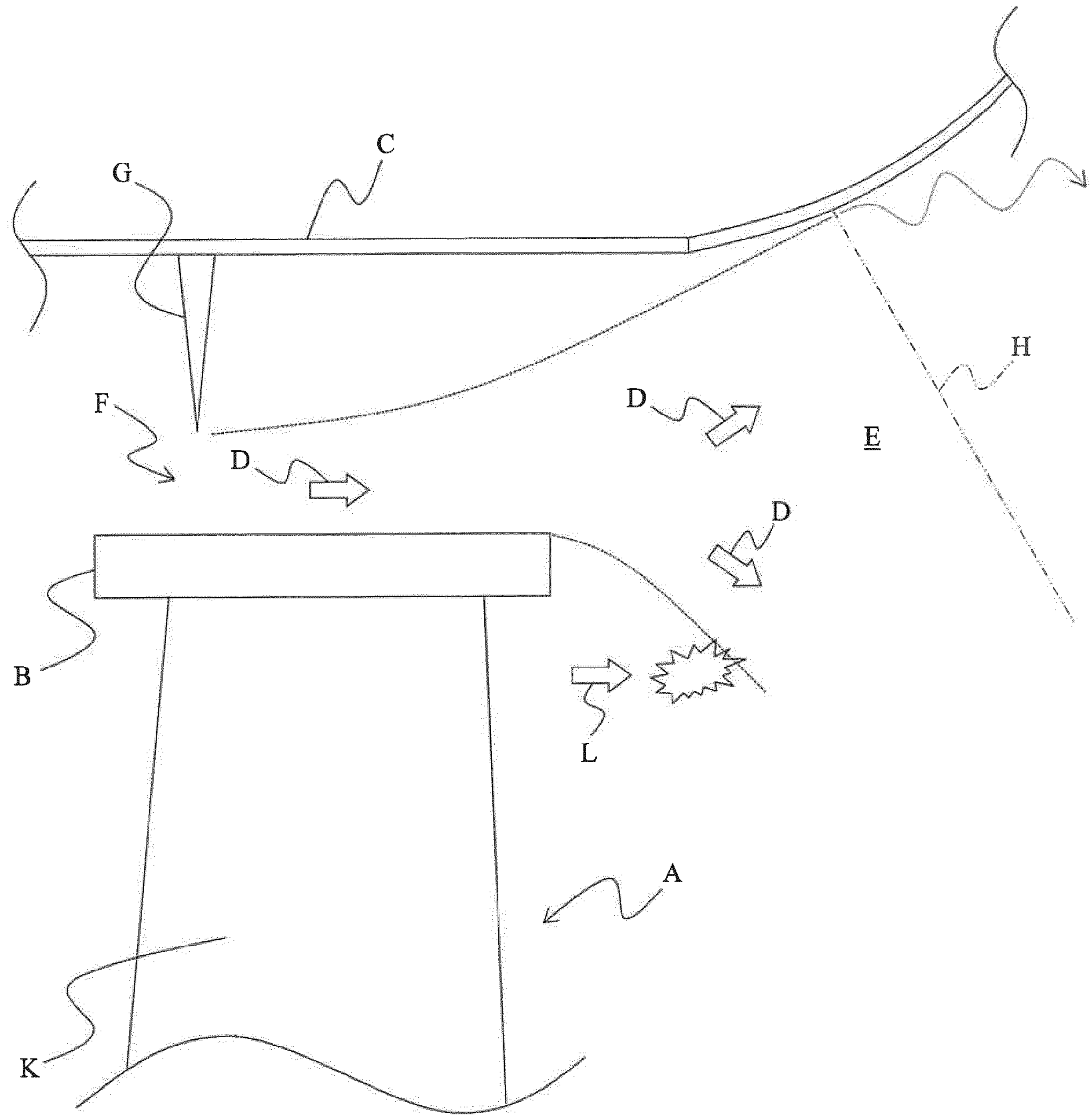


FIG. 8

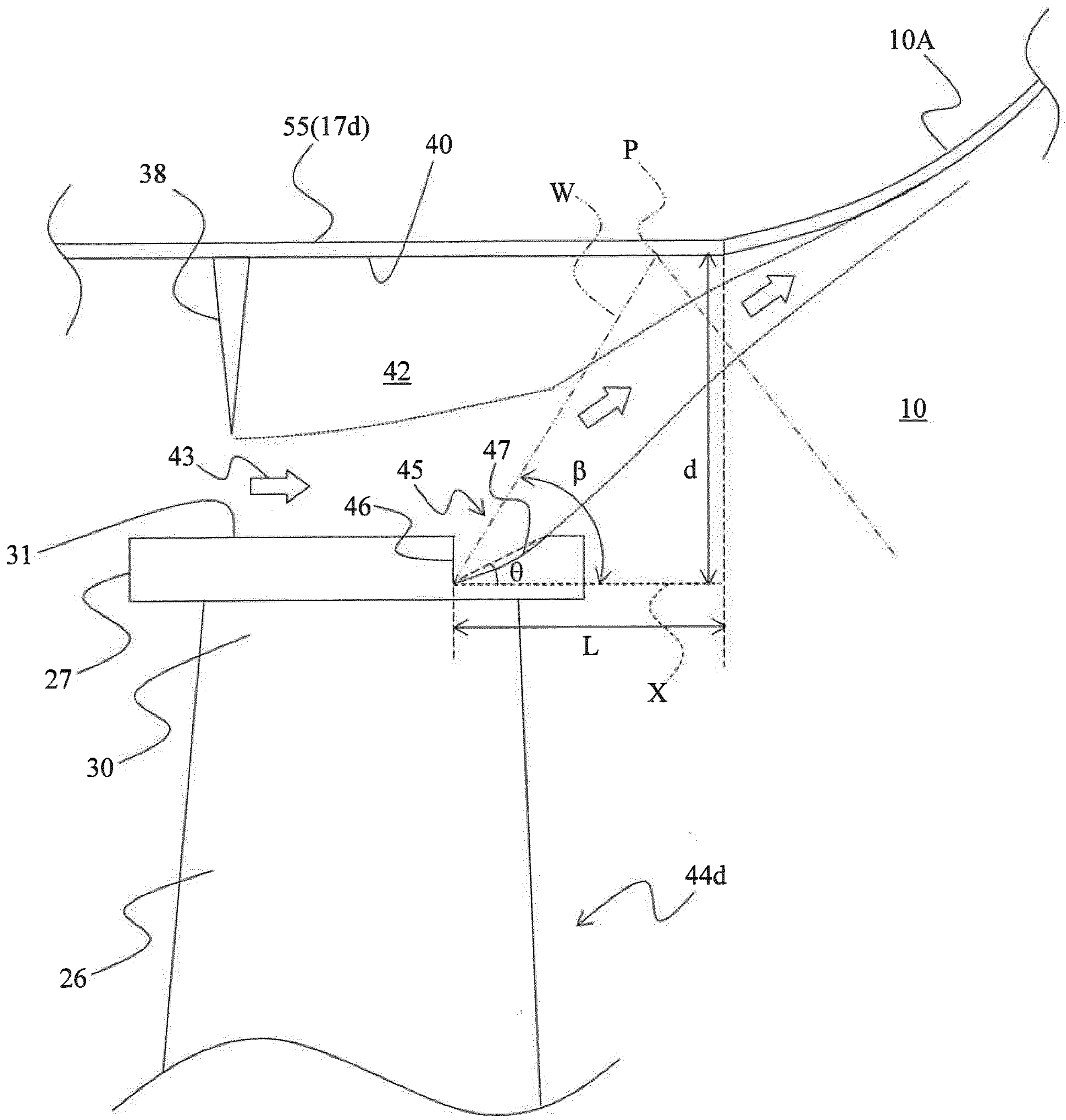
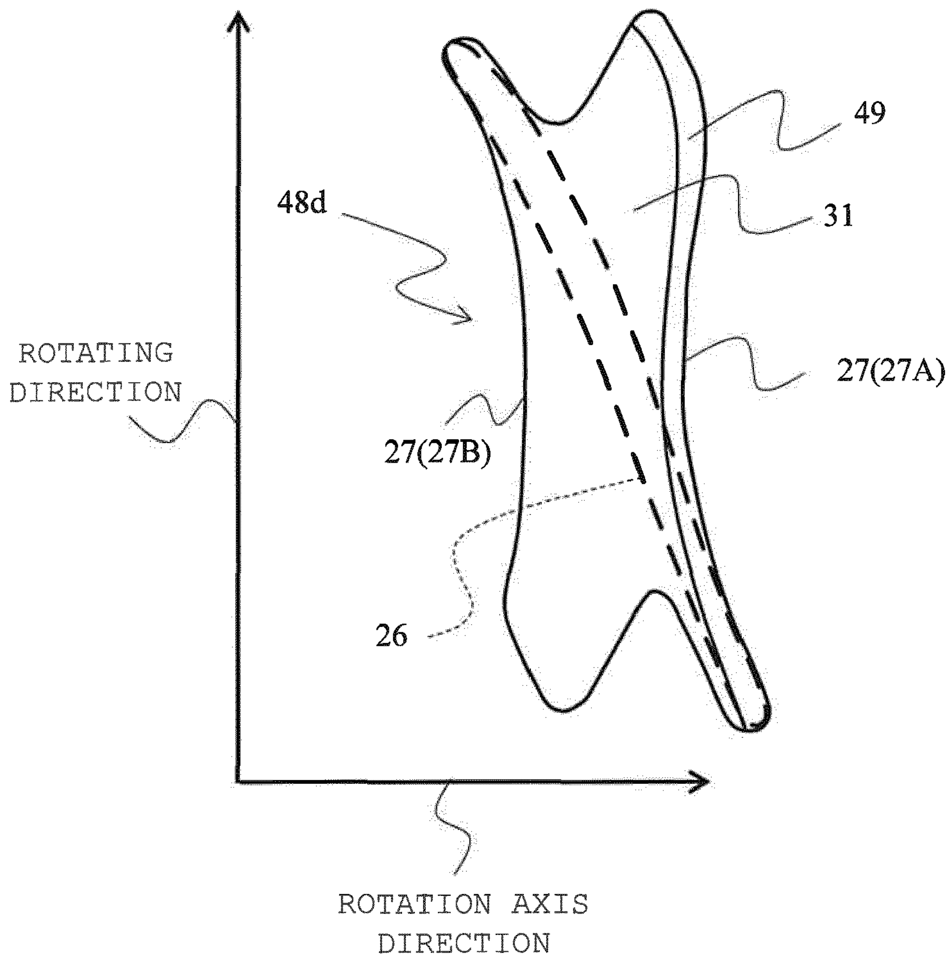


FIG. 9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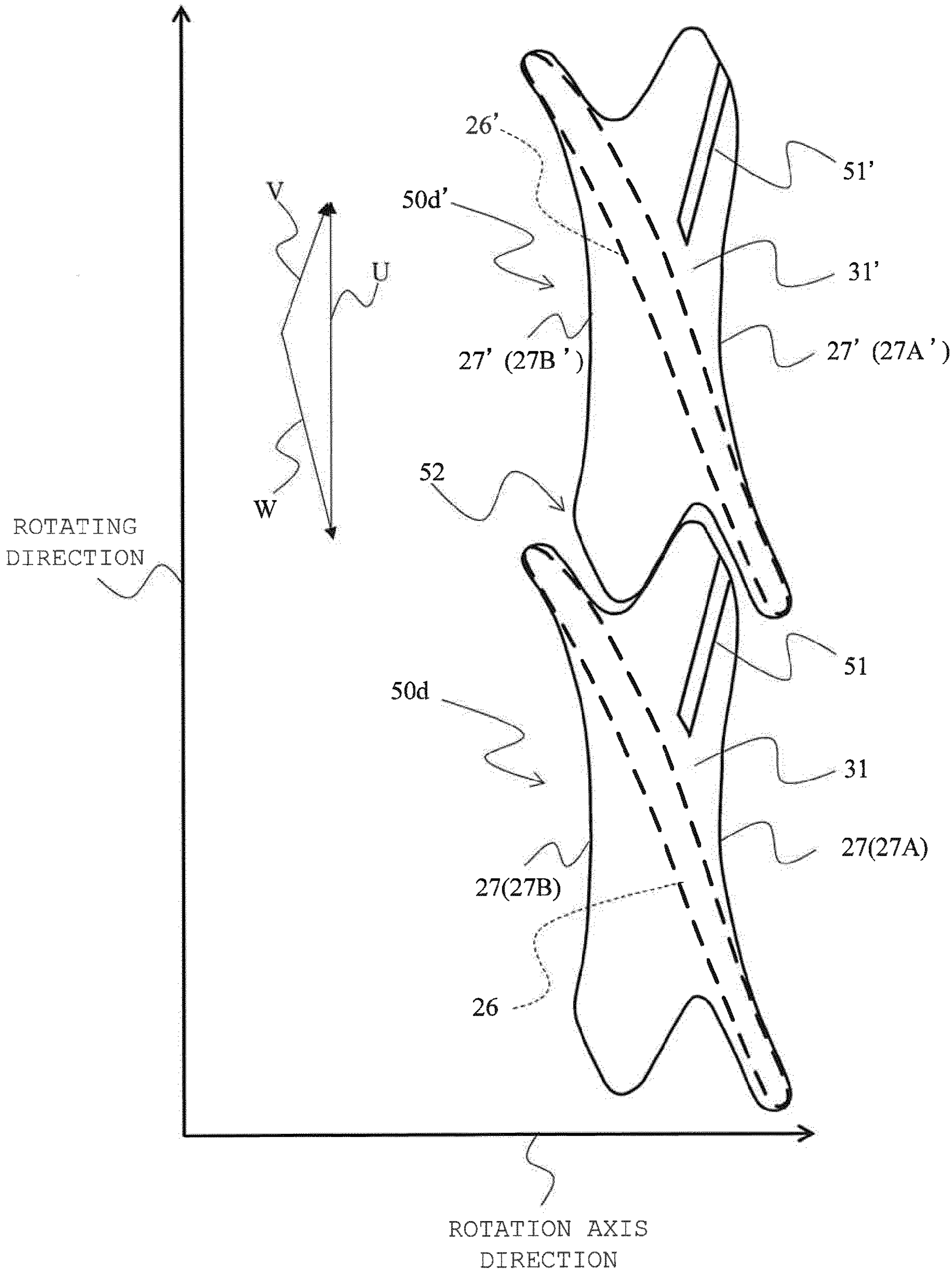
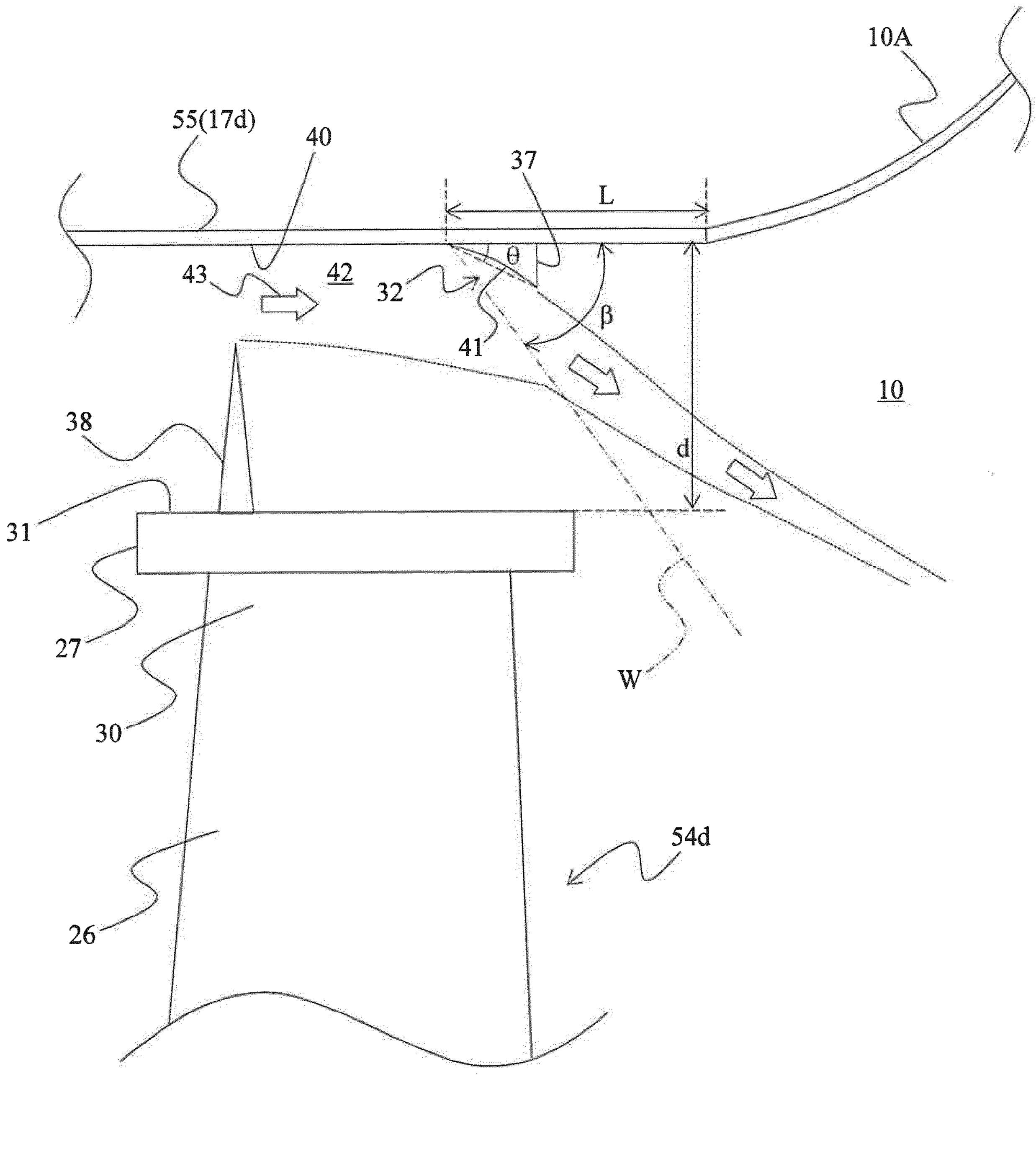
48d
31
ROTATING
DIRECTION
27(27A)
27(27B)
26
ROTATION AXIS
DIRECTION

FIG. 10



26'
V
50d'
51'
U
31'
27' (27B ')
27' (27A ')
52
W
ROTATING DIRECTION
51
50d
31
27(27A)
27(27B)
26
ROTATION AXIS DIRECTION

FIG. 11



REFERENCES CITED IN THE DESCRIPTION

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