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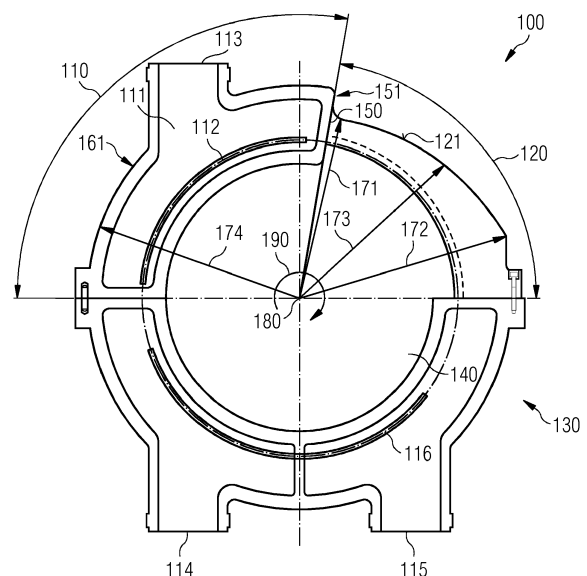
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(54) **NOZZLE CASING COMPONENT FOR A STEAM TURBINE**

(57) The present invention relates to a nozzle casing component (100) for a steam turbine (600), comprising a first section (110) extending along a circumferential direction (190) of the steam turbine (600), and a second section (120) extending along the circumferential direction (190) of the steam turbine (600). The first section (110) comprises a flow channel (111) and an outlet (112) configured such that a first inlet steam flow (653) flowing through the flow channel (111) is injectable through the outlet (112) into a flow path (140) of the steam turbine (600) upstream of a control wheel (791). The second section (120) comprises a flow deflecting surface (121) and a radius defined between the flow deflecting surface (121) and a rotation axis (180) of the steam turbine (600). The nozzle casing component (100) is arrangeable in a turbine casing (611) comprising a radially inner surface (623) and a further flow channel (629) is formable in-between the flow deflecting surface (121) and the radially inner surface (623). Furthermore, a second inlet steam flow (656) of the steam turbine (600) is guidable along the flow deflecting surface (121) such that the second inlet steam flow (656) enters the flow path (140) of the steam turbine (600) downstream of the control wheel (791). A length of the radius varies along the second section (120) in the circumferential direction (180) such that a volume of the further flow channel (629) varies depending on the variation of the length of the radius.

FIG 1



DescriptionField of invention

[0001] The present invention relates to the field of steam turbines. Particularly, the present invention relates to a nozzle casing component for a steam turbine, a steam turbine and a method for forming a nozzle casing component for a steam turbine.

Art Background

[0002] In today's steam turbines, the steam turbine comprises generally four inlets for steam input. This arrangement with four inlets is also possible to use for turbine by-pass solution. All four inlets (steam inputs) are connected to the turbine casing by welding. The steam flows into the nozzle casing through three of the four inlets. These three inlets are connected through the turbine casing directly to the nozzle casing on three different circumferential positions of the nozzle casing. Additionally, the flow rate at each of the three inlets may be controlled independently from the other two flow rates. Therefore, an inlet flow rate of the turbine may be individually controlled. Generally, steam flows into the flow path of the steam turbine at a position upstream of a control wheel. Therefore, the three inlets are connected at upstream positions of the control wheel. A fourth inlet is connected to the nozzle casing but at a different position in the axial direction of the steam turbine. Hence, the fourth inlet is connected to the flow path at a position downstream of the control wheel and at the same time upstream of the first guide blade carrier. Therefore, the fourth inlet provides a by-pass to the control wheel. At the fourth inlet, steam flows in a hollow space formed between an inner surface of the turbine casing and an outer side of the nozzle casing. In current steam turbines, this area is not adjusted and only a small cavity is provided between the nozzle casing and the turbine casing.

[0003] Fig. 9 shows a current design of a steam turbine 900 comprising a nozzle casing 921, 922 inside a turbine casing 911, 912 according to the prior art.

[0004] In Fig. 9 the nozzle casing 921, 922 is formed of an upper nozzle casing 921 and a lower nozzle casing 922. The upper nozzle casing 921 is surrounded by an upper turbine casing 911 and the lower nozzle casing 922 is surrounded by a lower turbine casing 912. A first turbine inlet 913 is connected to the upper turbine casing 911 at an upper right side of the steam turbine 900 in Fig. 9. Additionally, a second turbine inlet 914 and a third turbine inlet 915 are connected to the lower turbine casing 912 at a lower right side (second turbine inlet 914) and at a lower left side (third turbine inlet 915) of the steam turbine 900 in Fig. 9.

[0005] In conventional solutions, the control wheel is adjustable in such a way that the amount of steam of the first inlet steam flow 933, the second inlet steam flow 934 and the third inlet steam flow 935 are individually controlled depending on the load case.

[0006] On the upper left side of the turbine casing 911 in Fig. 9 is connected a bypass 936 for the control wheel. The bypass 936 is not adjustable. Additionally, the bypass 936 flows through a fourth inlet 916 into a hollow space 929. The hollow space 929 is formed in-between the upper nozzle casing 921 and the upper turbine casing 911.

[0007] In current steam turbines, the steam flow in the bypass may not be optimized and flow losses may occur.

Summary of the Invention

[0008] It may be an object of the present invention to provide a cost-efficient nozzle casing for a steam turbine which is easy to manufacture and easy to maintain. Additionally, the inventive nozzle casing has a higher stiffness and strength as well as an improved steam flow in the bypass.

[0009] This object is solved by a nozzle casing component for a steam turbine, a steam turbine comprising a nozzle casing component and a method for forming a nozzle casing component for a steam turbine.

[0010] According to a first aspect of the present invention, a nozzle casing component for a steam turbine is disclosed. The nozzle casing component comprises a first section extending along a circumferential direction of the steam turbine, and a second section extending along the circumferential direction of the steam turbine. The first section comprises a flow channel and an outlet configured such that a first inlet steam flow flowing through the flow channel is injectable through the outlet into a flow path of the steam turbine upstream of a control wheel. The second section comprises a flow deflecting surface and a radius defined between the flow deflecting surface and a rotation axis of the steam turbine. The nozzle casing component is arrangeable in a turbine casing comprising a radially inner surface. A further flow channel is formable in-between the flow deflecting surface and the radially inner surface, and a second inlet steam flow of the steam turbine is guidable along the flow deflecting surface such that the second inlet steam flow enters the flow path of the steam turbine downstream of the control wheel. Furthermore, a length of the radius varies along the second section in the circumferential direction such that a volume of the further flow channel varies depending on the variation of the length of the radius.

[0011] In other words, the second section comprises a flow deflecting surface, wherein the flow deflecting surface is spaced to a rotation axis by a radius, and wherein a length of the radius in circumferential direction along the flow deflecting surface varies such that a flow cross-section of the further flow channel varies along the circumferential direction.

[0012] The circumferential direction of the steam turbine describes the direction which is circumferential to an axial direction of the turbine. The axial direction is the direction extending parallel to a rotation axis of a turbine shaft.

[0013] The first section and the second section, respectively, may be a segment of the nozzle casing, wherein the first section and the second section may form one integral part and are directly interconnected with one another.

[0014] The flow channel may be a cavity, i.e. a hollow space, inside of the nozzle casing component. The flow channel may have an inlet and an outlet, which are arranged relatively to each other such that a fluid, particularly steam, flowing through the flow channel, is injected in the flow channel through the inlet and flows out of the flow channel through the outlet. The outlet is thereby connected to an inlet of the flow path of the steam turbine. In an exemplary embodiment, the outlet of the flow channel may form the inlet of the flow path.

[0015] Each of the inner surfaces of the flow channel, i.e. the whole inner surface of the flow channel, may have a geometry being formed in such a way that vortices are omitted or at least positively influenced. Therefore, the vortices do no longer disturb the mainstream. Additionally, a separation of a boundary layer formed on the inner surfaces of the flow channel is prevented by the chosen geometry.

[0016] The flow deflecting surface may be a radially outer surface of the nozzle casing component. The radially outer surface of the nozzle casing may have a normal which extends radially away from the rotation axis of the steam turbine. The flow deflecting surface may have a geometry which allows a fluid, particularly the steam, to develop a fitted flow which does not comprise any severe vortices. Hence, a flow separation of the boundary layer may be omitted by the geometry of the radially outer surface.

[0017] The radius may be a distance in the radial direction of the steam turbine. The radius is defined between the flow deflecting surface and the rotation axis of the steam turbine. Hence, the radius defines the radial distance between the flow deflecting surface and the rotation axis. The radius may be individually defined on each point of the flow deflecting surface seen in the circumferential direction. Each of the points of the flow deflecting surface may have an individual radius deferring from each of the other radii. The radius is perpendicular to the rotation axis.

[0018] The length of the radius varies along the second section, i.e. along the circumferential direction, describes that the flow deflecting surface comprises at each circumferential position of the flow deflecting surface a radius differing from the radius at a different circumferential position.

[0019] The radially inner surface may have a normal which extends radially towards the rotation axis of the steam turbine. The radially inner surface may have an inlet. The inlet is positioned near an interface between the first section and the second section. The normal may be parallel to the radius.

[0020] The further flow channel is formed as a cavity, i.e. a hollow space, between the radially inner surface and the flow deflecting surface. As the radius of the flow deflecting surface varies, a radial distance between the radially inner surface and the flow deflecting surface varies as well. Therefore, the further flow channel may have a different radial extension, i.e. a different flow cross-section, over its circumferential extension. Additionally, the further flow channel may have an inlet and an outlet. The inlet is formed on the radially inner surface. The outlet is formed as an inlet of the flow path of the steam turbine at an axial position downstream of the control wheel.

[0021] The radially inner surface and the flow deflecting surface may have a geometry being formed in such a way that vortices are omitted or at least influenced. Therefore, the vortices do no longer disturb the mainstream. In other words, the mainstream disturbing vortices can be reduced. Additionally, a separation of a boundary layer from the radially inner surface and the flow deflecting surface, respectively, is prevented by the chosen geometry.

[0022] The flow path may be the main path in a steam turbine in which the turbine fluid flows along the rotation axis of the steam turbine. Further, in the flow path, the rotor blades and stator blades are arranged. Hence, energy from the fluid is converted in rotational energy of the rotor blades and thus in rotational energy of the turbine shaft.

[0023] The outlet may be a connection between the flow channel and the flow path of the steam turbine. The geometry of the outlet is shaped such that a smooth steam flow may be developed on both sides of the outlet. Thereby, the boundary layer of the steam flow does not block the flow cross-section of the outlet. Additionally, the outlet may have a geometry which allows an injection of the steam over a wide circumferential range of the first section, preferably over the entire circumferential extension of the first section.

[0024] The control wheel may control the amount of steam entering the first stage of the steam turbine. Hence, the amount of steam may be adapted depending on the operating condition of the turbine. In the case of part load, the control wheel may only be partially opened such that a respective lower amount of steam may enter the first stage of the turbine. In the case of full load, the control wheel may be entirely opened such that the highest possible amount of steam may enter the first stage of the turbine.

[0025] Being guidable along the flow deflecting surface describes that the second inlet steam flow flows around the flow deflecting surface in such a way that the steam flow hits the flow deflecting surface. Additionally, a boundary layer

on the flow deflecting surface may be laminar and thin. Therefore, a separation of the boundary layer is omitted.

[0026] Hence, in contrast to conventional approaches, by the present invention, the second section of the nozzle casing component extending along the circumferential direction of the steam turbine, in particular the flow deflecting surface, has a radius, which varies in the circumferential direction. Thus, a bypass flow flowing along the flow deflecting surface, is more laminar and well developed. Hence, the bypass to a first guide blade carrier of the steam turbine may be laminar, completely developed and improved. Therefore, less flow disturbances occur at the first guide blade carrier, resulting in an improved efficiency of the steam turbine. At the same time, the circumferentially varying radius allows to maintain the stability and strength of the nozzle casing component even at connecting portions of the nozzle casing component.

[0027] In contrast, in conventional approaches, there may be only a smaller distance between the turbine casing and the conventional nozzle casing. This may result in an incorrect steam flow in this area.

[0028] Additionally, the nozzle casing component has a design which is easy to manufacture and may be used for retrofitting of existing steam turbines and in newly built steam turbines. Furthermore the inventive design of the nozzle casing component may have a higher stiffness and strength because of the varying radius of the second section.

[0029] According to a further exemplary embodiment, the nozzle casing component further comprises an interface between the first section and the second section. The radius at the interface is a first radius and the radius at a position circumferentially distanced from the interface is a second radius. Furthermore, the first radius is smaller than the second radius

[0030] The interface may be an intersection between the first section and the second section, being a solid wall. By forming the interface as a solid wall, the first inlet steam flow inside the flow channel may be separated from the second inlet steam flow along the flow deflecting surface. Hence, the second inlet steam flow may entirely bypass the control wheel. Hence, it is prevented that any of the second inlet steam flow enters the flow channel and thus is injected upstream of the control wheel. On the other hand, the first inlet steam flow in the flow channel only flows in the flow channel and may at no time flow in the further flow channel. Hence, a strict separation of the first inlet flow and the second inlet flow is provided.

[0031] The first radius and the second radius, respectively, describes a distance between a radial position on the flow deflecting surface and the rotation axis at a certain circumferential position. The first radius is defined as being positioned at the circumferential position of the interface. The second radius is defined as being positioned at any circumferential position spaced apart from the interface in the circumferential direction. In other words, the first radius and the second radius, respectively, describes a distance between a position on the flow deflecting surface and the rotational axis at a certain circumferential position. The first radius can be taken from a position at the circumferential position of the interface. The second radius can be taken from a position at any circumferential position spaced apart from the interface in the circumferential direction.

[0032] At the interface the first radius may be smaller than the second radius. Additionally, the first radius may be smaller than a radius between a radially outer surface of the first section and the rotation axis of the steam turbine. Hence, at the interface, there may be an edge extending in the radial direction.

[0033] According to a further exemplary embodiment of the present invention, the radius varies linearly between the first radius and the second radius. In other words, a surface between the first radius and the second radius is curved.

[0034] Varying linearly describes that between the first radius and the second radius a plurality of radii exist. The plurality of radii become larger step by step from the first radius to the second radius. A function describing the changes between different steps of adjacent radii, is a linear function.

[0035] By the above-described function, i.e. shape, the thickness of the second section may continuously, i.e. homogeneously, increase, particularly along the circumferential direction. Hence, the nozzle casing component is easy to manufacture because strains in the material may be omitted. At the same time, the steam flow at the flow deflecting surface may be laminar because no steps are formed on the flow deflecting surface, at which the flow would separate.

[0036] According to a further exemplary embodiment, the nozzle casing component is formed as a semi-circular component. The second section further comprise a connecting surface which is connectable to a further semi-circular component, wherein the radius at the connecting surface is a second radius. In one exemplary embodiment, the second radius is equal to a radius between the rotation axis and a radially outer surface of the first section.

[0037] The connecting surface may be a planar surface which fits to a respective connecting surface of a further semi-circular component. By forming the connecting surface as a planar surface, a connection to the connecting surface of the further semi-circular component may be easy to seal.

[0038] According to a further exemplary embodiment of the invention, the first section further comprises a first section depth and the second section further comprises a second section depth. The first section depth and the second section depth extend parallel to the rotation axis of the steam turbine. Additionally, the first section depth is larger than the second section depth.

[0039] Hence, the dimension and extension of the further flow channel between the turbine casing and the nozzle casing component may also vary in the axial direction of the steam turbine.

[0040] The difference between the first section depth and the second section depth may form a step. The step is formed in the axial direction in the second section. The second inlet steam flow may flow in the radial direction along the flow deflecting surface in the step and may enter the flow path of the steam turbine.

[0041] Hence, the volume of the further flow channel is yet further increased. Due to this, the bypass flow being injected in the flow path is a laminar bypass and does not separate.

[0042] According to a further exemplary embodiment of the present invention, the second inlet steam flow of the steam turbine is guidable along the flow deflecting surface such that the second inlet steam flow enters the flow path of the steam turbine upstream of the first guide blade carrier.

[0043] The first guide blade carrier may be the first blade stage of the steam turbine. In the first blade stage the steam flow in the flow path of the steam turbine is influenced depending on the load case. Therefore, in the first guide blade carrier, the steam flow is adapted to the fluid condition needed in the first rotor stage.

[0044] According to the further exemplary embodiment of the present invention, the bypass enters the flow path of the steam turbine between the control wheel and the first guide blade carrier bypassing the control wheel. Advantageously, even in very low load cases, where the control wheel is nearly completely closed and only a very low steam flow passes through the control wheel, the bypass is still provided to the first guide blade carrier. This results in a stable operation of the steam turbine even in low load cases and provides a short respond time when the steam turbine is switched from low load to high load.

[0045] According to a further exemplary embodiment, the first section and the second section are formed as one integral part.

[0046] The one integral part may be formed from one and the same material. Hence, the thermal expansion is uniform over the entire nozzle casing component. Additionally, a mounting of the nozzle casing component is easier because only one integral nozzle casing component must be directly integrated into the steam turbine.

[0047] According to a further exemplary embodiment, the outlet extends along an arc in the circumferential direction of the steam turbine, e.g. linear or curved. Further, the outlet is formed as a slit or a perforated grid.

[0048] The slit may extend along the entire circumferential length of the first section. By providing the outlet formed as a slit, the first inlet steam flow may enter the flow path of the turbine uniformly over the entire circumferential length of the first section. Hence, the same amount of first inlet steam may be provided at each circumferential position in the flow path.

[0049] In some embodiments, it may be preferred to provide the width of the slit with different dimensions. The width of the slit is defined as the dimension of the slit in the radial direction of the turbine. Therefore, on the one hand, if a higher amount of first inlet steam is needed at a specific circumferential position, the width of the slit may be designed greater. On the other hand, if a lower amount of first inlet steam flow is needed at another specific circumferential position, the width of the slit may be designed smaller.

[0050] By providing the perforated grid with different through-hole/grid ratio, the amount of the first inlet steam flow may be adapted depending on the preferred or optimal load case of the steam turbine.

[0051] Additionally, the shape of each through-hole may be individually adapted to the needed features of the first inlet steam flow. The through-holes may for example be circular, rectangular, rhombical, ellipsoid or squared. All of the through-holes may have the same shape. However, it may be understood that depending on the steam turbine it may also be advantageously, if each or a plurality of the through-holes have different shapes.

[0052] In another exemplary embodiment of the present invention, the nozzle casing component is a cast part.

[0053] Normally, the nozzle casing component is made of a metal, for example a titan alloy, because of thermal requirements that must be met in steam turbines. By casting the nozzle casing component, these thermal requirements may be met and at the same time manufacturing costs may be low.

[0054] According to a further exemplary embodiment, the nozzle casing component further comprises two connecting surfaces for connecting to the further semi-circular component, and an interface between the first section and the second section. Additionally, the second section extends from one of the two connecting surfaces to the interface, and the one of the two connecting surfaces and the interface form an angle between each other. The angle is in the range of 80° to 100°, in particular a 90° angle.

[0055] Each of the connecting surfaces may be a planar surface which fits to a respective connecting surface of the further semi-circular component. By forming the connecting surface as a planar surface, a connection to the connecting surface of the further semi-circular component may be easily sealed.

[0056] The further semi-circular component may comprise two nozzle inlets connected to the flow path of the steam turbine at a position upstream of the control wheel. In an exemplary embodiment, there are three inlets to the flow path of the steam turbine, which may be individually controlled. Therefore, the inlet steam flow to the control wheel may be varied over a wide range and a higher number of load cases may be driven by the steam turbine.

[0057] On the one hand, the nozzle casing component and the further semi-circular component may be connected together by screws or a flange. Thus, the nozzle casing and/or the further semi-circular component may be individually exchanged for example for maintenance or replacement. On the other hand, the nozzle casing component and the

further semi-circular component may be welded together, for example when no replacement of individual components is needed and when a rigid connection is preferred.

[0058] In one exemplary embodiment the nozzle casing component and the further semi-circular component may be formed, for example casted, as one integral part. This may have the advantage that the connection between the nozzle casing component and the further semi-circular component may be very strong because it is formed as one integral part.

[0059] By extending in the range of a 90° angle, the second section, particularly the flow deflecting surface, forms half of a semi-circular nozzle casing component. Hence, a cavity between the inner surface of the turbine casing and the flow deflecting surface also extends over half the semi-circular nozzle casing component. Therefore, the cavity is large enough such that the second inlet steam flow may develop a laminar steam flow on the flow deflecting surface before entering the flow path.

[0060] According to a further aspect of the present invention, a steam turbine is disclosed. The steam turbine comprises the nozzle casing as described above, the control wheel and the turbine casing comprising a radially inner surface.

[0061] The nozzle casing component is arranged in the turbine casing. A further flow channel is formed between the flow deflecting surface and the radially inner surface of the turbine casing. The further flow channel has a varying volume, i.e. flow cross-section, in its circumferential extension. The varying volume is caused by the varying radius defined between the flow deflecting surface and the radially inner surface.

[0062] According to a further exemplary embodiment, the steam turbine further comprises a further semi-circular component. The nozzle casing component is connected to the further semi-circular component such that the nozzle casing component and the further semi-circular component form a circular nozzle casing of the steam turbine.

[0063] By forming the circular nozzle casing from two independent parts, i.e. the nozzle casing component and the further semi-circular component, a maintenance of the steam turbine, particularly of the blades, is simplified. In the case of maintenance, the two halves may be easily disassembled and good access to the blades of the steam turbine may be provided. Furthermore, casting of a semi-circular component is easier than casting a circular part.

[0064] Additionally, a conventional steam turbine with a conventional nozzle casing design may be easily and faster retrofitted with the nozzle casing component according to the present invention. In particular, an upper half of the conventional nozzle casing may be replaced by the inventive nozzle casing component.

[0065] According to a further exemplary embodiment, the steam turbine further comprises a sealing. The sealing is arranged in-between the control wheel and the nozzle casing component.

[0066] The sealing between the control wheel and the nozzle casing component may be for example a sealing ring, a slight seal or a labyrinth seal. The specific type of sealing may be chosen dependent on the specific operating parameters or environmental conditions present at the control wheel.

[0067] According to a further embodiment of the present invention, the steam turbine further comprises a first inlet. Furthermore, the first section is connectable to the first inlet.

[0068] The steam for operating the steam turbine may be injected via the first inlet. The steam flow flows from the first inlet via the first section in the flow path of the steam turbine. Hence, the first section provides a connection between the first inlet and the flow path of the steam turbine.

[0069] According to a further exemplary embodiment, the turbine casing comprises a second inlet. The nozzle casing component is arranged in the turbine casing such that the further flow channel is formed in-between the flow deflecting surface and the radially inner surface. Furthermore, an outlet of the further flow channel is connected to the flow path of the steam turbine, and an inlet of the further flow channel is connected to the second inlet of the steam turbine.

[0070] The further flow channel may connect the second inlet of the steam turbine and the flow path of the steam turbine. Hence, the steam may be injected from the second inlet via the further flow channel in the flow path. The second inlet steam flow may be injected to the flow path at an axial position which is downstream of the axial position of the outlet of the first section.

[0071] The radially inner surface of the turbine casing and the flow deflecting surface are distanced from one another and form a cavity, i.e. the further flow channel. The geometry and size of the further flow channel is formed such that a laminar flow of the second inlet steam flow may develop in the further flow channel. The distance between the flow deflecting surface and the radially outer surface varies dependent on the varying radius defined between the flow deflecting surface and the rotation axis. If the radius is small, the distance between the flow deflecting surface and the radially inner surface is large and vice versa.

[0072] At the interface between the first section and the second section, the first radius is minimal. Hence, the distance between the flow deflecting surface and the radially inner surface is maximal. Additionally, the volume of the further flow channel is maximal. In other words, the flow cross-section of the further flow channel is maximal.

[0073] The second inlet is formed in the radially inner surface at a circumferential direction adjacent to the interface. Hence, the second inlet steam flow is injected in the further flow channel at the position where the largest volume, i.e. the largest flow cross-section, is provided. Therefore, there is enough space for the second inlet steam flow to develop such that less vortices are formed when the second inlet steam flow hit the flow deflecting surface.

[0074] Respectively, at the connecting surface, the radius is maximal, and thus the distance between the flow deflecting

surface and the radially inner surface is minimal. At this circumferential position the second inlet steam flow is already well established such that a small volume is sufficient for the established second inlet steam flow. Additionally, at this circumferential direction, the second section has the largest thickness in the radial direction. This is advantageously because the connection to the further semi-circular component is provided for example by a screw. The screw is easier

fixed in thick material than in a thin material. Furthermore, when the nozzle casing component is welded to the further semi-circular component, a thick material flange provides the advantage of a large weld contact area.

[0075] According to yet a further aspect of the present invention, a method for forming a nozzle casing component for a steam turbine is disclosed. The method comprises providing a first section with the flow channel and an outlet configured such that a first inlet steam flow flowing through the flow channel is injectable through the outlet into a flow path of the steam turbine upstream of a control wheel, and providing a second section with the flow deflecting surface and a radius defined between the flow deflecting surface and a rotation axis of the steam turbine. Furthermore, the nozzle component is arrangeable in a turbine casing comprising a radially inner surface. A first inlet steam flow of the steam turbine is guidable in the flow channel such that the first inlet steam flow enters the flow path of the steam turbine upstream of a control wheel. A second inlet steam flow of the steam turbine is guidable along the flow deflecting surface such that the second inlet steam flow enters the flow path of the steam turbine downstream of the control wheel. A further flow channel is formable in-between the flow deflecting surface and the radially inner surface. Additionally, a length of the radius varies along the circumferential direction such that a volume of the further flow channel varies depending on the variation of the length of the radius.

[0076] In other words, the second section comprises a flow deflecting surface, wherein the flow deflecting surface is spaced to a rotation axis by a radius, and wherein a length of the radius in circumferential direction along the flow deflecting surface varies such that a flow cross-section of the further flow channel varies along the circumferential direction.

[0077] It has to be noted that embodiments of the invention have been described with reference to different subject-matters. In particular, some embodiments have been described with reference to apparatus type claims whereas other embodiments have been described with reference to method type claims. However, a person skilled in the art will gather from the above and the following description that, unless other notified, in addition to any combination of features belonging to one type of subject-matter also any combination between features relating to different subject-matters, in particular between features of the apparatus type claims and features of the method type claims is considered as to be disclosed with this application.

Brief Description of the Drawings

[0078] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 shows a side view of a nozzle casing component according to one exemplary embodiment connected to a further semi-circular component.

Fig. 2 shows a sectional view of the nozzle casing component according to an exemplary embodiment of the invention.

Fig. 3 shows a top view of the nozzle casing component of Fig. 1.

Fig. 4 shows a sectional view of the nozzle casing component cut along the section IV-IV in Fig. 2.

Fig. 5 shows a sectional view of the nozzle casing component cut along the section V-V in Fig. 2.

Fig. 6 shows a sectional view of a steam turbine according to an exemplary embodiment of the invention.

Fig. 7 shows a half section of the steam turbine cut along the section VII-VII in Fig. 6.

Fig. 8 shows a half section of the steam turbine cut along the section VIII-VIII in Fig. 6.

Fig. 9 shows a current design of a steam turbine comprising a nozzle casing inside a turbine casing according to the prior art.

Detailed Description

[0079] The illustrations in the drawings are schematic. It is noted that in different figures similar or identical elements are provided with the same reference signs.

[0080] Fig. 1 shows a side view of a nozzle casing component 100 according to one exemplary embodiment connected to a further semi-circular component 130. The nozzle casing component 100 and the further semi-circular component 130 enclose a flow path 140 of a steam turbine.

[0081] In the steam turbine, a circumferential direction 190 denotes the direction being circumferential to an axial direction of the steam turbine. Further, in the steam turbine, the flow path 140 extends parallel to the rotation axis 180 of the turbine.

[0082] The nozzle casing component 100 comprises a first section 110 extending along the circumferential direction 190, and a second section 120 extending along the circumferential direction 190. The first section 110 is connected to the second section 120 at an interface 150. The interface 150, as shown in Fig. 1, is a solid wall which separates the first section 110 from the second section 120. Hence, a first inlet steam flow in the first section 110 is separated from a second inlet steam flow in the second section 120. Additionally, the first inlet steam flow flowing in a flow channel 111 in the first section 110 may not flow along a flow deflecting surface 121 in the second section 120.

[0083] The flow channel 111 is connectable to the flow path 140 via an outlet 112. The outlet 112 in Fig. 1 is a slit extending along the circumferential direction 190 of the steam turbine. Hence, in Fig. 1, the outlet 112 is a nozzle groove for an upper part, i.e. for the nozzle casing component 100.

The slit has a width which is significantly smaller than its length. Also as the slit is shown with a constant width over its entire length along the circumferential direction 190 in Fig. 1, it is emphasized that the width of the outlet may also vary over its length.

[0084] The flow channel 111 connects a first inlet 113 with the flow path 140. Additionally, as shown in Fig. 1, the further semi-circular component 130 comprises a fourth inlet 115 and a third inlet 114 which are both connected via a further outlet 116 to the flow path 140 of the steam turbine. Hence, in Fig. 1, the further outlet 116 is a nozzle groove for a lower part, i.e. for the further semi-circular component 130.

[0085] The second section 120 comprises the flow deflecting surface 121 as well as a radius between the flow deflecting surface and the rotation axis 180 of the steam turbine. The radius varies along the circumferential direction 190 of the second section 120. As shown in Fig. 1, a first radius being the radius at the circumferential position of the interface 150 is a first radius 171. The radius at a second circumferential position being spaced apart from the first radius 171 and being located in the second section 120, is a second radius 172. The first radius 171 is smaller than the second radius 172. A third radius 173 being circumferentially positioned in-between the first radius 171 and the second radius 172, comprises a length being larger than the first radius 171 and being smaller than the second radius 172. The length of the first radius 171 and the length of the second radius 172 describe two boundary values of a linear function. In other words, the flow deflecting surface 121 is spaced to the rotation axis 180 by a radius. Additionally, a surface between the first radius 171 and the second radius 172 is curved.

[0086] A distance 174 between the rotation axis 180 and a radial outer surface 161 of the first section 110 is larger than the first radius 171. Hence, at the interface 150, there is formed an edge. Additionally, the distance 174 is equal to the second radius 172. Any radius in-between the first radius 171 and the second radius 172 is smaller than the distance 174.

[0087] Further, as may be seen in Fig. 1, at the interface 150, the radial extension of the first section 110 is larger than the first radius 171. Hence, an edge 151 is formed at the interface 150.

[0088] Fig. 2 shows a sectional view of the nozzle casing component 100 according to an exemplary embodiment of the invention. The nozzle casing component 100 further comprises two connecting surfaces 260 which may be interconnected to the further semi-circular component 130 (shown in Fig. 1). The two connecting surfaces 260 are each planar and have a relative low value of surface roughness. Additionally, a sealing may be arranged in-between the nozzle casing 100 and the further semi-circular component 130 on the connecting surface 260, for ensuring a steam-seal flow path 140.

[0089] As may be seen in Fig. 2, the flow channel 111 is a cavity in the first section 110, having the first inlet 113 and the outlet 112 as connections to the environment of the nozzle casing component 100. The outlet 112 is formed as a slit. The second section 120 comprises the flow deflecting surface 121 which is a radial outer surface of the second section 120. The second section 120 is a solid body having an inner surface which forms the wall of the flow path 140 (shown in Fig. 1), and which has the flow deflecting surface 121 as its outer surface.

[0090] The first section 110 further comprises a radial outer surface 261 which has a normal pointing radially away from the rotation axis 180 of the steam turbine.

[0091] A distance 274 is defined between the radial outer surface 261 and the rotation axis 180. A distance between the flow deflecting surface 121 and the rotation axis 180 may be defined as a first radius 271. The first radius 271 is defined at a circumferential position in-between an interface 250 between the first section 110 and the second section

120, and the connecting surface 260. The distance 274 is larger than the first radius 271. Hence, a cavity between the flow deflecting surface 121 and a radial inner surface of a turbine casing 623 (shown in Fig. 6) may have a varying volume, particularly a varying flow cross-section, such that a laminar flow at the first guide blade carrier may be provided (shown in Fig. 7). Simultaneously, the thickness of the second section 120 in the radial direction at the connecting surface 260 may be large enough to ensure the stability of the nozzle casing component 100 in all load cases applied to the steam turbine.

[0092] A first radius 271 near the interface 250 is in this exemplary embodiment smaller than a second radius 272 at the connecting surface 260 in the second section 120.

[0093] Fig. 3 shows a top view of the nozzle casing component 100 of Fig. 1. As may be seen in Fig. 3, the first section 110 further comprises a first section depth 362 and the second section 120 further comprises a second section depth 363. The first section depth 362 and the second section depth 363 extend parallel to the rotation axis 180 of the steam turbine. Additionally, the first section depth 362 is larger than the second section depth 363. Hence, the dimension and extension of the further flow channel between the turbine casing (shown in Fig. 6) and the nozzle casing component 100 may also vary in the axial direction of the steam turbine.

[0094] The difference between the first section depth 362 and the second section depth of 363 forms a step 364. The step 364 is formed in the axial direction in the second section 120. The second inlet steam flow may flow in the radial direction along the flow deflecting surface 121 in the step 364 and may enter the flow path 140 of the steam turbine.

[0095] The first inlet steam flow may be injected in the flow channel 111 (shown in Fig. 1) through the first inlet 113 and may then flow in the flow path 140 through the outlet 112. As may be unambiguously seen from Fig. 3, the first inlet steam flow enters the flow path 140 of the steam turbine at a first position and the second inlet steam flow flows in the flow path of the steam turbine at a second position being downstream (seen in the flow direction 381) from the first position. Hence, the control wheel may be located between the first position and the second position. The control wheel is located in the flow path 140 at an axial position being in-between the first position and the second position. Therefore, the second inlet steam flow flowing along the step 364 bypasses the control wheel.

[0096] Fig. 4 shows a sectional view of the nozzle casing component 100 cut along the section IV-IV in Fig. 2. The nozzle casing component 100 is cut in the second section 120, and is shown with the first section 110 (depicted in a not cut away view). Hence, Fig. 4 shows the cross-section shape of the second section 120 and the cross sectional shape of the flow deflecting surface 121.

[0097] A surface of the second section 120, opposite of the flow deflecting surface 121 and forming a rectangular angle, forms a recess 471. In the recess 471 a sealing, for example a sealing ring, may be arranged to seal the gap between the second section 120 and the control wheel 791 (shown in Fig. 7). The sealing may be a rotational sealing for allowing the control wheel 791 to rotate in the nozzle casing component 100 and to ensure the functionality of the steam turbine.

[0098] The first section depth 362 is larger than the second section depth 363 for forming the step 364 (explained in detail with reference to Fig. 3).

[0099] Fig. 5 shows a sectional view of the nozzle casing component 100 cut along the section V-V in Fig. 2. The nozzle casing component 100 is cut in the first section 110. Hence, Fig. 5 shows the cross-section shape of the first section 110 and the cross sectional shape of the flow channel 111. The first inlet steam flow may be injected from the flow channel 111 in the flow path of the steam turbine through the outlet 112.

[0100] Fig. 6 shows a sectional view of a steam turbine 600 according to an exemplary embodiment of the invention. The steam turbine 600 comprises an upper turbine casing 611 and a lower turbine casing 612 connected together by two screws 617. Further, the steam turbine 600 comprises at its upper side in Fig. 6, the first inlet 113 and a second inlet 616. Additionally, the steam turbine 600 comprises at its lower side in Fig. 6, the third inlet 114 and the fourth inlet 115. Inside the upper turbine casing 611 connected to the lower turbine casing 612, is located a nozzle casing component 100 and a further semi-circular component 130. The nozzle casing component 100 and the further semi-circular component 130 are connected to each other by a screw 627 on the right side and by a pin 628 on the left side. Additionally, the nozzle casing component 100 and the further semi-circular component 130 are fixed relatively to the upper turbine casing 611 and the lower turbine casing 612, respectively.

[0101] The nozzle casing component 100 comprises a first section 110 and a second section 120 which are both formed as described in connection with the exemplary embodiments in Figures 1 to 5.

[0102] A first inlet steam flow 653 is injected in the flow path 140 of the steam turbine 600 via the first inlet 113, the flow channel 111 and the outlet 112. The outlet 112 is formed as a slit extending along a circumferential direction.

[0103] Additionally, a third inlet steam flow 654 is injected through the third inlet 114 and the further outlet 116 in the flow path 140 of the steam turbine 600. Respectively, a fourth inlet steam flow 655 is injected through the fourth inlet 115 and the further outlet 116 in the flow path 140 at the same axial position as the first inlet steam flow 653 and the third inlet steam flow 654. The first inlet steam flow 653, the third inlet steam flow 654 and the fourth inlet steam flow 655 are injected in the flow path 140 at a position upstream of the control wheel 791 (shown in Fig. 7).

[0104] A second inlet steam flow 656 is a bypass stream for the control wheel 791. The second inlet steam flow 656

is injected through a second inlet 616 in a further flow channel 629. The further flow channel 629 is formed by a radial inner surface 623 of the upper turbine casing 611 and the flow deflecting surface 121 of the second section 120. Due to the design of the second section 120, the further flow channel 629 has a size and a shape providing enough space for the second inlet steam flow 656 to develop such that for example vortices may be balanced out and the second inlet steam flow 656 may be laminar when flowing into the flow path 140 of the steam turbine 600.

[0105] Particularly, the second section 120 comprises the first radius 171 at the interface 150 between the first section 110 and the second section 120. Additionally, the second section 120 comprises the second radius 172 circumferentially spaced apart from the interface. The second radius 172 is larger than the first radius 171. As may be seen from Fig. 6, the further flow channel 629 has a larger radial extension near the interface 150 than near a flange where the screw 617 fixes the nozzle casing component 100 and the further semi-circular component 130 together. The second inlet 616 is formed in the radially inner surface 623 near the interface 150. Hence, the second inlet steam flow 656 is injected at the circumferential position where a distance between the radially inner surface 623 and the flow deflecting surface 121 is maximal due to the first radius 171 being minimal. The second inlet steam flow 656 may comprise the largest disturbances in the area near the second inlet 616. Hence, by providing the largest space of the further flow channel 628 near the interface 150 and at the same time near the second inlet 616, the second inlet steam flow 656 may have enough space to develop in this area before being injected to the flow path 140.

[0106] At the same time the second section 120 has a radial thickness at the circumferential position of the second radius 172, being enough such that a stable connection between the nozzle casing component 100 and the further semi-circular component 130 may be provided.

[0107] Fig. 7 shows a half section of the steam turbine 600 cut along the section VII-VII in Fig. 6.

[0108] The steam turbine 600 comprises the first inlet 113 and the second inlet 616. As the section VII-VII cuts the second section 120 of the nozzle casing component 100, the second inlet steam flow 656 is shown in Fig. 7. The second inlet steam flow 656 is injected in the steam turbine 600 through the second inlet 616.

[0109] The steam turbine 600 further comprises a turbine shaft 793, the control blade 791 and the first guide blade carrier 792. The flow direction 381 is shown in Fig. 7 from the left hand side to the right hand side. The control wheel 791 is arranged on the turbine shaft 793. The first guide blade carrier 792 is arranged on the turbine shaft 793 at a position downstream from the control wheel 794.

[0110] A sealing 770 is arranged in-between the radially outer tip of the control wheel 791 and the second section 120 in the recess 471, wherein the sealing is particularly formed as a nozzle ring 770. The sealing 770, particularly the nozzle ring 770, prevents the second inlet steam flow 656 from flowing into a part of the turbine being upstream of the control wheel 791. As depicted in Fig. 7, the further flow channel 629 is formed between the radially inner surface 623 of the upper turbine casing 611 and the flow reflecting surface 121.

[0111] The second inlet steam flow 656 is injected in the steam turbine 600 through the second inlet 616. Then the second inlet steam flow continues flowing through the further flow channel 629 and is injected in the flow path 140 of the steam turbine at a position upstream of the first guide blade carrier 792. Therefore, the second inlet steam flow 656 does not pass the control wheel 791. In fact the second inlet steam flow 656 bypasses the control wheel 791 and flows directly to the first guide blade carrier 792.

[0112] Fig. 8 shows a half section of the steam turbine 600 cut along the section VIII-VIII in Fig. 6.

[0113] The steam turbine 600 comprises the first inlet 113 and the second inlet 616. As the section VIII-VIII cuts the first section 110 of the nozzle casing component 100, a first inlet steam flow 653 flowing into the steam turbine 600 through the first inlet 113, is shown in Fig. 8.

[0114] The control wheel 791 and the first guide blade carrier 792 are arranged on a turbine shaft 793 such that the first guide blade carrier 792 is arranged downstream from the control wheel 791.

[0115] The first section 110 comprises the flow channel 111. The sealing 770 is arranged between the radially outer tip of the control wheel 791 and a radially inner surface of the first section 110 such that the flow channel 111 is sealed from a downstream position of the control wheel 791.

[0116] The first inlet steam flow 653 is injected in the steam turbine 600 through the first inlet 113 and passes the flow channel 111 before flowing in the flow path 140 (shown in Fig. 1) of the steam turbine 600 at a position upstream of the control wheel 791.

[0117] It should be noted that the term "comprising" does not exclude other elements or steps and "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

List of reference signs:

100	nozzle casing component	600	steam turbine
110	first section	611	upper turbine casing
111	flow channel	612	lower turbine casing

(continued)

	112	outlet / nozzle groove for upper part	616	second inlet
	113	first inlet	617	screw
5	114	third inlet	623	radially inner surface
	115	fourth inlet	627	screw
	116	further outlet / nozzle groove for lower part	628	pin
	120	second section	629	further flow channel
10	121	flow deflecting surface	653	first inlet steam flow
	130	further semi-circular component	654	third inlet steam flow
	140	flow path	655	fourth inlet steam flow
	150	interface	656	second inlet steam flow
	151	edge	770	sealing / nozzle ring
15	161	radially outer surface	791	control wheel
	171	first radius	792	first guide blade carrier
	172	second radius	793	turbine shaft
	173	third radius	900	steam turbine
	174	distance	911	upper turbine casing
20	180	rotation axis	912	lower turbine casing
	190	circumferential direction	913	first turbine inlet
	250	interface	914	second turbine inlet
	260	connecting surface	915	third turbine inlet
25	261	radially outer surface	916	fourth turbine inlet
	271	first radius	921	upper nozzle casing half
	272	second radius	922	lower nozzle casing half
	362	first section depth	929	hollow space
	363	second section depth	933	first inlet stream
30	364	step	934	second inlet stream
	381	flow direction	935	third inlet stream
	471	recess	936	bypass

Claims

1. Nozzle casing component (100) for a steam turbine (600), comprising
a first section (110) extending along a circumferential direction (190) of the steam turbine (600), and
a second section (120) extending along the circumferential direction (190) of the steam turbine (600),
wherein the first section (110) comprises a flow channel (111) and an outlet (112) configured such that a first inlet
steam flow (653) flowing through the flow channel (111) is injectable through the outlet (112) into a flow path (140)
of the steam turbine (600) upstream of a control wheel (791), wherein the second section (120) comprises a flow
deflecting surface (121) and a radius defined between the flow deflecting surface (121) and a rotation axis (180) of
the steam turbine (600),
wherein the nozzle casing component (100) is arrangeable in a turbine casing (611) comprising a radially inner
surface (623),
wherein a further flow channel (629) is formable in-between the flow deflecting surface (121) and the radially inner
surface (623), and
wherein a second inlet steam flow (656) of the steam turbine (600) is guidable along the flow deflecting surface
(121) such that the second inlet steam flow (656) enters the flow path (140) of the steam turbine (600) downstream
of the control wheel (791),
wherein a length of the radius varies along the second section (120) in the circumferential direction (180) such that
a volume of the further flow channel (629) varies depending on the variation of the length of the radius.
2. Nozzle casing component according to claim 1,
wherein the nozzle casing component further comprises an interface between the first section (110) and the second
section (120),

wherein the radius at the interface is a first radius, and the radius at a position circumferentially distanced from the interface is a second radius,
wherein the first radius is smaller than the second radius.

3. Nozzle casing component according to claim 2,
wherein the radius varies linearly between the first radius and the second radius.
4. Nozzle casing component (100) for a steam turbine (600) according to claim 2 or 3,
wherein the nozzle casing component (100) is formed as a semi-circular component,
wherein the second section (120) further comprises a connecting surface which is connectable to a further semi-circular component (130),
wherein the radius at the connecting surface is a second radius, and
wherein the second radius is equal to a radius between the rotation axis (180) and a radially outer surface (161) of the first section (110).
5. Nozzle casing component (100) according to one of the claims 1 to 4,
wherein the first section (110) further comprises a first section depth (362), and
wherein the second section (120) further comprises a second section depth (363),
wherein the first section depth (362) and the second section depth (363) extend parallel to the rotation axis (180) of the steam turbine (600), and
wherein the first section depth (362) is larger than the second section depth (363).
6. Nozzle casing component (100) according to one of the claims 1 to 5,
wherein the second inlet steam flow (656) of the steam turbine (600) is guidable along the flow deflecting surface (121) such that the second inlet steam flow (656) enters the flow path (140) of the steam turbine (600) upstream of a first guide blade carrier (792).
7. Nozzle casing component (100) for a steam turbine (600) according to one of the claims 1 to 6,
wherein the first section (110) and the second section (120) are formed as one integral part.
8. Nozzle casing component (100) for a steam turbine (600) according to one of the claims 1 to 7,
wherein the outlet (112) of the first section (110) extends along an arc of the circumferential direction, and
wherein the outlet (112) is formed as a slit or a perforated grid.
9. Nozzle casing component (100) for a steam turbine (600) according to one of the claims 1 to 8,
wherein the nozzle casing component (100) is a cast part.
10. Steam turbine (600), comprising
a nozzle casing component (100) according to one of the claims 1 to 9,
a control wheel (791), and
a turbine casing (611) comprising a radially inner surface (623).
11. Steam turbine (600) according to claim 10, further comprising
a further semi-circular component (130),
wherein the nozzle casing component (100) is formed as a semi-circular component, and
wherein the nozzle casing component (100) is connected with the further semi-circular component (130) such that the nozzle casing component (100) and the further semi-circular component (130) form a circular nozzle casing of the steam turbine (600).
12. Steam turbine (600) according to claim 10 or 11, further comprising
a sealing (770),
wherein the sealing (770) is arranged in-between the control wheel (791) and the nozzle casing component (100).
13. Steam turbine (600) according to one of the claims 10 to 12, further comprising
a first inlet (113),
wherein the first section (110) is connected to the first inlet (113).
14. Steam turbine (600) according to one of the claims 10 to 13,

wherein the turbine casing (611) comprises a second inlet (616),
 wherein the flow deflecting surface (121) is a radially outer surface of the nozzle casing component (100),
 wherein the nozzle casing component (100) is arranged in the turbine casing (611) such that a further flow channel
 (629) is formed in-between the flow deflecting surface (121) and the radially inner surface (623),
 wherein an outlet of the further flow channel (629) is connected to the flow path (140) of the steam turbine (600),
 and wherein an inlet of the further flow channel (629) is connected to the second inlet (616).

15. Method for forming a nozzle casing component (100) for a steam turbine (600), wherein the method comprises:

providing a first section (110) with a flow channel (111) and an outlet (112) configured such that a first inlet
 steam flow (653) flowing through the flow channel (111) is injectable through the outlet (112) into a flow path
 (140) of the steam turbine (600) upstream of a control wheel (791), and
 providing a second section (120) with a flow deflecting surface (121) and a radius defined between the flow
 deflecting surface (121) and a rotation axis (180) of the steam turbine (600),

wherein the nozzle component is arrangeable in a turbine casing (611) comprising a radially inner surface (623),
 wherein a first inlet steam flow (653) of the steam turbine (600) is guidable in the flow channel (111) such that the
 first inlet steam flow (653) enters a flow path (140) of the steam turbine (600) upstream of a control wheel (791),
 wherein a further flow channel (629) is formable in-between the flow deflecting surface (121) and the radially inner
 surface (623), and

wherein a second inlet steam flow (656) of the steam turbine (600) is guidable along the flow deflecting surface
 (121) such that the second inlet steam flow (656) enters the flow path (140) of the steam turbine (600) downstream
 of the control wheel (791),

wherein a length of the radius varies along the circumferential direction (180) such that a volume of the further flow
 channel (629) varies depending on the variation of the length of the radius.

FIG 1

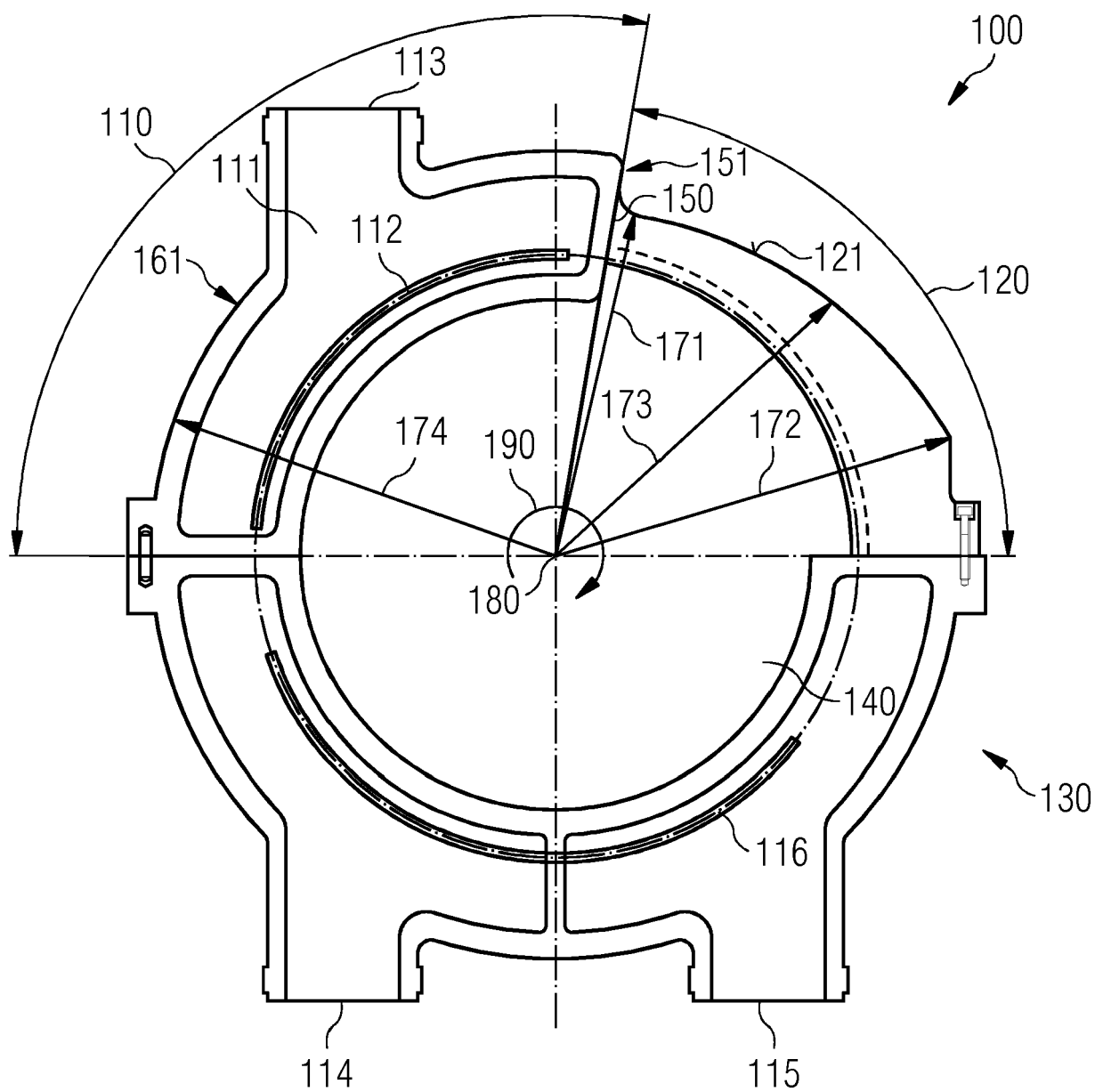


FIG 2

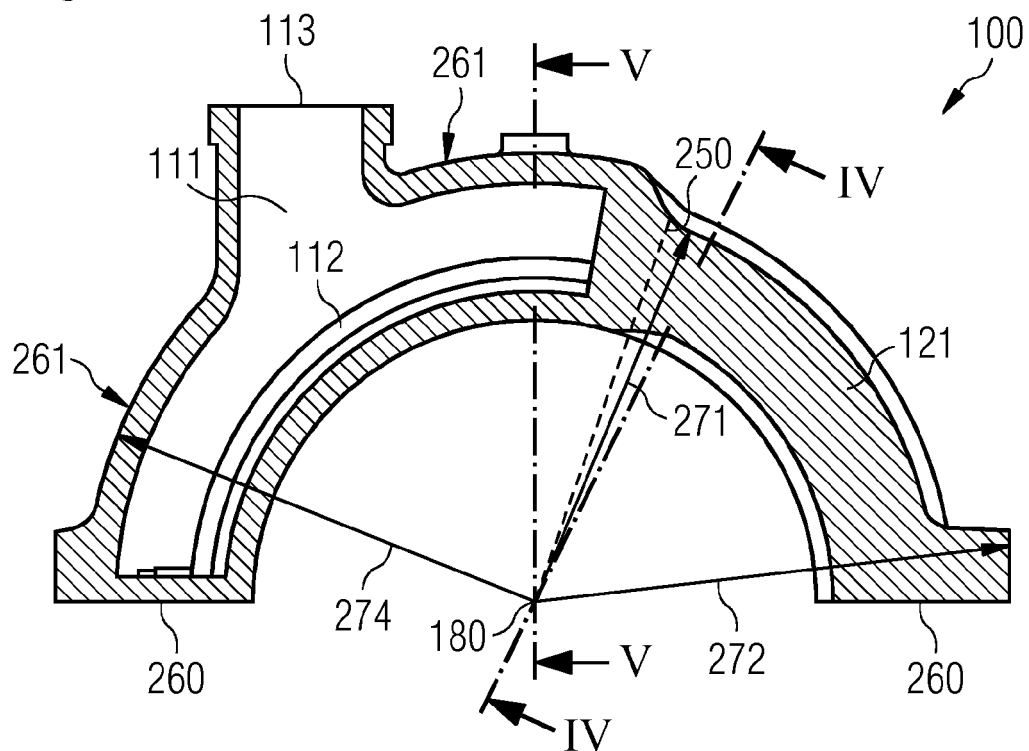


FIG 3

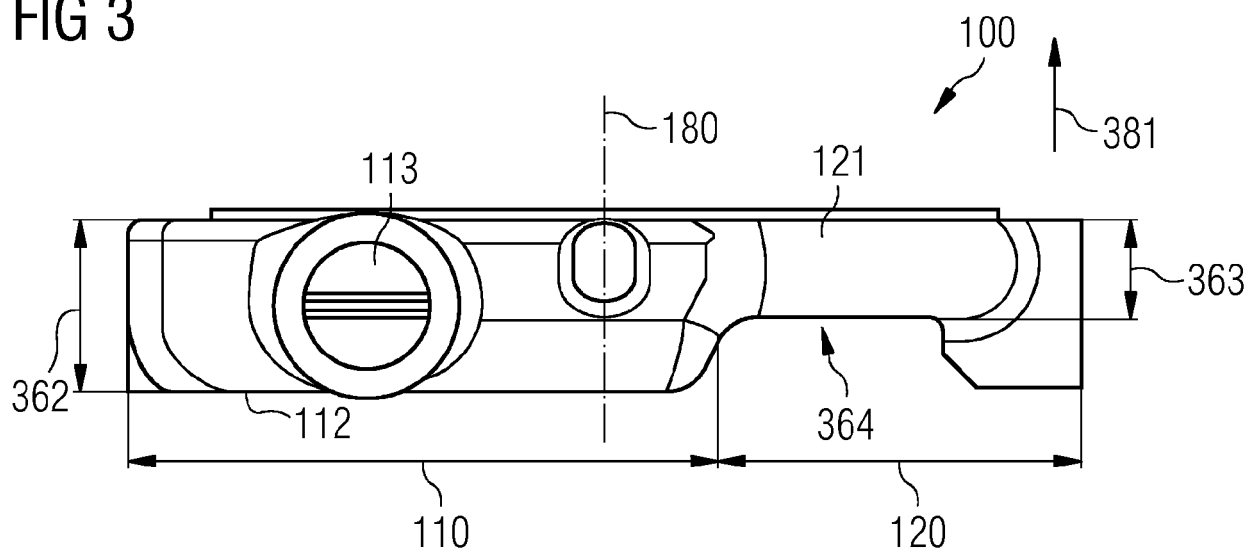


FIG 4

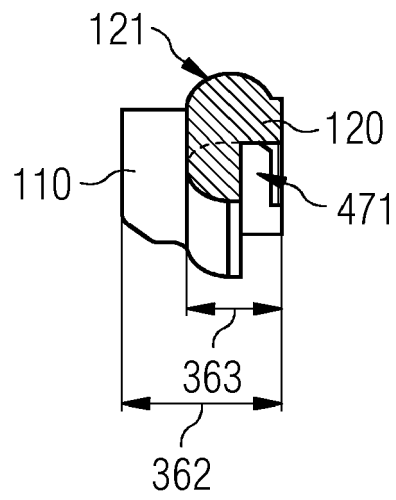


FIG 5

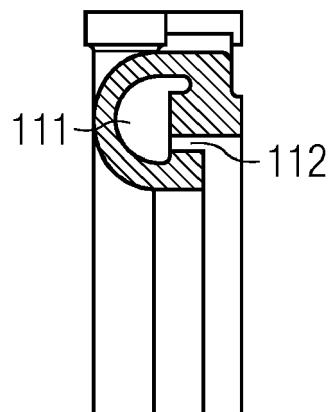


FIG 6

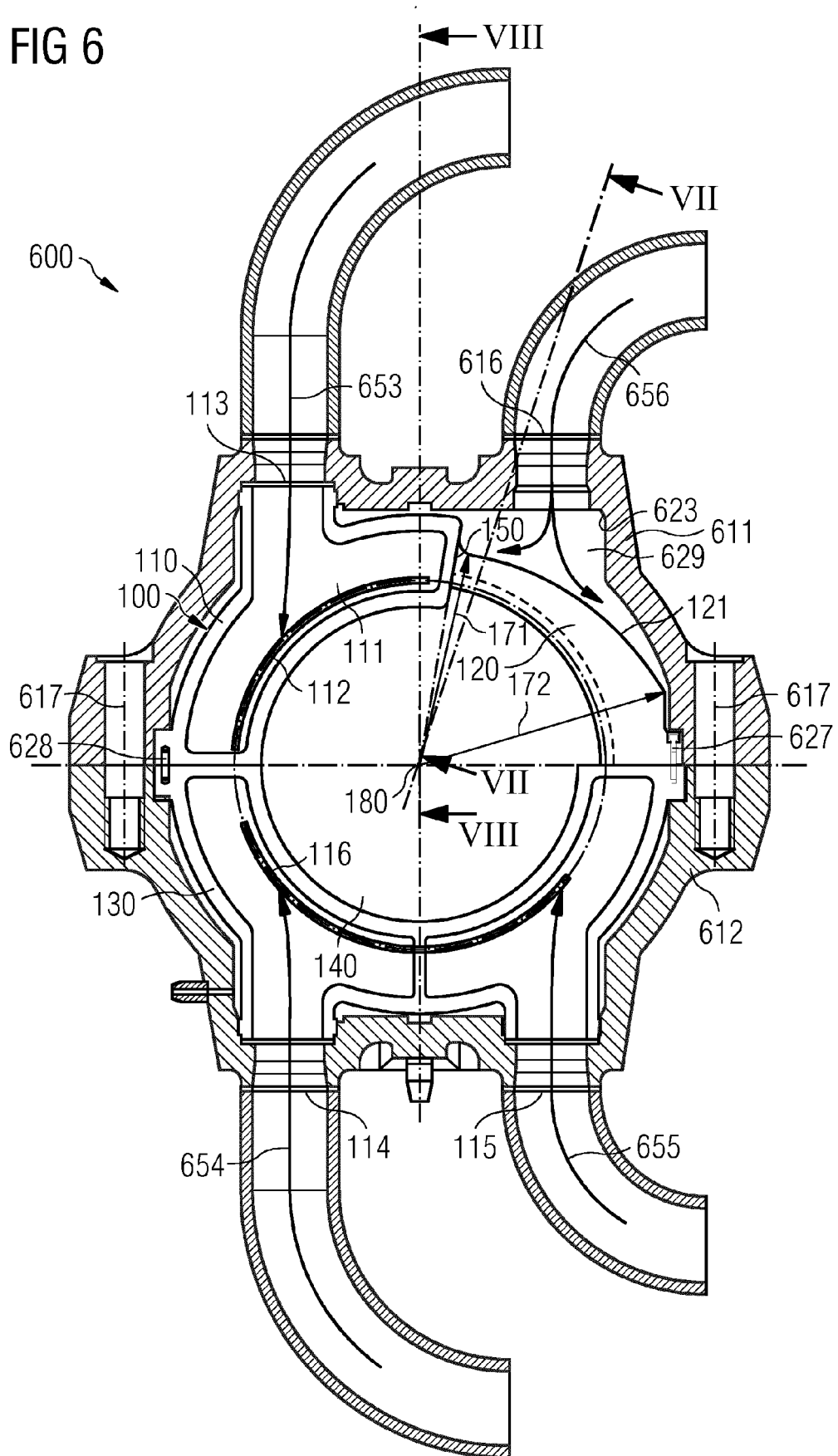


FIG 7

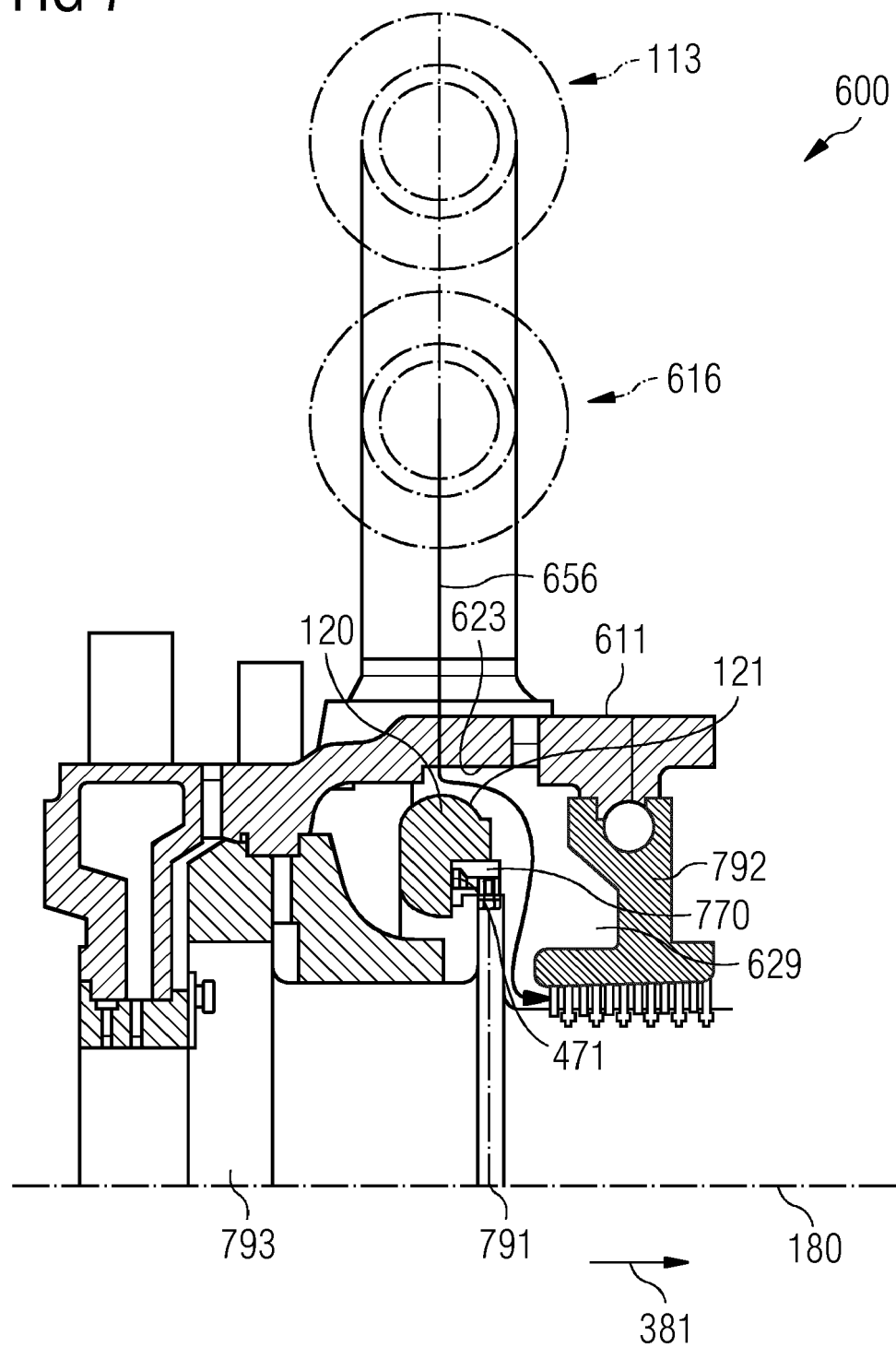


FIG 8

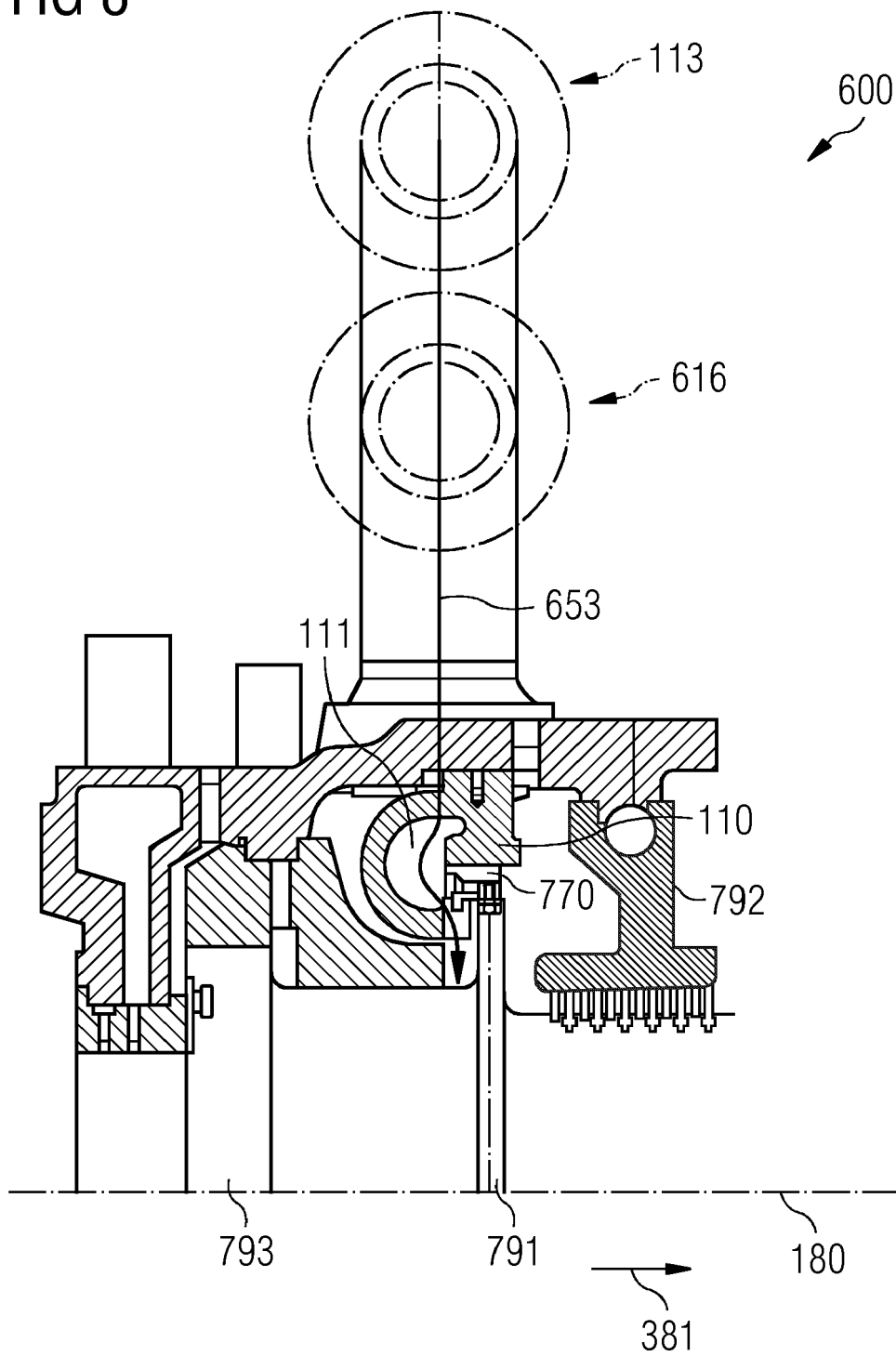
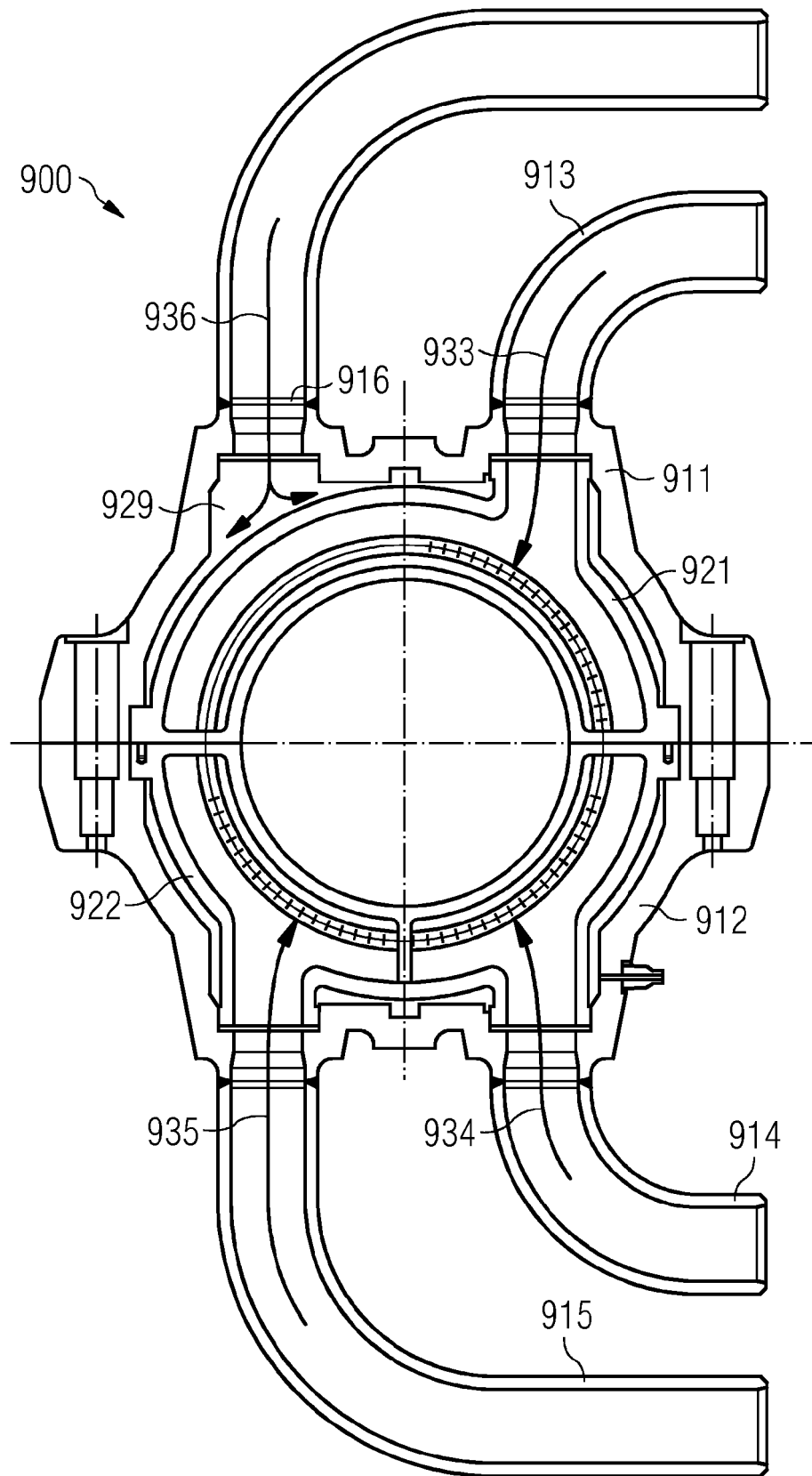


FIG 9 PRIOR ART





EUROPEAN SEARCH REPORT

Application Number
EP 17 17 3236

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			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 24 October 2017	Examiner de la Loma, Andrés
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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The members are as contained in the European Patent Office EDP file on
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