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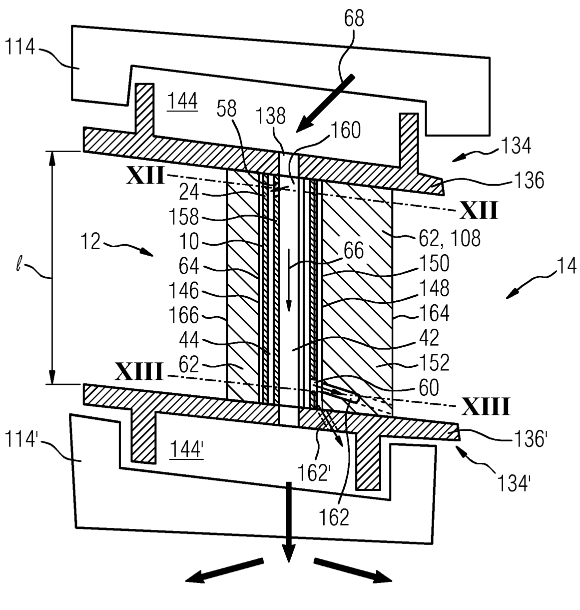
(54) CHANNELLING TUBE AND METHOD FOR MANUFACTURING A CHANNELLING TUBE

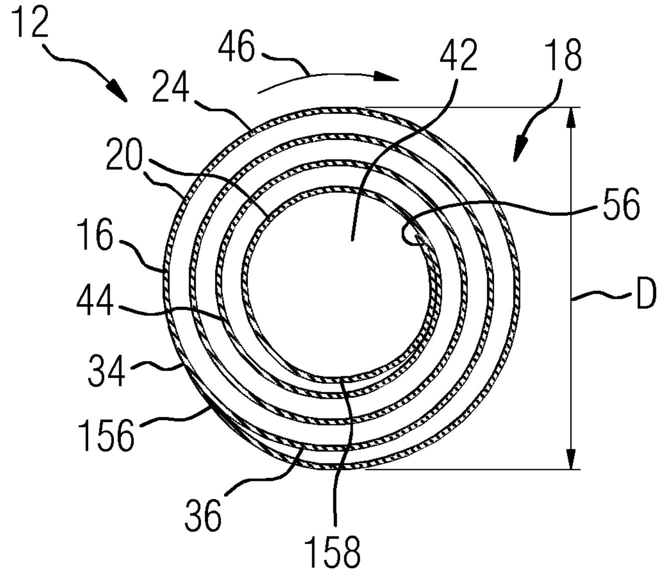
(57) The present invention relates to a method of manufacture of a channelling tube (10) with an insulating air gap (44) for transferring coolant from the outer platform to the inner platform of a hollow stator vane of a turbine. The purpose is to minimize heat transfer even at low flow rates of coolant in order to supply said coolant at the lowest possible temperature to the inner platform.
The tube is realized by tight rolling a flat metal sheet (16) in order to obtain a tight spiral defining a tube with an outer diameter d; said tube is then released so that it expands via a spring effect to an outer diameter D; the circumferential ends of the spiral are attached to the adjacent layer to define a central passage (42) for the coolant and the spiral gap (44) that creates insulation layer(s) around the central passage.

FIG 3



EP 3 156 595 A1

FIG 11



Description

Field of the Invention

[0001] The present invention relates to a method for assembling a channelling tube of a channelling tube assembly of a turbine assembly. The present invention further relates to a channelling tube assembly and to an aerofoil-shaped turbine assembly such as turbine rotor blades and stator vanes, wherein a channelling tube assembly is used in such components to aid the cooling and sealing system.

Background to the Invention

[0002] Modern turbines often operate at extremely high temperatures. The effect of temperature on the turbine blades, stator vanes and surrounding components can be detrimental to the efficient operation of the turbine and can, in extreme circumstances, lead to distortion and possible failure of such components. In order to overcome this risk, high temperature turbines may include hollow blades or vanes incorporating channelling tubes like so-called jumper tubes to aid the cooling and sealing flow systems by minimising the heat pickup within these flows, which can be especially critical for a disc region of the aerofoil assembly.

[0003] These so-called jumper tubes are hollow tubes that run radially within the blades or vanes. Air is forced into and along these tubes. The design intent is to minimise the heat pick up of the flow as it passes through the tube. To prevent heat transfer from the jumper tube to the aerofoil the jumper tube is arranged with an air gap in respect to an aerofoil cavity wall. The air gap creates an insulating layer of relatively low thermal conductivity. Heat transfer across the air gap is largely by radiation.

[0004] By operation with high flow rates through the jumper tube this design works very well. However, problems arise for low flow rates through the jumper tube causing high heat pickup of the cooling stream. When this temperature rise becomes excessive, the integrity of the disc cooling system can be significantly affected, and an excess cooling is required to compensate.

[0005] It is a first objective of the present invention to provide a method for assembling a channelling tube of a channelling tube assembly of a turbine assembly with which the above-mentioned shortcomings can be mitigated, and especially a more aerodynamic efficient aerofoil and gas turbine component is facilitated as well as a quick and uncomplex assembling or manufacturing process is provided.

[0006] It is a second objective of the invention to provide a channelling tube assembly comprising such an advantageous channelling tube that is especially used in a turbine assembly for cooling purposes. Furthermore, it is a third objective of the invention to provide an advantageous aerofoil-shaped turbine assembly such as a turbine rotor blade and a stator vane.

Summary of the Invention

[0007] Accordingly, the present invention provides a method for assembling a channelling tube of a channelling tube assembly of a turbine assembly.

[0008] It is provided that the method at least comprises the steps of: Rolling a sheet designed to be the channelling tube and freezing the rolled sheet in a configuration so that in a frozen configuration of the rolled sheet a circumferential sector of the channelling tube forms at least one double wall.

[0009] Due to the inventive method a channelling tube can be provided that is assembled or manufactured easily, quickly and at low cost. Moreover, the resulting channelling tube has a multiple layered approach that utilises a single sheet to create both the main flow passage of the channelling tube and additional layers surrounding the main flow passage. An air gap is located between each layer. Each layer acts as a radiation shield, significantly reducing the total heat transfer between an aerofoil equipped with such a channelling tube and a channelling tube flow. For example, the use of a single radiation shield layer can divide the radiation heat transfer by half and thus the associated heat pickup of the channelling tube flow. As a general rule, for constant wall emissivity, the radiative heat transfer is reduced by a factor of 1/(N_layers+1) for each layer. Hence, an excessive heat pickup in comparison with a standard design of the channelling tube especially by low channelling tube flow rates can be avoided. The invention is a simple modification to the standard design, thus saving costs and construction efforts. Further, an existing design may be retrofitted easily. Although some cooling flow is used to buffer the air gap cavity, the amount is only a fraction of that required to reduce the heat pickup of the standard design when excessive flow through the channelling tube is used to compensate.

[0010] Even if a term like channelling tube, sector, (double) wall, layer, expansion stopping device, spacer, aperture, end, passage, gap, bottom, part, embossment, aerofoil platform or cavity is used in the singular or in a specific numeral form in the claims and the specification the scope of the patent (application) should not be restricted to the singular or the specific numeral form. It should also lie in the scope of the invention to have more than one or a plurality of the above mentioned structure(s).

[0011] In this context a channelling tube is intended to mean a structure that primarily provides a channel for a flow medium, like cooling medium/air, and that allows the flow medium to reach the structure to be cooled (see below). The channelling tube may be any tube feasible for a person skilled in the art, like an impingement tube or a jumper tube. Preferably, the channelling tube is a jumper tube. Hence, the cooling medium can be lead to the region to be cooled efficiently.

[0012] In this context a jumper tube is intended to mean a hollow structure, like a tubular tube, that primary function is to connect cavities of platforms of the turbine assembly and to bridge the span of the aerofoil, to provide a passage for the cooling medium to flow with minimal heat pickup along the aerofoil or its cavity, respectively. Although not its prime function, it can be used to provide a cooling of the aerofoil itself. Thus, a jumper tube is no impingement tube, which has the primary function to cool walls of the cavity of the aerofoil housing the impingement tube by jets of cooling medium exiting a plurality of holes and impinging at the cavity wall.

[0013] A jumper tube in comparison with an impingement tube has or is likely to have:

- A greater portion of the air entering the jumper tube passing through its end. However, the through flow can vary significantly depending upon the system requirements.
- A smaller total aperture/hole area in the surface (wall) of the jumper tube.
- The cross section at the ends of the jumper tube is significantly larger than the aperture/hole area in the surface (wall). By specifically designing the inlet and exit areas in such a way pressure drops can be minimised.
- A lower or minimal number of apertures/holes.
- The locations of the apertures/holes are different, basically, not - homogenously - distributed along a span wise length and/or a contour/circumference of the jumper tube.
- A greater distance between the tube and the aerofoil wall is likely.
- Not following a contour of the aerofoil, not likely a fairly constant gap between the jumper tube and aerofoil cavity wall.
- Contour independent of the aerofoil contour (i.e. circular)
- Cooling medium would leave the jumper tube at a smaller radius compared to where it entered in relation to the centreline/axis of the gas turbine engine. In other words, the span wise length travelled by the cooling air is greater.

[0014] A turbine assembly is intended to mean an assembly provided for a turbine engine, like a gas turbine, wherein the assembly possesses at least an aerofoil. Preferably, the turbine assembly has a turbine wheel or a turbine cascade with circumferential arranged aerofoils and an outer and an inner platform arranged at opponent ends of the aerofoil(s). The part of the turbine assembly to be cooled may be any part arranged in radial direction between the aerofoil and an axis of the turbine engine and is preferably a disc. In case of a turbine wheel several aerofoils are connected with one another by a disc. Such a disc and the surrounding disc region are intended to be cooled by the turbine assembly.

[0015] In case of a turbine wheel the disc region is cooled by aerofoils of the turbine wheel. In case of a turbine cascade, in turn, the disc region of the upstream and downstream arranged turbine wheels are cooled, wherein the terms upstream and downstream refer to a flow direction of an airflow and/or working gas flow through the turbine engine. Thus, a turbine assembly may comprise two aerofoils with platforms, wherein the aerofoils are arranged in flow direction of the working gas one after the other, one being an aerofoil of a turbine cascade (turbine vane) and the other an aerofoil of a turbine wheel (turbine blade).

[0016] The term "rolling" should be understood as the process by which, starting from a flat basically two-dimensional structure/sheet, a three-dimensional structure and specifically a basically circular or spiral structure is achieved. Due to this a flow direction is predetermined depending on the entry or exit of the cooling medium. The term "freezing" should be understood as the achievement of an at least temporarily stable configuration of the rolled sheet in its rolled state. The freezing may be done by any method, characteristic or device feasible for a person skilled in the art. For example the freezing may be an *in situ* property of the material of the sheet, so that the rolled sheet maintains its rolled state because of the properties of the material used. Or the freezing may be triggered by an extern influence or device. For example it may be possible to use a material changing its properties triggered by an external factor, like a temperature change (heat), exposure to radiation (UV, IR, gamma rad. etc.). Such materials are well known on the art.

[0017] Moreover, the freezing may be done by connecting or permanently attaching at least two regions of the rolled sheet to one another. This can be done, for example, by a bonding method, like welding, bracing, gluing or the like. Thus, the resulting connection can be views as an expansion stopping device. Furthermore, it is possible to exert a pressure on the sheet in its rolled state that blocks the unfolding force of the rolled sheet at least in its end or final configuration (the configuration in which the channelling tube is employed in the turbine assembly). This may be done by using a substantial expansion stopping device, like a mounting/assembly ring or a cap.

[0018] In this context a circumferential sector is intended to mean a section of the rolled sheet where, after the rolling process, at least two layers of the sheet took a curved contour and are arranged basically in parallel or coaxial towards each other. Thus, each layer forms a wall of the double wall. Moreover, under the scope of the sector as circumferential not only strictly circumferential shapes but also oval or slightly bended shapes should apply. For simplicity the term circumferential is used in the following text.

[0019] In other words, in the rolled state at least two sections of the sheet overlap in basically circumferential direction of the rolled sheet. The circumferential section or the double wall section established after the freezing may have any circumferential length feasible for a person skilled in the art, like more than 90°, preferably more than 180° and most preferably more than 360°. For example, by rolling the sheet about 360° a single wall tube would be formed. By rolling the sheet about 450° a tubular structure would be reached where a circumferential section with a double wall of about 90° would be formed. Furthermore, by rolling the sheet about 720° the result would be a double wall of about 360°. In this case the first 360° would build an inner layer that surrounds a central passage of the channelling tube and the second 360° would build and outer layer radially restricting a circumferential 360° gap around the inner layer of the channelling tube and this the central passage. In case of a rolling of more than 720°, like 1080° or 1440° a circumferential section with tree walls or even four walls would be build, resulting in a multiwall structure. Thus, the rolled sheet or the resulting channelling tube would have a spiral shaped cross section, wherein the spiral would preferably be 720° or longer. In general, the greater the overlap the better the positive effects would be.

[0020] The used configuration would, for example, depend on the material used for the sheet, the radial distance adjusted between the layers of the rolled sheet (radial thickness of the resulting gap(s)), the dimensions of the channelling tube, the aerofoil or the cavity housing the channelling tube or the running properties of the turbine engine, like pressure or temperature. This would be selected from a person skilled in the art due to his knowledge in the field. Critical factors to be considered might be the integrity of the rolled sheet during the operation of the gas turbine engine, especially when subjected to temperature or pressure differences.

[0021] The extent of the resulting circumferential sector with the at least the double wall would of course be effected if there is a difference between the amount of overlap of the rolled sheet in the rolled state and the amount of overlap of the rolled sheet in the frozen state, like for example when the rolled sheet expands to a larger diameter after the rolling process and before the freezing. In this case the overlap would always be larger after in the rolled stated than in the frozen state. However, the given degrees of overlap above shout refer to the extent of overlap in the frozen state.

[0022] Preferably the method comprises the step of: rolling the sheet in such a way so that it is rolled in a tight configuration in which an outer diameter of at least a radially outermost layer of the rolled sheet is smaller than an outer diameter of at least a radially outermost layer of the rolled sheet in its frozen configuration. Thus, the sheet is rolled into a configuration where it can be assembled easily due to its smaller diameter.

[0023] In a further preferred embodiment of the invention the method comprises the step of: rolling the sheet over or around a centre tool, like a pin or a bar, in such a way so that it is rolled in a tight configuration in which an outer diameter of at least a radially outermost layer of the rolled sheet is smaller than an outer diameter of at least a radially outermost layer of the rolled sheet in its frozen configuration. Due to the centre tool the rolled sheet can be given a larger inner diameter than otherwise achievable. This centre tool is then removed, whilst the outer diameter of the rolled configuration remains unchanged. Moreover, the tightly rolled configuration can hold an expansion force to achieve the end configuration automatically. In case of this expansion the expansion occurred helically or spirally. Basically, all diameters of the spirally arranged layer would increase from a smaller diameter to a wider diameter. However, depending on the rolling force it would be also possible that only the outer layer(s) expand their diameter and the diameters of the inner layer(s) would be constant during the expansion process during assembly.

[0024] However, the diameter of all layers may change when the gas turbine engine is started and load is increasing, so does the pressure, leading to a movement in the spirally arranged layers outwards. When the gas turbines engine stops and the pressure decreases the movement is reversed. These effects may be prevented if the layers are fixed in their working configuration to the expansion stopping device (e.g. a cap) beforehand of the operation of the gas turbine engine, e.g. by welding or bracing (also see below).

[0025] The adjusted inner diameter may be locked into position to ensure the integrity of the central passage. For example a circumferential most inner end of the rolled sheet may be permanently attached to an adjacent next outer layer, e.g. by bracing or welding. Alternatively to the use of the centre tool, it may be possible to adjust the inner diameter by using a belt-like connection. Therefore, the end designed to be the circumferentially most inner end would have an elongated aperture through which the opposed end would be inserted. The sheet would comprise two radial locking slots at the circumferential position marking the desired inner diameter. The slots would engage with radial ends of the aperture at the circumferentially inner end to lock the inner diameter.

[0026] Beneficially, the method comprises the steps of: expanding the rolled sheet from its tight configuration and freezing the rolled sheet in its frozen configuration by at least a first expansion stopping device. Hence, the end configuration of the rolled sheet can be easily achieved. The expansion stopping device is preferably a radial expansion stopping device or radial restriction device.

[0027] As stated above, the expansion stopping device can be achieved by any method or be any means or device feasible skilled in the art. Suitable would be, for example, the attachment of the most radially arranged outer end of the sheet to the next innermost layer of the sheet by any attachment method (bracing, welding etc.). Further, the expansion stopping device may be at least one assembly ring in which the tightly rolled sheet is inserted beforehand of the expansion, wherein a radial abutment of the outer most layer with the ring would stop the expansion. After the expansion the frozen configuration might be further stabilised by additional attachment of sections of the rolled sheet to one another or by transferring the rolled sheet into (an) end fixture(s) for mounting the channelling tube in the aerofoil. Preferably, the expansion stopping device is the at least one end fixture for mounting the channelling tube in the aerofoil. Hence, further assembly steps may be omitted advantageously shortening the assembly process. The end fixture may be any device feasible for a person skilled in the art, like a ring, a clamp or a cap.

[0028] Preferably, the method comprises the step of: inserting the tightly rolled sheet beforehand of the expansion in at least a first expansion stopping device. Thus, the positioning in the first expansion stopping device can be done easily and the end configuration can be determined by the selected dimensions of the first expansion stopping device.

[0029] According to a further embodiment of the invention the method comprises the step of: equipping the sheet with at least one spacer. Due to this it can be ensured that a distance between the layers can be created to reduce heat transfer to radiation. In the best way of carrying out the invention substantially all of the cooling air flow would flow inside the most inner layer of the roll. This may be possible, for example if the layers (walls) are thin and the spaces (gap) between the layers are small. Moreover, the double wall structure or the gap between the layers of the rolled sheet can be held open. Hence, a collapsing of the gap along the spiral passage and thus a blockage of the flow passage for the cooling medium along the gap can be advantageously prevented. The spacer may be any structure feasible for a person skilled in the art, like a dimple or a rib (horizontal or vertical). Preferably, the spacer would be a dimple thus minimising a large metal to metal contact area between adjacent layers of the rolled sheet and further minimising are blocking effects. In case of the spacer embodied as a rib it should preferably be arranged in parallel to a centre line of the finished channelling tube. Moreover, to allow an air flow through the ribs (vertical) the ribs could be of a "dashed line type".

[0030] The spacer may be arranged in any feasible configuration or pattern at or on the sheet, e.g. in selected regions like a or the circumferential end(s) of the sheet or (homogeneously) all over the inner and/or outer surface of the sheet. The equipping of the sheet with the spacer(s) may be easily done using a pressing or punching technique to form the spacers. Thus, the spacer may be an embossment. Depending on the location of the spacer the equipping step can be done beforehand of the rolling or after the rolling/freezing of the sheet. To avoid inaccuracies or to achieve repeatable results it is preferred to do the equipping beforehand of the rolling.

[0031] The cooling medium entering the aerofoil needs to have a surplus pressure to reach its destination and there to cool or seal the component from hot gases. In other words, the pressure inside the channelling tube is higher than the pressure on the outside. Due to this pressure difference across the channelling tube wall the most inner circumferential end of the rolled sheet would tend to seal against the next outward layer. Thus, due to the pressure difference there is the need to secure a passage for the ventilation air. Thus, in a further realisation of the invention the method comprises the step of: equipping the sheet with at least one aperture. This aperture may be located at any region feasible for a person skilled in the art, but preferably it is positioned in such a way to allow cooling medium to enter and/or the exit the spiral passage or the gap of the rolled sheet; and hence at the circumferential inner and/or outer end of the rolled sheet. The aperture may be embodied in any way suitable for a person skilled in the art, like a hole (circular, oval, rectangular triangular etc.) or a corrugation that forms an aperture with an adjacent layer of the rolled sheet. In case of predrilled holes there is the need to drill them further away from the edge (circumferential end) to be clear of the layer below, to allow the cooling medium to flow.

[0032] It is also essential that the channelling tube is sealed such that the cooling medium it is transporting does not escape the gap. This can be done by attaching the outer most circumferential end of the rolled sheet to the adjacent radially next inner layer. Hence, the method comprises the step of: attaching at least one circumferential end (radially outer end) of the rolled sheet to a surface of the rolled sheet that is positioned radial inward to the at least one circumferential end (radially outer end). This step can be an additional step to the freezing (see above) or it can be the same action in which the frozen configuration is achieved by the attachment process.

[0033] Generally, it may be possible to achieve the attachment via a press or snap fit between the rolled sheet in its expanded configuration or its circumferential outer end (e.g. with corrugations), respectively, and the expansion stopping device. Moreover, it would be possible to use an additive manufacturing technique to build up the corrugation from metal powder.

[0034] Moreover, the method comprises the step of: attaching the at least first expansion stopping device to at least one axial end of the rolled sheet after the insertion of the rolled sheet in the at least first expansion stopping device and after the expansion of the rolled sheet. Hence, the rolled sheet is held securely in its expanded and rolled end configuration. The attachment is preferably done by welding or bracing. Preferably, a first and at least a second expansion stopping device are attached to at least one axial end of the rolled sheet. Moreover, due to thusly arranged expansion stopping deceives the main airflow through the channelling tube is ensured at all times. During assembly and in use in the gas turbine engine the channelling tube assembly may be subjected to forces from trying to bend the channelling tube or vibrations. If only relied on a spring force between the rolled sheet and the expansion stopping device, the integrity of the assembly may be jeopardised.

[0035] Preferably, the expansion stopping device is a cap. Since, only the location of the circumferential outer end of the rolled sheet is known, the rest of the spiral may vary in position. A cap would provide a sideways stability.

[0036] It would also be possible to brace the axial ends of the rolled sheet to a plane/flat washer, but offering a less stable assembly. If the aperture in the aerofoil platform has a "small" clearance and the channelling tube has been produced in an assembly fixture it would be possible to slide the channelling tube into position in the aerofoil. After that the aerofoil and the channelling tube can be made to rest on a washer that is then braced/welded to the channelling tube and aerofoil. The procedure is then repeated for the opposite side by turning the aerofoil upside down.

[0037] According to a further realisation of the invention, the method comprises the steps of: rolling the sheet, especially around a centre tool, in such a way so that it is rolled in a tight configuration in which an outer diameter of a radially outermost layer of the rolled sheet is smaller than an outer diameter of a radially outermost layer of the rolled sheet in its frozen configuration, inserting the rolled sheet in its tight configuration in at least a first expansion stopping device, expanding the rolled sheet from its tight configuration, freezing the rolled sheet in its frozen configuration by at least a first expansion stopping device, attaching at least one circumferential end of the rolled sheet in its frozen configuration to a surface of the rolled sheet that is positioned radial inward to the at least one circumferential end and attaching the at least first expansion stopping device to at least one axial end of the rolled sheet in its frozen configuration.

[0038] Hence, the method provides a channelling tube assembly that is manufactured easily and with low costs. Moreover, a state of the art turbine assembly can be easily retrofitted with such a channelling tube assembly. Furthermore, the heat transfer between the channelling tube and the aerofoil can be advantageously minimised.

[0039] The invention further refers to a use of a rolled sheet as a channelling tube and specifically, as a jumper tube.

[0040] The invention further relates to a channelling tube assembly for a turbine assembly comprising at least a channelling tube and at least a first freezing device.

[0041] It is proposed that the channelling tube is formed by a rolled sheet. Due to the inventive matter a channelling tube can be provided that has a multiple layered approach that utilises a single sheet to create both the main flow passage of the channelling tube and additional layers surrounding the main flow passage. An air gap is located between each layer. Each layer acts as a radiation shield, significantly reducing the total heat transfer between an aerofoil equipped with such a channelling tube and a channelling tube flow. For example, the use of a single radiation shield layer can divide the radiation heat transfer by half and thus the associated heat pickup of the channelling tube flow. As a general rule, for constant wall emissivity, the radiative heat transfer is reduced by a factor of $1/(N\_layers+1)$ for each layer. Hence, an excessive heat pickup in comparison with a standard design of the channelling tube especially by low channelling tube flow rates can be avoided. The invention is a simple modification to the standard design, thus saving costs and construction efforts. Further, an existing design may be retrofitted easily. Although some cooling flow is used to buffer the air gap cavity, the amount is only a fraction of that required to reduce the heat pickup of the standard design when excessive flow through the channelling tube is used to compensate.

[0042] As stated above, the channelling tube comprises a central passage and a gap extending at least partly in circumferential direction around the central passage. Thus, sufficient ventilation can be provided and the heat transfer between the channelling tube and the aerofoil can be advantageously minimised. In the embodiment with a 720° rolled sheet (see above) the first 360° of the sheet are the outer wall of the central passage as well as the inner wall of the gap. The second 360° of the sheet represent the outer wall of the circumferential gap. Thus, the gap is radially restricted by the inner and the outer walls.

[0043] Advantageously, the sheet is a thin metal sheet. Thus, the rolling can be executed easily. Moreover, a robust channelling tube can be provided. In this context, "thin" should be understood as with a thickness thicker than 0.2 millimetres (mm), preferably between 0.2 mm and 2 mm and most preferably about 0.3 mm and 0.75 mm. Due to the way the channelling tube is manufactured, the wall thickness would have to be smaller than the wall thickness used for a conventional channelling/jumper tube of the same diameter and length. This is due to the fact that a spring effect is wanted. In fact the inventive channelling tube will be stronger than a conventional tube due to its design.

[0044] The metal can be any metal or combination of metal or a metal alloy feasible for a person skilled in the art. Advantageously, the metal is for example stainless steel or nimonic. Furthermore, it would be possible to improve the invention by selecting specific materials or even paint/coat one side of the sheet for a more favourable radiative heat transfer.

[0045] The rolled sheet comprises two axial ends. Beneficially, the at least first expansion stopping device is positioned at at least one axial end. Hence, a span wise length of the channelling tube can be designed for further functions, like for the entry or exit of the cooling medium into the gap.

[0046] The expansion can be stopped especially effective, when the channelling tube assembly comprises at least a second expansion stopping device. Moreover, a homogeneous distribution of the expansion stopping forces can be provided when the first expansion stopping and the at least second expansion stopping device are arranged at opposed axial ends of the rolled sheet.

[0047] According to a further aspect of the invention the at least first expansion stopping device comprises a bottom with a solid part and at least one aperture. Thus, different parts of the expansion stopping device can have different functions. The solid part surrounds the at least one aperture. Preferably, the solid part covers the circumferential gap of the rolled sheet. Hence, a leakage of cooling medium at the axial ends of the rolled sheet can be avoided. Moreover, the at least one aperture is arranged at least partially flush with the central passage of the rolled sheet providing easy access for cooling air to travel the length of the channelling tube arrangement top cool adjacent regions, like the disc region. The expansion stopping device(s) e.g. embodied as caps, seal(s) the end of the spiral. They will be the interface with e.g. the platforms.

[0048] Alternatively, it would be possible to have at least one expansion stopping device that is used only for the expansion stop and during the freezing (e.g. welding/bracing the circumferential outer end to the adjacent layer). In other words, it is only an assembly fixture. Thereafter it would be removed and the rolled sheet would be positioned/installed in the turbine assembly or aerofoil, respectively, alone. After this instalment the axial ends would be added/sealed. To seal the ends *in-situ* in the aerofoil extra material may be added for machining on the aerofoil to a fixed dimension (corresponding to the length of the channelling tube).

[0049] As stated above, the rolled sheet comprises at least one embossment. Thus, selected means, like spacers or corrugations, can be easily added. These means can perform specific function, like ensuring unblocked ventilation or the entry/exit of cooling medium into the gap.

[0050] To provide a homogenous function of the means or embossment the rolled sheet comprises a plurality of embossments. Preferably, they are distributed evenly over at least one surface of the sheet. Preferably, the embodiments function is that of a spacer and to minimise metal to metal contact it is advantageously a dimple.

[0051] Alternatively or additionally, the embossment may be embodied as a corrugation. Such a corrugation e.g. positioned at the very edge of the sheet together with an adjacently arranged layer of the sheet can function as an entry or exit aperture. The corrugation provides the opening but can also function as a spacer to prevent collapsing of the gap e.g. at circumferential ends of the rolled sheet. The corrugation may be provided by punching appropriately sized dimples into a sheet and cutting the sheet so that the dimples are divided approximately in half, wherein the cutting edge will be a circumferential end of the sheet after the rolling. As a result, an inlet or outlet on the edge of the rolled up sheet is provided. This is dependent on in which direction the dimple was pressed, upwards or downwards. The "dimple" must at least cover the overlap between the edge of the sheet and the next layer. In other words, the "dimple" must exceed a contact area of the circumferential outer end and the adjacent most outer layer.

[0052] The rolled sheet comprises an inner end located at the radially most inner position of the rolled sheet and an outer end located at the radially most outer position of the rolled sheet. To allow cooling medium to enter or exit the channelling tube or its circumferential gap, respectively, the rolled sheet comprises at least one aperture positioned at the inner end of the sheet and/or wherein the rolled sheet comprises at least one aperture positioned at the outer end of the sheet.

[0053] As stated above, these apertures may be formed by the corrugation or it may be (a) drilled or punched hole(s). To vent out the whole volume of the gap the inlet and outlet apertures/holes are at opposite ends of the length of the channelling tube. Preferably, the apertures are drilled or punched in the correct positions (for the finished product) in the sheet before it is rolled. It might be also possible to drill apertures in the end surfaces (solid part of the bottom) of the expansion stopping device (cap).

[0054] The invention further relates to a turbine assembly comprising at least one channelling tube assembly with a channelling tube and at least one freezing device.

[0055] It is proposed that the channelling tube is formed by a rolled sheet. Due to the inventive matter a channelling tube can be provided that has a multiple layered approach that utilises a single sheet to create both the main flow passage of the channelling tube and additional layers surrounding the main flow passage. An air gap is located between each layer. Each layer acts as a radiation shield, significantly reducing the total heat transfer between an aerofoil equipped with such a channelling tube and a channelling tube flow. For example, the use of a single radiation shield layer can divide the radiation heat transfer by half and thus the associated heat pickup of the channelling tube flow. As a general rule, for constant wall emissivity, the radiative heat transfer is reduced by a factor of 1/(N_layers+1) for each layer. Hence, an excessive heat pickup in comparison with a standard design of the channelling tube especially by low channelling tube flow rates can be avoided. The invention is a simple modification to the standard design, thus saving costs and construction efforts. Further, an existing design may be retrofitted easily. Although some cooling flow is used to buffer the air gap cavity, the amount is only a fraction of that required to reduce the heat pickup of the standard design when excessive flow through the channelling tube is used to compensate.

[0056] In this context a freezing device is intended to mean any device or effect that triggered or assures the frozen state of the rolled sheet. In this case the freezing device is the expansion stopping device. It is also possible that the freezing device is a further means in addition to the expansion stopping device, like a material property or an external impulse acting on the rolled sheet.

[0057] In a further realisation of the invention the turbine assembly comprises a basically hollow aerofoil with at least one cavity spanning the aerofoil in span wise direction of the aerofoil and housing at least one channelling tube assembly with a channelling tube comprising a central passage and a gap extending at least partly in circumferential direction around the central passage, wherein the rolled sheet comprises an inner end located at the radially most inner position of the rolled sheet and an outer end located at the radially most outer position of the rolled sheet and/or wherein the rolled sheet comprises at least one entry aperture positioned at the radially inner end of the sheet to allowing cooling medium to enter from the central passage into the gap and/or wherein the rolled sheet comprises at least one exit aperture positioned at the radially outer end of the sheet to allow the cooling medium to exit the gap.

[0058] According to this a proper venting of the gap can be provided. Moreover, the heat transfer between the channelling tube and the aerofoil can be advantageously minimised.

[0059] In this context a "basically hollow aerofoil" means an aerofoil with a casing, wherein the casing encases at least one cavity. A structure, like a rip, which divides different cavities in the aerofoil from one another and for example extends in a span wise direction of the aerofoil, does not hinder the definition of "a basically hollow aerofoil". Preferably, the aerofoil is hollow. In particular, the basically hollow aerofoil, referred as aerofoil in the following description, has two cooling regions, a channelling cooling region at a leading edge of the aerofoil and a state of the art pin-fin/pedestal cooling region at the trailing edge. These regions could be separated from one another through a rip.

[0060] The aerofoil assembly further comprises outer platform and an inner platform, each comprising at least one cavity, which are in flow communication with each other over the central passage of the channelling tube. Each platform preferably comprises at least one wall segment being arranged basically perpendicular to the span wise direction of the aerofoil, wherein the wall segments of the platforms are arranged at opposite ends of the aerofoil and basically in parallel towards each other. A wall segment is intended to mean a region of the turbine assembly which confines at least a part of a cavity and in particular, a cavity of the aerofoil. Moreover, the wall segment comprises an aperture that provides access to the cavity of the aerofoil and may partially cover this cavity. Further, the inserted channelling tube may at least span a part of the aperture in span wise direction.

[0061] In the scope of an arrangement of the wall segment as "basically perpendicular" to a span wise direction should also lie a divergence of the wall segment in respect to the span wise direction of about 30°. Preferably, the wall segment is arranged perpendicular to the span wise direction. Moreover, a "basically parallel arrangement" is intended to mean a divergence of the arrangement of the wall segments in respect to each other of about 30° from their strictly parallel arrangement. A span wise direction of the aerofoil is defined as a direction extending basically perpendicular, preferably perpendicular, to a direction from the leading edge to the trailing edge of the aerofoil.

[0062] In this context a cavity of the platform is intended to mean an at least at two , preferably four sides enclosed space that is radially encased at at least one radial side from the platform or its wall segment. An opposed radial side may for example be restricted by a casing, like a casing of the turbine engine in which the turbine assembly is mounted. A flow communication through slots or apertures in the side wall, the casing or between them should not hinder the meaning of enclosed or encased.

[0063] The channelling tube may be arranged in the cavity of the aerofoil with a clearance between the most outer layer of the tube and an inner surface of the cavity. The channelling tube may be arranged coaxially with a cavity axis or it may be arranged off centre in respect to the axis. In other words, as long as the minimum distance is exceeded the distance between the aerofoil wall and the channelling tube does not have to be equal around its circumference. Moreover, the clearance may extend all around an outer contour, preferably the circumference, of the channelling tube preventing contact of the tube with the cavity wall and minimising heat transfer to the aerofoil.

[0064] The cooling medium entering the gap or spiral of the channelling tube is only a minor fraction and/or less than 10% of the cooling medium entering the channelling tube from the cavity of the platform. The purpose of the cooling medium traveling the gap is to vent away the radiative heat transfer or rather heat flux. The needed amount of cooling medium entering and traveling the gap will for example depend on the used methods of the aerofoil and/or the channelling tube. Thus, the heat flux may e.g. occur between two metal surfaces or a metal and a ceramic surface (coating of the channelling tube). In case of a ceramic surface and the low thermal conductivity of a ceramic would significantly lower the need for the purge flow and would for example be less than 2%. Thus, the gap provides a by-pass for cooling medium in respect to the main cooling flow along the channelling tube. The main flow of cooling medium is intended for cooling of the disc region and surrounding regions.

[0065] The entry or exit apertures into the spiral gap may be positioned directly adjacent to the outer and/or inner platform. The phrasing "directly adjacent" should be understood as in near proximity Moreover, the exits occur directly adjacent to the wall segments of the outer and the inner platform, respectively. Furthermore, the flow of cooling medium exits the gap or the clearance around the channelling tube into the gas path and especially away from the disc to be cooled.

[0066] Advantageously, the aerofoil comprises a single cavity. But the invention could also be realized for an aerofoil comprising two or more cavities e.g. each of them accommodating at least one channelling tube and/or being a cavity as a part of the fin-pin/pedestal cooling region.

[0067] Preferably, a cooling flow of the cooling medium flowing in span wise direction and spirally along the gap provides an insulation for the channelling tube to prevent a heat transfer between the channelling tube and the cavity wall of the aerofoil. Hence, heat pickup of the channelling tube flow can be minimised by using a buffer layer of cooling air to shield the channelling tube effectively. The temperature rise of the channelling tube flow can be adjusted by varying the amount of flow through the buffer cavity.

[0068] In a further advantageous embodiment at least 80% preferably at least 90% and most preferably at least 95% of a span wise length of the gap are travelled by the cooling medium. This ensures a proper insulation of the channelling tube. The metal temperature of the aerofoil may vary along the span wise length and the higher the temperature the more important the insulation effect. Hence, a proper insulation effect preferably along the whole span wise length will be most beneficial.

[0069] To provide an exit for the cooling medium travelling the spiral and if provided the clearance around the channelling tube the cavity wall of the aerofoil or at least one of the platforms comprises at least one aperture. Consequently, the discharged cooling medium can be directed away from the disc region to be cooled by the main cooling flow through the channelling tube. This aperture may be positioned at any suitable location of the aerofoil or platform, preferably it is near the exit aperture of the spiral to minimize travelling distances or to avoid turbulences.

[0070] The aerofoil comprises a suction side and a pressure side, wherein the aperture for the exit of the cooling medium from the aerofoil assembly directs the cooling flow of the cooling medium in direction of the pressure side. Consequently, the cooling medium exits the aerofoil at the pressure side. Due to this, the cooling flow will exit at a location of the aerofoil where the highest heat transfer will be present. This is caused by the so-called secondary flow effect where the main gas flow passing between the adjacent aerofoils also rotates, moving along the wall of one aerofoil to the opposite aerofoil. Moreover, since an aerofoil surface at the pressure side has a larger region it is able to discard the flow with less aerodynamic loss. In turn, a suction side flow must be discarded towards the leading edge before the throat region.

[0071] As stated above, the aerofoil comprises a leading edge and a trailing edge. A sufficient flow of cooling medium for the cooling of the disc region can be provided, when the channelling tube is arranged near the leading edge. Since, the leading edge has a relatively large cross section in comparison with other regions of the aerofoil, a low pressure drop can be provided in the channelling tube. This results in a low velocity of the cooling medium traveling the channelling tube. Furthermore, the low velocity creates low convective heat transfer inside the channelling tube, helping to minimise the heat pick up.

[0072] In a further advantageous embodiment the aerofoil is a turbine blade or vane, and especially a nozzle guide vane.

Brief Description of the Drawings

[0073] The above mentioned attributes and other features and advantages of this invention and the manner of attaining them will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein

FIG 1: shows a schematically and sectional view of a gas turbine engine comprising several inventive turbine assemblies,

FIG 2: shows a perspective view of a turbine assembly with a channelling tube assembly inserted into an aerofoil of the gas turbine engine of FIG 1,

FIG 3: shows a cross section through the turbine assembly and the channelling tube assembly along line III-III in FIG 2,

FIG 4: shows a sheet beforehand of the manufacturing of the channelling tube assembly shown in FIG 3,

FIG 5 shows a side view of the sheet from FIG 4 in its tightly rolled state,

FIG 6: shows a top view of the sheet from FIG 4 in its tightly rolled state,

FIG 7: shows two expansion stopping devices and the rolled sheet from FIG 5 and 6 beforehand of assembly,

FIG 8: shows a top view of an expansion stopping devices from FIG 7,

FIG 9: shows a bottom view of an expansion stopping devices from FIG 7,

FIG 10: shows in a side view the channelling tube assembly from FIG 3 in an assembled state,

FIG 11: shows a cross section through the channelling tube assembly along line XI-XI in FIG 10,

FIG 12: shows a cross section along line XII-XII in FIG 3,

FIG 13: shows a cross section along line XIII-XIII in FIG 3 depicting an aperture in a cavity wall of an aerofoil of the turbine assembly from FIG 2,

FIG 14: shows an alternatively embodied sheet with inserted spacers in a top view,

FIG 15: shows an alternatively embodied sheet with inserted corrugations in a side view and

FIG 16: shows the sheet from FIG 15 assembled in an alternative channelling tube assembly.

Detailed Description of the Illustrated Embodiments

[0074] The present invention is described with reference to the above exemplary turbine engine having a single shaft or spool connecting a single, multi-stage compressor and a single, one or more stage turbine. However, it should be appreciated that the present invention is equally applicable to two or three shaft engines and which can be used for industrial, aero or marine applications. In the present description, reference will only be made to a vane, for the sake of simplicity, but it is to be understood that the invention is applicable to both blades and vanes of a turbine engine. The terms upstream and downstream refer to the flow direction of the airflow and/or working gas flow through the engine 70 unless otherwise stated. The terms forward and rearward refer to the general flow of gas through the engine 70. If used in context to the engine 70, the terms axial, radial and circumferential are made with reference to a rotational axis 80 of the engine 70.

[0075] FIG 1 shows an example of a gas turbine engine 70 in a sectional view. The gas turbine engine 70 comprises, in flow series, an inlet 72, a compressor section 74, a combustion section 76 and a turbine section 78, which are generally arranged in flow series and generally in the direction of a longitudinal or rotational axis 80. The gas turbine engine 70 further comprises a shaft 82 which is rotatable about the rotational axis 80 and which extends longitudinally through the gas turbine engine 70. The shaft 82 drivingly connects the turbine section 78 to the compressor section 74.

[0076] In operation of the gas turbine engine 70, air 84, which is taken in through the air inlet 72 is compressed by the compressor section 74 and delivered to the combustion section or burner section 76. The burner section 76 comprises a burner plenum 86, one or more combustion chambers 88 defined by a double wall can 90 and at least one burner 92 fixed to each combustion chamber 88. The combustion chambers 88 and the burners 92 are located inside the burner plenum 86. The compressed air passing through the compressor section 74 enters a diffuser 94 and is discharged from the diffuser 94 into the burner plenum 86 from where a portion of the air enters the burner 92 and is mixed with a gaseous or liquid fuel. The air/fuel mixture is then burned and the combustion gas 96 or working gas from the combustion is channelled to the turbine section 78 via a transition duct 98.

[0077] This exemplary gas turbine engine 70 has a cannular combustor section arrangement 76, which is constituted by an annular array of combustor cans 90 each having the burner 92 and the combustion chamber 88, the transition duct 98 has a generally circular inlet that interfaces with the combustor chamber 88 and an outlet in the form of an annular segment. An annular array of transition duct outlets form an annulus for channelling the combustion gases 96 to the turbine section 78.

[0078] The turbine section 78 comprises a number of blade carrying discs 100 or turbine wheels 102 attached to the shaft 82. In the present example, the turbine section 78 comprises two discs 100 each carry an annular array of turbine assemblies 14, which each comprises an aerofoil 62 embodied as a turbine blade. However, the number of blade carrying discs 100 could be different, i.e. only one disc 100 or more than two discs 100. In addition, turbine cascades 104 are disposed between the turbine blades. Each turbine cascade 104 carries an annular array of turbine assemblies 14, which each comprises an aerofoil 62 in the form of guiding vanes, which are fixed to a stator 106 of the gas turbine engine 70. Between the exit of the combustion chamber 88 and the leading turbine blades inlet guiding vanes or nozzle guide vanes 108 are provided and turn the flow of working gas 96 onto the turbine blades.

[0079] The combustion gas 96 from the combustion chamber 88 enters the turbine section 68 and drives the turbine blades which in turn rotate the shaft 82. The guiding vanes 108 serve to optimise the angle of the combustion or working gas 96 on to the turbine blades. The turbine section 78 drives the compressor section 74.

[0080] The compressor section 74 comprises an axial series of guide vane stages 110 and rotor blade stages 112 with turbine assemblies 14 comprising aerofoils 62 or turbine blades or vanes, respectively. The rotor blade stages 112 comprise a rotor disc supporting an annular array of blades. The compressor section 74 also comprises a stationary casing 114 that surrounds the rotor stages 112 and supports the vane stages 110. The guide vane stages 110 include an annular array of radially extending vanes that are mounted to the casing 114. The vanes are provided to present gas flow at an optimal angle for the blades at a given engine operational point. Some of the guide vane stages 110 have variable vanes, where the angle of the vanes, about their own longitudinal axis, can be adjusted for angle according to air flow characteristics that can occur at different engine operations conditions

[0081] The casing 114 defines a radially outer surface 116 of the passage 118 of the compressor section 74. A radially inner surface 120 of the passage 118 is at least partly defined by a rotor drum 122 of the rotor which is partly defined by the annular array of blades.

[0082] FIG 2 shows in a perspective view a turbine assembly 14 of the gas turbine engine 70. The turbine assembly 14 comprises a basically hollow aerofoil 62, embodied as a nozzle guide vane 108, with two cooling regions, specifically, an channelling cooling region 124 and a fin-pin/pedestal cooling region 126. The former is located at a leading edge 128 and the latter at a trailing edge 130 of the aerofoil 62. At opposed ends 132, 132' of the aerofoil 62 an outer platform 134 and an inner platform 134' are arranged. The outer and the inner platform 134, 134' both comprise a wall segment 136, 136' which are oriented basically perpendicular to a span wise direction 66 of the aerofoil 62. Each wall segment 136, 136' has an insertion aperture 138 which provides access to the aerofoil 62 (only the insertion aperture of wall segment 136 could be seen in FIG 3). In a circumferential direction 140 of a not shown turbine wheel several aerofoils 62 could be arranged, wherein all aerofoils 62 where connected through the inner and the outer platforms 134, 134' with one another.

[0083] A casing 142 of the aerofoil 62 comprises or forms a cavity 64 spanning the aerofoil 62 in span wise direction 66, wherein the cavity 64 is located in the region of the leading edge 128. Via the insertion aperture 138 is a channelling tube arrangement 12 inserted inside the cavity 64 for cooling purpose.

[0084] As could be seen in FIG 3 that shows a cross section of the turbine assembly 14 along line III-III in FIG 2, the outer platform 134 and the inner platform 134' each comprises at least one cavity 144, 144'. This cavity 144, 144' either extends between the wall segment 136 of the outer platform 134 and the outer casing 114 of the gas turbine engine 70 or the wall segment 136' of the inner platform 134'2 and an inner casing 114' of the gas turbine engine 70. Moreover, the cavities 134, 134" are in flow communication with each other over a channelling tube 10 of a channelling tube arrangement 12.

[0085] The channelling tube arrangement 12 is inserted via the insertion aperture 138 into the cavity 64 of the aerofoil 62. The channelling tube 10 extends in span wise direction 66 along a whole length 1 of the cavity 64 of the aerofoil 62. Further, during an operation of the turbine assembly 14 the channelling tube 10 provides a flow path for a flow of a cooling medium 68, like air, from the cavity 144 of the outer platform 134 to the cavity 144' of the inner platform 134' where the cooling medium 68 exits into the gas path to cool a part of a aerofoil assembly, like a disc 100 in a disc region of adjacently arranged turbine blades (not shown in detail).

[0086] Moreover, the channelling tube 10 is arranged in the cavity 64 of the aerofoil 62 in such a way that a circumferential clearance 146 is formed between an outer surface 148 of the channelling tube 10 and an inner surface 150 of a cavity wall 152 of the cavity 64 of the aerofoil 62 (see also FIG 12 and 13).

[0087] The channelling tube assembly 12 comprises the channelling tube 10 and several expansion stopping devices 26, 26', 28 or freezing devices 26, 26', 28. The channelling tube 10 is formed by a rolled sheet 16 (see also FIG 12 and 13).

[0088] A method for assembling or manufacture the a channelling tube 10 and the channelling tube arrangement 12 will be described in the following passages in reference to FIG 4 to 11.

[0089] As could be seen in FIG 4 the assembling process starts with a thin, flat metal sheet 16, for example, made out of stainless steel. The sheet 16 is designed to be the channelling tube 10. This sheet 16 has e.g. a thickness of 0.4 mm. Moreover, it has for example a rectangular shape and its horizontal length L is longer than its vertical length 1, wherein the vertical length 1 is basically the span of the aerofoil 62. The horizontal ends of the sheet 16 are equipped each with at least one aperture 32 (one aperture 32 for each side is shown in bold lines and additional optional apertures are shown in dashed lines in FIG 4). The apertures 32 may for example be drilled into the sheet 16.

[0090] In a rolled state of the sheet 16 the end of the sheet 16 shown on the left hand side of FIG 4 will be a radially inner end 56 located at the radially most inner position of the rolled sheet 16 and the end shown on the right hand side will be a radially outer end 34 located at the radially most outer position of the rolled sheet 16.

[0091] In the next step the sheet 16 is rolled into a tight configuration, coil or spiral. This is shown in FIG 5 and 6, which show a side and top view of the sheet 16 in its tightly rolled state. The sheet is rolled around a centre tool in the form of a pin to limit an inner diameter of the spiral or to ensure a desired inner diameter of a central passage 42 (see below). The rolling is done in such a way so that it is rolled in a tight configuration in which an outer diameter d of a radially outermost layer 22 of the rolled sheet 16 is smaller than an outer diameter D of a radially outermost layer 24 of the rolled sheet 16 in its frozen configuration (compare FIG 6 and 11).

[0092] Subsequently, the tightly rolled sheet 16 is inserted in two expansion stopping devices 26, 26'. This is shown in FIG 7 that shows the two expansion stopping devices 26, 26' and the rolled sheet 16 beforehand of their assembly. The expansion stopping devices 26, 26' are positioned at opposed axial ends 38, 40 of the rolled sheet 16.

[0093] As can be seen in FIG 8 and 9 that show a top and bottom view of one expansion stopping device 26 the expansion stopping device 26 is embodied as a cap with a ring segment 154 and a bottom 48 arranged basically perpendicular to the ring segment 154. The bottom 48 comprises a solid part 50 and an aperture 52 that is surrounded by the aperture.

[0094] In the next step the tightly rolled sheet 16 will be expanded and it expands spirally. Due to the expansion stopping devices 26, 26' the rolled sheet 16 will be frozen in its expanded state which is the frozen configuration. This configuration is basically shown in FIG 10 that shows the channelling tube assembly 12 in a side view in an assembled state.

[0095] To ensure an controlled exit of the cooling medium 68 from the channelling tube 10 in the following step the circumferential most outer end 34 of the rolled sheet 16 in its frozen configuration is attached, e.g. by welding or bracing a connection seam 156, to a surface 36 of the rolled sheet 16 that is positioned radial inward to the circumferential end 34. Due to the attachment or the connecting seam 156 a further expansion stopping device 28 is formed. Moreover, to secure the expansion stopping devices 26, 26' they are attached, e.g. by welding or bracing a connection seam 156, to the axial ends 38, 40 of the rolled sheet 16 in its frozen configuration.

[0096] As can be seen in FIG 11 that shows a cross section through the channelling tube assembly 12 along line XI-XI in FIG 10 the expanded rolled sheet 16 or the channelling tube 10 in its frozen configuration comprises a central passage 42 and a spiral gap 44 extending in circumferential direction 46 around the central passage 42 (Expansion stopping device 26' is not shown in FIG 11). The central passage 42 is surrounded by the first 360° stretch of the rolled sheet 16 or inner layer 158. The most outer layer 22 has the wide expansion diameter D and surrounds the last 360° stretch of the gap 44.

[0097] Hence, the channelling tube 10 or the rolled sheet 16 is frozen in a configuration in that a circumferential sector 18 of the channelling tube 10 forms at least one double wall 20. In the shown exemplary embodiment a quadruple wall is formed.

[0098] The dimensions are for example selected in such that the rolled sheet 16 or the spiral would only take up about 50% to 20% of the diameter D. Consequently, the central passage 42 would take about 50% to 80% of the diameter D.

[0099] The arrangement of the expansion stopping devices 26, 26' in respect to the rolled sheet 16 is in such a way so that the solid part 50 of the bottom 48 covers the circumferential gap 44 of the rolled sheet 16 and the aperture 52 is arranged flush with the central passage 42 of the rolled sheet 16 (not shown in detail).

[0100] Not specifically shown in FIG 10 and 11 are the apertures 32 to allow the cooling medium 68 to enter the gap 44 from the central passage 42. However, in an assembled state in the aerofoil 62 the aperture 32 at the inner end 56 will be an entry aperture 58 to allowing cooling medium 68 to enter from the central passage 42 into the gap 44 and the outer end 34 will be an exit aperture 60 to allow the cooling medium 68 to exit the gap 44.

[0101] Generally, these apertures 58, 60 can be arranged at any span wise position at the circumferential ends 34, 56. Most beneficially, would for example be the positioning of the entry aperture 58 near the upper expansion stopping device 26 and the exit aperture near the lower expansion stopping device 26'. In an assembled state the entry would occur near the outer platform 134 and the exit near the inner platform 134'. As stated above also more than one aperture for entry or exit can be provided. For better presentability of the channelling tube 10 and its positioning in cavity 64 the rolled sheet 16 shown in FIG 3 is only shown with a double wall design.

[0102] Thus, with reference to FIG 3, the entry aperture 58 may be arranged in flow direction of the cooling medium 68 at a radial beginning of the clearance 146 or directly adjacent to the wall segment 136 of the outer platform 134. This allows a fraction 160 of the cooling medium 68 access into the gap 44. Further, to allow the cooling medium 68 to exit the gap 44 the exit aperture 60 is arranged near the inner platform 134' (The actual location of the aperture 60 is not shown in FIG 3, but a slightly circumferentially off-set position to depict its basic location. Aperture 60 would be located with a circumferential distance from end 34 and the connecting seam 156.). Further, to allow the cooling medium 68 to exit from the clearance 146 and the aerofoil 62 the cavity wall 152 of the aerofoil 62 comprises an aperture 162 arranged in flow direction of the cooling medium 68 e.g. at a radial end of the clearance or directly adjacent to the inner platform 134' or its wall segment 136'.

[0103] Alternatively or additionally, the wall segment 136' of the inner platform 134' may comprise an aperture 162', what is shown in dashed lines in FIG 3.

[0104] The positioning of the channelling tube 10 in the aerofoil 62 can be seen in FIG 12 that shows a cross section along line XII-XII in FIG 3. Further, the positioning of aperture 162 in the cavity wall 152 can be seen in FIG 13 that shows a cross section along line XIII-XIII in FIG 3. The aperture 162 in the cavity wall 152 directs the cooling flow of the cooling medium in direction of a pressure side 164 of the aerofoil 62 opposed arranged to the suction side 166.

[0105] The method for cooling the part 10, specifically the disc 100 of a turbine assembly 14 with the cooling medium 68 will be explained in the following text with respect to FIG 3.

[0106] Cooling medium 68 flows from the cavity 144 of the outer platform 134 into the central passage 42 of the channelling tube 10. A fraction 160 of the cooling medium 68 exits the channelling tube 10 through the entry aperture 58 and enters the gap 44. Inside the gap 44 the cooling medium 68 travels along the spiral as well as in span wise direction 66. However, the general direction is still the flow in span wise direction 66 from the outer platform 134 in direction to the inner platform 134'. Adjacent of the inner platform 134' the cooling medium 68 exits the gap 44 through exit aperture 60 into clearance 146 and from there through the aperture 162 in the cavity wall 152 of the aerofoil 62 to be exhausted into a flow path of a flow medium of the gas turbine engine 70.

[0107] The cooling flow 38 of the cooling medium 68 established long the gap 44 provides insulation for the channelling tube 10 to prevent a heat transfer between the channelling tube 10 and the cavity wall 152 of the aerofoil 62.

[0108] A main fraction 168 of cooling medium 68 travels the central passage 42 of the channelling tube 10 along a whole span of the aerofoil 62 and exits into the cavity 144' of the inner platform 134'. From there it is exhausted in such a way that it cools the disc 100 of up- and downstream arranged discs 100 of adjacent turbine wheels.

[0109] In FIG 14 to 16 alternative embodiments of the sheet 16 and the channelling tube assembly 12 are shown. Components, features and functions that remain identical are in principle substantially denoted by the same reference characters. To distinguish between the embodiments, however, the letter "a" and "b" has been added to the different reference characters of the embodiment in FIG 14 to 16. The following description is confined substantially to the differences from the embodiment in FIG 1 to 13, wherein with regard to components, features and functions that remain identical reference may be made to the description of the embodiment in FIG 1 to 13.

[0110] FIG 14 shows an alternatively embodied sheet 16a. The sheet 16a is equipped with spacers 30. The spacers 30 are imprinted embossments 54. In the rolled state of the sheet 16a the spacers 30 span the gap of the channelling tube from one layer to an adjacent layer 22, 24, 158 to ensure an unhindered flow of cooling medium and an integrity of a gap.

[0111] FIG 15 and 16 show a further alternatively embodied sheet 16b and an alternative channelling tube assembly 12b. The sheet 16b is equipped with embossments 54 in the form of a corrugation 170. The corrugation 170 is inserted at a circumferentially most outer end 34 of the rolled sheet 16b. The corrugation 170 together with an adjacent surface 36 of a most outer layer 24 of the rolled sheet 16b form an exit aperture 60 for cooling medium to exit the channelling tube 10. Sections of end 34 positioned vertically between the apertures 60 are attached (braced/welded) to surface 36.

[0112] 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.

[0113] Although the invention is illustrated and described in detail by the preferred embodiments, the invention is not limited by the examples disclosed, and other variations can be derived therefrom by a person skilled in the art without departing from the scope of the invention.

Claims

1. A method for assembling a channelling tube (10) of a channelling tube assembly (12, 12b) of a turbine assembly (14), characterised at least in the steps of:

   - rolling a sheet (16, 16a, 16b) designed to be the channelling tube (10) and
   - freezing the rolled sheet (16, 16a, 16b) in a configuration so that in a frozen configuration of the rolled sheet (16, 16a, 16b) a circumferential sector (18) of the channelling tube (10) forms at least one double wall (20).

2. A method according to claim 1, wherein the method comprises the step of: - rolling the sheet (16, 16a, 16b) in such a way so that it is rolled in a tight configuration in which an outer diameter (d) of at least a radially outermost layer (22) of the rolled sheet (16, 16a, 16b) is smaller than an outer diameter (D) of at least a radially outermost layer (24) of the rolled sheet (16, 16a, 16b) in its frozen configuration and specifically, - rolling the sheet (16, 16a, 16b) around a centre tool (172) in such a way so that it is rolled in a tight configuration in which an outer diameter (d) of at least a radially outermost layer (22) of the rolled sheet (16, 16a, 16b) is smaller than an outer diameter (D) of at least a radially outermost layer (24) of the rolled sheet (16, 16a, 16b) in its frozen configuration.

3. A method according to claim 2, wherein the method comprises the steps of: - expanding the rolled sheet (16, 16a, 16b) from its tight configuration and

   - freezing the rolled sheet (16, 16a, 16b) in its frozen configuration by at least a first expansion stopping device (26, 26'; 28).

4. A method according to any one of the proceeding claims, wherein the method comprises the step of: - equipping the sheet (16, 16a, 16b) with at least one spacer (30) and/or at least one aperture (32).

5. A method according to any one of the proceeding claims, wherein the method comprises the step of: - attaching at least one circumferential end (34) of the rolled sheet (16, 16a, 16b) to a surface (36) of the rolled sheet (16, 16a, 16b) that is positioned radial inward to the at least one circumferential end (34).

6. A method according to any one of the proceeding claims, wherein the method comprises the steps of:

   - rolling the sheet (16, 16a, 16b), especially around a centre tool (172), in such a way so that it is rolled in a tight configuration in which an outer diameter (d) of a radially outermost layer (22) of the rolled sheet (16, 16a, 16b) is smaller than an outer diameter (D) of a radially outermost layer (24) of the rolled sheet (16, 16a, 16b) in its frozen configuration,
   - inserting the rolled sheet (16, 16a, 16b) in its tight configuration in at least a first expansion stopping device (26, 26'),
   - expanding the rolled sheet (16, 16a, 16b) from its tight configuration,
   - freezing the rolled sheet (16, 16a, 16b) in its frozen configuration by at least a first expansion stopping device (26, 26'; 28),
   - attaching at least one circumferential end (34) of the rolled sheet (16, 16a, 16b) in its frozen configuration to a surface (36) of the rolled sheet (16, 16a, 16b) that is positioned radial inward to the at least one circumferential end (34) and
   - attaching the at least first expansion stopping device (26, 26') to at least one axial end (38, 40) of the rolled sheet (16, 16a, 16b) in its frozen configuration.

7. Channelling tube assembly (12, 12b) for a turbine assembly (14) comprising at least a channelling tube (10) and at least a first freezing device (26, 26'; 28), **characterised in that** the channelling tube (10) is formed by a rolled sheet (16, 16a, 16b).

8. A channelling tube assembly according to claim 7, wherein the channelling tube (10) comprises a central passage (42) and a gap (44) extending at least partly in circumferential direction (46) around the central passage (42).

9. A channelling tube assembly according to claim 7 or 8, wherein the sheet (16, 16a, 16b) is a thin metal sheet (16, 16a, 16b).

10. A channelling tube assembly according to any one of the proceeding claim 7 to 9, wherein the rolled sheet (16, 16a, 16b) comprises two axial ends (38, 40) and wherein the at least first expansion stopping device (26, 26') is positioned at at least one axial end (38, 40).

11. A channelling tube assembly according to claim 10, wherein the at least first expansion stopping device (26, 26') comprises a bottom (48) with a solid part (50) and at least one aperture (52), and/or wherein the solid part (50) covers the circumferential gap (44) of the rolled sheet (16, 16a, 16b) and/or wherein the at least one aperture (52) is arranged at least partially flush with the central passage (42) of the rolled sheet (16, 16a, 16b).

12. A channelling tube assembly according to any one of the proceeding claims 7 to 11, wherein the rolled sheet (16a, 16b) comprises at least one embossment (54).

13. A channelling tube assembly according to any one of the proceeding claims 7 to 12, wherein the rolled sheet (16, 16a, 16b) comprises an inner end (56) located at the radially most inner position of the rolled sheet (16, 16a, 16b) and an outer end (34) located at the radially most outer position of the rolled sheet (16, 16a, 16b) and wherein the rolled sheet (16, 16a, 16b) comprises at least one aperture (58) positioned at the inner end (56) of the sheet (16, 16a, 16b) and/or wherein the rolled sheet (16, 16a, 16b) comprises at least one aperture (60) positioned at the outer end (34) of the sheet (16, 16a, 16b).

14. A turbine assembly (14) comprising at least one channelling tube assembly (12, 12b) with a channelling tube (10) and at least one freezing device (26, 26'; 28), **characterised in that** the channelling tube (10) is formed by a rolled sheet (16, 16a, 16b).

15. A turbine assembly according to claim 14, **characterised by** a basically hollow aerofoil (62) with at least one cavity (64) spanning the aerofoil (62) in span wise direction (66) of the aerofoil (62) and housing at least one channelling tube assembly (12, 12b) with a channelling tube (10) comprising a central passage (42) and a gap (44) extending at least partly in circumferential direction (46) around the central passage (42), wherein the rolled sheet (16, 16a, 16b) comprises an inner end (56) located at the radially most inner position of the rolled sheet (16, 16a, 16b) and an outer end (34) located at the radially most outer position of the rolled sheet (16, 16a, 16b) and/or wherein the rolled sheet (16, 16a, 16b) comprises at least one entry aperture (58) positioned at the radially inner end (56) of the sheet (16, 16a, 16b) to allowing cooling medium (68) to enter from the central passage (42) into the gap (44) and/or wherein the rolled sheet (16, 16a, 16b) comprises at least one exit aperture (60) positioned at the radially outer end (34) of the sheet (16, 16a, 16b) to allow the cooling medium (68) to exit the gap (44).

FIG 1

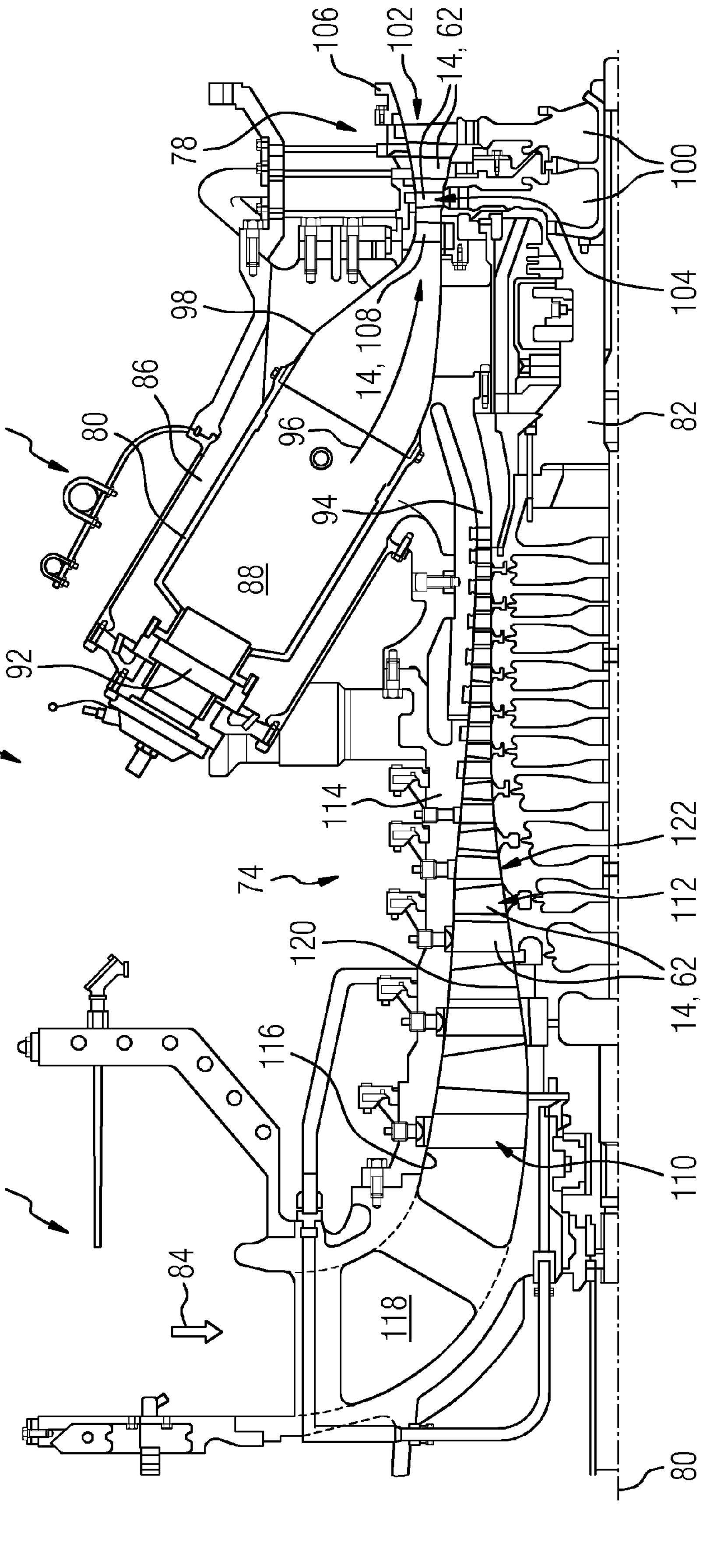

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FIG 2

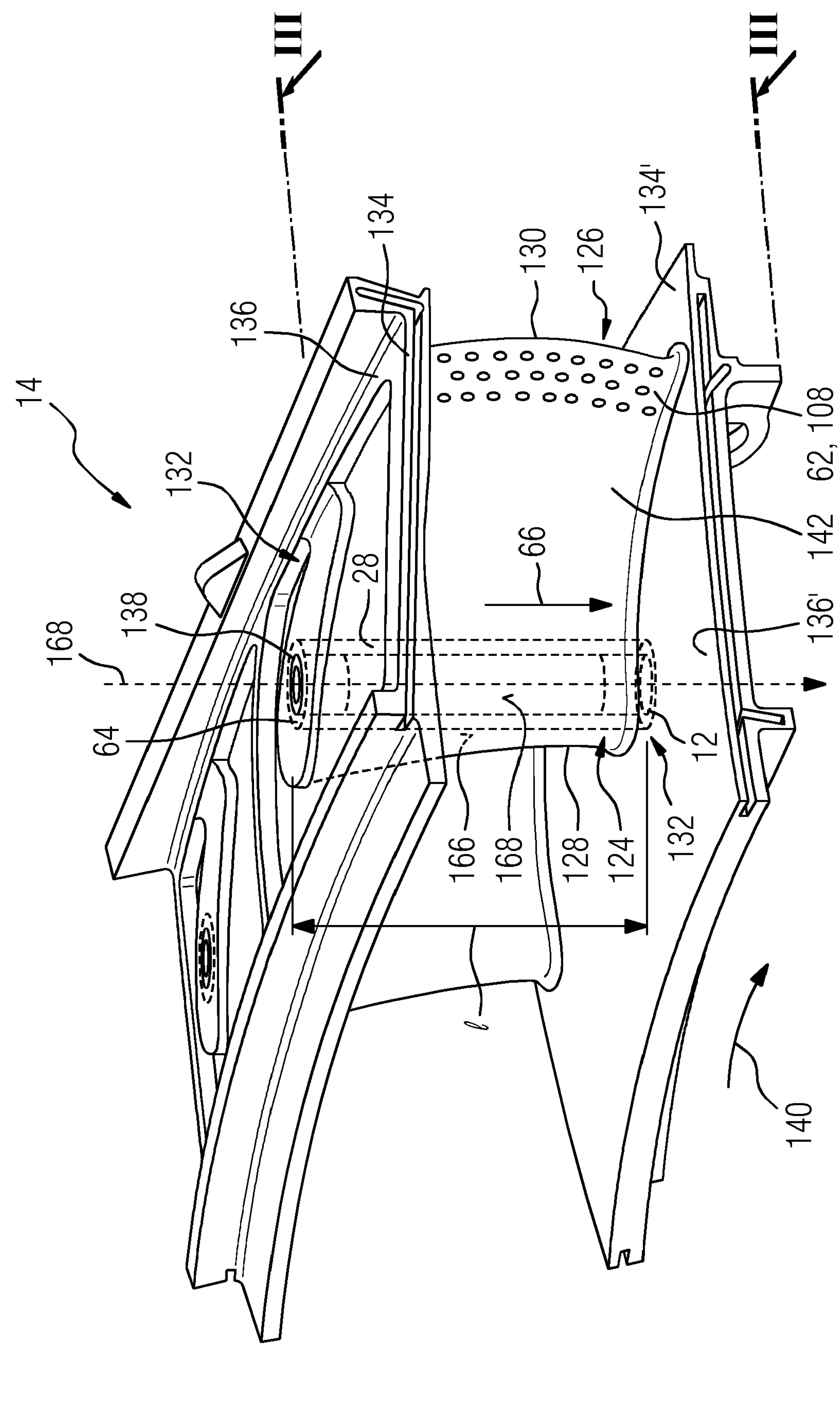
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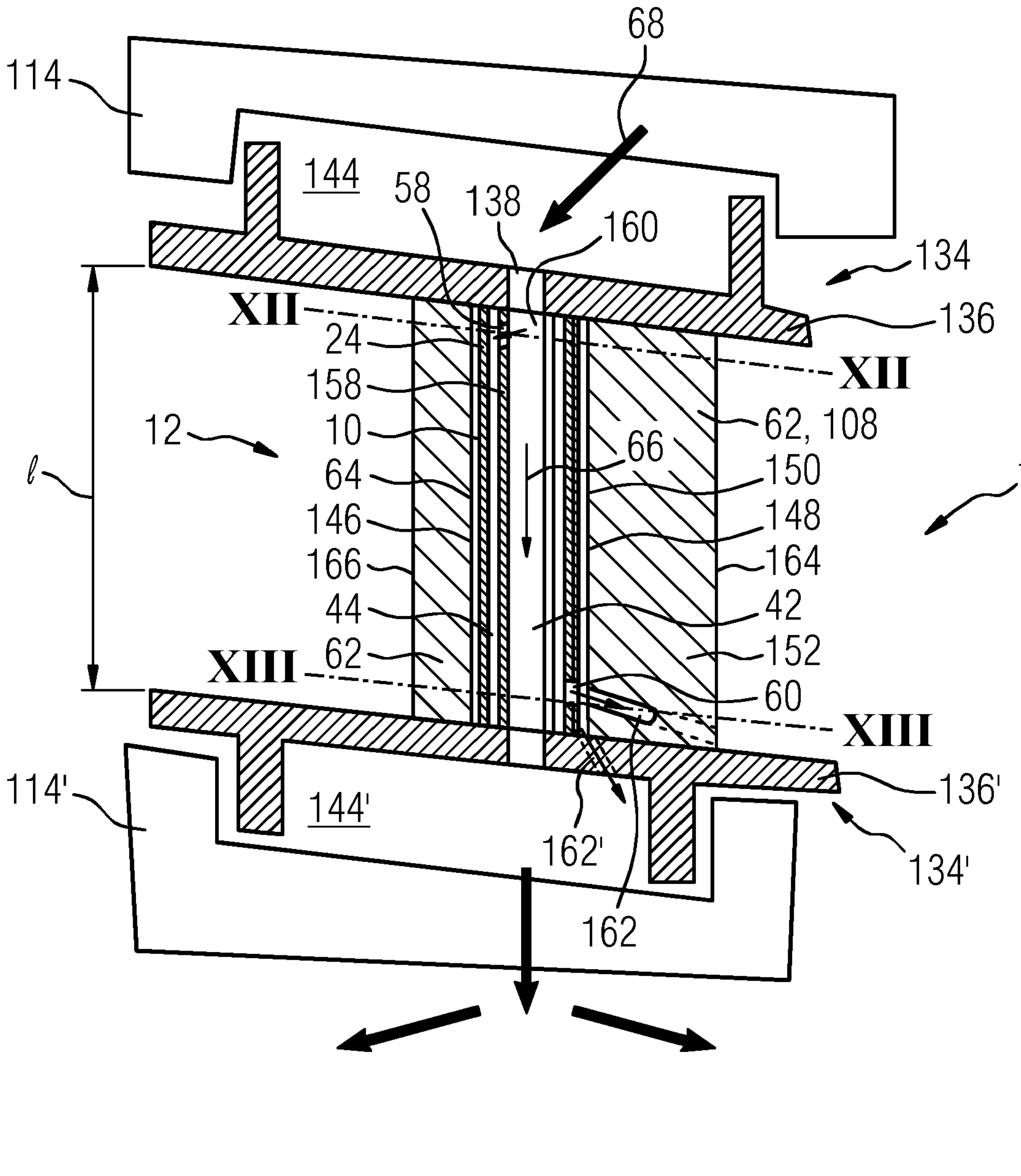
FIG 3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162

FIG 4

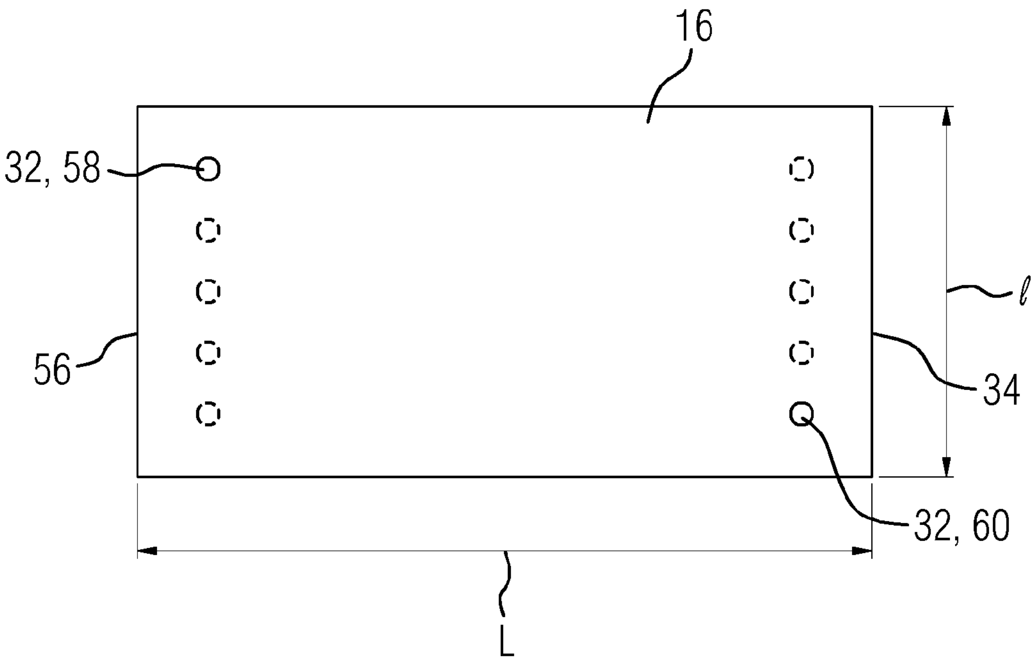


FIG 5

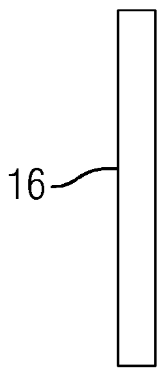


FIG 6

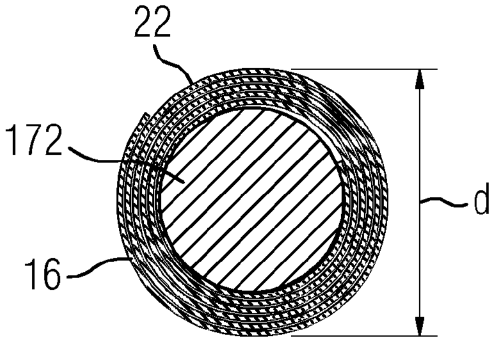


FIG 7

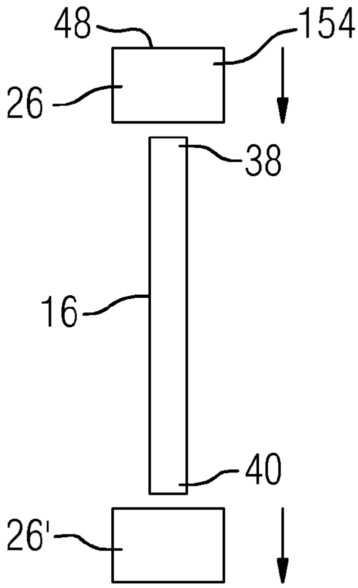


FIG 8

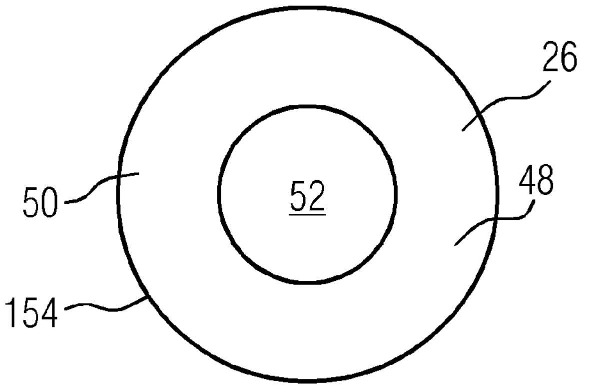


FIG 9

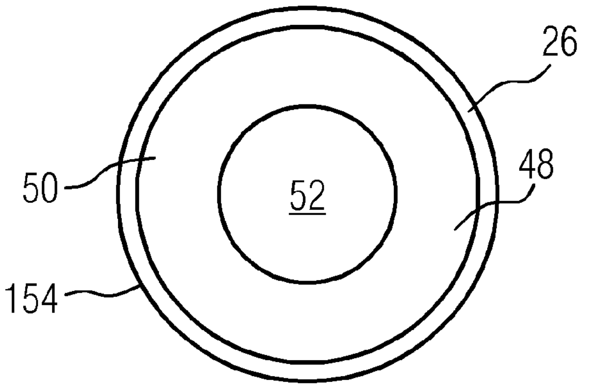


FIG 10

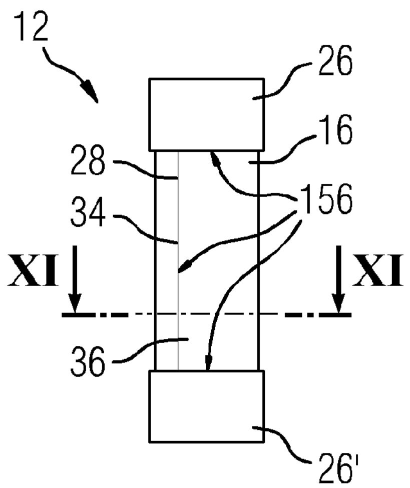


FIG 11

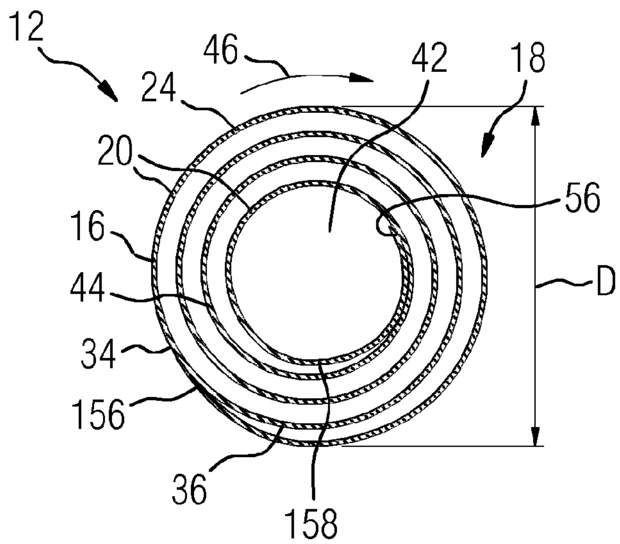


FIG 12

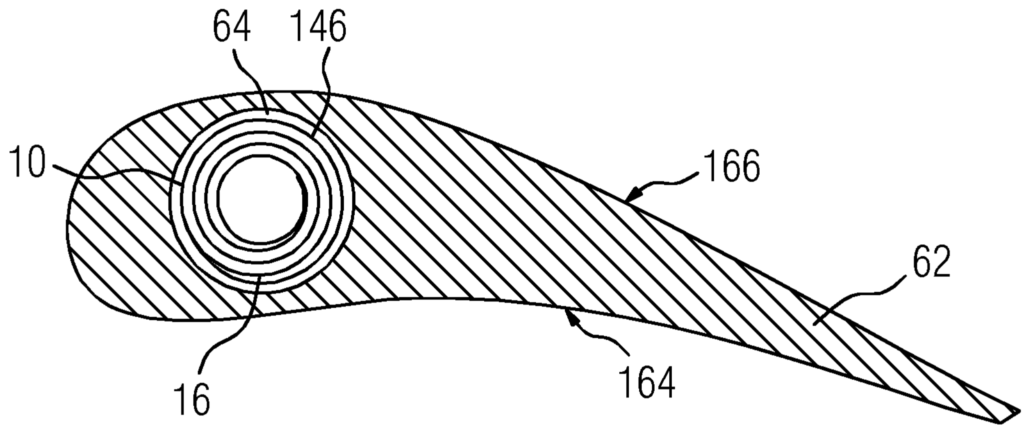


FIG 13

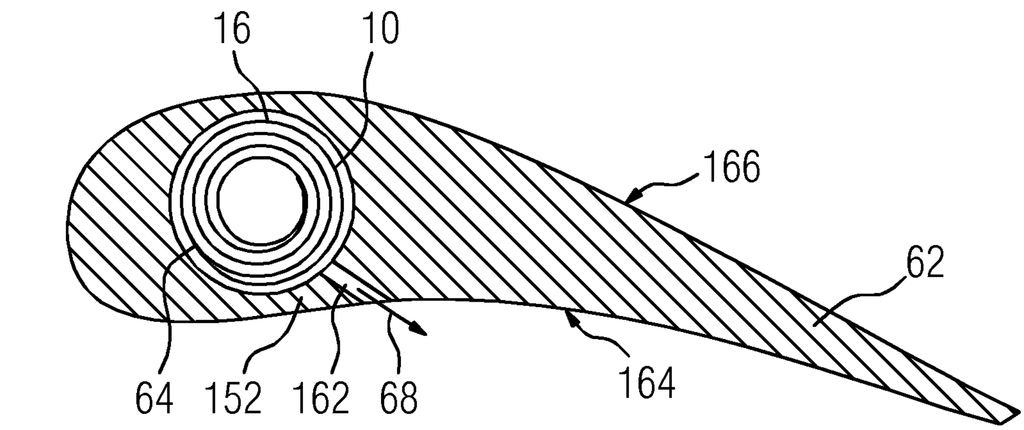


FIG 14

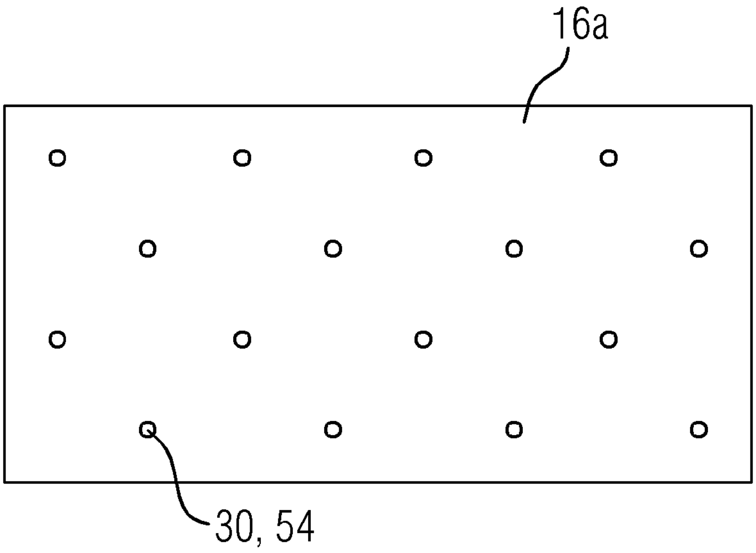


FIG 15

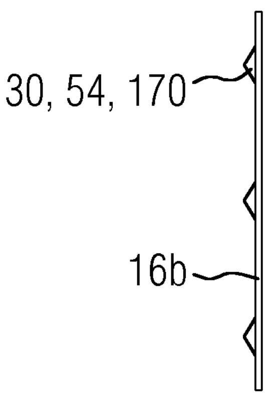
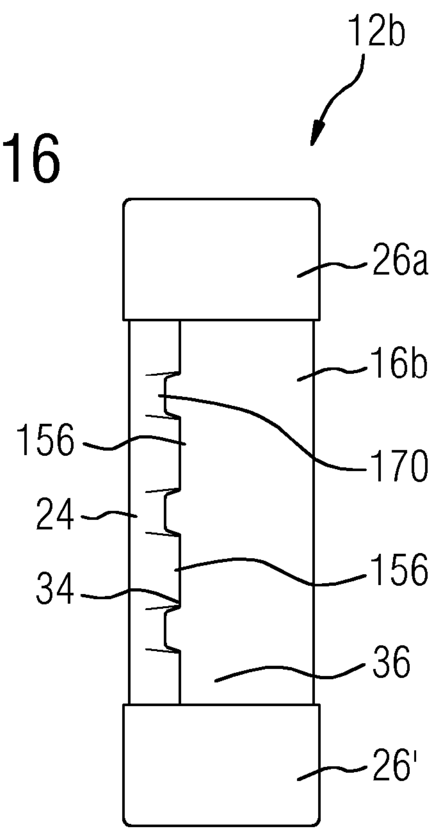


FIG 16



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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 9271

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 516 260 A (DAMLIS NICHOLAS [US] ET AL) 14 May 1996 (1996-05-14) * figures 4, 4A * * column 6, line 4 - line 28 * * column 7, line 8 - line 12 * -----	1-15	INV. F01D5/18
X	US 3 707 750 A (KLASS G) 2 January 1973 (1973-01-02) * figure 6 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F01D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 March 2016	Rolé, Florian

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17-03-2016

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