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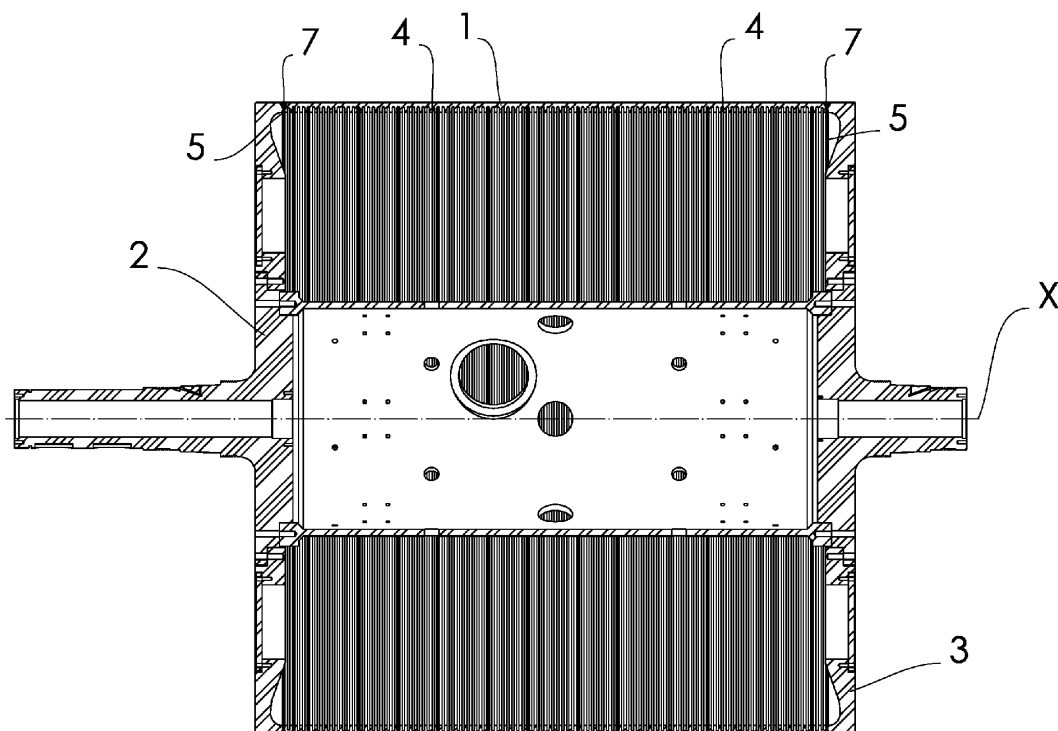
Remarks:

Amended claims in accordance with Rule 137(2) EPC.

(54) HIGH EFFICIENCY YANKEE CYLINDER

(57) A Yankee cylinder comprising two heads joined to the opposite ends of a cylindrical shell by means of two respective circumferential weld beads wherein circumferential grooves are defined in the inner surface of the

cylinder extending along the entire axial length of the shell up to the junction between the shell and each head so that there are no transition zones devoid of circumferential grooves between the shell and each head.

**FIG. 3**

Description

Technical field

[0001] This invention belongs to the technical field of Yankee drying cylinders used for drying paper in wet production plants of the paper industry, in particular, it relates to constructive refinements aimed at improving efficiency.

[0002] More specifically, the present invention relates to a steel-made Yankee cylinder having two heads, or end walls, welded at the opposite axial ends of a cylindrical shell.

Present status of the art

[0003] The production of paper is normally carried out by means of wet processes in which a continuous paper web is produced, which is then dried by means of a drying system comprising the device of the present invention, i.e., the so-called single-cylinder, also called a Yankee dryer or Yankee cylinder; this is a large cylinder which rotates according to a horizontal axis and is arranged orthogonally to the paper web production line.

[0004] The Yankee cylinder is heated internally by means of a thermal carrier fluid, e.g. such as water vapour, and is arranged in the production line in such a way that the paper web, as it advances, lies on it while it is still moist and thus dries out due to the heat of the cylinder, possibly combined with the use of air blowers.

[0005] Finally, the paper web is detached from the surface of the cylinder according to known procedures, e.g. by means of a doctor blade or by tensioning.

[0006] Traditionally, Yankee drying cylinders were made from cast iron, with obvious disadvantages due to both the large size and high mass and the limited heat transfer capability of cast iron, therefore steel made Yankee cylinders were later developed; various examples of Yankee cylinders are described in US 3914875A, in US 4320582A and in EP2126203B1.

[0007] Modern Yankee cylinders are assembled by bolting or welding the so-called heads, or end walls, to the opposite axial ends of a cylindrical shell, thus defining an enclosed space. The present invention relates to cylinders assembled by means of welding, more specifically by means of a circumferential weld bead which connects each axial end of the cylindrical shell to a respective head.

[0008] The cylindrical shell has an internal surface in which circumferential grooves are formed and within which the thermal carrier fluid condenses. In known cylinders these grooves are arranged in succession along the axial direction of the cylindrical shell, extending from the median portion of the cylindrical shell up to a certain distance from each of the axial ends of the shell, so that the internal surfaces of the cylindrical shell near each of its axial ends have no internal grooves. In other words, in known Yankee cylinders, between the outer-

most grooves and each of the axial ends of the cylindrical shell, where a circumferential weld with the respective head is formed, there is a portion of the cylindrical shell without internal grooves, which, depending on the different technical solutions adopted, may have a constant or variable thickness and/or depth, i.e., decreasing or increasing towards the ends of the shell.

[0009] Examples of such a component are disclosed in the above-mentioned patent EP2126203B1 where the thickness of the cylindrical shell gradually increases from a minimum-value zone adjacent to each outermost circumferential grooves to a maximum-value zone at the circumferential welds between the shell with and the two heads. Another example is disclosed in EP2920360B1 in which the wall thickness of the cylindrical shell is constant or decreases between the outermost circumferential grooves and the circumferential welds joining the shell to the heads.

[0010] When hot vapour is fed into the cylinder, the portions of the cylindrical shell without internal grooves could become excessively hot and cannot be used to dry the paper web because they would damage it irreparably.

[0011] Current Yankee cylinders with welded heads all include end portions of the cylindrical shell without internal grooves that are therefore unusable for processing the paper web and are heated unnecessarily, also contributing to an undesirable increase in the weight and internal volume of the cylinder, with the consequence that it is also necessary to heat a larger volume of vapour than would be strictly necessary to dry the processed paper web, further wasting energy.

[0012] Likewise, the lateral surfaces of both heads, which also lacks internal circumferential grooves and therefore heat up excessively, cannot be used to support and dry the paper web. These surfaces are therefore also heated unnecessarily and lead to further energy waste.

[0013] In current Yankee cylinders, therefore, two non-negligible portions of the external lateral surface, i.e., the two portions of the external lateral surface of the cylindrical shell near to the heads, are unusable for processing the paper web. Such surface areas, which are completely useless for the drying process, results in a disadvantageous higher weight of the cylinder, higher production costs as well as higher energy consumption, both thermal and mechanical.

Objects and summary of the invention

[0014] An object of this invention is to provide a Yankee dryer, or cylinder, that, for the same width of the paper web to be processed, is shorter and lighter than current known Yankee cylinders with the same external diameter.

[0015] A further object of the present invention is to provide a Yankee cylinder that is cheaper to produce and provides a saving in the energy consumed to dry wet paper.

[0016] The steel-made Yankee cylinder according to

this invention comprises a cylindrical shell with heads circumferentially welded at each axial end of the cylindrical shell, wherein the length of the lateral surface that can be used to process paper is maximised.

[0017] Advantageously the circumferential grooves defined on the internal surface of the cylindrical shell extend across the entire axial length of the shell itself, up to both opposite ends of the shell where the circular welding beads joining the shell and the heads are formed, i.e., at the junction between the shell and each head. The opposing coupling surfaces of the shell and each head are shaped in such a way that each of them defines a semi-groove, so that when the cylindrical shell is joined to the each of the heads a respective circumferential groove is formed on both the ends of the internal lateral surface of the cylinder. Thanks to this innovative configuration, there is no transition zone at the ends of the cylinder, in other words neither of the portions of the cylinder is without internal grooves, between the shell and each head.

[0018] Very advantageously, the cylindrical shell is joined to each head by a respective circumferential welding bead formed in correspondence with an internal circumferential groove, the latter being positioned in correspondence with the junction between the shell and the corresponding head.

[0019] In a possible embodiment, on the perimeter of each head stands a cylindrical edge that forms a respective extreme portion of the cylindric surface and one or more circumferential grooves are also defined on the internal lateral surface of these cylindrical edges standing on the perimeter of each head, in order to further minimize the portion of the cylinder that cannot be used for processing the paper web.

Brief description of the drawings

[0020] The invention is better understood following the description and the drawings, which show practical non limiting embodiments of the invention.

Fig. 1 shows a lateral view of the Yankee cylinder according to the present invention comprising a cylindrical shell (1) to the opposite ends of which heads (2, 3) are welded; the longitudinal rotation axis (X) is also shown.

Fig. 2 shows a front view of the Yankee cylinder; the cross-section plane A-A is indicated.

Fig. 3 shows the cross-sectional view of the Yankee cylinder along plane A-A.

Fig. 4 shows a close-up view of the junction between a head (2) and the cylindrical shell (1) according to an embodiment in which the circumferential groove (5) at the junction has the same depth as the grooves (4) defined in the shell (1).

Fig. 5 shows a close-up view of the junction between a head (2) and the cylindrical shell (1) according to an embodiment in which the depth of the circumferential

groove (5) at the junction is less than the depth of the grooves (4) defined in the shell (1), the latter all having the same depth.

Fig. 6 shows a close-up view of the junction between a head (2) and the cylindrical shell (1) according to an embodiment in which the circumferential groove (5) at the junction has a shallower depth than the immediately adjacent groove (4) defined in the shell (1) and the latter in turn has a shallower depth than the other adjacent grooves (4) defined in the shell (1).

Fig. 7 shows a close-up view of the junction between a head (2) and the cylindrical shell (1) according to an embodiment in which the circumferential groove (5) at the junction has the shallowest depth, while the depth of two of the adjacent grooves (4) defined in the shell (1) gradually increases toward the middle portion of the shell.

Fig. 8 shows a close-up view of the junction between a head (2) and the cylindrical shell (1) according to an embodiment in which grooves (6) are also defined in the head (2), the depth of said grooves (6) gradually increases from the outermost groove towards the groove (5) located at the junction between the head (2) and the shell (1).

Fig. 9 shows details of the bevels (11) on the shell and the bevels (21, 31) on both the heads, before the welding.

Detailed description of an embodiment of the invention

[0021] With reference to the embodiment shown in the attached drawings, the Yankee cylinder according to the present invention has a horizontal longitudinal rotation axis (X) and includes a cylindrical shell (1) and two circular-shaped heads (2, 3) welded at the opposite axial ends of said cylindrical shell (1).

[0022] The heads (2, 3) are axially connected to corresponding journals through which the cylinder is rotationally supported by means of bearings. A thermal carrier fluid, preferably water vapour, is circulated inside the cylinder, usually through said journals, and fills the internal chamber enclosed within the cylindrical shell (1) and the heads (2, 3).

[0023] A plurality of parallel circumferential grooves (4) is defined on the internal side surface of the cylindrical wall of the shell (1). The grooves (4) lie in planes perpendicular to said longitudinal axis (X) and are arranged in succession, preferably but not exclusively at a fixed distance from each other, along the entire axial length of the shell (1).

[0024] At each axial end of the shell (1) a circumferential first semi-groove (5a) is defined in the internal surface of the shell itself, and a corresponding second circumferential semi-groove (5b) is defined in the surface of each head (2, 3) facing the shell (1). Thanks to this particular configuration, the first semi-groove (5a) at one end of the shell (1) forms a complete groove (5) by

coupling with the second semi-groove (5b) defined on a respective head (2, 3).

[0025] The shell (1) is joined to the heads (2, 3) by means of respective circumferential weld beads (7). The latter are formed at each junction between the shell (1) and the heads (2, 3), i.e., in correspondence with a groove (5) formed by coupling a first semi-groove (5a) defined in the shell (1) with a respective second semi-groove (5b) defined in one of the heads (2, 3).

[0026] According to a preferred embodiment, each of the opposite surfaces of the shell (1) facing the heads (2, 3) has a circumferential bevel (11) and the surface of each head (2, 3) facing the cylindrical shell (1) also has a corresponding circumferential bevel (21, 31). In the welding preparation phase, when the head (2, 3) is put in contact with the cylindrical shell (1), the bevels on the opposing coupling surfaces form a circumferential cavity that opens on the outer surface of the cylinder and that is then filled with the weld bead (7). The cavity is located at the same cross-section of the cylinder where the groove (5) formed by two semi-grooves (5a, 5b) is also located.

[0027] In the embodiment shown in the attached drawings, and more particularly in figures from 4 to 8, the weld bead (7) is formed in the cavity defined between two opposite bevels, the first bevel (11) is defined on the circumferential edge of an axial end of the shell (1) while the second bevel (21, 31) is defined on the circumferential edge of the side of each head (2, 3) facing the shell (1). According to a different possible embodiment, a back circumferential weld is formed in the groove (5) on the internal surface of the cylinder. Different forms of coupling surfaces and different types of welding can be provided depending on the different possible embodiments of the invention.

[0028] According to a particularly complete embodiment of the invention, an annular depression or concavity is defined on the peripheral portion of the internal wall of each head (2, 3) facing the cylindrical shell (1). Said annular depression develops around the same longitudinal axis (X) of the cylinder and is adjacent to the portion of the head (2, 3) where the second semi-groove (5b) is defined. One or more circumferential grooves (6), lying in planes parallel to those on which the other grooves (4) defined in the shell (1) also lie, are defined in the internal surface of each head (2, 3) next to said second semi-groove (5b). This configuration advantageously allows not only the entire shell (1) but also at least a portion of the heads (2, 3) to be used for paper drying.

[0029] Preferably all circumferential grooves (4, 5, 6) are arranged symmetrically with respect to the median transversal section of the cylindrical shell (1). The circumferential welds (7) are also preferably formed symmetrically with respect to the median transversal section of the cylindrical shell (1).

[0030] Figures from 4 to 7 show several possible embodiments of the present invention in which grooves are defined only in the shell and at the junctions between the shell and the heads. These embodiments differ in the

depth of the grooves, which, depending on the embodiment, may or may not be constant or even gradually increasing from the outermost groove toward the middle portion of the shell. In other possible embodiments of the invention, all falling within the same inventive concept, the depth of the grooves, both those in the main body of the shell and those at the junction with the heads, varies differently.

[0031] Figure 4 shows an embodiment in which the circumferential groove (5) at the junction between the shell (1) and each head (2, 3) has the same depth of the grooves (4) defined in the shell (1).

[0032] Figure 5 shows a different embodiment in which the depth of the groove (5) at the junction between the shell (1) and each head (2, 3) is less than the depth of the grooves (4) defined in the shell (1), the latter all have the same depth.

[0033] Figure 6 shows a further possible embodiment of the invention in which the groove (5) at the junction between the shell (1) and each head (2, 3) have a shallower depth than the immediately adjacent groove (4) defined in the shell (1) and the latter in turn has a shallower depth than other adjacent grooves (4) defined in the shell (1).

[0034] Figure 7 shows an embodiment in which the groove (5) at the junction between the shell and each head has the shallowest depth while the depth of at least two of the adjacent grooves (4) defined in the shell gradually increases toward the middle portion of the shell.

[0035] Figure 8 shows a further possible embodiment of the invention in which grooves are also defined in the heads (2, 3). In the attached figure the depth of the grooves (6) defined in the heads (2, 3) gradually increases from the outermost groove towards the groove at the junction between the head and the shell. However different embodiments are possible in which the depth of the grooves (6) defined in the heads (2, 3) is constant and can be equal to, less than, or greater than the depth of the groove (5) at the junction between the shell (1) and the heads (2, 3). Different grooves (6) defined in the same head (2, 3) may also have a different depth to each other.

[0036] The heads (2, 3) and the shell (1) are preferably made of the same material: in a particularly effective and lightweight embodiment they are made of steel.

Claims

1. A Yankee cylinder comprising a cylindrical shell (1) having a longitudinal axis (X) and two opposite axial ends each of which is connected via a circumferential welding seam (7) to a respective head (2, 3), the cylindrical shell (1) further having an internal surface in which circumferential grooves (4) are defined, **characterized in that** at each axial end of the shell (1) a first circumferential semi-groove (5a) is defined, and a corresponding second circumferential semi-

- groove (5b) is respectively defined in each head (2, 3), so that in correspondence of each welded junction between the shell (1) and the head (2, 3) the first semi-groove (5a) at one end of the shell (1) and the second semi-groove (5b) on a respective head (2, 3) form a complete groove (5).
2. A Yankee cylinder according to the preceding claim **characterized in that** a first circumferential bevel (11) is formed at each of the opposite ends of the shell (1) and a corresponding second circumferential bevel (21, 31) is formed at each side of the heads (2, 3) facing said shell (1), said first and second bevels forming an external circumferential cavity within which said weld bead (7) is formed.
 3. A Yankee cylinder according to the preceding claim **characterized in that** said first bevel (11) is defined on the circumferential edge of an axial end of the shell (1) while said second bevel (31) is defined on the circumferential edge of the side of each head (2, 3) facing the shell (1).
 4. A Yankee cylinder according to claim 2 or 3 **characterized in that** a back circumferential weld is formed inside each of the grooves (5) respectively located at the junctions between the shell (1) and each head (2, 3).
 5. A Yankee cylinder according to one of the preceding claims **characterized in that** an annular depression is defined on the peripheral portion of the internal wall of each head (2, 3) facing the cylindrical shell (1), said annular depression develops around said longitudinal axis (X) and is adjacent to the portion of the head (2, 3) where the second semi-groove (5b) is defined.
 6. A Yankee cylinder according to one of the preceding claims **characterized in that** on the perimeter of each head (2, 3) stands a cylindrical edge that forms a respective extreme portion of the cylindrical surface **and in that** on the inner surface of each of said cylindrical edges one or more circumferential grooves (6) are defined, next to said second semi-groove (5b).
 7. A Yankee cylinder according to one of the preceding claims **characterized in that** the groove (5) at the junction between the shell (1) and each head (2, 3) has the same depth of all the other grooves (4) defined in the shell (1).
 8. A Yankee cylinder according to one of claims from 1 to 6 **characterized in that** the depth of the groove (5) at the junction between the shell (1) and each head (2, 3) is less than the depth of the grooves (4) defined in the shell (1), the latter all having the same depth.
 9. A Yankee cylinder according to one of claims from 1 to 6 **characterized in that** the groove (5) at the junction between the shell (1) and each head (2, 3) have a shallower depth than the immediately adjacent groove (4) defined in the shell (1) and the latter in turn has a shallower depth than the other grooves (4) defined in the shell (1), the latter all having the same depth.
 10. A Yankee cylinder according to one of claims from 1 to 6 **characterized in that** the groove (5) at the junction between the shell (1) and each head (2, 3) has the shallowest depth while the depth of at least two of the adjacent grooves (4) defined in the shell (1) gradually increases toward the middle portion of the shell.
 11. A Yankee cylinder according to one of claims from 6 to 10 **characterized in that** the depth of said grooves (6) defined in each head (2, 3) gradually increases from the outermost groove towards the junction between the head (2, 3) and the shell (1).
 12. A Yankee cylinder according to one of the preceding claims **characterized in that** said shell (1) and said heads (2, 3) are made of steel.
- Amended claims in accordance with Rule 137(2) EPC.**
1. A Yankee cylinder comprising a cylindrical shell (1) having a longitudinal axis (X) and two heads (2, 3), each of the two opposite axial ends of said cylindrical shell being connected via a circumferential welding seam (7) to a respective head (2, 3), the cylindrical shell (1) further having an internal surface in which circumferential grooves (4) are defined, an annular depression (22, 32) being defined on the peripheral portion of the internal wall of each head (2, 3) facing the cylindrical shell (1) and developing around said longitudinal axis (X), **characterized in that** at the circumferential edge of each axial end of the cylindrical shell (1) facing a respective head (2, 3) a first circumferential semi-groove (5a) is defined, and a corresponding second circumferential semi-groove (5b) is respectively defined in the circumferential edge of each head (2, 3) facing the cylindrical shell (1), said annular depression (22, 32) being adjacent to the respective portion of the each head (2, 3) where the second semi-groove (5b) is defined, so that, in correspondence of each welded junction between the opposite axial ends of said cylindrical shell (1) and the respective head (2, 3), the first semi-groove (5a) at one end of said cylindrical shell (1) and the second semi-groove (5b) on the respective head (2, 3) form a complete groove (5), each of said complete groove (5) being located at the interface between the shell (1) and the respective head (2, 3).

2. A Yankee cylinder according to the preceding claim **characterized in that** a first circumferential bevel (11) is formed at each of the opposite ends of the shell (1) and a corresponding second circumferential bevel (21, 31) is formed at each side of the heads (2, 3) facing said shell (1), said first and second bevels forming an external circumferential cavity within which said weld bead (7) is formed. 5
3. A Yankee cylinder according to the preceding claim **characterized in that** said first bevel (11) is defined on the circumferential edge of an axial end of the shell (1) while said second bevel (31) is defined on the circumferential edge of the side of each head (2, 3) facing the shell (1). 10 15
4. A Yankee cylinder according to claim 2 or 3 **characterized in that** a back circumferential weld is formed inside each of the grooves (5) respectively located at the junctions between the shell (1) and each head (2, 3). 20
5. A Yankee cylinder according to one of the preceding claims **characterized in that** on the perimeter of each head (2, 3) stands a cylindrical edge that forms a respective extreme portion of the cylindrical surface **and in that** on the inner surface of each of said cylindrical edges one or more circumferential grooves (6) are defined, next to said second semi-groove (5b). 25 30
6. A Yankee cylinder according to one of the preceding claims **characterized in that** the groove (5) at the junction between the shell (1) and each head (2, 3) has the same depth of all the other grooves (4) defined in the shell (1). 35
7. A Yankee cylinder according to one of claims from 1 to 5 **characterized in that** the depth of the groove (5) at the junction between the shell (1) and each head (2, 3) is less than the depth of the grooves (4) defined in the shell (1), the latter all having the same depth. 40
8. A Yankee cylinder according to one of claims from 1 to 5 **characterized in that** the groove (5) at the junction between the shell (1) and each head (2, 3) have a shallower depth than the immediately adjacent groove (4) defined in the shell (1) and the latter in turn has a shallower depth than the other grooves (4) defined in the shell (1), the latter all having the same depth. 45 50
9. A Yankee cylinder according to one of claims from 1 to 5 **characterized in that** the groove (5) at the junction between the shell (1) and each head (2, 3) has the shallowest depth while the depth of at least two of the adjacent grooves (4) defined in the shell (1) gradually increases toward the middle portion of the shell. 55
10. A Yankee cylinder according to one of claims from 5 to 9 **characterized in that** the depth of said grooves (6) defined in each head (2, 3) gradually increases from the outermost groove towards the junction between the head (2, 3) and the shell (1).
11. A Yankee cylinder according to one of the preceding claims **characterized in that** said shell (1) and said heads (2, 3) are made of steel.

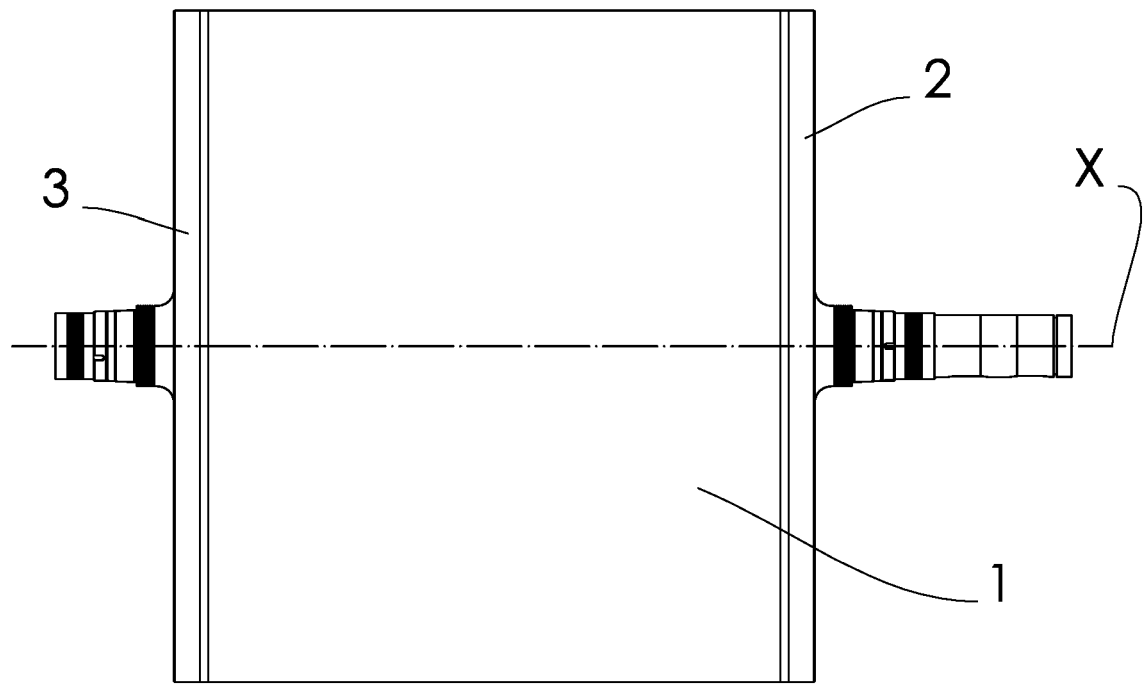


FIG. 1

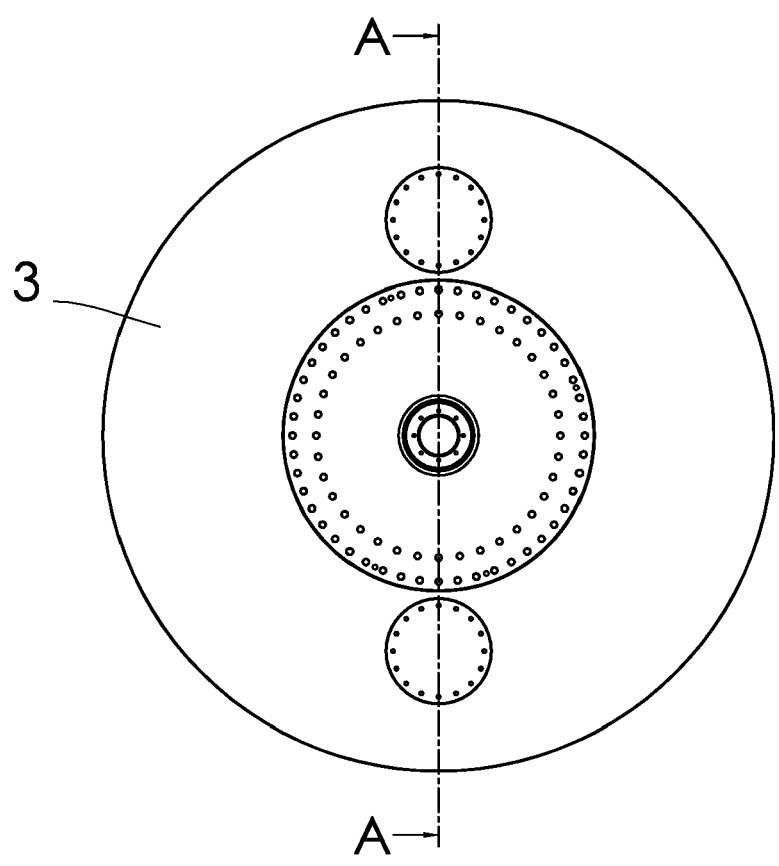


FIG. 2

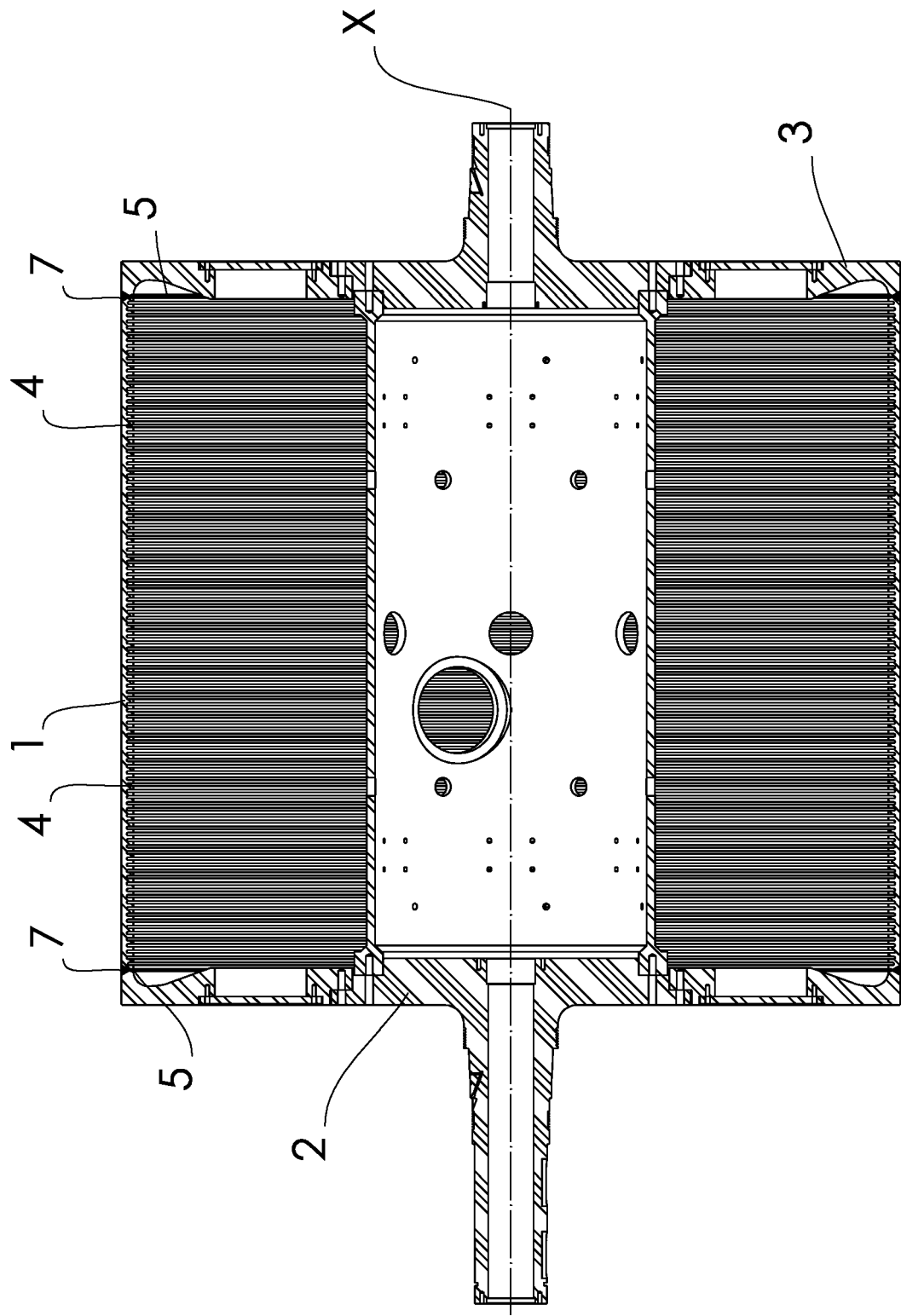


FIG. 3

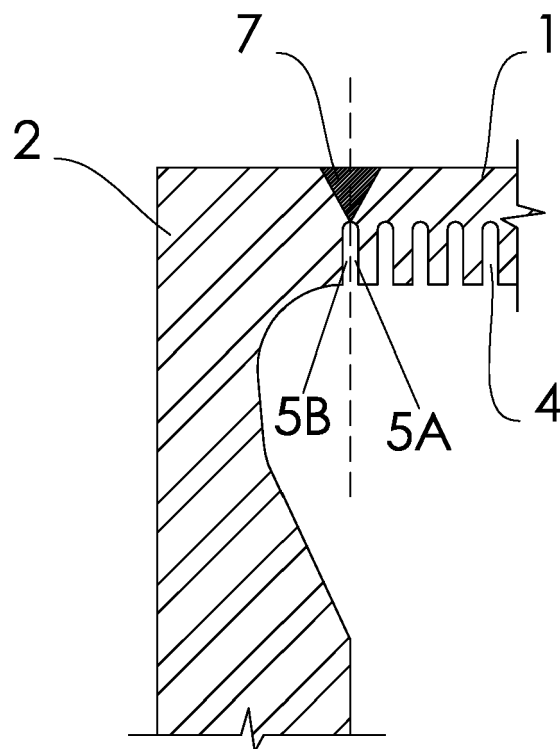


FIG. 4

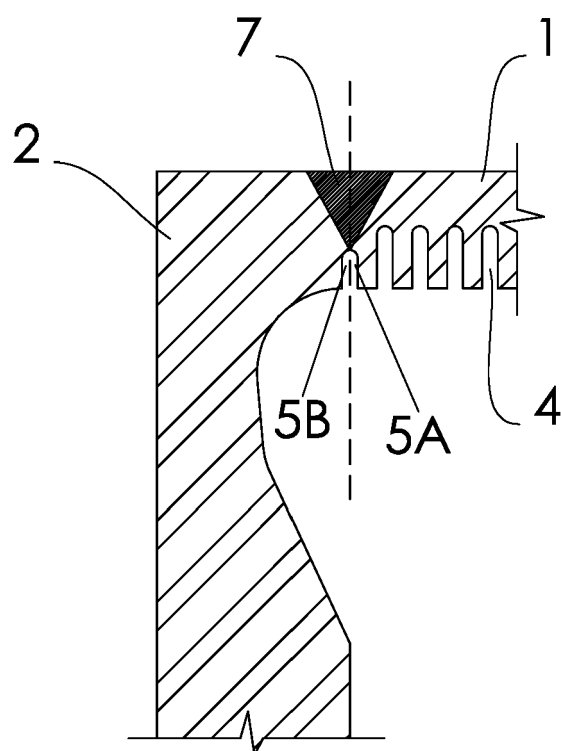


FIG. 5

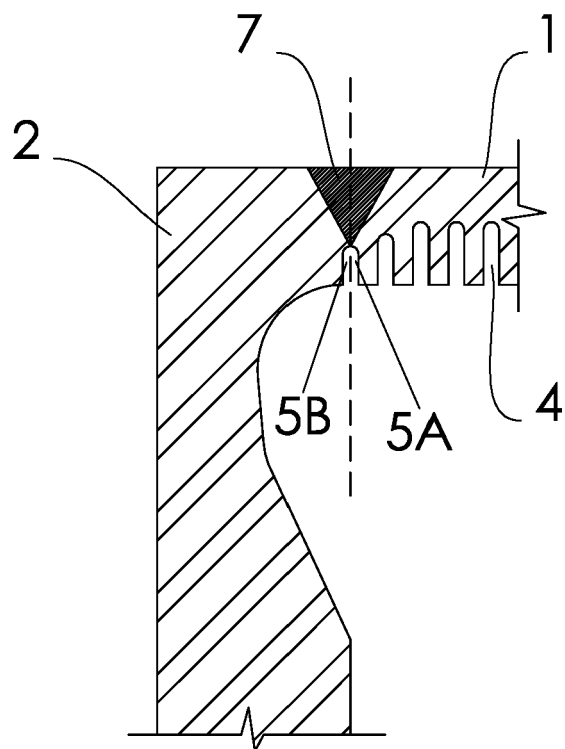


FIG. 6

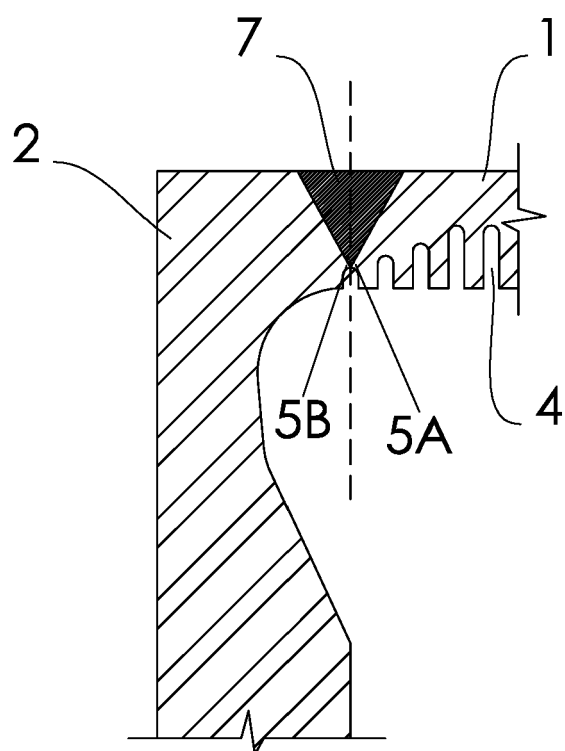


FIG. 7

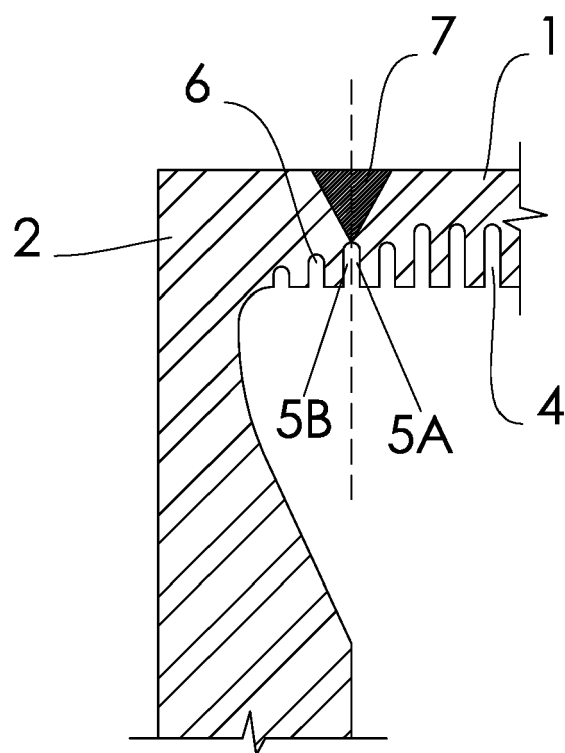


FIG. 8

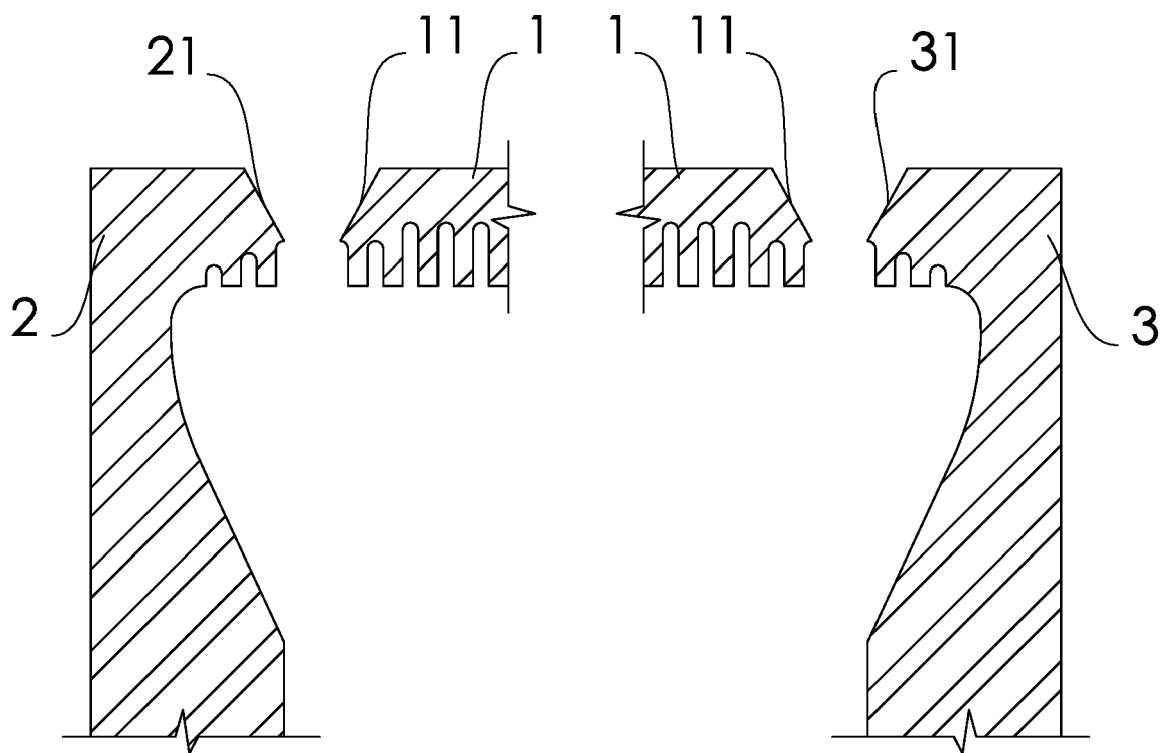


FIG. 9



EUROPEAN SEARCH REPORT

Application Number

EP 23 21 6255

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			D21F D21J
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		7 March 2024	Arndt, Markus
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			
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