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(54) Screen basket having diagonal slots for top separator of a digester

(57) A screen basket (36) in a top separator (14) for a cellulosic material treatment vessel (10) includes a cylindrical plate having a vertical joint connecting opposite edges of the plate, and rows (50) of slots (48, 70) extending through the plate. Each slot (48, 70) has a curved or chamfered inlet corner edge (72) adjacent an inside surface (62) of the plate and is oblique to a vertical axis of the basket (36).

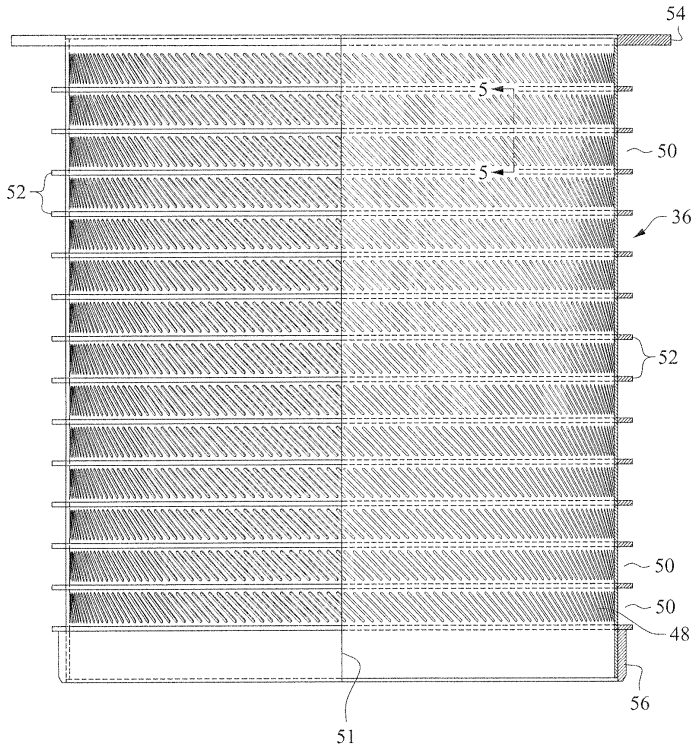

FIG. 3

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Description

BACKGROUND OF THE INVENTION

[0001] The present application is generally directed to making pulp and is more specifically directed to top separators for pulp digester systems including digesters, impregnation vessels or other treatment vessels used in the processing of cellulosic material such as the production of pulp.

[0002] Wood chips and other cellulosic fibrous material are treated in treatment vessels, such as digester vessels and impregnation vessels. These treatment vessels can be continuous or batch and contain a section near the top of the vessel where hot vapor (such as steam) or other hot gaseous material is used to heat the cellulosic material or wood chips entering the vessel, commonly referred to as vapor phase vessels (digesters) or they can be hydraulically filled vessels where liquid is used to heat the cellulosic material, commonly referred to as hydraulic vessels (digesters). In this application the term "wood chips" refers to all cellulosic fibrous material and is not limited to true "wood" based material. An impregnation vessel is typically used to infuse liquids and chemicals into the fibers of wood chips. A digester vessel chemically separates fibers in the chips and material by removing lignin. The chips after the removal of lignin are referred to as pulp. In this application, impregnation and digester vessels are both treatment vessels and either, or both, could use the top separator described.

[0003] The wood chips are treated in a digester vessel with heat, liquid, and chemicals to convert the chips to pulp. A continuous digester vessel is typically an upright cylinder with an upper inlet to receive chips in a continuous flow. The chips flow slowly through the digester vessel, 100 to 300 feet tall (30 to 100 meters) in a generally downward direction. The digester vessel may be a hydraulic or vapor phase vessel.

[0004] The wood chips are typically transported, e.g., pumped or via another pressure transferring means, to a treatment vessel in a slurry through conduits, e.g., pipes, which feed the wood chips to the top of the treatment vessel. The liquid content of the slurry used to transport the chips tends to be substantially higher than the necessary or desired liquid content of the treatment vessel. Liquid is removed as the slurry enters the treatment vessel. The removed liquid may be reintroduced to the wood chips being transported to the treatment vessel. After removal of a portion of the liquid, the slurry of wood chips and a reduced amount of liquid are discharged from the top separator and move down through the treatment vessel.

[0005] A conventional screen basket for a top separator is formed by parallel bars separated by narrow gaps. Conventional top separators are described in US Patent (USP) 6,325,889; USP 7,105,076; USP 7,309,401 and USP 7,658,818. The bars extend vertically and form a circular array of bars, wherein the circle is a horizontal cross-section. The bars are held together by one or more horizontal wires, horizontal metal rings or backing bars.

[0006] The gaps between the bars of a conventional top separator tend to become blocked with fibers and other debris, such as rocks. As the gaps between the bars becomes blocked, the volume of the liquid removed from the slurry is reduced and adversely affects the overall operation of the treatment vessel. These adverse effects can include reduced amount of liquid removed by the top separator, reduced availability of heat energy that can be extracted from the liquid extracted by the top separator, a greater requirement for externally supplied liquid to transport the wood chips to the treatment vessel, and non-optimal treatment of the wood chips in the treatment vessel. There is a long felt need for a screen basket for a top separator with reduced tendencies for the slots in the screen basket becoming blocked or clogged.

BRIEF DESCRIPTION OF THE INVENTION

[0007] A novel screen basket has been developed comprising a solid screen plate, rolled to form a basket, the plate having openings in the plate of slanted slots having curved or chamfered inlet edges to minimize chips begin caught on the edges and to deflect chips into the wood mass. The curved or chamfered inlet slot edges are adjacent the inside surface of the screen plate and face the wood chip or pulp flow. Note that the inlet slot edges, although often simply described as "curved or chamfered" throughout the present specification, may in fact be at least one of curved, rounded, sloped, chamfered, or inclined. For example, inlets may have a generous radius of curvature equal to one third to two thirds the thickness of the plate. The curved or chamfered inlets may be only on the lower side surface of a slot or on the upper and lower slot side surfaces. A curved or chamfered inlet only on the lower side surface is suitable for a continuous digester in which the wood chip or pulp flow is generally downward and chips tend to impinge on the inlet edge of the lower sides of slots. Curved or chamfered inlets on both the upper and lower side surfaces of slots are suitable for both continuous and batch digesters. In addition, the lower side surface of the slot may be horizontal in cross-section or be inclined upward from the inside surface of the plate to the outer surface. Such a horizontal or upwardly inclined lower slot surface tends to deflect chips in the slot out of the slot and into the pulp stream.

[0008] The present invention provides a screen basket for a top separator for a cellulosic material treatment vessel, the screen basket comprising: a cylindrical plate having a vertical joint connecting opposite edges of the plate, and rows of slots extending through the plate, wherein each slot has a curved or chamfered inlet corner edge adjacent an inside surface of the plate and each slot is oblique to a vertical axis of the basket. The curved or chamfered corner inlet slot edge may be at least one of curved, rounded, chamfered, sloped or inclined. The

curved inlet corner edge may have a radius of curvature in a range of one third to two thirds a thickness of the plate. The curved or chamfered corner edge may be only at one of a lower edge or upper edge of each slot.

[0009] The slots may be each offset along an axis from the inside surface to an outside surface of the plate by an angle of between 5 degrees to 45 degrees, or 5 degrees to 30 degrees, or 5 degrees to 15 degrees or any variant therein. The slots may be oblique to the vertical axis at an angle of 1 degree to 75 degrees, or 30 degrees to 60 degrees, or preferably 40 degrees to 50 degrees or 45 degrees. The rows of slots may be uniform in height and orientation of the slots or the slots in each row may be uniform in shape and dimensions, while the dimensions of the slots differ from row to row.

[0010] A method has been conceived for extracting a liquid from a top separator of a treatment vessel, the method comprising: feeding a slurry of cellulosic material and a liquid in the top separator screen basket of a vessel, wherein the slurry of cellulosic material and liquid flows into the screen basket; extracting a portion of the liquid in the slurry of cellulosic material and liquid through a screen basket assembly, wherein the screen basket is formed of a screen basket plate within the top separator and is formed around a conveyor screw device, and the screen basket plate includes slots having curved or chamfered inlet corner edges adjacent an inside surface of the screen basket plate and facing a flow of slurry of cellulosic material and liquid, and deflecting cellulosic material flowing through the top separator with the curved or chamfered inlet corner edges to avoid the material from becoming caught in the slots of the screen basket.

[0011] A top separator has been conceived for use in a treatment vessel comprising: a rolled plate formed into a cylindrical screen; rows of diagonal slots formed in the plate and oriented horizontally; a single welded joint extending vertically between abutting edges of the plate; a conveyor screw within the cylindrical screen, wherein a gap between an outer edge of the screw and an interior surface of the cylindrical screen is no greater than thirty thousandths of an inch, preferably no greater than ten thousandths of an inch; a housing supporting the cylindrical screen and forming a liquid chamber between the housing and screen, and a vertical shaft supporting the screw and extending vertically through the cylindrical screen.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIGURE 1 is a front view of a conventional continuous digester shown schematically and partially cut away.

[0013] FIGURE 2 is a front view, of a conventional top separator, shown in cross-section of the digester shown schematically in Figure 1.

[0014] FIGURE 3 is a front view of a novel screen basket for the top separator, showing the screen basket in cross-section.

[0015] FIGURES 4, 5 and 6 show the interior surface of a portion of the novel screen basket, the portion of the basket in cross-section, and the outer surface of the portion of the screen basket, respectively.

[0016] FIGURE 7 shows a cross-section of a slot in the novel screen basket.

[0017] FIGURE 8 shows a cross-section of an alternative slot for the novel screen basket.

DETAILED DESCRIPTION OF THE INVENTION

[0018] FIGURE 1 is a side view of a continuous vertical digester vessel 10 for processing wood chips into pulp. Though a vertical continuous digester is shown, the screen basket and screen slots described herein are applicable to other types of digesters, impregnation or other treatment vessels. The digester shown in FIGURE 1 is typically referred to as a vapor phase digester. It is understood by one skilled in the art that a top separator (as described in this invention) is and can be used in both vapor phase any hydraulic phase treatment vessels, treatment vessels such as impregnation vessels or digesters or even in systems where the separator is located outside of the treatment vessel such as described in US 5,413,677. The digester vessel 10 may comprise a cylindrical wall 12 that typically forms a column of, for example, 100 feet (30 meters) tall. The top and bottom of the digester vessel are capped. A top separator 14 may be mounted to the top cap 16 of the vessel. A discharge outlet 18 may be mounted to the bottom cap 20.

[0019] The wood chips 21 enter the digester vessel as a slurry through the top separator 14. The slurry is formed of wood chips and liquid such as cooking chemicals and water (many times referred to as liquor). The slurry flows to the top separator through a conduit 22, which may be coupled to pumps, high pressure feeders, a chip supply bin or pretreatment vessel. The slurry flowing into the inlet of the top separator 14 has a liquor to chip ratio that is high relative to the desired ratio of liquor to chips for the process preformed in the digester vessel. The top separator extracts liquor from the slurry entering the treatment vessel. The extracted liquor flows through an outlet conduit 24 and may be added to inlet conduit 22 feeding the slurry to the top separator.

[0020] Wood chips 21 are continually added to a continuous treatment vessel while the chips already in the treatment vessel are processed and pulp 26 is discharged from the bottom of the vessel. Heat energy and pressure may be added to the vessel such as by injecting steam 28 into the top of the vessel. As the chips and liquid cooking chemicals move down through the treatment vessel, heat, pressure and chemical reactions within the vessel dissolve or breakdown the lignin binding fibers together in the chips. The removal of the lignin releases the fibers from being bound within the chips and converts the chips to pulp.

[0021] The chips may form a pile (dotted line 23 represents the top of the pile) in the vessel that is at least

partially immersed in the liquid of cooking chemicals, generally referred to as cooking liquor (see dotted line 25 representing liquid surface). In a vapor phase vessel 10, a vapor filled region may be in the upper portion of the vessel that is above the chip pile and surface of the cooking liquor. In a hydraulic vessel, the liquor may fill the vessel such that there is no vapor filled area in the vessel.

[0022] Screen assemblies 18 may be at one or more elevations in the digester vessel 10. The screen assemblies are conventionally formed of screen plates 30 in an annular array and mounted to the wall of the vessel. Each screen plate is typically a rectangular metal plate having a slight arch to conform to the curvature of the cylindrical vessel. Slots in the screen plates may be vertical or slanted. Cooking liquor is extracted from the wood chips in the vessel through the slots of the screen plates. The fibrous pulp 26 and remaining spent cooking liquor is discharged as pulp from the outlet 18 at the bottom 20 of the digester vessel.

[0023] The wood chips enter bottom or top of the top separator 14 depending on whether the separator is inverted. An inverted top separator, such as shown in Figures 1 and 2, may be used in a vapor phase digester vessel. As the slurry of chip enter the top separator, a screw conveyor 32 moves the chips through the separator. The screw conveyor may be driven turned by a gear and motor arrangement 34 coupled by a vertical shaft 35 (Fig. 2) for the screw conveyor. A screen basket 36 forms a cylindrical wall around the outer edges of the screw conveyor. The screen basket has slots to allow liquor from the slurry to flow into an annular chamber 38 and flow into the liquor outlet conduit 24. As the wood chips move through the separator, the chips are discharged (see arrows 40) from the top separator and flow down to the chip pile 23 in the vessel 10.

[0024] FIGURE 2 is a schematic diagram of the top separator 14, showing the screen basket 36 in cross-section. The screen basket 36 includes a cylindrical shell. A support structure for the basket may include a cylindrical housing 42 that mounts to the top cap 16 of the digester vessel and supports the screen basket. The housing 42 may also define the chamber 38 for liquor extracted through the screen basket.

[0025] The screen basket has cylindrical inner wall that is adjacent the outer edges 44 of the screw conveyor. The gap 46 between the edges 44 of the screw conveyor and the wall of the screen basket narrow, such as less than thirty thousandths of an inch. Due to the narrow gap 46 and the rotation of the screw, the edges of the screw move across the surface of the inner wall of the screen basket. The screen basket may have structural rigidity and be built to tight tolerances to ensure that gap 46 remains constant as the edges 44 of the conveyor swipe across the interior surface of the screen basket.

[0026] FIGURE 3 is a side view of an exemplary screen basket 36 which is a metal plate formed into a cylindrical shell. The screen basket may have a diameter of 36 to 96 inches and a vertical length of 48 to 120 inches. These dimensions are exemplary.

[0027] Slots 48 extend through the plate of the screen basket and are sized to allow liquor to pass and block fibers and the wood chips. The slots are slanted with respect to vertical and horizontal orientations. The slots are arranged in rows 50 that may be horizontal rows extending completely around the cylinder of the screen basket.

[0028] The screen basket 36 may be formed of a metal plate rolled to form a cylinder, wherein the edges of the plate are welded along a vertical joint 51. Rather than a metal material, the screen basket may be formed of another material suitable for use in a treatment vessel which typically houses an environment having acidic and alkaline chemicals. Due to the narrow diameter of the screen basket and the proximity of the screw conveyor, the thickness of the plate forming the screen basket will tend to be thicker than the thickness of screen plates 30 used elsewhere in the treatment vessel such as extraction screens within a digester vessel as shown in Figure 1. The relatively greater thickness and single vertical weld of the screen basket assists in minimizing damage to the interior surface of the screen basket due to continuous mechanical action of the conveyor screw device.

[0029] The screen basket differs in several respects from a conventional screen plate 30 mounted to the sidewall of a digester vessel in that the screen basket of this invention (used for example in the top separator of a treatment vessel) requires substantial structural rigidity in view of the narrow gap 46 and the proximity of the edges of the screw conveyor. Further, the screen basket may be formed of a single metal plate rolled into a cylinder, whereas a screen plate 30 is assembled with other plates to form the screen assembly. Each plate 30 need have a relatively small arc which conforms to the wall of the vessel. Because of the close tolerances of the gap between the conveyor screw device and the screen basket surface, the screen basket may be formed as a precision piece having narrow machining tolerances.

[0030] The slots 48 may be arranged in rows 50 on the screen basket. Each slot may have, for example, a length of three (3) to fourteen (14) inches (8 mm to 36 mm). The vertical height of each row 50 may be 2 to 10 inches (5 mm to 25 mm). The number of slots in each row is dependent on the circumference of the screen basket. The number of slots in each row and the dimensions, e.g., vertical height, each row may be uniform in the screen basket or vary from row to row. Within any row 50, the slots sizes (slot width, relief angle and diagonal angle relative to the horizontal) may remain constant from slot to slot. The slot size (slot width, relief angle and diagonal angle relative to the horizontal) may vary from row to row. The number of rows may depend on the desired open area in the screen basket to allow for the desired flow of liquor extracted from the chip slurry in the top separator.

[0031] To help support the screen basket, rows of horizontal rings 52, ribs or other stiffeners may be attach to

the basket at the horizontal solid ring region between the rows of slots in the basket. Flanges 54, 56 at the top and bottom of the screen basket provided supports for mounting the screen basket to the housing 42 and the top cap of the digester or treatment vessel. The flanges may be metal rings that hold the top and bottom of the screen plate in a cylindrical shape.

[0032] FIGURES 4 to 7 show screen basket in detail. Figure 4 shows an outer surface 60 of a portion of the screen basket. Figure 5 is a cross-sectional view of the screen basket taken along lines 5-5 shown in Figure 3. Figure 6 shows an interior surface 62 of the screen basket. Figure 7 is a cross-section al view of the screen basket taken along lines 7-7 in Figure 4.

[0033] The slots 48 in the rows 50 of slots in the screen basket are configured to minimize the clogging of cellulosic material in the screens. Each slot may have a width (throat) of 3 to 9 mm and a length of 25 to 100 mm. The slots may be wide at the outer surface 60 of the screen basket and narrow to the interior surface 62. The slots may taper from the inside to outer surfaces of the basket at relief angle 63 of 5° to 45°, or 5° to 30°, or 5° to 15° or any variant therein. Further, the slots may be offset such that the opening 64 of each slot is axially offset from the exit 66. The offset may be generally aligned with the swiping motion of the edges of the conveyor screw. This offset is selected to enhance the effect of pumping the liquor through the slots due to the swiping motion of the conveyor screw. The offset may orient the axis of the slot at an angle, e.g., 10 to 25 degrees, or 15 degrees. The offset is opposite to the swiping direction of the edges of the screw conveyor. The offset reduces the tendency of fibers entering the slots by pointing the axis of the slot away from the direction of chip flow through the top separator. Similarly, the slots 48 may be oriented at an angle 68 of 45 degrees or in a range of 40 to 50 degrees or zero (vertical) to 75 degrees. The angle of the slots may be arranged to slant the slots in the opposite direction as the rotation of the screw conveyor.

[0034] FIGURE 8 shows in cross-section another exemplary slot 70 in a screen basket for a top separator, wherein the slot has an edge 72 at the inlet opening 74 which is at least one of curved, rounded, chamfered, sloped or inclined. The slot extends through the plate 76 of the screen basket. The thickness (T) of the plate may be 9 to 10 mm, 8 to 11 mm or 7 to 12 mm. The throat (x), which is the narrowest portion of the slot, may have a width of 3mm to 8mm, such as 6mm.

[0035] The slot may expand from the inlet opening 74 to the outlet opening 90 at a relief angle (β) of 15 to 45 degrees, such as 30 degrees. The axis (see flow arrow 80) of the slot may be offset in a direction opposite to the movement (see arrow 82) of the edges of the screw conveyor. The offset may be at an angle such as 30 degrees formed by the angle (ω) of one of the sides slot and one-half the relief angle for the slot.

[0036] The upper and lower edges of the slots may be curved, e.g., uniform radius of curvature, or chamfered. Avoiding sharp angles in the slots reduces the tendency of fibers being cut or caught at the edges of the slots. The edges of the slots at the opening 74 may be curved, rounded, chamfered, sloped or inclined. For example, the openings 74 may have a generous radius of curvature equal to one third to two thirds the thickness of the plate.

[0037] The curved or chamfered edge 72 may be only on the side of a slot facing the direction of movement 82 of the edges of the screw conveyor. For a top separator having an upper inlet, the slots may have a curved or chamfered edge at the lower edge of the slot opening. For an inverted top separator, the curved or chamfered edge may be at the upper edge of the slot openings. The curved or chamfered edge 72 is less susceptible to catching fibers (cellulosic material) in the slurry flowing through the top separator. The curved or chamfered inlet on the slot tends to deflect cellulosic material into the flow and away from the slot. The curvature of the slot inlet may be defined by a radius of the curvature. The radius may be, for example, one-third to two-third of the thickness of the plate.

[0038] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

Claims

1. A screen basket (36) for a top separator (14) for a cellulosic material treatment vessel (10), the screen basket (36) comprising:

   a plate formed into a cylinder and having a vertical joint (51) connecting opposite edges of the plate, and
   rows (50) of slots (48, 70) extending through the plate, wherein each slot (48, 70) has an inlet corner edge (72) adjacent an inside surface (62) of the plate, which inlet corner edge (72) is at least one of curved, rounded, chamfered, sloped or inclined, and each slot (48, 70) is oblique to a vertical axis of the basket (36).

2. The screen basket (36) of claim 1, wherein the inlet corner edge (72) has a radius of curvature in a range of one third to two thirds a thickness of the plate.

3. The screen basket (36) of claim 1 or 2, wherein the inlet corner edge (72) which is at least one of curved, rounded, chamfered, sloped or inclined is only at a lower edge of each slot (48, 70).

4. The screen basket (36) of any one of claims 1 to 3, wherein the slots (48, 70) are each offset along an

axis from the inside surface (62) to an outside surface (60) of the plate by an angle of between 5 degrees and 45 degrees.

5. The screen basket (36) of any one of claims 1 to 4, wherein the inlet corner edge (72) which is at least one of curved, rounded, chamfered, sloped or inclined is limited to an upper corner edge or a lower corner edge.

6. The screen basket (36) of any one of claims 1 to 5, wherein the slots (48, 70) are oblique to the vertical axis at an angle of 1 degree to 75 degrees.

7. The screen basket (36) of any one of claims 1 to 6, wherein the rows (50) of slots (48, 70) are uniform in height and orientation of the slots (48).

8. The screen basket (36) of any one of claims 1 to 6, wherein the slots (48, 70) in each row (50) are uniform in shape and dimensions, and the dimensions of the slots (48, 70) differ from row (50) to row (50).

9. A method for extracting a liquid from a top separator (14) of a treatment vessel (10), the method comprising:

feeding a slurry of cellulosic material and a liquid in the top separator screen basket (36) of a vessel (10), wherein the slurry of cellulosic material and liquid flows into the screen basket (36);
extracting a portion of the liquid in the slurry of cellulosic material and liquid through a screen basket assembly, wherein the screen basket (36) is formed of a screen basket plate within the top separator (14) and is formed around a conveyor screw device, and the screen basket plate includes slots (48, 70) having inlet corner edges (72) adjacent an inside surface of the screen basket plate (62), which inlet corner edges (72) are at least one of curved, rounded, chamfered, sloped or inclined, and facing a flow of slurry of cellulosic material and liquid, and
deflecting cellulosic material flowing through the top separator (14) with the curved or chamfered inlet corner edges (72) to avoid the material become caught in the slots (48, 70) of the screen basket (36).

10. A top separator (14) for use in a treatment vessel (10) comprising:

a rolled plate formed into a cylindrical screen basket (36);
rows (50) of diagonal slots (48, 70) formed in the plate and oriented horizontally, wherein each slot (48, 70) has an inlet corner edge (72) adjacent an inside surface (62) of the screen basket (36), which inlet corner edge (72) is at least one of curved, rounded, chamfered, sloped or inclined;
a single welded joint (51) extending vertically between abutting edges of the plate;
a conveyor screw (32) within the cylindrical screen basket (36), wherein a gap (46) between an outer edge of the screw (32) and an interior surface (62) of the cylindrical screen basket (36) is no greater than thirty thousandths of an inch, preferably no greater than ten thousandths of an inch;
a housing supporting the cylindrical screen basket (36) and forming a liquid chamber between the housing and screen basket (36),
and
a vertical shaft (35) supporting the screw (32) and extending vertically through the cylindrical screen basket (36).

11. The top separator (14) of claim 10, in which the screen basket (36) is constructed in accordance with any one of claims 1 to 8.

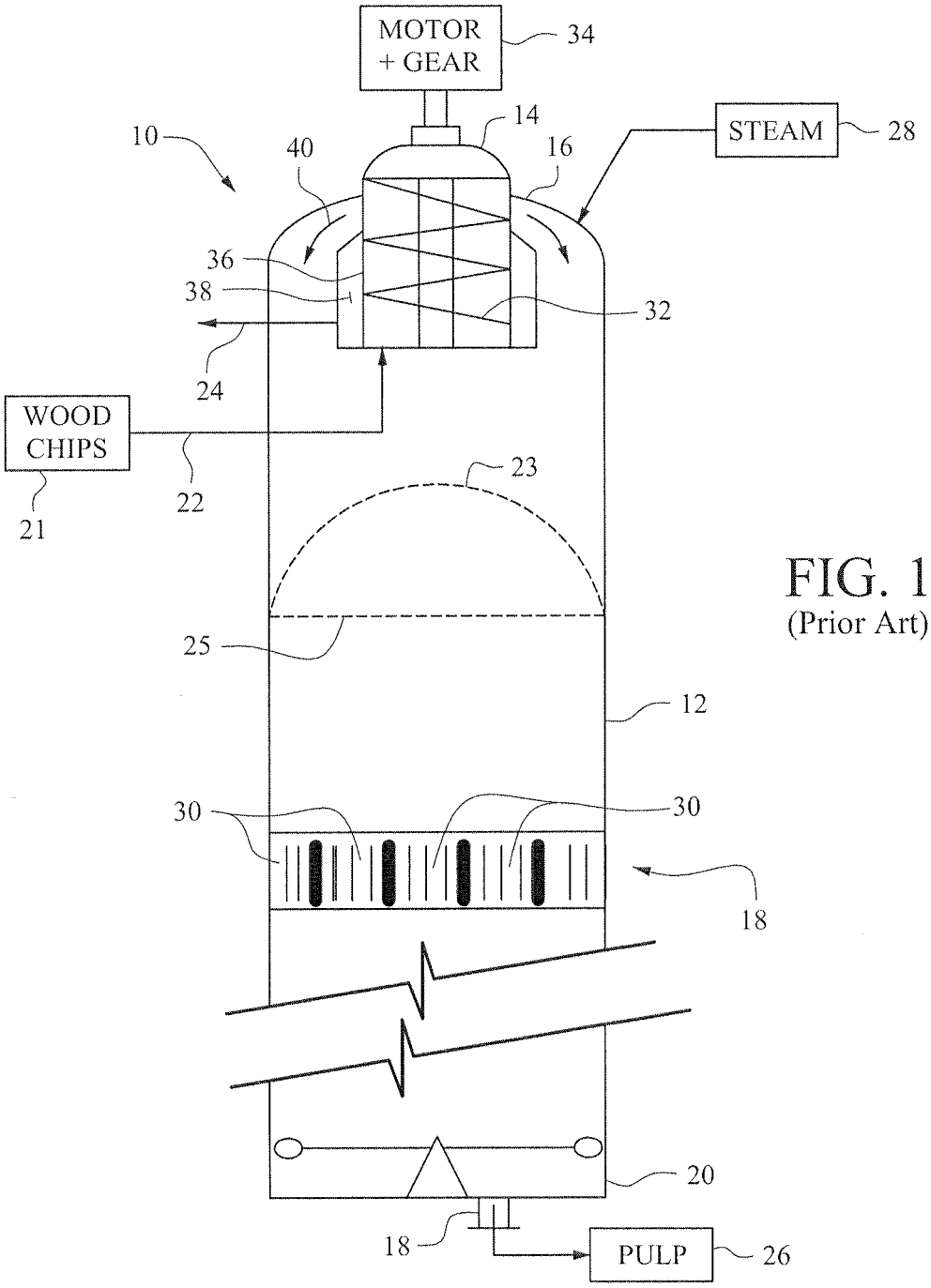

FIG. 1
(Prior Art)

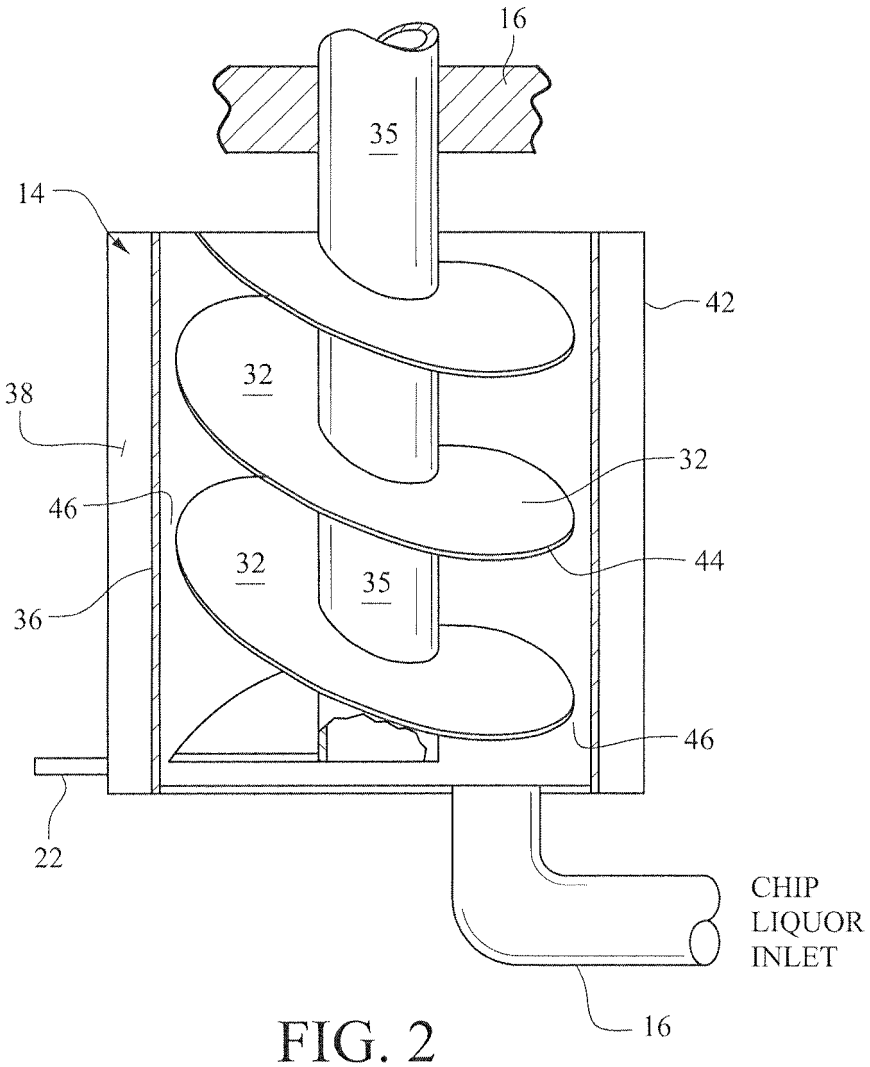

FIG. 2
(Prior Art)

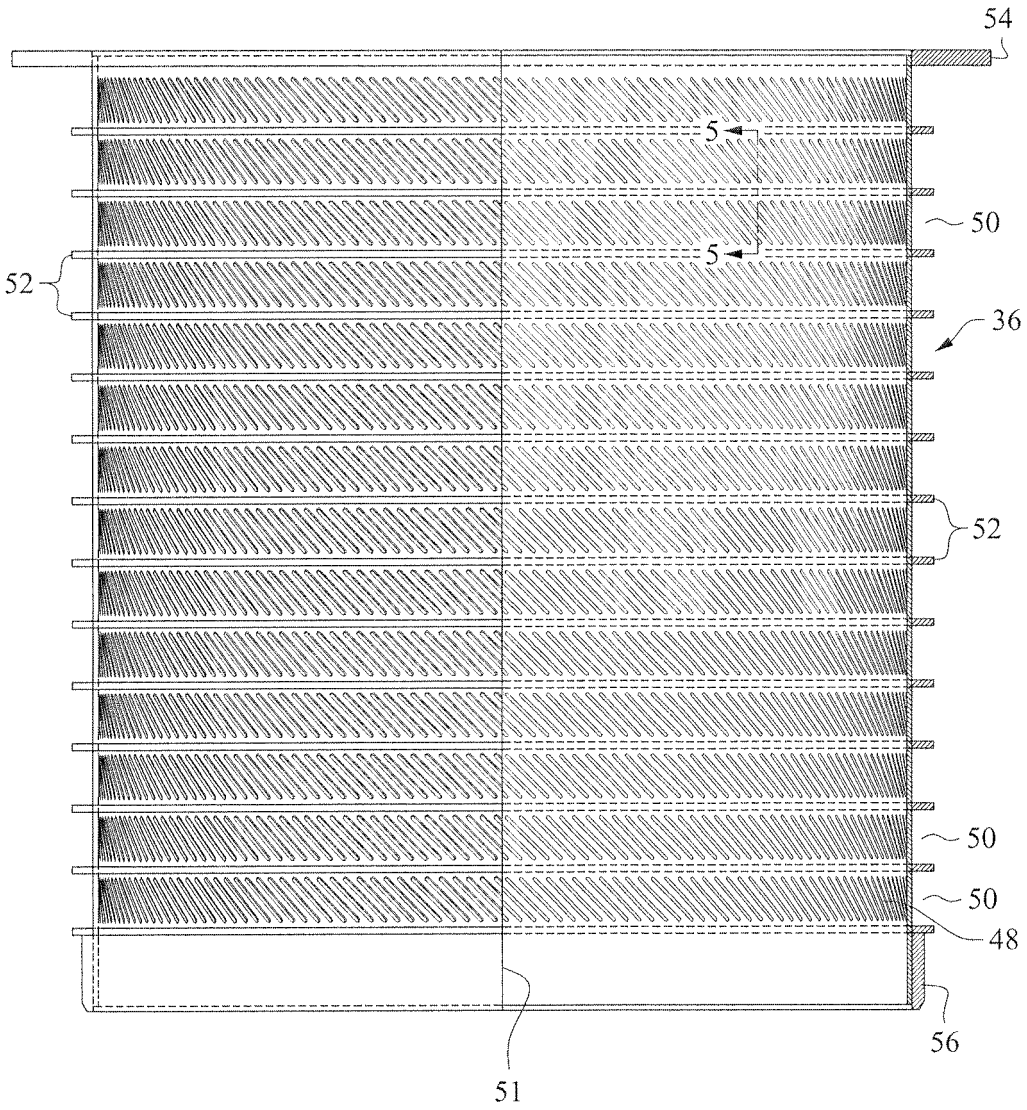

FIG. 3

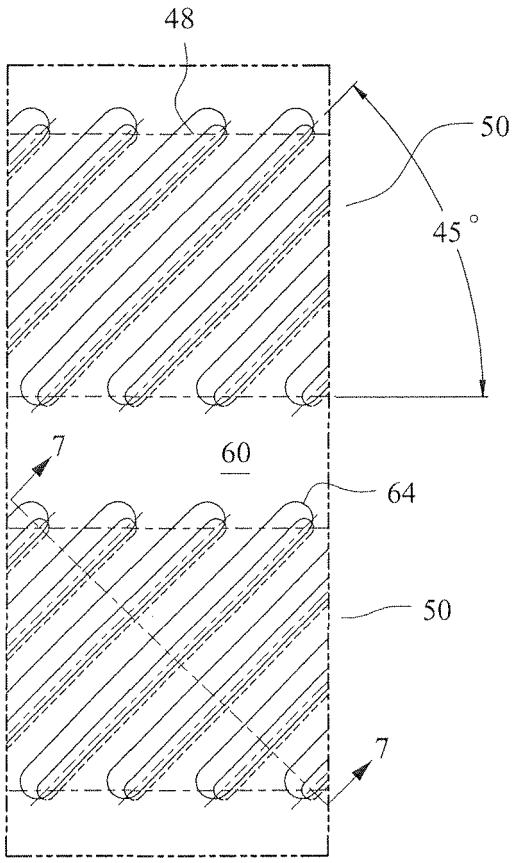

FIG. 4

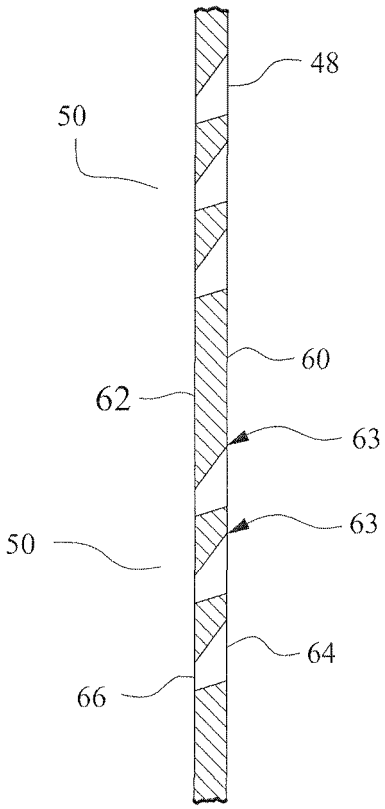

FIG. 5

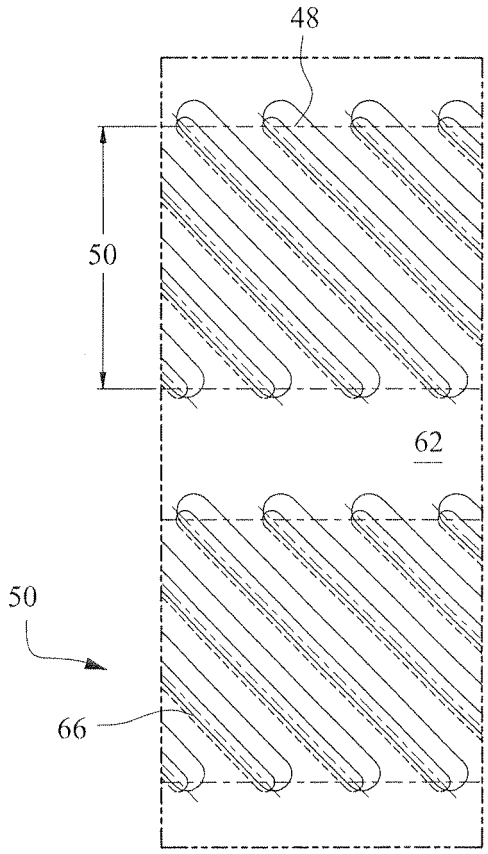

FIG. 6

FIG. 7

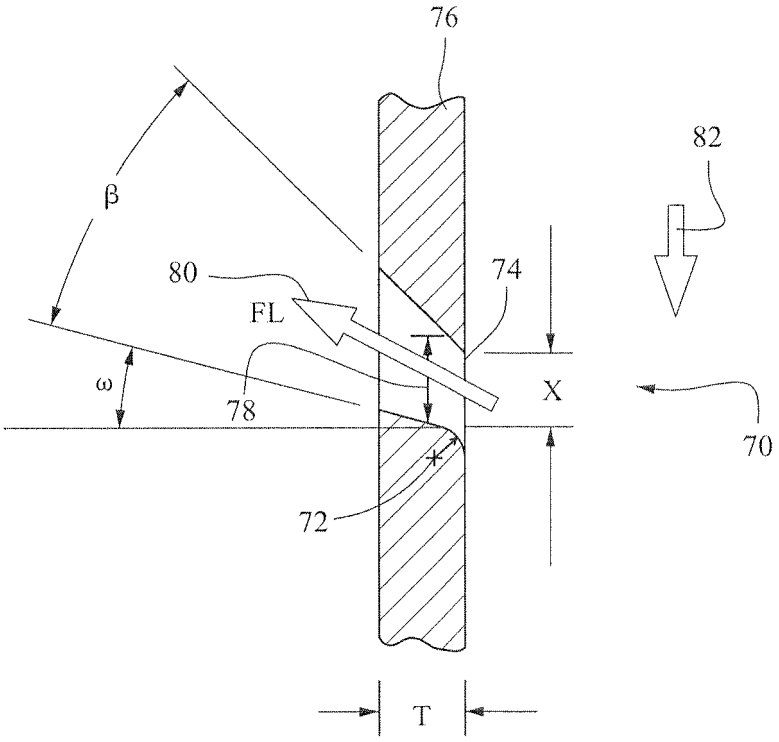

FIG. 8

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 12 19 5822

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	US 6 325 889 B2 (SNEKKENES VIDAR [SE] ET AL) 4 December 2001 (2001-12-04) * the whole document *	1-10	INV. D21C7/06
A,D	US 7 105 076 B2 (STROMBERG C BERTIL [US] ET AL) 12 September 2006 (2006-09-12) * abstract *	1-10	
A,D	US 7 309 401 B2 (VOGEL KEITH P [US] ET AL) 18 December 2007 (2007-12-18) * the whole document *	1,9,10	
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A,D	US 5 413 677 A (COLLINS ROBERT H [US]) 9 May 1995 (1995-05-09) * abstract *	1,9,10	

TECHNICAL FIELDS SEARCHED (IPC)

D21C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 May 2013	Naeslund, Per

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 5822

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17-05-2013

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