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(54) Benevnelse **HEAT EXCHANGER AND METHOD FOR DISTRIBUTING A LIQUID PHASE IN A HEAT EXCHANGER**

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Description

Heat exchanger and method for distributing a liquid phase in a heat exchanger

The invention relates to a helically coiled heat exchanger according to the preamble of Claim 1 for carrying out an indirect heat transfer between at least one first medium, which is carried in a bundle of tubes of the heat exchanger, and a second medium or fluid, which is carried in the shell space of the heat exchanger, and also to a method for distributing a liquid phase of the second medium to the bundle of tubes of the heat exchanger.

Such heat exchangers are used for example in LNG plants, the refrigerant or second medium that enters in a two-phase state generally being divided into a gas phase and a liquid phase by means of gravity separation in a pre-distributor. This separation preferably takes place in an annular channel, which extends on the inner side of the shell in the circumferential direction of the shell. The liquid phase of the second medium/refrigerant is then fed directly into the distributor arms connected to the annular channel. From there, the distribution to the bundle of tubes of the heat exchanger takes place.

In the case of large containers, the weight of what is known as the hold-up becomes very great because of the large diameter of the shell of the heat exchanger and a hold-up height of the liquid phase required by the process, and that has a corresponding influence on the statics, and consequently on the wall thicknesses, of the heat exchanger.

Furthermore, because of the structure of the annular channel and the distributor arms, there is a greater distance between the bundle of tubes and the distributor arms. As a result, there may be a crossflow, which can have the consequence of a poor distribution of the liquid phase on the shell side, and may consequently lead to losses in performance. Similarly, it results in a greater distance between tubesheets and the upper end of the bundle, which requires a longer and heavier core tube. This in turn has effects on production and statics.

Furthermore, the structural design and the required production sequence mean that it is not possible for the bundle and the distributor system to be produced in parallel. Against this background, the present invention is based on the object of providing a heat exchanger that is improved with regard to the aforementioned problems.

This object is achieved by a heat exchanger having the features of Claim 1. Advantageous configurations of the heat exchanger according to the invention are provided in the subclaims and are described below.

According to Claim 1, a heat exchanger for indirect heat exchange between at least one first medium and a second medium is provided, comprising:

- a shell, which surrounds a shell space of the heat exchanger,
- a core tube, which is made to extend along a longitudinal axis and onto which a plurality of tubes for receiving the first medium are coiled, the tubes forming a bundle of tubes, wherein a number of upper end portions of the tubes of the bundle of tubes are brought together and connected to a tubesheet, which is fixed laterally on the shell,
- an annular channel for receiving the second medium,
- an inlet nozzle, which is provided laterally on the shell and by way of which the second medium can be introduced into the annular channel,
- a plurality of distributor arms, which respectively have a base by way of which the liquid phase can be distributed to the bundle of tubes, wherein the distributor arms are respectively in flow connection with the annular channel, and wherein the bases of the distributor arms are arranged under the annular channel with respect to the longitudinal axis.

According to the invention, it is also provided that the tubesheet is fixed on the shell above the bases of the distributor arms and also below the annular channel with respect to the longitudinal axis. In other words, the at least one tubesheet is fixed or arranged on the shell between the annular channel and the bases of the distributor arms. The term “upper end portions” of the tubes relates in particular to the vertically aligned longitudinal axis of the core tube.

Preferably, the tubesheet fixed laterally on the shell is connected to a cylindrical portion of the shell of the heat exchanger.

It is also preferred to provide or fix the inlet nozzle provided laterally on the shell on a or the cylindrical portion of the shell of the heat exchanger.

The heat exchanger may have multiple tubesheets, upper end portions of the tubes then being respectively gathered into multiple groups or tube clusters, wherein the upper end portions of a group or a tube cluster are then connected to or anchored in an assigned tubesheet. In this case, preferably all of the tubesheets are fixed on the shell above the bases of the distributor arms and below the annular channel with respect to the longitudinal axis.

In previous designs, by contrast, the tubesheets for the upper tube end portions were arranged above the annular channel. The necessary length of the core tube is advantageously reduced by the measure according to the invention. Furthermore, the level of the medium required by the process can be ensured by means of the configuration according to the invention, by it being moved into the distributor arms. The distributor arms preferably have in this case a comparatively small volume, so that there is only a correspondingly small hold-up. As a result, a weight reduction can be advantageously achieved, having beneficial effects on the static design (earthquake and wind load) of the heat exchanger.

The arrangement of the tubesheets also makes it possible for the distributor system to be decoupled from the bundle of tubes, and consequently allows the subsequent installation of the distributors. As a result, the distance between the distributor arms and the bundle of tubes can be reduced. In particular, as a result of the structure according to the invention - the annular channel now lies above the tubesheets/clusters - there are no longer any undercuts between the bundle of tubes and the distributor, so that the entire distributor system can be separately prefabricated and attached by a weld to the container or shell.

According to one embodiment of the invention, the core tube is arranged coaxially with respect to the shell along the longitudinal axis. Furthermore, the tubes of the bundle of tubes are preferably coiled onto the core tube in such a way that the latter can absorb or carry away the load of the tubes of the tube bundle.

Furthermore, it is provided according to one embodiment of the invention that the core tube is not in flow connection with the distributor arms.

In particular, it is provided according to one embodiment of the invention that the annular channel is connected to the respective distributor arm in each case by way of a flow path, wherein the respective flow path (for example downpipe or shaft, see below) runs completely outside the core tube.

Furthermore, it is provided according to one embodiment of the invention that the annular channel extends along an inner side of the shell that is facing the shell space, to be precise in particular in a plane running perpendicularly to the longitudinal axis or perpendicularly to the core tube. Furthermore, the bases of the distributor arms also preferably extend in a plane that runs perpendicularly to the longitudinal axis of the shell or the core tube.

According to a further embodiment of the invention, it is provided that the annular channel is set against the inner side of the shell, so that in particular the shell forms an outer wall of the annular channel.

Furthermore, it is provided according to one embodiment of the invention that the distributor arms respectively extend inwardly in the direction of the core tube along or counter to a radial direction. The respective radial direction is in this case perpendicular to the longitudinal axis of the core tube and is directed outward toward the shell.

Furthermore, it is provided according to one embodiment of the invention that the respective distributor arm is flow-connected to the annular channel by way of in each case a downpipe that is made to extend along the longitudinal axis, wherein in particular the respective downpipe is set against a base and/or against an inner wall of the annular channel, wherein the inner wall lies opposite the outer wall or is surrounded by the outer wall.

Furthermore, it is provided according to one embodiment of the invention that the respective distributor arm is closed in the upward direction by a roof, wherein in particular the respective downpipe adjoins the roof of the assigned distributor arm from above. For this purpose, an opening which is in fluid connection with the respective downpipe may be formed in the respective roof.

Furthermore, it is provided according to one embodiment of the invention that the roof of the respective distributor arm falls away inwardly (along the radial direction of the shell or bundle of tubes) in the direction of the core tube. That is to say in particular that the cross section of the distributor arm decreases inwardly along the radial direction.

It is provided according to a further embodiment of the invention that the respective distributor arm has a degassing flue, which in particular is formed separately from the respective downpipe. The respective degassing flue in this case preferably adjoins an opening in the roof of the distributor arm concerned.

It is provided in this respect according to one embodiment of the invention that the respective degassing flue protrudes upward from the roof of the respective distributor arm and extends along the longitudinal axis, wherein in particular the respective degassing flue protrudes upward from an end portion of the respective distributor arm that is arranged adjacent the core tube.

Furthermore, it is provided according to one embodiment of the invention that the roof of the respective distributor arm has a portion that rises up in the direction of the respective degassing flue.

Through the rising portion of the roof, the gas or the gaseous phase of the second medium will rise in the inward direction and follow the respective degassing flue upward. This has the advantage that the gas does not have to rise up counter to the flow of the liquid. Consequently, the components leading the liquid phase of the second medium in the downward direction can be advantageously made smaller.

It is provided according to an alternative embodiment of the invention that the respective distributor arm is formed by a lower portion of a shaft that extends downward from the annular channel along the longitudinal axis, wherein the respective shaft has an inner wall that is facing the core tube and runs inclined in relation to the longitudinal axis, so that the respective shaft tapers upward (i.e. toward the annular channel) in cross section, i.e. in a horizontal sectional plane.

In the case of the aforementioned shaft variant, the downpipes (also referred to as downcomer pipes) are therefore replaced by a distributor shaft, which comprises downpipes and distributor arms combined, wherein in particular an upper portion of the respective distributor shaft that assumes the function of a downpipe goes over continuously into a lower portion of the respective shaft that assumes the function of a distributor arm. In particular, instead of the downpipes which introduce the liquid phase from the annular channel into the respective distributor arm, shafts which can change the shape in the upward direction, in particular can taper in cross section, are installed with the base area or the base of the respective distributor arm. The shafts have the advantage over the other structure that the segregation of gas and liquid is thereby improved. As a result of the greater cross section, a greater dwell time and a lower sinking rate of the liquid are achieved, which improves the separation of gas and liquid.

In principle, it may be provided according to one embodiment of the present invention that adjacent distributor arms are in flow connection with one another by way of an equalizing line, so that the liquid level of the liquid phase located in the distributor arms can be equalized by a flow of the liquid phase by way of the at least one equalizing line. The equalizing line may be in particular an annular line connecting the distributor arms to one another.

In principle, the invention also makes possible a small distance between the bases of the distributor arms and an upper side of the bundle of tubes that is made to extend along a horizontal plane (or perpendicularly to the longitudinal axis), wherein according to one embodiment that distance may lie in a range from 50 mm to 500 mm, in particular 50 mm to 100 mm.

According to a further aspect of the present invention, a method for distributing a liquid phase to a bundle of tubes of a heat exchanger according to the invention is proposed, wherein the first medium is directed into the annular channel and from there is fed into the distributor arms of the main distributor exclusively by way of flow paths running outside the core tube, and from there is passed to the bundle of tubes of the heat exchanger.

According to one embodiment of the method according to the invention, the respective flow path is formed by a downpipe or a shaft (also see above).

According to a further embodiment of the method according to the invention, it is provided that, during operation of the heat exchanger as intended, the liquid phase is in the respective flow path (for example downpipe or shaft), i.e. has within the flow path a specific level of the medium corresponding to the operating case.

The present invention provides in particular a distributor system that allows as much parallel production as possible. Furthermore, the design according to the invention has the effect in particular of reducing the hold-up and minimizing the weight of the container. Finally, the invention allows a reduction of the distance between the bases of the distributor arms and the bundle of tubes, in order to minimize poor distribution of the liquid at the upper end of the bundle.

Further details and advantages of the invention are explained by the following descriptions of figures of exemplary embodiments on the basis of the figures, in which:

Fig. 1 shows a heat exchanger according to the invention in which the annular channel is connected to the distributor arms by way of downpipes (downcomers);

Fig. 2 shows a heat exchanger according to the invention, degassing flues additionally branching off from the distributor arms;

Fig. 3 shows a heat exchanger according to the invention, the distributor arms being configured here in the manner of shafts; and

Fig. 4 shows a schematic plan view of the bases of the distributor arms of a heat exchanger according to the invention.

Figure 1 shows a helically coiled heat exchanger 1 according to the invention, comprising a bundle of tubes 2, which serves for receiving a first medium M1, which is intended to enter into an indirect heat exchange with a liquid phase F of a second medium M2, which is carried in a shell space 5 surrounding the bundle of tubes 2. The shell space 5 is in this case bounded by a pressure-bearing shell 4, which extends along a longitudinal or cylinder axis Z, which in the operationally ready state of the heat exchanger 1 is arranged parallel to the vertical.

The bundle of tubes 2 has a plurality of tubes 20, which are respectively coiled, in particular helically, i.e. in the form of a helical line, onto a core tube 3 that is made to extend along the longitudinal axis Z and is arranged coaxially in relation to the shell 4 in the shell space 5. In this case, the core tube 3 absorbs the load of the bundle of tubes 2. For the sake of simplicity, in the present case only one tube 20 is depicted in Figures 1 to 3.

For distributing the liquid phase F to the bundle of tubes 2, first a two-phase mixture or the second medium M2 is introduced by way of an inlet nozzle 104, which is formed laterally on the cylindrical shell 4, into an annular channel 100, which runs around on an inner side 4a of the shell that is facing the shell space 5 and is set against said inner side of the shell. The annular channel 100 has an outer wall 103, which is formed by the shell 4, and also an inner wall 102, which lies opposite the outer wall 103 in the radial direction R of the shell 4 or the bundle of tubes 2. The outer wall 103 and the inner wall 102 are connected to one another by way of a base 101 of the annular channel 100.

The annular channel 100 forms a pre-distributor, in which the two-phase mixture/second medium M2 is first calmed and a gaseous phase G is separated, and then the liquid phase F is directed downward into distributor arms 201 of the heat exchanger 1, which undertake the distribution of the liquid phase F of the second medium M2 to the bundle of tubes 2.

According to Figures 1 to 4, the distributor arms 201 respectively have a base 202 with outlet openings 207, by way of which the liquid phase F can flow away to the bundle of tubes 2. The distributor arms 201 also have an outer side 206, which is facing the inner side 4a of the shell 4, wherein they respectively extend from the outer wall 206 along the radial direction R of the bundle of tubes 2/shell 4 inwardly toward an inner wall 208, which is facing the core tube 3. The outer and inner walls 206, 208 are connected to one another by side walls 204, 205 of the distributor arms 201 that are made to extend in the radial direction R.

The bases 202 of the distributor arms 201 are arranged under the annular channel 100 along the longitudinal axis Z. According to Figure 4, between distributor arms 201 that are adjacent in the circumferential direction there are gaps 6, through which upper end portions of the tubes 20 are led to tubesheets 21, which in turn are fixed laterally on the shell 4. The tubesheets 21 are in this case fixed on the shell 4 above the bases 202 of the distributor arms 201 and below the annular channel 100 with respect to the longitudinal axis Z

In the present case, the core tube 3 is not in flow connection with the distributor arms 201 and does not take part in the distribution of the liquid phase F.

According to the embodiment shown in Figure 1, the respective distributor arm 201 is flow-connected to the annular channel 101 by way of in each case a downpipe 10 that is made to extend along the longitudinal axis Z. The downpipes 10 in this case have in particular a constant circular cross section. Furthermore, the respective distributor arm 201 is closed in the upward direction by a roof 203, from which the respective downpipe 10 protrudes in the upward direction. Formed in particular in the respective roof 203 is an opening 203a, which is adjoined by the respective downpipe 10.

It is preferably also provided that the respective roof 203 falls away inwardly in the direction of the core tube 3, so that a gaseous phase G outgassing in the respective distributor arm 201 can rise up along the roof 203 into the respective downpipe 10. Here, the respective downpipe 10 therefore also forms a degassing flue.

According to Figure 1, the individual downpipes 10 may be set against the base 101 and the inner wall 102 of the annular channel 100, so that the liquid phase F can flow out of the annular channel 100 by way of an opening in the inner wall 102 and in the base 101 into the respective downpipe 10.

In order to improve the degassing further, according to Figure 2 each distributor arm 201 may also have a separate degassing flue 210, which protrudes upward from an end portion of the respective distributor arm 201 parallel to the core tube 3, likewise from the roof 203, wherein the respective roof 203 preferably rises in the upward direction toward the respective degassing flue 210, so that the gaseous phase can rise up along the respective roof 203 into the assigned degassing flue 210. The respective degassing flue 210 adjoins in particular an opening 203b formed in the roof 203.

It is provided according to a further embodiment that the respective distributor arm 201 is formed by a lower portion of a shaft 11 that extends downward from the annular channel 100 along the longitudinal axis Z, wherein the respective shaft 11 has an inner wall 208 that is facing the core tube 3 and runs inclined in relation to the longitudinal axis Z, so that the respective shaft 11 tapers upward in cross section, i.e. with respect to a horizontal plane. In this case, the respective shaft 11 is in turn preferably set against the inner wall 102 or the base 101 of the annular channel 100, so that the liquid phase F can fall or flow into the respective shaft 11 by way of the base 101 / inner wall 102. As a result of the inclined inner wall 208, here the gaseous phase G can rise up along the inner wall 208 of the respective shaft 11.

According to Figure 4, in all of the embodiments adjacent distributor arms 201 may be connected to one another by way of an equalizing line 209, so that the level of the liquid phase F in the distributor arms 201 can equalize itself. The equalizing line 209 may be divided into portions that respectively extend between two adjacent distributor arms 201.

In principle, the invention makes it possible for there to be a small distance A between the bases 202 of the distributor arms 201 and an upper side 2a of the bundle of tubes 2 that is made to extend along a horizontal plane, that distance being able to lie for example in a range from 50 mm to 500 mm. Furthermore, the invention also allows a flat design in the direction of the longitudinal axis Z, typical heights H of the distributor, that is to say from the base 202 of the respective distributor arm 201 to an upper periphery of the annular channel 100, being able to lie in the range from 1000 mm to 5000 mm. The shells 4 considered have in the region of the distributor arms 201 for example a diameter in the range from 1000 mm to 6000 mm.

List of reference numerals

1	Heat exchanger
2	Bundle of tubes
2a	Upper side
3	Core tube
4	Shell
4a	Inner side
5	Shell space
6	Gap
10	Downpipe
11	Shaft
20	Tube
21	Tubesheet
100	Annular channel
101	Base
102	Inner wall
103	Outer wall
104	Inlet nozzle
201	Distributor arm
202	Base
203	Roof
203a, 203b	Opening
204,205	Side wall
206	Outer wall
207	Outlet opening
208	Inner wall
209	Equalizing line
210	Degassing flue
F	Liquid phase
A	Distance
G	Gaseous phase
H	Height

M1	First medium
M2	Second medium (2-phase inlet flow)
R	Radial direction
Z	Longitudinal axis

Patentkrav

1. Varmeveksler (1) for indirekte varmeveksling mellom et første medium (M1) og et andre medium (M2), omfattende:

- et skall (4) som omgir et skallrom (5) av varmeveksleren (1),
- et kjernerør (3), som er laget for å strekke seg langs en lengdeakse (Z) og hvorpå en flerhet av rør (20) for mottak av det første mediet (M1) er sammenrullet, og rørene (20) danner en rørbunt (2), hvori et antall av øvre endedeler av rørene (20) til rørbunten (2) bringes sammen og kobles til en rørplate (21), som festes til skallet (4),
- en ringformet kanal (100) som strekker seg i omkretsretningen av skallet (4) og beregnet for mottak av det andre mediet (M2),
- en innløpsdyse (104), som er tilveiebrakt sideveis ved skallet (4) og som det andre mediet (M2) kan føres inn i den ringformede kanalen (100) med,
- en flerhet av fordelerarmer (201), som henholdsvis har en base (202) med utløpsåpninger (207), ved hjelp av hvilken en væskefase (F) av det andre mediet (M2) kan fordeles på rørbunten (2), hvori fordelerarmene (201) er respektivt i strømningsforbindelse med den ringformede kanalen (100), og hvori basene (202) til fordelerarmene (201) anordnes under den ringformede kanalen (100) med hensyn til lengdeaksen (Z),

Karakterisert ved at rørplaten (21) festes ved skallet (4) over basene (202) til fordelerarmene (201) og under den ringformede kanalen (100) i forhold til lengdeaksen (Z).

2. Varmeveksler (1) ifølge krav 1, **karakterisert ved at** kjernerøret (3) ikke er i strømningsforbindelse med fordelerarmene (201).

3. Varmeveksler (1) ifølge krav 1 eller 2, **karakterisert ved at** den ringformede kanalen (100) strekker seg langs en indre side (4a) av skallet (4) som vender mot skallrommet (5).

4. Varmeveksler ifølge krav 3, **karakterisert ved at** den ringformede kanalen (100) er anordnet mot innersiden (4a) av skallet (4), slik at spesielt skallet (4) danner en yttervegg (103) av den ringformede kanalen (100).

5. Varmeveksler ifølge ett av de foregående kravene, **karakterisert ved at** fordelerarmene (201) strekker seg henholdsvis langs en radiell retning (R), som er vinkelrett på lengdeaksen (z), hvori spesielt fordelerarmene (201) strekker seg fra henholdsvis skallet (4) mot kjernerøret (3).

6. Varmeveksler ifølge ett av de foregående kravene, **karakterisert ved at** den respektive fordelerarmen (201) er strømningsforbundet til den ringformede kanalen (100) ved hjelp av i hvert tilfelle et nedløpsrør (10) som er laget for å strekke seg langs lengdeaksen (Z).

7. Varmeveksler ifølge ett av de foregående kravene, **karakterisert ved at** den respektive fordelerarmen (201) har et tak (203).

8. Varmeveksler ifølge krav 7, **karakterisert ved at** det respektive taket (203) faller bort innover i retning av kjernerøret (3).

9. Varmeveksler ifølge krav 7, **karakterisert ved at** den respektive fordeleren (201) har en avgassingskanal (210).

10. Varmeveksler ifølge krav 9, **karakterisert ved at** den respektive avgassingskanalen (210) stikker oppover fra en åpning (203b) i taket (203) til den respektive fordelerarmen (201) og strekker seg langs lengdeaksen (Z).

11. Varmeveksler ifølge krav 10, **karakterisert ved at** taket (203) til den respektive fordelerarmen (201) har en del som stiger opp i retning av den respektive avgassingskanalen (210).

12. Varmeveksler ifølge ett av kravene 1 til 5, **karakterisert ved at** den respektive fordelerarmen (201) dannes av en nedre del av en aksel (11) som strekker seg nedover fra den ringformede kanalen (100) langs lengdeaksen (Z) hvori den respektive akselen (11) har en indre vegg (208) som vender mot kjernerøret (3) og går skrått i forhold til lengdeaksen (Z), slik at den respektive akselen (11) avsmalner oppover i tverrsnitt.

13. Varmeveksler ifølge ett av de foregående kravene, **karakterisert ved at** fordelerarmene (201) som er tilstøtende i omkretsretningen til skallet (4) er i strømningsforbindelse med hverandre ved hjelp av en utjevningsledning (209), slik at væskenivået til væskefasen (F) lokalisert i fordelerarmene (201) kan utjevnes med en strømning av væskefasen (F) ved hjelp av utjevningsledningen (209).

14. Fremgangsmåte for å fordele en væskefase (F) til en rørbunt (2) av en varmeveksler (1) ifølge ett av de foregående kravene, hvori det andre mediet (M2) ledes inn i den ringformede kanalen (100) og føres derfra inn i fordelerarmene (201) til varmeveksleren (1) utelukkende ved hjelp av strømningsbaner (10, 11) som løper utenfor kjernerøret (3), og derfra føres en væskefase (F) av det andre mediet (M2) til rørbunten (2) av varmeveksleren (1).

15. Fremgangsmåte ifølge krav 14, **karakterisert ved at** den respektive strømningsbanen dannes av et nedløpsrør (10) eller av en aksel (11).

Fig. 1

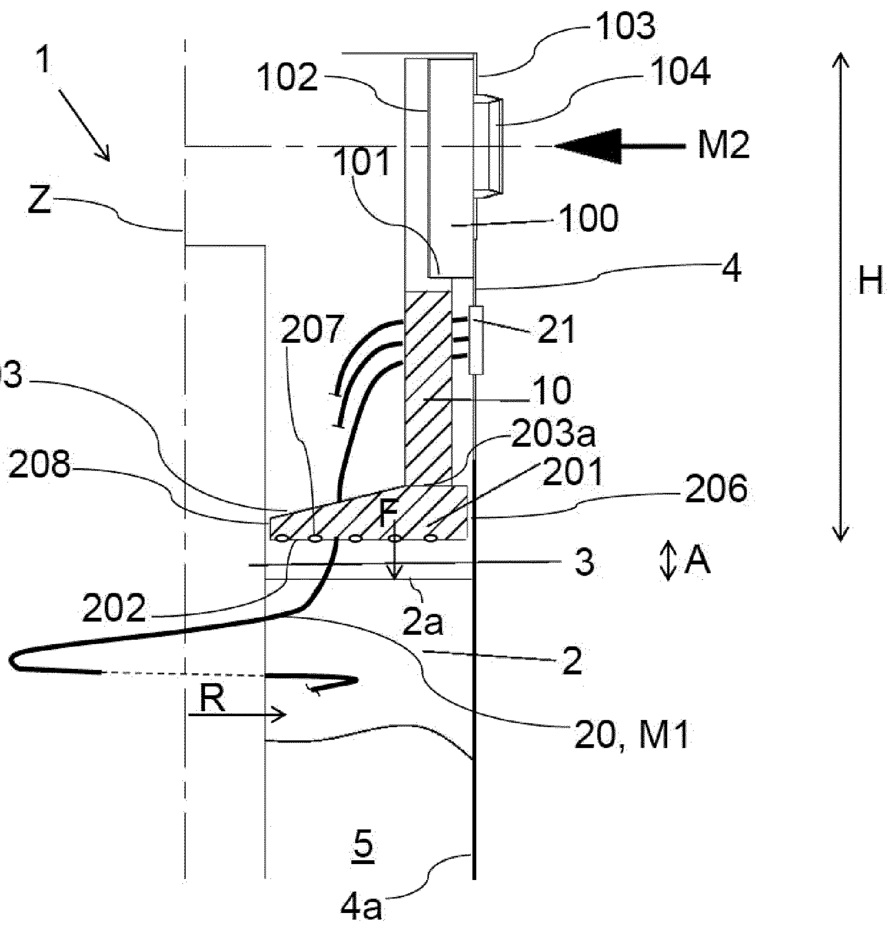
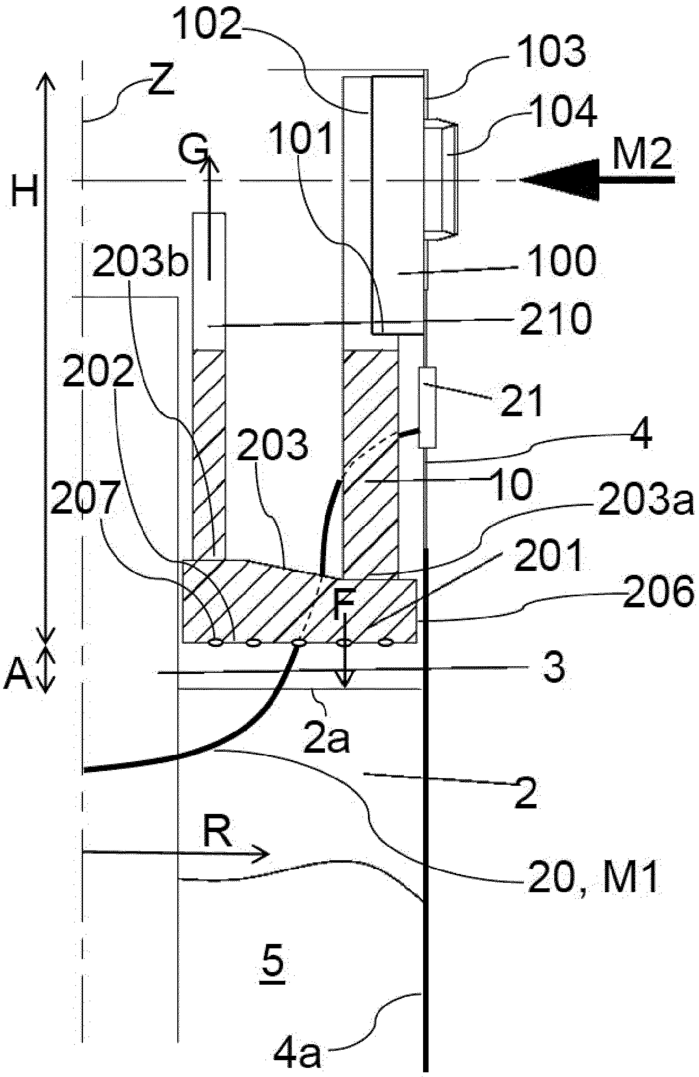

1
Z
102
103
104
M2
101
100
4
H
207
21
203
10
203a
201
208
206
F
3
A
202
2a
2
R
20, M1
5
4a

Fig. 2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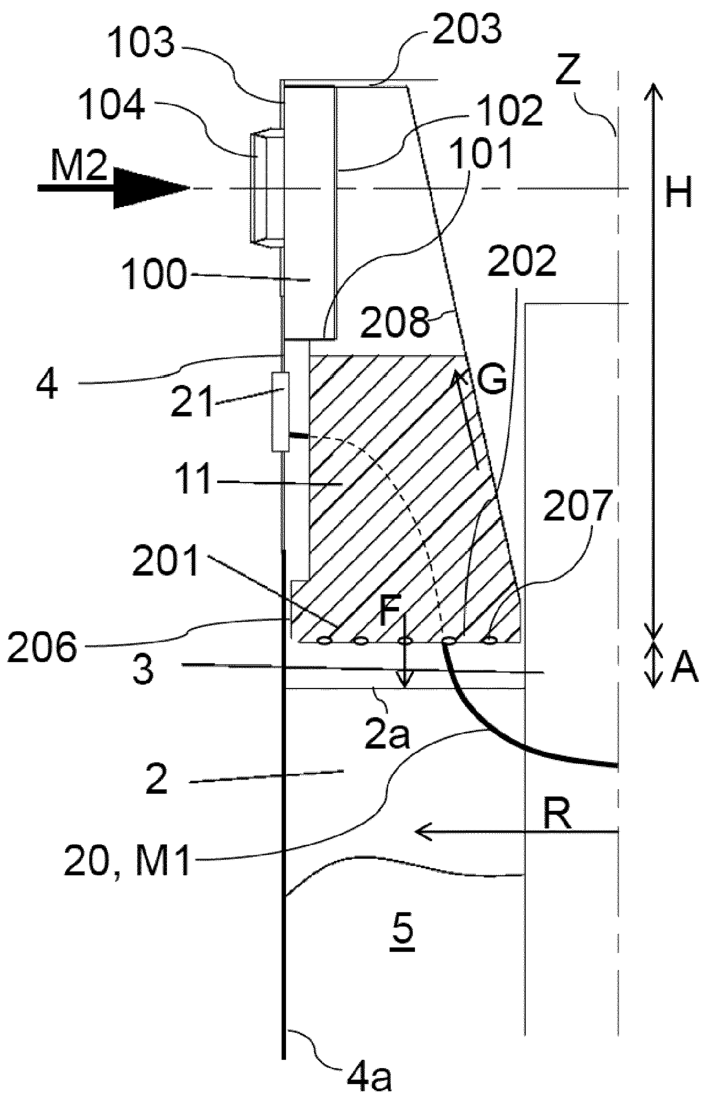
103
104
Z
G
101
M2
H
203b
100
210
202
21
203
4
207
10
203a
201
206
F
A
3
2a
2
R
20, M1
5
4a

Fig. 3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203
Z
104
102
M2
101
H
100
202
208
4
G
21
11
207
201
F
206
3
A
2a
2
R
20, M1
5
4a

Fig. 4