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(54) Title: SHELL AND TUBE EVAPORATOR

(57) Abstract: Provided is a shell and tube type evaporator (100, 400) for a chiller system. The evaporator (100, 400) includes a re-
frigerant box (130, 230) having features configured to help distribute the refrigerant evenly into heat-exchanging tubes (120, 420) of
the evaporator (100, 400). The shell side of evaporator (100, 400) includes sealing plates (150, 450) to help reducing process fluid
by-passing a tube bundle (119, 419) in the shell side. The configuration disclosed herein may help increase efficiency and reliability
of the evaporator (100, 400), and may help reduce a size of the evaporator (100, 400).



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SHELL AND TUBE EVAPORATOR

Field

The disclosure herein relates to a heating, ventilation, and air-conditioning (“HVAC”) system, and more particularly to a shell and tube type evaporator used in a HVAC chiller system. Generally, systems and methods are described to manage a fluid(s) (such as refrigerant and a process fluid) in a shell and tube type evaporator such as may be used in chillers.

Background

A chiller, such as used in a HVAC system, may generally include a compressor, a condenser, and an evaporator to form a refrigeration loop. The compressor is generally configured to compress a refrigerant vapor and the condenser is generally configured to condense the refrigerant vapor to liquid refrigerant. The evaporator is generally configured to vaporize the refrigerant liquid and condition a process fluid, such as water.

The evaporator of the chiller can be a shell and tube type heat exchanger, which typically includes heat-exchanging tubes running across a sealed shell. The shell and tube type evaporator generally has a shell side and a tube side. In some evaporators, such as a dry-expansion evaporator, the shell side can be configured to carry the process fluid, such as water; and the tube side can be configured to carry the refrigerant. The evaporator can be configured to help exchange heat between the refrigerant in the tube side with the process fluid in the shell side. To facilitate distributing the refrigerant into the heat-exchanging tubes, the evaporator typically has a distributor assembly in a refrigerant box.

Summary

Embodiments of a shell and tube type evaporator are disclosed herein. In some embodiments, the evaporator may include a shell side and a tube side. In some embodiments, the shell side is configured to receive a process fluid; and the tube side is configured to receive a refrigerant. In some embodiments, the shell and tube type evaporator may be configured to have features that may help distribute refrigerant evenly to the tube side of the evaporator.

Some evaporators may include internal baffles. The internal baffles are typically configured to direct a process fluid flow in the shell side of the evaporator. The process fluid may by-pass a tube bundle at a region between the tube bundle and an inner surface of the shell. The process fluid may also by-pass the internal baffles between the baffles and an inner surface of the shell. In some embodiments, the evaporator may be configured to have features that may help prevent process fluid from by-passing between internal baffles and the inner surface of a shell of the evaporator, as well as between the tube bundle and an inner surface of the shell.

In some embodiments, the evaporator may include a refrigerant box that includes a refrigerant inlet and a refrigerant outlet. The evaporator may include a refrigerant distribution assembly, which includes a distribution box and a plurality of refrigerant distributors. In some embodiments, the distribution box may be configured to cover the refrigerant inlet, and the refrigerant inlet may be in fluid communication with the plurality of refrigerant distributors through the distribution box. In some embodiments, the plurality of refrigerant distributors are laterally located relative to the refrigerant inlet in a direction of the distribution box.

In some embodiments, each of the plurality of refrigerant distributors includes a dome-shaped section sitting on top of a column-shaped section, and the dome-shaped section and the column-shaped section are configured to have a plurality of apertures to distribute refrigerant.

In some embodiments, the dome-shaped section may include a relatively closed end portion. In some embodiments, the relatively closed end portion may be configured to be free of apertures. In some embodiments, the plurality of refrigerant distributors may have apertures configured to allow refrigerant flowing out of the distribution assembly.

In some embodiments, the refrigerant outlet and the refrigerant inlet of the refrigerant box may be divided by a divider. The divider may form a refrigerant-tight seal between the refrigerant outlet and the refrigerant inlet with a tube sheet of the evaporator.

In some embodiments, the refrigerant box may include a lower partition, the lower partition may be positioned lower than the refrigerant inlet toward a bottom of the evaporator relative to the refrigerant inlet. In some embodiments, the lower partition may form a gap with the tube sheet.

In some embodiments, the evaporator may include a plurality of internal baffles, and each

of the internal baffles may have a cut-out region configured to form a space between the baffle and an inner surface of the evaporator. The side cut-out region is configured to receive a sealing plate extending a full length of the evaporator. In some embodiments, the sealing plate is configured to form a first process fluid-tight seal between the sealing plate and the inner surface of the shell, and a second process fluid-tight seal between the sealing plate and each of the plurality of internal baffles. The seals formed by the sealing plate with the inner surface of the shell and the internal baffles may help prevent process fluid by-passing between the internal baffles and the inner surface of the shell. The sealing plate can also help displace the process fluid out of the region that has the relatively low heat exchange efficiency due to lack of heat-exchanging tubes.

Other features and aspects of the embodiments will become apparent by consideration of the following detailed description and accompanying drawings.

Brief Description of the Drawings

Reference is now made to the drawings in which like reference numbers represent corresponding parts throughout.

Fig. 1 is a partial cut-out and exploded perspective view of an evaporator, according to one embodiment. It is noted that some heat-exchanging tubes are omitted from Fig. 1.

Figs. 2A to 2E illustrate different aspects of a refrigerant box, according to another embodiment. Fig. 2A is a front perspective view. Fig. 2B is a front perspective view with a refrigerant distribution assembly removed. Fig. 2C illustrates a perspective view of the refrigerant distribution assembly. Fig. 2D illustrates a front view of the refrigerant box. Fig. 2E is a cross-section view from the line 2E-2E in Fig. 2D.

Fig. 3 illustrates another embodiment of a refrigerant distributor.

Figs. 4A to 4C illustrate different aspects of an evaporator, according to another embodiment. Fig. 4A illustrates a perspective view with the shell of the evaporator removed. Fig. 4B illustrates an internal baffle of the evaporator. Fig. 4C illustrates a front sectional view of the evaporator.

Detailed Description

Various shell and tube types of evaporators have been developed. Typically, the shell and tube type evaporator include heat-exchanging tubes running across a sealed shell of the evaporator. The heat-exchanging tubes are configured to carry one fluid, forming a tube side.

- 5 The shell is configured to carry another fluid, forming a shell side. The tube side and the shell side can form a heat-exchanging relationship to help heat exchange between the two fluids. In some evaporators, such as a dry expansion evaporator, the shell side is configured to carry a process fluid and the tube side is configured to carry refrigerant.

- Embodiments disclosed herein are directed to a shell and tube type evaporator, such as a
10 dry expansion evaporator. In some embodiments, a tube side is configured to carry a refrigerant; and the shell side is configured to carry a process fluid, such as water. In some embodiments, the evaporator may include a distributor assembly having features configured to help distribute the refrigerant evenly into heat-exchanging tubes of the tube side. In some embodiments, the shell side may include sealing plates to help reduce process fluid from by-passing between a tube
15 bundle and an inner surface of the shell, and/or between internal baffles and the inner surface of the shell in the shell side. The embodiments disclosed herein may help increase efficiency and reliability of the evaporator, and may help reduce a size of the evaporator.

- References are made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration of the embodiments in which the embodiments may be practiced.
20 The term “fluid” is a general term that can be referred to refrigerant and/or a process fluid, such as water. It is to be understood that the terms used herein are for the purpose of describing the figures and embodiments and should not be regarded as limiting the scope of the present application.

- Fig. 1 illustrates a partial cut-out and exploded view of a shell and tube type evaporator
25 100, according to one embodiment. The evaporator 100 includes a shell 110 having a first end 112 and a second end 114. The shell 110 includes a process fluid inlet 116 and a process fluid outlet 118, forming a shell side. The process fluid inlet 116 is configured to receive a process fluid, such as water; and the process fluid outlet 118 is configured to direct the conditioned process fluid out of the shell 110. Typically, the process fluid inlet 116 is located closer to the

first end 112 and the process fluid outlet 118 is located closer to the second end 114. It is to be appreciated that in some embodiments, the process fluid outlet can be closer to the first end 114 and the process fluid outlet can be closer to the second end 116 of the evaporator 100.

5 A tube bundle 119, which includes a plurality of heat-exchanging tubes 120, runs across the shell 110 between the first end 112 and the second end 114 in the longitudinal direction defined by the length L of the shell 110. The heat-exchanging tubes 120 of the tube bundle 219 form a tube side. Open ends 122 of the heat-exchanging tubes 120 are attached to a tube sheet 140 close to the first end 112 of the shell 110. The open ends 122 form an inlet region 122a and an outlet region 122b on the tube sheet 140. The inlet region 122a is typically configured to
10 receive refrigerant and distribute the refrigerant to the heat-exchanging tubes 120. The outlet region 122b is typically configured to direct the refrigerant out of the heat-exchanging tubes 120. The evaporator 100 also includes a refrigerant box 130 that is configured to be attached to the tube sheet 140. The refrigerant box 130 is configured to distribute refrigerant into the heat
exchanging tubes 120 and to direct refrigerant out of the heat-exchanging tubes 120.

15 The evaporator 100 also includes a sealing plate(s) 150 that runs across the shell 110 in a longitudinal direction that is defined by a length L of the shell 110. The sealing plate(s) 150 is configured to engage internal baffles 152 inside the shell 110. The internal baffles 152 may be configured to direct a process fluid flow inside the shell 110. The sealing plate(s) 150 may help fill in a region between the tube bundle 119 and an inner surface 190 of the evaporator, and
20 displace the process fluid from the region. The sealing plate(s) 150 can also help form a process fluid-tight seal between the internal baffles 152 and the shell 110, and/or help displace the process fluid inside the shell 110.

Generally, each of the heat-exchanging tubes 120 starts at the inlet region 122a of the tube sheet 140, runs across the shell 110 in the longitudinal direction defined by the length L,
25 and then makes a “U” bend 121 at the second end 114 of the shell 110. The heat-exchanging tube 120 then runs across the shell 110 in the longitudinal direction defined by the length L again, then ends at the outlet region 122b of the tube sheet 140. In some embodiments, the heat-exchanging tubes are a continuous tube, which may be referred to as “U” tubes.

In the evaporator 100, it is typical that an area toward a bottom 111 of the shell 110 does

not have any heat-exchanging tubes 120, which generally resembles a blanket area 122c on the tube sheet 140 toward the bottom 111 of the shell 110.

The refrigerant box 130 has a refrigerant inlet 132 that forms fluid communication with the inlet region 122a of the tube sheet 140, and a refrigerant outlet 134 that forms fluid communication with the outlet region 122b of the tube sheet 140. The refrigerant inlet 132 is configured to receive refrigerant and distribute the refrigerant to the heat-exchanging tubes 120 through the inlet region 122a. The refrigerant outlet 134 is configured to receive refrigerant coming out of the heat-exchanging tubes 120 through the outlet region 122b.

In operation, the refrigerant can be distributed into the heat-exchanging tubes 120 through the refrigerant inlet 132 at the first end 112 of the shell 110, flow through the heat-exchanging tubes 120 in the longitudinal direction that is defined by the length L, then turn back through the “U” bend 121, and run through the heat-exchanging tube 120 again. The refrigerant then flows back to the first end 112 of the shell 110, and can be collected and directed out of the shell 110 through the refrigerant outlet 134.

The process fluid may be directed into the shell 110 through the process fluid inlet 116, then flow in the longitudinal direction defined by the length L, and be directed out of the shell from the process fluid outlet 118. The process fluid flow direction is generally directed by the internal baffles 152. Using internal baffles 152 inside the evaporator 100 to direct the process fluid flow is generally known in the art. The process fluid in the shell 110 and the refrigerant in the heat-exchanging tubes 120 can form a heat-exchanging relationship that helps exchange heat between the process fluid and the refrigerant.

A region between the outermost heat-exchanging tubes 120 of the tube bundle 119 and the inner surface 190 of the evaporator 100 may not have any heat-exchanging tubes 120, because it may be difficult to install heat-exchanging tubes 120 close to the inner surface 190 of the evaporator 100. Because the region generally does not have any heat-exchanging tubes 120, the heat exchanging efficiency of the process fluid in the region may be relatively low. The sealing plate(s) 150 can help fill in the region of relatively low heat-exchanging efficiency and displace the process fluid out of this region. (See Fig. 4C for more discussion regarding the space and the sealing plates.)

It is also possible for the process fluid to by-pass the internal baffles 152 between the inner surface 190 of the shell and the internal baffles 152. The sealing plate(s) 150 may also help displace the process fluid inside the shell 110. The sealing plate(s) may help increase heat exchanging efficiency between the process fluid and the refrigerant.

5 Figs. 2A to 2F illustrated different aspects of a refrigerant box 230, according to one embodiment. As illustrated in Figs. 2A and 2B, the refrigerant box 230 may include a head 231, a divider 233, a lower partition 235, and a refrigerant distribution assembly 260 that is positioned between the divider 233 and the lower partition 235. The refrigerant box 230 has a refrigerant inlet 232 and a refrigerant outlet 234.

10 The refrigerant box 230 can be configured to work with the evaporator 100 as illustrated in Fig. 1. Referring to Figs. 1, 2A and 2B, when assembled, the divider 233 is typically configured to form a refrigerant-tight seal with the tube sheet 140 between the inlet region 122a and the outlet region 122b. The refrigerant-tight seal formed by the divider 233 and the tube sheet 140 can help separate refrigerant flowing into the head 231 from the refrigerant inlet 232 and refrigerant flowing out of the head 231 from the refrigerant outlet 234.

As illustrated in Figs. 2A and 2C, the refrigerant distribution assembly 260 includes a distribution box 262 and at least one refrigerant distributor 264. The embodiment as illustrated includes two refrigerant distributors 264 sitting on top of the distribution box 262. It is appreciated that the number of the refrigerant distributors 264 can be more than two.

20 The refrigerant distribution assembly 260, particularly the distributor box 262 of the refrigerant distribution assembly 260, is configured to cover an opening 232a of the refrigerant inlet 232 as illustrated in Fig. 2B. As illustrated, the distributor box 262 can be configured to have a rectangular-shaped profile. It is to be appreciated that the distributor box 262 can be shapes other than rectangular. When refrigerant flows into the refrigerant inlet 232, the velocity of the refrigerant can be relatively high. The distributor box 262 can help reduce the velocity of the refrigerant.

The refrigerant distributor 264 has apertures 265 that are configured to allow refrigerant to flow out of the apertures 265 from the distributor box 262. When assembled, the refrigerant distributors 264 and the opening 232a of the refrigerant inlet 232 are positioned on opposite sides

relative to the distributor box 262. The refrigerant distributor 264 is configured to point to an inlet region (such as the inlet region 122a in Fig. 1) of a tube sheet (such as the tube sheet 140 in Fig. 1). The refrigerant inlet 232, the distribution box 262 and the refrigerant distributors 264 can be in fluid communication. Refrigerant can be directed into the refrigerant inlet 232 and
5 flow out of the apertures 265 of the refrigerant distributor 264 through the distribution box 262.

The refrigerant distributor 264 can be configured to be positioned off-set relative to the opening 232a of the refrigerant inlet 232 in a direction of the distributor box 262 that is defined by a length L2. The refrigerant distributor 264 can be positioned more laterally than the relative location of the opening 232 in the longitudinal direction defined by the length L2. When the
10 refrigerant flows into the distributor box 262, the distributor box 262 not only can help reduce the velocity of the refrigerant, but also can help distribute the refrigerant laterally in the longitudinal direction defined by the length L2. The refrigerant can then flow into the distributor 264 to flow out of the apertures 265 of the refrigerant distributor 264.

In operation, after the refrigerant flows out of the apertures 265 of the refrigerant
15 distributor 264, the refrigerant can then flow into heat-exchanging tubes (such as heat-exchanging tubes 120 in Fig. 1).

Referring to Figs. 1, 2A and 2D, the lower partition 235 is typically configured to help prevent the refrigerant from being distributed toward the blank area 122c of the tube sheet 140. The lower partition 235 is typically positioned just below the inlet region 122a of the tube sheet
20 140 when assembled.

Referring to Fig. 2E, a cross-section along line 2E-2E in Fig. 2D is shown. The lower partition 235 is positioned so that there is a gap G2 between the lower partition 235 and an interface 239 of the head 231.

Referring to Figs. 1, 2A, 2D and 2E, when the header 231 is assembled with, for
25 example, the evaporator 100 as shown in Fig. 1, the lower partition 235 does not touch the tube sheet 140 because of the gap G2. This is different from the divider 233, which is configured to form a refrigerant-tight seal with the tube sheet 140.

The gap G2 can be relatively small, such as for example about 3mm, so that the gap G2 generally does not allow a large amount of refrigerant to flow through the gap G2. Therefore,

the gap G2 generally does not interfere distributing the refrigerant into the heat-exchanging tubes in the inlet region 122a.

In an evaporator without the gap G2, the lower partition 235 may form an airtight seal with the tube sheet 140. As a result, some air will be trapped in the space 238. During operation of the evaporator, a pressure difference between the air trapped in the space 238 and the refrigerant inlet region (such as the inlet region 122a in Fig. 1) may cause the lower partition 235 to deform. Air trapped in the space 238 may leak out, reducing the performance of the evaporator. The gap G2 can help remove the air from the space 280, such as by vacuum, when the evaporator is assembled.

Referring to Figs. 2C and 2D, the refrigerant distributor 264 as illustrated include a column-shaped section 264a and a dome-shaped section 264b along a height H2 of the refrigerant distributor 264. Both the column-shaped section 264a and the dome-shaped section 264b are configured to have a plurality of apertures 265. The apertures 265 in the column section 264a and the dome section 264b can be arranged into rows at different heights along the height H2.

In some embodiments, the number of apertures 265 in each row in the column-shaped section 264a may be the same, while the number of apertures 265 in each row in the dome-shaped section 264b may be different. However, it is to be appreciated that the arrangements of the apertures 265 are exemplary.

The apertures 265 as illustrated generally have a circular shape. This is exemplary. It is appreciated that the apertures 265 can be configured to have other shapes, such as triangular or slots.

An end portion 269 of the dome section 264b can be configured to be relatively closed. For example, the end portion 269 can be configured to not include any apertures 265. The relatively closed end portion 269 may help push the refrigerant out of the apertures 265 located along the column-shaped section 264a and the dome-shaped section 264b. This configuration can help direct refrigerant more evenly.

The refrigerant distribution assembly 260 can be configured to have a plurality of refrigerant distributors 264. In the illustrated embodiment, the number of the refrigerant

distributors 264 is two, with the appreciation that the number can be more than two. It is to be appreciated that arrangement of the refrigerant distributors 264 on the distribution box 262 may vary to achieve, for example, even distribution of refrigerant.

Fig. 3 illustrates another embodiment of a refrigerant distributor 364. As illustrated, the refrigerant distributor 364 is configured to have a column section 364a. The refrigerant distributor 364 is configured not to have a dome section, such as the dome section 264b as illustrated in Fig. 2C. The refrigerant distributor 364 can be configured to have a closed flat top 369 without any apertures. The column section 364a can have a plurality of apertures 365 to help distribute refrigerant.

It is to be appreciated that the configurations of the refrigerant distributor as illustrated in Figs. 2C and 3 are exemplary. The refrigerant distributor can be configured to have other shapes or configurations. For example, the dome-shaped section 264b as illustrated in Fig. 2C may be configured to have a cone shape. Size and positions of the apertures can also be varied. Generally, the configurations of the refrigerant distributor and the apertures (including the shape of the refrigerant distributor, the number and arrangement of distributors, and the size and positions of the apertures) may be configured to help distribute the refrigerant evenly into the heat-exchanging tubes. In some embodiments, refrigerant distributors may be configured to achieve a desired pressure drop across the apertures. In some embodiments, the distribution assembly may not include any refrigerant distributors; instead, the distribution box itself may include apertures to distribute the refrigerant. Computer simulation may be used to help determine the configurations of the refrigerant distributor and the apertures.

Figs. 4A illustrates an evaporator 400 with a shell 410 (as shown in Fig. 4C) of the evaporator 400 removed, according to one embodiment. The evaporator 400 includes a tube sheet 440 that is connected to a tube bundle 419. The tube bundle 419 is made of a plurality of heat-exchanging tubes 420. The evaporator 400 also includes a plurality of internal baffles 452 that are spaced out along a longitudinal direction that is defined by a length L4 of the evaporator 400 (the length L4 can be similar to the length L1 of the evaporator 100 as shown in Fig. 1).

The evaporator 400 includes two sealing plates 450 flanking the plurality of internal baffles 452. The sealing plates 450 extend along the length L4. As illustrated in Fig. 4A, the

sealing plates 450 can extend the full length L4 of the evaporator 400 (the sealing plates 150 can extend the full length L1 of the evaporator 100 as shown in Fig. 1).

Fig. 4B illustrates a front view of one of the internal baffles 452. The internal baffle 452 includes a plurality of apertures 455 that are configured to receive the heat-exchanging tubes 420. The internal baffle 452 also includes a first cut-out region 456a and a second cut-out region 456b on two sides of the internal baffle 452. The cut-out regions 456a and 456b generally correspond to regions that do not typically have the heat-exchanging tubes 420 running through.

Referring to Fig. 4C, a front sectional view of the evaporator 400 is shown. The evaporator includes the shell 410. The internal baffle 452 is typically shaped in accordance with an inner surface 490 of the shell 410, so that the internal baffle 452 can be fitted tightly inside the shell 410.

Referring to Figs. 1, 4A and 4C, the internal baffles 452 can be used in the shell side of an evaporator, such as the evaporator 100 in Fig. 1, to direct a process fluid flow. The process fluid flows flowing into the shell 110 from the process fluid inlet 116. The internal baffles 452 are configured to direct the process fluid to form a serpentine-like fluid flow. It is known in the art that the serpentine-like fluid flow can help heat exchange between the fluid flow and the heat-exchanging tubes 120.

Sometimes, the inner surface 190 of the shell 110 and the internal baffles 452 may not form a process fluid-tight seal, the process fluid may by-pass the internal baffles 452 in the gap between the internal baffles 452 and the inner surface 190 of the shell 110. Consequently, some portion of the process fluid may short-cut the serpentine-like fluid flow in the gap between the internal baffles 452 and the inner surface 190 of the shell, causing undesired reduction in heat-exchanging efficiency.

In the evaporator 400, it can be typically difficult to run heat-exchanging tubes 420 very close to the inner surface 190 of the shell 140. The cut-out regions 456a and 456b typically correspond to areas that are close to the inner surface 190 of the shell 410, where it may be difficult to run heat-exchanging tubes 420. Because there are no heat-exchanging tubes 420 that run through this region, the heat exchange efficiency between the process fluid and the refrigerant in the heat-exchanging tubes 420 is relatively low. In an evaporator such as shown in

Fig. 1, serpentine-like fluid flow is employed through a plurality of baffles 152, the process fluid in the areas that correspond to the cut-out regions 456a and 456b typically receives less heat exchange than the other areas. It may be therefore desirable to displace the process fluid out of the areas.

5 The cut-out regions 456a and 456b are configured to accept the sealing plates 450. The sealing plates 450 extend between the inner surface 190 of the shell 410 and the cut-out regions 456a and 456b, and fill the cut-out regions 456a and 456b.

 The sealing plates 450 includes a first side 450a that is configured to conform to a shape of the inner surface 490 of the shell 410, and a second side 450b that is configured to conform to
10 a shape of the cut-out regions 456a, 456b. Bottoms 457a and 457b of the cut-out regions 456a and 456b respectively are positioned respectively close to the outermost holes 455a and 455b of the holes 455 that are configured to receive heat-exchanging tubes 420. Therefore, the sealing plates 450 can substantially fill the region between the tube bundle 419 and the inner surface 490 of the shell 410. The sealing plates 450 can also form process fluid-tight seals with the cut-out
15 regions 456a, 456b and the inner surface 490 of the shell 410.

 In a conventional evaporator that does not have the cut-out regions 456a, 456b and the sealing plates 450, the process fluid may stay in areas that corresponds to the sealing plates 450. The process fluid in these areas may have relatively low (or no) heat transfer efficiency because no heat-exchanging tubes are present in these areas. The sealing plates 450 can help displace the
20 process fluid out of these areas, increasing the heat transfer efficiency of the evaporator 400.

 In a conventional evaporator that does not have the cut-out regions 456a, 456b and the sealing plates 450, the internal baffles may not form process fluid-tight seals with the inner surface of the shell. Therefore, the process-fluid may by-pass the internal baffles between the inner surface of the shell and the internal baffles. Because the sealing plates 450 form the
25 process-fluid tight seals between the cut-out regions 456a, 456b and the shell 410, the sealing plates 450 can also help reduce the undesired effect of process fluid by-passing the internal baffle 452.

 With regard to the foregoing description, it is to be understood that changes may be made in detail, without departing from the scope of the present invention. It is intended that the

specification and depicted embodiments are to be considered exemplary only, with a true scope and spirit of the invention being indicated by the broad meaning of the claims.

Claims

What claimed is:

1. A shell and tube type evaporator, comprising:

a shell side, the shell side configured to receive a process fluid;

5 a tube side, the tube side configured to receive a refrigerant;

a refrigerant box, the refrigerant box including a refrigerant inlet;

a refrigerant distribution assembly, the distribution assembly including a distribution box and a plurality of refrigerant distributors, the distribution box having a longitudinal direction defined by a length of the distribution box;

10 wherein the distribution box is configured to cover the refrigerant inlet, the refrigerant inlet is in fluid communication with the plurality of refrigerant distributors, and the plurality of refrigerant distributors are laterally located relative to the refrigerant inlet in the longitudinal direction.

15 2. The shell and tube type evaporator of claim 1, wherein each of the plurality of refrigerant distributors includes a dome-shaped section sitting on top of a column-shaped section, wherein the dome-shaped section and the column-shaped section are configured to have a plurality of apertures.

20 3. The shell and tube type evaporator of claim 2, wherein the dome-shaped section includes an end portion that is free of apertures.

4. The shell and tube type evaporator of claim 1, wherein each of the plurality of refrigerant distributors includes a column-shaped section and a closed flat top.

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5. The shell and tube type evaporator of claim 1, wherein the plurality of refrigerant distributors have apertures configured to allow refrigerant to flow out of the distribution assembly.

6. The shell and tube type evaporator of claim 1, further comprising:

a tube sheet;

a refrigerant outlet;

wherein the refrigerant outlet and the refrigerant inlet are divided by a divider, the divider forms a refrigerant-tight seal between the refrigerant outlet and the refrigerant inlet with the tube sheet.

7. The shell and tube type evaporator of claim 1, further comprising:

a tube sheet;

a lower partition, the lower partition positioned below the refrigerant inlet toward a

bottom of the evaporator relative to the refrigerant inlet;

wherein the lower partition forms a gap with the tube sheet.

8. The shell and tube type evaporator of claim 1, further comprising:

a plurality of internal baffles;

a sealing plate, the sealing plate extending a full length of the evaporator;

wherein each of the plurality of internal baffles includes a side cut-out region between the internal baffle and an inner surface of the shell, the sealing plate is configured to be positioned in the cut-out region.

9. The shell and tube type evaporator of claim 8, wherein the sealing plate is configured to form a first process fluid-tight seal between the sealing plate and the inner surface of the shell, and a second process fluid-tight seal between the sealing plate and each of the plurality of internal baffles.

10. A refrigerant distribution assembly of an evaporator, comprising:

a distribution box, the distribution box configured to cover a refrigerant inlet of an evaporator;

a plurality of refrigerant distributors;

wherein, relative to the distribution box, the plurality of refrigerant distributors are

positioned on the distribution box at a side that is opposite to the refrigerant inlet that the distribution box is configured to cover,

the distribution box has a longitudinal direction, and in the longitudinal direction, the plurality of refrigerant distributor are laterally located relative to the refrigerant inlet that the

5 distribution box is configured to cover.

11. The refrigerant distribution assembly of claim 10, wherein each of the plurality of refrigerant distributors includes a dome-shaped section sitting on top of a column-shaped section, wherein the dome-shaped section and the column-shaped section are configured to have a plurality of
10 apertures.

12. The refrigerant distribution assembly of claim 10, wherein the plurality of refrigerant distributors have apertures configured to allow refrigerant flowing out of the distribution assembly.

15

13. The refrigerant distribution assembly of claim 11, wherein the dome-shaped section includes an end portion that is free of apertures.

14. The refrigerant distribution assembly of claim 10, wherein each of the plurality of refrigerant
20 distributors includes a column-shaped section and a closed flat top.

15. A shell and tube type evaporator, comprising:

a plurality of internal baffles;

a sealing plate, the sealing plate extending a full length of the evaporator;

25 wherein each of the plurality of internal baffles includes a side cut-out region between the internal baffle and an inner surface of the shell, the sealing plate is configured to be positioned in the cut-out region.

16. The shell and tube type evaporator of claim 15, wherein the sealing plate is configured to

form a first process fluid-tight seal between the sealing plate and the inner surface of the shell, and a second process fluid-tight seal between the sealing plate and each of the plurality of internal baffles.

5 17. A baffle for a shell and tube type evaporator, comprising:

Two side cut-out regions, wherein each of the side cut-out regions is configured to form a space between the baffle and an inner surface of the evaporator, and the space is configured to receive a sealing plate configured to seal the space.

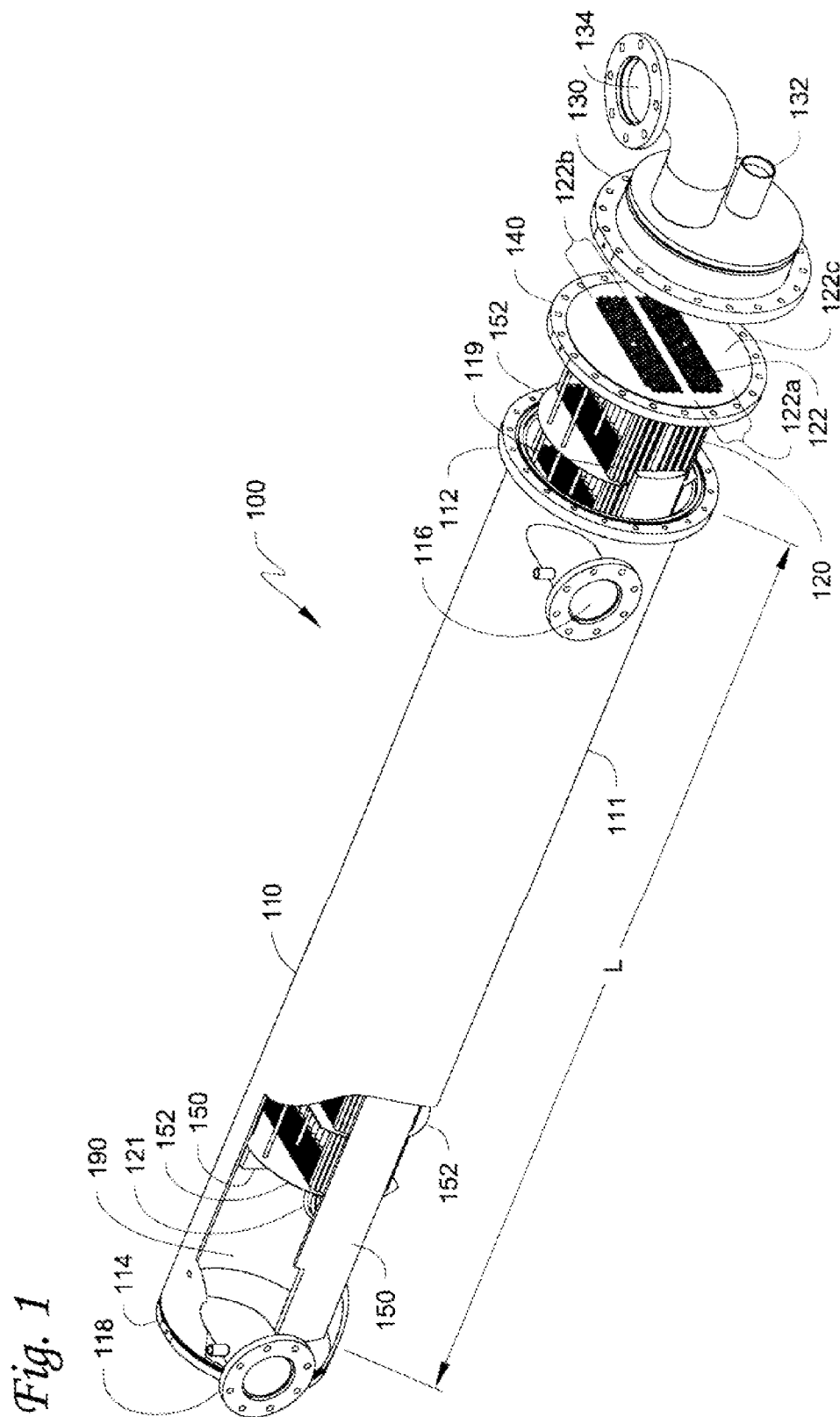


Fig. 2B

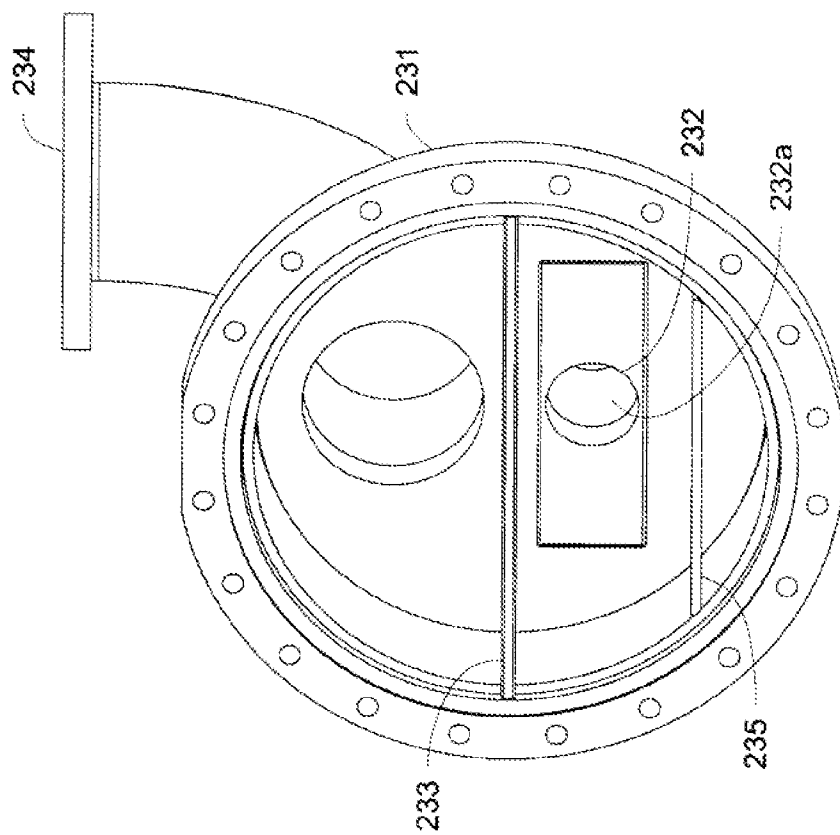


Fig. 2A

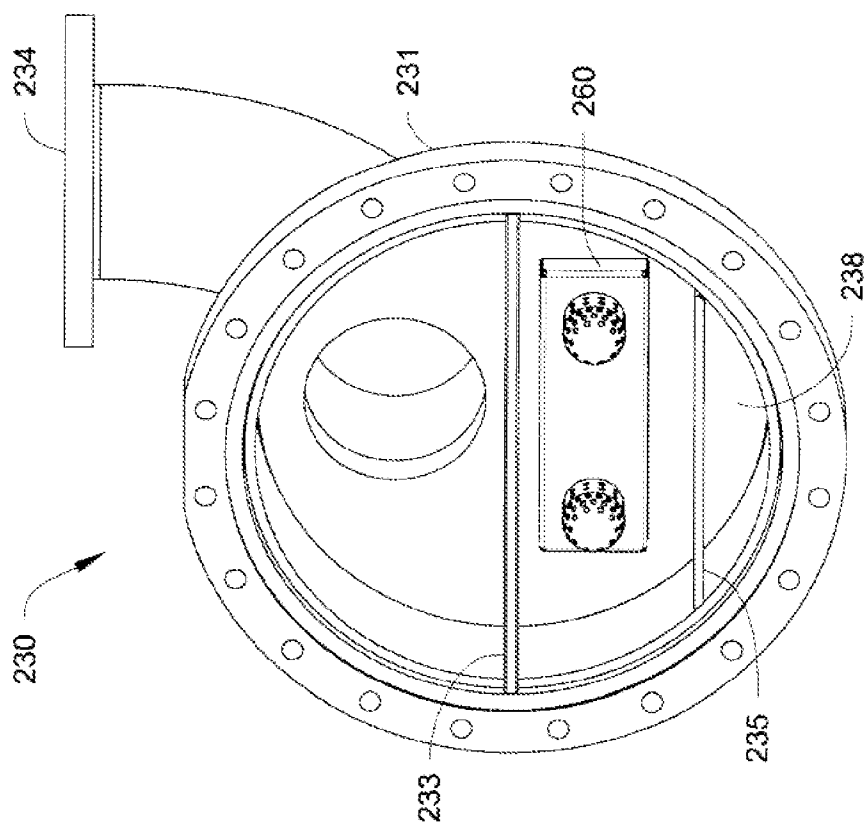


Fig. 2C

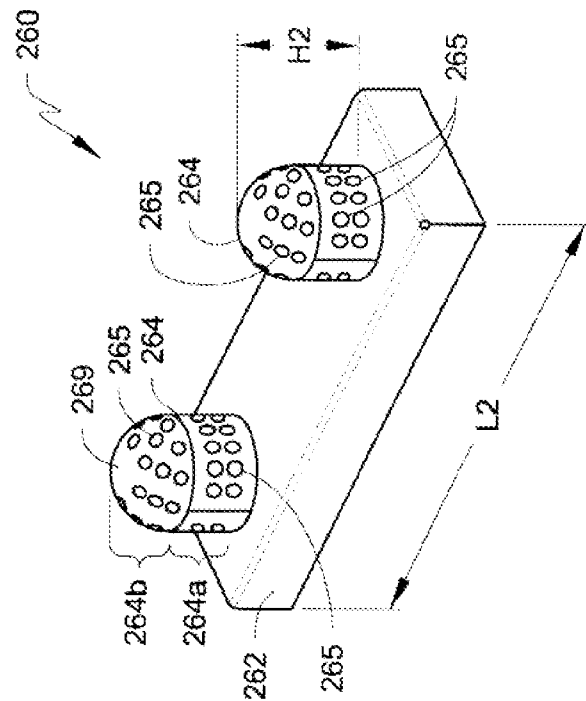


Fig. 2D

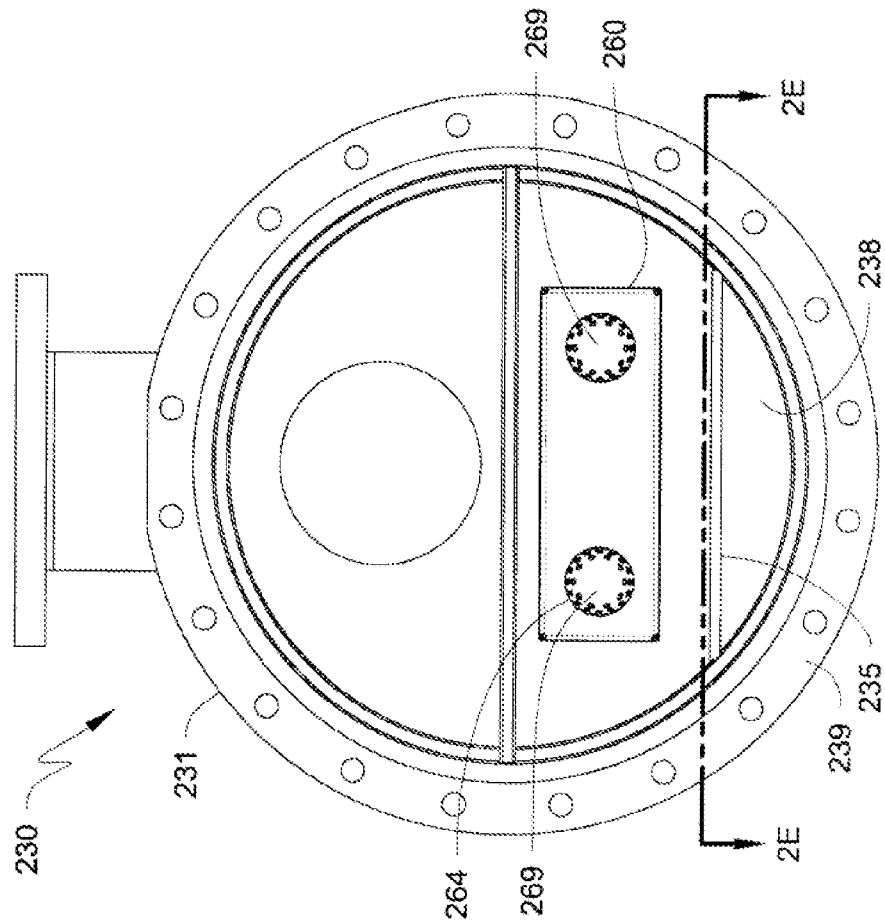


Fig. 3

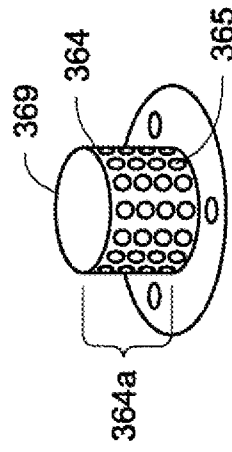
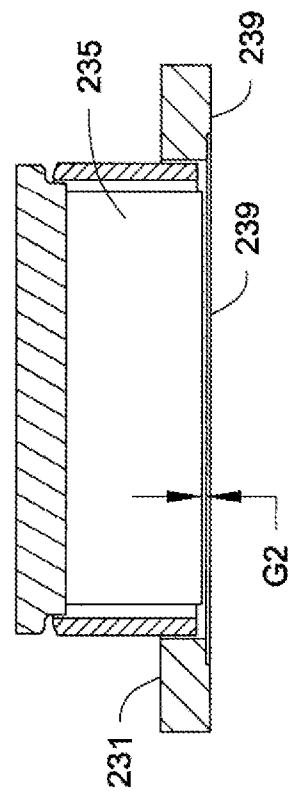


Fig. 2E



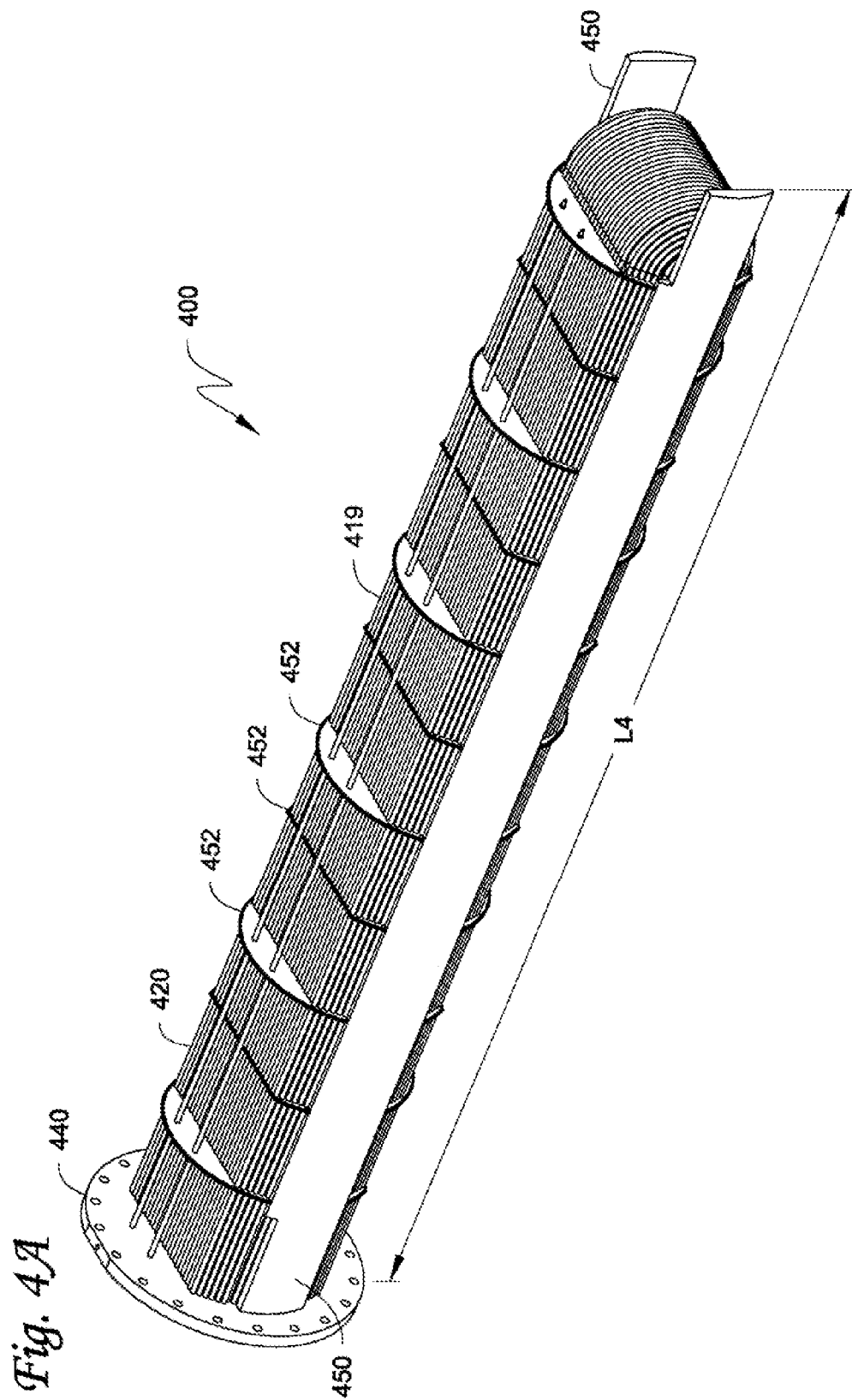


Fig. 4B

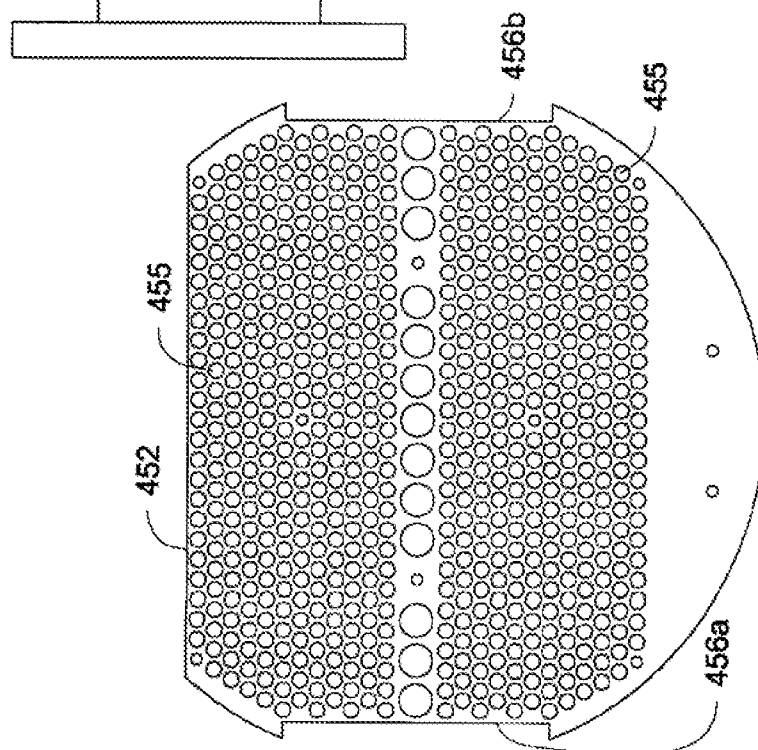
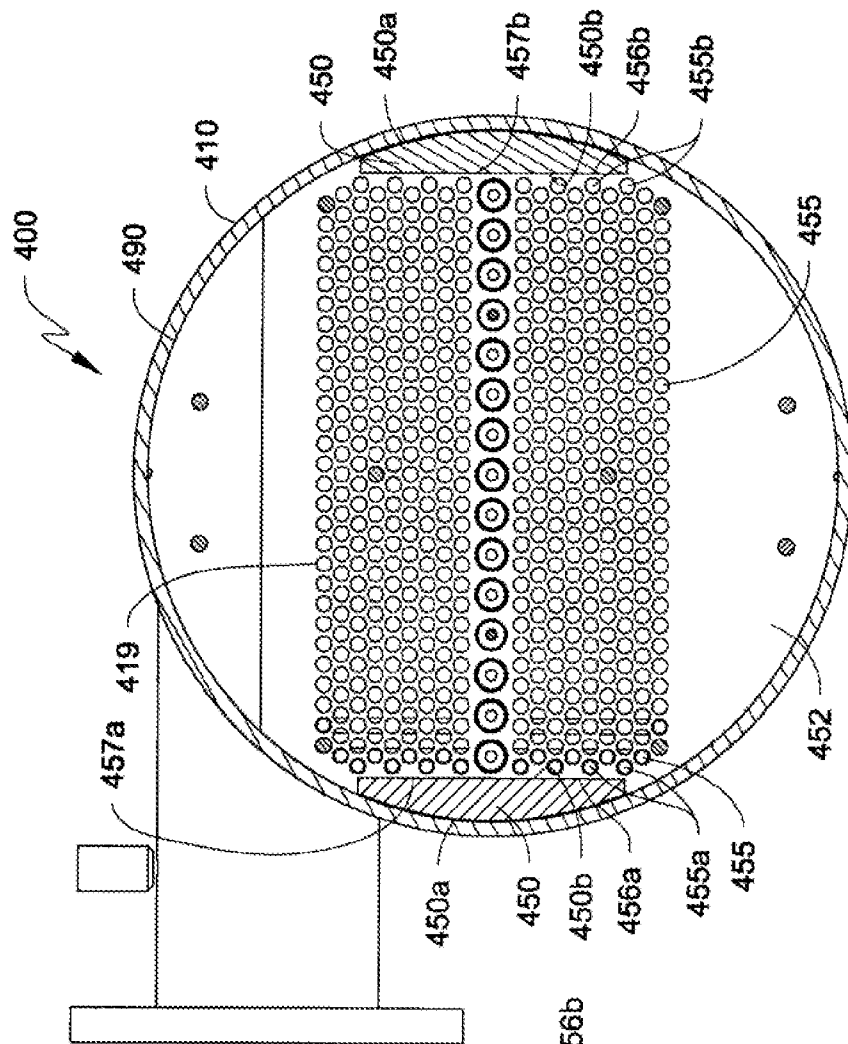


Fig. 4C



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/087174

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F25B 39/- F25B 41/- F28 B01D 1/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC: shell, tube, duct, pipe, dry, distribut+, divider, baffle

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 202432766 U (CHONGQING GEN IND GROUP CO LTD) 12 September 2012 (12.09.2012) description, paragraphs [0011] to [0015] and figures 1 and 2	1, 5, 6, 10, 12
A	CN 201772808 U (GUANGDONG MIDEA ELECTRIC APPLIANCES CO LTD) 23 March 2011 (23.03.2011) description, paragraphs [0004] to [0018] and figures 1 to 3	15 to 17
A	CN 201724594 U (CHANGZHOU ASTERAS CENT AIR CONDITIONING CO LTD) 26 January 2011 (26.01.2011) the whole document	1 to 14
A	CN 201811640 U (KUNSHAN TAIJIA ELECTROMECHANICAL CO LTD) 27 April 2011 (27.04.2011) the whole document	1 to 14
A	JP 2002295992 A (CALSONIC CORP et al.) 09 October 2002 (09.10.2002) the whole document	1 to 14

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 01 September 2013 (01.09.2013)	Date of mailing of the international search report 03 Oct. 2013 (03.10.2013)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer LI, Hong Telephone No. (86-10)62084858

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/087174

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2264384 A1 (JOHNSON CONTROLS BUILDING EFFICIENCY TEC et al.) 22 December 2010 (22.12.2010) the whole document	1 to 14
A	JPS 6222994 A (TOSHIBA CORP) 31 January 1987 (31.01.1987) the whole document	15 to 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/087174

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1 to 14 are direct to the refrigerant distribution assembly of a shell and tube type evaporator, claims 15 to 17 are direct to the baffle for a shell and tube type evaporator, and there is no common or corresponding technical feature between claims 1 to 14 and claims 15 to 17, accordingly, there is no common or corresponding special technical feature between them, therefore, the application does not meet the requirements of unity of invention as defined in PCT Rule 13.1 and 13.2.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/087174

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 202432766 U	12.09.2012	None	
CN 201772808 U	23.03.2011	None	
CN 201724594 U	26.01.2011	None	
CN 201811640 U	27.04.2011	None	
JP 2002295992 A	09.10.2002	None	
EP 2264384 A1	22.12.2010	US 2010300134 A1	02.12.2010
		CN 101907376 A	08.12.2010
		CN 101907376 B	25.07.2012
JPS 6222994 A	31.01.1987	None	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/087174

CLASSIFICATION OF SUBJECT MATTER

F25B 39/02 (2006.01) i

F25B 41/00 (2006.01) i

F28F 9/22 (2006.01) i