



(51) International Patent Classification:

F25B 39/04 (2006.01) *F28D 7/16* (2006.01)
F25B 9/00 (2006.01) *F25B 40/02* (2006.01)
F28B 1/02 (2006.01)

(21) International Application Number:

PCT/IB2011/001465

(22) International Filing Date:

21 April 2011 (21.04.2011)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant (for all designated States except US): **CARRIER CORPORATION** [US/US]; One Carrier Place, Farmington, Connecticut 06034 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **GRABON, Michel** [FR/FR]; Les Croix, Route de Dagneux, F-01360 Bressolles (FR). **TERRAZ, Gregory** [FR/FR]; 34, rue Jeanne Hachette, F-69003 Lyon (FR).

(74) Agents: **SLATE, William B.** et al.; Bachman & LaPointe, P.C., 900 Chapel Street, Suite 1201, New Haven, CT 06510-2802 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) Title: CONDENSER/ACCUMULATOR AND SYSTEMS AND OPERATION METHODS

(57) Abstract: A condenser/accumulator (60) has a shell (62). A coolant flowpath extends from a coolant (144) inlet to a coolant outlet (146). An upper tube bundle (68) is within the shell, a first branch of the coolant flowpath passing through tubes of the upper tube bundle. A lower tube bundle (70) is within the shell, a second branch of the coolant flowpath passing through tubes of the lower tube bundle. A refrigerant flowpath extends from a refrigerant inlet (64) to a refrigerant outlet (66) and is in heat transfer relation with the coolant flowpath. There is a vertical gap (76) between the upper tube bundle and the lower tube bundle and comprising at least 50% of a free volume of a refrigerant space within the shell.



WO 2012/143751 A2

CONDENSER/ACCUMULATOR AND SYSTEMS AND OPERATION METHODS

BACKGROUND

[0001] The disclosure relates to refrigeration. More particularly, the disclosure relates to accumulators for CO₂ refrigeration systems.

[0002] Refrigeration circuits which operate with significant capacity variation and which have large circuit volumes (e.g., due to long piping connections between main components) are subjected to relatively large variation of active refrigerant charge. An accumulator may be used to remove and return refrigerant from the active charge in the remainder of the circuit.

[0003] FIG. 1 shows a prior art cooling unit 20 which receives chilled liquid (coolant, e.g., water or brine) from a chiller 22. The chiller feeds a water supply circuit having a supply/feed/output line 24 and a return line 26. The unit 20 includes a refrigerant loop/flowpath/circuit 30 along which a refrigerant-air heat exchanger 32 is located. The refrigerant-air heat exchanger 32 may be part of an air handling unit (AHU; fan 33 and airflow shown) and the refrigerant may consist essentially of carbon dioxide (CO₂). The refrigerant circuit 30 also includes one or more heat exchangers such as a condenser 34 and a subcooler 36.

[0004] The refrigerant tends to migrate to the coldest point in the system which may typically be the condenser (more particularly, the coldest part of the condenser at the subcooler). A pump 38 (not a compressor) draws the refrigerant from the condenser and drives the refrigerant flow through the circuit 36 in a downstream direction. The pump requires a supply of sub-cooled liquid refrigerant to ensure proper pump operation (e.g., prevent cavitation). The exemplary pump is a fixed volume pump which delivers the same amount of refrigerant regardless of the cooling load. The exemplary refrigerant remains sub-cooled at the refrigerant inlet of the refrigerant-air heat exchanger 32. While passing through the heat exchanger 32, the refrigerant is warmed by the airflow through the AHU. As refrigerant passes downstream within the heat exchanger 32, it thus progressively transitions from the sub-cooled liquid state to a two-phase and gas & liquid state and eventually to a saturated gas or superheated gas.

[0005] The actual state of refrigerant exiting the refrigerant outlet of the heat exchanger 32 will depend upon the actual cooling load. In a maximal load condition (e.g., characterized by high air temperature entering the AHU), all refrigerant will evaporate while passing through the heat exchanger 32 and exit the refrigerant outlet of the heat exchanger 32 in the superheated state. In a more moderate load condition (e.g., a lower temperature of air entering

the AHU), not enough heat is absorbed to evaporate all refrigerant, thus two-phase refrigerant will exit the refrigerant outlet of the heat exchanger 32 and return to the condenser.

[0006] In an extreme low load condition, refrigerant will exit the heat exchanger 32 still in a liquid state.

[0007] The exemplary system includes an accumulator 40 containing an accumulation 42 of refrigerant. The exemplary accumulator is immediately downstream of the condenser 34 and upstream of the subcooler 36 along the flowpath 30. The exemplary condenser 34 and subcooler 36 each are formed as refrigerant-water heat exchangers whose water legs 44 and 46 are in parallel with each other. The exemplary pump, condenser, and subcooler are shown mounted in common on a skid 50. FIG. 1 shows a relatively large accumulation 42 associated with a high load condition. FIG. 2 shows a second condition wherein the accumulation has shrunk in a low load condition. Exemplary use of the unit 20 is in data center cooling wherein each of one or more such units may have one or more such heat exchangers 32 for cooling computer servers or similar equipment. In such a situation, the accumulator may need to hold up to 50% of the total refrigerant charge of the unit. In a low load condition, there is a relative high amount of liquid refrigerant in the heat exchangers 32 which is thus not in the accumulator. In a high load condition, refrigerant in the heat exchangers 32 is more fully evaporated, thereby necessitating its accumulation in the accumulator. For proper operation, the accumulator contains two-phase refrigerant (i.e., liquid and gas). The volume of the accumulator 40 may be selected based upon an anticipated range of operating conditions.

SUMMARY

[0008] One aspect of the disclosure involves, a condenser/accumulator having a shell. A coolant flowpath extends from a coolant inlet to a coolant outlet. An upper tube bundle is within the shell, a first branch of the coolant flowpath passing through tubes of the upper tube bundle. A lower tube bundle is within the shell, a second branch of the coolant flowpath passing through tubes of the lower tube bundle. A refrigerant flowpath extends from a refrigerant inlet to a refrigerant outlet and is in heat transfer relation with the coolant flowpath. There is a vertical gap between the upper tube bundle and the lower tube bundle and comprising at least 50% of a free volume of a refrigerant space within the shell.

[0009] In various implementations, the first branch may be in parallel to the second branch and rejoin to pass through the remaining tubes of the upper tube bundle. The vertical gap may comprise 60-80% of the free volume. A vertical height of the gap may be at least 50% (more narrowly, 80-120%) of a characteristic internal radius of the shell. A refrigerant volume below the upper tube bundle and outside of a subcooling chamber around the lower

tube bundle may represent at least 30% of a total free volume of the refrigerant space. The lower tube bundle may be within a subcooler chamber having refrigerant inlet ports and having a refrigerant outlet port positioned upstream of the refrigerant outlet. The coolant inlet and coolant outlet may be on a first end dome. The shell may comprise a circular cylindrical body and a pair of end plates forming bolting flanges (easy for mounting a pair of end domes).

[0010] A cooling system may comprise such a condenser/accumulator, a pump coupled to the refrigerant outlet, and a heat exchanger having a refrigerant inlet coupled to the pump and a refrigerant outlet coupled to the refrigerant inlet of the condenser/accumulator. A fan may be positioned to drive an airflow across the heat exchanger. There may be a plurality of such heat exchangers coupled in parallel to a single such condenser/accumulator. There may be an associated plurality of such fans respectively associated with such heat exchangers. The refrigerant charge may comprise at least 50% carbon dioxide by weight.

[0011] The system may include a chiller coupled to the coolant inlet and coolant outlet so that the coolant flowpath is along a coolant loop of the chiller.

[0012] The system may be operated by running the pump to: draw into the pump and discharge from the pump a flow of the refrigerant as supercooled liquid; pass the flow of the refrigerant through the heat exchanger where it draws heat from an external flow and becomes vapor; and pass the flow of the refrigerant to the condenser/accumulator wherein the flow of the refrigerant discharges heat to the coolant and condenses back to liquid. The method may comprise: operating in a first condition wherein a surface of a liquid accumulation of the refrigerant in the vessel is within the gap; operating in a second condition, at higher cooling load than the first condition, wherein the surface of the liquid accumulation of the refrigerant in the vessel is also within the gap but higher than in the first condition; and shutting down the pump to go into a third condition wherein the surface of the liquid accumulation of the refrigerant in the vessel is above the gap. The buildup of liquid accumulation between the first condition and the second condition may be at least 30% of a free internal volume of the vessel. A buildup of the liquid accumulation between the first and the third condition may be at least 150% of the buildup of the liquid accumulation between the first condition and the second condition.

[0013] Another aspect of the disclosure involves the method for operating a cooling system. The cooling system comprises: a condenser/accumulator having a coolant flowpath and a refrigerant flowpath; a refrigerant air heat exchanger along the refrigerant flowpath; and a pump along the refrigerant flowpath downstream of the condenser/accumulator and

upstream of the refrigerant air heat exchanger. The method comprises: operating in a first condition wherein a surface of a liquid accumulation of the refrigerant within the condenser/accumulator is at a first level; operating in a second condition, at higher cooling load than the first condition, wherein the surface of the liquid accumulation is at a second level higher than the first level; and shutting down the pump to go into a third condition wherein the surface of the liquid accumulation is at a third level, higher than the second level. The first level and the second level may be below a condenser tube bundle and above a subcooler tube bundle while the third level may be above at least a bottom of the condenser tube bundle.

[0014] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is a schematic view of a prior art system in a high load condition.

[0016] FIG. 2 is a user system of FIG. 1 in a low load condition.

[0017] FIG. 3 is a schematic view of a system in a low load condition.

[0018] FIG. 4 is a view of the system of FIG. 3 in a high load condition.

[0019] FIG. 5 is a view of the system of FIG. 3 in an off condition.

[0020] FIG. 6 is a view of a condenser/accumulator unit.

[0021] FIG. 7 is a side view of the condenser/accumulator unit.

[0022] FIG. 8 is an end view of the condenser/accumulator unit.

[0023] FIG. 9 is a central longitudinal vertical sectional view of the condenser/accumulator unit, taken along line 9-9 of FIG. 8.

[0024] FIG. 10 is a bottom view of the condenser/accumulator unit.

[0025] FIG. 11 is a central transverse vertical sectional view of the condenser/accumulator unit, taken along line 11-11 of FIG. 7.

[0026] FIG. 12 is a transverse vertical cutaway view of a first end manifold area of the condenser/accumulator unit.

[0027] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0028] FIG. 3 shows a modified unit 58 wherein the condenser, subcooler, and accumulator are combined in a single condenser/accumulator unit 60. The unit 58 may be used similarly to the unit 20 in data center cooling with a plurality of units 58 coupled in parallel to one or more chillers. Each unit 60 and its associated pump may be on an associated skid. An exemplary data center cooling use is shown in PCT/FR2011/000224, the disclosure of which is incorporated by reference in its entirety herein as if set forth at length. The unit 60 has a shell 62 and has a refrigerant inlet 64 and a refrigerant outlet 66 along the refrigerant circuit 30. As is discussed further below, the unit 60 includes an upper tube bundle 68 and a lower tube bundle 70. The lower tube bundle is located within a subcooler chamber 72 discussed further below.

[0029] The unit 60 includes a main interior volume 74 along the refrigerant flowpath between the inlet 64 and outlet 66. A portion of the volume 74 is represented by a vertical gap 76 between the tube bundles 68 and 70. By providing a sufficiently large gap and volume associated therewith, the unit 60 may serve as an accumulator. FIG. 3 shows a liquid refrigerant accumulation 80 having a surface 82. FIG. 3 represents a minimum load condition (e.g., essentially no load). It may be desirable to size the system so that the minimum load liquid accumulation at least fully covers the tubes of the lower bundle 70 and may also at least just cover the upper surface of the chamber 72. Sizing the system to maintain at least this minimum level of accumulation prevents gas bypass (e.g., maintains the pump inlet flow as sub-cooled liquid to prevent cavitation).

[0030] FIG. 4 represents an anticipated maximum load condition wherein the level 82 has risen. The shell is advantageously sized so that the level 82 remains below the lowest tubes of the upper bundle 68 even in this max load condition. If the liquid reaches the upper tube bundle, then there is a "flooded condenser" condition with reduced tube surface area for condensing (thereby causing insufficient condensing) which causes a pressure increase and performance degradation.

[0031] The flow at the refrigerant inlet 64 may represent superheated gas and transition passing over the tubes of the upper bundle 68 to a region 90 of saturated gas. The superheated gas is quickly cooled to the saturation temperature (within the first (upper) couple of tube rows). Thereafter it is two-phase transitioning from saturated gas to saturated liquid.

[0032] FIG. 5 shows a pump-off (shut down) condition wherein there is still a coolant flow through the unit 60 but no refrigerant flow. This, for example, may represent a condition wherein the AHU(s) are being serviced or the pump is otherwise shut down. The heat

exchanger(s) 32 may equilibrate to ambient temperature and, therefore, may fully contain superheated gas. Upstream of the pump 38 along the refrigerant flowpath, there may still be sub-cooled liquid. With superheated vapor in the heat exchanger 32, the greatest amount of refrigerant must be maintained within the shell. The exemplary liquid surface 82 is within or above the upper tube bundle 68. This leaves the saturated vapor 90 thereabove. The chamber 72 subcools the refrigerant so that saturated refrigerant enters the chamber 72 and is quickly subcooled and exits in a subcooled state.

[0033] As is discussed further below, the exemplary main interior volume 74 is circular cylindrical having a radius R_1 from a central axis 500. An exemplary height H_1 of the gap 76 is at least 50% of R_1 , more narrowly, at least 70% or 80-120%. Similarly, the volume of the space 74 within the gap 76 may represent at least 50% of a total free volume of the space 74 (more particularly, at least 60% or 60-80%). For example, the free volume may be volume not occupied by the tubes (and their coolant) or other components. Alternatively measured, the free volume of the space below the upper bundle may represent at least 30%, more narrowly 40-90% or 50-80% of a total free volume of the space 74 (e.g., excluding the subcooling chamber).

[0034] In terms of liquid refrigerant buildup, an exemplary buildup of the liquid accumulation between the minimum load condition and the maximum condition is at least 30% of a free internal volume of the vessel, more narrowly 35-70%. An exemplary buildup of the liquid accumulation between the minimum load condition and the pump-off condition is at least 140% of the buildup of the liquid accumulation between the minimum load condition and the maximum load condition, more narrowly, at least 150% or 150-300% or 160-200%.

[0035] FIG. 6 shows the unit 60. The exemplary unit has a shell 62 comprising a circular cylindrical pipe 120 having first and second ends at first and second end bolt flanges 122 and 124. Each of the end flanges bears a domed cover 126, 128 secured such as via bolt circles. The exemplary unit 60 has a central longitudinal axis 500 (FIG. 7) which, in an exemplary embodiment, is maintained horizontal. The exemplary refrigerant inlet 64 and outlet 66 are formed on respective fittings 134 and 136. In the exemplary embodiments, these fittings are positioned centrally along the sidewall of the pipe 120 at respective top and bottom locations and share a common axis 502. FIG. 6 also shows respective upper and lower observation port fittings 140 and 142 (e.g., sight glasses).

[0036] The exemplary first end cover 126 (FIG. 9) bears the coolant inlet 144 and coolant outlet 146 receiving chilled water from the supply line 24 and returning warmed water to the

return line 26, respectively. In the exemplary embodiment, the flanges are shown as being formed by peripheral portions of endplates 150 and 152 (e.g., welded to the pipe 120). Associated ends of the tubes of the upper and lower bundles are mounted in apertures of these endplates to communicate with plenums between the covers and the endplates. FIG. 9 shows plenums 160 and 162 beneath the cover 126 and separated by a dividing wall 164 formed as a portion of the cover 126 such as via casting or machining of metal. The plenum 160 is an inlet plenum communicating with the inlet port 144. The plenum 162 is an outlet plenum communicating with the outlet port 146. FIG. 12 shows the position of the wall 164 via a gasket portion 164'. The wall subdivides the tubes of the upper bundle into a first subgroup 68-1 and a second subgroup 68-2. The first ends of the first subgroup and those of the lower bundle 70 are open to (at) the plenum 160. The first ends of the tubes of the subgroup 68-2 are open to the outlet plenum 162.

[0037] FIG. 9 shows a single plenum 170 between the cover 128 and the wall 152. The second ends of all the tubes are open to the plenum 70. Accordingly, the inlet flow passing through the inlet 144 divides at the plenum 160 into two main branches: a first branch 200-1 (FIG. 9) passing through the tubes of the first group 68-1; and a second branch 200-2 passing through the tubes of the lower bundle 70 (with each of these two branches subdividing into sub-branches through the individual tubes. The branches and sub-branches merge in the plenum 170 and then pass through the tubes of the second group into the plenum 162 and therefrom out the outlet 146.

[0038] FIG. 11 shows the subcooler chamber having a pair of lateral walls 220 and 222, an upper wall 224, and a lower wall 226. An outlet conduit 228 extends from a central port/opening 230 in the lower wall. The walls 220, 222, 224, and 226 extend between the endplates to surround an interior space 232 of the subcooler chamber.

[0039] FIG. 10 shows inlet ports 240 to the subcooler chamber formed as holes in the lower wall 230 in pairs adjacent the opposite endplates (which form end walls of the subcooler chamber). Refrigerant from the bottom of the shell interior flows upward through the ports 240 to be cooled by the water flowing through the bundle 70 and then exits via the pipe 228.

[0040] Refrigerant entering the inlet 64 may be spread via a baffle 250 (FIG. 9) spaced below the end of an inlet pipe/conduit 252. This may direct refrigerant over the upper bundle to be cooled by coolant (water) flowing: (1) through the first group 68-1 along the branch 200-1; and the merged coolant flow through the second group 68-2.

[0041] FIG. 9 further shows structural braces along inboard surfaces of the end walls 150 and 152 and a central tube template 260 for maintaining relative position of tubes of the upper bundle.

[0042] In one example of an operational condition, an air outlet temperature from the heat exchanger 32 is 22C. A refrigerant inlet temperature to the unit 60 is 19C and the needed refrigerant outlet temperature is 12C. An exemplary water inlet temperature is 7C. Along the first branch 200-1, the water is heated to 10C. Along the second branch, the water is heated to 8C. With a higher amount of flow through the first branch, the combined flows are at 9.5C in the mixing plenum. The combined flow passing through the group 68-2 is then heated to a water outlet temperature of 12C.

[0043] The refrigerant passing through the upper bundle is cooled, reaching an exemplary 16C (e.g., 5-10C less than the air outlet temperature to the space being cooled) within the two-phase section. Finally, in the subcooler, it cools down to the outlet temperature (e.g., 12C). With an exemplary/target air temperature other than 22C, the refrigerant and coolant temperatures would need to be correspondingly adjusted.

[0044] Manufacture of the unit 60 may be of materials and techniques typical for condenser units used with CO₂ refrigerant.

[0045] Although an embodiment is described above in detail, such description is not intended for limiting the scope of the present disclosure. It will be understood that various modifications may be made without departing from the spirit and scope of the disclosure. For example, when implemented the retrofit of an existing system, details of the existing system may influence details of any particular implementation. Accordingly, other embodiments are within the scope of the following claims.

CLAIMS

What is claimed is:

1. A condenser/accumulator (60) comprising:
 - a shell (62);
 - a coolant flowpath extending from a coolant (144) inlet to a coolant outlet (146);
 - an upper tube bundle (68) within the shell, a first branch (200-1) of the coolant flowpath passing through tubes of the upper tube bundle;
 - a lower tube bundle (70) within the shell, a second branch (200-2) of the coolant flowpath passing through tubes of the lower tube bundle;
 - a refrigerant flowpath extending from a refrigerant inlet (64) to a refrigerant outlet (66) and in heat transfer relation with the coolant flowpath; and
 - a vertical gap (76) between the upper tube bundle and the lower tube bundle and comprising at least 50% of a free volume of a refrigerant space within the shell
2. The condenser/accumulator of claim 1 wherein:
 - the first branch is in parallel to the second branch, re-joining to pass through remaining tubes of the upper tube bundle.
3. The condenser/accumulator of claim 1 wherein:
 - the vertical gap comprises 60-80% of the free volume.
4. The condenser/accumulator of claim 1 wherein:
 - a vertical height (H_1) of the gap is at least 50% of a characteristic internal radius (R_1) of the shell.
5. The condenser/accumulator of claim 1 wherein:
 - a vertical height of the gap is 80-120% of a characteristic internal radius (R_1) of the shell.
6. The condenser/accumulator of claim 1 wherein:
 - a refrigerant volume below the upper tube bundle and outside of a subcooling chamber around the lower tube bundle represents at least 30% of a total free volume of the refrigerant space.

7. The condenser/accumulator of claim 1 wherein:
the lower tube bundle is within a subcooler chamber having refrigerant inlet ports and having a refrigerant outlet port positioned upstream of the refrigerant outlet.
8. The condenser/accumulator of claim 1 wherein:
the coolant inlet and coolant outlet are on a first end dome.
9. The condenser/accumulator of claim 1 wherein the shell comprises:
a circular cylindrical tubular body; and
a pair of end plates forming bolting flanges.
10. A cooling system comprising:
the condenser/accumulator of claim 1;
a pump coupled to the refrigerant outlet of the condenser/accumulator; and
a heat exchanger having a refrigerant inlet coupled to the pump and a refrigerant outlet coupled to the refrigerant inlet of the condenser/accumulator.
11. The system of claim 10 wherein:
a fan is positioned to drive an airflow across the heat exchanger.
12. The system of claim 10 wherein:
there are a plurality of said heat exchangers coupled in parallel to a single said condenser/accumulator; and there are an associated plurality of said fans respectively associated with said heat exchangers.
13. The system of claim 10 wherein:
a refrigerant charge comprises at least 50% carbon dioxide by weight.
14. The system of claim 10 further comprising:
a chiller (22) coupled to the coolant inlet to the coolant outlet so that the coolant flowpath is along a coolant loop (24, 26) of the chiller.
15. A method for operating the system of claim 10, the method comprising running the pump to:

draw into the pump and discharge from the pump a flow of the refrigerant as supercooled liquid;

pass the flow of the refrigerant through the heat exchanger where it draws heat from an external flow and becomes vapor; and

pass the flow of the refrigerant to the condenser/accumulator wherein the flow of the refrigerant discharges heat to the coolant and condenses back to liquid.

16. A method for operating the system of claim 10, the method comprising:

operating in a first condition wherein a surface of a liquid accumulation of the refrigerant in the vessel is within the gap;

operating in a second condition, at higher cooling load than the first condition, wherein the surface of the liquid accumulation of the refrigerant in the vessel is also within the gap but higher than in the first condition; and

shutting down the pump to go into a third condition wherein the surface of the liquid accumulation of the refrigerant in the vessel is above the gap.

17. The method of claim 16 wherein:

a buildup of the liquid accumulation between the first condition and the second condition is at least 30% of a free internal volume of the vessel; and

a buildup of the liquid accumulation between the first condition and the third condition is at least 150% of the buildup of the liquid accumulation between the first condition and the second condition.

18. A method for operating a cooling system, the cooling system comprising:

a condenser/accumulator (60) having a coolant flowpath and a refrigerant flowpath;

a refrigerant-air heat exchanger (32) along the refrigerant flowpath; and

a pump (38) along the refrigerant flowpath downstream of the condenser/accumulator and upstream of the refrigerant-air heat exchanger, the method comprising:

operating in a first condition wherein a surface of a liquid accumulation of the refrigerant within the condenser/accumulator is at a first level;

operating in a second condition, at higher cooling load than the first condition, wherein the surface of the liquid accumulation is at a second level higher than the first level; and

shutting down the pump to go into a third condition wherein the surface of the liquid accumulation is at a third level, higher than the second level.

19. The method of claim 18 wherein:

the first level and the second level are below a condenser tube bundle and above a subcooler tube bundle; and

the third level is above at least a bottom of the condenser tube bundle.

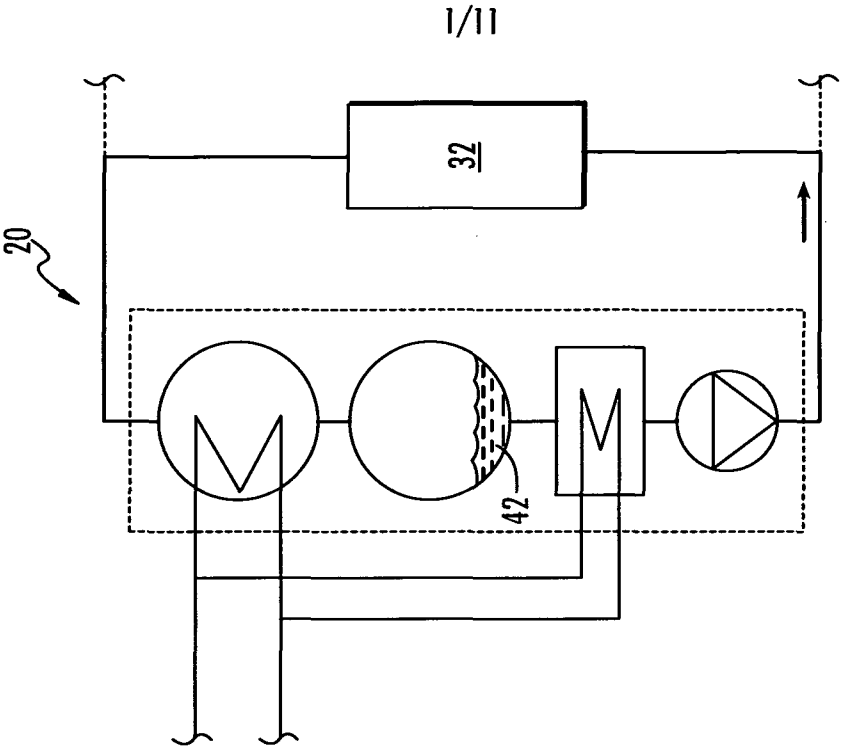


FIG. 2
(PRIOR ART)

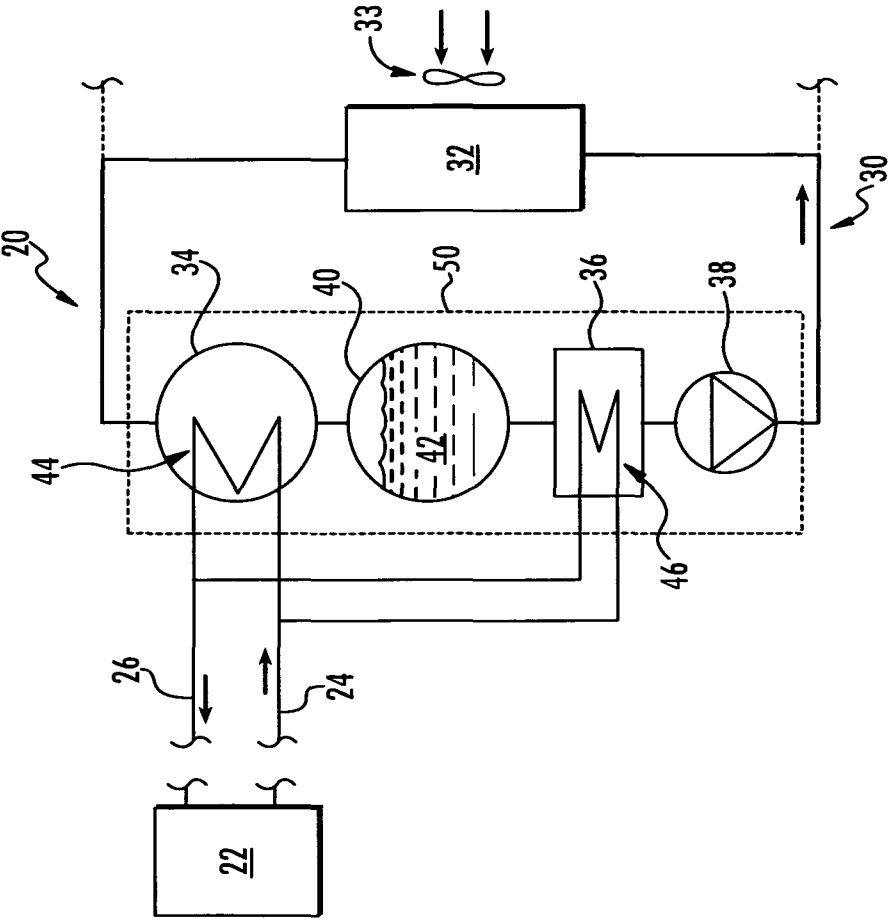
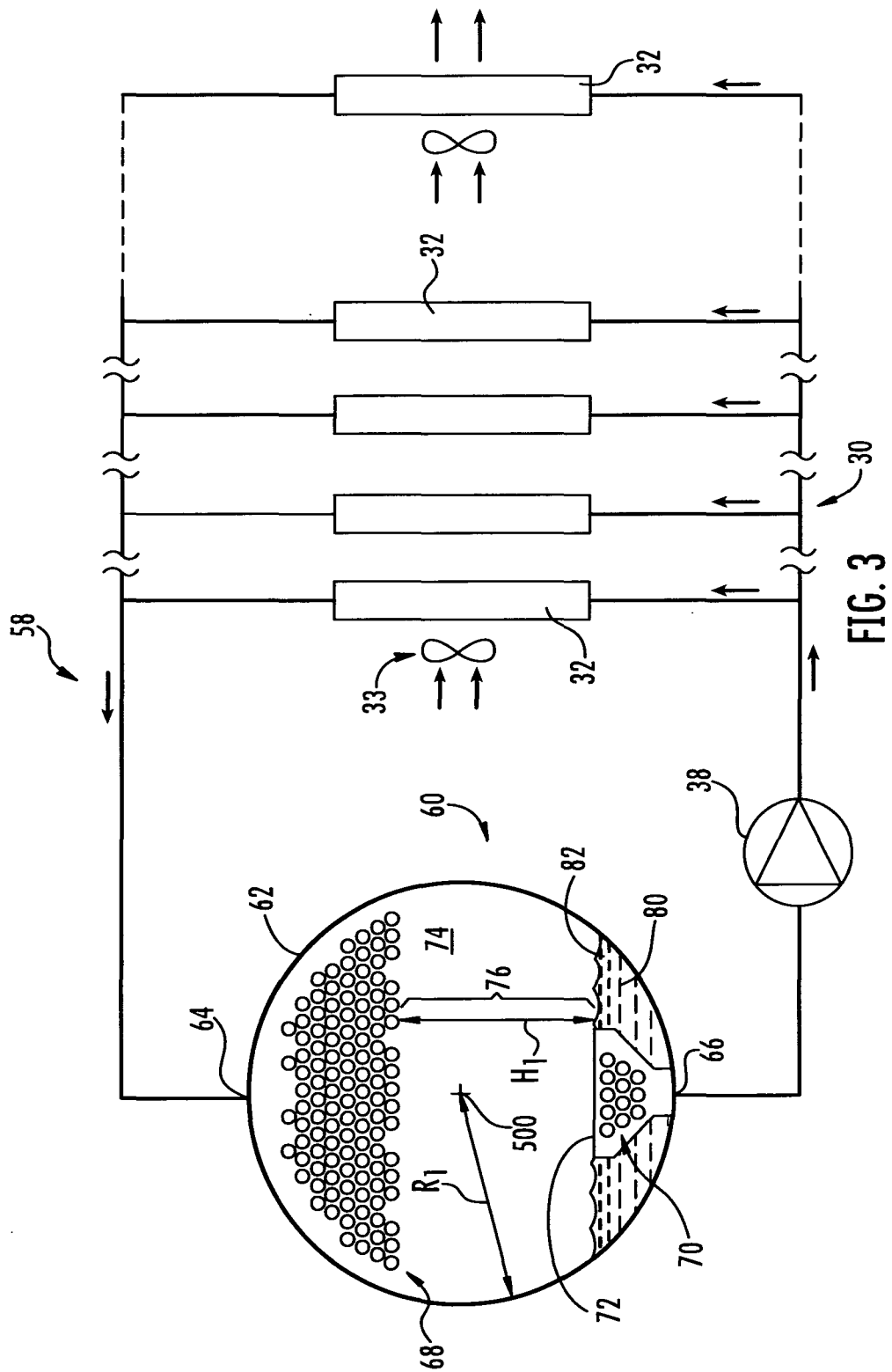
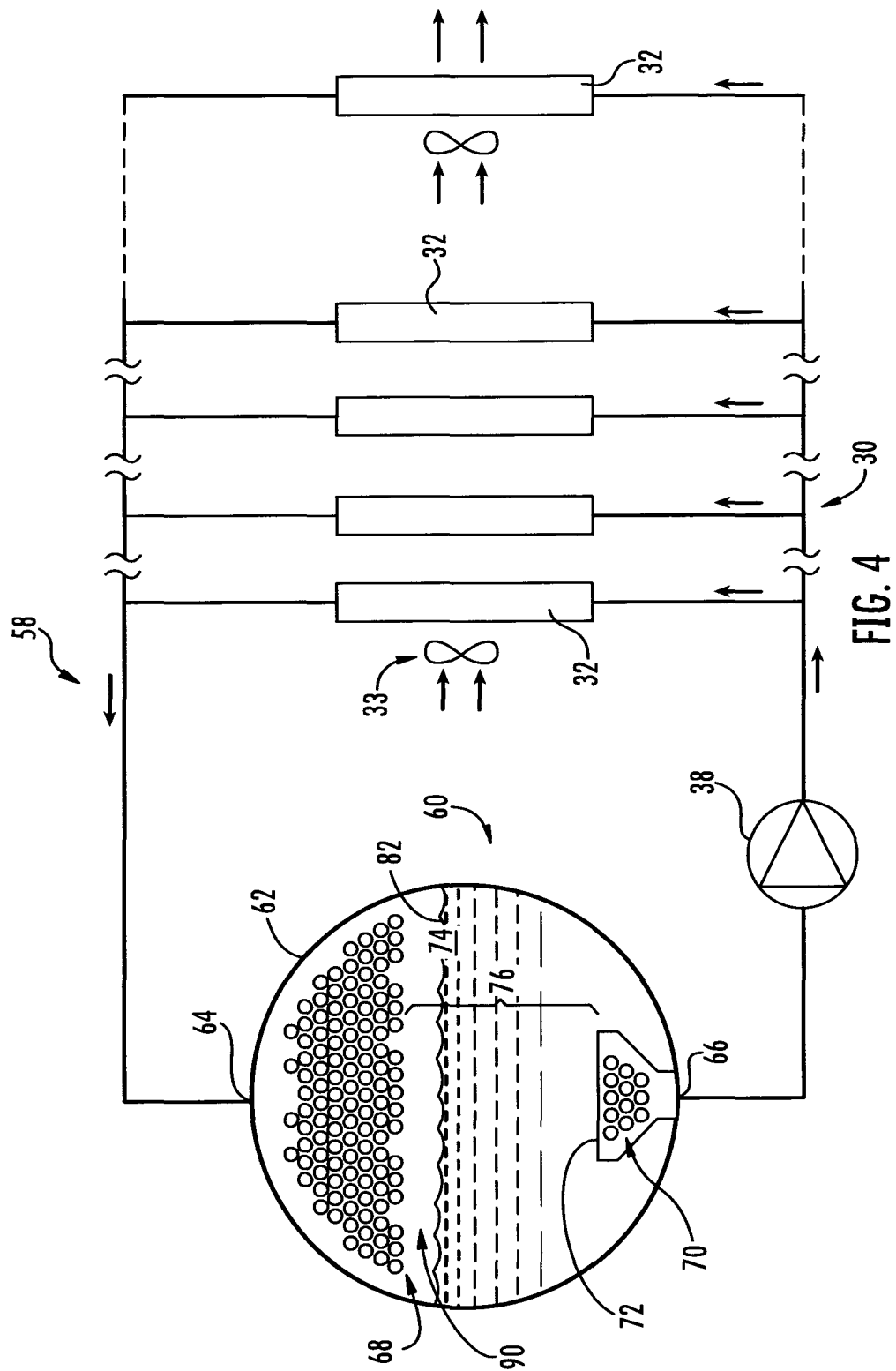
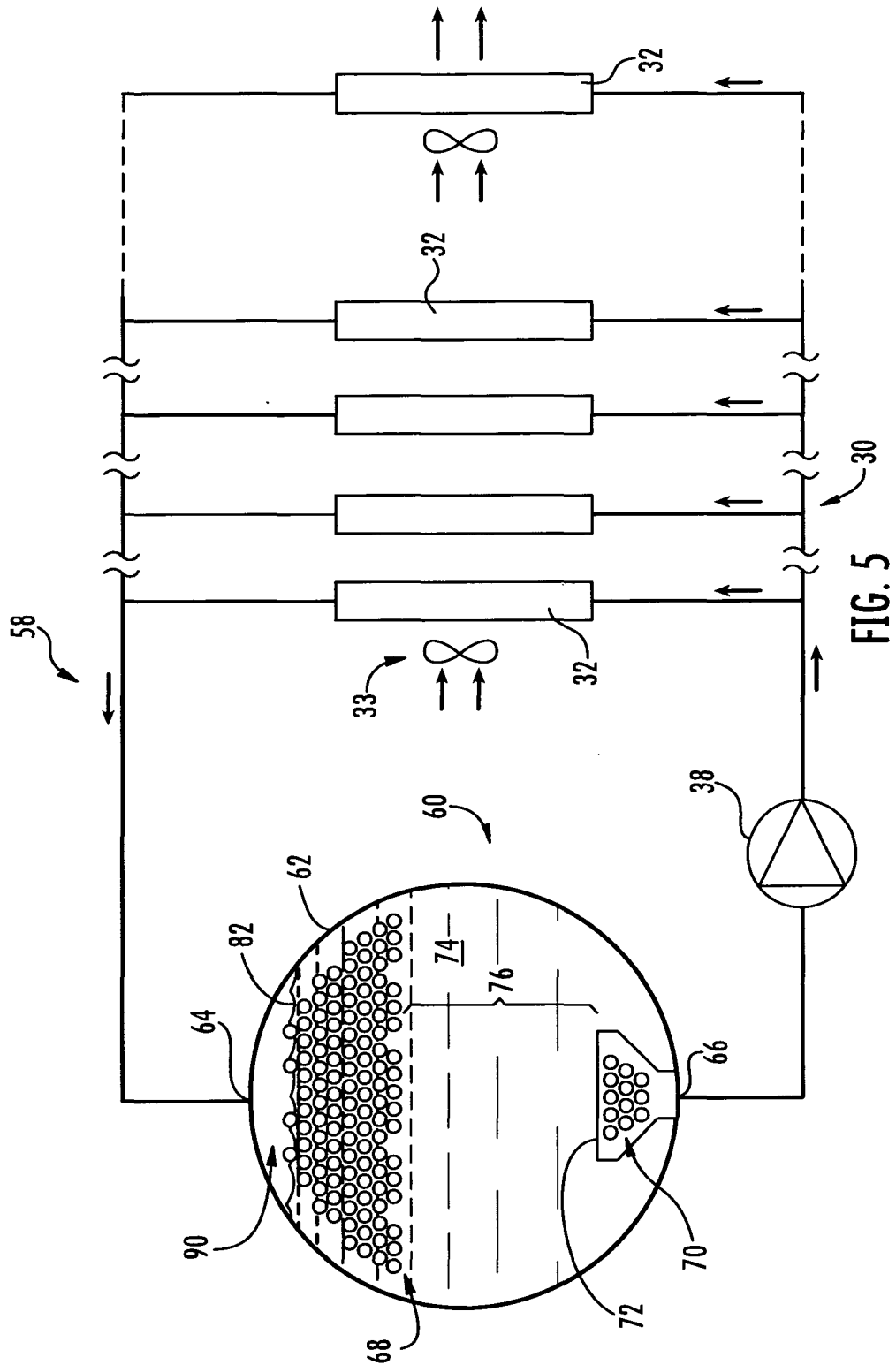


FIG. 1
(PRIOR ART)



3/11





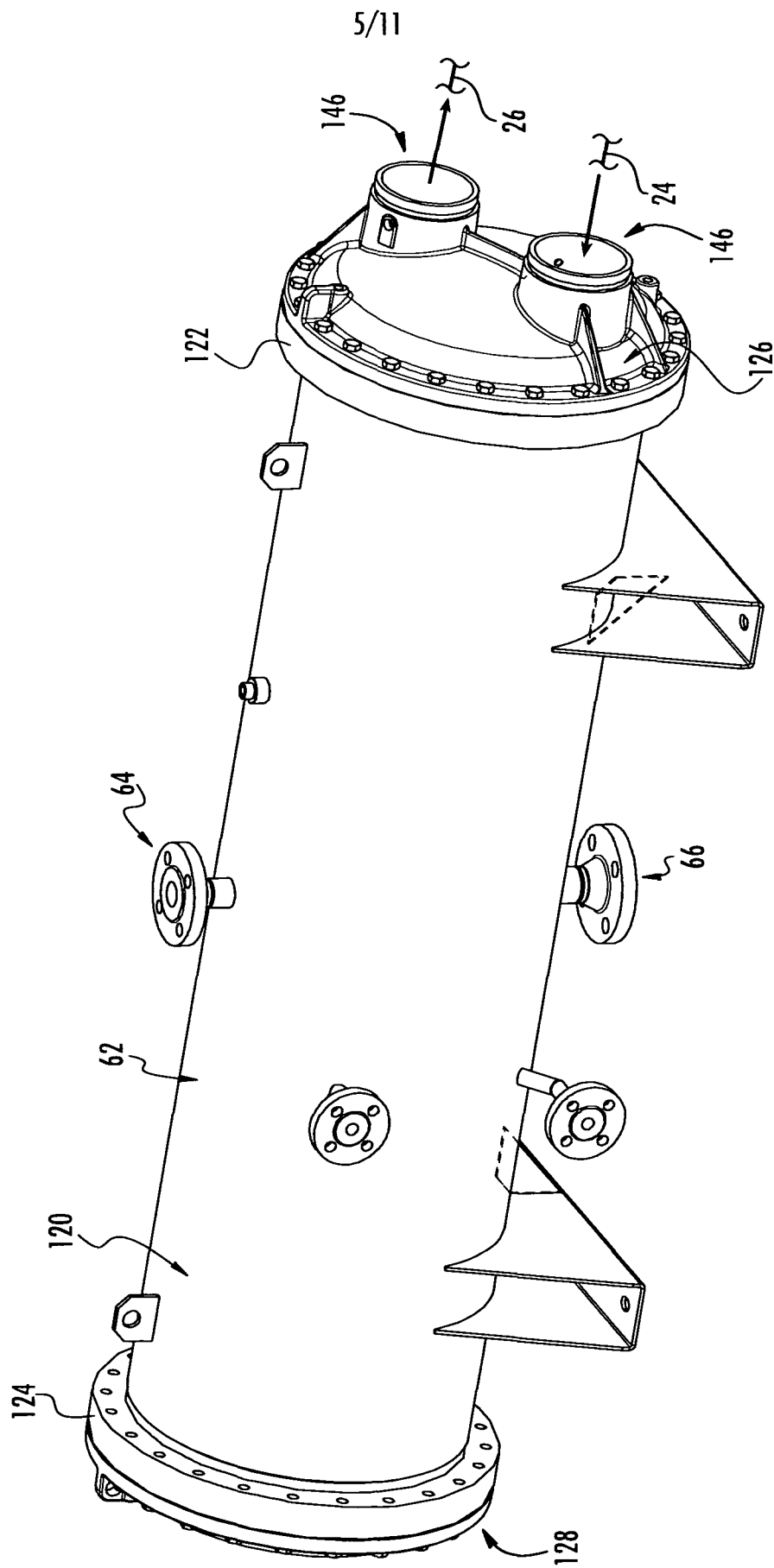


FIG. 6

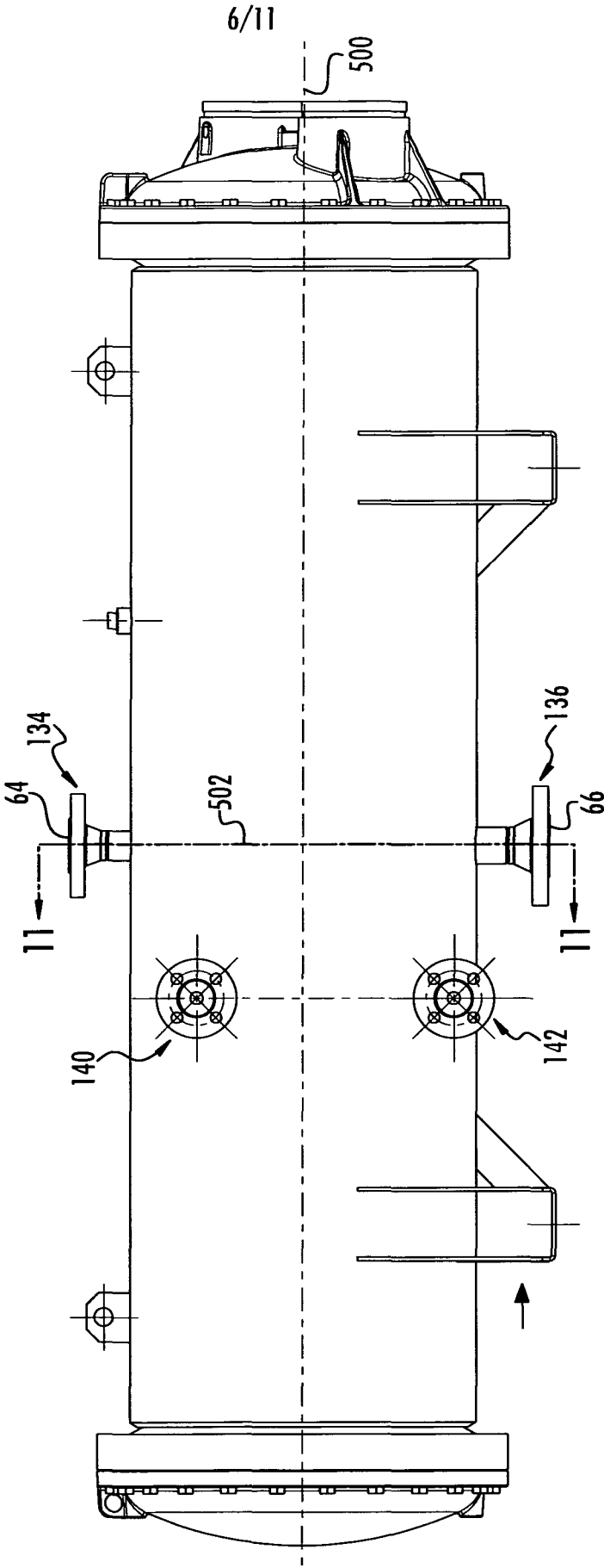


FIG. 7

7/11

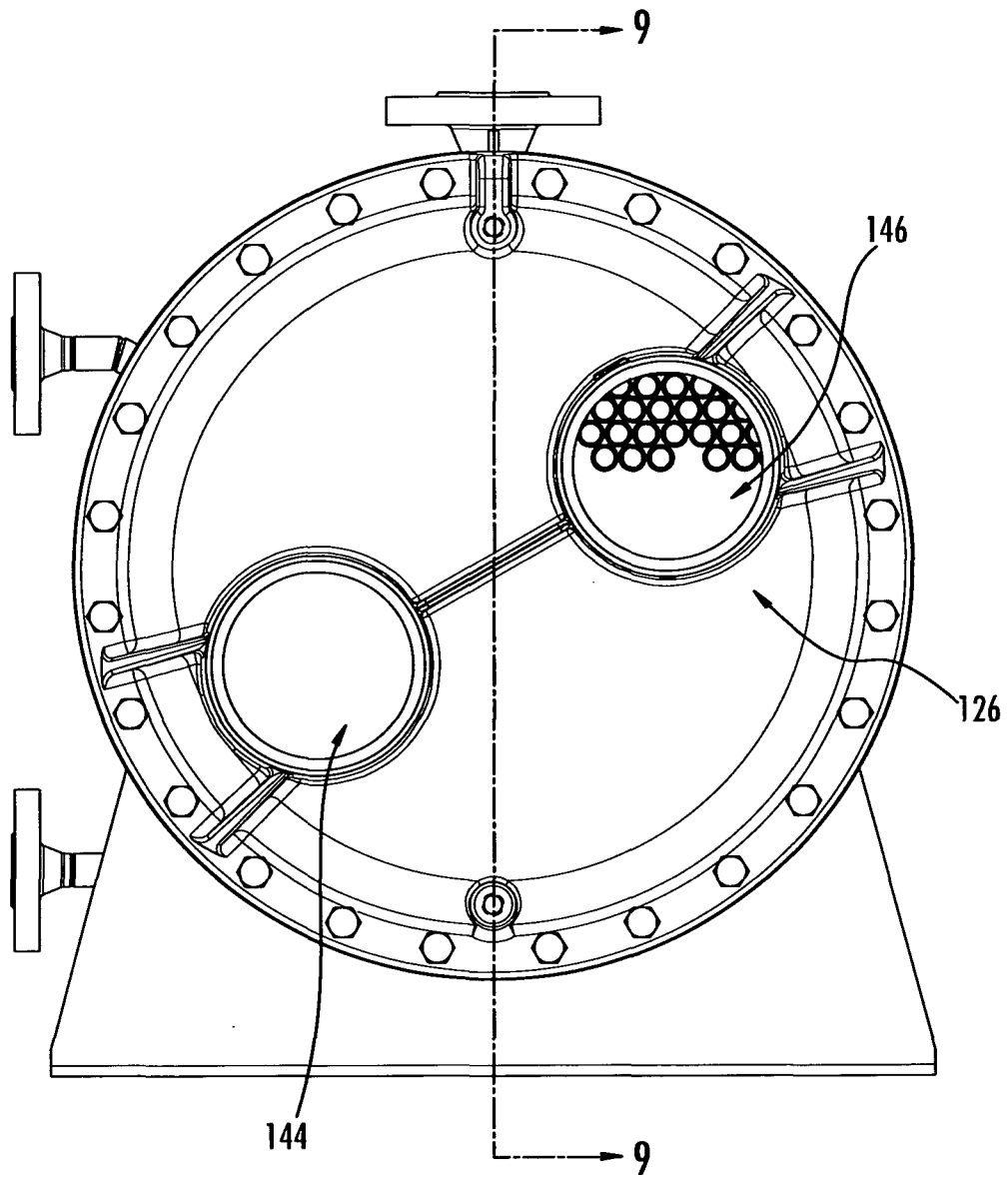


FIG. 8

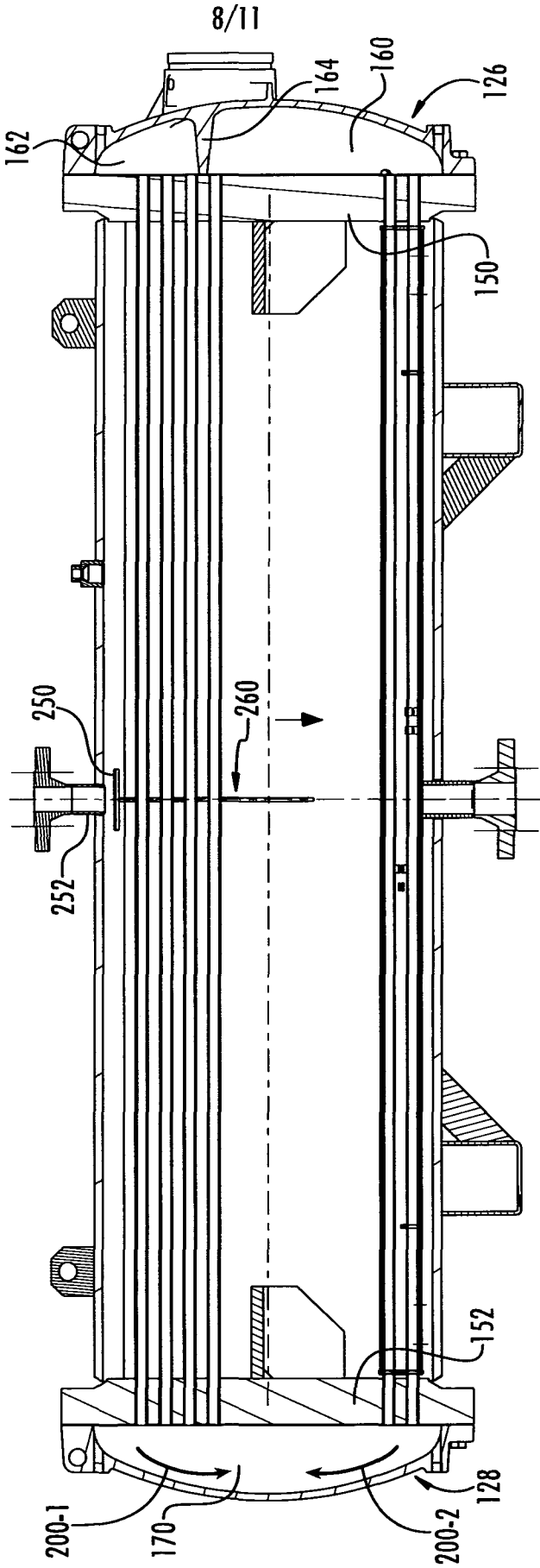
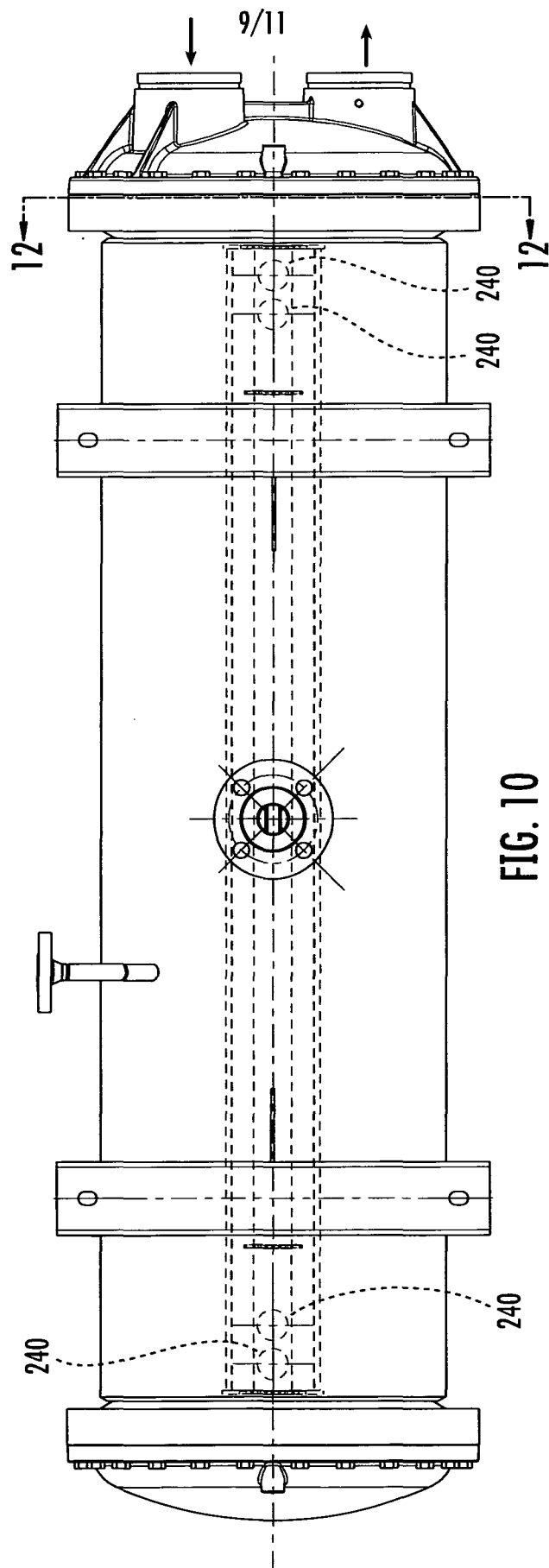


FIG. 9



10/11

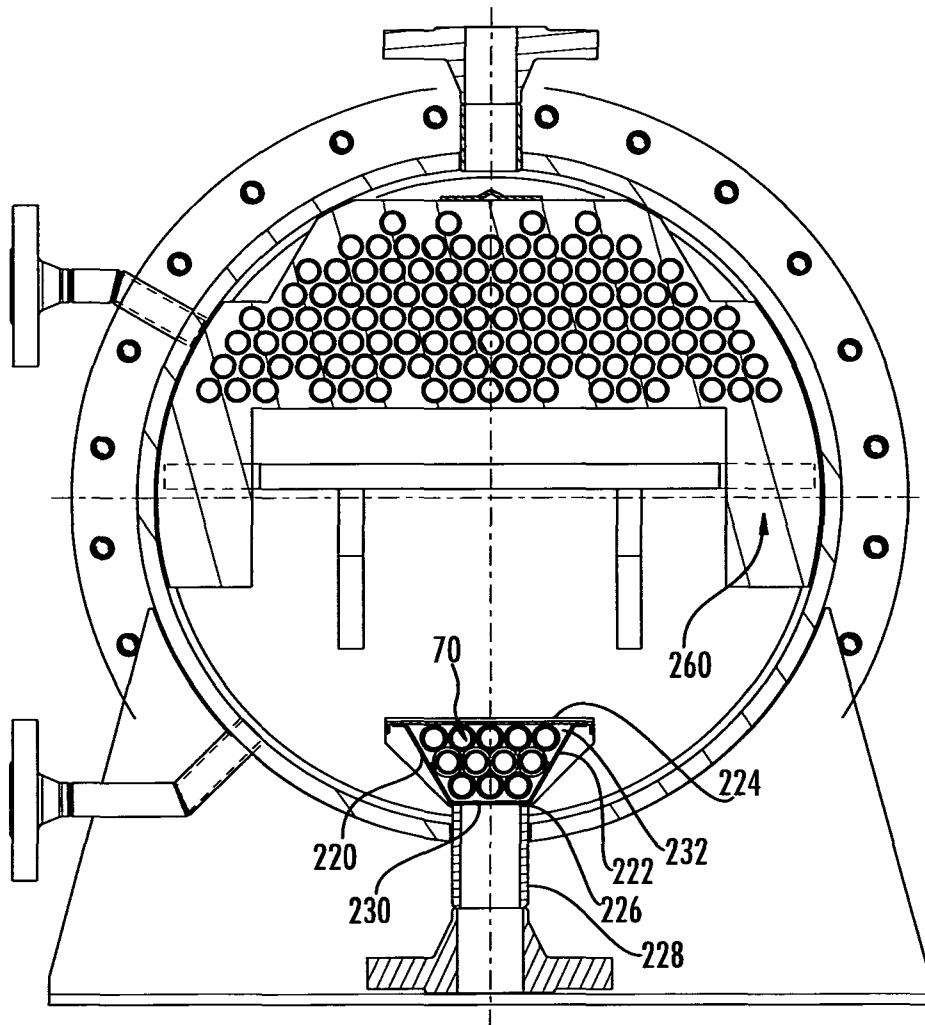


FIG. 11

11/11

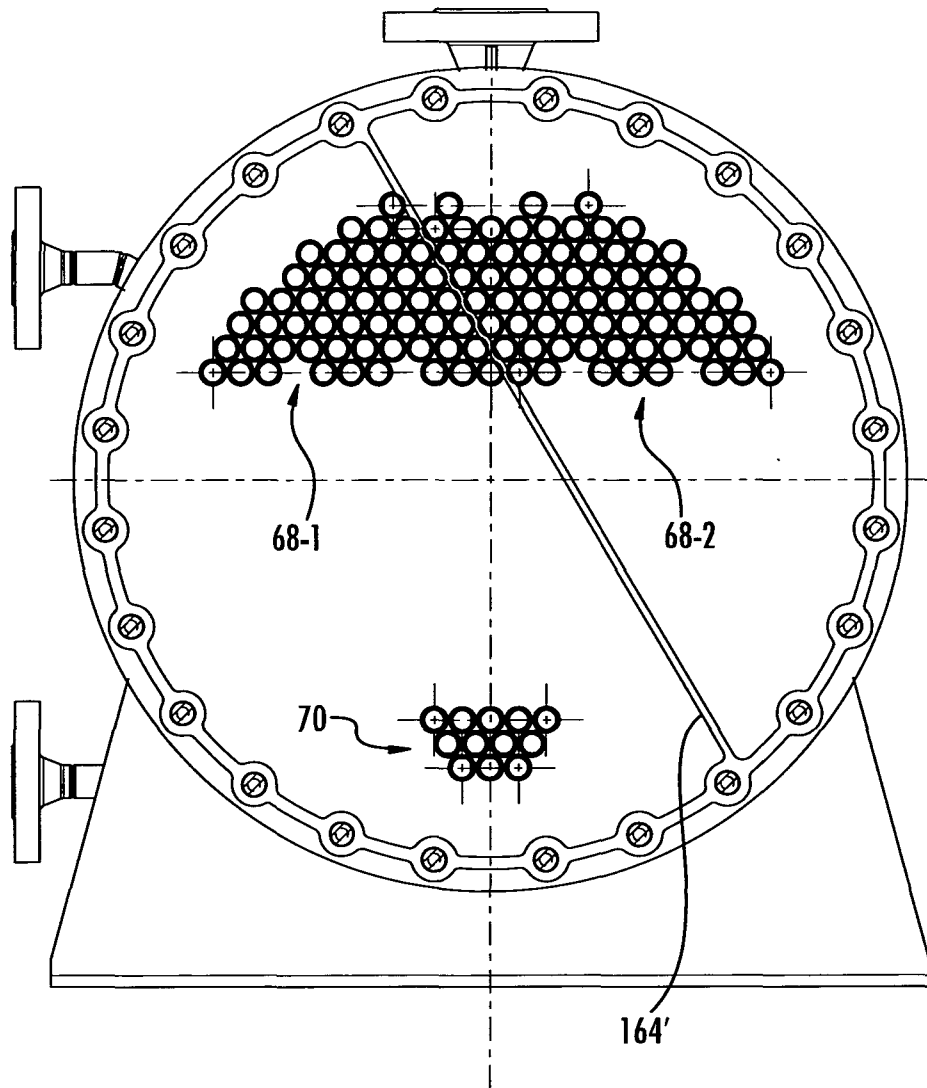


FIG. 12