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(54) Title: A HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC&R) SYSTEM HAVING AN EVAPORATOR WITH A MESH ELIMINATOR ASSEMBLY, AND A METHOD OF CONSTRUCTING A MESH ELIMINATOR ASSEMBLY

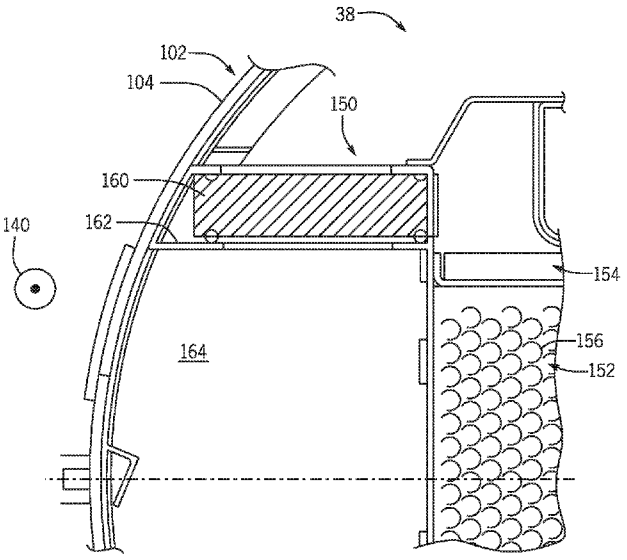


FIG. 6

(57) Abstract: A falling film evaporator including a one-piece shell having a plurality of heat exchange tubes disposed at least partially underneath a hood. The falling film evaporator includes a mesh eliminator assembly disposed within a shell to block liquid carryover. The mesh eliminator assembly includes a support structure having a first channel element extending axially within the shell and coupled to an inner surface of the shell, and having a second channel element extending axially within the one-piece shell and coupled to the hood of the falling film evaporator. The mesh eliminator assembly includes a mesh element having one or more layers of a metal mesh disposed within the support structure, and a grid plate disposed within the support structure beneath the mesh element to support a lower surface of the mesh element and having openings of a larger dimension than openings of the metal mesh.

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A HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC&R) SYSTEM HAVING AN EVAPORATOR WITH A MESH ELIMINATOR ASSEMBLY, AND A METHOD OF CONSTRUCTING A MESH ELIMINATOR ASSEMBLY

BACKGROUND

[0001] The present disclosure relates generally to heating, ventilating, air conditioning, and refrigeration (HVAC&R) systems, and, more particularly, to systems and methods for assembling mesh eliminators for falling film evaporators in HVAC&R systems.

[0002] Vapor compression systems utilize a working fluid, typically referred to as a refrigerant, which changes phases between vapor, liquid, and combinations thereof in response to being subjected to different temperatures and pressures associated with operation of the vapor compression system. Certain vapor compression systems include an evaporator that vaporizes a refrigerant therein. For example, a falling film evaporator of a vapor compression system may deposit a refrigerant liquid onto a tube bundle, which transfers heat to the refrigerant. Then, refrigerant vapor may travel out of the falling film evaporator to continue within the vapor compression system. Unfortunately, the refrigerant vapor traveling out of the falling film evaporator may include entrained liquid droplets, or liquid carryover of the refrigerant, which may cause degradation of downstream portions of the vapor compression system. Thus, the falling film evaporator may require more maintenance and repairs due to the entrained liquid droplets. Moreover, certain equipment employed to remove the liquid carryover, such as baffles, may undesirably increase a pressure drop and/or complicate a construction process for the falling film evaporator.

SUMMARY

[0003] In one embodiment of the present disclosure, a heating, ventilation, air conditioning, and refrigeration (HVAC&R) system includes a falling film evaporator including a one-piece shell having a plurality of heat exchange tubes disposed at least partially underneath a hood of the falling film evaporator. The falling film evaporator

includes a mesh eliminator assembly disposed within a shell of the falling film evaporator to block liquid carryover. The mesh eliminator assembly also includes a support structure having a first channel element extending axially within the shell and coupled to an inner surface of the shell, and having a second channel element extending axially within the one-piece shell and coupled to the hood of the falling film evaporator. The first channel element and the second channel element include respective open sides that face one another. Additionally, the mesh eliminator assembly includes a mesh element having one or more layers of a metal mesh disposed within the support structure. Further, the mesh eliminator assembly includes a grid plate disposed within the support structure beneath the mesh element to support a lower surface of the mesh element. The grid plate includes openings having a larger dimension than openings of the metal mesh.

[0004] In another embodiment of the present disclosure, a heating, ventilation, air conditioning, and refrigeration (HVAC&R) system includes a falling film evaporator including a one-piece shell having a plurality of heat exchange tubes disposed at least partially underneath a hood disposed between the plurality of tubes and a vapor channel. The falling film evaporator includes a mesh eliminator assembly disposed within the one-piece shell of the falling film evaporator to block liquid carryover. The mesh eliminator assembly includes a support structure defining a receiving space. The support structure includes an inner baffle coupled to an outer surface of the hood, a hood extension of the outer surface of the hood and vertically opposed from the inner baffle, a short outer baffle coupled to an inner wall of the one-piece shell and horizontally opposed from the hood extension, and a long outer baffle coupled to the inner wall of the one-piece shell, vertically opposed from the short outer baffle, and horizontally opposed from the inner baffle. The mesh eliminator assembly also includes a mesh element having one or more layers of a metal mesh disposed within the receiving space of the support structure. Additionally, the mesh eliminator assembly includes a grid plate disposed within the receiving space of the support structure beneath the mesh element to support a lower surface of the mesh element. The grid plate includes openings having a larger dimension than openings of the metal mesh.

[0005] In a further embodiment of the present disclosure, a method of constructing a mesh eliminator assembly within a falling film evaporator includes coupling a support structure between an inner surface of a one-piece shell of the falling film evaporator and a hood disposed between a plurality of heat exchange tubes and a vapor channel within the falling film evaporator. The method also includes disposing a lower grid plate on a lower surface of a mesh element including one or more layers of a metal mesh. Additionally, the method includes moving the mesh element and the lower grid plate within a receiving space defined within the support structure.

[0006] Other features and advantages of the present application will be apparent from the following, more detailed description of the embodiments, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the application.

DRAWINGS

[0007] FIG. 1 is a perspective view of an embodiment of a building that may utilize a heating, ventilation, air conditioning, and refrigeration (HVAC&R) system in a commercial setting, in accordance with the present techniques;

[0008] FIG. 2 is a perspective view of an embodiment of a vapor compression system, in accordance with the present techniques;

[0009] FIG. 3 is a schematic diagram of an embodiment of the vapor compression system, in accordance with the present techniques;

[0010] FIG. 4 is a schematic diagram of an embodiment of the vapor compression system, in accordance with the present techniques;

[0011] FIG. 5 is a perspective view of an embodiment of an evaporator of the vapor compression system having a one-piece shell, in accordance with the present techniques;

[0012] FIG. 6 is an axial cross-sectional view of an embodiment of the evaporator having a mesh eliminator assembly, in accordance with the present techniques;

[0013] FIG. 7 is a cross-sectional view of an embodiment of a support structure of the mesh eliminator assembly, in accordance with the present techniques;

[0014] FIG. 8 is an axial perspective view of an embodiment of mesh elements of the mesh eliminator assembly partially moved into an operating position, in accordance with the present techniques;

[0015] FIG. 9 is a bottom perspective view of an embodiment of the mesh eliminator assembly having an overlap region, in accordance with the present techniques;

[0016] FIG. 10 is a bottom perspective view of an embodiment of the mesh eliminator assembly having an inner plate, in accordance with the present techniques;

[0017] FIG. 11 is an axial cross-sectional view of an embodiment of a mesh eliminator assembly having a one-piece mesh element, in accordance with the present techniques;

[0018] FIG. 12 is a perspective view of an embodiment of two intermediate mesh assemblies, in accordance with the present techniques;

[0019] FIG. 13 is an axial perspective view of an embodiment of a first transition assembly, in accordance with the present techniques;

[0020] FIG. 14 is an axial perspective view of an embodiment of a second transition assembly, in accordance with the present techniques;

[0021] FIG. 15 is an axial perspective view of an embodiment of a third transition assembly, in accordance with the present techniques; and

[0022] FIG. 16 is an axial perspective view of an embodiment of a fourth transition assembly, in accordance with the present techniques.

DETAILED DESCRIPTION

[0023] The present disclosure is directed to heating, ventilation, air conditioning, and refrigeration (HVAC&R) systems and systems and methods for falling film evaporator mesh eliminator assembly and associated components. In general, HVAC&R systems include a closed refrigeration circuit having an evaporator configured to vaporize, or evaporate, a refrigerant therein to enable the HVAC&R system to condition an interior space. By employing a falling film evaporator, the HVAC&R system may employ a reduced amount of low pressure refrigerant and/or an enhanced performance as compared to traditional flooded evaporators. Additionally, embodiments discussed herein may include a mesh eliminator assembly to remove, reduce, or eliminate carryover of liquid portions of the low pressure refrigerant with vapor exiting the falling film evaporator. The mesh eliminator assembly is constructed in place within a shell of the falling film evaporator. However, as compared to traditional falling film evaporators, the present embodiments for constructing the mesh eliminator assembly enable the shell to be formed from one piece.

[0024] For example, the mesh eliminator assembly includes a support structure that is coupled within the falling film evaporator. Then, multiple axially adjacent mesh elements or a one-piece mesh element may be captured between corresponding grid plates to add structural support to the mesh elements. Additionally, the mesh elements and grid plates may be slid within a receiving space defined within the support structure. The receiving space may have a smaller width or height than a respective width or height of the mesh elements, such that the mesh elements compress within the support structure. The resulting mesh eliminator assemblies disposed along a flow path between one or more tube bundles of the falling film evaporator and a refrigerant outlet thus provide a tortuous path for the low pressure refrigerant flowing through the evaporator, and thus the liquid within the low pressure refrigerant vapor impinges on the mesh eliminator assembly and fall back into a refrigerant pool within the falling film evaporator. In this

manner, the mesh eliminator assembly is capable of being assembled in-situ within the falling film evaporator.

[0025] Turning now to the drawings, FIG. 1 is a perspective view of an embodiment of an environment for a heating, ventilation, air conditioning, and refrigeration (HVAC&R) system 10 in a building 12 for a typical commercial setting. The HVAC&R system 10 may include a vapor compression system 14 that supplies a chilled liquid, which may be used to cool the building 12. The HVAC&R system 10 may also include a boiler 16 to supply warm liquid to heat the building 12 and an air distribution system which circulates air through the building 12. The air distribution system can also include an air return duct 18, an air supply duct 20, and/or an air handler 22. In some embodiments, the air handler 22 may include a heat exchanger that is connected to the boiler 16 and the vapor compression system 14 by conduits 24. The heat exchanger in the air handler 22 may receive either heated liquid from the boiler 16 or chilled liquid from the vapor compression system 14, depending on the mode of operation of the HVAC&R system 10. The HVAC&R system 10 is shown with a separate air handler on each floor of building 12, but in other embodiments, the HVAC&R system 10 may include air handlers 22 and/or other components that may be shared between or among floors.

[0026] FIGS. 2 and 3 are embodiments of the vapor compression system 14 that can be used in the HVAC&R system 10. The vapor compression system 14 may circulate a refrigerant through a circuit starting with a compressor 32. The circuit may also include a condenser 34, an expansion valve(s) or device(s) 36, and a liquid chiller or an evaporator 38. The vapor compression system 14 may further include a control panel 40 that has an analog to digital (A/D) converter 42, a microprocessor 44, a non-volatile memory 46, and/or an interface board 48.

[0027] Some examples of fluids that may be used as refrigerants in the vapor compression system 14 are hydrofluorocarbon (HFC) based refrigerants, for example, R-410A, R-407, R-134a, hydrofluoro olefin (HFO), "natural" refrigerants like ammonia (NH3), R-717, carbon dioxide (CO2), R-744, or hydrocarbon based refrigerants, water

vapor, or any other suitable refrigerant. In some embodiments, the vapor compression system 14 may be configured to efficiently utilize refrigerants having a normal boiling point of about 19 degrees Celsius (66 degrees Fahrenheit) at one atmosphere of pressure, also referred to as low pressure refrigerants, versus a medium pressure refrigerant, such as R-134a. As used herein, "normal boiling point" may refer to a boiling point temperature measured at one atmosphere of pressure.

[0028] In some embodiments, the vapor compression system 14 may use one or more of a variable speed drive (VSDs) 52, a motor 50, the compressor 32, the condenser 34, the expansion valve or device 36, and/or the evaporator 38. The motor 50 may drive the compressor 32 and may be powered by a variable speed drive (VSD) 52. The VSD 52 receives alternating current (AC) power having a particular fixed line voltage and fixed line frequency from an AC power source, and provides power having a variable voltage and frequency to the motor 50. In other embodiments, the motor 50 may be powered directly from an AC or direct current (DC) power source. The motor 50 may include any type of electric motor that can be powered by a VSD or directly from an AC or DC power source, such as a switched reluctance motor, an induction motor, an electronically commutated permanent magnet motor, or another suitable motor.

[0029] The compressor 32 compresses a refrigerant vapor and delivers the vapor to the condenser 34 through a discharge passage. In some embodiments, the compressor 32 may be a centrifugal compressor. The refrigerant vapor delivered by the compressor 32 to the condenser 34 may transfer heat to a cooling fluid (e.g., water or air) in the condenser 34. The refrigerant vapor may condense to a refrigerant liquid in the condenser 34 as a result of thermal heat transfer with the cooling fluid. The liquid refrigerant from the condenser 34 may flow through the expansion device 36 to the evaporator 38. In the illustrated embodiment of FIG. 3, the condenser 34 is water cooled and includes a tube bundle 54 connected to a cooling tower 56, which supplies the cooling fluid to the condenser 34.

[0030] The liquid refrigerant delivered to the evaporator 38 may absorb heat from another cooling fluid, which may or may not be the same cooling fluid used in the condenser 34. The liquid refrigerant in the evaporator 38 may undergo a phase change from the liquid refrigerant to a refrigerant vapor. As shown in the illustrated embodiment of FIG. 3, the evaporator 38 may include a tube bundle 58 having a supply line 60S and a return line 60R connected to a cooling load 62. The cooling fluid of the evaporator 38 (e.g., water, ethylene glycol, calcium chloride brine, sodium chloride brine, or any other suitable fluid) enters the evaporator 38 via return line 60R and exits the evaporator 38 via supply line 60S. The evaporator 38 may reduce the temperature of the cooling fluid in the tube bundle 58 via thermal heat transfer with the refrigerant. The tube bundle 58 in the evaporator 38 can include a plurality of tubes and/or a plurality of tube bundles. In any case, the vapor refrigerant exits the evaporator 38 and returns to the compressor 32 by a suction line to complete the cycle.

[0031] FIG. 4 is a schematic diagram of the vapor compression system 14 with an intermediate circuit 64 incorporated between condenser 34 and the expansion device 36. The intermediate circuit 64 may have an inlet line 68 that is directly fluidly connected to the condenser 34. In other embodiments, the inlet line 68 may be indirectly fluidly coupled to the condenser 34. As shown in the illustrated embodiment of FIG. 4, the inlet line 68 includes a first expansion device 66 positioned upstream of an intermediate vessel 70. In some embodiments, the intermediate vessel 70 may be a flash tank (e.g., a flash intercooler). In other embodiments, the intermediate vessel 70 may be configured as a heat exchanger or a "surface economizer." In the illustrated embodiment of FIG. 4, the intermediate vessel 70 is used as a flash tank, and the first expansion device 66 is configured to lower the pressure of (e.g., expand) the liquid refrigerant received from the condenser 34. During the expansion process, a portion of the liquid may vaporize, and thus, the intermediate vessel 70 may be used to separate the vapor from the liquid received from the first expansion device 66. Additionally, the intermediate vessel 70 may provide for further expansion of the liquid refrigerant because of a pressure drop experienced by the liquid refrigerant when entering the intermediate vessel 70 (e.g., due

to a rapid increase in volume experienced when entering the intermediate vessel 70). The vapor in the intermediate vessel 70 may be drawn by the compressor 32 through a suction line 74 of the compressor 32. In other embodiments, the vapor in the intermediate vessel may be drawn to an intermediate stage of the compressor 32 (e.g., not the suction stage). The liquid that collects in the intermediate vessel 70 may be at a lower enthalpy than the liquid refrigerant exiting the condenser 34 because of the expansion in the expansion device 66 and/or the intermediate vessel 70. The liquid from intermediate vessel 70 may then flow in line 72 through a second expansion device 36 to the evaporator 38.

[0032] With the above understanding of the HVAC&R system 10 in mind, FIG. 5 is a perspective view of the evaporator 38 (e.g., falling film evaporator) having a shell 102. As shown, the shell 102 is circumferentially formed from one piece, as enabled by the slide-in mesh eliminator assembly discussed herein. That is, the shell 102 may not split into two circumferential sections that fasten together, in contrast to shells of certain evaporators. Instead, the shell 102 includes a main body 104 formed primarily of one piece of a structurally strong material, such as steel.

[0033] The evaporator 38 also includes a first tubesheet 106 attached to a first end 108 of the main body 104, and a second tubesheet 110 attached to a second end 112 of the main body 104. Additionally, a first waterbox 116 coupled to the first tubesheet 106 includes a cooling fluid inlet 118 and a cooling fluid outlet 120 respectively coupling one or more tube bundles within the evaporator 38 to the supply line 60S and the return line 60R (e.g., connected to the cooling load 62). The shell 102 additionally includes a refrigerant inlet 124 to receive low pressure refrigerant liquid 126. As discussed above, the evaporator 38 reduces the temperature of the cooling fluid in the tube bundles via thermal heat transfer with the refrigerant deposited on the tube bundles, while evaporating the low pressure refrigerant liquid 126 into a low pressure refrigerant gas 128. The low pressure refrigerant gas 128 may thus exit the evaporator 38 via a refrigerant outlet 130 fluidly coupled to the compressor 32.

[0034] However, in certain conditions, the low pressure refrigerant gas 128 may entrain or "carryover" liquid out of the refrigerant outlet 130, which can damage impellers of the compressor 32 or other components of the HVAC&R system 10. Thus, to reduce, block, or eliminate carryover of liquid refrigerant in the evaporator 38, the evaporator 38 includes mesh eliminator assemblies, as discussed in more detail below. Further, because the main body 104 of the shell 102 is formed from one piece, the mesh eliminator assemblies are designed to enable mesh elements to slide axially (e.g., along an axial direction 140 substantially parallel to, such as within a five percent difference from the axial direction 140, of an axis 142 of the evaporator 38) into the main body 104 during assembly of the evaporator 38.

[0035] FIG. 6 is an axial cross-sectional view of a portion of an embodiment of the evaporator 38 including a mesh eliminator assembly 150. During operation of the evaporator 38, liquid refrigerant (e.g., the low pressure refrigerant liquid 126) is deposited onto a tube bundle 152 by a distributor 154, thus enabling the liquid refrigerant to absorb thermal energy from the cooling fluid flowing within tubes 156 of the tube bundle 152. The mesh eliminator assembly 150 enables the resulting refrigerant vapor (e.g., the low pressure refrigerant gas 128) to exit the evaporator 38, while blocking entrained liquid refrigerant from leaving the evaporator (e.g., as liquid carryover). The mesh eliminator assembly 150 may cause a low pressure drop in the refrigerant vapor as compared to other passive devices that reduce liquid carryover, such as baffles disposed within a flow path of the refrigerant vapor. Moreover, the mesh eliminator assembly 150 may be constructed within the shell 102 of the evaporator 38, thus enabling the main body 104 of the shell 102 to be formed from only one piece (e.g., one-piece construction). In other words, the mesh eliminator assembly 150 may be assembled in-situ within the shell 102.

[0036] In the present embodiment, the mesh eliminator assembly 150 includes a plurality of mesh elements 160 (e.g., axially adjacent mesh elements) disposed end-to-end along the axial direction 140 within the shell 104. Each mesh element 160 may be a

flexible stack or roll of multiple layers of metal mesh (e.g., metal cloth) formed from metal wires (e.g., stainless steel 304) having a relatively small diameter. For example, in some embodiments, the metal mesh has a diameter of or less than 0.05 inches, 0.01 inches, 0.0098 inches, 0.005 inches, or less. Thus, the mesh elements 160 define a tortuous path through open areas between adjacent portions of the metal mesh, such that liquid droplets entrained within the refrigerant vapor traveling through the mesh elements 160 impinge against the metal mesh and drop back down into the evaporator 38.

[0037] Additionally, the mesh elements 160 are disposed within a support structure 162 of the mesh eliminator assembly 150. As will be discussed in greater detail with reference to FIG. 7, the support structure 162 includes two axially-extending channels (e.g., channel elements) that are coupled within the shell 102. Moreover, although only one mesh eliminator assembly 150 is shown in a first side 164 of the evaporator 38, it is to be understood that an additional mesh eliminator assembly is disposed on a second side of the evaporator 38, such that at least a majority of the refrigerant vapor produced within the evaporator 38 traverses through either the mesh eliminator assembly 150 or the additional mesh eliminator assembly before traveling out of the evaporator 38 and into the compressor 32.

[0038] Indeed, looking more closely at the support structure 162, FIG. 7 illustrates an embodiment of a cross-sectional view of the support structure 162 having an asymmetrical section 200 and a symmetrical section 202. In some embodiments, the asymmetrical section 200 includes an irregular cross-section, such as the illustrated cross-section having an obtuse angle 206 defined between a short leg 208 (e.g., extension) and a slanted middle portion 210 (e.g., bridge portion) of the asymmetrical section 200. Additionally, the present cross-section of the asymmetrical section 200 includes an acute angle 212 defined between a long leg 214 and the slanted middle portion 210 of the asymmetrical section 200. In contrast, the symmetrical section 202 includes a cross-section having two approximately right angles 218 respectively defined between two level legs 220 (e.g., extensions) and a straight middle portion 222 (e.g., bridge portion).

In this manner, the slanted middle portion 210 of the asymmetrical section 200 may be attached to a curved inner surface of the shell 102, such that an outer edge 224 of the asymmetrical section 202 corresponds to (e.g., mates with, substantially aligns with) the inner surface of the shell. Further, an outer edge 226 of the straight middle portion 222 of the symmetrical section 202 may be attached to (or include portions of) support elements adjacent to the distributor 154 and/or the tube bundle 152, such as a hood (e.g., tube hood).

[0039] Both sections 200, 202 may be channel shaped (e.g., C channels) and extend along a length of the evaporator 38. Thus, open sides of the sections 200, 202 face one another, such that a receiving space 230 is defined to receive and retain the plurality of mesh elements 160 therein. In certain embodiments, the receiving space 230 of the support structure 162 includes a width 232 and/or a length 234 that are each smaller than a respective width and a respective length of each mesh element 160. Thus, each mesh element 160 may be compressed in at least one direction (e.g., vertically, horizontally) during assembly within the support structure 162. Such compression of the mesh elements 160 thus reduces or blocks bypass flow paths of the refrigerant vapor between the support structure 162 and the mesh elements 160 during operation of the evaporator 38.

[0040] Moreover, FIG. 8 is an axial perspective view of the mesh elements 160 partially moved into an operating position within the support structure 162. As illustrated, the mesh elements 160 are compressed between the asymmetrical section 200 and the symmetrical section 202 of the support structure 162. Additionally, a support plate, such as the illustrated grid plate 250, may be disposed on top and/or underneath each mesh element 160 or a plurality of mesh elements 160 to provide support during assembly and operation of the mesh eliminator assembly 150. The grid plate 250 may include a relatively large open area (e.g., as compared to an open area of the metal mesh of the mesh elements 160) to avoid or reduce a pressure drop of the refrigerant vapor through the grid plate 250. As shown, the grid plate 250 and the mesh elements 160 may

be moved into place within the support structure 162 to construct the mesh eliminator assembly 150.

[0041] Indeed, with the above understanding of the components of the mesh eliminator assembly 150, a process for assembling the mesh eliminator assembly 150 (e.g., assembly process, construction process) can be more readily understood. For example, the process includes coupling the support structure 162 within the shell 102 of the evaporator 38 (e.g., via spot welding). Additionally, the process includes disposing the one or more grid plates 250 onto the respective mesh elements 160. Then, the grid plates 250 may be coupled to the mesh elements 160 via welding, adhesive, bindings, etc. to provide structural support and/or a generally uniform thickness (e.g., non-sloped profile) to the mesh elements 160. Additionally, the mesh elements 160 coupled to the grid plates 250 may be may be moved (e.g., slid, pushed, pulled) within the support structure 162, as illustrated in FIG. 8, until the mesh elements 160 reach a target operating position. In this manner, the mesh eliminator assembly 150 may be constructed in-situ within the evaporator 38.

[0042] Additionally, it is to be noted that certain steps of the process may be omitted, such as coupling the grid plates 250 to the mesh elements 160, or certain steps may be performed simultaneously. In certain embodiments, mesh elements 160 and accompanying grid plates 250 may be moved within the support structure 162 from both axial ends of the support structure 162, such that the mesh elements 160 meet in the middle. Moreover, further steps, such as those included in FIGS. 9 and 10 may also be included in the process to construct the mesh eliminator assembly 150.

[0043] FIG. 9 is a bottom perspective view of the mesh eliminator assembly 150. As shown, the mesh eliminator assembly 150 includes the grid plates 250 disposed beneath the mesh elements 160. To further reduce an amount of bypass flow paths through the mesh eliminator assembly 150, an overlap region 270 is provided between axial adjacent mesh elements 160 (e.g., relative to the axial direction 140 substantially parallel to the axis 142 of the evaporator 38). The overlap region 270 includes compressed end portions

of the mesh elements 160, which are compressed together or overlapped during construction of the mesh eliminator assembly 150 to reduce an open space and resulting bypass flow paths therebetween. Indeed, by providing the end portions of the mesh elements 160 that protrude beyond the grid plates 250, the axially adjacent mesh elements 160 may be pushed or moved closer to one another, such that the end portions compress to form the overlap region 270 for improved eliminator performance therebetween.

[0044] FIG. 10 is a bottom perspective view of the mesh eliminator assembly 150 having an inner plate 280 (e.g., radially extending plate) for blocking carryover between axially adjacent mesh elements 160. For example, the inner plate 280 may be coupled between (e.g. form a bridge across) inner surfaces of the asymmetrical section 200 and the symmetrical section 202 via spot welding or another suitable attachment process. By positioning the inner plate 280 between target operating positions of the mesh elements 160, the inner plate 280 is capable of blocks or prevents refrigerant vapor from passing through gaps or bypass flow paths defined between the mesh elements 160. Multiple inner plates 280 may be disposed within the support structure 162 before the mesh elements 160 and grid plates 250 are moved into the target operating positions. For example, in embodiments having a 4 m long shell 102, the mesh eliminator may include five mesh elements 160, each having a respective length of 0.8 m. Thus, four inner plates 280 may be coupled to the support structure 162 at the four locations at which the five mesh elements 160 are to be disposed, such as at 0.8 m, 1.6 m, 2.4 m, and 3.2 m. In this manner, the inner plates 280 may be used instead of or in addition to the overlap region 270 of FIG. 9 to further block liquid carryover through the mesh eliminator assembly 150.

[0045] Additionally, in certain embodiments, another process and accompanying components may be employed to assemble a one-piece mesh element within the shell 102. For example, FIG. 11 is an axial cross-sectional view of an embodiment of a mesh eliminator assembly 300 having a one-piece mesh element 302 disposed within a support structure 304. As shown, the support structure 304 includes multiple supporting elements

(e.g., angled baffles and/or extensions) that maintain the one-piece mesh element 302 in place. Indeed, the support structure 304 includes a short outer baffle 310 (e.g., defining an acute angle 311) and a long outer baffle 312 (e.g., lead rail, defining an obtuse angle 313) that are vertically opposed from one another across the one-piece mesh element 302. The support structure 304 also includes an inner baffle 314 (e.g., having a right angle 315) vertically opposed from an extension 316 of a hood 320 (e.g., hood extension) disposed within the evaporator 38. The hood 320 may be a axially-extending sheet or baffle disposed between the tube bundle 152 and a vapor channel 322 to block the liquid refrigerant from bypassing the tube bundle 152 during operation. In the illustrated embodiment, the extension 316 of the hood 320 functions as an additional baffle to retain the one-piece mesh element 302 in an operating position. However, in embodiments without the extension 316, an additional inner baffle (e.g., hood extension) may be placed within the evaporator 38 and/or coupled to or through an outer surface of the hood 320.

[0046] Further, the support structure 304 includes an inner support clip 326 disposed beneath the inner baffle 314 and an outer support clip 328 disposed beneath the long outer baffle 312. The support clips 326, 328 may be welded or otherwise fixed within the shell 102 before the other components of the mesh eliminator assembly 300 are assembled to provide reference points for uniform and efficient assembly of the baffles 310, 312, 314 therein. Compared to the mesh eliminator assembly 150 of FIG. 6, the mesh eliminator assembly 300 may use a lower amount of material (e.g., steel), a reduced amount of welding (and accompanying service hours), or an alternative assembly process, as discussed in more detail with reference to the assembly process shown in FIGS. 12-16 below.

[0047] FIG. 12 is a perspective view of two intermediate mesh assemblies 350 including two one-piece mesh elements 302. As shown, one-piece grid plates 352 are disposed on top of the one-piece mesh elements 302. Additionally, in some embodiments, end portions 360 of the one-piece mesh elements 302 and the one-piece grid plates 352 are fastened together (e.g. coupled) via wires extended through both the

one-piece mesh elements 302 and the one-piece grid plates 352 (e.g., threaded together), welding, fasteners, or another suitable fastening means. In some embodiments, the end portions 360 of the intermediate mesh assemblies 350 are placed into the shell 102 first, such that additional structural integrity provided by the fastened end portions 360 assists in the assembly process. Additionally, in certain embodiments, additional end portions 362 of the one-piece mesh elements 302 and the one-piece grid plates 352 are fastened together in a similar manner. Moreover, although described herein as having the one-piece mesh elements 302 and the one-piece grid plates 352, it is to be understood that the intermediate mesh assemblies 350 may alternatively include the one-piece mesh elements 302 and multiple grid plates, or the one-piece grid plates 352 and multiple mesh elements.

[0048] As shown, the intermediate mesh assemblies 350 each include a respective length 366 that corresponds to a length of the shell 102, or a length of a portion of the shell designed to receive the intermediate mesh assemblies 350. Similarly, the intermediate mesh assemblies 350 include respective widths 368 that correspond to a width of a receiving space within the support structure 304 designed to receive the intermediate mesh assemblies 350. In certain embodiments, the one-piece mesh elements 302 include additional mesh that is wider or longer than the receiving space within the shell 102, such that the additional mesh is compressed within the receiving space to block bypass flow paths therethrough, as discussed above.

[0049] Looking now to an assembly process of the mesh eliminator assemblies 300, FIG. 13 is an axial perspective view of a first transition assembly 400 of the mesh eliminator assembly 300 of the evaporator 38. As shown, the shell 102 is rotated approximately 180 degrees (e.g., within ten percent of 180 degrees), such that the refrigerant outlet 130 is disposed between the shell 102 and terrain 402 on or above which the evaporator 38 is being assembled. Thus, the evaporator 38 may not yet be coupled to other components of the HVAC&R system, such as the compressor 32 and the expansion device 36.

[0050] To form the first transition assembly 400, components in a middle portion 404 of the shell 102, including the hood 320 having the extension 316, as well as the support clips 326, 328 are disposed within the shell 102 (e.g., either before or after rotating the shell 102 180 degrees). Then, the short outer baffle 310 is coupled to an inner wall 408 of the shell 102 (e.g., via welding, spot-welding, epoxy, fasteners, etc.) As shown, the short outer baffle 310 is horizontally aligned with the extension 316, thus forming a level receiving plane 410 having an unfilled middle portion on each side of the shell 102.

[0051] Further, FIG. 14 is an axial perspective view of a second transition assembly 430 of the mesh eliminator assembly 300. To form the second transition assembly 430 from the first transition assembly 400, the intermediate mesh assemblies 350 of FIG. 12 are disposed on the respective short outer baffles 310 and the respective extensions 316 of the hood 320. In some embodiments, the intermediate mesh assemblies 350 are slid, pushed, pulled, lowered, or otherwise moved on top of the outer baffles 310 and the extensions 316 until the intermediate mesh assemblies 350 reach the illustrated target operating position 432, in which lateral ends 434 of the intermediate mesh assemblies 350 align or otherwise correspond to lateral ends 436 of the short outer baffles 310 and the extensions 316.

[0052] Additionally, FIG. 15 is an axial perspective view of a third transition assembly 450 of the mesh eliminator assembly 300. To form the third transition assembly 450 from the second transition assembly 430, the inner baffles 314 are aligned underneath the inner support clips 326 and attached to the outer surface of the hood 320, thus maintaining an inner portion 454 (e.g., radially inward portion) of each intermediate mesh assembly 350 in the target operating position. In certain embodiments, the inner baffles 314 are also attached to the one-piece grid plates 302, though in other embodiments, a bent angle (e.g., 90 degree angle) of the inner baffles 314 enables a respective protruding portion of the inner baffles 314 to maintain sufficient contact with the intermediate mesh assemblies 350 without attachment therebetween. Additionally, in some embodiments, pressure tweezers, pressure fixtures, or other clamping devices are

employed during construction of the mesh eliminator assembly 300 to compress and hold the baffles and/or intermediate mesh assemblies 350 in place.

[0053] Moreover, FIG. 16 is an axial perspective view of a fourth transition assembly 470 of the mesh eliminator assembly 300. To form the fourth transition assembly 470 from the third transition assembly 450, the long outer baffles 312 are aligned underneath the outer support clips 328 and attached to the inner wall 408 of the shell 102, thus maintaining an outer portion 474 (e.g., radially outward portion) of each intermediate mesh assembly 350 in the target operating position. In certain embodiments, the long outer baffles 312 are also attached to the one-piece grid plates 302, though in other embodiments, a bent angle (e.g., obtuse angle) of long outer baffles 312 enables a respective protruding portion of the inner baffles 314 to maintain sufficient contact with the intermediate mesh assemblies 350 without attachment therebetween.

[0054] Moreover, in some embodiments, each component of the mesh eliminator assembly may be disposed in a respective target position within the shell 102 before each component is secured in place. For example, each baffle of the baffles 310, 312, 314 may be placed into the respective operating positions, and then welded into place during one or more welding sessions. In some embodiments, joints are welded completely, mostly, or partly across contact regions between the intermediate mesh assembly 350 and the respective components of the support structure 304 having the baffles 310, 312, 314 and the extension 316. Thus, after the components are welded or otherwise attached together, the fourth transition assembly 470 may be rotated by 180 degrees to an upright position, and then fitted with tubesheets, connections to other components, charged with the low pressure refrigerant, and then operated as the functioning evaporator having the mesh eliminator assemblies 300 for blocking liquid carryover.

[0055] Accordingly, the present techniques are directed to embodiments of a mesh eliminator assembly of a falling film evaporator to remove, reduce, or eliminate liquid carryover with the low pressure refrigerant vapor exiting the falling film evaporator. Moreover, the mesh eliminator assembly may be constructed within a one-piece shell of

the falling film evaporator, thus reducing an amount of components and an operating time associated with constructing the mesh eliminator assembly. To enable assembly within the falling film evaporator, the mesh eliminator assembly includes a support structure that is coupled within the falling film evaporator, such as between an inner surface of the shell and an outer surface of a hood. Then, multiple axially adjacent mesh elements or a one-piece mesh element is disposed between one or more corresponding grid plates to add structural support to the mesh elements. Additionally, the mesh elements and grid plates may be moved within a receiving space defined within the support structure. To enable compression of the mesh elements within the receiving space and to therefore reduce an amount of bypass flow paths between the support structure and the mesh elements, the receiving space may have a smaller width or height than a respective width or height of the mesh elements. The resulting mesh eliminator assemblies disposed along a flow path between one or more tube bundles of the falling film evaporator and a refrigerant outlet thus provide a tortuous path for the low pressure refrigerant flowing through the evaporator, and thus the liquid within the low pressure refrigerant vapor impinges on the mesh eliminator assembly and fall back into a refrigerant pool within the falling film evaporator. In this manner, the mesh eliminator assembly is capable of being constructed in place within the one-piece shell of the falling film evaporator, thus improving a structural integrity and improving a construction process for the falling film evaporator.

[0056] While only certain features and embodiments of the present disclosure have been illustrated and described, many modifications and changes may occur to those skilled in the art (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters (e.g., temperatures, pressures, etc.), mounting arrangements, use of materials, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited in the claims. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the disclosure. Furthermore, in an effort to provide a concise description of the

embodiments, all features of an actual implementation may not have been described (i.e., those unrelated to the presently contemplated best mode of carrying out the disclosure, or those unrelated to enabling the claimed features). It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation specific decisions may be made. Such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure, without undue experimentation.

CLAIMS:

1. A heating, ventilation, air conditioning, and refrigeration (HVAC&R) system, comprising:

a falling film evaporator comprising a one-piece shell having a plurality of heat exchange tubes disposed at least partially beneath a hood of the falling film evaporator, wherein the falling film evaporator comprises a mesh eliminator assembly disposed within the one-piece shell of the falling film evaporator to block liquid carryover, and wherein the mesh eliminator assembly comprises:

a support structure comprising a first channel element extending axially within the shell and coupled to an inner surface of the one-piece shell, and comprising a second channel element extending axially within the one-piece shell and coupled to the hood of the falling film evaporator, wherein the first channel element and the second channel element each comprise respective open sides that face one another;

a mesh element comprising one or more layers of a metal mesh disposed within the support structure; and

a grid plate disposed within the support structure beneath the mesh element to support a lower surface of the mesh element, wherein the grid plate comprises first openings comprising a larger dimension than second openings of the metal mesh.

2. The HVAC&R system of claim 1, wherein the support structure is welded within the one-piece shell of falling film evaporator, and wherein the mesh element and the grid plate are configured to be axially moved within the support structure.

3. The HVAC&R system of claim 1, wherein the first channel element comprises an asymmetrical cross section having a first long extension that extends radially outward toward the one-piece shell, bends to form a slanted middle portion that is attached to the inner surface of the shell, and bends to form a second short extension that extends radially inward from the one-piece shell, such that the slanted middle portion substantially aligns with a curve of the inner surface of the one-piece shell.

4. The HVAC&R system of claim 1, wherein the second channel element comprises a symmetrical cross section having a first level extension that extends radially outward toward the one-piece shell, bends to form a vertical middle portion that is attached to the hood of the evaporator, and bends to form a second level extension that extends radially inward from the one-piece shell, wherein the first level extension and the second level extension comprise a same length.

5. The HVAC&R system of claim 1, wherein the mesh element is compressed within the support structure vertically, compressed within the support structure horizontally, or a combination thereof.

6. The HVAC&R system of claim 1, wherein the mesh eliminator assembly comprises an additional mesh element disposed within the support structure, wherein the additional mesh element is axially adjacent to the mesh element.

7. The HVAC&R system of claim 6, wherein the mesh element and the additional mesh element are compressed together at respective adjacent ends, such that an overlap region is formed between the respective adjacent ends of the mesh element and the additional mesh element.

8. The HVAC&R system of claim 6, wherein the mesh eliminator assembly comprises an inner plate coupled between respective inner surfaces of the first channel element and the second channel element to block at least a portion of bypass flow paths defined between the mesh element and the additional mesh element.

9. The HVAC&R system of claim 1, wherein the hood comprises an axially extending extending sheet disposed between the plurality of heat exchange tubes and a vapor channel configured to direct a flow of low pressure refrigerant gas through the

mesh eliminator assembly, wherein the hood is configured to block the liquid refrigerant from bypassing the plurality of heat exchange tubes during operation.

10. A heating, ventilation, air conditioning, and refrigeration (HVAC&R) system, comprising:

a falling film evaporator comprising a one-piece shell having a plurality of heat exchange tubes disposed at least partially underneath a hood disposed between the plurality of tubes and a vapor channel, wherein the falling film evaporator comprises a mesh eliminator assembly disposed within the one-piece shell of the falling film evaporator to block liquid carryover, and wherein the mesh eliminator assembly comprises:

a support structure defining a receiving space, wherein the support structure comprises an inner baffle coupled to an outer surface of the hood, a hood extension of the outer surface of the hood and vertically opposed from the inner baffle, a short outer baffle coupled to an inner wall of the one-piece shell and horizontally opposed from the hood extension, and a long outer baffle coupled to the inner wall of the one-piece shell, vertically opposed from the short outer baffle, and horizontally opposed from the inner baffle; and

a mesh element comprising one or more layers of a metal mesh disposed within the receiving space of the support structure; and

a grid plate disposed within the receiving space of the support structure beneath the mesh element to support a lower surface of the mesh element, wherein the grid plate comprises openings having a larger dimension than openings of the metal mesh.

11. The HVAC&R system of claim 10, wherein the mesh element comprises a mesh element length that is substantially similar to a support structure length of the support structure.

12. The HVAC&R system of claim 11, wherein the grid plate comprises a grid plate length that is substantially similar to the support structure length.

13. The HVAC&R system of claim 10, wherein at least one axial end of the grid plate is coupled to at least one axial end of the mesh element.

14. The HVAC&R system of claim 10, wherein the hood extension comprises a bent portion of a sheet portion of the hood.

15. The HVAC&R system of claim 10, wherein the hood extension comprises an additional inner baffle coupled to an outer surface of the hood.

16. The HVAC&R system of claim 10, wherein the mesh eliminator assembly comprises an inner support clip disposed beneath the inner baffle and an outer support clip disposed beneath the long outer baffle.

17. A method of constructing a mesh eliminator assembly within a falling film evaporator, comprising:

coupling a support structure between an inner surface of a one-piece shell of the falling film evaporator and a hood disposed between a plurality of heat exchange tubes and a vapor channel within the falling film evaporator;

disposing a lower grid plate on a lower surface of a mesh element comprising one or more layers of a metal mesh; and

moving the mesh element and the lower grid plate within a receiving space defined within the support structure.

18. The method of claim 17, comprising disposing an upper grid plate on an upper surface of the mesh element, and moving the upper grid plate within the receiving space with the mesh element and the lower grid plate.

19. The method of claim 17, comprising disposing an additional lower grid plate on a lower surface of an additional mesh element, and moving the additional mesh element and the additional lower grid plate within the support structure until the additional mesh element is axially adjacent to the mesh element.

20. The method of claim 19, comprising compressing respective adjacent portions of the mesh element and the additional mesh elements together to form an overlapping region of the one or more layers of a metal mesh therebetween.

21. The method of claim 17, wherein coupling the support structure between the inner surface of the one-piece shell and the hood comprises coupling a first channel element to the inner surface of the one-piece shell and coupling a second channel element to an outer surface of the hood.

22. The method of claim 17, wherein the mesh element comprises a one-piece mesh element that extends along a length of the support structure.

23. The method of claim 22, wherein coupling the support structure between the inner surface of the one-piece shell and the hood comprises coupling a short outer baffle to the inner surface of the one-piece shell, coupling a large outer baffle to the inner surface of the one-piece shell, and coupling an inner baffle to an outer surface of the hood, and wherein the mesh element is moved within the receiving space defined within the support structure after the short outer baffle is coupled, and before the large outer baffle and the inner baffle are coupled.

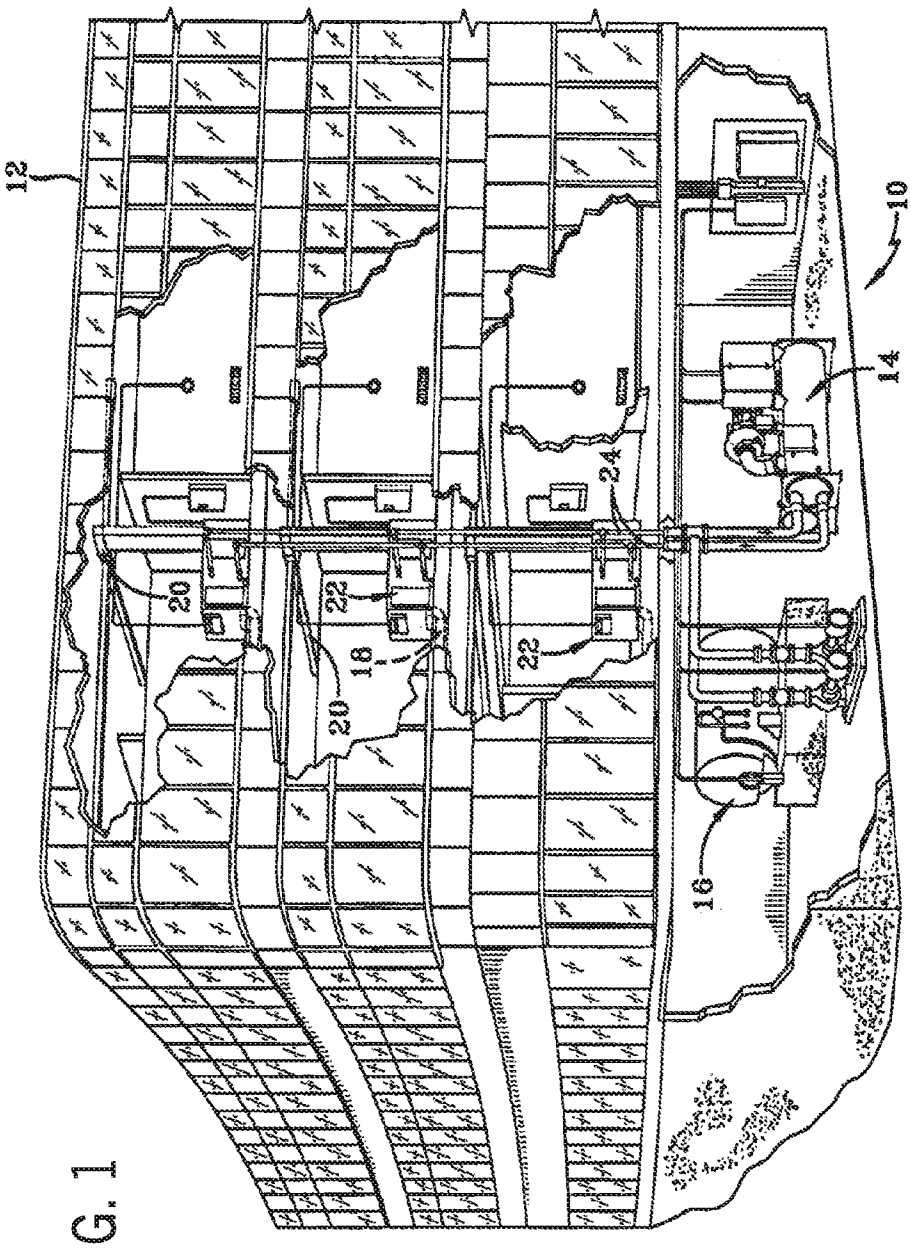


FIG. 1

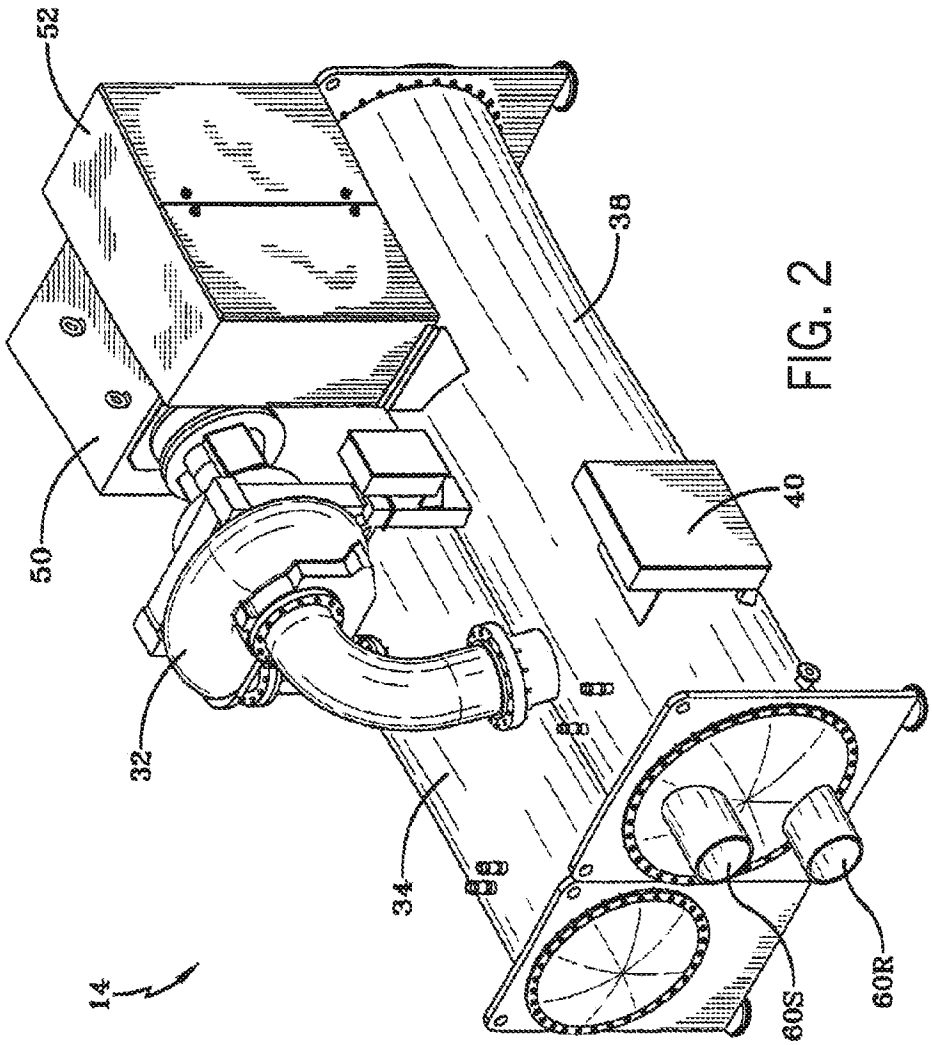


FIG. 2

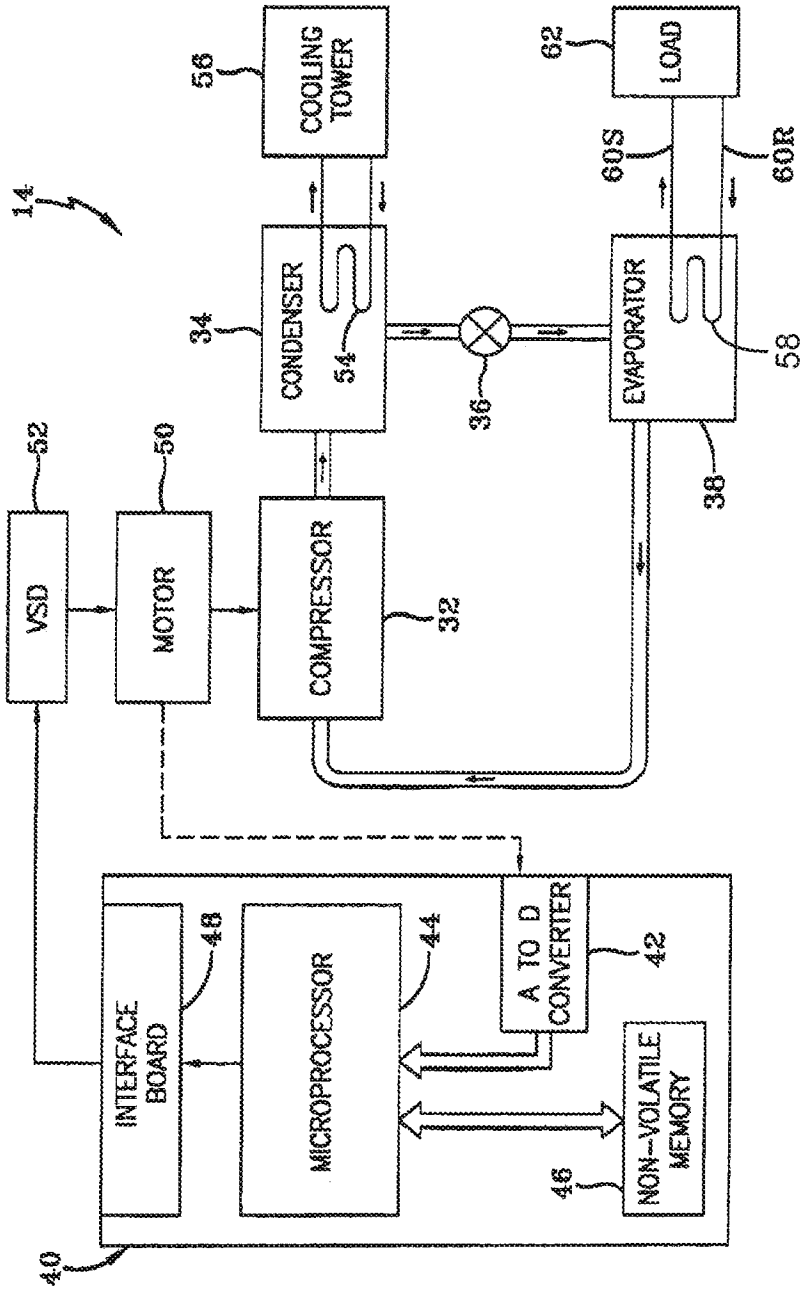

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FIG. 3

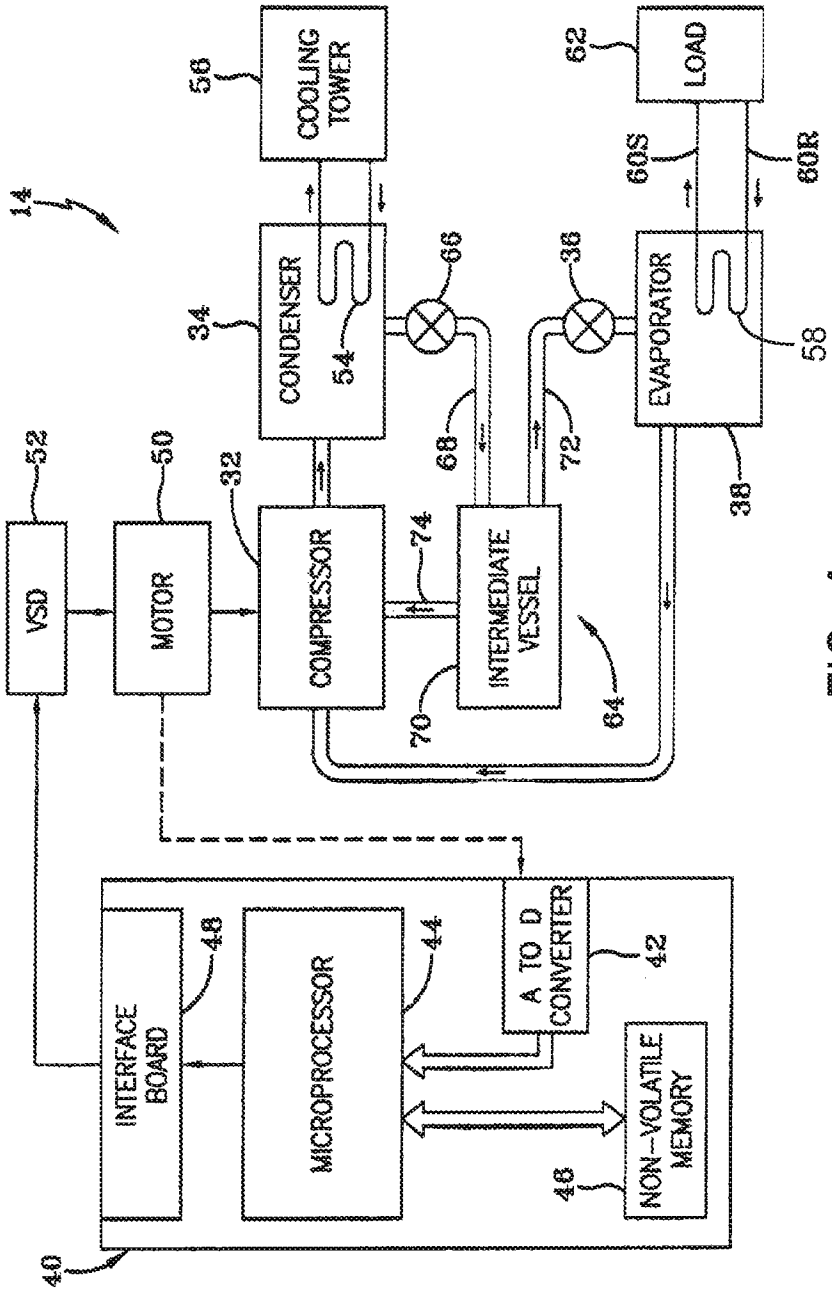

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FIG. 4

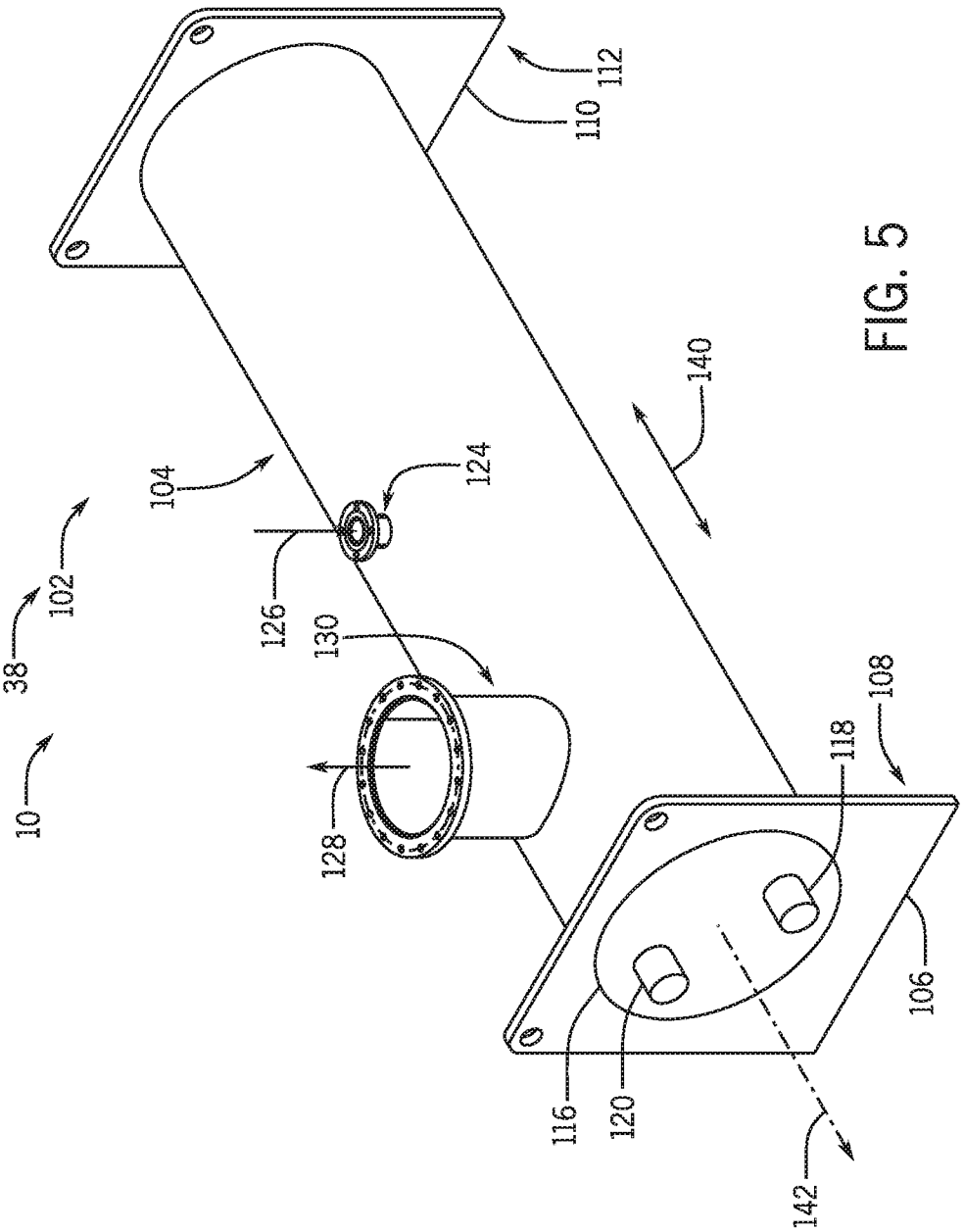


FIG. 5

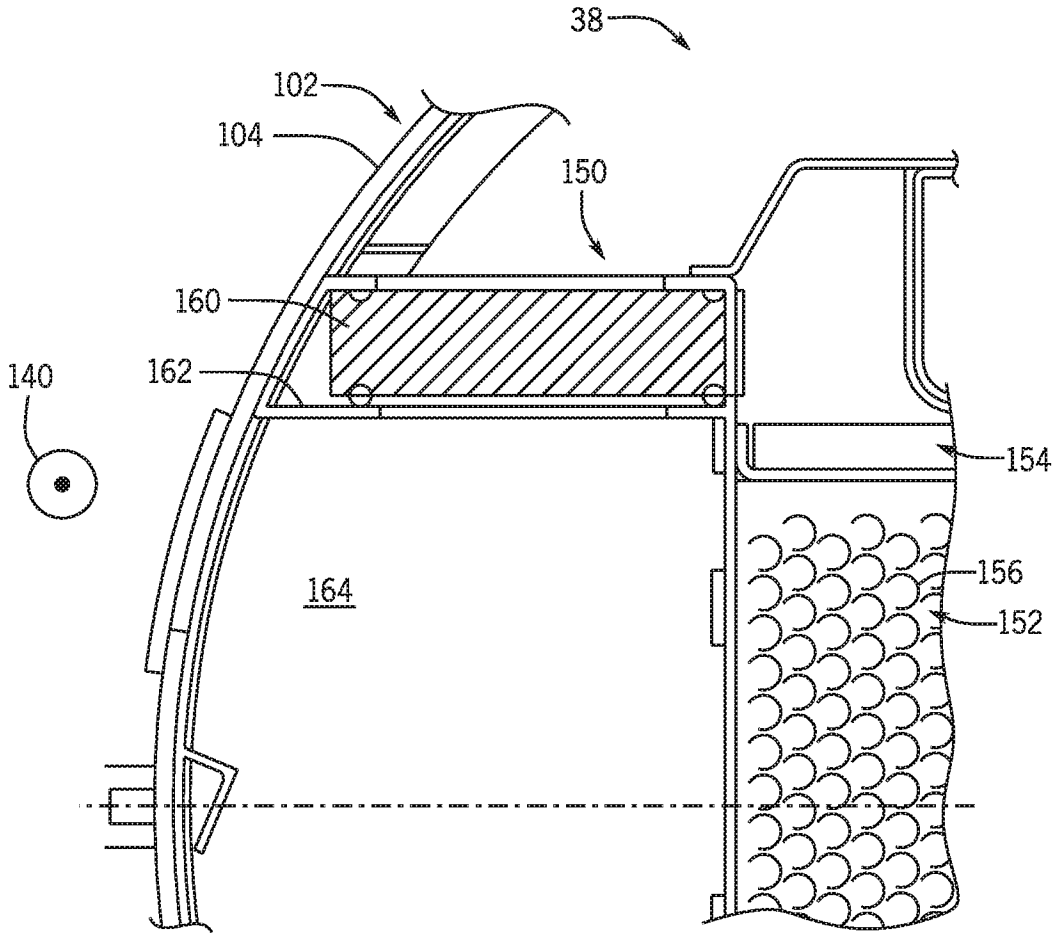


FIG. 6

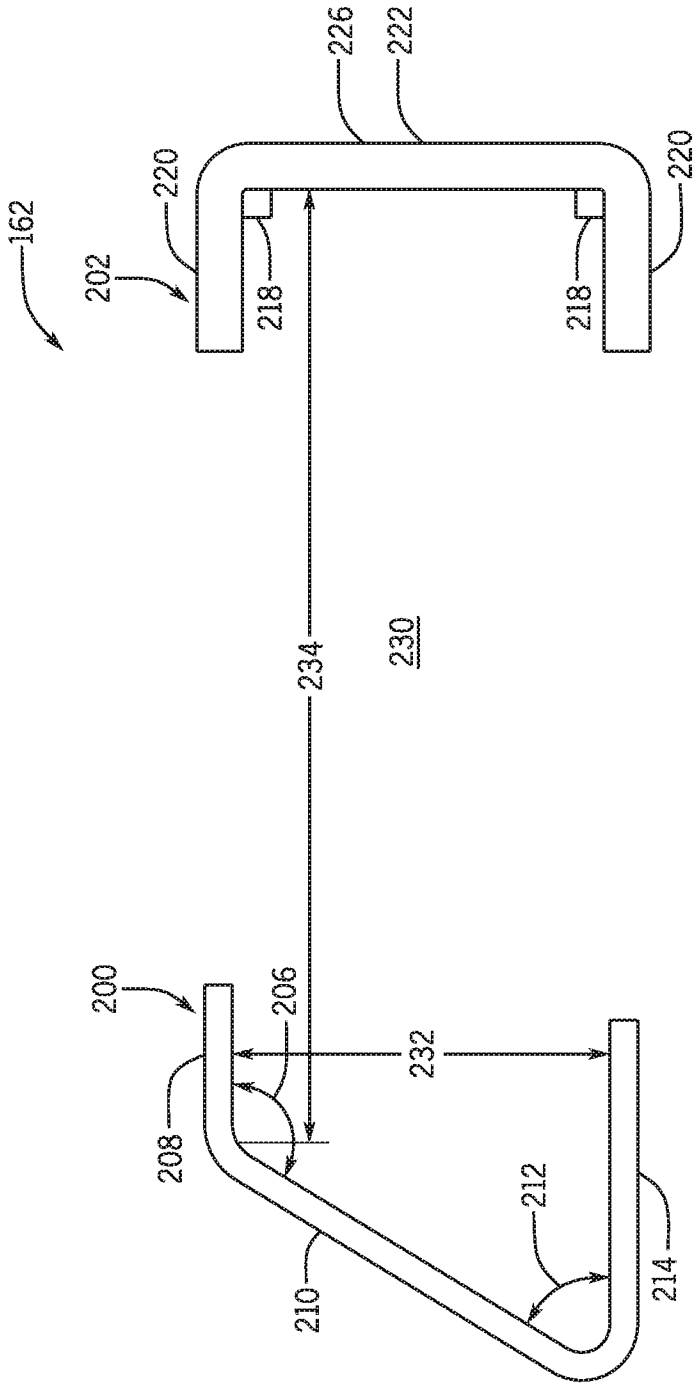

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FIG. 7

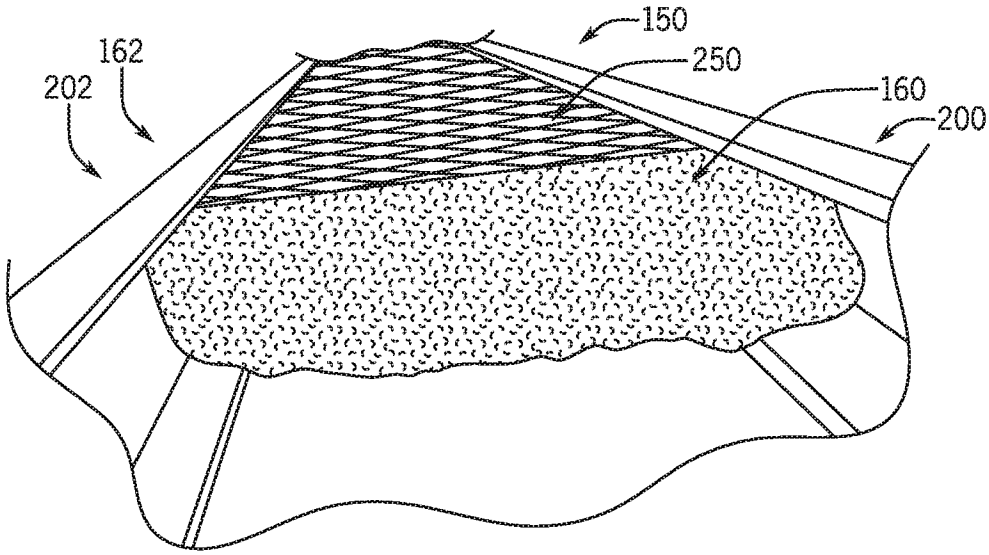


FIG. 8

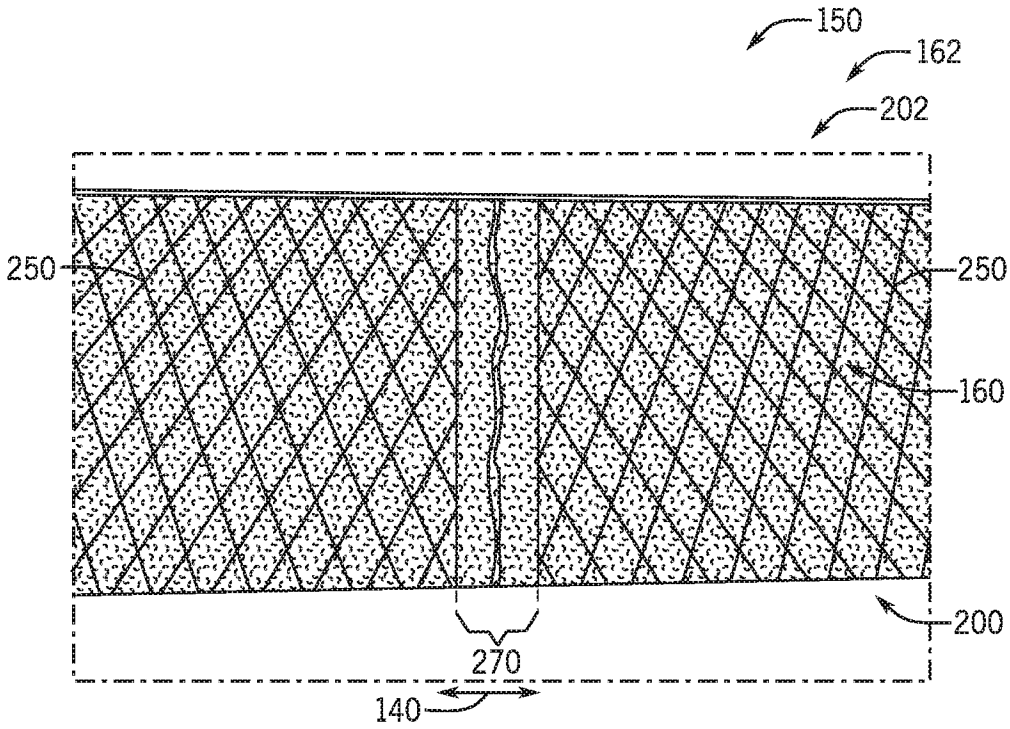


FIG. 9

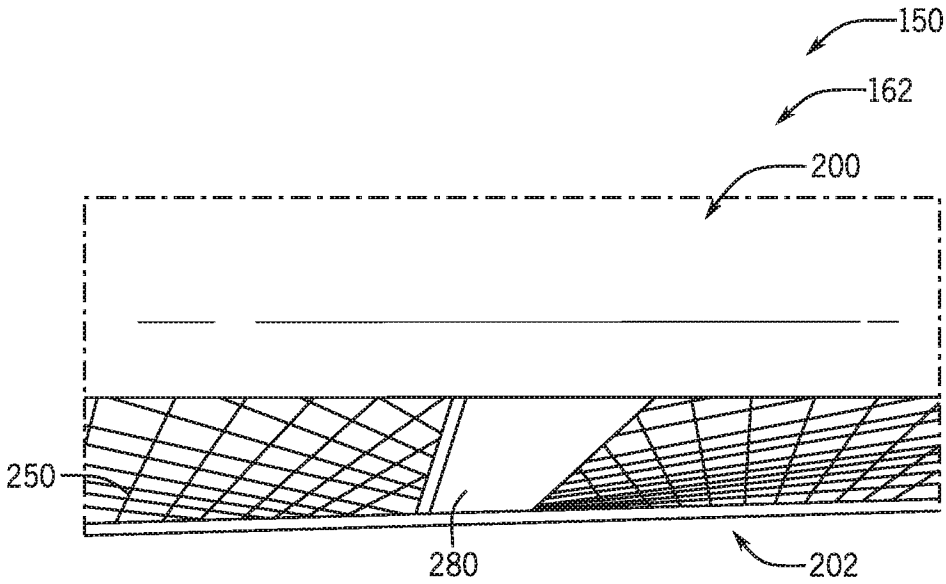

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FIG. 10

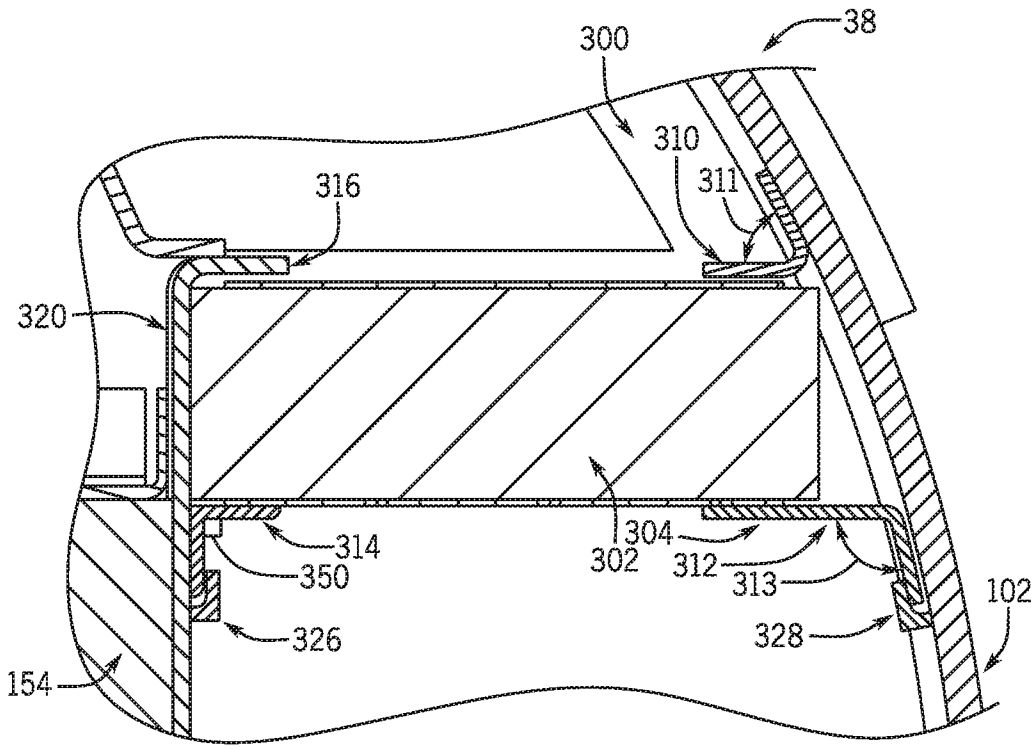

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FIG. 11

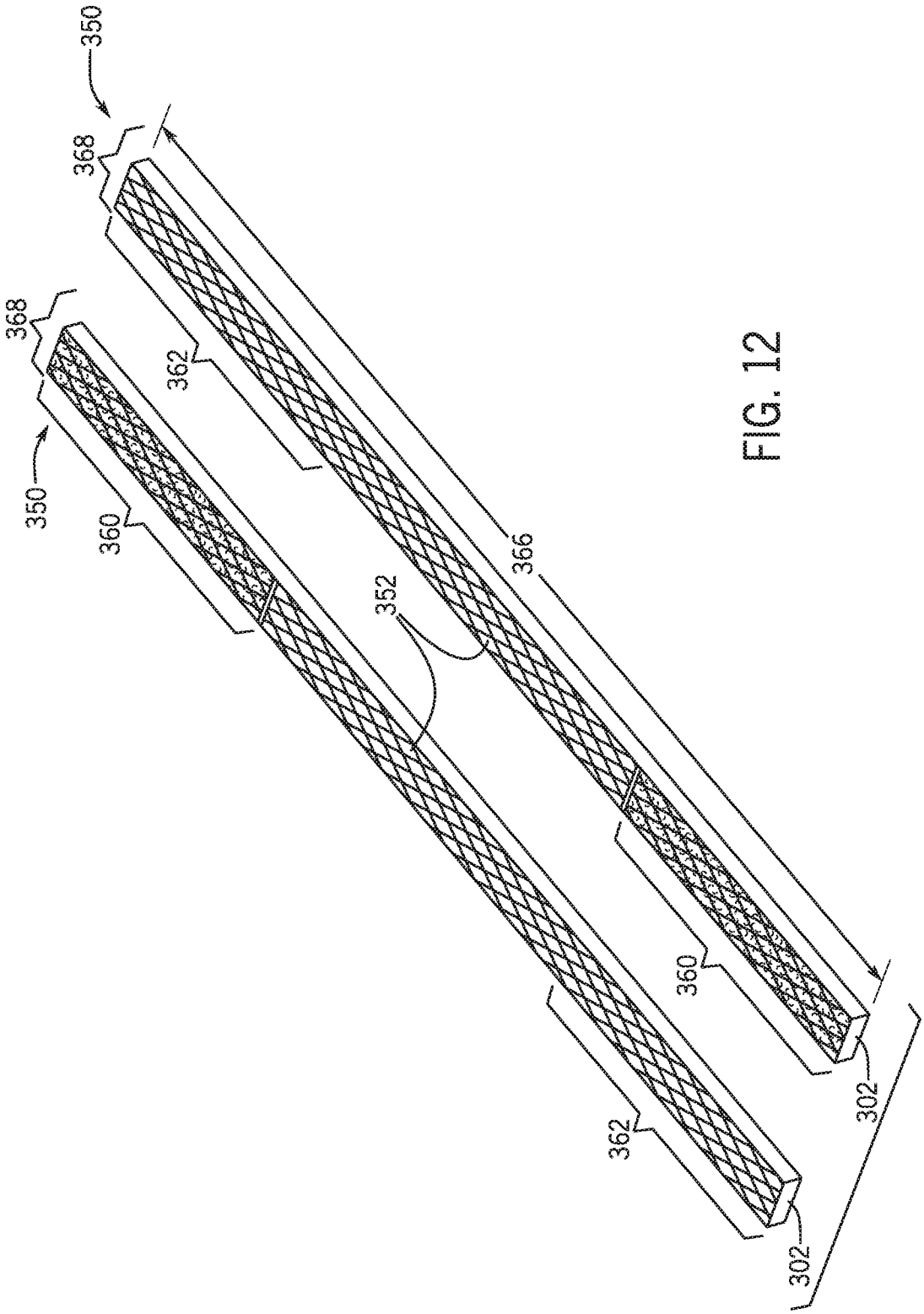


FIG. 12

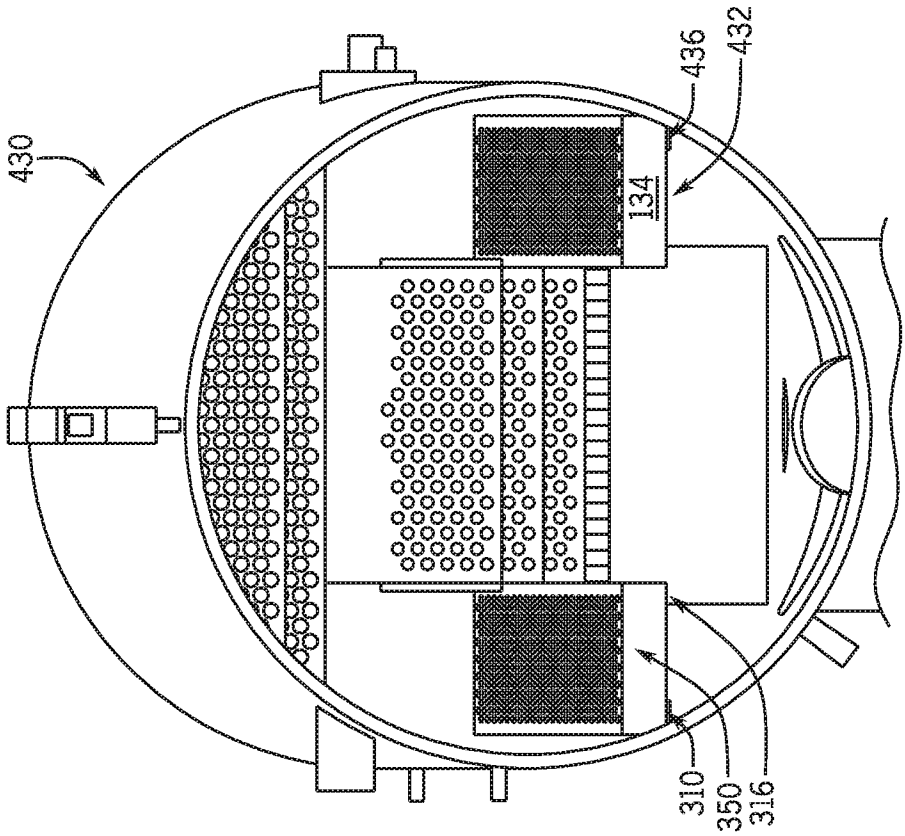

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FIG. 14

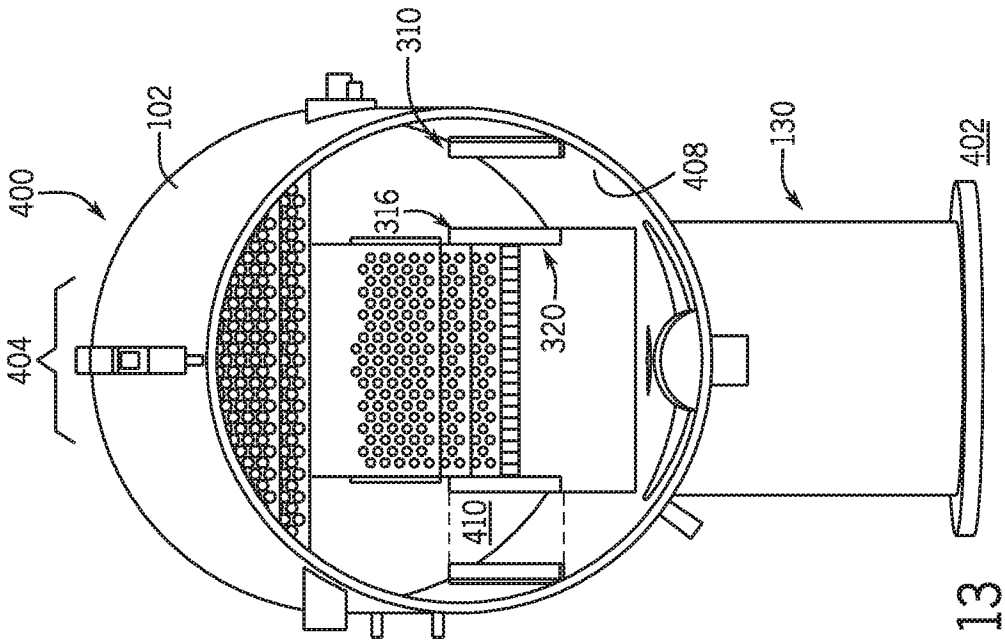

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FIG. 13

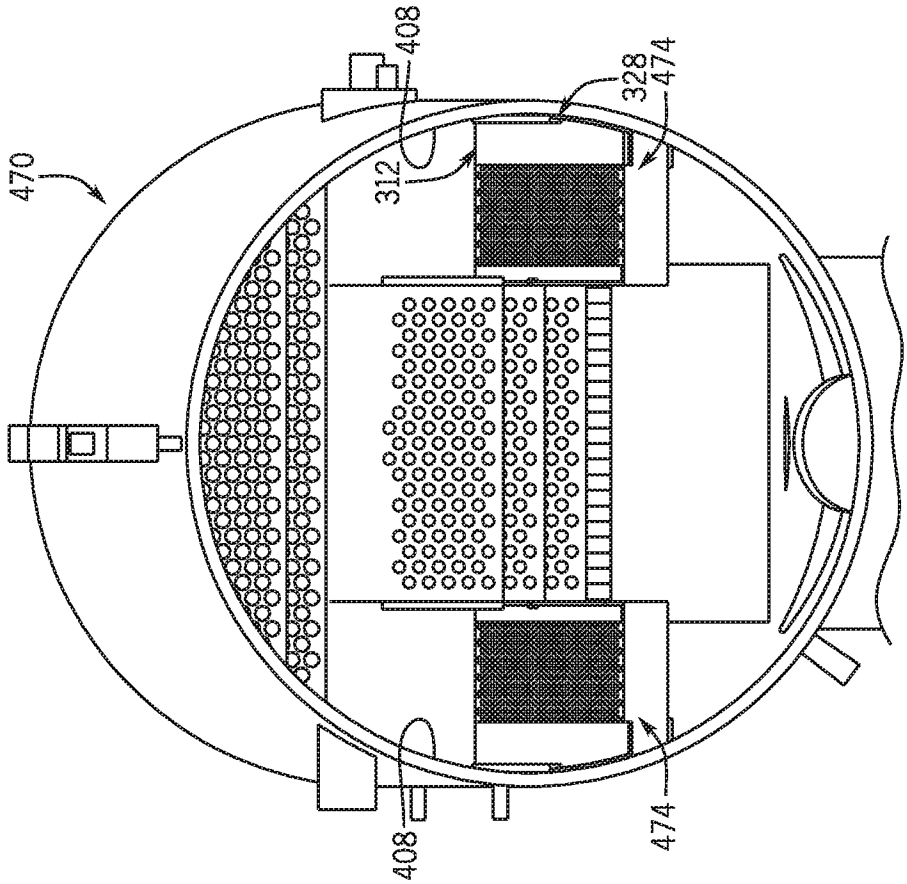


FIG. 16

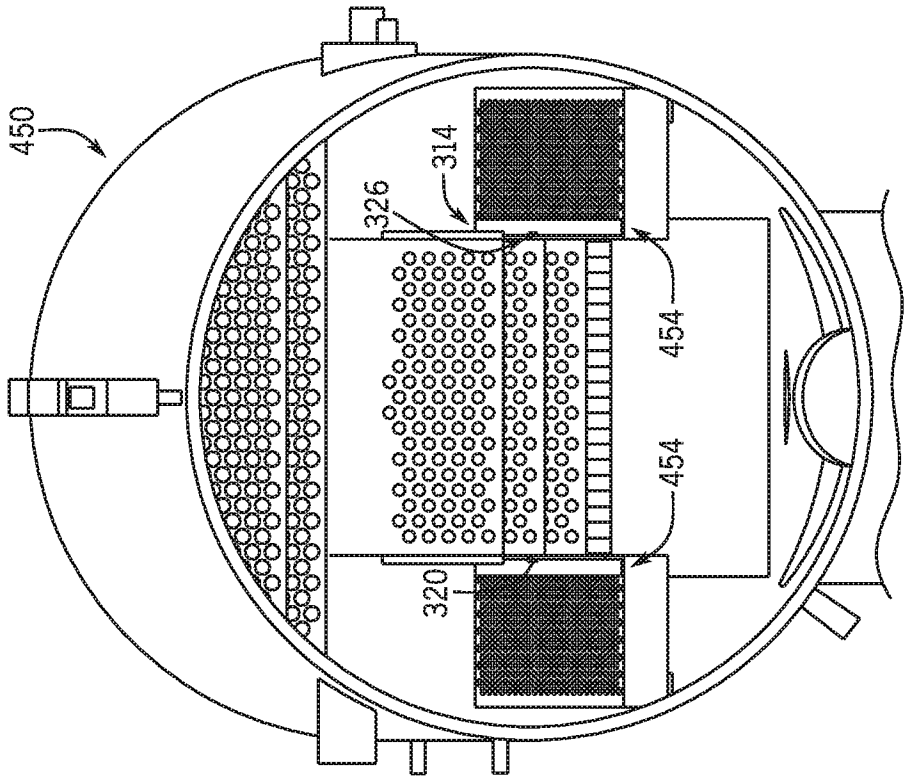


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/057835

A. CLASSIFICATION OF SUBJECT MATTER
INV. F28D7/16 F28F9/02 F25B39/02 F28D5/02 F28F25/08
B01J19/30 B01J19/32 F25B25/00 F25B49/02 F28D21/00
ADD.
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)
F28D F28F F25B B01J

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2002 340444 A (MITSUBISHI HEAVY IND LTD) 27 November 2002 (2002-11-27) paragraphs [0019] - [0028]; figures 1,4	1-15, 17-23 16
A	WO 2011/007606 A1 (MITSUBISHI HEAVY IND LTD [JP]; TAKEUCHI KATSUJI; FUKUSHIMA RYO) 20 January 2011 (2011-01-20) figure 1	1-23
A	JP 2004 340546 A (MITSUBISHI HEAVY IND LTD) 2 December 2004 (2004-12-02) figures 1,2	1-23
A	DE 10 2013 010510 A1 (GEA REFRIGERATION GERMANY GMBH [DE]) 6 March 2014 (2014-03-06) figure 1	1-23

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 March 2019	14/03/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Amous, Moez

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/057835

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 868 695 B1 (DINGEL B E; LARSON J W) 22 March 2005 (2005-03-22) figure 1 -----	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2018/057835

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO 2011007606 A1	20-01-2011	JP 2011021856 A	03-02-2011
		WO 2011007606 A1	20-01-2011
JP 2004340546 A	02-12-2004	NONE	
DE 102013010510 A1	06-03-2014	NONE	
US 6868695 B1	22-03-2005	NONE	