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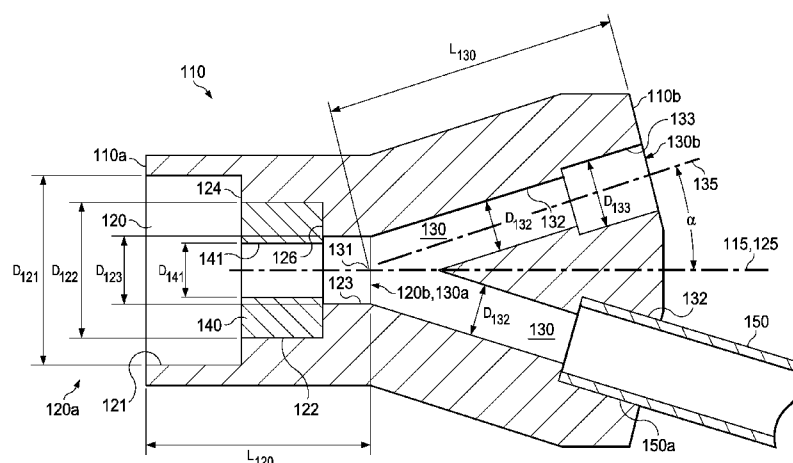


FIG. 4

(57) Abstract: A distributor assembly has a distributor (110) extending along a central axis between a first end (120) and a second end opposite the first end. The distributor has a flow passage extending from the first end of the distributor and a plurality of feeder ports (130) extending from the second end of the distributor to the flow passage and each feeder port is in fluid communication with the flow passage. Each feeder port extends along a central axis from a first end at the flow passage to a second end (130b) at the second end of the distributor and each feeder port comprises a first axial segment and a second axial segment, the first axial segment being connected between the flow passage and the second axial segment and the second axial segment being connected between the first axial segment and the second end of the distributor.

PRESSURE CORRECTING DISTRIBUTOR FOR HEATING AND COOLING SYSTEMS

BACKGROUND

[0001] This disclosure relates generally to heating and cooling systems, and more particularly to a distributor assembly positioned between an expansion valve and a multi-circuit evaporator in a heating or cooling system. In a heat pump and refrigeration cycle, refrigerant alternately absorbs and gives up thermal energy as it circulates through the system and is compressed, condensed, expanded, and evaporated. In particular, a liquid refrigerant flows from a condenser, through an expansion device (e.g., expansion valve) and into an evaporator. As the refrigerant flows through the expansion device and evaporator, the pressure of the refrigerant decreases, the refrigerant phase changes into a gas, and the refrigerant absorbs thermal energy. From the evaporator, the gaseous refrigerant proceeds to a compressor, and then back to the condenser. As the refrigerant flows through the compressor and condenser, the pressure of the refrigerant increases, the refrigerant phase changes back into a liquid, and the refrigerant gives up thermal energy. The process is repeated to emit thermal energy into a space (e.g., heat a house) or remove thermal energy from a space (e.g., air condition a house).

[0002] Some conventional evaporators have a plurality of refrigerant flow paths or circuits, each flowing through a different portion of the evaporator. Such evaporators, referred to as multi-circuit evaporators, utilize a distributor device or assembly positioned upstream of the evaporator to divide and direct the flow of refrigerant from the expansion device into the plurality of circuits in the evaporator. The distributor assembly also functions to provide substantially equal distribution of gaseous and liquid refrigerant from the expansion device to each circuit of the evaporator and further to provide substantially even distribution of refrigerant to each of the evaporator circuits. Still further, the distributor assembly is configured to generate a pressure drop in the refrigerant flowing therethrough in route to the evaporator so that the pressure of the refrigerant continues to decrease and the refrigerant absorbs thermal energy, expands, and phase changes into a gas.

SUMMARY OF THE DISCLOSURE

[0003] In some embodiments of the disclosure, a distributor assembly is provided that comprises a distributor extending along a central axis between a first end and a second end opposite the first end. The distributor may comprise a flow passage extending from the first end of the distributor and a plurality of feeder ports extending from the second end of the distributor to the flow passage, each feeder port being in fluid communication with the flow passage. Each feeder port may extend along a central axis from a first end at the flow passage to a second end at the second end of the distributor and each feeder port may comprises a first axial segment and a second axial segment, the first axial segment being connected between the flow passage and the second axial segment and the second axial segment being connected between the first axial segment and the second end of the distributor.

[0004] In other embodiments of the disclosure, a distributor assembly is provided that comprises a distributor extending along a central axis between a first end and a second end opposite the first end, the distributor comprising. The distributor may comprise a flow passage extending from the first end of the distributor and a plurality of feeder ports extending from the second end of the distributor to the flow passage, each feeder port being in fluid communication with the flow passage. Each feeder port may comprises a first axial segment and a second axial segment, the first axial segment being connected between the flow passage and the second axial segment and the second axial segment being connected between the first axial segment and the second end of the distributor, and at least two of the first axial segments may comprise different first axial segment diameters.

[0005] In still other embodiments of the disclosure, a method of modifying refrigerant distribution through a distributor assembly is disclosed that comprises at least one of (1) increasing a feeder port diameter and increasing a length of an associated feeder conduit and (2) decreasing a feeder port diameter and decreasing a length of an associated feeder conduit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] For a more complete understanding of the present disclosure and the advantages thereof, reference is now made to the following brief description, taken in

connection with the accompanying drawings and detailed description, wherein like reference numerals represent like parts.

[0007] Figure 1 is a simplified schematic view of a refrigeration system according to an embodiment of this disclosure;

[0008] Figure 2 is an a simplified schematic view of a distributor assembly and a multi-circuit evaporator of Figure 1;

[0009] Figure 3 is an end view of the distributor of Figure 2;

[0010] Figure 4 is a partial cross-sectional side view of the distributor of Figures 2 and 3, taken along section lines 4-4 of Figure 3;

[0011] Figure 5 is a schematic diagram of an alternative embodiment of a pressure correcting distributor assembly of the disclosure; and

[0012] Figure 6 is a flowchart of a method of constructing a distributor assembly and a method of modifying distribution of refrigerant through a distributor assembly.

DETAILED DESCRIPTION

[0013] Distributor assemblies sometimes comprise a distributor and a plurality of elongate feeder tubes extending from the distributor to the evaporator. In some applications, the distributor may divide the flow of refrigerant into multiple flow paths, and each feeder tube may direct refrigerant from one of the divided flow paths to one of the evaporator circuits. To achieve a desired pressure drop across the distributor assembly, some conventional feeder tubes are relatively long - about 30 in. (~0.76 m) long. Such relatively long feeder tubes may present design and servicing limitations since their size may limit the potential locations of certain components of the refrigeration system such as the distributor, the evaporator, etc. In addition, long feeder tubes may negatively impact access to other components of the system during servicing. Accordingly, the present disclosure provides more compact distributor assemblies that enable a sufficient refrigerant pressure drop, provide a lower cost alternative to conventional distributor assemblies, and allow easier servicing of a refrigeration system comprising the more compact distributor assemblies.

[0014] Referring now to Figure 1, a climate control system 10 is schematically shown. In general, system 10 may be used to manage and control the temperature of a space, such as the inside of a house, an office building, a vehicle cabin, etc. System 10 includes

a compressor 20, a condenser 30 in fluid communication with compressor 20, an expansion device 40 in fluid communication with condenser 30, a distributor assembly 100 in fluid communication with expansion device 40, and a multi-circuit evaporator 50 in fluid communication with distributor assembly 100 and compressor 20. A fluid refrigerant (i.e., liquid and/or gas) represented by flow arrows 60, in some embodiments, circulates through system 10 flowing through compressor 20, condenser 30, expansion device 40, distributor assembly 100, and evaporator 50 back to compressor 20.

[0015] During each cycle, at least a portion of fluid refrigerant 60 may phase change from liquid to gas, or from gas to liquid. For example, in compressor 20, a substantially gaseous refrigerant 60 is compressed and pumped to condenser 30 where refrigerant 60 gives up thermal energy and condenses into a substantially liquid refrigerant 60. Thus, thermal energy is transferred from refrigerant 60 to the surrounding environment at condenser 30, thereby providing a heating effect at condenser 30. Liquid refrigerant 60 then flows from condenser 30 through expansion device 40 (e.g., an expansion valve) and distributor assembly 100 where it is expanded, undergoes a pressure reduction, and transitions into a mixed gaseous/liquid refrigerant 60. From distributor assembly 100, the mixed gaseous/liquid refrigerant 60 flows through evaporator 50 where refrigerant 60 absorbs thermal energy, and expands into a substantially gaseous refrigerant 60. Thus, thermal energy is transferred from the surrounding environment at evaporator 50 into refrigerant 60, thereby providing a cooling effect at evaporator 50. From evaporator 50, the substantially gaseous refrigerant 60 returns to the compressor 20 and the cycle repeats. It should be appreciated that system 10 is a closed-loop system, and thus, the mass flow rate of refrigerant 60 through any particular region of system 10 is substantially the same.

[0016] As described above, thermal energy is transferred from refrigerant 60 to the surrounding environment at condenser 30, and thermal energy is transferred from the surrounding environment to refrigerant 60 at evaporator 50. Depending on the location of evaporator 50 and condenser 30, system 10 may generally be used to provide heating or cooling. For example, system 10 may be arranged such that evaporator 50 absorbs heat from inside a house and gives up this absorbed heat outside through condenser 30, thereby providing air conditioning to the house. Alternatively, system 10 may be

configured such that condenser 30 emits heat inside the house through condenser 30 and absorbs heat from outside the house through evaporator 50, thereby providing heat to the house. By inclusion of a reversing valve, the system shown in Figure 1 (e.g., system 10) may alternatively be configured to selectively provide both heating and cooling to a particular space (i.e., configured as a heat pump in which the functions of the condenser 30 and the evaporator 50 may be reversed depending on whether heating or cooling is desired).

[0017] Referring now to Figures 1 and 2, in this embodiment, evaporator 50 is a multi-circuit evaporator including a plurality of internal flow passages or circuits 51. When refrigerant 60 flows from distributor assembly 100 through evaporator 50 to compressor 20 as shown in Figure 1, each circuit 51 has an upstream inlet 51a and a downstream outlet 51b. Between inlets 51a and outlets 51b, refrigerant 60 flowing through each circuit 51 is separated from the refrigerant 60 flowing through the other circuits 51. In addition, evaporator 50 includes a discharge header 52 having a plurality of inlets 52a and an outlet 52b in fluid communication with compressor 20. Each circuit outlet 51b is in fluid communication with one of the header inlets 52a.

[0018] During operation of system 10, refrigerant 60 from distributor assembly 100 enters one of the plurality of circuits 51 at its corresponding inlet 51a, flows downstream through the circuit 51 to its outlet 51b, where it then flows into discharge header 52 through its corresponding header inlet 52a. Refrigerant 60 enters header 52 from all of the circuits 51, recombines, and flows downstream through header outlet 52b to compressor 20. Thus, refrigerant 60 flowing through each circuit 51 comes together and recombines in header 52, and then flows to compressor 20 via outlet 52b.

[0019] As best shown in Figure 2, distributor assembly 100 includes a distributor 110 and a plurality of elongate feeder conduits 150, each conduit 150 extending between distributor 110 and evaporator 50. In this embodiment, each feeder conduit 150 is sized and configured substantially the same. In particular, each feeder conduit 150 has a central or longitudinal axis 155, a first or distributor end 150a attached to distributor 110, a second or evaporator end 150b attached to evaporator 50, and a central flow passage 151 extending between ends 150a, b. When refrigerant 60 flows through flow passage 151 of each feeder conduit 150 from distributor end 150a to evaporator end 150b, flow

passage 151 defines a feeder conduit inlet 151a at distributor end 150a and a feeder conduit outlet 151b at evaporator end 150b. As will be described in more detail below, flow passage 151 of each feeder conduit is in fluid communication with a feeder port 130 of distributor 110 (Figures 3 and 4) and one evaporator circuit 51. Thus, in this embodiment, one feeder conduit 150 is provided for each outlet feeder port 130 of distributor 110, and one circuit 51 is provided for each feeder conduit 150.

[0020] Without being limited by this or any particular theory, an efficiency of the system (e.g., system 10) may be improved by (a) substantially evenly distributing the refrigerant across the plurality of feeder conduits of the distributor assembly (e.g., feeder conduits 150); (b) moving substantially the same mass flow rate of refrigerant through each feeder conduit; and (c) generating substantially the same pressure drop across each feeder conduit. Configuring and sizing each feeder conduit of the distributor assembly (e.g., each feeder conduit 150) substantially the same offers the potential to desirably achieve even distribution of refrigerant across the plurality of feeder conduits, uniform mass flow rate of refrigerant through each feeder conduit, and equal pressure drop across each feeder conduit. Accordingly, in some embodiments described herein, each feeder conduit of the distributor assembly (e.g., each feeder conduit 150) may be sized and configured substantially the same.

[0021] Referring still to Figure 2, each feeder conduit 150 has a length L_{150} measured parallel to its axis 155 between ends 150a, b. As noted above, in this embodiment, each feeder conduit 150 is sized and configured substantially the same, and thus, each feeder conduit 150 has substantially the same length L_{150} . In some embodiments, the length of each feeder conduit (e.g., length L_{150} of each feeder conduit 150) may be between about 10 in. to about 30 in., and alternatively may be between about 15 in. to about 20 in.

[0022] In general, the feeder conduits (e.g., conduits 150) may comprise any suitable materials including, without limitation, metals and metal alloys (e.g., stainless steel, brass, copper, aluminum, etc.), non-metal (e.g., ceramic), or composite (e.g., carbon fiber substrate and epoxy matrix composite). However, in some embodiments, the feeder conduits 150 may comprise corrosion resistant material(s) suitable for use with compressed refrigerants such as brass, copper, or aluminum. Although feeder conduits

150 shown in Figures 2 and 4 are cylindrical tubes, in other embodiments, the feeder conduits may have different cross-sectional shapes (e.g., rectangular).

[0023] Referring now to Figures 1-4, distributor 110 extends along a central or longitudinal axis 115 between a first or inlet end 110a and a second or outlet end 110b. Inlet end 110a is coupled to refrigerant pipe 41 and the plurality of feeder conduits 150 are coupled to and extend from outlet end 110b. As shown in Figures 1 and 2, pipe 41 supplies refrigerant 60 to distributor assembly 100 and distributor 110 from condenser 30. In this embodiment, inlet end 110a of distributor 110 is sized and configured to be received by the end of pipe 41. Distributor 110 may be coupled to the end of pipe 41 in any suitable manner including, without limitation, welding, brazing, adhesive, mating threads, or combinations thereof.

[0024] Referring still to Figures 1-4, distributor 110 also includes inlet flow passage 120 extending axially (relative to axis 115) from first end 110a and a plurality of feeder ports 130 extending from inlet flow passage 120 to second end 110b. Inlet flow passage 120 has a central or longitudinal axis 125 coincident with axis 115, a first end 120a at first end 110a of distributor 110 and a second end 120b at its intersection with feeder ports 130. When refrigerant 60 flows through distributor 110 from first end 110a to second end 110b as shown in Figure 1, first end 120a of inlet flow passage 120 may be described as an "inlet," and second end 120b of inlet flow passage 120 may be described as an "outlet."

[0025] Each feeder port 130 has a central or longitudinal axis 135, a first end 130a at its intersection with inlet flow passage 120, and a second end 130b at second end 110b of distributor 110. When refrigerant 60 flows through distributor 110 from first end 110a to second end 110b as shown in Figure 1, first end 130a of each feeder port 130 may be described as an "inlet," and second end 130b of each feeder port may be described as an "outlet."

[0026] First ends 130a of all the feeder ports 130 converge at second end 120b of inlet flow passage 120, and central axis 135 of each outlet feeder port 130 intersects at a common point 131 disposed on axes 115, 125. Further, as best shown in Figure 3, second ends 130b of feeder ports 130 are substantially uniformly circumferentially spaced about axis 115.

[0027] Without being limited by this or any particular theory, an efficiency of the system (e.g., system 10) may be improved by (a) substantially evenly distributing the refrigerant across the plurality of feeder ports of the distributor (e.g., feeder ports 130 of distributor 110); (b) moving refrigerant at substantially the same mass flow rate through each feeder port; and (c) generating substantially the same pressure drop across each feeder port. Configuring, orienting, and sizing each feeder port of the distributor substantially the same offers the potential to achieve these performance characteristics. Accordingly, in some embodiments, each feeder port 130 may be configured and sized substantially the same.

[0028] Referring specifically to Figure 4, each feeder port 130 is oriented at an acute angle α relative to axes 115, 125. For a given outlet feeder port 130, angle α is the angle measured between axes 115, 125 and axis 135 when viewed perpendicular to a plane containing axes 115, 125 and axis 135. In this embodiment, each feeder port 130 is oriented at substantially the same angle α measured between axes 115, 125 and axis 135 when viewed perpendicular to a plane containing axes 115, 125 and axis 135. In some embodiments, angle α for each outlet feeder port 130 may be an acute angle between about 10° to about 45° and alternatively between about 15° to about 20° . In general, the orientation angle of the feeder ports 130 (e.g., angle α of feeder ports 130) may be varied as needed to accommodate different numbers of feeder ports 130 and the desired circumferential spacing of the outlet ends of the feeder ports 130 (e.g., outlets 130b of feeder ports 130).

[0029] Referring still to Figure 4, inlet flow passage 120 has a length L_{120} measured parallel to axis 125 from first end 120a to second end 120b at the intersection of axis 125 and axis 135. In other words, length L_{120} is measured parallel to axis 125 from first end 120a to point 131. In some embodiments, the length of the inlet flow passage of the distributor 110 (e.g., the length L_{120} of inlet flow passage 120) may be between about 1/8 in. to about 3 in., and alternatively between about 1/4 in. to about 3/8 in.

[0030] Each feeder port 130 has a length L_{130} measured parallel to its axis 135 from its first end 130a at the intersection of axis 135 and axes 115, 125 to its second end 130b. In other words, length L_{130} of each feeder port 130 is measured parallel to its axis 135 from point 131 to its second end 130b. As noted above, in this embodiment, each feeder

port 130 is configured and sized substantially the same, and thus, each feeder port 130 has substantially the same length L_{130} . In some embodiments, the length of each feeder port of the distributor (e.g., the length L_{130} of each feeder port 130) may be between about 1/8 in. to about 1/2 in., and alternatively between about 0.2 in. to about 0.3 in.

[0031] In the embodiment shown in Figure 4, inlet flow passage 120 is defined by a series of axial counterbores formed in distributor 110 and an annular flow restrictor 140 disposed within distributor 110. In this embodiment, three counterbores, 121, 122, and 123, are positioned between ends 120a, b. A first counterbore 121 extends axially (relative to axes 115, 125) from first end 120a of inlet flow passage 120 to a second counterbore 122. A second counterbore 122 extends axially (relative to axes 115, 125) from the first counterbore 121 to a third counterbore 123. The third counterbore 123 extends axially (relative to axes 115, 125) from second end 120b of inlet flow passage 120 to second counterbore 122. First counterbore 121 has a diameter D_{121} , second counterbore 122 has a diameter D_{122} that is less than diameter D_{121} , and third counterbore 123 has a diameter D_{123} that is less than diameter D_{122} . Each diameter D_{121} , D_{122} , D_{123} is measured perpendicular to axes 115, 125. While each of the counterbores sets comprising counterbores 121, 122, and 123 may be substantially equal so that the various inlet flow passages 120 are substantially similar, in alternative embodiments, the counterbores 121, 122, and 123 may vary amongst the various inlet flow passages 120.

[0032] Referring still to Figure 4, cylindrical flow restrictor 140 has substantially the same axial length (relative to axes 115, 125) as second counterbore 122 and is coaxially disposed in second counterbore 122. Flow restrictor 140 comprises a central throughbore or orifice 141 coaxially aligned with counterbores 121, 122, 123 and inlet flow passage 120. In this embodiment, orifice 141 has a diameter D_{141} (measured perpendicular to axes 115, 125) that is less than diameters D_{121} , D_{122} , D_{123} . In general, the orifice diameter (e.g., diameter D_{141}) may be less than or equal to the smallest diameter of the inlet flow passage (e.g., diameter D_{123} of counterbore 123 of inlet flow passage 120). Flow restrictor 140 generally axially abuts shoulder 126.

[0033] In this embodiment, flow restrictor 140 is coupled to distributor 110 via an interference fit. However, in general, flow restrictor 140 may be coupled to distributor 110 within second counterbore 122 in any suitable manner including, without limitation, press

fit, adhesive, brazing, welding, threaded, machined, and/or or combinations thereof. Due to the reduced diameter of orifice 141, and substantially constant mass flow rate through system 10, as refrigerant 60 flows through flow restrictor 140, refrigerant velocity generally increases and refrigerant pressure generally decreases as compared to the velocity and pressure of refrigerant immediately upstream of the orifice 141.

[0034] Due to the differences in diameters D_{121} and D_{122} and diameters D_{121} and D_{141} , an annular shoulder 124 is formed in inlet flow passage 120 at the intersection of counterbores 121, 122. The abrupt change in the internal diameter of inlet flow passage 120 at shoulder 124 and flow restrictor 140 offers the potential to increase the turbulence of refrigerant flow through inlet flow passage 120, in some cases, increasing mixing of the liquid and gaseous phases of refrigerant 60 passing through inlet flow passage 120 and eventually into feeder ports 130. Without being limited by this or any particular theory, increased turbulence and mixing of refrigerant 60 flowing through inlet flow passage 120 may provide for more even distribution of refrigerant 60 among feeder ports 130.

[0035] Referring now to Figures 3 and 4, as previously described, each feeder port 130 extends between first end 130a at its intersection with inlet flow passage 120 and second end 130b at second end 110b of distributor 110. In this embodiment, each feeder port 130 comprises a first or reduced diameter axial segment 132 and a second or increased diameter axial segment 133. First axial segment 132 extends axially (relative to axis 135) from first end 130a to second axial segment 133, and second axial segment 133 extends axially (relative to axis 135) from second end 130b to first axial segment 132. First axial segment 132 has a substantially constant or substantially uniform diameter D_{132} . As noted above, in this embodiment, each feeder port 130 is configured and sized substantially the same, and thus, diameter D_{132} of first axial segment 132 of each feeder port 130 is substantially the same. In some embodiments, diameter D_{132} of first axial segment 132 of each feeder port 130 may be less than or equal to 0.125 in. (1/8"), and alternatively between about 0.046875 in. (3/64") to about 0.125 in. (1/8").

[0036] Second axial segment 133 of each feeder port 130 has a substantially constant or substantially uniform diameter D_{133} that is greater than diameter D_{132} . Consequently, the second axial segment 133 and second end 130b may also be referred to as forming a "counterbore" extending axially from distributor end 110b. As noted above, in this

embodiment, each feeder port 130 is configured and sized substantially the same, and thus, diameter D_{133} of second axial segment 133 of each feeder port 130 is substantially the same. Second axial segment 133 of each feeder port 130 is adapted to receive end 150a of one of the feeder conduits 150. As best shown in Figure 4, diameter D_{133} is substantially the same or slightly larger than the outer diameter of end 150a of its corresponding feeder conduit 150, and diameter D_{132} may be smaller than the inner diameter of end 150a of its corresponding feeder conduit 150. Thus, there may be a drop in pressure and associated increase in velocity of refrigerant as it passes through first axial segment 132.

[0037] In general, each feeder conduit 150 may be coupled to its corresponding second axial segment 133 in any suitable manner including, without limitation, welding, brazing, mating threads, machining, etc. The connection between each second axial segment 133 and feeder conduit 150 may form a generally annular substantially fluid tight seal, thereby preventing refrigerant leaks and/or loss of refrigerant 60 flowing through distributor assembly 100.

[0038] Referring again to Figures 2-4, in this embodiment, one feeder conduit 150 is provided for each distributor feeder port 130 and one evaporator circuit 51 is provided for each feeder conduit 150. Thus, the number of feeder ports 130 in distributor 110 is substantially the same as the number of feeder conduits 150, which in turn is substantially the same as the number of circuits 51 in evaporator 50. In this embodiment, distributor assembly 100 includes four feeder conduits 150, evaporator 50 includes four circuits 51, and distributor 110 includes four feeder ports 130. However, in other embodiments, the distributor assembly (e.g., assembly 100), the evaporator (e.g., evaporator 50), and the distributor (e.g., distributor 110) may have any suitable number of feeder conduits (e.g., feeder conduits 150), circuits (e.g., circuits 51), and feeder ports (e.g., feeder ports 130), respectively, although the number of feeder conduits, circuits, and feeder ports in the distributor may be substantially the same (i.e., one feeder conduit is provided for each feeder port, and one evaporator circuit is provided for each feeder conduit). The number of feeder conduits, feeder ports, and circuits may be varied depending on a variety of factors including, without limitation, the application (e.g., residential, commercial, etc.), the volume or size of space to be climate controlled (e.g., number of cubic feet), the desired

amount of air conditioning capacity (e.g., number of tons and/or BTUs of the heating and/or cooling capacity), the desired pressure drop across the distributor assembly (e.g., assembly 100), and/or combinations thereof.

[0039] In general, the distributor (e.g., distributor 110) may comprise any suitable material(s) including, without limitation, metals and metal alloys (e.g., stainless steel, aluminum, etc.), non-metal (e.g., ceramic), and/or composite (e.g., carbon fiber substrate and epoxy matrix composite). In some embodiments, the distributor 110 may comprise corrosion resistant material(s) suitable for use with compressed refrigerants such as aluminum and/or stainless steel.

[0040] In some embodiments, the feeder conduits 150 of the distributor assembly 100 may be significantly shorter than some conventional feeder conduits. In particular, some conventional feeder conduits have a length of about 30 in. In comparison, the length of some feeder conduits 150 of some embodiments of this disclosure may comprise a length L_{150} of each feeder conduit 150 that may be between about 10 in. to about 20 in., and alternatively between about 12 in. to about 15 in. However, it will be appreciated that if a feeder conduit of a conventional distributor assembly 100 were simply shortened, an overall pressure drop across the distributor assembly 100 would decrease. This disclosure provides systems and methods for maintaining an overall pressure drop across a distributor assembly 100 having shortened feeder conduits 150 as compared to conventional feeder conduits. In some embodiments, an overall pressure drop across the entire distributor assembly 100 is achieved and/or maintained in spite of having substantially shorter feeder conduits 150 (as compared to conventional feeder conduits) by selectively reducing a diameter of a feeder port 130.

[0041] Referring again to Figure 4, in some embodiments, a distributor assembly 100 may accommodate shorter feeder conduits 150 without impacting an overall pressure drop across the distributor assembly 100 by reducing the diameters D_{132} of first axial segments 132 of feeder ports 130. Such a reduction in the diameters D_{132} may be selected and/or determined so that the reductions in D_{132} increases an overall pressure drop across the distributor assembly 100 substantially that is equivalent to any reduction in overall pressure drop of the distributor assembly 100 attributable to the feeder conduits 150 having shorter lengths L_{150} . In some embodiments described herein, the diameter of

the first or reduced diameter segment of each feeder port (e.g., diameter D_{132} of first axial segment 132) may be less than or equal to about 0.125 in., and alternatively between about 0.046875 in. (3/64") to about 0.125 in. (1/8").

[0042] Referring now to Figure 5, a simplified schematic representation of an alternative embodiment of a pressure correcting distributor assembly 500 is shown. Pressure correcting distributor assembly 500 is substantially similar to distributor assembly 100 with the exceptions that distributor assembly 500 comprises three feeder ports 530 rather than four feeder ports, each of the first axial segments 532 of feeder ports 530 comprise different diameters, and the feeder conduits 550 have different lengths L_{550} . More specifically, because first axial segment 532a of feeder port 530a comprises a relatively larger diameter D_{532a} as compared to the other feeder ports 530, the feeder port 530a is coupled and/or associated with a feeder conduit 550a having a relatively longer length L_{550a} . Similarly, because second axial segment 532b of feeder port 530b comprises a relatively smaller diameter D_{132b} as compared to D_{532a} , the feeder port 530b is coupled and/or associated with a feeder conduit 550b having a relatively shorter length L_{550b} as compared to length L_{550a} . Further, because third axial segment 532c of feeder port 530c comprises a relatively smaller diameter D_{132c} as compared to D_{532b} , the feeder port 530c is coupled and/or associated with a feeder conduit 550c having a relatively shorter length L_{550c} as compared to length L_{550b} . In some embodiments, the pressure drop across each pair of the above-described feeder ports 530 and associated feeder conduits 550 may be substantially equal so that a mass flow rate of refrigerant delivered through each feeder conduit 550 is substantially the same. Accordingly, the distributor assembly 500 may be well suited for using just enough feeder conduit material to make the fluid connections between, for example, but not limited to, the distributor 510 and the multiple circuits of an evaporator.

[0043] Referring now to Figure 6, flowchart of a method 600 of constructing a distributor assembly is shown. In some embodiments, the flowchart of Figure 6 may also be referred to as a method of modifying distribution of refrigerant through a distributor assembly. It will be appreciated that various software simulator programs may be used to simulate HVAC system performance according to so-called performance models that comprise simulations elements representative of the features and/or components of the

distributor assembly 100 as well as other elements of an HVAC system. In some simulator programs, assumptions and/or criteria such as mass flow rate of refrigerant and other operating conditions and/or physical component sizing may be specified and held constant. In some cases, by holding many of the variables constant and only selectively changing particular ones of simulation parameters, such as, but not limited to, component dimensions, relative simulation performance results may be compared to determine an effect of having changed a simulation parameter. Accordingly, this disclosure contemplates utilizing HVAC operation simulation software to study a conventional and/or existing design of a distributor assembly 100 to determine a functional relationship between diameters D_{132} and lengths L_{150} .

[0044] More specifically, the method 600 may begin at block 602 by first analyzing an existing distributor assembly 100 configuration (either experimentally or through simulation) to gather data related to a functional relationship between diameters D_{132} and lengths L_{150} for a particular distributor assembly 100. In some embodiments, the data may be gathered as the result of noting system performance differences caused by at least one of selectively altering a diameter D_{132} and/or a length L_{150} . In some embodiments, each of the lengths L_{150} may be altered by a same amount while keeping diameters D_{132} constant. Alternatively, in some embodiments, the lengths L_{150} may be altered by different amounts while keeping diameters D_{132} constant. Still further, in other embodiments, each of the diameters D_{132} may be altered by a same amount while keeping lengths L_{150} constant. Alternatively, in some embodiments, the diameters D_{132} may be altered by different amounts while keeping constant lengths L_{150} .

[0045] Regardless of how the functional relationship between diameters D_{132} and lengths L_{150} are determined, at block 604, mathematical regression techniques may be used to produce a second-order polynomial equation that defines a relationship between diameters D_{132} and lengths L_{150} . In some embodiments, an equation may take the form of: $D_{132} = a + b * L_{150}$, where the variables "a" and "b" are determined as a result of the above-described regression applied to the simulation and/or experimentation test results. In alternative embodiments, other regression techniques and/or methods may be used to generate relationships and/or equations of lesser or greater order (i.e., first degree

polynomial equations, third degree polynomial equations, fourth degree polynomial equations, etc.).

[0046] Once the above-described equation has been generated, at block 606, a particular desired length L_{150} may be used in the above-described equation to determine an appropriate diameter D_{132} for use in designing a customized distributor assembly 100. It will be appreciated that a distributor assembly 100 comprising the particular desired length L_{150} and the appropriate diameter D_{132} would result in a distributor assembly 100 that generates substantially the same total pressure differential across the conventional distributor assembly studied above in block 602. Accordingly, by altering the conventional distributor assembly studied above in block 602 and mathematically modeled in block 604 to have the particular desired length L_{150} and the associated calculated appropriate diameter D_{132} , a conventional distributor assembly that is normally restricted to operation with lengths L_{150} may be customized to have any desired lengths L_{150} without incurring substantial detriments to operation.

[0047] While the above-described diameter D_{132} may be the preferred diameter D_{132} , there is a high likelihood that the diameter determined above is not one that is easily implemented in a manufacturing environment. Accordingly, at block 608, the two nearest standardized drill bit sizes may be determined, regardless of systems of measurement (i.e., ANSI drill bit sizes, ISO metric drill sizes, and/or other).

[0048] Next, at block 610, the above-described desired length L_{150} in a first one of the two nearest standardized drill bit sizes may be used in the above-described simulation and/or experimental test setup to determine system performance results. Also block 610, a second one of the two nearest standard size drill bit sizes may be used in the above-described simulation and/or experimental test setup to determine another set of system performance results.

[0049] At block 612, a customized distributor assembly 100 may reliably be produced by selecting the one of the two nearest standardized drill bit sizes described above it has resulted in most desirable performance results.

[0050] In a first example of implementing blocks 606-612, a functional relationship between diameter D_{132} and length L_{150} may have been determined as: $D_{132} = 0.0958 + 0.000997 * L_{150}$ from performance of blocks 602-604. Accordingly, at block

606, where a desired length L_{150} is 15in., the 15in. value may be used in the above equation to determine that $D_{132} = 0.110755$ in. Next at block 608, because 0.110755in. is not a standardized drill bit size, the two nearest drill bit sizes may be determined by determining the two nearest drill bit ANSI and ISO size. Particularly, with $D_{132} = 0.110755$ in., the value is bracketed by ANSI drill bit sizes #35 and #34, having sizes of 0.11in. and 0.111in., respectively. Similarly, with $D_{132} = 0.110755$ in., the value is bracketed by ISO drill bit sizes 2.8mm and 2.9mm, equating to sizes of 0.1102in. and 0.1142in., respectively. Accordingly, $D_{132} = 0.110755$ in. is most closely bracketed from below by the ISO drill bit size of 2.8mm (with a difference of 0.000555in.) and from above by the ANSI drill bit size #34 (with a difference of 0.000245in.). Next, the 0.1102in. and 0.111in. values are substituted for the previously determined $D_{132} = 0.110755$ in. in the system performance evaluations of block 610. After comparing the performance results obtained at block 610, at block 612, D_{132} may be finally selected as the drill bit size yielding the most desirable performance results. The following table further demonstrates the relationship between diameter D_{132} and length L_{150} according to the equation of this example.

L_{150} in.	D_{132} in.
30	0.126
29	0.125
28	0.124
27	0.123
26	0.122
25	0.121
24	0.120
23	0.119
22	0.118
21	0.117
20	0.116
19	0.115
18	0.114
17	0.113
16	0.112
15	0.111

14	0.110
13	0.109
12	0.108
11	0.107
10	0.106

[0051] In other embodiments, alternative equations may be produced in blocks 602 and 604. For example, the relationship between diameter D_{132} and length L_{150} may be determined to be $D_{132} = -0.0630 + 0.000946 * L_{150}$, or alternatively, $D_{132} = 0.0816 + 0.00158 * L_{150}$, among others. In determining the above equations, in some embodiments, some parameters of operation and/or simulation may generally be held constant amongst various experimental and/or simulation scenarios. For example, a mass flow rate of refrigerant may be held substantially constant at 100lb/hr per each refrigerant circuit 51. Also, an internal diameter of feeder conduits may be held constant.

[0052] This disclosure contemplates providing distributor assemblies comprising different numbers and sizes of feeder ports and/or feeder conduits. Further this disclosure demonstrates that, in some embodiments, an overall pressure drop across a distributor assembly may be maintained in spite of the use of shorter feeder conduits and that overall pressure drop may be maintained by generating an internal pressure drop within the distributor to compensate for the loss in pressure drop attributable to the use of shorter feeder conduits. The use of feeder ports having reduced diameters in conjunction with feeder conduits having decreased lengths may provide a distributor assembly that may allow a reduced size and/or cost of manufacturing the distributor assembly. In some embodiments, reducing the length of the feeder conduits may reduce material costs to manufacture the distributor assembly while also providing a smaller distributor assembly. Further, one or more of the features and/or components of the distributor assemblies disclosed herein may comprise a so-called venturi profile, such as, but not limited to orifice 141 of flow restrictor 140. For example, in some alternative embodiments, the distributor may comprise a venturi profile comprising an initially large but decreasing diameter mouth. In some cases, a large chamfered interior wall of the distributor may transition to a curved or “bell-mouthed” wall and the walls may be formed integrally with a

body of the distributor. Other alternative embodiments may comprise a sharp edged orifice. In some cases, a sharp edged orifice may comprise a thin plate with a small clean hole drilled through the thin plate. The sharp edged orifice may restrict flow regardless of fluid viscosity so that fluids of varying temperature and viscosity are restricted in substantially the same manner.

[0053] In some embodiments, a conventional distributor assembly may be retrofitted in accordance with the method of Figure 6. In cases where a conventional distributor assembly comprises an existing D_{132} smaller than a D_{132} associated with a desired L_{150} , the existing diameter may be enlarged using the appropriate drill bit size determined at block 612. In cases where a conventional distributor assembly comprises an existing D_{132} greater than a D_{132} associated with a desired L_{150} , a tubular reducer, in some embodiments, comprising a metallic cylindrical tube, may be inserted into the port to reduce the effective diameter of the port through which refrigerant may travel.

[0054] Although climate control system 10 has been shown and described primarily from the perspective of an air conditioning system (i.e., to provide cooling to a space), embodiments of the distributor assembly (e.g., distributor assembly 100) and the distributor (e.g., distributor 110) described herein may be used in any suitable refrigerant based heating and/or cooling climate control systems. For example, the components shown in Figure 1 may alternatively be arranged to provide heating and/or the system shown in Figure 1 may be configured as a heat pump by inclusion of a reversing valve.

[0055] At least one embodiment is disclosed and variations, combinations, and/or modifications of the embodiment(s) and/or features of the embodiment(s) made by a person having ordinary skill in the art are within the scope of the disclosure. Alternative embodiments that result from combining, integrating, and/or omitting features of the embodiment(s) are also within the scope of the disclosure. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). For example, whenever a numerical range with a lower limit, R_l , and an upper limit, R_u , is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are

specifically disclosed: $R = R_l + k * (R_u - R_l)$, wherein k is a variable ranging from 1 percent to 100 percent with a 1 percent increment, i.e., k is 1 percent, 2 percent, 3 percent, 4 percent, 5 percent,...50 percent, 51 percent, 52 percent,...95 percent, 96 percent, 97 percent, 98 percent, 99 percent, or 100 percent. Moreover, any numerical range defined by two R numbers as defined in the above is also specifically disclosed. Use of the term "optionally" with respect to any element of a claim means that the element is required, or alternatively, the element is not required, both alternatives being within the scope of the claim. Use of broader terms such as comprises, includes, and having should be understood to provide support for narrower terms such as consisting of, consisting essentially of, and comprised substantially of. Accordingly, the scope of protection is not limited by the description set out above but is defined by the claims that follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated as further disclosure into the specification and the claims are embodiment(s) of the present invention.

CLAIMS

What is claimed is:

1. A distributor assembly, comprising:

a distributor extending along a central axis between a first end and a second end opposite the first end, the distributor comprising:

a flow passage extending from the first end of the distributor and a plurality of feeder ports extending from the second end of the distributor to the flow passage, each feeder port being in fluid communication with the flow passage;

wherein each feeder port extends along a central axis from a first end at the flow passage to a second end at the second end of the distributor; and

wherein each feeder port comprises a first axial segment and a second axial segment, the first axial segment being connected between the flow passage and the second axial segment and the second axial segment being connected between the first axial segment and the second end of the distributor.

2. The distributor assembly according to claim 1, wherein the plurality of feeder ports are located in a substantially evenly distributed angular array.

3. The distributor assembly according to claim 1, wherein a diameter of the first axial segment is less than a diameter of the second axial segment.

4. The distributor assembly according to claim 1, wherein at least one of the first segment and the second segment are configured to receive a feeder conduit.

5. The distributor assembly according to claim 1, further comprising:

at least one of a venturi profile and sharp edged orifice associated with the flow passage.

6. The distributor assembly according to claim 1, further comprising:
a feeder conduit received within a feeder port.
7. The distributor assembly according to claim 6, wherein the feeder conduit comprises
an internal diameter greater than a diameter of an associated first axial
segment.
8. The distributor assembly according to claim 6, further comprising:
a plurality of feeder conduits, at least two of the plurality of feeder conduits
comprising different feeder conduit lengths.
9. The distributor assembly according to claim 1, wherein at least two of the plurality of
feeder ports comprise different first axial segment diameters.
10. A distributor assembly, comprising:
a distributor extending along a central axis between a first end and a
second end opposite the first end, the distributor comprising:
a flow passage extending from the first end of the distributor and a
plurality of feeder ports extending from the second end of the distributor to
the flow passage, each feeder port being in fluid communication with the
flow passage
wherein each feeder port comprises a first axial segment and a
second axial segment, the first axial segment being connected between the
flow passage and the second axial segment and the second axial segment
being connected between the first axial segment and the second end of the
distributor; and
wherein at least two of the first axial segments comprise different first
axial segment diameters.

11. The distributor assembly according to claim 10, further comprising:
a first feeder conduit received within a first of the plurality of feeder ports;
and
a second feeder conduit received within a second of the plurality of feeder ports;
wherein a diameter of the first feeder port is greater than a diameter of the second feeder port and wherein a length of the first conduit is greater than a length of the second feeder conduit.
12. The distributor assembly according to claim 11, wherein a pressure drop measured across an inlet to the first feeder port and an outlet of the first feeder conduit is substantially similar to a pressure drop measured across an inlet to the second feeder port and an outlet of the second feeder conduit.
13. The distributor assembly according to claim 11, wherein an inner diameter of a feeder conduit is greater than a diameter of an associated feeder port.
14. The distributor assembly according to claim 10, further comprising:
three feeder ports, none of the first axial segment diameters being equal.
15. The distributor assembly according to claim 10, further comprising:
at least one of a venturi profile and sharp edged orifice associated with the flow passage.
16. A method of modifying refrigerant distribution through a distributor assembly, comprising:
at least one of (1) increasing a feeder port diameter and increasing a length of an associated feeder conduit and (2) decreasing a feeder port diameter and decreasing a length of an associated feeder conduit.
17. The method of claim 16, further comprising:

increasing a first feeder port diameter and increasing a length of an associated first feeder conduit; and

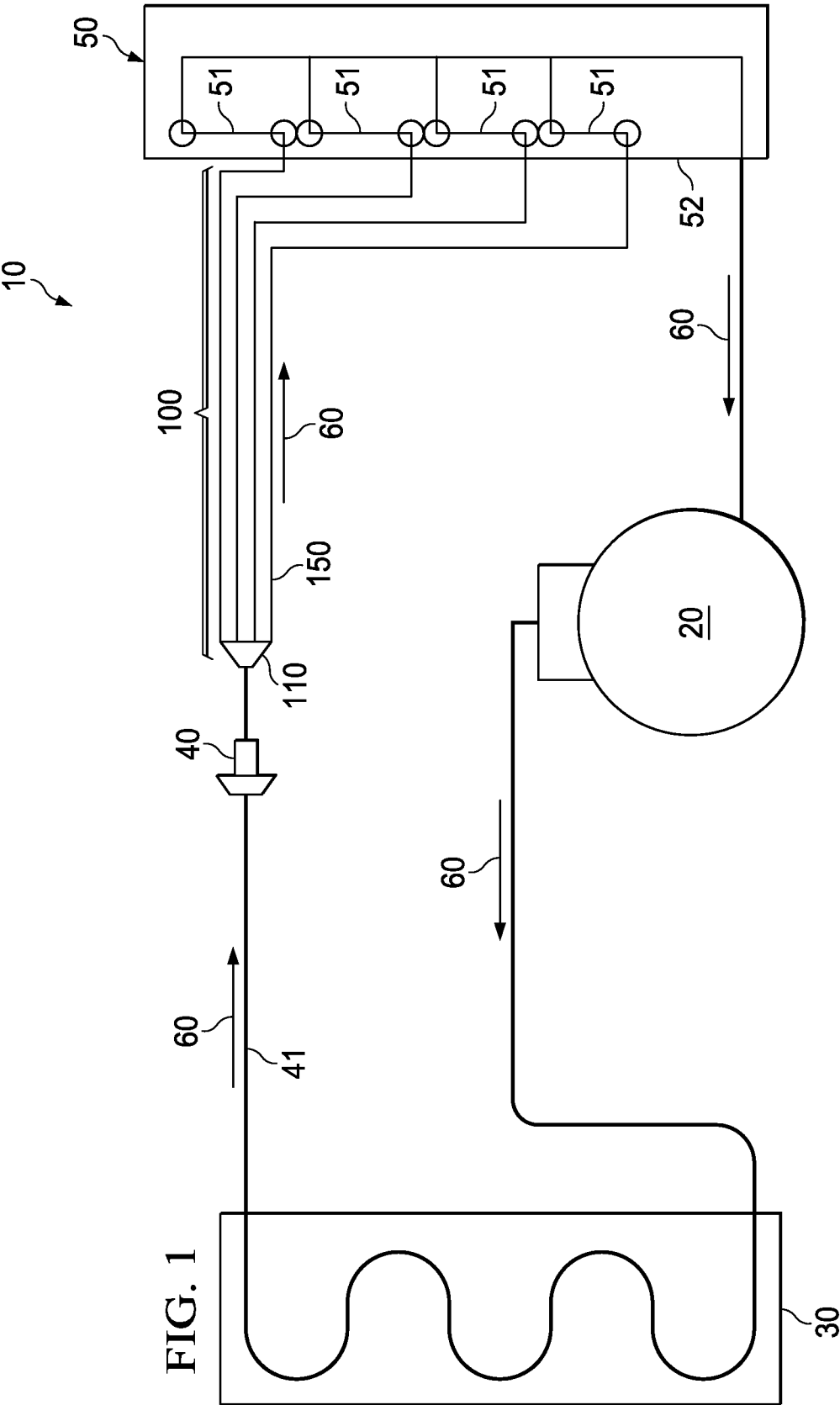
increasing a second feeder port diameter and increasing a length of an associated second feeder conduit.

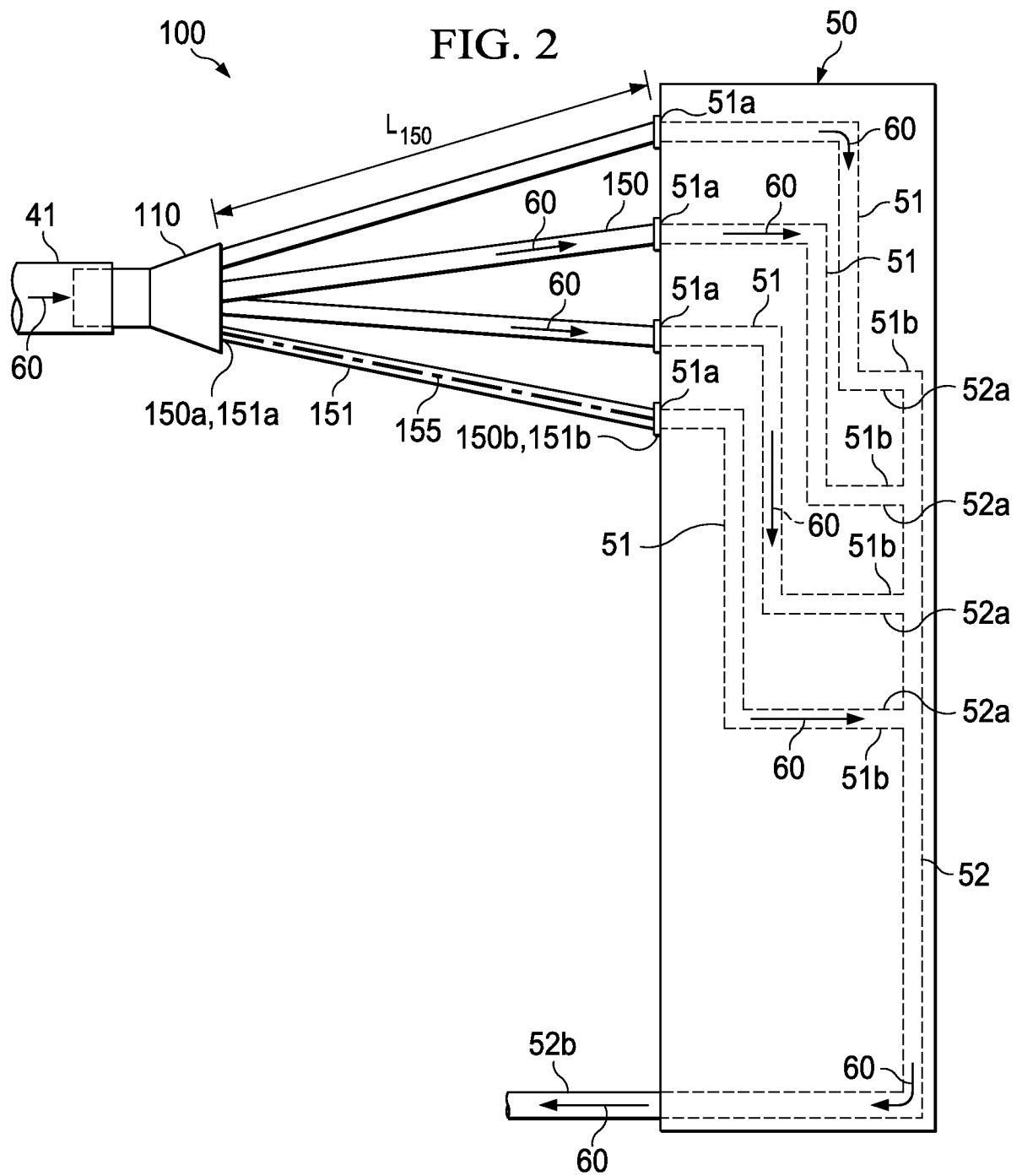
18. The method of claim 17, wherein the increased first feeder port diameter is greater than the increased second feeder port diameter.

19. The method of claim 18, wherein the increased length of the first feeder conduit is greater than the increased length of the second feeder conduit.

20. The method of claim 19, further comprising:

passing refrigerant through at least one of a venturi profile and sharp edged orifice associated with the flow passage of the distributor assembly.





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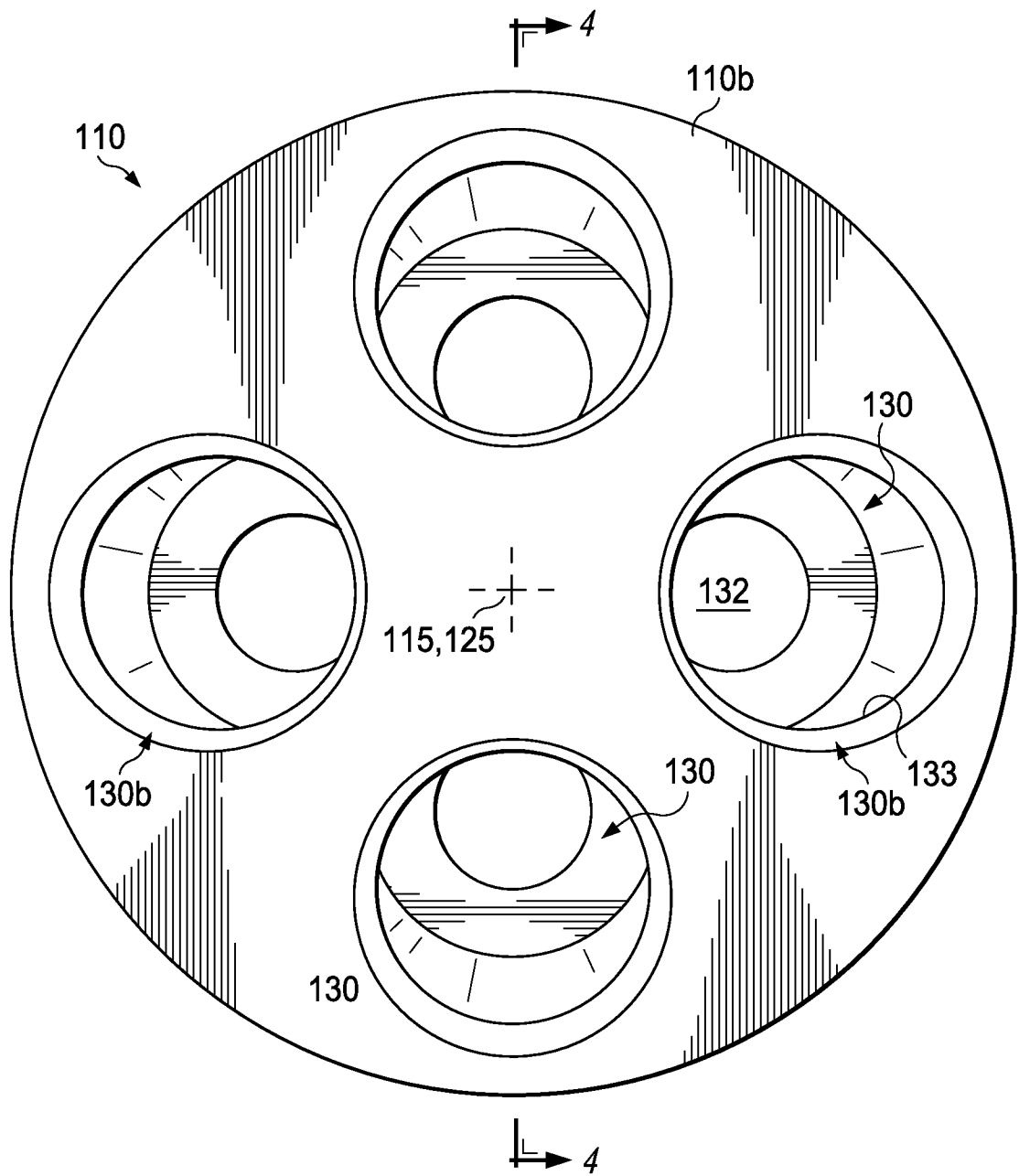


FIG. 3

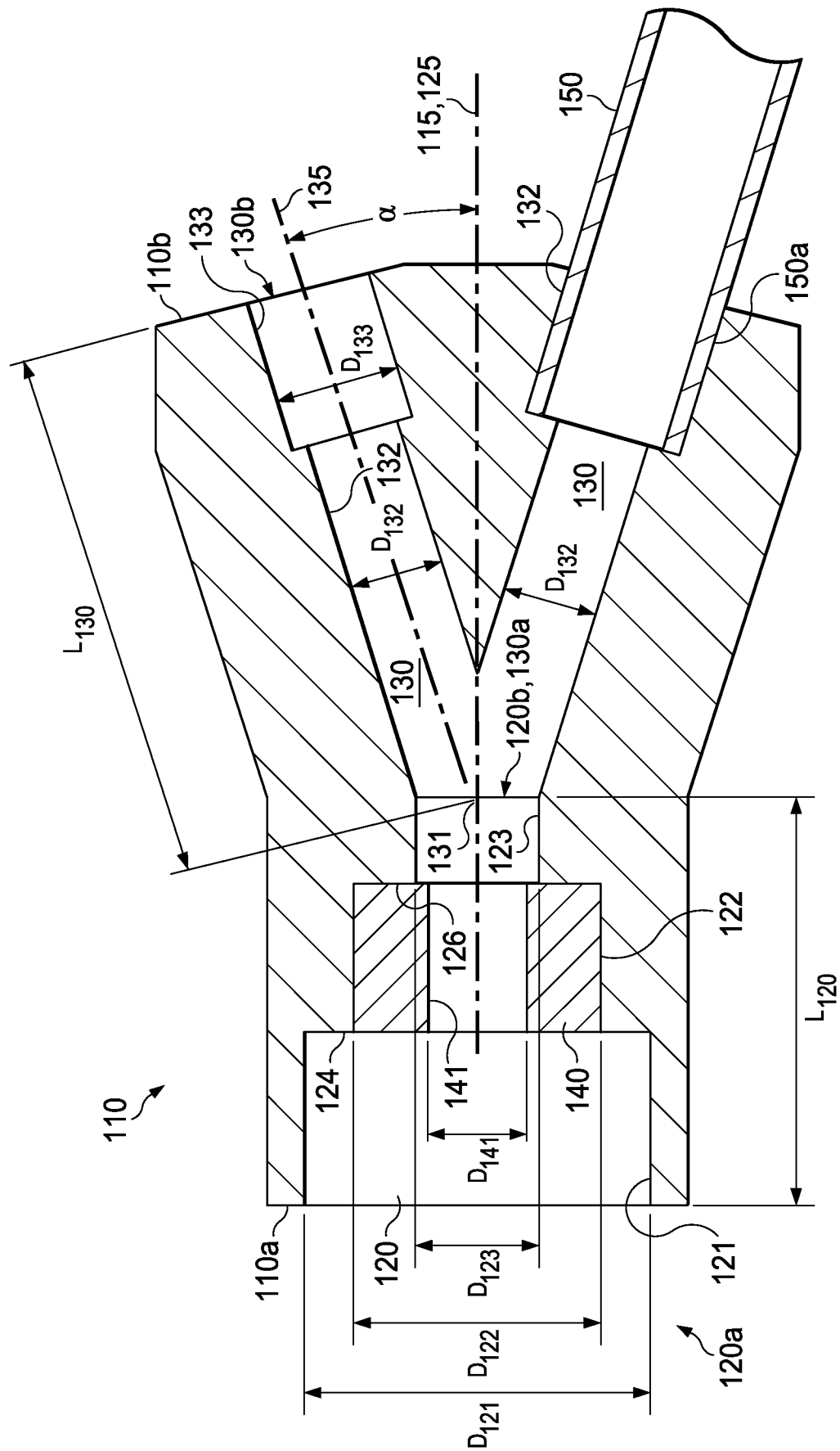


FIG. 4

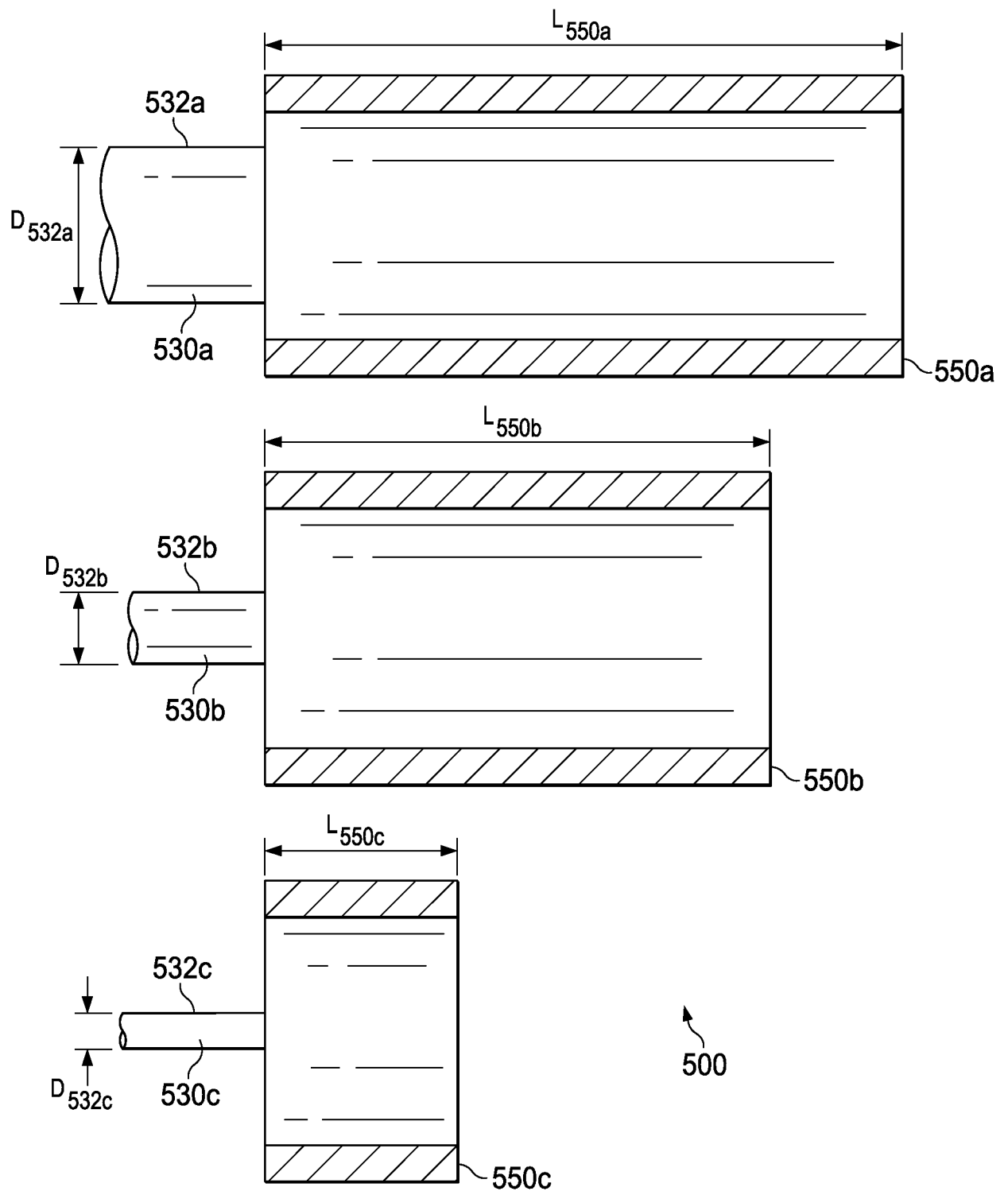


FIG. 5

6/6

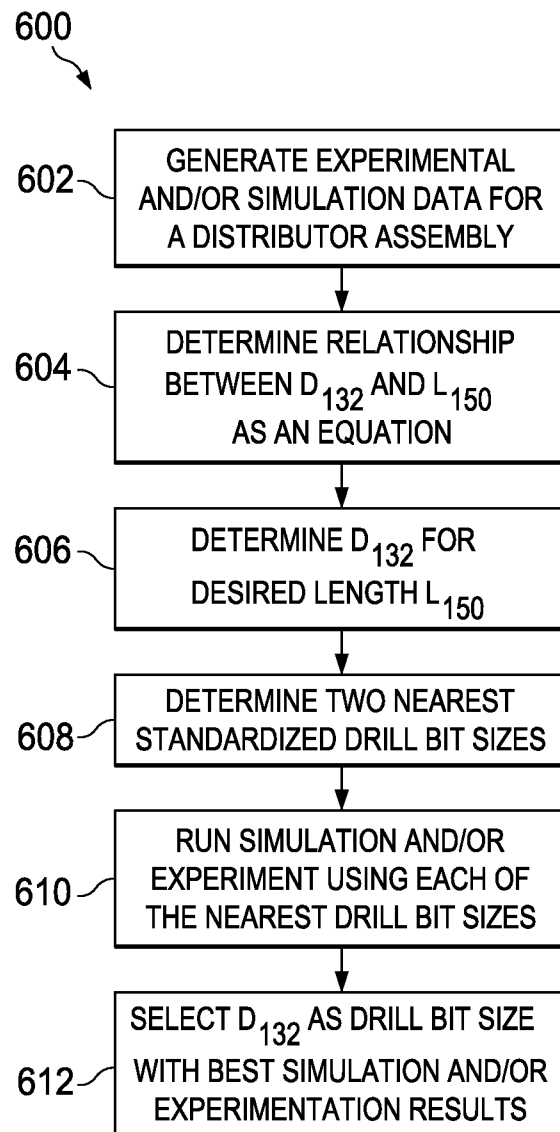


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/059018

A. CLASSIFICATION OF SUBJECT MATTER
INV. F25B39/02
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)
F25B

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)

EP0-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	US 2 787 138 A (BOYLE JOHN R) 2 April 1957 (1957-04-02) column 2, line 36 - column 3, line 20; figure 2	1-6
X	----- EP 0 895 051 A1 (D APPLIC THERMIQUES C I A T CO [FR] CIE IND D APPLIC THERMIQUES C [FR]) 3 February 1999 (1999-02-03) figure 2	1-6
X	----- EP 1 707 902 A2 (LG ELECTRONICS INC [KR]) 4 October 2006 (2006-10-04) figure 2	1-4,6
A	-----	5

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

☒ 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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

13 December 2012

Date of mailing of the international search report

12/03/2013

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Ritter, Christoph

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/059018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2787138	A	02-04-1957	NONE

EP 0895051	A1	03-02-1999	AT 228640 T 15-12-2002
		DE 69809652 D1	09-01-2003
		DE 69809652 T2	17-07-2003
		EP 0895051 A1	03-02-1999
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EP 1707902	A2	04-10-2006	AT 473403 T 15-07-2010
		AU 2006221214 A1	14-09-2006
		EP 1707902 A2	04-10-2006
		ES 2347068 T3	25-10-2010
		US 2006201197 A1	14-09-2006
		WO 2006095993 A2	14-09-2006

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/059018

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

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

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

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

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

see additional sheet

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

1-6

Remark on Protest

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

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6

distributor assembly with venturi profil

2. claims: 1, 7-20

distributor with particular feeder port dimensions and
feeder dimension and method for choosing the dimensions of
the feeder ports diameter and the feeder conduit length
