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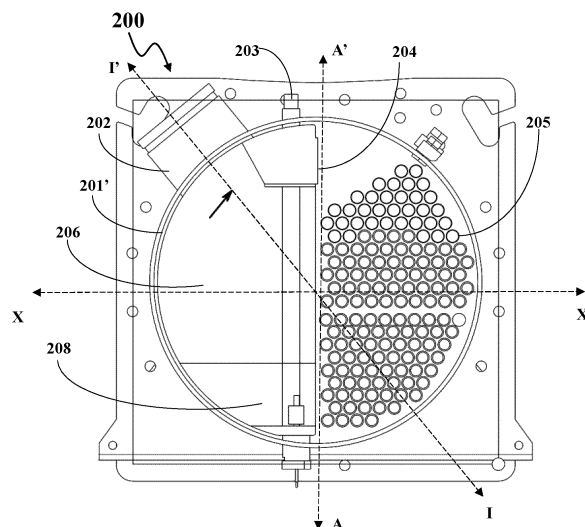
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(54) **A CONDENSER VESSEL, SYSTEM, AND METHOD FOR SEPARATING OIL FROM AN OIL-REFRIGERANT MIXTURE**

(57) A condenser vessel having an oil storage and separation portion for separating a refrigerant vapor from oil in a temperature conditioning system includes a casing and a separator wall positioned inside the casing. The casing includes an inlet for receiving a mixture of oil and refrigerant vapor and an outlet for transferring the oil separated from the mixture of the oil and the refrigerant

vapor outside the condenser vessel. The separator wall is positioned inside the casing along a lateral axis (A-A') of the casing substantially perpendicular relative to a horizontal axis (X-X') through a centre of the casing. The separator wall defines a condenser portion and an oil storage and separation portion within the casing.

**FIG. 3**

Description

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/587,833 filed on October 04, 2023, which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The disclosure relates to a condenser vessel including an oil storage and separation portion, system, and method for separating oil from an oil and refrigerant fluid mixture in a temperature conditioning system.

BACKGROUND

[0003] Heating, Ventilation, Air Conditioning and Refrigeration (HVAC&R) systems work to regulate the air quality, humidity, and temperature levels to ensure the air within the enclosed space is comfortable and habitable irrespective of the environmental conditions outside the enclosed space. Such temperature conditioning systems regulate the parameters within the enclosed space by exchanging heat with a refrigerant flowing through an evaporator. The heated refrigerant is conveyed to a compressor for increasing the temperature and pressure of the refrigerant. The superheated high pressure refrigerant exchanges heat with water or other cooling liquids when conveyed through a condenser. The compressor uses a combination of moving components, such as reciprocating and rotary components, to increase the pressure and temperature of the refrigerant. Alternatively, the compressor may also be a screw compressor. As such, lubricating oils are essential for the smooth functioning of the compressor. Because refrigerants and lubricating oils are miscible in one another, there will always be some oil that leaves the compressor with the refrigerant being circulated throughout the refrigeration system. It is in this regard that the provision of an oil storage and separation portion is essential with the objective of separating oil and refrigerant before the refrigerant enters the condenser.

[0004] Typically, condenser vessels are installed after a discharge line of the compressor/ compressors. Condenser vessels sometimes include oil separators that are usually vertical containers with the discharge gas connections at a top portion and an oil return port at the bottom. This return line may be piped directly to an oil suction line of the compressor units. Some condenser vessels have a reservoir built into the bottom portion of the container with the upper portion operating as the separator. From the reservoir, the oil is then returned to the compressors by use of a mechanical or electronic oil level control valve adapted to regulate the flow of oil based on the level of oil in the reservoir. Oil that gets past the compressor and into the system through the con-

denser not only robs the compressor crankcase of vital lubrication, but the oil proceeds also to coat the walls of the condenser and the evaporator. Oil film on the walls of these important heat exchangers will reduce their heat transfer abilities drastically. The condenser will not be able to reject heat as efficiently as it should. Increased head pressures, causing higher compression ratios and lower volumetric efficiencies with lower-than-normal system capacities are some of the effects of the circulation of oil within the system away from the compressor.

[0005] Similarly, oil that coats the walls of the evaporator will decrease heat transfer to the refrigerant in the evaporator. A film of oil, which acts as a very good insulator, will form on the inside of the evaporator causing a reduced heat load that will lower the suction pressure further. Lower suction pressures cause higher compression ratios and lower volumetric efficiencies. The result is lower system capacity with much longer running times. Furthermore, most control valves, including capillary tubes and the like, also experience inefficient performance due to the pressure of oil film formation. The capillary tubes suffer wide variation in flow rates. Temperature sensors, therefore, may not detect the correct refrigerant temperature at the evaporator outlet, causing improper superheat control further affecting the system efficiency. The efficient functioning of the oil separator with reduced chances of oil being conveyed to the condenser unit, is therefore desirable.

[0006] Existing oil separators that are housed within a shell containing a condenser include an oil separator portion and a condenser portion separated by a separator wall. The existing design increases the chances of oil overflowing into the condenser. This is because the oil level within the oil separator portion is high and almost reaches the vents that are provided for transferring refrigerant vapor to the condenser. As a result, instead of the refrigerant vapor alone reaching the condenser, oil droplets also are entrained within the vapor and are conveyed to the condenser. An improved oil separator design, capable of preventing the transfer of oil to a condenser portion, is therefore desirable. Moreover, an improved oil separator capable of storing an increased volume of oil for a particular diameter of the condenser vessel casing is desired. Furthermore, an improved oil separator capable of improved oil separation is desired.

SUMMARY

[0007] This summary is provided to introduce a selection of concepts in a simplified format that are further described in the detailed description of the disclosure. This summary is not intended to identify key or essential inventive concepts of the disclosure, nor is it intended for determining the scope of the disclosure.

[0008] The disclosure discloses an improved oil separator design, capable of preventing transfer of oil to a condenser portion. Moreover, the disclosure discloses an improved oil separator, capable of storing increased

volume of oil for a particular diameter of the oil separator casing. Furthermore, the disclosure discloses an improved oil separator, capable of improved refrigerant-oil separation.

[0009] The condenser vessel, disclosed herein, includes an oil storage and separation portion for separating a refrigerant fluid from oil in a temperature conditioning system. The condenser vessel includes a casing and a separator wall. The casing includes an inlet for receiving a mixture of oil and refrigerant fluid and an outlet. The outlet of the casing facilitates transfer of the oil separated from the mixture of the oil and the refrigerant fluid outside the condenser vessel. A separator wall is positioned inside the casing to define the condenser portion and the oil storage and separation portion within the casing. The separator wall is positioned inside the casing such that the separator wall is positioned along a lateral axis (A-A') of the casing substantially perpendicular to a horizontal axis (X-X') passing through a center of the casing.

[0010] Optionally, the separator wall includes a plurality of vents defined proximal to an upper end of the separator wall for transferring refrigerant vapor separated from the mixture of the oil and the refrigerant fluid to the condenser portion.

[0011] Optionally, the condenser portion condenses the refrigerant vapor to refrigerant liquid and transfers the refrigerant fluid to an expansion valve via the refrigerant liquid line.

[0012] Optionally, the oil storage and separation portion is enclosed within a secondary casing inside the casing of the condenser vessel.

[0013] Optionally, the oil storage and separation portion also includes a plurality of mesh eliminators disposed on the separator wall on both sides of the inlet and in contact with an inner periphery of the casing. The mesh eliminators may be spaced apart from each other and function to filter the mixture further thereby causing coalescence. The term "coalescence" refers to the aggregation of oil particulates causing larger oil droplets to form and drop to the bottom of the oil storage and separator portion of the condenser vessel under the effect of gravitational forces.

[0014] Optionally, each of the mesh eliminators define a reservoir portion downstream of the mesh eliminators enclosed by the casing.

[0015] Optionally, the inlet of the condenser vessel further comprises a nozzle seated within the inlet. The nozzle may include a hollow shaft having an external diameter smaller than an internal diameter of the inlet. The hollow shaft of the nozzle may be adapted to be removably fastened to the inlet for temporary adjustment before welding to the casing of the condenser vessel. Alternatively, the nozzle may also be welded to the main shell of the condenser assembly. The nozzle may also include a pair of protruding jaw portions extending from the hollow shaft and disposed radially opposite to each other. In an exemplary embodiment according to the disclosure, the pair of protruding jaw portions are

adapted to support a face plate.

[0016] Optionally, a central axis (I-I') of the inlet is inclined at an acute angle relative to the lateral axis (A-A') of the casing.

[0017] Optionally, the face plate is oriented orthogonally relative to a central axis (I-I') of the inlet for redirecting a flow of a mixture of oil and refrigerant vapor to at least one of an inner surface of the casing, a surface of a separator wall, and a bottom portion of the casing. The main function of the face plate is impingement of the oil refrigerant vapor mixture which helps to achieve the first step of separation. A significant amount of oil is expected to be collected on the face plate and fall by gravity. The redirected flow then contacts the inner surface of the casing, the surface of the separator wall, and the bottom portion of the casing causing secondary impingement with further separation of oil by the same effect.

[0018] Optionally, the vents are defined in the separator wall proximal to ends of the casing and distal from the inlet of the casing.

[0019] Optionally, an internal volume of the oil storage and separation portion is at least equal to an internal volume of the condenser portion.

[0020] Optionally, the condenser vessel also includes at least one sensor adapted to detect an oil level in the reservoir portion.

[0021] Optionally, the at least one sensor is mounted on a bottom surface of the reservoir portion of the casing.

[0022] Optionally, the condenser vessel further includes at least one outlet tube immersed in each of the reservoir portions of the oil storage and separation portion such that the outlet tube is adapted to transfer oil from the reservoir portion to the outlet of the casing.

[0023] Optionally, an oil level of each of the reservoir portions is greater than an oil level in a portion of the casing below the inlet of the casing.

[0024] A temperature conditioning system having a refrigerant circuit according to the disclosure, including a compressor, a condenser vessel, an expansion valve, and an evaporator, is also disclosed. The compressor compresses a refrigerant vapor. The condenser vessel includes an oil storage and separation portion that separates oil from a mixture of oil and refrigerant vapor discharged from the compressor. The oil storage and separation portion is adapted to transfer refrigerant vapor separated from the mixture of oil and refrigerant fluid to a condenser portion. The condenser portion condenses the refrigerant vapor to a refrigerant fluid, which is then supplied to the expansion valve. The expansion valve expands the condensed refrigerant fluid. The evaporator evaporates the refrigerant fluid and subsequently low temperature, low pressure refrigerant vapor is supplied back to the compressor to complete the refrigerant circuit. The compressor, the condenser vessel, the condenser portion, the expansion valve, and the evaporator are connected in this order or in sequence.

[0025] Optionally, the condenser vessel of the temperature conditioning system includes a separator wall

positioned inside a casing to define the condenser portion and the oil storage and separation portion within the casing. The separator wall is positioned along a lateral axis (A-A') of the casing substantially perpendicular to a horizontal axis (X-X') through a center of the casing.

[0026] Optionally, an internal volume of the oil storage and separation portion is at least equal to an internal volume of the condenser portion.

[0027] Optionally, a method for separating oil from a refrigerant fluid in a temperature conditioning system, includes the following steps. First, a condenser vessel including a casing and a separator wall is provided. The casing includes an inlet and an outlet. The separator wall is positioned inside the casing to define a condenser portion and an oil storage and separation portion including an envelope or shell that is completely inserted within the casing, such that the separator wall is positioned along a lateral axis (A-A') of the casing. Next, a mixture of oil and refrigerant vapor is received via the inlet. Then, the refrigerant vapor is separated by impinging the received mixture of oil and refrigerant vapor on at least one of a face plate of a nozzle seated within the inlet and the separator wall. A plurality of mesh eliminators filter the mixture to aggregate oil particulates from the mixture to form larger oil droplets collected by a bottom portion of the oil storage and separator portion. The oil separated from the mixture of the oil and the refrigerant vapor is discharged, via the outlet, outside the condenser vessel. Finally, the separated refrigerant vapor is conveyed, via a plurality of vents defined in the separator wall, to the condenser portion.

[0028] To further clarify the advantages and features of the method and system, a more particular description of the method and system will be rendered by reference to specific embodiments thereof, which is illustrated in the appended drawing. It is appreciated that these drawings depict only typical embodiments of the disclosure and are therefore not to be considered limiting its scope. The disclosure will be described and explained with additional specificity and detail with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] These and other features, aspects, and advantages will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIG. 1 illustrates a schematic diagram depicting a refrigerant circuit of a temperature conditioning system;

FIG. 2 illustrates a perspective view of an oil storage and separation portion of a condenser vessel;

FIG. 3 illustrates a side view of the condenser vessel;

FIG. 4 illustrates a perspective view of a nozzle of the condenser vessel; and

FIG. 5 illustrates a flowchart depicting a method for separating oil from a refrigerant fluid in a temperature conditioning system.

[0030] Further, skilled artisans will appreciate that elements in the drawings are illustrated for simplicity and may not have necessarily been drawn to scale. For example, the flow charts illustrate the method in terms of the most prominent steps involved to help to improve understanding of aspects of the disclosure. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the disclosure so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION

[0031] It should be understood at the outset that although illustrative implementations of embodiments are illustrated below, system and method may be implemented using any number of techniques. The disclosure should in no way be limited to the illustrative implementations, drawings, and techniques illustrated below, including the exemplary design and implementation illustrated and described herein, but may be modified within the scope of the appended claims along with their full scope of equivalents.

[0032] The term "some" as used herein is defined as "one, or more than one, or all." Accordingly, the terms "one," "more than one," but not all" or "all" would all fall under the definition of "some." The term "some embodiments" may refer to no embodiments or one embodiment or several embodiments or all embodiments. Accordingly, the term "some embodiments" is defined as meaning "one embodiment, or more than one embodiment, or all embodiments."

[0033] The terminology and structure employed herein are for describing, teaching, and illuminating some embodiments and their specific features and elements and do not limit, restrict, or reduce the spirit and scope of the claims or their equivalents.

[0034] More specifically, any terms used herein such as but not limited to "includes," "comprises," "has," "have" and grammatical variants thereof do not specify an exact limitation or restriction and certainly do not exclude the possible addition of one or more features or elements, unless otherwise stated, and must not be taken to exclude the possible removal of one or more of the listed features and elements, unless otherwise stated with the limiting language "must comprise" or "needs to include."

[0035] The term "unit" used herein may imply a unit

including, for example, one of hardware, software, and firmware or a combination of two or more of them. The "unit" may be interchangeably used with a term such as logic, a logical block, a component, a circuit, and the like. The "unit" may be a minimum system component for performing one or more functions or may be a part thereof.

[0036] Unless otherwise defined, all terms, and especially any technical and/or scientific terms, used herein may be taken to have the same meaning as commonly understood by one having ordinary skill in the art.

[0037] Embodiments will be described below in detail with reference to the accompanying drawings. **FIG. 1** illustrates a schematic diagram depicting a refrigerant circuit of a temperature conditioning system 100 according to the disclosure. As used herein, "temperature conditioning system 100" refers to conventional chillers or heat pumps that employ compressors, oil separators, condensers, expansion valves, and evaporators connected in this order. A compressor 101 used in such temperature conditioning systems 100 may include, but are not limited to, reciprocating compressors, rotary compressors, scroll compressors, screw compressors, centrifugal compressors, and the like. The compressor 101 of the temperature conditioning system 100, disclosed herein, compresses a refrigerant vapor, which increases the pressure and temperature of the refrigerant vapor up to superheated levels. The compressor 101 discharges the superheated refrigerant vapor in addition to oil via a discharge line exemplarily illustrated in **FIG. 1**. As used herein, "oil" refers to lubricating oil used to lubricate the moving components of the compressor 101. The oil in the compressor 101 also functions to cool the bearings down and to improve the tightness of the moving parts to each other and to the casing, increasing the system efficiency.

[0038] A condenser vessel 200 is adapted to receive the mixture of oil and refrigerant vapor discharged from the compressor 101. The condenser vessel 200 that includes an oil storage and separation portion 206 is discussed in detail in the detailed description of **FIGS. 2-3**. In an embodiment according to the disclosure, the condenser vessel 200 includes the oil storage and separation portion 206 that functions to separate oil from the mixture of oil and refrigerant vapor discharged from the compressor 101. In an embodiment, the oil storage and separation portion 206 may be housed within a secondary casing 201' inside a single casing 201 as exemplarily illustrated in **FIG. 3**. Alternatively, the oil storage and separation portion 206 and a condenser portion 205 may be enclosed within the single casing 201. The remaining oil is collected in the oil storage and separation portion 206 and supplied back to the compressor 101 via an oil return line. On the other hand, the separated refrigerant vapor rises and is transferred to the condenser portion 205 as disclosed in the detailed description of **FIG. 2**.

[0039] The separated oil within the oil storage and

separation portion 206 of the condenser vessel 200 is continually supplied to the compressor 101 through the oil return line connected to the compressor 101. In case the residual oil levels are insufficient to supply the compressor 101, the oil level switches will detect the lack of oil and controls will trip the system off and raise an alarm. The pressure difference between the high and low sides of the temperature conditioning system 100 is the driving force for the oil to travel from the condenser vessel 200 to the compressor 101. In certain embodiments, auxiliary components such as oil pumps may also be utilized to supply oil to the compressor 101.

[0040] The oil storage and separation portion 200 is adapted to transfer the refrigerant vapor separated from the mixture of oil and refrigerant vapor from the oil storage and separation portion 206 to the condenser portion 205 of the condenser vessel 200. The condenser portion 205 condenses the separated refrigerant vapor to a high temperature refrigerant fluid. A cooling water circuit 104 exchanges heat with the condenser portion 205 thereby cooling the refrigerant vapor to form the high temperature refrigerant fluid. The high temperature refrigerant fluid is then passed through an expansion valve 102 for expanding the condensed refrigerant fluid. After the refrigerant fluid passes through the expansion valve 102 or metering device, the pressure of the refrigerant fluid is further reduced which lowers the temperature of the refrigerant fluid thereby supplying a low temperature and low pressure refrigerant fluid to an evaporator 103. The evaporator 103 evaporates the refrigerant fluid. A chilled water circuit 104' exchanges heat with the refrigerant fluid in the evaporator 103. The chilled water circuit 104' may then be circulated to external terminal units, for example, fan coil units, to exchange heat with air from the space to be cooled. While the low temperature and low pressure refrigerant fluid passes through the evaporator 103, the chilled water circuit 104' to be cooled exchanges heat with the refrigerant fluid thereby converting the refrigerant fluid completely to low temperature and low pressure refrigerant vapor. Finally, the low-pressure refrigerant vapor is supplied back to the compressor 101 to complete the refrigerant circuit.

[0041] **FIG. 2** illustrates a perspective view of the oil storage and separation portion 206 of the condenser vessel 200 according to the disclosure. **FIG. 3** illustrates a side view of the condenser vessel 200 according to the disclosure. The condenser vessel 200 includes the casing 201 and a separator wall 204. In an exemplary embodiment, the casing 201 includes an inlet 202, for receiving a mixture of oil and refrigerant vapor and an outlet 203 for transferring the oil separated from the mixture of the oil and the refrigerant vapor outside the condenser vessel 200. As used herein, the outlet 203 may include a plurality of outlets 203 or two outlets 203 for transferring the oil as shown in **FIG. 2**. Moreover, the outlet 203 may also refer to a plurality of vents 204a defined proximal to an upper end of the separator wall 204 for transferring refrigerant vapor separated from the mixture of the oil and

the refrigerant vapor to the condenser portion 205. The separated oil is circulated back to the compressor 101 as exemplarily illustrated in FIG. 1. The separator wall 204 is positioned inside the casing 201 to define the condenser portion 205 and the oil storage and separation portion 206 within the casing 201. The oil storage and separation portion 206 includes an envelope or shell or the secondary casing 201' and is a unit by itself to be inserted into the condenser vessel 200.

[0042] Alternatively, the oil storage and separation portion 206 may be defined by welding a single separator wall 204 to the casing 201 and adding endplates. As such, the single separator wall 204, and the endplates may collectively define an internal volume of the oil storage and separation portion 206. The separator wall 204 is positioned along a lateral axis (A-A') of the casing 201. In an embodiment according to the disclosure, the lateral axis (A-A') is substantially perpendicular to a horizontal axis (X-X') passing through a centre of the casing 201 as exemplarily illustrated in FIG. 2. The term "substantially perpendicular" is defined to include an inclination of the lateral axis (A-A') to the horizontal axis (X-X') preferably falling between 30 degrees and 90 degrees. When the separator wall 204 is inclined at 90°, an oil level switch can be directly mounted underneath the casing 201. On the other hand, inclinations lower than 90 degree and higher than 30 degrees may involve the inclusion of extra piping and external level sensors.

[0043] The separator wall 204 includes the plurality of vents 204a defined proximal to the upper end of the separator wall 204 for transferring refrigerant vapor separated from the mixture of the oil and the refrigerant vapor to the condenser portion 205. The condenser portion 205 condenses the refrigerant vapor to refrigerant fluid and transfers the refrigerant fluid to an expansion valve 102 via a refrigerant liquid line 205a. In an embodiment, the internal volume of the oil storage and separation portion 206 is at least equal to an internal volume of the condenser portion 205.

[0044] The inclination of the separator wall 204 falling between 80 to 90 degrees ensures that the height between the bottom portion of the oil storage and separation portion 206 and the vents 204a is increased and highest for the casing 201 having a tubular configuration or a hollow cylindrical configuration. This means more oil can be collected within the oil storage and separation portion 206 of an existing casing 201 without altering the dimensions of the casing 201. Moreover, the increased height ensures improved separation of oil from the received mixture of oil and refrigerant vapor. Furthermore, the increased height reduces the tendency of re-entrainment of oil. This is because in conventional condenser vessels 200, the inclination of the separator wall 204 fell between 30 and 60 degrees causing the oil level to be higher and closer to the vents 204a. Consequently, the chances of residual oil being transferred to the condenser portion 205 in addition to the refrigerant vapor are higher than in the embodiment according to the disclosure.

[0045] In an embodiment, the condenser vessel 200 is made of steel. As the mixture of oil and refrigerant vapor enters the large internal volume of the condenser vessel 200, a nozzle 209 (exemplarily illustrated in FIG. 4) seated in the inlet 202 of the casing 201 immediately slows down the velocity of the mixture. The nozzle 209 redirects and forces the mixture of oil and refrigerant vapor to change direction. On impact with the nozzle 209 and portions of the separator wall 204, the refrigerant vapor separates from the mixture and the oil collects at the bottom portion of the oil storage and separation portion 206 under the effect of gravitational forces. The oil storage and separation portion 206 further comprises a plurality of mesh eliminators 207 disposed on the separator wall 204 on both sides of the inlet 202. Moreover, the mesh eliminators 207 are in contact with an inner periphery of the casing 201 and are spaced apart from each other. The mesh eliminators 207 function to further separate the oil and refrigerant vapor, causing larger oil droplets to form by coalescence and drop to the bottom portion of the condenser vessel 200. By varying characteristics of the mesh eliminators 207 such as density of the mesh material, diameters of knitted wires and how they are knitted together, as well as guaranteeing no gap between the mesh and the envelope which would cause bypasses, the coalescence efficiency or rate of coalescence is enhanced. The mesh wires may be made from stainless steel. For example, exceptionally fine oil particles collide with one another and form heavier particles.

[0046] Each of the mesh eliminators 207 defines a reservoir portion 208 downstream of the mesh eliminators 207 enclosed by the casing 201 as exemplarily illustrated in FIG. 2. The reservoir portions 208 prevent excessive rise of residual oil towards the refrigerant outlets 204a of the condenser vessel 200. This feature improves the detection of the oil level using the sensor 210. The oil accumulates downstream rather than upstream the mesh eliminators 207 by the natural effect of pressure losses through the mesh eliminators 207. The static pressure is higher upstream than downstream, therefore pushing the oil toward the downstream section. The residual oil or the separated oil is continually returned to the compressor 101 through an oil return line connected to the compressor 101 shown in FIG. 1. The pressure difference between the high and low sides of the temperature conditioning system is the driving force for the oil to travel from the condenser vessel 200 to the compressor 101.

[0047] The condenser vessel 200 also includes at least one outlet tube 211 immersed in each of the reservoir portions 208 of the oil storage and separation portion 206. The outlet tube 211 is adapted to transfer oil from the reservoir portion 208 to the outlet 203 of the casing 201. Moreover, the provision of the outlet tubes 211 for supplying the separated oil to the outlets 203 eliminates external connections and external tubing from the bottom or side of the casing 201 as in the case of existing

products for supplying the oil back to the compressor 101 as exemplarily illustrated in **FIG. 1**.

[0048] **FIG. 4** illustrates a perspective view of a nozzle 209 of the condenser vessel 200 according to the disclosure. As the mixture of oil and refrigerant vapor enters the large internal volume of the condenser vessel 200, the nozzle 209 functions to continually supply the mixture of oil and refrigerant vapor. The nozzle 209, seated within the inlet 202, includes a hollow shaft 209a, a pair of protruding jaw portions 209b, and a face plate 209c. In an embodiment, the hollow shaft 209a has an external diameter smaller than an internal diameter of the inlet 202. The hollow shaft 209a of the nozzle 209 is adapted to be removably fastened to the inlet 202 for temporary adjustment before welding to the casing 201 of the condenser vessel 200. In an embodiment, external screw threads are defined on an exterior surface of the hollow shaft 209a to fasten the hollow shaft with corresponding internal screw threads defined in an interior portion of the inlet 202 exemplarily illustrated in **FIG. 2**. Moreover, the hollow shaft 209a of the nozzle 209 may also have a welded connection with the casing 201. The pair of protruding jaw portions 209b extend from the hollow shaft 209a and are adapted to support a face plate 209c. In an embodiment, the protruding jaw portions 209b are disposed radially opposite to each other.

[0049] The face plate 209c functions to provide a surface upon which the mixture of oil and refrigerant vapor impinges to redirect the mixture towards the upper and bottom portion of the oil storage and separation portion 206 exemplarily illustrated in **FIG. 2**. In one or more embodiments according to the disclosure, a central axis (I-I') of the inlet 202 is inclined at an acute angle relative to the lateral axis (A-A') of the casing 201 as exemplarily illustrated in **FIG. 3**. The face plate 209c is oriented orthogonally relative to a central axis (I-I') of the inlet 202 for redirecting a flow of a mixture of oil and refrigerant vapor to an inner surface of the oil storage and separation portion 206, a surface of a separator wall 204, and/or a bottom portion of the oil storage and separation portion 206. The main function of the face plate 209c is impingement of the oil refrigerant vapor mixture which helps to achieve the first step of separation. A significant amount of oil is expected to be collected on the face plate 209c and fall by gravity. The redirected flow then contacts the inner surface of the oil storage and separation portion 206, the surface of the separator wall 204, and the bottom portion of the oil storage and separation portion 206 causing secondary impingement with further separation of oil by the same effect.

[0050] **FIG. 5** illustrates a flowchart depicting a method 500 for separating oil from the refrigerant fluid in a temperature conditioning system 100, according to the disclosure.

[0051] At Step 501, the condenser vessel 200 including the casing 201 having the inlet 202 and the outlet 203 and the separator wall 204 positioned inside the casing 201, is provided. The separator wall 204 defines the

condenser portion 205 and the oil storage and separation portion 206 within the casing 201 as exemplarily illustrated in **FIGS. 1-2**. The separator wall 204 is positioned along the lateral axis (A-A') of the casing 201. The lateral axis (A-A') of the casing 201 is substantially perpendicular to the horizontal axis (X-X') through the centre of the casing 201 as exemplarily illustrated in **FIG. 2**.

[0052] At Step 503, a mixture of oil and refrigerant vapor is received via the inlet 202. As the mixture of oil and refrigerant vapor enters the large internal volume of the condenser vessel 200, a nozzle 209 (exemplarily illustrated in **FIG. 4**) functions to immediately supply the mixture of oil and refrigerant vapor. The nozzle 209, seated within the inlet 202, includes the hollow shaft 209a, the pair of protruding jaw portions 209b, and the face plate 209c as disclosed in the detailed description of **FIG. 4**.

[0053] At Step 505, the mixture of oil and refrigerant vapor is separated by impinging the received mixture of oil and refrigerant vapor on either the face plate 209c of the nozzle 209 seated within the inlet 202 or the separator wall 204 or both. In an embodiment, the face plate 209c is oriented orthogonally relative to the central axis (I-I') of the inlet for redirecting the flow of the mixture of oil and refrigerant vapor to one or more of the inner surface of the oil storage and separation portion 206, the surface of the separator wall 204, and the bottom portion of the oil storage and separation portion 206 as exemplarily illustrated in **FIGS. 2-4**. The multiple impingement surfaces, such as, the face plate 209c, the inner surface of the oil storage and separation portion 206, and the surface of the separator wall 204 facing the oil storage and separation portion 206 improves separation of the refrigerant vapor from the mixture. The oil component of the mixture collects in the reservoir portion 208 of the oil storage and separation portion 206 as exemplarily illustrated in **FIG. 2** under the forces of gravity.

[0054] At Step 507, the plurality of mesh eliminators 207 further filter the mixture to aggregate oil particulates from the mixture to form larger oil droplets collected by a bottom portion of the oil storage and separator portion 206. Each mesh occupies the entire cross section of the oil storage and separator portion 206 so that the fluid mixture is forced to go through the mesh eliminators 207 on its path.

[0055] At Step 509, the oil separated from the mixture of the oil and the refrigerant fluid is discharged via the outlets 203 outside the condenser vessel 200. The condenser vessel 200 also includes the at least one outlet tube 211 immersed in each of the reservoir portions 208 of the oil storage and separation portion 206, such that the outlet tube 211 is adapted to transfer oil from the reservoir portion 208 to the outlet 203 of the casing 201.

[0056] At Step 511, the separated refrigerant vapor is conveyed, via the plurality of vents 204a defined in the separator wall 204, to the condenser portion 205. The refrigerant vapor is then condensed within the condenser portion 205 and subsequently cooled to a liquid state and

conveyed to the expansion valve 102 using the refrigerant liquid line 205a as exemplarily illustrated in **FIG. 1**.

[0057] The condenser vessel 200 according to the disclosure, exemplarily illustrated in **FIGS. 1-4**, have several advantages over the existing designs of the condenser vessel 200. Most importantly, the height of the vents 204a defined in the separator wall 204 from the oil level surface is increased to the highest level possible in the casing 201 having a hollow cylindrical geometrical configuration. This increase in height between the oil level surface and the vents 204a is achieved by inclining the separator wall 204 substantially perpendicular to the horizontal axis X-X' as exemplarily illustrated in **FIGS. 2-3**. The inclination of the separator wall 204 may be in a range of 80° to 90° instead of 30° as in the case of existing designs. The increased height also means the internal storage volume of the oil storage and separation portion 206 is increased. This increased storage volume prevents overflow of oil at operating conditions into the condenser portion 205 of the condenser vessel 200.

[0058] Secondly, the mesh eliminators 207 on each side of the inlet 202 define the reservoir portion 208. The reservoir portions 208 extend downstream from the mesh eliminators 207 in a direction towards the lateral ends of the casing 201. This increased area of the reservoir portions 208 on either side of the inlet 202 allows the accumulation of more oil without raising the oil level in the internal volume of the casing 201. In an embodiment, the oil level of each of the reservoir portions 208 is greater than the oil level in a portion of the casing 201 below the inlet 202 of the casing 201. The reservoir portions 208 prevent excessive rise of residual oil towards the refrigerant outlets 204a of the condenser vessel 200. This feature prevents re-entrainment and improves the detection of the oil level using the sensor 210. Moreover, the reservoir portions 208 provide an increased area for collecting the separated oil for a particular shell diameter.

[0059] Thirdly, existing oil storage and separation portion 206 designs incorporate a dual entry-single exit arrangement. This means existing oil storage and separation portion 206 designs include two or more inlet means in addition to a single outlet means. However, in the embodiment according to the disclosure, the oil storage and separation portion 206 utilizes a single entry-dual exit arrangement. This means the oil storage and separation portion 206 includes a single inlet 202 and two or more outlets 203. This arrangement reduces the flow velocity of the mixture of oil and refrigerant vapor thereby enhancing separation of oil in addition to preventing oil particles from inadvertently being conveyed to the condenser portion 205. Moreover, the provision of the outlet tubes 211 for supplying the separated oil to the outlets 203 eliminates external connections and external tubing from the bottom or side of the casing 201 as in the case of existing products for supplying the oil back to the compressor 101 as exemplarily illustrated in **FIG. 1**.

[0060] Fourth, the provision of multiple impingement surfaces, such as, the face plate 209c, the inner surface

of the casing 201, and the surface of the separator wall 204 facing the oil storage and separation portion 206 improves the separation of the refrigerant vapor from the mixture of oil and the refrigerant vapor.

[0061] Fifth, the sensor 210 for detecting the level of oil is mounted directly on a bottom surface of the reservoir portion 208 of the casing 201 as exemplarily illustrated in **FIG. 1**. This configuration ensures improved accuracy and robust installation of the sensor 210.

[0062] As would be apparent to a person in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein.

[0063] Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts.

[0064] The drawings and the forgoing description give examples of embodiments. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For example, orders of processes described herein may be changed and are not limited to the manner described herein.

[0065] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the described benefits, advantages, solutions to problems, and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as limiting. Instead, the scope of protection is defined only by the appended claims.

Claims

1. A condenser vessel (200) including an oil storage and separation portion (206) for separating a refrigerant vapor from oil in a temperature conditioning system (100), the condenser vessel comprising: a casing (201) having an inlet (202), adapted to receive a mixture of oil and refrigerant vapor, and an outlet (203) adapted to transfer the oil separated from the mixture of the oil and the refrigerant vapor outside the condenser vessel; and a separator wall (204) positioned inside the casing to define a condenser portion (205) and the oil storage and separation portion within the casing, wherein the separator wall is positioned along a lateral axis (A-A') of the casing.
2. The condenser vessel according to claim 1, wherein the lateral axis (A-A') is substantially perpendicular to a horizontal axis (X-X') passing through a centre of the casing.

3. The condenser vessel according to claim 1 or 2, wherein the separator wall comprises a plurality of vents (204a) defined proximal to an upper end of the separator wall for transferring refrigerant vapor separated from the mixture of the oil and the refrigerant vapor to the condenser portion. 5
4. The condenser vessel according to any preceding claim, wherein the condenser portion condenses the refrigerant vapor to refrigerant fluid and transfers the refrigerant fluid to an expansion valve (102) via a refrigerant liquid line. 10
5. The condenser vessel according to any preceding claim, wherein the oil storage and separation portion is enclosed within a secondary casing (201') inside the casing of the condenser vessel. 15
6. The condenser vessel according to any preceding claim, wherein the oil storage and separation portion further comprises a plurality of mesh eliminators (207) disposed on the separator wall on both sides of the inlet and in contact with an inner periphery of the casing, wherein the mesh eliminators are spaced apart from each other; and, optionally, wherein each of the mesh eliminators define a reservoir portion (208) downstream of the mesh eliminators enclosed by the casing. 20
7. The condenser vessel according to any preceding claim, wherein the inlet further comprises a nozzle (209) seated within the inlet, wherein the nozzle comprises: 25
 - a hollow shaft (209a) having an external diameter smaller than an internal diameter of the inlet, the hollow shaft adapted to be removably fastened to the inlet; and
 - a pair of protruding jaw portions (209b) extending from the hollow shaft and disposed radially opposite to each other, wherein the pair of protruding jaw portions are adapted to support a face plate (209c); 30

and, optionally, wherein a central axis (I-I') of the inlet is inclined at an acute angle relative to the lateral axis (A-A') of the casing. 35
8. The condenser vessel according to claim 7, wherein the face plate is oriented orthogonally relative to a central axis (I-I') of the inlet to redirect a flow of a mixture of oil and refrigerant vapor to at least one of an inner surface of the casing, a surface of a separator wall, and a bottom portion of the casing. 40
9. The condenser vessel according to any preceding claim, wherein the vents are defined in the separator wall proximal to ends of the casing and distal from the inlet of the casing; and/or wherein an internal volume of the oil storage and separation portion is at least equal to an internal volume of the condenser portion. 45
10. The condenser vessel according to any preceding claim, further comprising at least one sensor (210) adapted to detect an oil level in the reservoir portion. 50
11. The condenser vessel according to claim 10, wherein the at least one sensor is mounted on a bottom surface of the reservoir portion of the casing. 55
12. The condenser vessel according to any preceding claim, further comprising at least one outlet tube (211) immersed in each of the reservoir portions of the oil storage and separation portion, wherein the outlet tube is adapted to transfer oil from the reservoir portion to the outlet of the casing; and/or wherein an oil level of each of the reservoir portions is greater than an oil level in a portion of the casing below the inlet of the casing.
13. A temperature conditioning system (100), having a refrigerant circuit comprising:
 - a compressor (101), for compressing a refrigerant vapor;
 - a condenser vessel (200) including an oil storage and separation portion for separating oil from a mixture of oil and refrigerant vapor discharged from the compressor, the oil storage and separation portion adapted to transfer the separated refrigerant vapor to a condenser portion;
 - the condenser portion for condensing the separated refrigerant vapor;
 - an expansion valve (102) for expanding the condensed refrigerant fluid; and
 - an evaporator (103) for evaporating the refrigerant fluid, wherein the compressor, the condenser vessel, the condenser portion, the expansion valve, and the evaporator are connected in sequence, and wherein the condenser vessel is according to any of the preceding claims.
14. The system according to claim 13, wherein the condenser vessel comprises a separator wall positioned inside a casing to define the condenser portion and the oil storage and separation portion within the casing, wherein the separator wall is positioned along a lateral axis (A-A') of the casing substantially perpendicular to a horizontal axis (X-X') through a center of the casing; and/or wherein an internal volume of the oil storage and separation portion is at least equal to an internal volume of the condenser portion.

15. A method (500) for separating oil from a refrigerant fluid in a temperature conditioning system, the method comprising:
providing (501) a condenser vessel comprising:

a casing having an inlet and an outlet; and
a separator wall positioned inside the casing to define a condenser portion and an oil storage and separation portion within the casing, wherein the separator wall is positioned along a lateral axis (A-A') of the casing; and
receiving (503), via the inlet, a mixture of oil and refrigerant vapor;
separating (505) refrigerant vapor by impinging the received mixture of oil and refrigerant vapor on at least one of a face plate of a nozzle seated within the inlet and the separator wall;
filtering (507) the mixture using a plurality of mesh eliminators to aggregate oil particulates from the mixture to form larger oil droplets collected by a bottom portion of the oil storage and separator portion;
discharging (509), via the outlet, the oil separated from the mixture of the oil and the refrigerant vapor outside the condenser vessel; and
conveying (511) the separated refrigerant vapor, via a plurality of vents defined in the separator wall, to the condenser portion.

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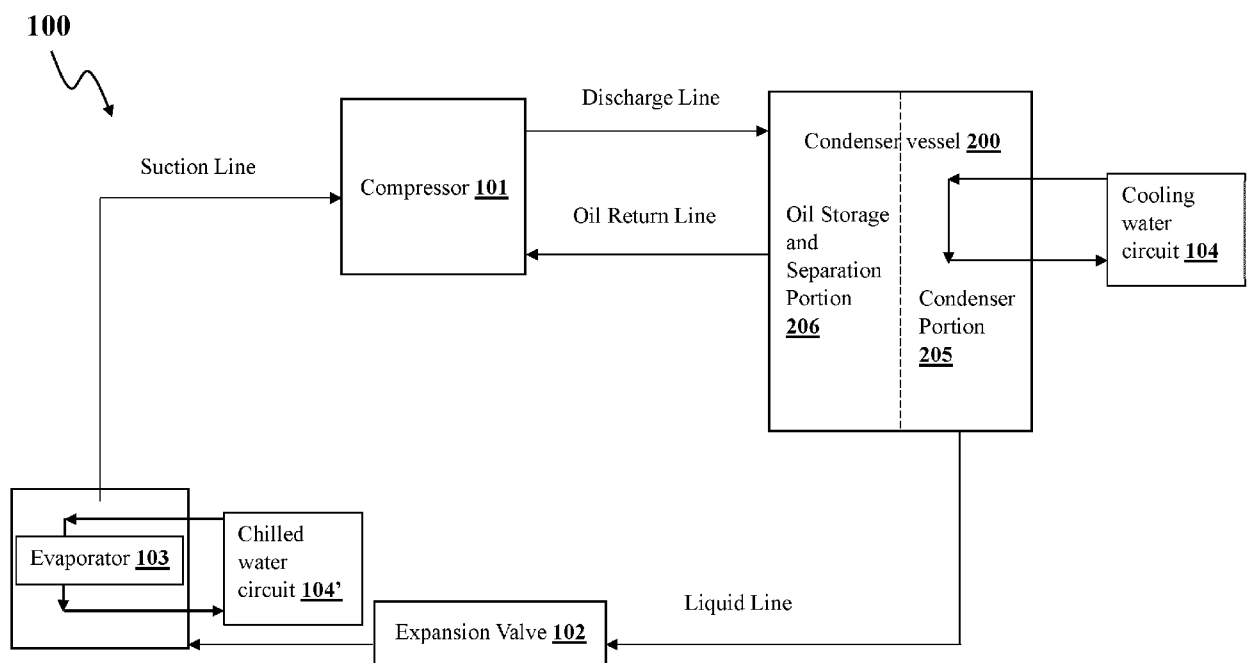


FIG. 1

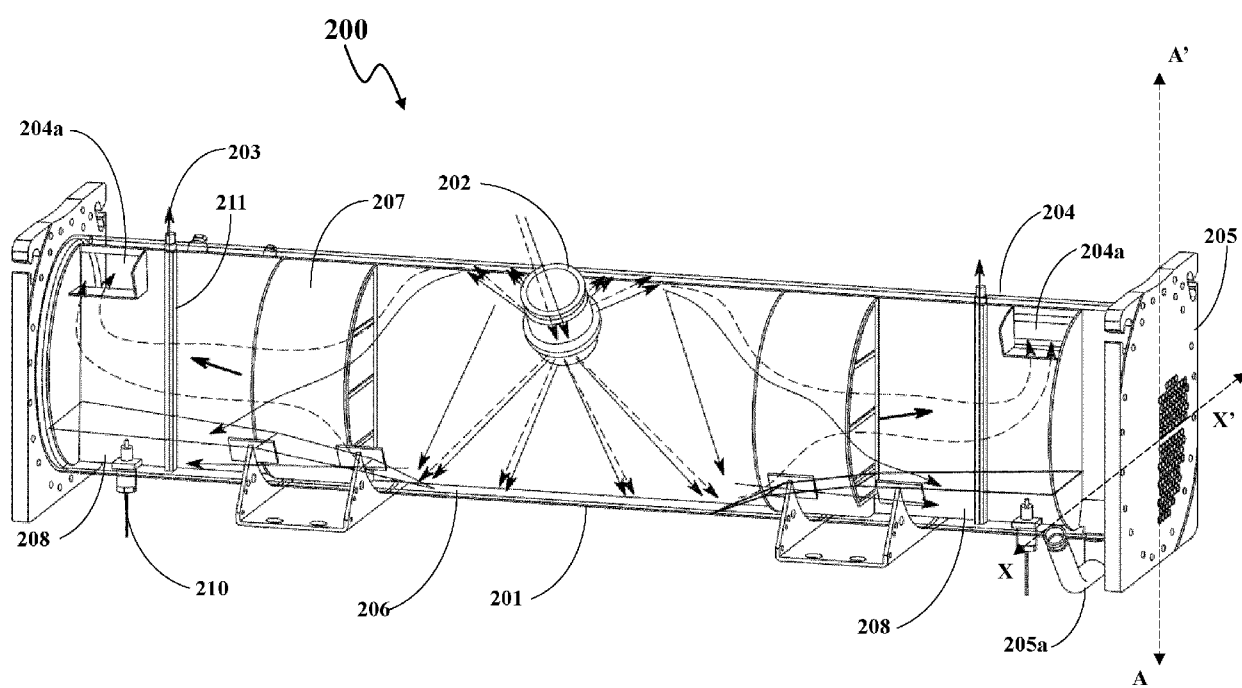


FIG. 2

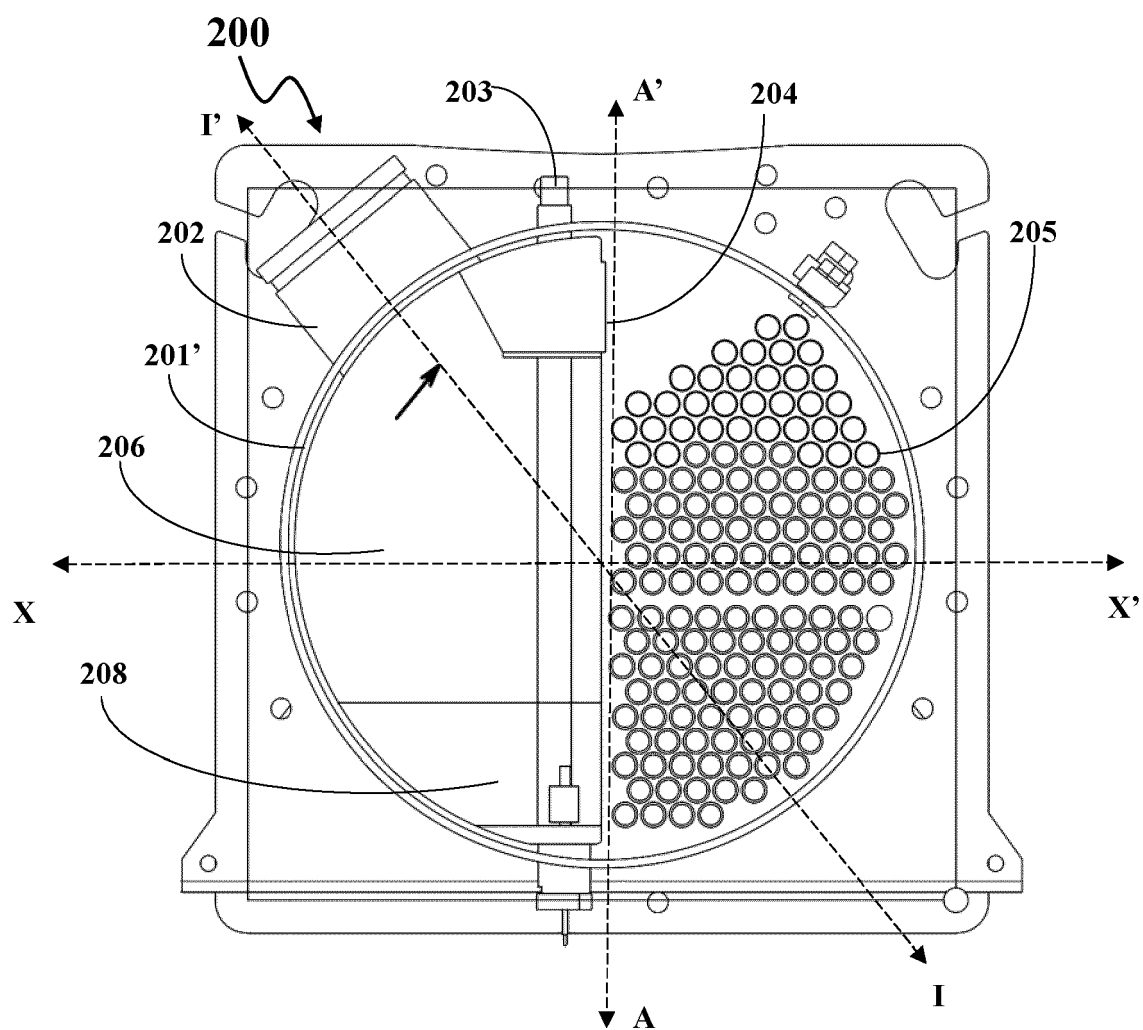


FIG. 3

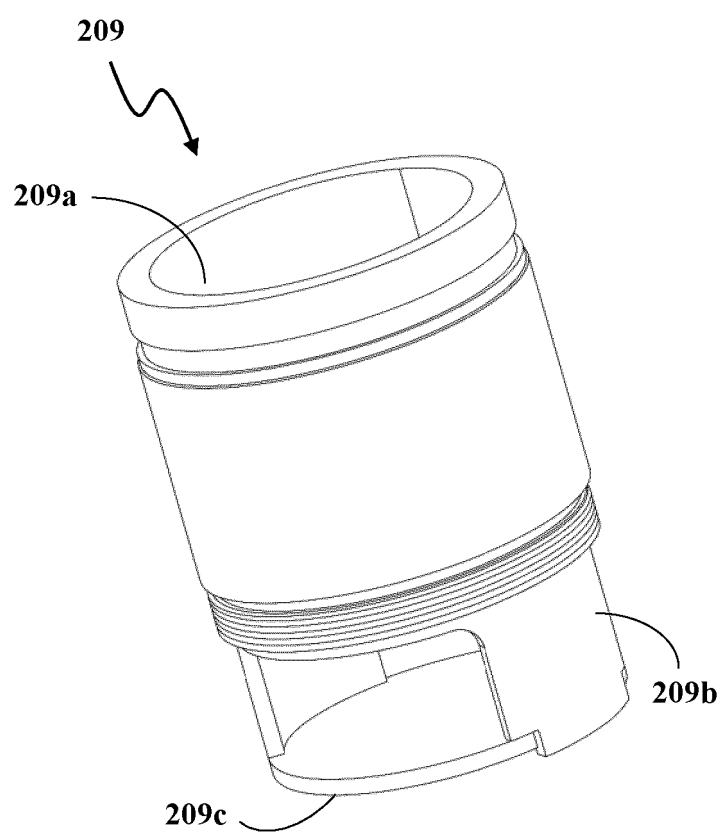
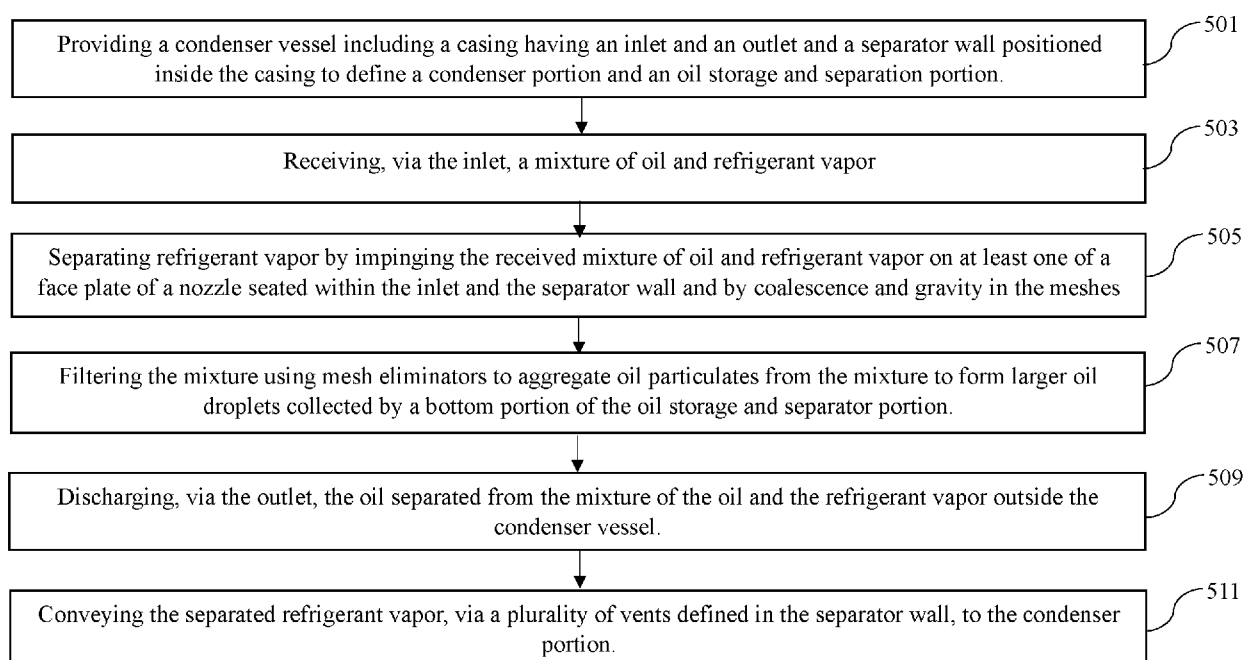


FIG. 4

500**FIG. 5**



EUROPEAN SEARCH REPORT

Application Number

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Place of search Munich		Date of completion of the search 18 March 2025	Examiner Lepers, Joachim
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