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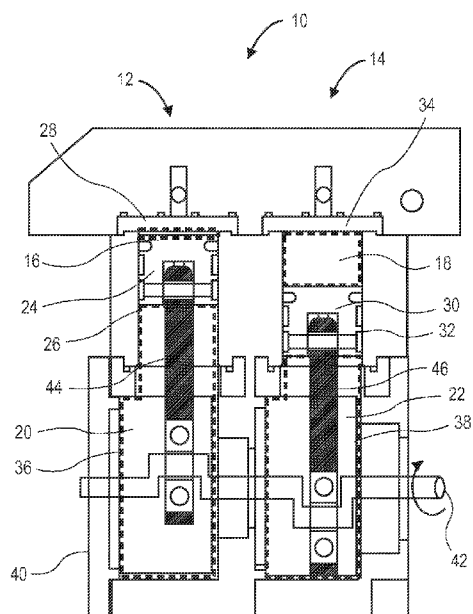


FIG. 1

(57) Abstract: A compressor includes a first piston, a second piston, and a crank. A first case chamber is defined by a lower surface of a first piston head, a portion of a first cylinder surface disposed below the lower surface of the first piston head, and a first case surface. A second case chamber is defined by a lower surface of a second piston head, a portion of a second cylinder surface disposed below the lower surface of the second piston head, and a second case surface. The first case chamber and the second case chamber are fluidly isolated from one another. The crank is to reciprocate the first piston head and the second piston head up and down.

COMPRESSOR DEVICE AND METHOD

FIELD OF THE INVENTION

[0001] The disclosure generally relates to a refrigerant recovery unit. More particularly, the disclosure relates to an improved compressor and method of utilizing the improved compressor in the refrigerant recovery unit.

BACKGROUND OF THE INVENTION

[0002] Portable refrigerant recovery units or carts are used in connection with the service and maintenance of refrigeration systems, such as a vehicle's air conditioning system. The refrigerant recovery unit connects to the air conditioning system of the vehicle to recover refrigerant out of the system, separate out oil and contaminants from the refrigerant in order to recycle the refrigerant, and recharge the system with additional refrigerant.

[0003] During refrigerant recovery, the refrigerant recovery unit draws the refrigerant out of the air conditioning system or other such refrigeration system. The refrigerant is generally drawn out in vapor phase and is typically compressed by the refrigerant recovery unit and then cooled in order to collect the refrigerant in a storage container. Unfortunately, this compression uses a significant amount of energy and relatively powerful motors that may be large and heavy may be used in order to compress the refrigerant quickly. However, particularly in a portable refrigerant recovery unit, a heavy motor can negatively impact the portability, ease of use, and/or ease of storage.

[0004] Accordingly, it is desirable to provide a device and method capable of overcoming the disadvantages described herein at least to some extent.

SUMMARY OF THE INVENTION

[0005] The foregoing needs are met, to a great extent, by the present invention, wherein in some respects an improved compressor and method of utilizing the improved compressor in a refrigerant recovery unit is provided.

[0006] An embodiment of the present invention pertains to a compressor. The compressor includes a first piston, a second piston, and a crank. The first piston has a first piston head, a first cylinder surface, a first case surface, a first piston chamber, and a first case chamber. The first case chamber is defined by a lower surface of the first piston head, a portion of the first cylinder surface disposed below the lower surface of the first piston head, and the first case surface. The second piston has a second piston head, a second cylinder surface, a second case surface, a second piston chamber, and a second case chamber. The second case chamber is defined by a lower surface of the second piston head, a portion of the second cylinder surface disposed below the lower surface of the second piston head, and the second case surface. The first case chamber and the second case chamber are fluidly isolated from one another. The crank is to reciprocate the first piston head and the second piston head up and down.

[0007] Another embodiment of the present invention relates to a refrigerant recovery unit. The refrigerant recovery unit includes a service coupler and a compressor. The service coupler is configured to convey a refrigerant to a refrigeration system. The compressor includes a first piston, a second piston, and a crank. The first piston has a first piston head, a first cylinder surface, a first case surface, a first piston chamber, and a first case chamber. The first case chamber is defined by a lower surface of the first piston head, a portion of the first cylinder surface disposed below the lower surface of the first piston head, and the first case surface. The second piston has a second piston head, a second cylinder surface, a second case surface, a second piston chamber, and a second case chamber. The second case chamber is defined by a lower surface of the second piston head, a portion of the second cylinder surface disposed below the lower surface of the second piston head, and the second case surface. The first case chamber and

the second case chamber are fluidly isolated from one another. The crank is to reciprocate the first piston head and the second piston head up and down.

[0008] Yet another embodiment of the present invention pertains to a method of compressing a refrigerant. In this method, the refrigerant is compressed with a first piston having a first piston head, a first cylinder surface, a first case surface, a first piston chamber, and a first case chamber. The first case chamber is defined by a lower surface of the first piston head, a portion of the first cylinder surface disposed below the lower surface of the first piston head, and the first case surface. The refrigerant is also compressed with a second piston having a second piston head, a second cylinder surface, a second case surface, a second piston chamber, and a second case chamber. The second case chamber is defined by a lower surface of the second piston head, a portion of the second cylinder surface disposed below the lower surface of the second piston head, and the second case surface. The first case chamber and the second case chamber are fluidly isolated from one another. The first piston head and the second piston head are reciprocated up and down with a crank.

[0009] There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

[0010] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

[0011] As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a cutaway view of an isolated piston compressor in accordance with an embodiment.

[0013] FIG. 2 is another cutaway view of the isolated piston compressor in accordance with the embodiment of FIG. 1.

[0014] FIG. 3 is a perspective view of a refrigerant recovery unit in accordance with an embodiment.

[0015] FIG. 4 is a schematic diagram illustrating components of the refrigerant recovery unit shown in FIG. 1.

[0016] FIG. 5 is a schematic diagram illustrating another example of components of the refrigerant recovery unit shown in FIG. 1.

DETAILED DESCRIPTION

[0017] According to various embodiments described herein, an isolated piston compressor is provided that exhibits improved efficiency as compared to conventional compressors. For the purposes of this disclosure, the term, “isolated pistons” refers to pistons that have case chambers in fluid isolation from one another. The term, “case chamber” as used herein refers to a chamber disposed below the piston head. The isolated piston compressor is particularly suitable for use with a refrigerant recovery unit to service a refrigeration system. As used herein, the term, “servicing” refers to any suitable procedure performed on a refrigeration or air conditioning system such as, for example, recovering refrigerant, recharging refrigerant into the refrigeration

system, testing refrigerant, leak testing the refrigeration system, recovering the lubricant, replacing the lubricant, and the like. An embodiment of the isolated piston compressor disclosed herein may be used to improve compressor performance by improving efficiency, reducing start-up load, distributing load throughout the compression cycle, and the like. In this or other embodiments, the efficiencies gained by the improved isolated piston compressor performance may be utilized to decrease the power requirements of a motor used to drive the isolated piston compressor while maintaining compressor performance of a more powerful motor, increase compressor performance relative to motors of the same power output, or a combination of both. This improved compressor performance is particularly beneficial to portable refrigerant recovery units that are carried from place to place.

[0018] Embodiments will now be described with reference to the drawing figures, in which like reference numerals refer to like parts throughout. As shown in FIG. 1, an isolated piston compressor 10 includes a pair of pistons 12 and 14, having respective piston chambers 16 and 18 and respective case chambers 20 and 22. The piston chamber 16 is defined by an upper face of a piston head 24, side walls of a cylinder 26, and a cylinder head 28. The piston chamber 18 is defined by an upper face of a piston head 30, side walls of a cylinder 32, and a cylinder head 34. The case chamber 20 is defined by a lower face of the piston head 24 and side walls of a case 36. The case chamber 22 is defined by a lower face of the piston 30 and side walls of a case 38. The case chambers 20 and 22 are disposed within a crank case 40. The isolated piston compressor 10 includes a crank 42 that is rotated by a motor (shown in FIG. 4). Rotation of the crank 42 urges the piston heads 24 and 30 to reciprocate respectively within the piston chambers 16 and 18 respectively via a pair of piston rods 44 and 46.

[0019] Of note, while two pistons 12 and 14 are shown and described herein, the various embodiments need not be confined to two pistons, but rather, may include any suitable number of pistons. For example, the isolated piston compressor 10 may include 3, 4, 5, 6, or more pistons. In an embodiment, each of these multiple pistons are isolated as shown and described herein.

[0020] Due to physical traits of gas approximated by the ideal gas law expressed by the equation $PV=nRT$ (Pressure multiplied by Volume is equal to an amount of gas multiplied by the gas constant multiplied by the temperature), the decrease of volume in the downstroke position (e.g., piston 14 in FIG.1) causes the pressure within the case chamber 22 to increase. This pressure creates a resultant force in the same direction that the piston 14 moves in its upstroke (Shown in FIG. 2), increasing efficiency. This increased efficiency is due to fluidly isolating the case chamber 20 from the case chamber 22. Separately isolating the pistons 12 and 14 and their corresponding case chambers 20 and 22 in the crank case 40 exploits the internal pressure advantages a single piston design evokes. That is, as each piston 12 and 14 ascends on its upstroke, it is further supported by the internal pressure build up in its individual case chamber 20 and 22 volume which occurred on the respective downstroke. However, it also exploits rapid recovery advantages of having multiple pistons. For example, the upstroke portion (e.g., piston 12 in FIG. 1) of the piston cycle generally utilizes more power from the motor turning the crank 42 than the downstroke portion of the piston cycle (e.g., piston 14 in FIG. 1). However, having two (or more) pistons facilitates balancing power output from the motor because as piston 12 is in the upstroke portion of the piston cycle, piston 14 is in the downstroke portion of the piston cycle due to the configuration of the crank 42.

[0021] In operation, the case chambers 20 and 22 receive gas via leakage between the respective piston head 24 and 30 and the respective cylinder 26 and 32. While the leakage is relatively small, over time, the case chambers 20 and 22 come to a dynamic equilibrium with the respective piston chambers 16 and 18. That is, leakage proceeds from the piston chamber 16 to the case chamber 20 during the upstroke of the piston 12 and leakage proceeds from the case chamber 20 to the piston chamber 16 during the downstroke of the piston 12. The term, “dynamic equilibrium” refers to the state at which the leakage back and forth past the piston head 24 is approximately equal. A similar dynamic equilibrium occurs between the case chamber 22 and the piston chamber 18. Of note, because the case chambers 20 and 22 are isolated from one another, each of the case chambers 20 and 22 are free to maintain an individual pressure. That is, the

pressure in the case chamber 20 need not be the same as the pressure in the case chamber 22. This is a particular advantage if the flow of compressed fluid is conveyed in series from piston 12 to piston 14. In such an instance, the pressure achieved in the piston chamber 18 is relatively greater than the pressure in the piston chamber 16. As such, a higher case chamber pressure in the case chamber 22 (relative to the case chamber 20) facilitates greater efficiency. Due to the isolated piston configuration, each of the case chambers 20 and 22 can independently achieve a beneficial case chamber pressure.

[0022] FIG. 2 is another cutaway view of the isolated piston compressor 10 in accordance with the embodiment of FIG. 1. FIG. 2 is similar to FIG. 1, and thus, for the sake of brevity, those elements described in FIG. 1 will not be described again with reference to FIG. 2. As shown in FIG. 2, the volume of the piston chamber 16 increases as the piston head 24 is moved to the downstroke position and the volume of the case chamber 20 decreases a corresponding amount. As the volume of the case chamber 20 decreases, the pressure in the case chamber 20 increases and urges the piston head 24 back up. This urging of the piston head 24 augments power from the motor (shown in FIG. 4) which decreases the power requirements of the motor.

[0023] FIG. 3 is a perspective view illustrating an exemplary portable refrigerant recovery unit 100 that is suitable for use with the isolated piston compressor 10. However, the isolated piston compressor 10 need not be used with the portable refrigerant recovery unit 100, but rather, may be used with any suitable device. Examples of suitable devices generally include any machine for compressing a compressible fluid such as refrigerant, air, and the like. To continue, the refrigerant recovery unit 100 includes an enclosure 112 that may be made from molded plastic and the like. The enclosure 112 can be designed to enclose the major components of the refrigerant recovery unit 100 as discussed herein. The portable refrigerant recovery unit 100 can also include a handle 114 for a user to move the refrigerant recovery unit 100 from one place to another. The handle 114 can be made from the same material as the enclosure 112 or from an elastomeric material for more comfort to the user. Feet 116 can be positioned on a bottom portion of the enclosure 112 in order to keep the refrigerant recovery unit 100 from touching the ground.

[0024] A power connection 118 can be used to provide power to the refrigerant recovery unit 100 when plugged into a power source (not shown). A circuit breaker 120 can be provided to protect the refrigerant recovery unit 100 from any surge in the power source. In one embodiment, the circuit breaker 120 and power connection 118 can be provided on a front portion of the refrigerant recovery unit 100.

[0025] The front portion of the refrigerant recovery unit 100 also includes an inlet fitting 122 and an outlet fitting 124. The inlet fitting 122 can be used to receive refrigerant from a refrigerant containing system (not shown), such as an air conditioning system, and the outlet fitting 124 can be used to send the recovered refrigerant to the refrigerant containing system (not shown). The inlet fitting 122 can include a replaceable filter (not shown) to remove any contaminants that may be in the recovered refrigerant of the refrigerant containing system (not shown). A control knob 126 can be used to control the functionality of the inlet fitting 122 and a control knob 128 can control the functionality of the outlet fitting 124. A self purge knob 130 can be provided to purge contaminants or remaining refrigerant from the refrigerant containing system. High side and low side pressure gauges 132 and 134 can be provided on a top surface to show the respective pressures. A power button 136 can also be provided on the top surface to turn on and off the refrigerant recovery unit 100.

[0026] Referring now to FIGS. 4 and 5, components of the refrigerant recovery unit 100 in accordance with aspects of the present invention are illustrated. FIG. 5 differs from FIG. 4 in that a flow path 214 is divided into two to provide a more even distribution for pistons 12 and 14 (shown in FIGS. 1 and 2) in the isolated piston compressor 10 to reciprocate accordingly. Additionally, although like reference numerals refer to like parts throughout, this is not to imply that referenced parts or equivalents in relation to any one aspect may not be used alone, excluded, or used in combination with other parts described in other embodiments.

[0027] As shown in FIGS. 4 and 5, a motor 210 can be coupled to the isolated piston compressor 10. The inlet fitting 122 can include an inlet valve 212 that may be controlled by the control knob 126 to open or close. As noted, the refrigerant from the refrigerant containing

system (not shown) can enter the inlet valve 212 and flow to the isolated piston compressor 10 as shown in a flow path 214. In some embodiments, including but not limited to the exemplary embodiment depicted in FIG. 4, the flow path 214 may split into flow paths 216 and 218 that enter into separate piston chambers (shown in FIGS. 1 and 2) of the isolated piston compressor 10.

[0028] The motor 210 operates to rotate the crank 42 and cause the pistons 12 and 14 in the isolated piston compressor 10 to force the refrigerant at the respective ends of the isolated piston compressor 10 into one or more flow paths. For example, in FIG. 4 the refrigerant is forced into two flow paths 220 and 222, which combine back into a single flow path 224. As depicted in FIG. 5, the refrigerant can be pushed into a single flow path 224 and then proceed through a valve 227. Valve 227 can relate, for example, to a purge function of the refrigerant recovery unit 100. From valve 227, the refrigerant can travel via flow path 228 into a condenser 232. A fan 230 can help keep the condenser 232 cool while it is operating. Condensed refrigerant may be conveyed along a flow path 236, past a check valve 238, and out an outlet 242. The outlet 242 may be connected to a refrigerant storage tank or the like.

[0029] In accordance with the present invention, a load controller 300 system and associated methods can be implemented by the refrigerant recovery unit 100 to relieve the higher pressure loads the compressor's motor 210 is subjected to during start up and/or during abnormal refrigerant flow. As depicted in FIGS. 4 and 5, the load controller 300 system comprises a solenoid 305 configured to control refrigerant flow through a compressor bypass loop line 310 with a first end 301 connected to the flow path 214 going into an inlet of the isolated piston compressor 10 and a second end 302 connected to the flow path 224 connected to the outlet of the isolated piston compressor 10. The compressor bypass loop line 310 may be a flexible hose or any other suitable conduit providing a liquid connection therebetween.

[0030] The many features and advantages of the invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the true spirit and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not

desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed is:

1. A compressor comprising:

a first piston having a first piston head, a first cylinder surface, a first case surface, a first piston chamber, and a first case chamber, the first case chamber being defined by a lower surface of the first piston head, a portion of the first cylinder surface disposed below the lower surface of the first piston head, and the first case surface;

a second piston having a second piston head, a second cylinder surface, a second case surface, a second piston chamber, and a second case chamber, the second case chamber being defined by a lower surface of the second piston head, a portion of the second cylinder surface disposed below the lower surface of the second piston head, and the second case surface, wherein the first case chamber and the second case chamber are fluidly isolated from one another; and

a crank to reciprocate the first piston head and the second piston head up and down.

2. The compressor according to claim 1, further comprising a motor to rotate the crank.

3. The compressor according to claim 1, further comprising a refrigerant flow path from an inlet, through the compressor, and to an outlet.

4. The compressor according to claim 3, wherein the refrigerant flow path flows in parallel through the first piston and the second piston.

5. The compressor according to claim 3, wherein the refrigerant flow path flows in series from the first piston to the second piston.

6. The compressor according to claim 3, further comprising a condenser in fluid communication with the refrigerant flow path.

7. The compressor according to claim 1, further comprising a third piston having a third piston head, a third cylinder surface, a third case surface, a third piston chamber, and a third case chamber, the third case chamber being defined by a lower surface of the third piston head, a portion of the third cylinder surface disposed below the lower surface of the third piston head, and the third case surface, wherein the first case chamber, the second case chamber, and the third case chamber are fluidly isolated from one another.

8. A refrigerant recovery unit, comprising:

a service coupler configured to convey a refrigerant to a refrigeration system; and

a compressor comprising:

a first piston having a first piston head, a first cylinder surface, a first case surface, a first piston chamber, and a first case chamber, the first case chamber being defined by a lower surface of the first piston head, a portion of the first cylinder surface disposed below the lower surface of the first piston head, and the first case surface;

a second piston having a second piston head, a second cylinder surface, a second case surface, a second piston chamber, and a second case chamber, the second case chamber being defined by a lower surface of the second piston head, a portion of the second cylinder surface disposed below the lower surface of the second piston head, and the second case surface, wherein the first case chamber and the second case chamber are fluidly isolated from one another; and

a crank to reciprocate the first piston head and the second piston head up and down.

9. The refrigerant recovery unit according to claim 8, further comprising a motor to rotate the crank.

10. The refrigerant recovery unit according to claim 8, further comprising a refrigerant flow path from an inlet, through the compressor, and to an outlet.
11. The refrigerant recovery unit according to claim 10, wherein the refrigerant flow path flows in parallel through the first piston and the second piston.
12. The refrigerant recovery unit according to claim 10, wherein the refrigerant flow path flows in series from the first piston to the second piston.
13. The refrigerant recovery unit according to claim 10, further comprising a condenser in fluid communication with the refrigerant flow path.
14. The refrigerant recovery unit according to claim 8, further comprising a third piston having a third piston head, a third cylinder surface, a third case surface, a third piston chamber, and a third case chamber, the third case chamber being defined by a lower surface of the third piston head, a portion of the third cylinder surface disposed below the lower surface of the third piston head, and the third case surface, wherein the first case chamber, the second case chamber, and the third case chamber are fluidly isolated from one another.
15. A method of compressing a refrigerant comprising the steps of:
 - compressing the refrigerant with a first piston having a first piston head, a first cylinder surface, a first case surface, a first piston chamber, and a first case chamber, the first case chamber being defined by a lower surface of the first piston head, a portion of the first cylinder surface disposed below the lower surface of the first piston head, and the first case surface;
 - compressing the refrigerant with a second piston having a second piston head, a second cylinder surface, a second case surface, a second piston chamber, and a second case chamber, the second case chamber being defined by a lower surface of the second piston head, a portion of the

second cylinder surface disposed below the lower surface of the second piston head, and the second case surface, wherein the first case chamber and the second case chamber are fluidly isolated from one another; and

reciprocating the first piston head and the second piston head up and down with a crank.

16. The method according to claim 15, further comprising the step of:
rotating the crank with a motor.
17. The method according to claim 15, further comprising the step of:
conveying the refrigerant through a refrigerant flow path from an inlet, through the compressor, and to an outlet.
18. The method according to claim 17, further comprising the step of:
conveying the refrigerant in parallel through the first piston and the second piston.
19. The method according to claim 17, further comprising the step of:
conveying the refrigerant in series from the first piston to the second piston.
20. The method according to claim 17, further comprising the step of:
condensing the refrigerant with a condenser in fluid communication with the refrigerant flow path.

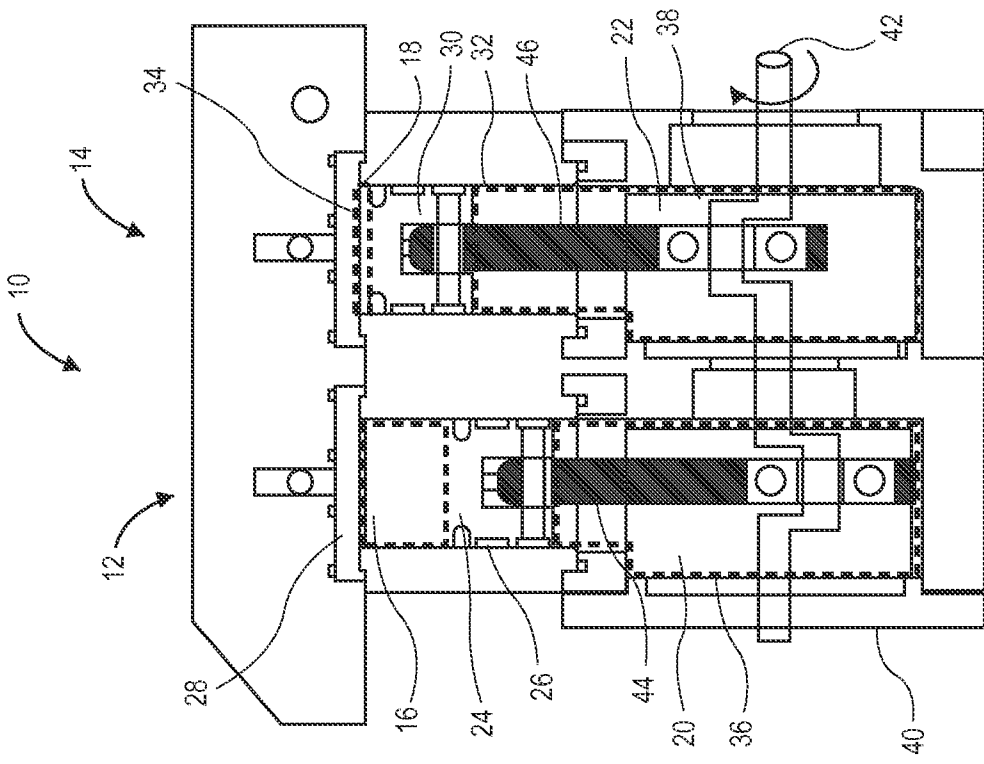


FIG. 1

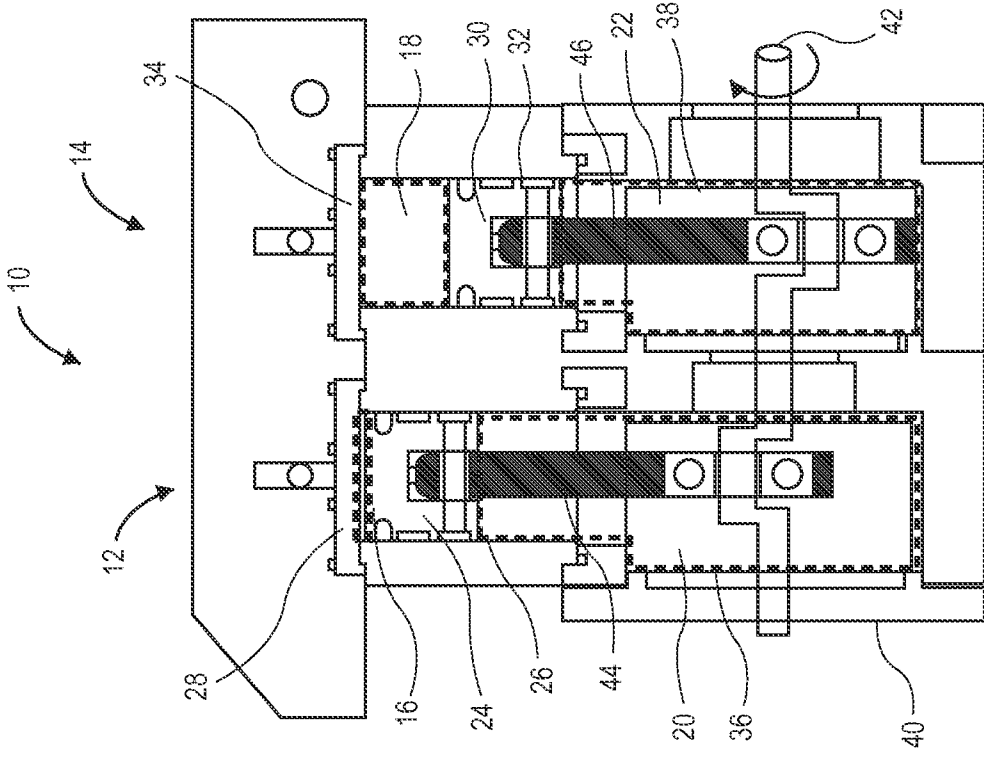


FIG. 2

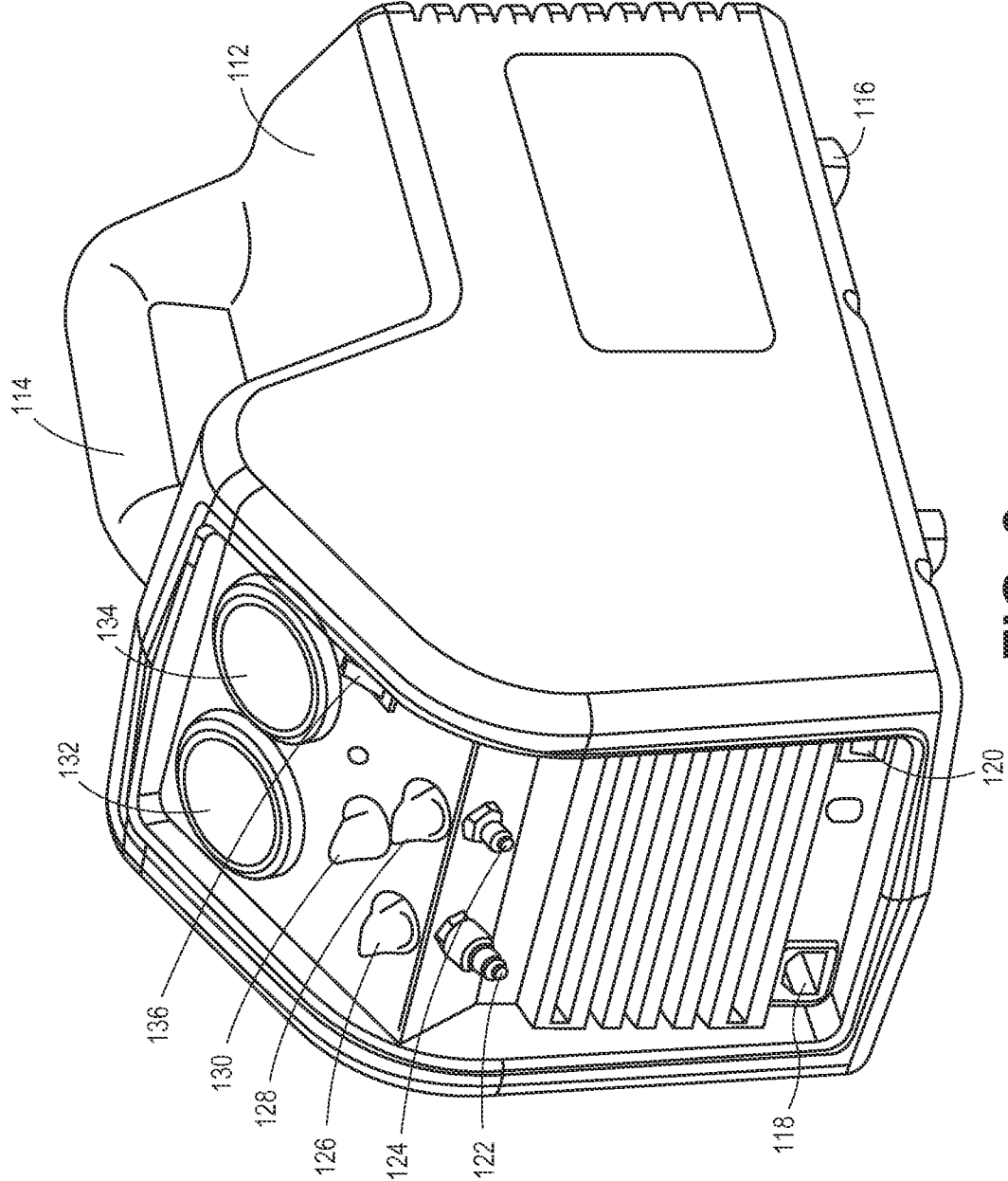


FIG. 3

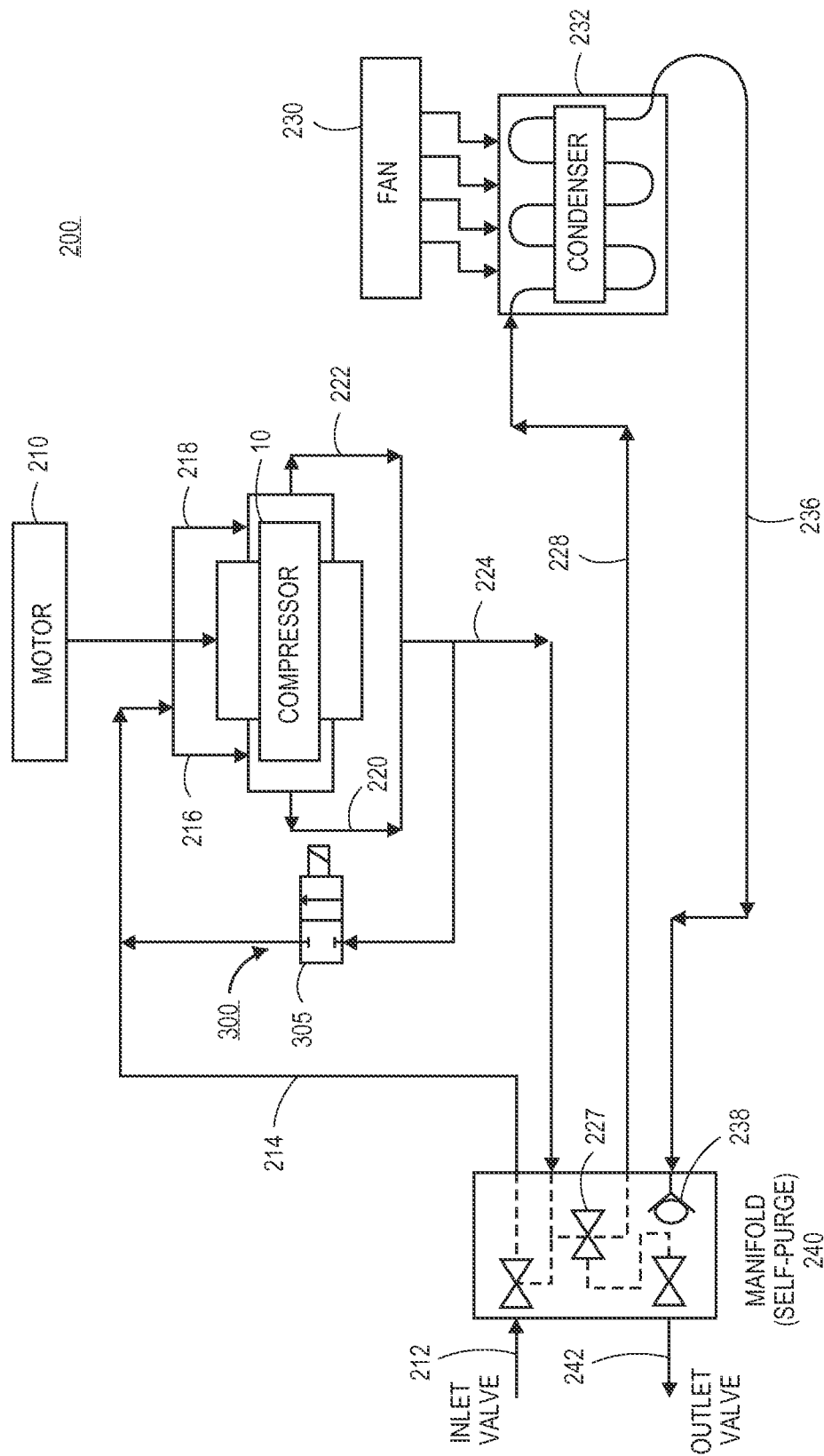


FIG. 4

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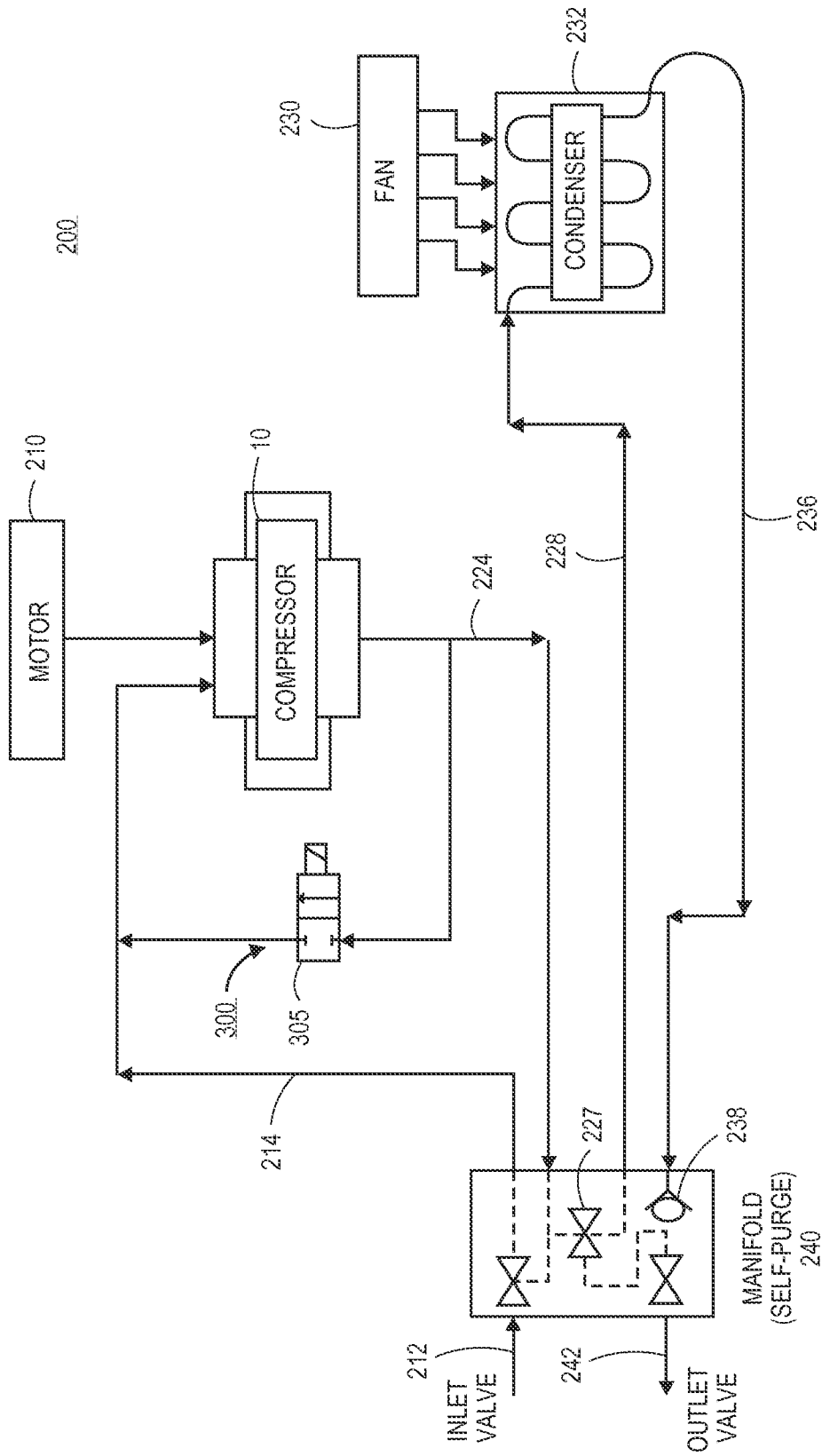


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/027903**A. CLASSIFICATION OF SUBJECT MATTER****F25B 43/00(2006.01)i, F25B 49/00(2006.01)i**

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 43/00; F15B 13/00; F04B 53/16; F16H 21/36; F15B 1/02; F25D 25/00; F25B 45/00; F25B 49/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: refrigerant, recovery, piston, crank, chamber, compressor, and path**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010-0154442 A1 (SCHOENOFF et al.) 24 June 2010 See abstract; paragraphs [0017]-[0027]; and figures 1-4.	1-20
A	US 2011-0120242 A1 (SUNDHEIM, GREGORY S.) 26 May 2011 See paragraphs [0024]-[0029]; and figures 1-5.	1-20
A	US 5,090,211 A (PETERS, RAYMOND L.) 25 February 1992 See column 4, line 13 - column 5, line 20; and figures 1,2.	1-20
A	US 2011-0132018 A1 (CHANG, AN CHAO) 09 June 2011 See paragraphs [0012]-[0019]; and figures 1-3.	1-20
A	US 2012-0119513 A1 (MCBRIDE et al.) 17 May 2012 See paragraph [0085]; and figure 5.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

26 June 2014 (26.06.2014)

Date of mailing of the international search report

27 June 2014 (27.06.2014)

Name and mailing address of the ISA/KR

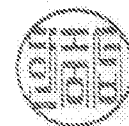
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/027903

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