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(54) **LINEAR COMPRESSOR FOR REFRIGERATION APPLIANCE AND REFRIGERATION SYSTEM**

(57) Disclosed is a refrigeration system, comprising a linear compressor (64), a casing (302), and a condenser (66), wherein the linear compressor (64) can comprise a shell (308) and a piston (316); the shell (308) can extend axially from a first end portion (304) to a second end portion (306); the shell (308) comprises an air cylinder assembly (310) for defining a cavity (312) approaching the second end portion (306), and the piston (316) can be received in the cavity (312) of the air cylinder assembly (310) in a slidable manner; the shell (308) further defines an oil reservoir (386), an oil drain (390) and a vent (392); the casing (302) defines an interior volume (303) enclosing the linear compressor (64) and lubricating oil therein; and on the downstream side, the condenser (66) is in fluid communication with the linear compressor (64) to receive a compressed refrigerant therefrom. The linear compressor can limit friction or contact between the piston and an air cylinder wall during operation.

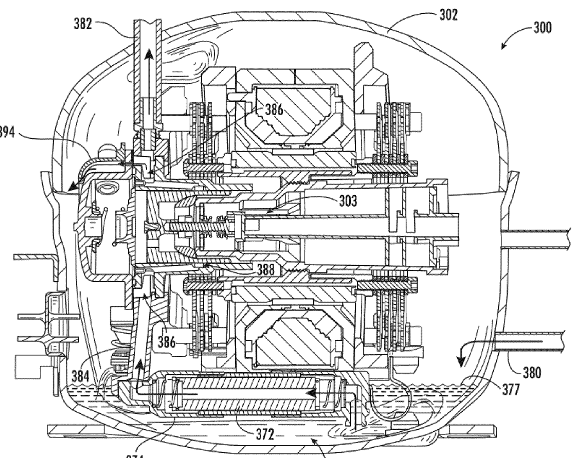

FIG. 4

EP 4 036 406 A1

Description

FIELD OF THE INVENTION

[0001] The present subject matter relates generally to compressor for an appliance, such as a refrigerator appliance.

BACKGROUND OF THE INVENTION

[0002] Certain refrigerator appliances include sealed systems for cooling chilled chambers of the refrigerator appliance. The sealed systems generally include a compressor that generates compressed refrigerant during operation of the sealed system. The compressed refrigerant flows to an evaporator where heat exchange between the chilled chambers and the refrigerant cools the chilled chambers and food items located therein.

[0003] Recently, certain refrigerator appliances have included linear compressors for compressing refrigerant. Linear compressors generally include a piston and a driving coil. The driving coil generates a force for sliding the piston forward and backward within a chamber. During motion of the piston within the chamber, the piston compresses refrigerant. However, friction between the piston and a wall of the chamber can negatively affect operation of the linear compressors if the piston is not suitably aligned within the chamber. In particular, friction losses due to rubbing of the piston against the wall of the chamber can negatively affect an efficiency of an associated refrigerator appliance. Such friction can also reduce heat lubrication oil between the piston and the wall of the chamber and thereby reduce an effectiveness of the lubrication oil.

[0004] Along with friction concerns generally, linear compressors may have concerns caused by the mixing of refrigerant with lubrication oil. For example, outgassing of refrigerant within the linear compressor may prevent lubrication oil from flowing as needed (e.g., to/from the piston). Specifically, outgassing of oil during operation of the compressor can lead to a lack of lubrication condition on the piston of the compressor, causing damage over time and higher friction levels. In order to address this issue, typical rotating shaft type compressors (i.e., reciprocating, rotary, scroll, screw, etc.) include vents on a rotating shaft that is typically used to pump oil using centrifugal force. These vents in the shaft can allow refrigerant to escape and separate from the oil, preventing vapor lock and permitting lubrication oil to bearings and sliding surfaces as needed. In a linear compressor, no such rotating oil pump exists, thus it can be especially difficult to remove refrigerant vapor from the oil as it is being pumped and delivered to surfaces needing lubricant (i.e., the piston sliding in the cylinder).

[0005] Accordingly, a linear compressor with features for limiting friction or contact between a piston and a wall of a cylinder during operation of the linear compressor would be useful. Additionally or alternatively, a linear compressor with features for cooling lubrication oil of the linear compressor would be useful. Also additionally or alternatively, a linear compressor with features for preventing lack of lubrication due to outgassing of refrigerant within the linear compressor would be useful.

BRIEF DESCRIPTION OF THE INVENTION

[0006] Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0007] In one exemplary aspect of the present disclosure, a sealed system is provided. The sealed system may include a linear compressor, a shell, a condenser, an oil outlet conduit, and a heat exchanger. The linear compressor may include a casing and a piston. The casing may extend along an axial direction from a first end portion to a second end portion. The casing may include a cylinder assembly defining a chamber proximal to the second end portion. The piston may be slidably received within the chamber of the cylinder assembly. The shell may define an internal volume enclosing the linear compressor and lubrication oil therein. The condenser may be in downstream fluid communication with the linear compressor to receive a compressed refrigerant therefrom. The oil outlet conduit may extend through the shell to the casing of the linear compressor. The heat exchanger may be spaced apart from the internal volume in fluid communication with the oil outlet conduit to receive lubrication oil from the linear compressor. The casing may further define an oil reservoir, an oil exhaust, and a gas vent. The oil reservoir may be positioned radially outward from the chamber of the cylinder assembly to selectively direct lubrication oil thereto. The oil exhaust may extend from the oil reservoir to the oil outlet conduit. The gas vent may extend from the oil reservoir to the internal volume in fluid parallel with the oil exhaust.

[0008] In another exemplary aspect of the present disclosure, a sealed system is provided. The sealed system may include a linear compressor, a shell, and a condenser. The linear compressor may include a casing and a piston. The casing may extend along an axial direction from a first end portion to a second end portion. The casing may include a cylinder assembly defining a chamber proximal to the second end portion. The piston may be slidably received within the chamber of the cylinder assembly. The shell may define an internal volume having a sump. The shell may enclose the linear compressor and lubrication oil therein. The condenser may be in downstream fluid communication with the linear compressor to receive a compressed refrigerant therefrom. The casing may further define an oil reservoir and a gas vent. The oil reservoir may be positioned radially outward from the chamber of the cylinder assembly to selectively direct lubrication oil thereto. The gas vent may extend from the oil reservoir to the internal volume through the second end portion. The linear compressor may further include an oil shield disposed on the casing at the second end portion in front of the gas vent to direct lubrication oil downward from the gas vent to the sump of the shell.

[0009] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures.

FIG. 1 is a front elevation view of a refrigerator appliance according to exemplary embodiments of the present disclosure.

FIG. 2 is a schematic view of certain components of the exemplary refrigerator appliance of FIG. 1 with respective exemplary oil cooling circuits according exemplary embodiments of the present disclosure.

FIG. 3 provides a section view of an exemplary linear compressor according to exemplary embodiments of the present disclosure.

FIG. 4 provides a section view of the exemplary linear compressor of FIG. 3, illustrating a flow path according to exemplary embodiments of the present disclosure.

FIG. 5 provides a side perspective section view of a portion of the exemplary linear compressor of FIG. 3.

FIG. 6 provides a bottom perspective section view of a portion of the exemplary linear compressor of FIG. 3.

DETAILED DESCRIPTION

[0011] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0012] As used herein, the terms "first," "second," and "third" may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components. The terms "upstream" and "downstream" refer to the relative flow direction with respect to fluid flow in a fluid pathway. For example, "upstream" refers to the flow direction from which the fluid flows, and "downstream" refers to the flow direction to which the fluid flows. The term "or" is generally intended to be inclusive (i.e., "A or B" is intended to mean "A or B or both").

[0013] Turning now to the figures, FIG. 1 depicts a refrigerator appliance 10 that incorporates a sealed refrigeration system 60 (FIG. 2). It should be appreciated that the term "refrigerator appliance" is used in a generic sense herein to encompass any manner of refrigeration appliance, such as a freezer, refrigerator/freezer combination, and any style or model of conventional refrigerator. In addition, it should be understood that the present disclosure is not limited to use in refrigerator appliances. Thus, the present subject matter may be used for any other suitable purpose, such as vapor compression within air conditioning units or air compression within air compressors.

[0014] In the illustrated exemplary embodiment shown in FIG. 1, the refrigerator appliance 10 is depicted as an upright refrigerator having a cabinet or casing 12 that defines a number of internal chilled storage compartments. In particular, refrigerator appliance 10 includes upper fresh-food compartments 14 having doors 16 and lower freezer compartment 18 having upper drawer 20 and lower drawer 22. The drawers 20 and 22 are "pull-out" drawers in that they can be manually moved into and out of the freezer compartment 18 on suitable slide mechanisms.

[0015] FIG. 2 provides schematic views of certain components of refrigerator appliance 10, including a sealed refrigeration system 60 of refrigerator appliance 10. In particular, FIG. 2 provides exemplary oil cooling circuit with sealed refrigeration system 60 according exemplary embodiments of the present disclosure. It should be understood that, except as otherwise indicated, the exemplary oil cooling circuit of FIG. 2 may be modified or used in or with any suitable appliance in alternative exemplary embodiments. For example, the exemplary oil cooling circuit of FIG. 2 may be used in or with heat pump dryer appliances, heat pump water heater appliance, air conditioner appliances, etc.

[0016] A machinery compartment of refrigerator appliance 10 may contain components for executing a known vapor compression cycle for cooling air. The components include a compressor 64, a condenser 66, an expansion device 68, and an evaporator 70 connected in series and charged with a refrigerant. As will be understood by those skilled in the art, refrigeration system 60 may include additional components (e.g., at least one additional evaporator, compressor, expansion device, or condenser). As an example, refrigeration system 60 may include two evaporators.

[0017] Within refrigeration system 60, refrigerant generally flows into compressor 64, which operates to increase the pressure of the refrigerant. This compression of the refrigerant raises its temperature, which is lowered by passing the refrigerant through condenser 66. Within condenser 66, heat exchange with ambient air takes place so as to cool the refrigerant. A condenser fan 72 is used to pull air across condenser 66 so as to provide forced convection for a more rapid and efficient heat exchange between the refrigerant within condenser 66 and the ambient air. Thus, as will be understood by those skilled in the art, increasing air flow across condenser 66 can, for example, increase the efficiency of condenser 66 by improving cooling of the refrigerant contained therein.

[0018] An expansion device (e.g., a valve, capillary tube, or other restriction device) 68 receives refrigerant from condenser 66. From expansion device 68, the refrigerant enters evaporator 70. Upon exiting expansion device 68 and entering evaporator 70, the refrigerant drops in pressure. Due to the pressure drop or phase change of the refrigerant, evaporator 70 is cool relative to compartments 14 and 18 of refrigerator appliance 10. As such, cooled air is produced and refrigerates compartments 14 and 18 of refrigerator appliance 10. Thus, evaporator 70 is a type of heat exchanger which transfers heat from air passing over evaporator 70 to refrigerant flowing through evaporator 70.

[0019] Collectively, the vapor compression cycle components in a refrigeration circuit, associated fans, and associated compartments are sometimes referred to as a sealed refrigeration system operable to force cold air through compartments 14, 18 (FIG. 1). The refrigeration system 60 depicted in FIG. 2 is provided by way of example only. Thus, it is within the scope of the present disclosure for other configurations of the refrigeration system to be used as well.

[0020] In some embodiments, an oil cooling circuit 200 according exemplary embodiments of the present disclosure is shown with refrigeration system 60. Compressor 64 of refrigeration system 60 may include or be provided within a shell 302 (FIG. 3) that also holds a lubrication oil therein. The lubrication oil may assist with reducing friction between sliding or moving components of compressor 64 during operation of compressor 64. For example, the lubrication oil may reduce friction between a piston and a cylinder of compressor 64 when the piston slides within the cylinder to compress refrigerant, as discussed in greater detail below.

[0021] During operation of compressor 64, the lubrication oil may increase in temperature. Thus, oil cooling circuit 200 is provided to assist with rejecting heat from the lubrication oil. By cooling the lubrication oil, an efficiency of compressor 64 may be improved. Thus, oil cooling circuit 200 may assist with increasing the efficiency of compressor 64 (e.g., relative to a compressor without oil cooling circuit 200) by reducing the temperature of the lubrication oil within compressor 64.

[0022] Oil cooling circuit 200 includes a heat exchanger 210 may be spaced apart from at least a portion of compressor 64. A lubrication oil conduit 220 extends between compressor 64 and heat exchanger 210. Lubrication oil from compressor 64 may flow to heat exchanger 210 via lubrication oil conduit 220. As shown in FIG. 2, lubrication oil conduit 220 may include a supply conduit 222 and a return conduit 224. Supply conduit 222 extends between compressor 64 and heat exchanger 210 and is configured for directing lubrication oil from compressor 64 to heat exchanger 210. Conversely, return conduit 224 extends between heat exchanger 210 and compressor 64 and is configured for directing lubrication oil from heat exchanger 210 to compressor 64.

[0023] Within heat exchanger 210, the lubrication oil may reject heat to ambient air about heat exchanger 210. From heat exchanger 210, the lubrication oil flows back to compressor 64 via lubrication oil conduit 220. In such a manner, lubrication oil conduit 220 may circulate lubrication oil between compressor 64 and heat exchanger 210, and heat exchanger 210 may reduce the temperature of lubrication oil from compressor 64 before returning the lubrication oil to compressor 64. Thus, oil cooling circuit 200 may remove lubrication oil from compressor 64 via lubrication oil conduit 220 and return the lubrication oil to compressor 64 via lubrication oil conduit 220 after cooling the lubrication oil in heat exchanger 210.

[0024] In optional embodiments, heat exchanger 210 is positioned at or adjacent fan 72. For example, heat exchanger 210 may be positioned and oriented such that fan 72 pulls or urges air across heat exchanger 210 so as to provide forced convection for a more rapid and efficient heat exchange between lubrication oil within heat exchanger 210 and ambient air about refrigeration system 60. In certain exemplary embodiments, heat exchanger 210 may be disposed between fan 72 and condenser 66. Thus, heat exchanger 210 may be disposed downstream of fan 72 and upstream of condenser 66 relative to a flow of air from fan 72, in certain exemplary embodiments. In such a manner, air from fan 72 may heat exchange with lubrication oil in heat exchanger 210 prior to heat exchange with refrigerant in condenser 66.

[0025] In additional or alternative embodiments, heat exchanger 210 is positioned at or on condenser 66. For example, heat exchanger 210 may be mounted to condenser 66 such that heat exchanger 210 and condenser 66 are in conductive thermal communication with each other. Thus, condenser 66 and heat exchanger 210 may conductively exchange heat. In such a manner, heat exchanger 210 and condenser 66 may provide for heat exchange between lubrication oil within heat exchanger 210 and refrigerant within condenser 66. In certain exemplary embodiments, heat exchanger 210 may be a tube-to-tube heat exchanger 210 integrated within or onto condenser 66 (e.g., a portion of condenser 66). For example, heat exchanger 210 may be welded or soldered onto condenser 66. In optional embodiments, heat exchanger 210 is disposed on a portion of condenser 66 between an inlet and an outlet of condenser 66. For example, refrigerant may enter condenser 66 at the inlet of condenser 66 at a first temperature (e.g., one hundred and fifty degrees Fahrenheit (150° F)), and heat exchanger 210 may be positioned on condenser 66 downstream of the inlet of condenser 66 such that refrigerant immediately upstream of the portion of condenser 66 where heat exchanger 210 is mounted may have a second temperature (e.g., ninety degrees Fahrenheit (90° F)). Heat exchanger 210 may also be positioned on condenser 66 upstream of the outlet of condenser 66 such that refrigerant immediately downstream of the portion of condenser 66 where heat exchanger 210 is mounted may have a third temperature (e.g., one hundred and five degrees Fahrenheit (105° F)), and refrigerant may exit condenser 66 at the outlet of condenser 66 at a fourth temperature (e.g., ninety degrees Fahrenheit (90° F)). Thus, refrigerant within condenser 66 may increase in temperature at the portion of condenser 66 where heat exchanger 210 is mounted during operation of compressor 64 in order to cool lubrication oil within heat exchanger 210. However, the portion of condenser 66 downstream of heat exchanger 210 may assist with rejecting heat to ambient air about condenser 66.

[0026] Turning now to FIGS. 3 through 6, various sectional views are provided of a linear compressor 300 according to an exemplary embodiments of the present disclosure. As discussed in greater detail below, linear compressor 300 is operable to increase a pressure of fluid within a chamber 312 of linear compressor 300. Linear compressor 300 may be used to compress any suitable fluid, such as refrigerant. In particular, linear compressor 300 may be used in a refrigerator appliance, such as refrigerator appliance 10 (FIG. 1) in which linear compressor 300 may be used as compressor 64 (FIG. 2). As may be seen in FIG. 3, linear compressor 300 defines an axial direction A and a radial direction R. Linear compressor 300 may be enclosed within a hermetic or airtight shell 302. In other words, linear compressor 300 may be enclosed within an internal volume 303 defined by shell 302. When assembled, hermetic shell 302 hinders or prevents refrigerant or lubrication oil from leaking or escaping refrigeration system 60 (FIG. 2).

[0027] Linear compressor 300 includes a casing 308 that extends between a first end portion 304 and a second end portion 306 (e.g., along the axial direction A). Casing 308 includes various relatively static or non-moving structural components of linear compressor 300. In particular, casing 308 includes a cylinder assembly 310 that defines a chamber 312. Cylinder assembly 310 is positioned at or adjacent second end portion 306 of casing 308. Chamber 312 extends longitudinally along the axial direction A.

[0028] In some embodiments, a motor mount mid-section 314 (e.g., at the second end portion 306) of casing 308 supports a stator of the motor. As shown, the stator may include an outer back iron 364 and a driving coil 366 sandwiched between the first end portion 304 and the second end portion 306. Linear compressor 300 also includes one or more valves (e.g., a discharge valve assembly 320 at an end of chamber 312) that permit refrigerant to enter and exit chamber 312 during operation of linear compressor 300.

[0029] In some embodiments, a discharge valve assembly 320 is mounted to the casing 308 (e.g., at the second end portion 306). Discharge valve assembly 320 may include a muffler housing 322, a valve head 324, and a valve spring 338.

[0030] Muffler housing 322 may include an end wall 326 and a cylindrical side wall 328. Cylindrical side wall 328 is mounted to end wall 326, and cylindrical side wall 328 extends from end wall 326 (e.g., along the axial direction A) to cylinder assembly 310 of casing 308. A refrigerant outlet conduit 330 may extend from or through muffler housing 322 and through shell 302 (e.g., to or in fluid communication with condenser 66-FIG. 2) to selectively permit refrigerant from discharge valve assembly 320 during operation of linear compressor 300.

[0031] Muffler housing 322 may be mounted or fixed to casing 308, and other components of discharge valve assembly 320 may be disposed within muffler housing 322. For example, a plate 332 of muffler housing 322 at a distal end of cylindrical side wall 328 may be positioned at or on cylinder assembly 310, and a seal (e.g., O-ring or gasket) may extend between cylinder assembly 310 and plate 332 of muffler housing 322 (e.g., along the axial direction A) in order to limit fluid leakage at an axial gap between casing 308 and muffler housing 322. Fasteners may extend through plate 332 into casing 308 to mount muffler housing 322 to casing 308.

[0032] Valve head 324 is positioned at or adjacent chamber 312 of cylinder assembly 310. Valve head 324 selectively covers a passage that extends through the cylinder assembly 310 (e.g., along the axial direction A). Such a passage may be contiguous with chamber 312. Valve spring 338 is coupled to muffler housing 322 and valve head 324. Valve spring 338 may be configured to urge valve head 324 towards or against cylinder assembly 310 (e.g., along the axial direction A).

[0033] A piston assembly 316 with a piston head 318 is slidably received within chamber 312 of cylinder assembly 310. In particular, piston assembly 316 is slidable along the axial direction A within chamber 312. During sliding of piston head 318 within chamber 312, piston head 318 compresses refrigerant within chamber 312. As an example, from a top dead center position, piston head 318 can slide within chamber 312 towards a bottom dead center position along the axial direction A (i.e., an expansion stroke of piston head 318). When piston head 318 reaches the bottom dead center position, piston head 318 changes directions and slides in chamber 312 back towards the top dead center position (i.e., a compression stroke of piston head 318). As, or immediately prior to, piston head 318 reaching the top dead center position, expansion valve assembly 320 may open. For instance, valve head 324 may be urged away from cylinder assembly 310, permitting refrigerant from chamber 312 and through discharge valve assembly 320 to refrigerant outlet conduit 330.

[0034] It should be understood that linear compressor

300 may include an additional piston head or additional chamber at an opposite end of linear compressor 300 (e.g., proximal to first end portion 304). Thus, linear compressor 300 may have multiple piston heads in alternative exemplary embodiments.

[0035] In certain embodiments, linear compressor 300 includes an inner back iron assembly 352. Inner back iron assembly 352 is positioned in the stator of the motor. In particular, outer back iron 364 or driving coil 366 may extend about inner back iron assembly 352 (e.g., along a circumferential direction). Inner back iron assembly 352 also has the outer surface. At least one driving magnet 362 is mounted to inner back iron assembly 352 (e.g., at the outer surface of inner back iron assembly 352). Driving magnet 362 may face or be exposed to driving coil 366. In particular, driving magnet 362 may be spaced apart from driving coil 366 (e.g., along the radial direction R by an air gap). Thus, the air gap may be defined between opposing surfaces of driving magnet 362 and driving coil 366. Driving magnet 362 may also be mounted or fixed to inner back iron assembly 352 such that the outer surface of driving magnet 362 is substantially flush with the outer surface of inner back iron assembly 352. Thus, driving magnet 362 may be inset within inner back iron assembly 352. In such a manner, the magnetic field from driving coil 366 may have to pass through only a single air gap between outer back iron 364 and inner back iron assembly 352 during operation of linear compressor 300, and linear compressor 300 may be more efficient relative to linear compressors with air gaps on both sides of a driving magnet 362.

[0036] As may be seen in FIG. 3, driving coil 366 extends about inner back iron assembly 352 (e.g., along the circumferential direction). Generally, driving coil 366 is operable to move the inner back iron assembly 352 along the axial direction A during operation of driving coil 366. As an example, a current may be induced in driving coil 366 by a current source (not pictured) to generate a magnetic field that engages driving magnet 362 and urges piston assembly 316 to move along the axial direction A in order to compress refrigerant within chamber 312, as described above. In particular, the magnetic field of driving coil 366 may engage driving magnet 362 in order to move inner back iron assembly 352 and piston head 318 the axial direction A during operation of driving coil 366. Thus, driving coil 366 may slide piston assembly 316 between the top dead center position and the bottom dead center position during operation of driving coil 366.

[0037] In optional embodiments, linear compressor 300 includes various components for permitting or regulating operation of linear compressor 300. In particular, linear compressor 300 includes a controller that is configured for regulating operation of linear compressor 300. The controller is in, for example, operative, communication with the motor (e.g., driving coil 366 of the motor). Thus, the controller may selectively activate driving coil 366, for example, by supplying current to driving coil 366, in order to compress refrigerant with piston assembly 316 as described above.

[0038] The controller includes memory and one or more processing devices such as microprocessors, CPUs or the like, such as general or special purpose microprocessors operable to execute programming instructions or micro-control code associated with operation of linear compressor 300. The memory can represent random access memory such as DRAM, or read only memory such as ROM or FLASH. The processor executes programming instructions stored in the memory. The memory can be a separate component from the processor or can be included onboard within the processor. Alternatively, the controller may be constructed without using a microprocessor (e.g., using a combination of discrete analog or digital logic circuitry; such as switches, amplifiers, integrators, comparators, flip-flops, AND gates, and the like) to perform control functionality instead of relying upon software.

[0039] Linear compressor 300 also includes one or more spring assemblies 340, 342 mounted to casing 308. In certain embodiments, a pair of spring assemblies (i.e., a first spring assembly 340 and a second spring assembly 342) bounds driving coil 366 along the axial direction A. In other words, a first spring assembly 340 is positioned proximal to the first end portion 304 and a second spring assembly 342 is positioned proximal to the second end portion 306.

[0040] In some embodiments, each spring assembly 340 and 342 includes one or more planar springs that are mounted or secured to one another. In particular, planar springs may be mounted or secured to one another such that each planar spring of a corresponding assembly 340 or 342 are spaced apart from one another (e.g., along the axial direction A).

[0041] Generally, the pair of spring assemblies 340, 342 assists with coupling inner back iron assembly 352 to casing 308. In some such embodiments, a first outer set of fasteners 344 (e.g., bolts, nuts, clamps, tabs, welds, solders, etc.) secure first and second spring assemblies 340, 342 to casing 308 (e.g., a bracket of the stator) while a first inner set of fasteners 346 that are radially inward (e.g., closer to the axial direction A along a perpendicular radial direction R) from the first outer set of fasteners 344 secure first spring assembly 340 to inner back iron assembly 352 at first end portion 304. In additional or alternative embodiments, a second inner set of fasteners 350 that are radially inward (e.g., closer to the axial direction A along the radial direction R) from the first outer set of fasteners 344 secure second spring assembly 342 to inner back iron assembly 352 at second end portion 306.

[0042] During operation of driving coil 366, the spring assemblies 340, 342 support inner back iron assembly 352. In particular, inner back iron assembly 352 is suspended by the spring assemblies 340, 342 within the stator or the motor of linear compressor 300 such that motion of inner back iron assembly 352 along the radial direction R is hindered or limited while motion along the axial direction A is relatively unimpeded. Thus, the spring assemblies 340, 342 may be substantially stiffer along the radial direction R than along the axial direction A. In such a manner, the spring assemblies 340, 342 can assist with maintaining a uniformity of the air gap between driving magnet 362 and driving coil 366 (e.g., along the radial direction R) during operation of the motor and movement of inner back iron assembly 352 on the axial direction A. The spring assemblies 340, 342 can also assist with hindering side pull forces of the motor from transmitting to piston assembly 316 and being reacted in cylinder assembly 310 as a friction loss.

[0043] Inner back iron assembly 352 includes an outer cylinder 354 and a sleeve 360. Sleeve 360 is positioned on or at the inner surface of outer cylinder 354. A first interference fit between outer cylinder 354 and sleeve 360 may couple or secure outer cylinder 354 and sleeve 360 together. In alternative exemplary embodiments, sleeve 360 may be welded, glued, fastened, or connected via any other suitable mechanism or method to outer cylinder 354.

[0044] Sleeve 360 extends about the axial direction A (e.g., along the circumferential direction). In exemplary embodiments, a first interference fit between outer cylinder 354 and sleeve 360 may couple or secure outer cylinder 354 and sleeve 360 together. In alternative exemplary embodiments, sleeve 360 is welded, glued, fastened, or connected via any other suitable mechanism or method to outer cylinder 354. As shown, sleeve 360 extends within outer cylinder 354 (e.g., along the axial direction A) between first and second end portions 304 and 306 of inner back iron assembly 352 130. First and second spring assemblies 340, 342 and are mounted to sleeve 360 (e.g., with inner set of fasteners 346 and 350).

[0045] Outer cylinder 354 may be constructed of or with any suitable material. For example, outer cylinder 354 may be constructed of or with a plurality of (e.g., ferromagnetic) laminations. The laminations are distributed along the circumferential direction in order to form outer cylinder 354 and are mounted to one another or secured together (e.g., with rings pressed onto ends of the laminations). Outer cylinder 354 defines a recess that extends inwardly from the outer surface of outer cylinder 354 (e.g., along the radial direction R). Driving magnet 362 is positioned in the recess on outer cylinder 354 (e.g., such that driving magnet 362 is inset within outer cylinder 354).

[0046] In some embodiments, a piston flex mount 368 is mounted to and extends through inner back iron assembly 352. In particular, piston flex mount 368 is mounted to inner back iron assembly 352 via sleeve 360 and spring assemblies 340, 342. Thus, piston flex mount 368 may be coupled (e.g., threaded) to sleeve 360 in order to mount or fix piston flex mount 368 to inner back iron assembly 352. A coupling 370 extends between piston flex mount 368 and piston assembly 316 (e.g., along the axial direction A). Thus, coupling 370 connects inner back iron assembly 352 and piston assembly 316 such that motion of inner back iron assembly 352 (e.g., along the axial direction A) is transferred to piston assembly 316. Coupling 370 may extend through driving coil 366 (e.g., along the axial direction A).

[0047] Piston flex mount 368 defines at least one passage 369. Passage 369 of piston flex mount 368 extends (e.g., along the axial direction A) through piston flex mount 368. Thus, a flow of fluid, such as air or refrigerant, may pass through piston flex mount 368 via passage 369 of piston flex mount 368 during operation of linear compressor 300. As shown, one or more refrigerant inlet conduits 331 may extend through shell 302 to return refrigerant from evaporator 70 (or another portion of sealed system 60) (FIG. 2) to compressor 300.

[0048] Piston head 318 also defines at least one opening (e.g., selectively covered by a head valve). The opening of piston head 318 extends (e.g., along the axial direction A) through piston head 318. Thus, the flow of refrigerant may pass through piston head 318 via the opening of piston head 318 into chamber 312 during operation of linear compressor 300. In such a manner, the flow of fluid (that is compressed by piston head 318 within chamber 312) may flow through piston flex mount 368 and inner back iron assembly 352 to piston assembly 316 during operation of linear compressor 300.

[0049] As shown, linear compressor 300 includes features for directing oil through linear compressor 300 and oil cooling circuit 200 (FIG. 2). One or more oil inlet conduits 380 or oil outlet conduits 382 may extend through shell 302 to direct oil to/from oil cooling circuit 200.

[0050] Optionally, oil inlet conduit 380 may be coupled to return conduit 224 of oil cooling circuit 200 (FIG. 2). Thus, from heat exchanger 210, lubrication oil may flow to linear compressor 300 via oil inlet conduit 380. Optionally, oil inlet conduit 380 may be positioned at or adjacent sump 376. Thus, lubrication oil to linear compressor 300 at oil inlet conduit 380 may flow into sump 376. As discussed above, oil cooling circuit 200 may cool lubrication oil from linear compressor 300. After such cooling, the lubrication oil is returned to linear compressor 300 via oil inlet conduit 380. Thus, the lubrication oil in oil inlet conduit 380 may be relatively cool and assist with cooling lubrication oil in sump 376.

[0051] In some embodiments, linear compressor 300 includes a pump 372. Pump 372 may be positioned at or adjacent a sump 376 of shell 302 (e.g., within a pump housing 374). Sump 376 corresponds to a portion of shell 302 at or adjacent a bottom of shell 302. Thus, a volume of lubrication oil 377 within shell 302 may pool within sump 376 (e.g., because the lubrication oil is denser than the refrigerant within shell 302). During use, pump 372 may draw the lubrication oil from the volume 377 within sump 376 to pump 372 via a supply line 378 extending from pump 372 to sump 376. For instance, a pair of check valves within a pump housing 374 at opposite ends of pump 372 may selectively permit/release oil to/from pump housing 374 as pump 372 oscillates within pump housing 374 (e.g., as motivated by oscillations of casing

308). Additionally or alternatively, the volume of lubrication oil 377 may be maintained at a predetermined level (e.g., even with a vertical midpoint of pump 372) while pump 372 is actively oscillating.

[0052] An internal conduit 384 may extend from pump 372 (e.g., pump housing 374) to an oil reservoir 386 defined within casing 308. In some embodiments, oil reservoir 386 is positioned radially outward from the chamber 312 of cylinder assembly 310. For instance, oil reservoir 386 may be defined to extend along the circumferential direction (e.g., about the axial direction A) as an annular chamber around chamber 312 of cylinder assembly 310.

[0053] Generally, lubrication oil may be selectively directed to cylinder assembly 310 from oil reservoir 386. In particular, one or more passages (e.g., radial passages) may extend from oil reservoir 386 to the chamber 312. Such radial passages may terminate at a portion of the sliding path of piston head 318 (e.g., between top dead center and bottom dead center relative to the axial direction A). As piston head 318 slides within chamber 312, a sidewall of piston head 318 may receive lubrication oil. In optional embodiments, the radial passages terminate at a groove 388 defined by the cylinder assembly 310 within the chamber 312. Thus, the groove 388 may be open to the chamber 312. Lubrication oil from oil reservoir 386 may flow into chamber 312 of cylinder assembly 310 (e.g., via radial passages to the groove 388) in order to lubricate motion of piston assembly 316 within chamber 312 of cylinder assembly 310.

[0054] Along with the chamber 312 and oil reservoir 386, casing 308 may define an oil exhaust 390. In some embodiments, oil exhaust 390 extends from oil reservoir 386. For example, oil exhaust 390 may extend through casing 308 outward from oil reservoir 386. Oil exhaust 390 may thus be in fluid communication with oil reservoir 386. During use, at least a portion of the lubrication oil urged to oil reservoir 386 may flow to the oil exhaust 390 (e.g., as motivated by pump 372). From oil exhaust 390, lubrication oil may exit the casing 308 (and linear compressor 300 generally). In certain embodiments, oil exhaust 390 is connected in fluid communication to the oil outlet conduit 382. Thus, pump 372 may generally urge lubrication oil from the internal volume 303, through casing 308, and to the oil outlet conduit 382. Oil outlet conduit 382 may be coupled to supply conduit 222 of oil cooling circuit 200 (FIG. 2). Thus, pump 372 may urge lubrication oil from sump 376 into supply conduit 222. In such a manner, pump 372 may supply lubrication oil to oil cooling circuit 200 in order to cool the lubrication oil from linear compressor 300, as discussed above.

[0055] In addition to oil exhaust 390, casing 308 defines a gas vent 392. In particular, gas vent 392 extends through from oil reservoir 386 to the internal volume 303. As shown, gas vent 392 is defined in fluid parallel with oil exhaust 390. Thus, fluid is separately directed through gas vent 392 and oil exhaust 390. Generally, gas vent 392 may be sized to restrict fluid more than oil exhaust 390. For example, the minimum diameter of gas vent 392 may still be smaller than the minimum diameter of the oil exhaust 390. Optionally, the minimum diameter of gas vent 392 may be less than two millimeters while the minimum diameter of oil exhaust is greater than four millimeters. Along with being smaller in diameter, the gas vent 392 may further be shorter in length than oil exhaust 390. Under typical pumping operations, a greater volume of lubrication oil may be motivated through oil exhaust 390 than gas vent 392. Nonetheless, gas (e.g., produced during an outgassing within oil reservoir 386) may be permitted to internal volume 303 through gas vent 392 while advantageously permitting the continued flow of lubrication oil from oil reservoir 386 to oil exhaust 390 or chamber 312.

[0056] Gas vent 392 may be defined at an upper portion of casing 308 (e.g., at an upper end of oil reservoir 386). Additionally or alternatively, gas vent 392 may extend above the discharge valve assembly 320 (e.g., parallel to the axial direction A). Gas vent 392 may further be located below (e.g., lower along a vertical direction V than) oil exhaust 390. In some embodiments, gas vent 392 is located at the second end portion 306 of casing 308. Fluid from gas vent 392 may be directed forward into internal volume 303.

[0057] In some embodiments, an oil shield 394 is provided in front of gas vent 392. As shown, oil shield 394 may be disposed on casing 308 (e.g., at second end portion 306). Between oil shield 394 and, for example, muffler housing 322, a drip passage may be defined. For instance, oil shield 394 may extend outward from casing 308 to a curved or inward-extending wall portion 396. Additionally or alternatively, oil shield 394 may extend about a portion of muffler housing 322. For instance, oil shield 394 may extend 180° along a top side of muffler housing 322. During use, lubrication oil discharged through gas vent 392 may be directed downward to the sump 376. Advantageously, the positioning or shape of oil shield 394 may prevent lubrication oil from striking shell 302 (e.g., at a high velocity, which might otherwise cause atomizing of lubrication oil within internal volume 303).

[0058] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

Claims

1. A sealed system (60) for an appliance, comprising:

   a linear compressor (300) comprising

      a casing (308) extending along an axial direction from a first end portion (304) to a second end portion (306), the casing (308) comprising a cylinder assembly (310) defining a chamber (312) proximal to the second end portion (306), and
      a piston slidably received within the chamber (312) of the cylinder assembly (310);

   a shell (302) defining an internal volume (303) enclosing the linear compressor (300) and lubrication oil therein;
   a condenser (66) in downstream fluid communication with the linear compressor (300) to receive a compressed refrigerant therefrom;
   an oil outlet conduit (382) extending through the shell (302) to the casing (308) of the linear compressor (300); and
   a heat exchanger (210) spaced apart from the internal volume (303) in fluid communication with the oil outlet conduit (382) to receive lubrication oil from the linear compressor (300),
   wherein the casing (308) further defines an oil reservoir (386), an oil exhaust (390), and a gas vent (392), the oil reservoir (386) positioned radially outward from the chamber (312) of the cylinder assembly (310) to selectively direct lubrication oil thereto, the oil exhaust (390) extending from the oil reservoir (386) to the oil outlet conduit (382), the gas vent (392) extending from the oil reservoir (386) to the internal volume (303) in fluid parallel with the oil exhaust (390).

2. The sealed system (60) of claim 1, wherein the linear compressor (300) further comprises an oil shield (394) disposed on the casing (308) at the second end portion (306) in front of the gas vent (392) to direct lubrication oil downward from the gas vent (392) to a sump (376) of the shell (302).

3. The sealed system (60) of claim 1, further comprising:
   a refrigerant conduit that extends between the linear compressor (300) and the condenser (66), the refrigerant conduit directing compressed refrigerant from the linear compressor (300) to the condenser (66) during operation of the linear compressor (300), the oil outlet conduit (382) directing lubrication oil from the linear compressor (300) to the heat exchanger (210) during operation of the linear compressor (300).

4. The sealed system (60) of claim 1, wherein the linear compressor (300) further comprises a pump (372), the pump (372) operable to urge a flow of lubrication oil from the linear compressor (300) to the heat exchanger (210) during operation of the linear compressor (300).

5. The sealed system (60) of claim 4, wherein the pump (372) is disposed within the internal volume (303) of the shell (302) to urge lubrication oil from the internal volume (303) to the oil reservoir (386).

6. The sealed system (60) of claim 1, further comprising:
   a discharge valve assembly (320) mounted to the casing (308) at the second end portion (306) in front of the chamber (312) along the axial direction, wherein the gas vent (392) is disposed above the discharge valve assembly (320).

7. The sealed system (60) of claim 6, wherein the linear compressor (300) further comprises an oil shield (394) disposed on the casing (308) at the second end portion (306), the oil shield (394) extending in front of the gas vent (392) and over the discharge valve assembly (320) to direct lubrication oil downward from the gas vent (392) to a sump (376) of the shell (302).

8. The sealed system (60) of claim 6, wherein the oil reservoir (386) extends annularly about the axial direction.

9. The sealed system (60) of claim 1, wherein the cylinder assembly (310) further defines a groove (388) extending annularly about the piston within the chamber (312), the groove (388) being in fluid communication with the oil reservoir (386).

10. The sealed system (60) of claim 1, wherein the gas vent (392) defines a diameter smaller than the diameter of the oil exhaust (390).

11. A sealed system (60) for an appliance, comprising:

   a linear compressor (300) comprising

      a casing (308) extending along an axial direction from a first end portion (304) to a second end portion (306), the casing (308) comprising a cylinder assembly (310) defining a chamber (312) proximal to the second end portion (306), and
      a piston slidably received within the chamber (312) of the cylinder assembly (310);

   a shell (302) defining an internal volume (303) having a sump (376), the shell (302) enclosing

the linear compressor (300) and lubrication oil therein; and
a condenser (66) in downstream fluid communication with the linear compressor (300) to receive a compressed refrigerant therefrom;
wherein the casing (308) further defines an oil reservoir (386) and a gas vent (392), the oil reservoir (386) positioned radially outward from the chamber (312) of the cylinder assembly (310) to selectively direct lubrication oil thereto, the gas vent (392) extending from the oil reservoir (386) to the internal volume (303) through the second end portion (306), and
wherein the linear compressor (300) further comprises an oil shield (394) disposed on the casing (308) at the second end portion (306) in front of the gas vent (392) to direct lubrication oil downward from the gas vent (392) to the sump (376) of the shell (302).

12. The sealed system (60) of claim 11, further comprising:

a refrigerant conduit that extends between the linear compressor (300) and the condenser (66); and
an oil outlet conduit (382) extending through the shell (302) to the casing (308) of the linear compressor (300), the refrigerant conduit directing compressed refrigerant from the linear compressor (300) to the condenser (66) during operation of the linear compressor (300), the oil outlet conduit (382) directing lubrication oil from the linear compressor (300) and out of the shell (302) during operation of the linear compressor (300).

13. The sealed system (60) of claim 11, wherein the linear compressor (300) further comprises a pump (372), the pump (372) operable to urge a flow of lubrication oil from the sump (376) to the linear compressor (300) during operation of the linear compressor (300).

14. The sealed system (60) of claim 12, wherein the pump (372) is disposed within the internal volume (303) of the shell (302) to urge lubrication oil from the internal volume (303) to the oil reservoir (386).

15. The sealed system (60) of claim 11, further comprising:
a discharge valve assembly (320) mounted to the casing (308) at the second end portion (306) in front of the chamber (312) along the axial direction, wherein the gas vent (392) is disposed above the discharge valve assembly (320).

16. The sealed system (60) of claim 11, wherein the oil shield (394) extends in front of the gas vent (392) and over the muffler housing (322) to direct lubrication oil downward from the gas vent (392) to a sump (376) of the shell (302).

17. The sealed system (60) of claim 11, wherein the oil reservoir (386) extends annularly about the axial direction.

18. The sealed system (60) of claim 11, wherein the cylinder assembly (310) further defines a groove (388) extending annularly about the piston within the chamber (312), the groove (388) being in fluid communication with the oil reservoir (386).

19. The sealed system (60) of claim 11, wherein the gas vent (392) defines a diameter smaller than the diameter of the oil exhaust (390).

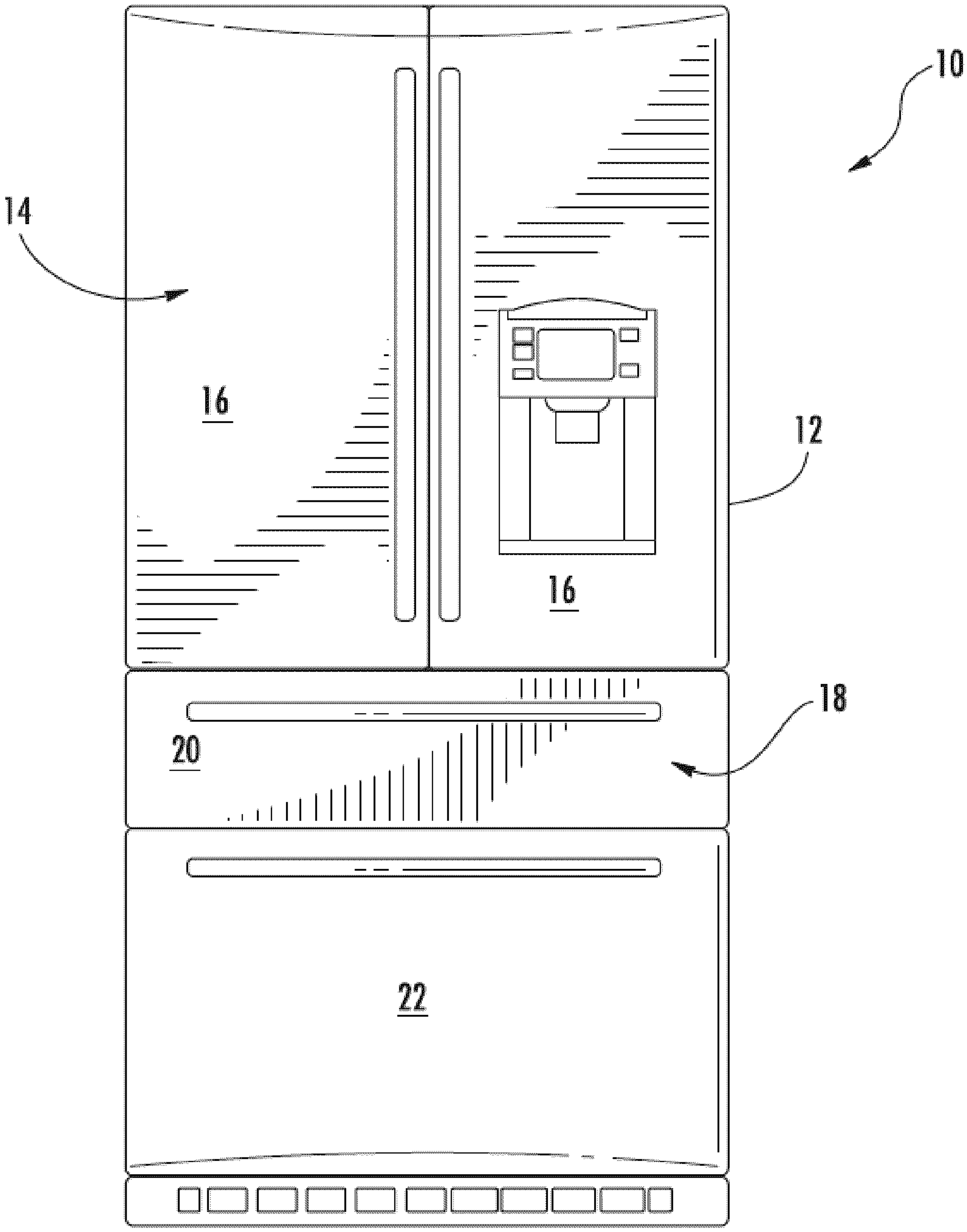

FIG. 1

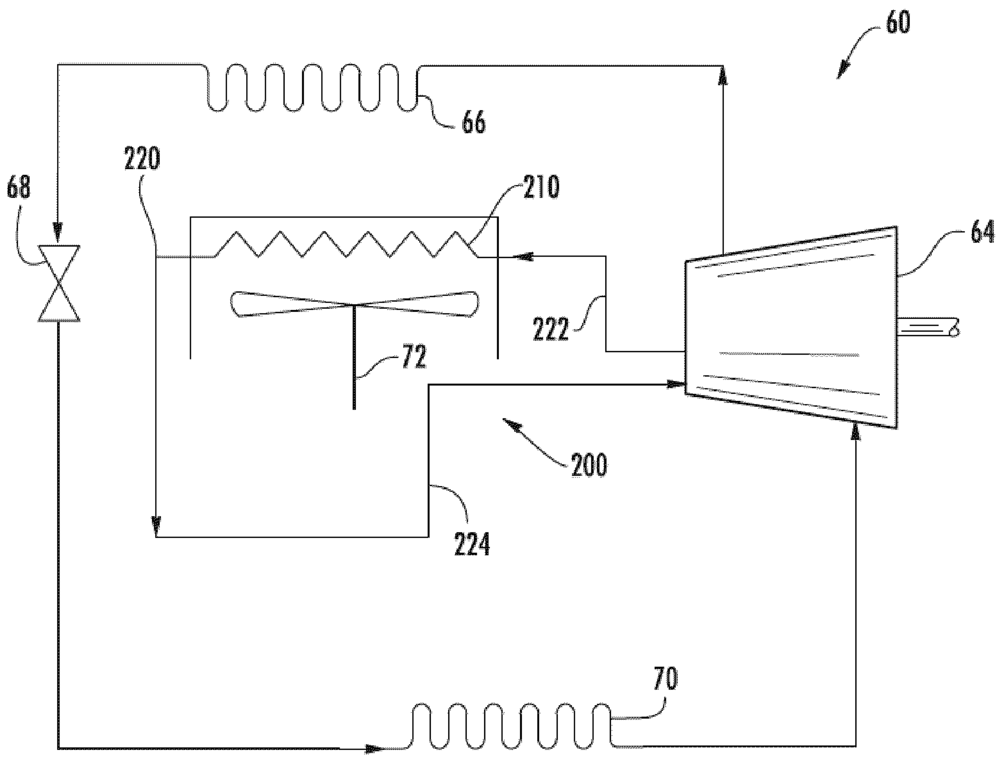

FIG. 2

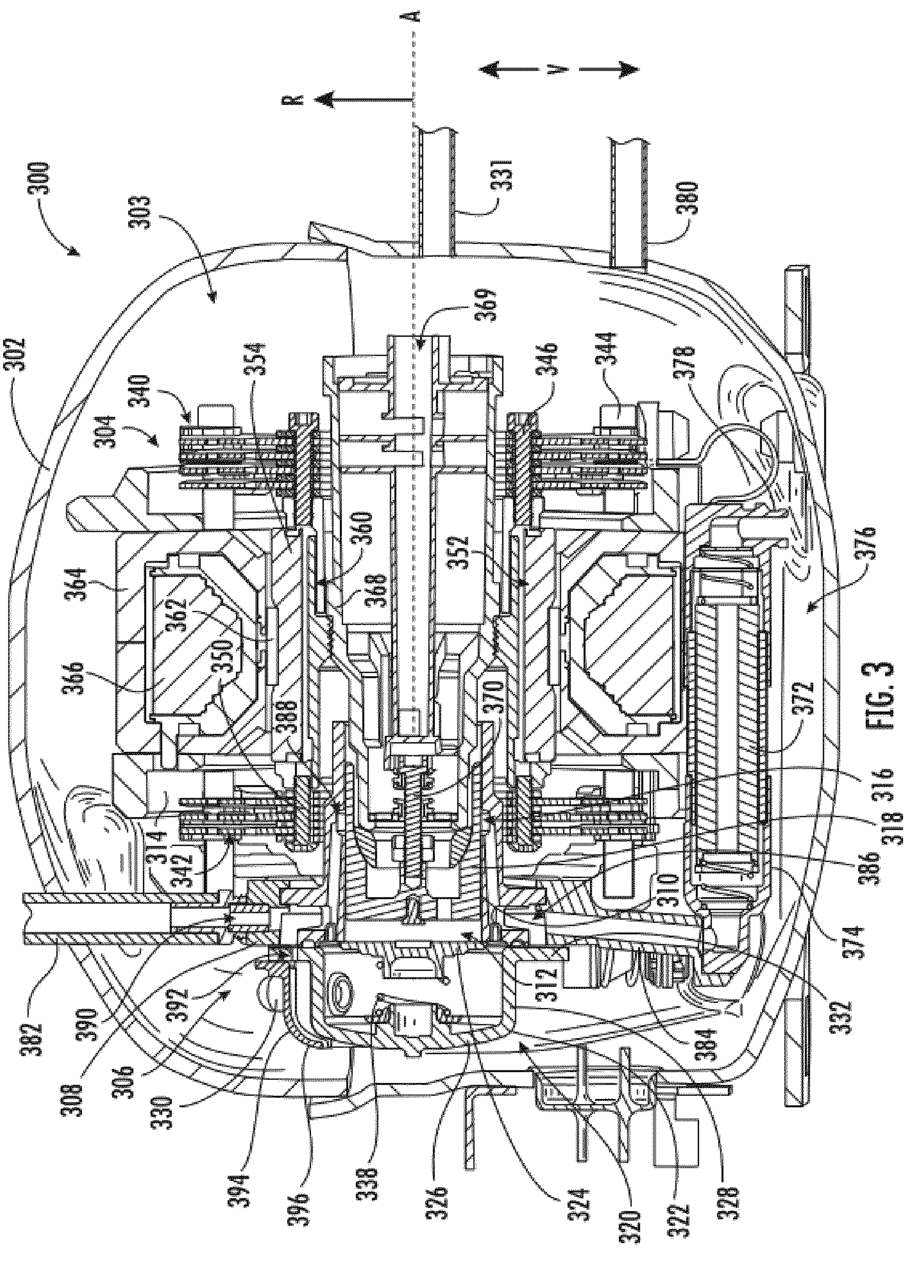
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FIG. 3

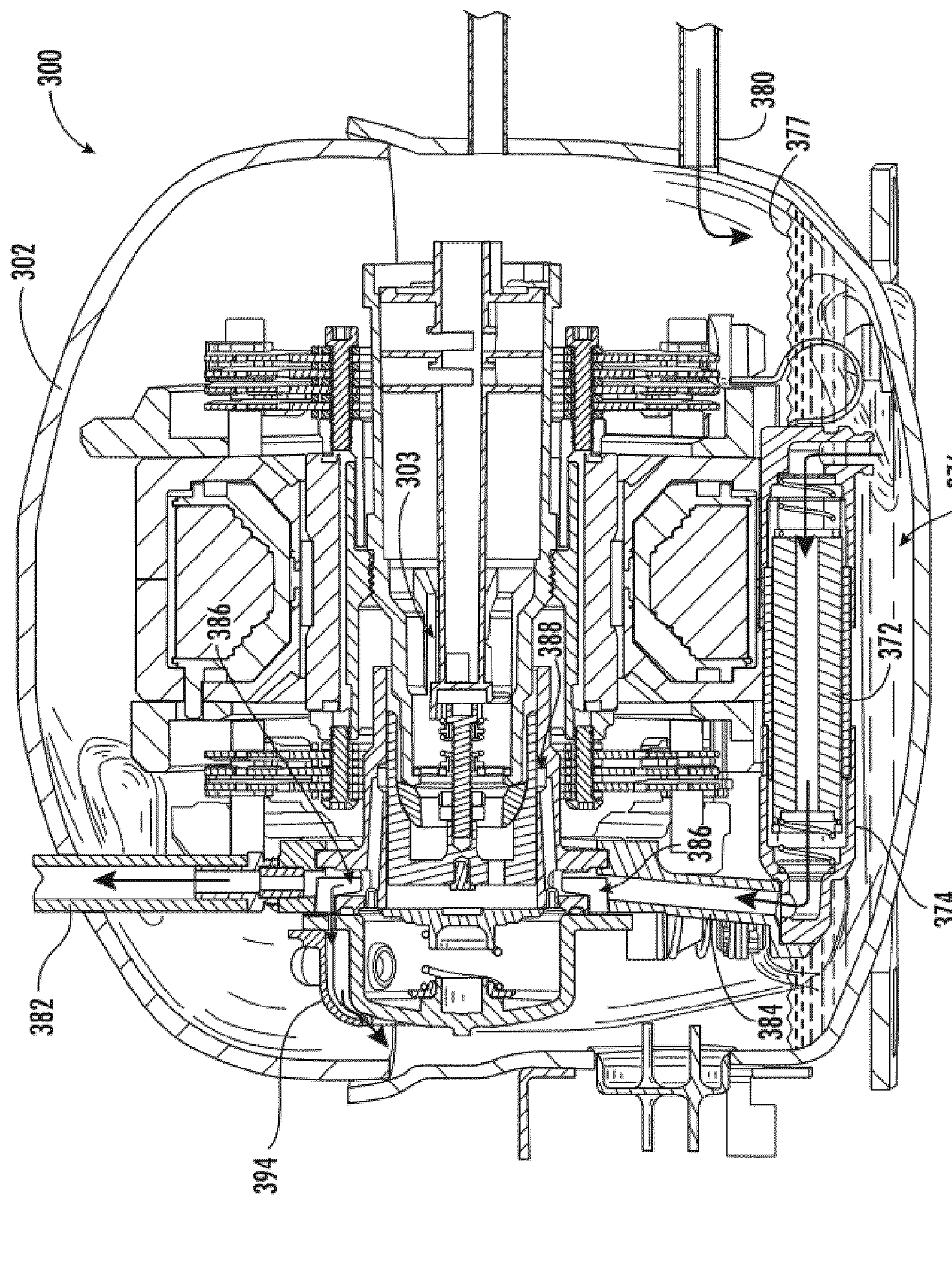

FIG. 4

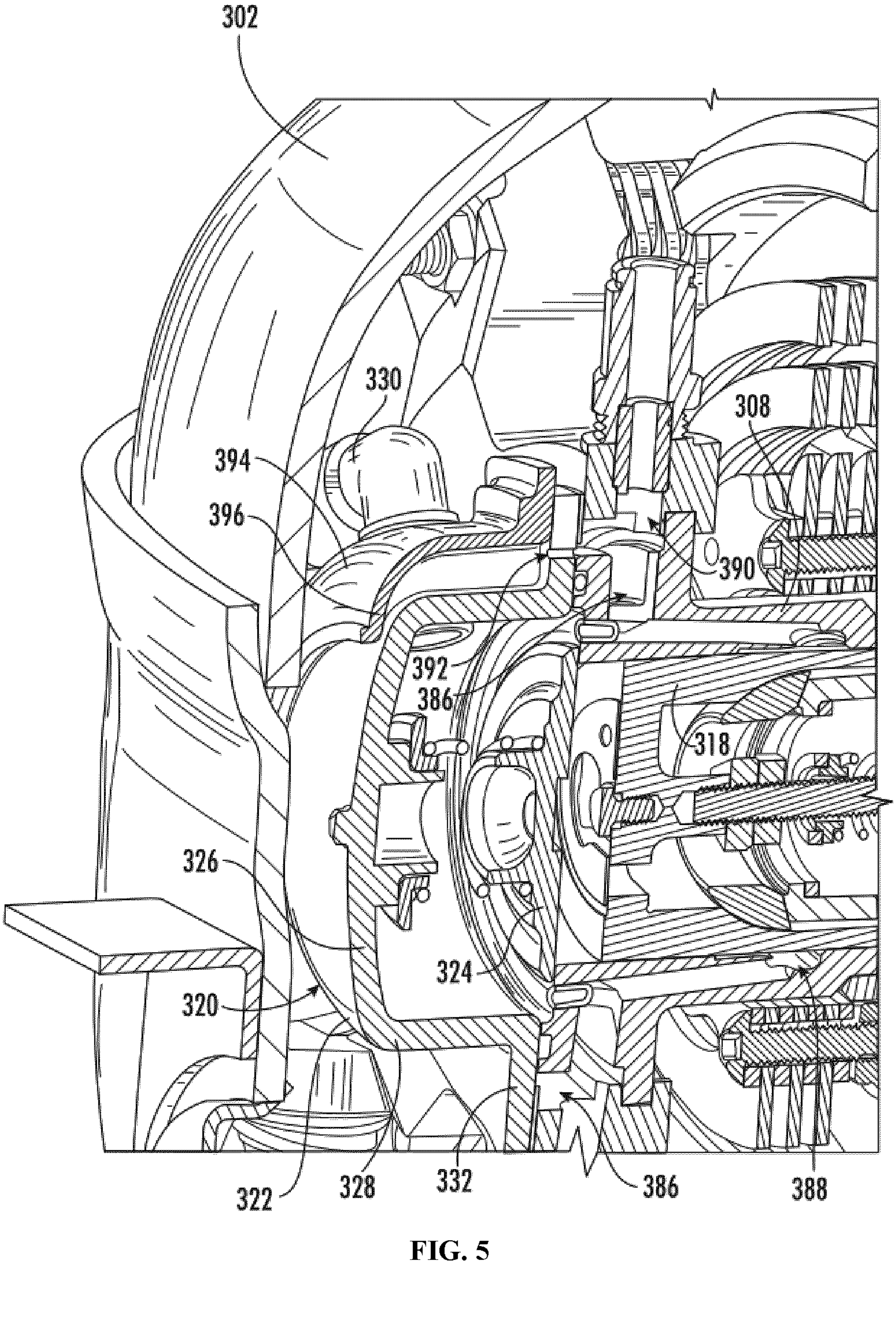
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FIG. 5

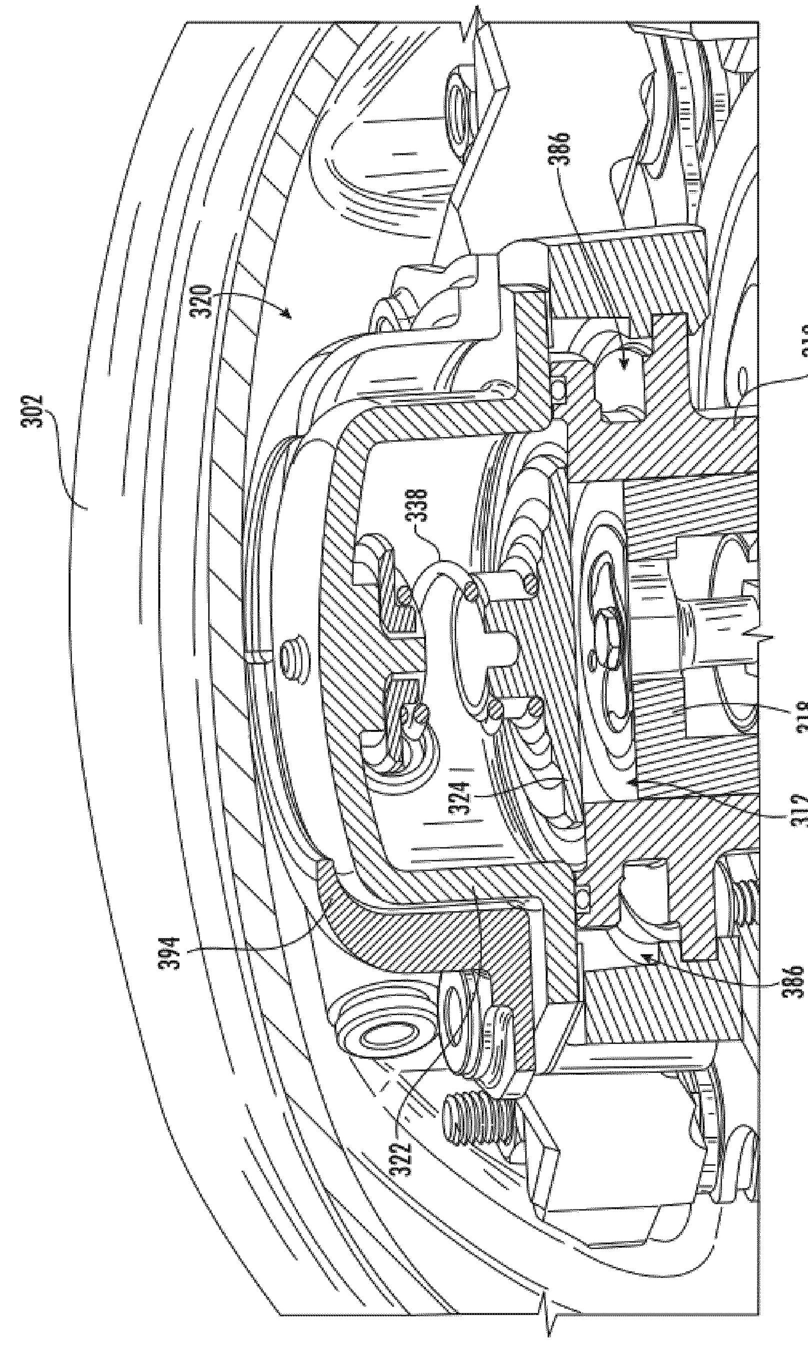

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/117284

A. CLASSIFICATION OF SUBJECT MATTER

F04B 39/02(2006.01)i；F04B 53/18(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)

F04B;F04C

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)

SIPOABS; CNABS; CNKI; DWPI: 线性压缩机, 壳, 活塞, 气缸, 润滑, 冷凝器, 蒸发器, 冷却, 阀, linear, compressor, shell, housing, casing, piston, cylinder, lubricat+, cool+, condenser, evaporator, valve

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 103362783 A (TIANJIN TANFENG TECHNOLOGY CO., LTD.) 23 October 2013 (2013-10-23) see description, paragraphs [0002]-[0009], figure 1	1-19
A	CN 101205891 A (TAIZHOU LG ELECTRONICS REFRIGERATION CO., LTD.) 25 June 2008 (2008-06-25) see entire document	1-19
A	CN 104110360 A (HAIER GROUP CORPORATION et al.) 22 October 2014 (2014-10-22) see entire document	1-19
A	EP 0994253 B1 (MATSUSHITA ELECTRIC IND CO., LTD.) 10 August 2005 (2005-08-10) see entire document	1-19
A	KR 20060086674 A (LG ELECTRONICS INC.) 01 August 2006 (2006-08-01) see entire document	1-19

☐ 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
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 December 2020	**04 January 2021**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/117284

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Form PCT/ISA/210 (patent family annex) (January 2015)