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(54) **COMPRESSOR WITH ROTOR COOLING PASSAGEWAY**

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(57) **ABSTRACT**

A centrifugal compressor for a refrigeration system is disclosed. The centrifugal compressor includes an electric motor, which includes a rotor and a stator. The compressor further includes a housing enclosing the electric motor, a stator cooling passage provided within the housing, and a rotor cooling passageway provided within the housing. The rotor cooling passageway is independent of the stator cooling passageway.

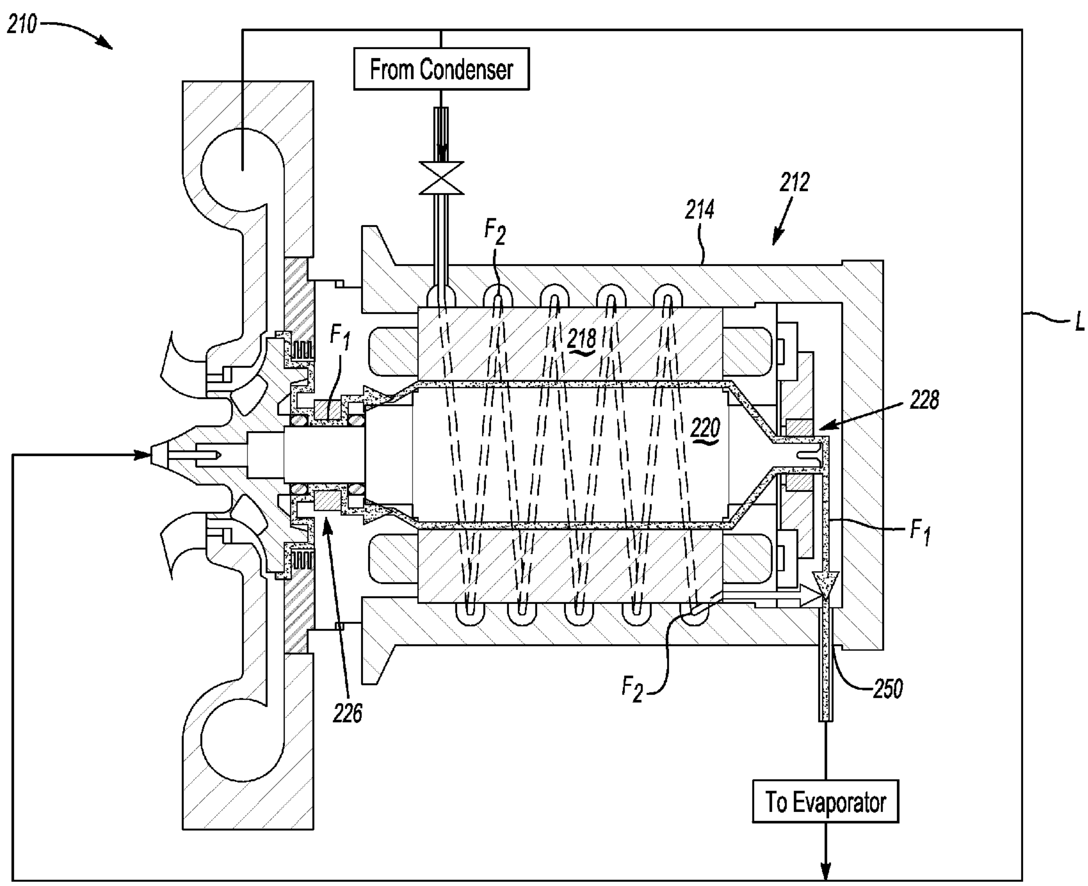
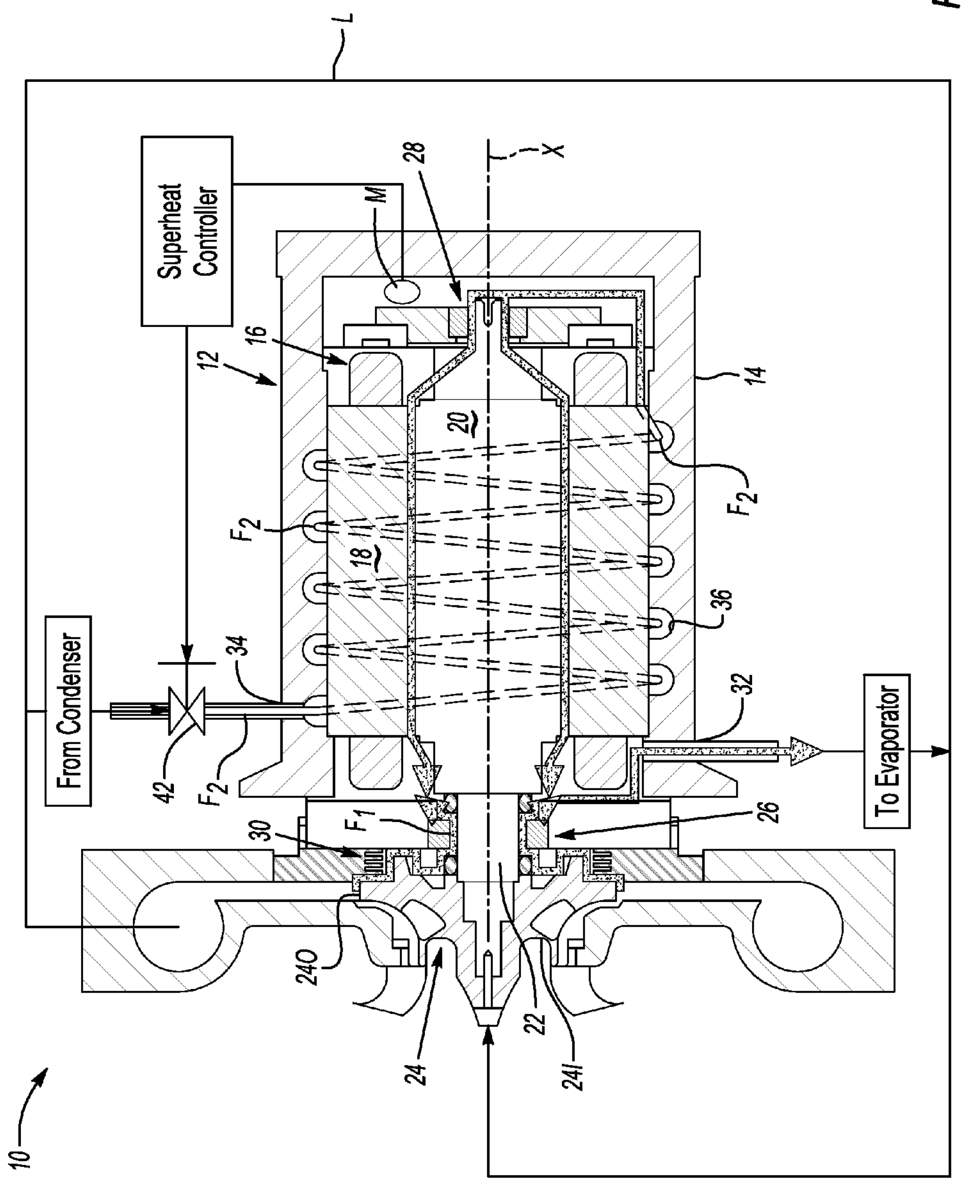


Fig-1
PRIOR ART



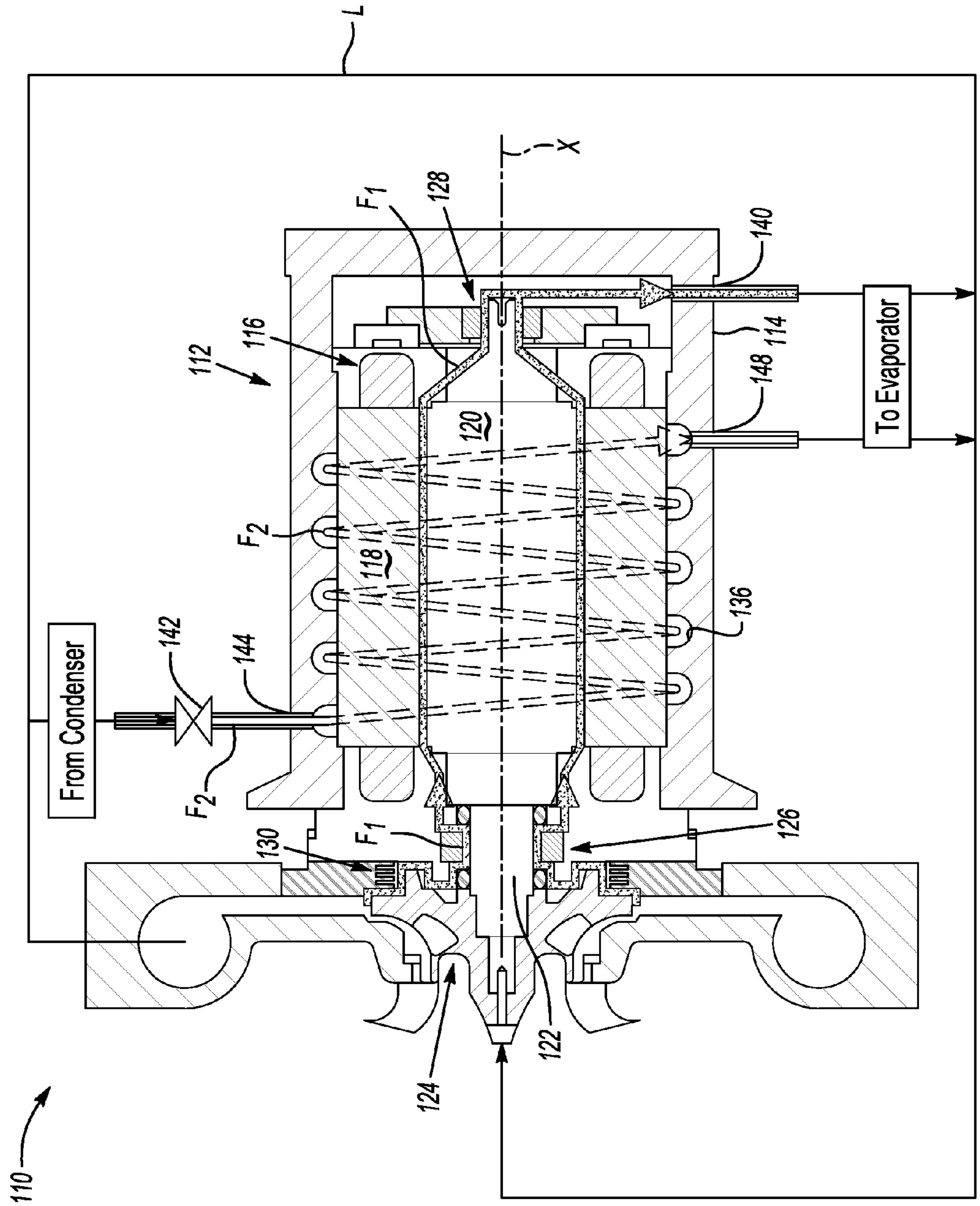

L
X
F_1
128
140
116
112
114
To Evaporator
148
120
F_2
118
136
From Condenser
142
144
F_2
130
F_1
126
122
124
110

Fig-2

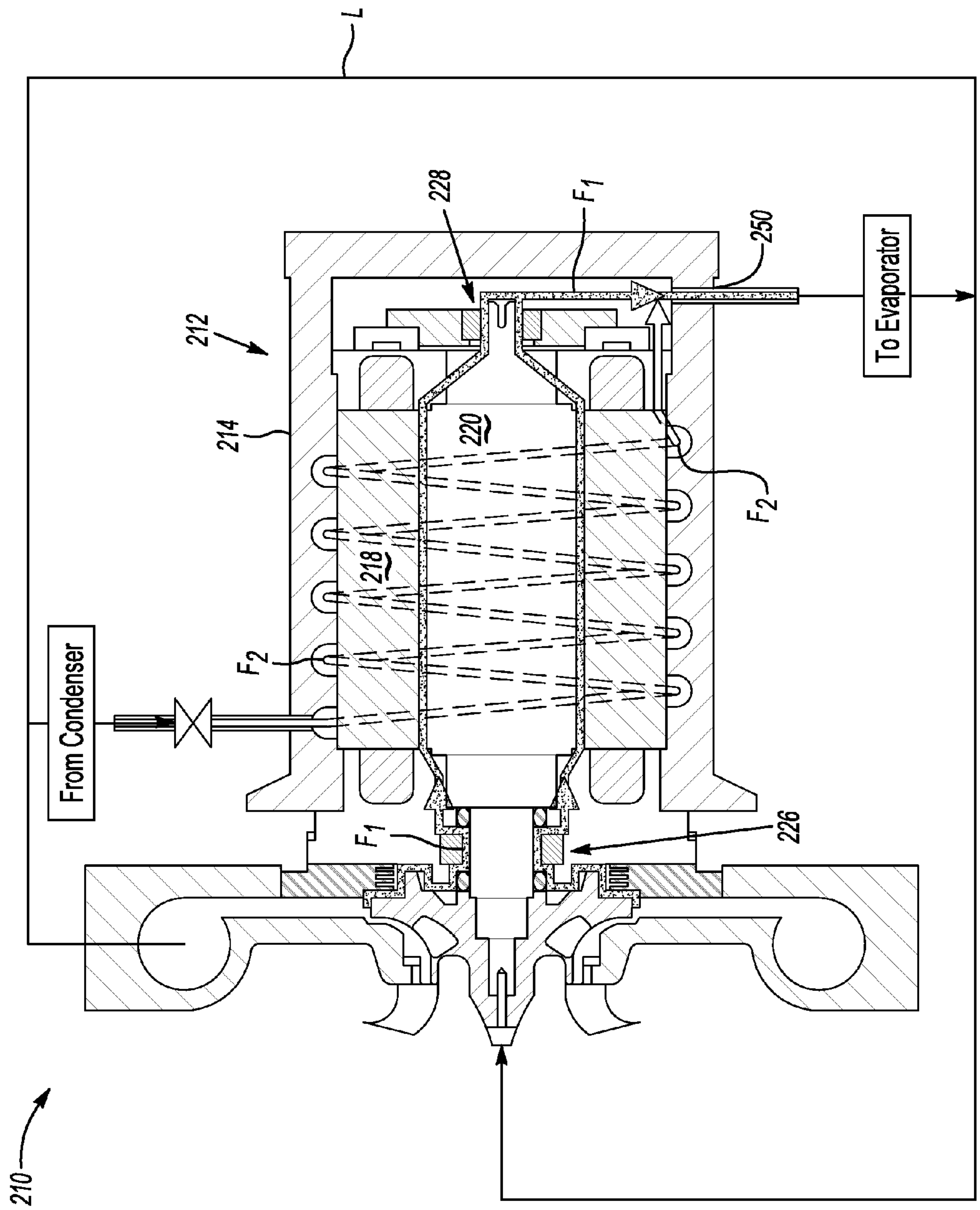

L
228
F_1
250
To Evaporator
212
214
220
F_2
218
From Condenser
F_2
F_1
226
210

Fig-3

COMPRESSOR WITH ROTOR COOLING PASSAGEWAY

BACKGROUND

[0001] This disclosure relates to cooling of a motor for a centrifugal compressor of a refrigeration system. Centrifugal refrigerant compressors are known, and include one or more impellers driven by a motor. The motor in some examples is an electric motor including a rotor and a stator. In one known example the motor is cooled by circulating refrigerant about the stator, to cool the stator, and then directing that refrigerant between the rotor and the stator to cool the rotor. After cooling the rotor, the refrigerant is returned to a refrigeration loop.

SUMMARY

[0002] One exemplary embodiment of this disclosure includes a centrifugal compressor for a refrigeration system having an electric motor, which includes a rotor and a stator. The compressor further includes a housing enclosing the electric motor, a stator cooling passageway provided within the housing, and a rotor cooling passageway provided within the housing. The rotor cooling passageway is independent of the stator cooling passageway.

[0003] Another exemplary embodiment of this disclosure includes a centrifugal compressor for a refrigeration system including an impeller, and an electric motor including a rotor and a stator. The electric motor is configured to rotationally drive the impeller via a shaft, and the impeller is separated from the electric motor by a seal. The compressor further includes a housing enclosing the electric motor. A rotor cooling passageway is provided within the housing, and is configured to provide a flow of fluid to cool the rotor. The rotor cooling passageway is provided with a flow of fluid leaked over the seal.

[0004] A further exemplary embodiment of this disclosure includes a refrigeration system having a refrigerant loop including a condenser, an evaporator, and an expansion device. The refrigeration system further includes a compressor in fluid communication with the refrigerant loop. The compressor has an electric motor including a rotor and a stator, a housing enclosing the electric motor, a stator cooling passageway provided within the housing, and a rotor cooling passageway provided within the housing. The rotor cooling passageway is independent of the stator cooling passageway.

[0005] These and other features of the present disclosure can be best understood from the following drawings and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The drawings can be briefly described as follows:

[0007] FIG. **1** is a highly schematic view of a prior art refrigeration system.

[0008] FIG. **2** is a highly schematic view of a refrigeration system according to this disclosure.

[0009] FIG. **3** is a highly schematic view of another refrigeration system according to this disclosure.

DETAILED DESCRIPTION

[0010] FIG. **1** schematically illustrates an example refrigeration system **10**. In the example, the refrigeration system **10** includes a centrifugal refrigerant compressor **12** for circulating a refrigerant. The compressor **12** includes a housing **14** within which an electric motor **16** is arranged. The electric motor **16** includes a stator **18** arranged radially outside of a rotor **20**. The rotor **20** is connected to a rotor shaft **22**, which rotates to drive an impeller **24** about an axis X to compress refrigerant. Although only one impeller **24** is shown, this disclosure may be used in compressors having more than one impeller. The rotor shaft **22** is rotatably supported by first and second bearing assemblies **26**, **28**.

[0011] In this example, the compressor **12** is in fluid communication with a refrigeration loop L. While not illustrated, refrigeration loops, such as the refrigeration loop L, are known to include a condenser, an evaporator, and an expansion device. In some known examples, the refrigeration loop L circulates refrigerant to a load, such as a chiller.

[0012] In this example, as refrigerant enters an inlet end **241** of the impeller **24** and is expelled radially outward from an outlet end **240** thereof, a flow F**1** is leaked over the labyrinth seal **30** (e.g., in particular, the flow F**1** leaks axially between the radial clearance between the rotor shaft **22** and the labyrinth seal **30**), and is directed downstream toward the first bearing assembly **26**. The flow F**1** is then directed out an outlet **32** of the housing **14** at a point upstream of the motor **16**. The outlet **32** of the housing **14** is directed to the evaporator of the refrigerant loop L.

[0013] With further reference to FIG. **1**, the electric motor **16** is cooled by tapping a cooling flow F**2** of refrigerant from the refrigerant loop L, and directing it into an inlet **34** in the housing **14**. In some examples, an expansion device **42** is provided upstream of the inlet **34**. The expansion device **42** may either be a fixed orifice or a controlled valve. Upstream of the expansion device **42**, the cooling flow F**2** is initially in sub-cooled liquid state, and downstream thereof the cooling flow F**2** is a liquid-vapor mixture. The cooling flow F**2** proceeds to circulate about the stator **18** by way of a circumferential passageway **36**. In one example, the outer radial boundary of the circumferential passageway **36** is provided in part by a helical channel formed in an inner wall of the housing **14**. In this example, an outer surface of the stator **18** provides an inner radial boundary for the circumferential passageway **36**. While a helical channel is illustrated, other types of circumferential passageways **36** come within the scope of this disclosure. As used herein, the term circumferential passageway refers to a passageway provided adjacent the outer circumference of the stator **18**.

[0014] Downstream of the stator **18**, the cooling flow F**2** is directed toward the second bearing assembly **28**, and passes axially between the rotor **20** and the stator **18** to cool the rotor. Then, the cooling flow F**2** intermixes with the flow F**1** at a point adjacent the first bearing assembly **26**, flows to the outlet **32**, and ultimately is directed to the evaporator of the refrigerant loop L.

[0015] Again, in this example, the cooling flow F**2** is provided into the housing **14** initially as a liquid-vapor mixture. However, the cooling flow F**2** is required to be in a gaseous state when passing between the rotor **20** and the stator **18**. Thus, in the example of FIG. **1**, the cooling flow F**2** is continually monitored, at M, by a superheat controller for at least one of pressure and temperature, to ensure that the cooling flow F**2** has changed phase into a gaseous state (e.g., by virtue of being heated by the stator **18**) before cooling the rotor **20**. One or more conditions of the refrigeration system **12** may have to be adjusted, depending on the measured conditions of the cooling flow F**2**, at M, to ensure that the appropriate phase change has occurred in the cooling flow F**2**.

[0016] FIG. **2** illustrates an example refrigeration system **110** according to this disclosure. To the extent not otherwise described or shown, the reference numerals in FIG. **2** generally correspond to those of FIG. **1**, with like parts having reference numerals prepended with a "**1**." Unlike the compressor **12**, however, the compressor **112** is arranged to have independent rotor and stator cooling passageways, as will be discussed below.

[0017] In this example, a rotor cooling passageway is provided from a flow F**1** leaked over the labyrinth seal **130**. As used herein, the term rotor cooling passageway refers to the passageway providing fluid to cool the rotor **120**. As one skilled in this art would appreciate, the rotor cooling passageway also provides cooling to the radially inner surface of the stator **118**, however. As refrigerant is expelled radially outwardly from the impeller **124**, a flow F**1** is leaked over the labyrinth seal **130** between a radial clearance between the rotor shaft **122** and the labyrinth seal **130**. The flow F**1** then passes downstream to the first bearing assembly **126**, and then between a radially inner surface of the stator **118** and a radially outer surface of the rotor **120**. Next, the flow F**1** passes downstream to the second bearing assembly **128**, and then to a rotor cooling outlet **140** of the housing **114** provided downstream of the motor **116**. The flow F**1** is ultimately directed to the evaporator of the refrigerant loop L, in one example.

[0018] Regarding the stator cooling passageway, a flow of fluid F**2** is tapped from the refrigerant loop L, and may optionally be expanded by an expansion device **142** before entering a stator cooling inlet **144** of the housing **114**. Downstream of the stator cooling inlet **144**, the fluid F**2** circulates radially around the stator **118** by way of a circumferential passageway **136**. After circulating about the stator **118**, the fluid F**2** is directed to a stator cooling outlet **148**, and ultimately back to the refrigerant loop L, in this example to the evaporator. Accordingly, the rotor and stator cooling passageways are independent of one another, as the fluid cooling the stator **118** is not also used to cool the rotor **120**. In other words, the stator **118** and the rotor **120** are cooled in parallel, and not in series like in the prior art system of FIG. **1**.

[0019] The impeller **124** compresses refrigerant in a gaseous state. The flow F**1** is thus initially in a gaseous state, and remains in a gaseous state as it flows within the rotor cooling passageway to cool the rotor **120**. Accordingly, there is no need to continually monitor the fluid cooling the rotor for a phase change, and thus the superheat controller of FIG. **1** is not required. Thus, having independent rotor and stator cooling passageways increases the reliability and safety of the system, while eliminating the need to continually monitor the fluid cooling the rotor.

[0020] FIG. **3** illustrates another example refrigeration system **210** according to this disclosure. To the extent not otherwise described or shown, the reference numerals in FIGS. **3** correspond with like parts in FIG. **2**, although the reference numerals are prepended with a "**2**" instead of a "**1**."

[0021] In FIG. **3**, the housing **214** includes a single outlet **250** for directing both the flow F**1** and the cooling flow F**2** back to the evaporator of the refrigerant loop L. While in this example the flow F**1** and the cooling flow F**2** are intermixed inside the housing **214**, this intermixing occurs downstream of the motor **216**. Thus, the rotor and stator cooling passageways are still independent of one another, in that fluid cooling the stator **218** (e.g., the cooling flow F**2**) is not also used to cool the rotor **220** (e.g., which is cooled with the flow F**1**).

[0022] Although the different examples have the specific components shown in the illustrations, embodiments of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[0023] One of ordinary skill in this art would understand that the above-described embodiments are exemplary and non-limiting. That is, modifications of this disclosure would come within the scope of the claims. Accordingly, the following claims should be studied to determine their true scope and content.

What is claimed is:

1. A centrifugal compressor for a refrigeration system, comprising:

an electric motor including a rotor and a stator;

a housing enclosing the electric motor;

a stator cooling passageway provided within the housing; and

a rotor cooling passageway provided within the housing, the rotor cooling passageway independent of the stator cooling passageway.

2. The centrifugal compressor as recited in claim **1**, wherein the electric motor is configured to rotationally drive an impeller via a shaft, the impeller provided at an axial inlet of the housing, wherein fluid being compressed by the impeller is substantially separated from the electric motor by a labyrinth seal.

3. The centrifugal compressor as recited in claim **2**, wherein the rotor cooling passageway is provided in part between the rotor and the stator, the rotor cooling passageway provided with a flow of fluid leaked over the labyrinth seal.

4. The centrifugal compressor as recited in claim **3**, wherein the housing includes a rotor cooling outlet in communication with the rotor cooling passageway.

5. The centrifugal compressor as recited in claim **4**, wherein the rotor cooling passageway is arranged such that the fluid within the rotor cooling passageway flows to the rotor cooling outlet without intermixing with fluid flowing through the stator cooling passageway.

6. The centrifugal compressor as recited in claim **5**, including first and second bearing assemblies supporting the shaft, the first bearing assembly provided downstream of the labyrinth seal and upstream of the motor, and the second bearing assembly provided downstream of the motor and upstream of the rotor cooling outlet, fluid within the rotor cooling passageway flowing axially from the labyrinth seal, to the first bearing assembly, to the motor, to the second bearing assembly, and then to the rotor cooling outlet.

7. The centrifugal compressor as recited in claim **1**, wherein a portion of the stator cooling passageway is provided in part by a circumferential passageway provided around the stator.

8. The centrifugal compressor as recited in claim **7**, wherein the housing includes a helical channel providing a portion of the circumferential passageway, and an outer surface of the stator provides a radially inner boundary for the circumferential passageway.

9. The centrifugal compressor as recited in claim **8**, wherein the housing includes a stator cooling inlet and a stator cooling outlet in communication with the circumferential passageway.

10. The centrifugal compressor as recited in claim **9**, wherein fluid within the stator cooling passageway flows from the stator cooling inlet to the stator cooling outlet without intermixing with fluid flowing within the rotor cooling passageway.

11. The centrifugal compressor as recited in claim **10**, wherein the stator cooling passageway consists of the stator cooling inlet, the circumferential passageway, and the stator cooling outlet.

12. The centrifugal compressor as recited in claim **10**, including an expansion device upstream of the stator cooling inlet for expanding a fluid before being circulated within the stator cooling passageway.

13. A centrifugal compressor for a refrigeration system, comprising:

an impeller;

an electric motor including a rotor and a stator, the electric motor configured to rotationally drive the impeller via a shaft, the impeller separated from the electric motor by a seal;

a housing enclosing the electric motor; and

a rotor cooling passageway provided within the housing, the rotor cooling passageway configured to provide a flow of fluid to cool the rotor, wherein the rotor cooling passageway is provided with a flow of fluid leaked over the seal.

14. The centrifugal compressor as recited in claim **13**, wherein the seal is a labyrinth seal.

15. The centrifugal compressor as recited in claim **13**, wherein the rotor cooling passageway is provided in part between the rotor and the stator.

16. The centrifugal compressor as recited in claim **15**, wherein the housing includes a rotor cooling outlet, the fluid within the rotor cooling passageway flowing from the seal to the rotor cooling outlet.

17. A refrigeration system comprising:

a refrigerant loop including a condenser, an evaporator, and an expansion device;

a compressor in fluid communication with the refrigerant loop, the compressor having an electric motor including a rotor and a stator, a housing enclosing the electric motor, a stator cooling passageway provided within the housing, and a rotor cooling passageway provided within the housing, the rotor cooling passageway independent of the stator cooling passageway.

18. The refrigeration system as recited in claim **17**, wherein the electric motor is configured to rotationally drive an impeller via a shaft, the impeller provided at an axial inlet of the housing, the impeller separated from the electric motor by a labyrinth seal.

19. The refrigeration system as recited in claim **18**, wherein the rotor cooling passageway is provided with a flow of fluid leaked over the labyrinth seal.

20. The refrigeration system as recited in claim **19**, wherein fluid within the rotor cooling passageway is configured to flow therein without intermixing with fluid flowing through the stator cooling passageway.

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