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(54) **INTERNAL LIQUID SUCTION HEAT EXCHANGER**

WÄRMETAUSCHER MIT INTERNER FLÜSSIGKEITSANSAUGUNG

ÉCHANGEUR DE CHALEUR À ASPIRATION DE LIQUIDE INTERNE

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Description

FIELD OF THE INVENTION

[0001] The subject matter disclosed herein relates to a refrigeration system.

BACKGROUND

[0002] Compressors are commonly employed to circulate a refrigerant through a refrigeration cycle in a cooling system. One particular use of the compressor is in a refrigeration system commonly known as a chiller. In addition to the compressor, the typical chiller also includes a condenser, an evaporator or cooler, and in some applications an oil-refrigerant separator. These components are connected to each other by tubing that circulates the refrigerant through the system. The evaporator typically includes a plurality of tubes that circulate water, which is cooled by an evaporating refrigerant, and the cooled water is circulated in a closed loop to another heat exchanger or cooling coil. At the cooling coil, circulating building or process air is directed through the cooling coil by a fan so that heat is removed from the circulating air.

[0003] With the adoption of low global warming potential (GWP) refrigerants, the characteristics of refrigerant cycles may result in lower discharge superheat. Due to the lower discharge superheat, oil may not be effectively separated from the discharge gas in the oil separator. This may cause excessive oil circulation, oil foaming in the evaporator, and/or a loss in performance.

[0004] Further, a refrigerant may contain residual atomized liquid particles (carryover) at the end of a heat exchange stage (mostly due to low superheating of the vapor and high vapor exit velocities), which may damage components downstream of the heat exchanger or result in operational issues. In addition, some known systems have poor versatility in response to changes in the fluid temperature and flowrate requirements downstream. Accordingly it is desirable to provide a system that overcomes the aforementioned drawbacks.

[0005] US 2010/0132927 A1 discloses a "flooded" type evaporator for the use in a refrigeration system. The evaporator is fluidly coupled between the condenser and the compressor and is provided with a superheating unit. The superheating unit is disposed within the evaporator and fluidly coupled between the condenser and the evaporator.

BRIEF DESCRIPTION OF THE INVENTION

[0006] In one aspect, there is provided a refrigeration system comprising: a compressor; a condenser fluidly coupled to the compressor; an evaporator having an inlet and an outlet, the evaporator fluidly coupled between the condenser and the compressor; a liquid suction heat exchanger fluidly coupled between the condenser and the evaporator, the liquid suction heat exchanger disposed within the evaporator for heat exchange between liquid refrigerant from the condenser and refrigerant vapor in the evaporator; a superheat sensor disposed in the evaporator outlet; and an expansion valve disposed between the liquid suction heat exchanger and the evaporator, wherein the expansion valve is operably coupled to the superheat sensor. A refrigeration system according to the invention is defined by claim 1.

[0007] In another aspect, there is provided a method of increasing suction superheat in a refrigeration system having a compressor, a condenser, an evaporator, and a liquid suction heat exchanger disposed in the evaporator, the method comprising: supplying liquid refrigerant from the condenser to the liquid suction heat exchanger; cooling the liquid refrigerant in the liquid suction heat exchanger against refrigerant vapor in the evaporator; supplying the cooled liquid refrigerant to the evaporator; vaporizing and superheating the cooled liquid refrigerant into the refrigerant vapor; increasing the superheat of the refrigerant vapor through heat exchange with the liquid refrigerant in the liquid suction heat exchanger; and supplying the refrigerant vapor to the compressor; further comprising measuring the superheat temperature differential relative to the saturation temperature of the refrigerant vapor passing through an outlet of the evaporator; and controlling an expansion valve based on the measured superheat, the expansion valve disposed between the liquid suction heat exchanger and the evaporator. A method of increasing suction superheat in a refrigeration system according to the invention is defined by claim 7.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic illustration of an exemplary refrigeration system;

FIG. 2 is a cross-sectional view of an exemplary flooded evaporator that may be used with the refrigeration system shown in FIG. 1; and

FIG. 3 is a perspective view of another exemplary flooded evaporator that may be used with the refrigeration system shown in FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0009] Described herein is an evaporator or chiller that includes a liquid suction heat exchanger installed inside the evaporator. The liquid suction heat exchanger increases suction superheat, by transferring heat form the liquid refrigerant leaving the condenser to the refrigerant gas existing in the evaporator heat exchanger, thereby increasing system efficiency and capacity. Transferring heat from the refrigerant gas leaving the evaporator to the liquid refrigerant is a cycle enhancement that is used to improve the performance of a refrigeration system as well as add additional superheat to the suction gas to enable better control of refrigerant flow control devices (e.g., expansion valves).

[0010] FIG. 1 illustrates an exemplary refrigeration system 10 that generally includes a compressor 12, an oil separator 14, a condenser 16, a liquid suction heat exchanger 18, an expansion valve 20, and an evaporator 22. In the exemplary embodiment, compressor 12 is a screw compressor and evaporator 22 is a flooded-type evaporator. However, compressor 12 may be any suitable type of compressor (e.g., centrifugal), and evaporator 22 may be any suitable evaporator that enables system 10 to function as described herein. Moreover, system 10 may not require oil separator 14.

[0011] Refrigeration system 10 is a closed loop system through which refrigerant is circulated in various states such as liquid and vapor. As such, a low temperature, low pressure superheated gas refrigerant is drawn into compressor 12 through a conduit 24 from evaporator 22. The refrigerant is compressed and the resulting high temperature, high pressure superheated gas is discharged from compressor 12 to condenser 16 through a conduit 26. Oil separator 14 is positioned on line 26 between compressor 12 and condenser 16 and separates compressor lubricant from the refrigerant before delivering the refrigerant to condenser 16.

[0012] In condenser 16, gaseous refrigerant is condensed into liquid as it gives up heat. The superheated gas refrigerant enters condenser 16 and is de-superheated, condensed, and sub-cooled through a heat exchanger process with, for example, water flowing through condenser 16 to absorb heat. However, condenser 16 may be air cooled or evaporatively cooled. The liquid refrigerant is discharged from condenser 16 and supplied through a conduit 28 to liquid suction heat exchanger 18.

[0013] In the exemplary embodiment, liquid suction heat exchanger 18 is a finned tube coil positioned within evaporator 22. However, heat exchanger 18 may be any suitable type of heat exchanger that enables system 10 to function as described herein. As such, a separate external casing to contain vapor refrigerant leaving the evaporator that is used with conventional liquid suction external heat exchangers is eliminated. The liquid refrigerant is cooled in heat exchanger 18 against vaporized and/or vaporizing refrigerant in evaporator 22 and subsequently supplied to evaporator 22 through a conduit 30. The cooled liquid refrigerant passes through a metering device or expansion valve 20, which converts the relatively higher temperature, high pressure sub-cooled liquid to a low temperature saturated liquid-vapor mixture.

[0014] The low temperature saturated liquid-vapor refrigerant mixture then enters evaporator 22 where it boils and changes states to a superheated gas as it absorbs the required heat of vaporization from chilled water (or other fluid) supplied through a tube bundle 32. The low pressure superheated gas then passes in heat exchange relation with heat exchanger 18, where it is further heated to increase the superheat of the gas and vaporize any residual liquid droplets that may pass tube bundle 32. The superheated gas is then drawn into the inlet of compressor 12 and the cycle is repeated. The chilled water is then circulated through a distribution system (not shown) to cooling coils for providing air conditioning, or for other purposes.

[0015] With reference to FIG. 2, evaporator 22 includes a pressure vessel shell 34 having an inlet 36 and an outlet or suction nozzle 38. Tube bundle 32 includes plurality of tubes 40 positioned for heat exchange with the refrigerant entering evaporator distribution system or inlet 36. Liquid suction heat exchanger 18 is located inside pressure vessel 34 above tube bundle 32 such as by brackets 42. However, heat exchanger 18 may be secured inside pressure vessel 34 by any suitable means (e.g., a fixing system). Heat exchanger 18 may be oriented in any suitable position relative to tube bundle 32 so that all or a part of the suction gas passing bundle 32 passes over heat exchanger 18. For example, heat exchanger 18 may be angled relative to tube bundle 32. Moreover, liquid suction heat exchanger 18 may comprise one or more distinct heat exchangers. Heat exchanger 18 includes at least one finned tube configured to receive liquid refrigerant from condenser 16 for heat exchange with the refrigerant vapor passing from tube bundle 32 to evaporator outlet 38. However, other heat exchanger configurations may be used.

[0016] In addition, a temperature sensor 44 (e.g., a superheat sensor) may be positioned within suction nozzle 38 to measure the suction gas temperature, which may then be used to calculate superheat above the saturation temperature of the refrigerant, which may be measured with a pressure or temperature sensor located in system 10. Such measurements may be used to control expansion valve 20. Thus, system 10 may subsequently eliminate the need for expensive liquid level sensors or complicated software or algorithms, and simple suction superheat control may be used. Heat exchanger 18 can also vaporize any residual liquid refrigerant that is drawn past tube bundle 32, which then allows for better use of heat transfer surfaces of bundle 32.

[0017] A method of increasing suction superheat in refrigeration system 10 includes supplying liquid refrigerant from condenser 16 to liquid suction heat exchanger 18, cooling the liquid refrigerant in liquid suction heat exchanger 18 against refrigerant vapor in evaporator 22, and supplying the cooled liquid refrigerant to evaporator 22. The cooled liquid refrigerant is subsequently vaporized into the refrigerant vapor, and the superheat of the refrigerant vapor is increased through heat exchange with the liquid refrigerant in liquid suction heat exchanger 18. The refrigerant vapor is then supplied to compressor 12.

[0018] FIG. 3 illustrates another exemplary embodiment of evaporator 22, which includes a pressure vessel 134 having an inlet 136 and an outlet or suction nozzle 138. A tube bundle 132 includes a plurality of tubes 140 fluidly coupled to a fluid inlet 141 (e.g., water inlet) and fluid outlet 143 and positioned for heat exchange with refrigerant entering evaporator inlet 136.

[0019] A liquid suction heat exchanger 118 is located inside pressure vessel 134 above tube bundle 132 such as by brackets (now shown). Heat exchanger 118 generally includes an inlet 146, an outlet 148, and a plurality of finned tubes 150 fluidly coupled between headers 152 and 154. Heat exchanger 118 may be oriented in any suitable position relative to tube bundle 132. For example, heat exchanger 118 may be angled relative to tube bundle 132. Moreover, liquid suction heat exchanger 118 may comprise one or more distinct heat exchangers.

[0020] As such, system 10 improves the overall refrigerant cycle capacity, efficiency, and reliability of compressor 12. System 10 also improves the ability to separate oil from the refrigerant gas leaving the compressor in systems having oil separator. Locating the liquid suction heat exchanger inside the evaporator effectively uses the space within evaporator 22 and eliminates the need for a separate pressure vessel to contain the liquid suction heat exchanger. Further, system 10 provides a flooded evaporator 22 in a system with reciprocating, screw, centrifugal, or scroll compressors, and provides an evaporator 22 that is efficient and effective in use. System 10 also increases compressor discharge superheat, which results in better oil separation efficiency and higher viscosities which are needed for proper lubrication of the compressor. Cycle efficiency and capacity is improved, and system 10 has lower liquid entrainment and better performance of the cooler as well as increased life of the compressor.

[0021] Further, the described refrigeration system adds a liquid suction heat exchanger to transfer heat from the suction gas to the liquid refrigerant leaving the condenser to improve the efficiency of the chiller. The added cooling to the liquid refrigerant improves the subcooling of the refrigerant, which improves the overall refrigerant efficiency. In addition, the added heat to the suction gas results in some superheating of the suction gas, which protects the compressor from liquid carryover. The added superheat to the suction gas also enables better control of the expansion valve that is used to regulate the refrigerant flow to the evaporator and can be done with a low cost suction superheat temperature sensor.

[0022] The systems and method described herein provide a liquid suction heat exchanger located within a chiller above its tube bundle. Liquid refrigerant from the condenser is routed through the liquid suction heat exchanger to exchange heat between the liquid refrigerant the suction refrigerant vapor. Thus, the warm liquid refrigerant from the condenser is further cooled by the suction vapor, which increases the liquid subcooling and the performance of the cycle. At the same time, the suction gas is warmed by the liquid, resulting in increased suction superheat elimination of liquid carryover and performance of the oil separator. As such, the evaporator and liquid suction heat exchanger assembly increases system performance with refrigerants such as, for example, low GWP refrigerants.

[0023] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. While various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A refrigeration system comprising:

    a compressor (12);
    a condenser (16) fluidly coupled to the compressor;
    an evaporator (22) having an inlet and an outlet, the evaporator fluidly coupled between the condenser and the compressor;
    a liquid suction heat exchanger (18) fluidly coupled between the condenser (16) and the evaporator (22), the liquid suction heat exchanger disposed within the evaporator for heat exchange between liquid refrigerant from the condenser and refrigerant vapor in the evaporator;
    a superheat sensor (44) disposed in the evaporator outlet; and
    an expansion valve (20) disposed between the liquid suction heat exchanger (18) and the evaporator (22), wherein the expansion valve is operably coupled to the superheat sensor.

2. The refrigeration system of claim 1, further comprising an oil separator (14) disposed between the compressor (12) and the condenser (16).

3. The refrigeration system of claim 1, wherein the liquid suction heat exchanger (18) comprises at least one finned tube.

4. The refrigeration system of claim 1, further comprising a tube bundle (32) disposed within the evaporator (22), the tube bundle configured to receive a fluid for heat exchange with the refrigerant in the evaporator.

5. The refrigeration system of claim 4, wherein the liquid suction heat exchanger (18) is disposed between the tube bundle (32) and the evaporator outlet.

6. The refrigeration system of claim 1, wherein the evaporator is a flooded-type evaporator or a falling film type evaporator.

7. A method of increasing suction superheat in a refrigeration system having a compressor (12), a condenser (16), an evaporator (22), and a liquid suction heat exchanger (18) disposed in the evaporator, the method comprising:

supplying liquid refrigerant from the condenser (16) to the liquid suction heat exchanger (18);
cooling the liquid refrigerant in the liquid suction heat exchanger against refrigerant vapor in the evaporator (22);
supplying the cooled liquid refrigerant to the evaporator;
vaporizing and superheating the cooled liquid refrigerant into the refrigerant vapor;
increasing the superheat of the refrigerant vapor through heat exchange with the liquid refrigerant in the liquid suction heat exchanger (18); and
supplying the refrigerant vapor to the compressor;
further comprising measuring the superheat temperature differential relative to the saturation temperature of the refrigerant vapor passing through an outlet of the evaporator; and
controlling an expansion valve (20) based on the measured superheat, the expansion valve disposed between the liquid suction heat exchanger and the evaporator. ◦

Patentansprüche

1. Kühlsystem, umfassend:

einen Kompressor (12);
einen Kondensator (16), der mit dem Kompressor fluidgekoppelt ist;
einen Verdampfer (22) mit einem Einlass und einem Auslass, wobei der Verdampfer zwischen dem Kondensator und dem Kompressor fluidgekoppelt ist;
einen Flüssigkeitsansaugwärmetauscher (18), der zwischen dem Kondensator (16) und dem Verdampfer (22) fluidgekoppelt ist, wobei der Flüssigkeitsansaugwärmetauscher innerhalb des Verdampfers zum Wärmetausch zwischen flüssigem Kältemittel vom Kondensator und Kältemitteldampf im Verdampfer angeordnet ist;
einen Überhitzungssensor (44), der im Verdampferauslass angeordnet ist; und
ein Expansionsventil (20), das zwischen dem Flüssigkeitsansaugwärmetauscher (18) und dem Verdampfer (22) angeordnet ist, wobei das Expansionsventil betreibbar an den Überhitzungssensor gekoppelt ist.

2. Kühlsystem nach Anspruch 1, weiter umfassend einen Ölabscheider (14), der zwischen dem Kompressor (12) und dem Kondensator (16) angeordnet ist.

3. Kühlsystem nach Anspruch 1, wobei der Flüssigkeitsansaugwärmetauscher (18) mindestens ein Rippenrohr umfasst.

4. Kühlsystem nach Anspruch 1, weiter umfassend ein Rohrbündel (32), das innerhalb des Verdampfers (22) angeordnet ist, wobei das Rohrbündel zum Aufnehmen eines Fluids zum Wärmetausch mit dem Kältemittel im Verdampfer ausgelegt ist.

5. Kühlsystem nach Anspruch 4, wobei der Flüssigkeitsansaugwärmetauscher (18) zwischen dem Rohrbündel (32) und dem Verdampferauslass angeordnet ist.

6. Kühlsystem nach Anspruch 1, wobei der Verdampfer ein Flutverdampfer oder ein Fallfilmverdampfer ist.

7. Verfahren zum Erhöhen einer Ansaugüberhitzung in einem Kühlsystem mit einem Kompressor (12), einem Kondensator (16), einem Verdampfer (22) und einem Flüssigkeitsansaugwärmetauscher (18), der im Verdampfer angeordnet ist, wobei das Verfahren umfasst:

Zuführen eines flüssigen Kältemittels von dem Kondensator (16) zu dem Flüssigkeitsansaugwärmetauscher (18);
Kühlen des flüssigen Kältemittels im Flüssigkeitsansaugwärmetauscher gegen Kältemitteldampf in dem Verdampfer (22);
Zuführen des gekühlten flüssigen Kältemittels zum Verdampfer;
Verdampfen und Überhitzen des gekühlten flüssigen Kältemittels in den Kältemitteldampf;
Erhöhen der Überhitzung des Kältemitteldampfs durch Wärmetausch mit dem flüssigen Kältemittel in dem Flüssigkeitsansaugwärmetauscher (18) und
Zuführen des Kältemitteldampfs zum Kompressor;
weiter umfassend ein Messen der Überhitzungstemperaturdifferenz bezogen auf die Sättigungstemperatur des Kältemitteldampfs, der durch einen Auslass des Verdampfers hindurchgeht; und
Steuern eines Expansionsventils (20) basierend auf der gemessenen Überhitzung, wobei das Expansionsventil zwischen dem Flüssigkeitsansaugwärmetauscher und dem Verdampfer angeordnet ist.

Revendications

1. Système de réfrigération comprenant :

un compresseur (12) ;
un condenseur (16) accouplé fluidiquement au compresseur ;
un évaporateur (22) ayant une entrée et une sortie, l'évaporateur étant accouplé fluidiquement entre le condenseur et le compresseur ;
un échangeur de chaleur à aspiration de fluide (18) accouplé fluidiquement entre le condenseur (16) et l'évaporateur (22), l'échangeur de chaleur à aspiration de fluide étant disposé à l'intérieur de l'évaporateur pour un échange de chaleur entre un fluide frigorigène provenant du condenseur et une vapeur de fluide frigorigène dans l'évaporateur ;
un capteur de surchauffe (44) disposé dans la sortie de l'évaporateur ; et
une soupape de détente (20) disposée entre l'échangeur de chaleur à aspiration de fluide (18) et l'évaporateur (22), dans lequel la soupape de détente est accouplée fonctionnellement au capteur de surchauffe.

2. Système de réfrigération selon la revendication 1, comprenant en outre un séparateur d'huile (14) disposé entre le compresseur (12) et le condenseur (16).

3. Système de réfrigération selon la revendication 1, dans lequel l'échangeur de chaleur à aspiration de fluide (18) comprend au moins un tube à ailettes.

4. Système de réfrigération selon la revendication 1, comprenant en outre un faisceau de tubes (32) disposé à l'intérieur de l'évaporateur (22), le faisceau de tubes étant configuré pour recevoir un fluide pour un échange de chaleur avec le fluide frigorigène dans l'évaporateur.

5. Système de réfrigération selon la revendication 4, dans lequel l'échangeur de chaleur à aspiration de fluide (18) est disposé entre le faisceau de tubes (32) et la sortie de l'évaporateur.

6. Système de réfrigération selon la revendication 1, dans lequel l'évaporateur est un évaporateur de type inondé ou un évaporateur de type à flux descendant.

7. Procédé d'augmentation de la surchauffe à l'aspiration dans un système de réfrigération présentant un compresseur (12), un condenseur (16), un évaporateur (22) et un échangeur de chaleur à aspiration de fluide (18) disposé dans l'évaporateur, le procédé comprenant :

la fourniture de fluide frigorigène entre le condenseur (16) et l'échangeur de chaleur à aspiration de fluide (18) ;
le refroidissement du fluide frigorigène dans l'échangeur de chaleur à aspiration de fluide contre la vapeur de fluide frigorigène dans l'évaporateur (22) ;
la fourniture du fluide frigorigène refroidi à l'évaporateur ;
la vaporisation et la surchauffe du fluide frigorigène refroidi dans la vapeur de fluide frigorigène ;
l'augmentation de la surchauffe de la vapeur de fluide frigorigène par l'échange de chaleur avec le fluide frigorigène dans l'échangeur de chaleur à aspiration de fluide (18) ; et
la fourniture de la vapeur de fluide frigorigène au compresseur ;
comprenant en outre la mesure du différentiel de température de surchauffe par rapport à la température de saturation de la vapeur de fluide frigorigène passant par une sortie de l'évaporateur ; et
la commande d'une soupape de détente (20) sur la base de la surchauffe mesurée, la soupape de détente étant disposée entre l'échangeur de chaleur à aspiration de fluide et l'évaporateur.

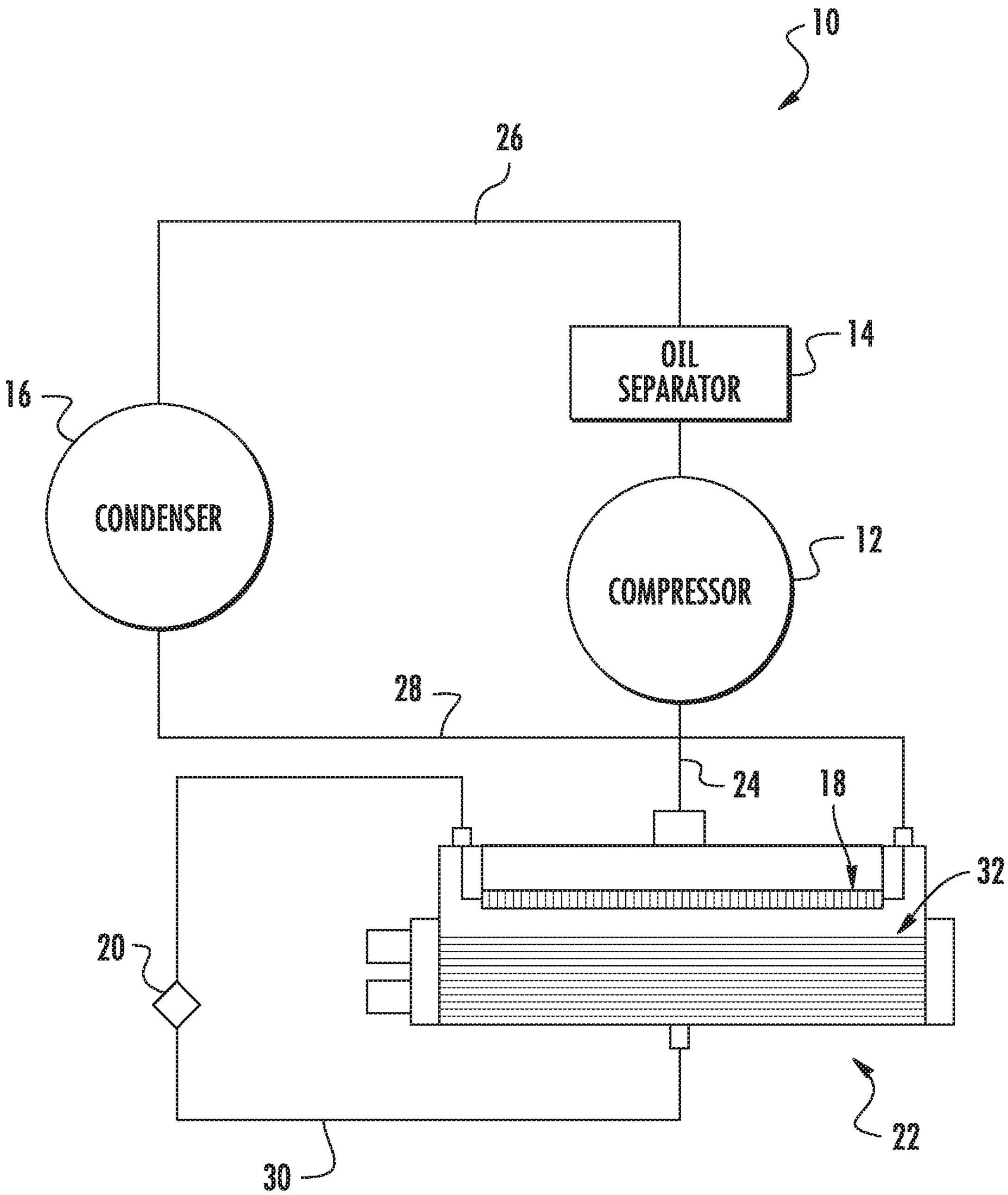
10
26
14
OIL
SEPARATOR
16
CONDENSER
COMPRESSOR
12
28
24
18
32
20
22
30

FIG. 1

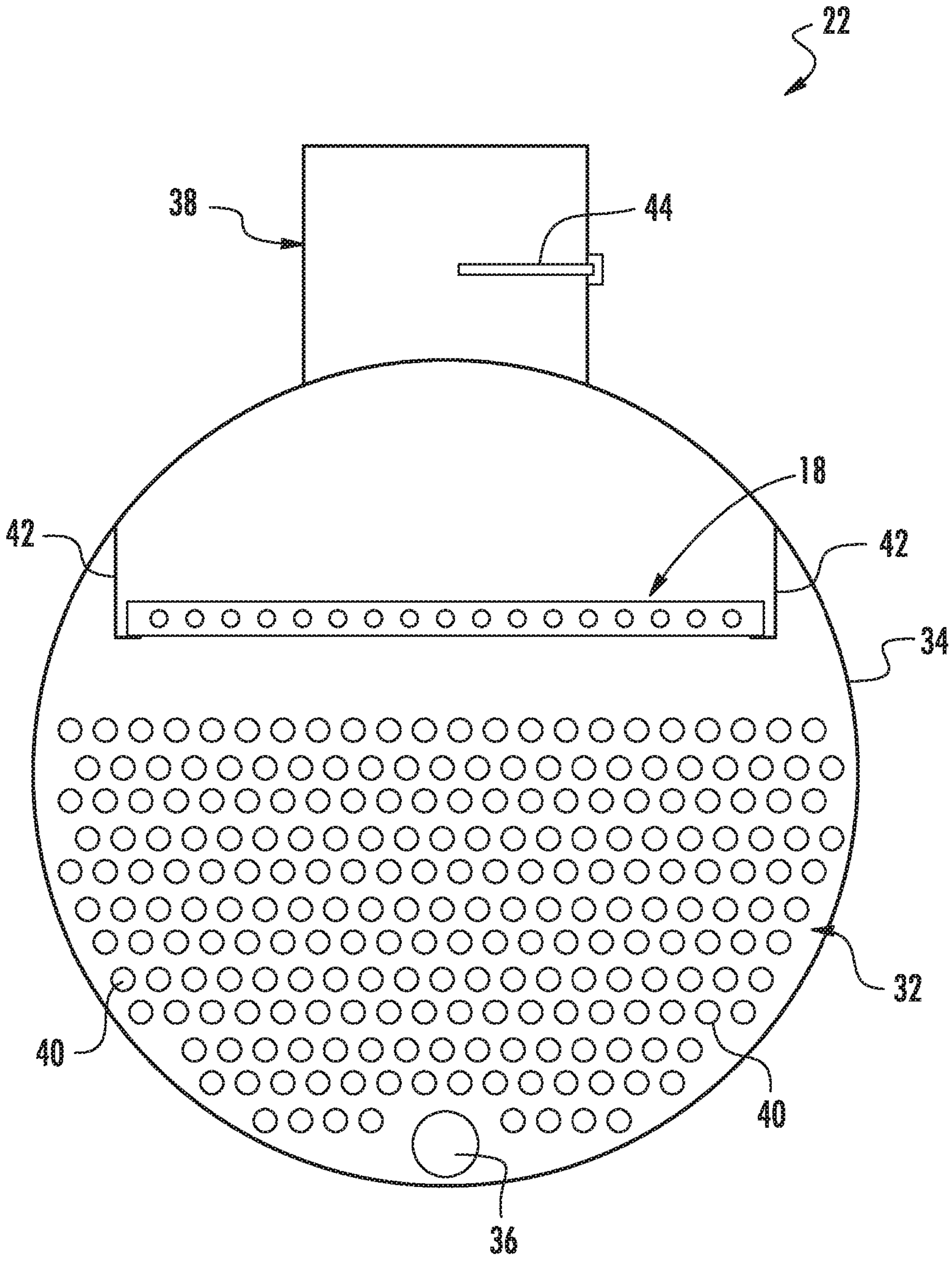

FIG. 2

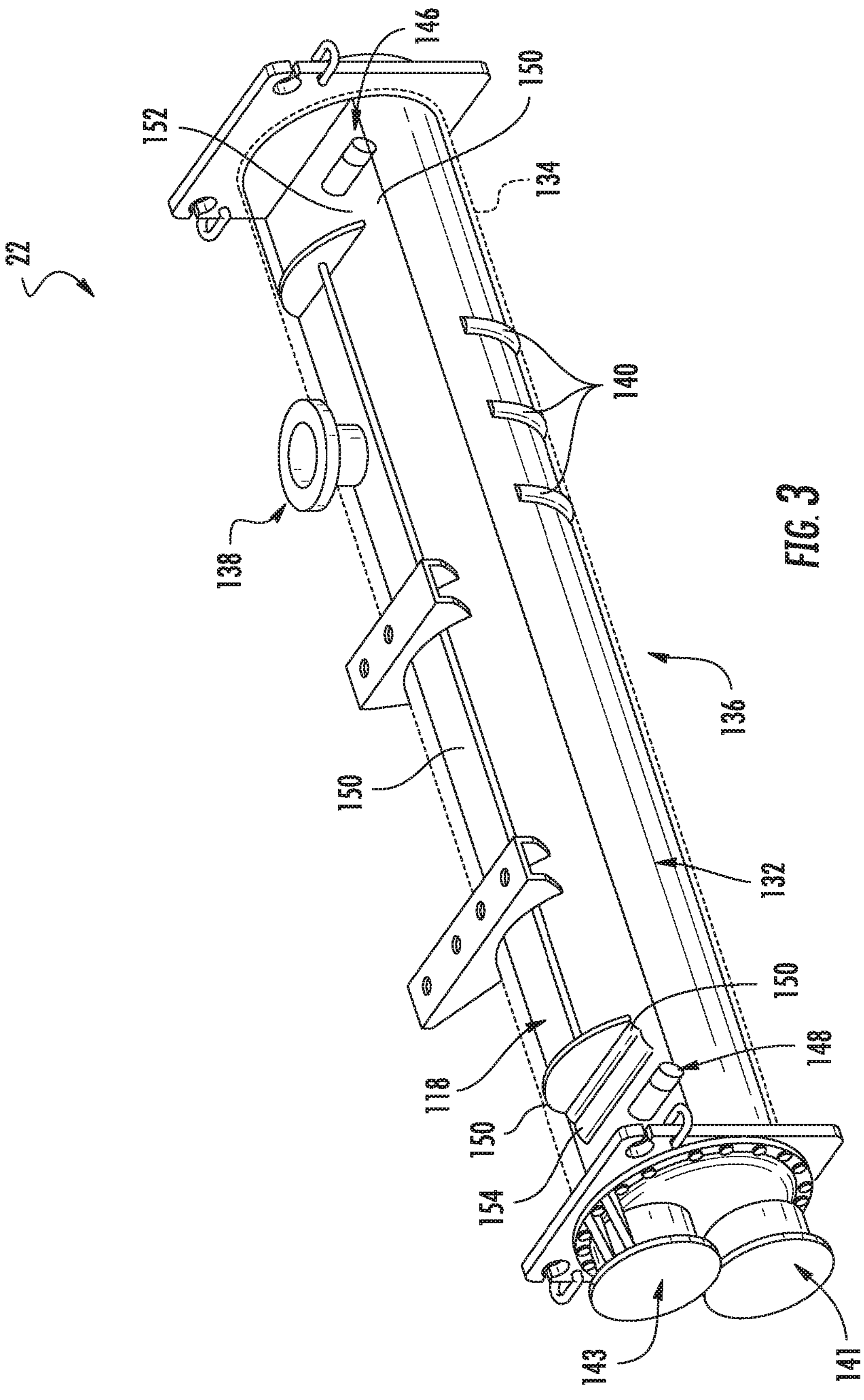
22
146
150
152
134
140
138
136
150
132
150
148
118
150
154
143
141

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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