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(54) **COMPRESSOR SYSTEM WITH CONTROLLED LUBRICANT RECLAIM**

KOMPRESSORSYSTEM MIT GESTEUERTER SCHMIERMITTELRÜCKGEWINNUNG

SYSTEME DE COMPRESSEUR AVEC RECUPERATION DE LUBRIFIANT COMMANDEE

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(73) Proprietor: **Carrier Corporation**
Farmington, CT 06034-4015 (US)

(72) Inventor: **HOLMES, Cornelius**
North Syracuse, NY 13212 (US)

(74) Representative: **Leckey, David Herbert**
Dehns
St Bride's House
10 Salisbury Square
London
EC4Y 8JD (GB)

(56) References cited:
US-A- 6 082 982
US-B1- 6 672 102
US-B1- 6 672 102

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Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to compressor systems and, more particularly, the invention relates to a system and method for controlled recovery of lubricant for such systems.

[0002] Compressors, for example screw compressors, are commonly used in various applications including, for example, water-cooled chillers.

[0003] A typical compressor requires oil to lubricate bearings, seals, gaps between rotors and between the rotors and adjacent stationary components such as the housing and end plates, and the like.

[0004] The bearing load carrying capacity depends heavily upon oil viscosity. Further, the sealing characteristics of the oil are dependent upon viscosity.

[0005] The oil to provide such sealing and lubrication is typically circulated through the system along with refrigerant. Oil entrained with the refrigerant is circulated from the compressor discharge through the system.

[0006] Separation and recycle of this oil, while maintaining acceptable oil viscosity, is a pressing need in the industry.

[0007] It is therefore a primary object of the present invention to provide a system and method whereby recovery of the oil and desired viscosity levels are efficiently accomplished and maintained.

[0008] Other objects and advantages of the present invention will appear herein below.

[0009] A compressor system having the features of the preamble of claim 1 is disclosed in US-A-6082982.

SUMMARY OF THE INVENTION

[0010] In accordance with the present invention, the foregoing objects and advantages have been readily attained.

[0011] According to the invention, a compressor system with controlled lubricant reclaim is provided as set forth in claim 1.

[0012] By controlling the rate of exposure of refrigerant- lubricant mixture to heat, control of the resulting lubricant viscosity is advantageously accomplished.

[0013] In further accordance with the invention, a method is provided for controlling reclaim of lubricant in a compressor system as set forth in claim 8.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] A detailed description of preferred embodiments of the present invention follows, with reference to the attached drawings wherein:

Figure 1 schematically illustrates a system and method in accordance with the present invention.

DETAILED DESCRIPTION

[0015] The invention relates to a system and method for controlled recovery of lubricant such as oil in a compressor system whereby resulting viscosity of the oil can be controlled and maintained.

[0016] Figure 1 shows a system 10 in accordance with the present invention. This basic system, without the additional features disclosed herein, is the subject of commonly owned U.S. Patent No. 6,672,102 to Huenniger et al. issued January 6, 2004.

[0017] Referring to Figure 1 herein, system 10 includes a compressor circuit including a compressor 12, a condenser 14 and an evaporator 16 which are connected by refrigerant lines 18, 20 for flow of refrigerant through these components as desired. A typical system includes a further flow line from condenser 14 through an expansion device (not shown) and to evaporator 16. These components and lines complete a typical compressor circuit.

[0018] In further accordance with the invention, a lubricant circuit is provided for conveying oil from an oil sump 22 through an oil pump 24 and to an oil inlet 26 of compressor 12. A filter 28 can be positioned along oil line 30, if desired. An oil drain 32 carries oil from compressor 12 back to oil sump 22.

[0019] As set forth above, during operation of the compressor circuit and lubricant circuit, oil or other suitable lubricant is mixed with refrigerant discharged through line 18 to condenser 14, the expansion device and evaporator 16. Separation and reclaim of the oil for further use within the system, while maintaining oil viscosity at desired values, is the focus of the present invention.

[0020] According to the invention, the mixture within evaporator 16 is therefore metered or fed to a reclaim vaporizer 34, wherein the mixture is exposed to heat so as to separate the refrigerant from the lubricant. This heat boils the refrigerant off from the lubricant, and the refrigerant passes through vent lines 36 back to line 20 and to the suction inlet 38 of compressor 12. Due to the control of the present invention, remaining oil has at this point been sufficiently purged of refrigerant as to have a viscosity suitable to maintain sealing and lubrication of the compressor as desired.

[0021] Note that a vent line 38 is also communicated with oil sump 22 for carrying any further boiled off refrigerant from this location back to suction inlet 38 as well.

[0022] Oil separated within reclaim vaporizer 34 passes through an oil discharge line 40 and back to sump 22 for further circulation within the lubricant circuit.

[0023] In accordance with the invention, heat is preferably applied to the refrigerant-lubricant mixture within vaporizer 34 from hot gas from the discharge of compressor 12, which can be fed to vaporizer 34, for example through line 42 which advantageously is separated off of main line 18 upstream of condenser 14. This hot gas from compressor 12 will be at a temperature greater than the temperature of the mixture of refrigerant and lubricant

within evaporator 16. Thus, the gas discharge from compressor 12 can advantageously be used to provide heat to the mixture, and the resulting cooled refrigerant is then passed through line 44 to evaporator 16 and back to suction inlet 38 of compressor 12.

[0024] Under certain operating conditions, sufficient heat may not be provided from the gas discharge of compressor 12, To this end, the system in accordance with the present invention may further preferably include a supplemental heat source 46, which is schematically shown in the drawings, and which can be a heater device and/or a further flow of fluid from the system, either of which can be controlled to provide additional heat to vaporizer 34 as needed.

[0025] In accordance with the present invention, it has been found that the viscosity of lubricant circulating within the lubricant circuit can be controlled by controlling the rate of separation of refrigerant from the lubricant within vaporizer 34. To this end, a control valve 48 is advantageously positioned along line 50 for carrying the mixture from evaporator 44 to reclaim vaporizer 34. This valve 48 is advantageously adapted to be controlled by a control unit 50 which includes sensors of the mixture temperature (T_{ref}), for example within evaporator 44, and the temperature of reclaimed oil (T_{oil}), for example within line 40 to sump 22.

[0026] It has been found that the temperature differential between T_{oil} and T_{ref} is directly proportional to the resulting viscosity of this separated oil. Thus, control unit 50 can advantageously be adapted to sense or otherwise determine these temperatures, and then operate control valve 48 so as to control flow rate of the mixture from evaporator 16 to reclaim vaporizer 34 and thereby control the temperature difference between T_{oil} and T_{ref}. In accordance with the present invention, a pre-selected range of temperature difference can be entered into control unit 50 and control unit 50 can be adapted or otherwise programmed to control valve 48 so as to maintain the temperature difference within this pre-selected range.

[0027] As the flow rate of mixture from evaporator 16 is increased, the amount of refrigerant boiled off within reclaim vaporizer 34 per flow volume will decrease, and the viscosity of resulting separated lubricant will be reduced. As the flow rate of mixture from evaporator 16 is decreased, further separation is accomplished per flow volume by the heat applied thereto, and the resulting separated lubricant will contain less refrigerant and have a higher viscosity.

[0028] Control unit 50 can be any suitable processor unit programmed with proper command instructions as set forth above. Specifically, control unit 50 is adapted to receive signals that are indicative of the temperatures T_{oil} and T_{ref}, and to utilize these signals to determine a proper operating position for valve 48.

[0029] It should readily be appreciated that the system and method in accordance with the present invention could readily be accomplished through other approaches as well. Specifically, it is considered to be well within the scope of the present invention to control resulting viscosity of separated lubricant by instead controlling the amount of heat applied within vaporizer 34, and/or controlling both the amount of heat and the flow rate through valve 48 as described above.

[0030] Also as shown in Figure 1, supplemental heater 46, if needed, is further advantageously controlled by control unit 50. Such control would involve control unit 50 receiving the sensed signal related to temperatures T_{oil} and T_{ref}, and would be programmed under situations where the difference between these temperatures is insufficient and valve 48 cannot be further closed to operate supplemental heater 46 to apply further heat as desired.

[0031] It should readily be appreciated that while portions of the above disclosure refer to the lubricant as oil, the system of the present invention is readily applicable to systems utilizing other fluids as lubricant as well, so long as this other lubricant is to be separated from refrigerant with which it is mixed during operation of the compressor and lubricant circuits.

[0032] It should also be appreciated that while this disclosure is made in terms of a screw compressor, the system and method of the present invention are readily applicable to any type of compressor system wherein the lubricant is mixed with refrigerant during some portion of operation, and must later be separated from same.

[0033] Finally, although the preferred embodiment of the present invention shows heat applied to the mixture within reclaim vaporizer 34 being supplied from hot gas discharged from compressor 12, the system of the present invention whereby heat exchange within vaporizer 34 is controlled to provide desired lubricant viscosity could be accomplished utilizing other sources of heat as well, and this is well within the broad scope of the present invention.

[0034] An illustrative example of operation of the invention is provided herein. Assume a system as shown in Figure 1 is operating with valve 48 fully open. Mixture from evaporator 16 to reclaim vaporizer 34 is at a maximum flow rate. At this operation, control unit 50 has been programmed to maintain a difference (ΔT) between T_{oil} and T_{ref} at between about a low value of X AND a high value of Y. Assume the temperature difference ΔT drops to a level which is less than X. At this point, control unit 50 would partially close valve 48 to slow the flow of mixture to reclaim vaporizer 34. This results in greater heating of the mixture and a higher T_{oil}, which also leads to an increase in ΔT.

[0035] Assume that ΔT now exceeds the value Y. At this point, control unit 50 will open valve 48 further to increase flow of mixture to reclaim vaporizer 34. In this way, flow rate to reclaim vaporizer 34 is optimized to maximize oil reclaim volume while maintaining the desired ΔT and, accordingly, a desired oil viscosity.

[0036] Assume next that after the first partial closing of valve 48, the ΔT value remains less than X. Valve 48 is therefore closed further by control unit 50 to attempt

to raise ΔT to the desired value. Control unit 50 continues to close valve 48 until valve 48 reaches a maximum closed setting wherein a minimum flow is fed to reclaim vaporizer 34. If at this point, ΔT is still too low, supplemental heater 46 can be activated to provide more heat and raise ΔT to the desired range.

[0037] It should be appreciated that a control system has been provided according to the invention which advantageously provides control of oil viscosity in reclaimed oil whereby the viscosity can be maintained at desired levels, for example to ensure good lubrication and sealing at expected operating conditions of the compressor.

[0038] It is to be understood that the invention is not limited to the illustrations described and shown herein, which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are susceptible of modification of form, size, arrangement of parts and details of operation.

Claims

1. A compressor system (10) with controlled lubricant reclaim, comprising:

a compressor circuit comprising a compressor (12), a condenser (14), and an evaporator (16) connected by refrigerant flow line;
a lubricant circuit for circulating lubricant to the compressor (12);
a reclaim vaporizer (34) adapted to heat a refrigerant-lubricant mixture from the evaporator (16) whereby the mixture is heated and lubricant and refrigerant are separated to provide reclaimed lubricant to the lubricant circuit and reclaimed refrigerant to the compressor circuit; and
a control unit (50); **characterised in that**:

said control unit is adapted to control flow of the mixture from the evaporator (16) to the reclaim vaporizer (34) based upon temperature (T_{ref}) of the mixture from the evaporator (16) and temperature (T_{oil}) of reclaimed lubricant leaving the reclaim vaporiser (34).

2. The system of claim 1, wherein the control unit (50) comprises a valve (48) positioned along a discharge line (50) for conveying the mixture from the evaporator (16) to the reclaim vaporizer (34).

3. The system of claim 2, wherein the control unit is adapted to operate the valve (48) to control flow rate of the mixture to the reclaim vaporiser (34) so as to maintain a temperature difference between the reclaimed lubricant and the mixture within a preselected range.

4. The system of claim 1, wherein the control unit is adapted to control flow rate of the mixture to the reclaim vaporiser (34) so as to maintain a temperature difference between the reclaimed lubricant and the mixture within a preselected range.

5. The system of any preceding claim, wherein the reclaim vaporizer (34) is communicated with discharge gas from the compressor (12) to heat the mixture.

6. The system of claim 5, further comprising a supplemental heater (46) for providing additional heat to the mixture in the reclaim vaporizer (34).

7. The system of any preceding claim, wherein the compressor (12) is a screw compressor.

8. A method for controlling reclaim of lubricant in a compressor system (10) according to claim 1, comprising the steps of:

operating the compressor circuit so as to provide a refrigerant-lubricant mixture leaving the evaporator (16);
exposing the mixture to heat in the reclaim vaporizer (34) so as to provide reclaimed lubricant to the lubricant circuit and reclaimed refrigerant to the compressor circuit; **characterized by**
controlling flow rate of the mixture to the reclaim vaporizer (34) based upon temperature (T_{ref}) of the mixture leaving the evaporator and temperature (T_{oil}) of the reclaimed lubricant leaving the reclaim vaporizer.

9. The method of claim 8, wherein the controlling step comprises sensing the temperature of the mixture and the reclaimed lubricant, and controlling flow of the mixture to the reclaim vaporizer to maintain a temperature difference between reclaimed lubricant temperature and mixture temperature within a preselected range.

Patentansprüche

1. Kompressorsystem (10) mit gesteuerter Schmiermittelrückgewinnung, umfassend:

einen Kompressorkreislauf, umfassend einen Kompressor (12), einen Kondensator (14) und einen Evaporator (16), die durch eine Kühlmittelflussleitung verbunden sind;
einen Schmiermittelkreislauf zum Zirkulieren von Schmiermittel zum Kompressor (12);
einen Rückgewinnungsverdampfer (34), der dazu ausgebildet ist, ein Kühlmittel-Schmiermittel-Gemisch vom Evaporator (16) zu erwärmen, wodurch das Gemisch erwärmt wird und das

Schmiermittel und das Kühlmittel getrennt werden, um rückgewonnenes Schmiermittel an den Schmiermittelkreislauf und rückgewonnenes Kühlmittel an den Kompressorkreislauf bereitzustellen; und
eine Steuereinheit (50), **dadurch gekennzeichnet, dass**:

die Steuereinheit dazu ausgebildet ist, den Fluss des Gemischs vom Evaporator (16) zum Rückgewinnungsverdampfer (34) auf Grundlage der Temperatur (T_{ref}) des Gemischs vom Evaporator (16) und der Temperatur (T_{oil}) von rückgewonnenem Schmiermittel zu steuern, das den Rückgewinnungsverdampfer (34) verlässt.

2. System nach Anspruch 1, wobei die Steuereinheit (50) ein Ventil (48) umfasst, das an einer Auslaufleitung (50) zum Fördern des Gemischs vom Evaporator (16) zum Rückgewinnungsverdampfer (34) angeordnet ist.

3. System nach Anspruch 2, wobei die Steuereinheit dazu ausgebildet ist, das Ventil (48) so zu betätigen, dass die Durchflussrate des Gemischs zum Rückgewinnungsverdampfer (34) gesteuert wird, um eine Temperaturdifferenz zwischen dem rückgewonnenen Schmiermittel und dem Gemisch innerhalb eines im Voraus ausgewählten Bereichs zu halten.

4. System nach Anspruch 1, wobei die Steuereinheit dazu ausgebildet ist, die Durchflussrate des Gemischs zum Rückgewinnungsverdampfer (34) zu steuern, um eine Temperaturdifferenz zwischen dem rückgewonnenen Schmiermittel und dem Gemisch innerhalb eines im Voraus ausgewählten Bereichs zu halten.

5. System nach einem der vorangehenden Ansprüche, wobei der Rückgewinnungsverdampfer (34) mit Fördergas vom Kompressor (12) in Verbindung steht, um das Gemisch zu erwärmen.

6. System nach Anspruch 5, ferner umfassend eine ergänzende Heizeinrichtung (46) zum Bereitstellen von zusätzlicher Wärme an das Gemisch im Rückgewinnungsverdampfer (34).

7. System nach einem der vorangehenden Ansprüche, wobei der Kompressor (12) ein Schneckenkompressor ist.

8. Verfahren zum Steuern der Rückgewinnung von Schmiermittel in einem Kompressorsystem (10) nach Anspruch 1, folgende Schritte umfassend:

Betreiben des Kompressorkreislaufs, um ein Kühlmittel-Schmiermittel-Gemisch bereitzustellen, das den Evaporator (16) verlässt;
Aussetzen des Gemischs an Wärme im Rückgewinnungsverdampfer (34), um rückgewonnenes Schmiermittel an den Schmiermittelkreislauf und rückgewonnenes Kühlmittel an den Kompressorkreislauf bereitzustellen; **gekennzeichnet durch**
Steuern der Flussrate des Gemischs an den Rückgewinnungsverdampfer (34) auf Grundlage der Temperatur (T_{ref}) des Gemischs, das den Evaporator (16) verlässt, und der Temperatur (T_{oil}) von rückgewonnenem Schmiermittel zu steuern, das den Rückgewinnungsverdampfer verlässt.

9. Verfahren nach Anspruch 8, wobei der Steuerschritt Folgendes umfasst: Messen der Temperatur des Gemischs und des rückgewonnenen Schmiermittels, und Steuern des Flusses des Gemischs zum Rückgewinnungsverdampfer, um eine Temperaturdifferenz zwischen der Temperatur des rückgewonnenen Schmiermittels und der Gemischtemperatur innerhalb eines im Voraus ausgewählten Bereichs zu halten.

Revendications

1. Système à compresseur (10) à récupération régulée de lubrifiant, comprenant :

un circuit à compresseur comprenant un compresseur (12), un condenseur (14) et un évaporateur (16) reliés par une ligne d'écoulement de réfrigérant ;
un circuit de lubrifiant permettant de faire circuler le lubrifiant vers le compresseur (12) ;
un vaporisateur (34) de récupération conçu pour chauffer un mélange réfrigérant lubrifiant à partir de l'évaporateur (16), moyennant quoi le mélange est chauffé et le lubrifiant et le réfrigérant sont séparés pour obtenir du lubrifiant récupéré dans le circuit de lubrifiant et un réfrigérant récupéré dans le circuit à compresseur ; et
une unité (50) de commande ; **caractérisé en ce que** :

ladite unité de commande est conçue pour réguler le débit du mélange à partir de l'évaporateur (16) vers le vaporisateur (34) de récupération en fonction de la température ($T_{réf}$) du mélange partant de l'évaporateur (16) et de la température (T_{OIL}) du lubrifiant récupéré quittant le vaporisateur (34) de récupération.

2. Système selon la revendication 1, dans lequel l'unité

de commande (50) comprend une soupape (48) positionnée le long d'une conduite d'évacuation (50) pour acheminer le mélange à partir de l'évaporateur (16) vers le vaporisateur (34) de récupération.

3. Système selon la revendication 2, dans lequel l'unité de commande est conçue pour actionner la soupape (48) pour réguler le débit du mélange acheminé vers le vaporisateur (34) de récupération de manière à maintenir une différence de température entre le lubrifiant récupéré et le mélange dans un intervalle présélectionné.

4. Système selon la revendication 1, dans lequel l'unité de commande est conçue pour réguler le débit du mélange vers le vaporisateur (34) de récupération de manière à maintenir une différence de température entre le lubrifiant récupéré et le mélange dans un intervalle présélectionné.

5. Système selon l'une quelconque des revendications précédentes, dans lequel le vaporisateur (34) de récupération communique avec le gaz d'évacuation provenant du compresseur (12) afin de chauffer le mélange.

6. Système selon la revendication 5, comprenant en outre un dispositif supplémentaire de chauffage (46) permettant de fournir une chaleur supplémentaire au mélange dans le vaporisateur (34) de récupération.

7. Système selon l'une quelconque des revendications précédentes, dans lequel le compresseur (12) est un compresseur à vis.

8. Procédé de régulation la récupération de lubrifiant dans un système à compresseur (10) selon la revendication 1, comprenant les étapes suivantes :

actionnement du circuit à compresseur de manière à obtenir un mélange réfrigérant lubrifiant quittant l'évaporateur (16) ;
exposition du mélange à la chaleur dans le vaporisateur (34) de récupération, de manière à acheminer le lubrifiant récupéré dans le circuit à lubrifiant et le réfrigérant récupéré vers le circuit à compresseur ; **caractérisé par**
la régulation du débit du mélange vers le vaporisateur (34) de récupération en fonction de la température ($T_{réf}$) du mélange partant de l'évaporateur et de la température (T_{OIL}) du lubrifiant récupéré quittant le vaporisateur de récupération.

9. Procédé selon la revendication 8, dans lequel l'étape de régulation comprend la détection de la température du mélange et du lubrifiant récupéré, et la régulation du débit du mélange vers le vaporisateur de récupération, afin de maintenir une différence de température entre la température de lubrifiant récupéré et la température de mélange dans un intervalle présélectionné.

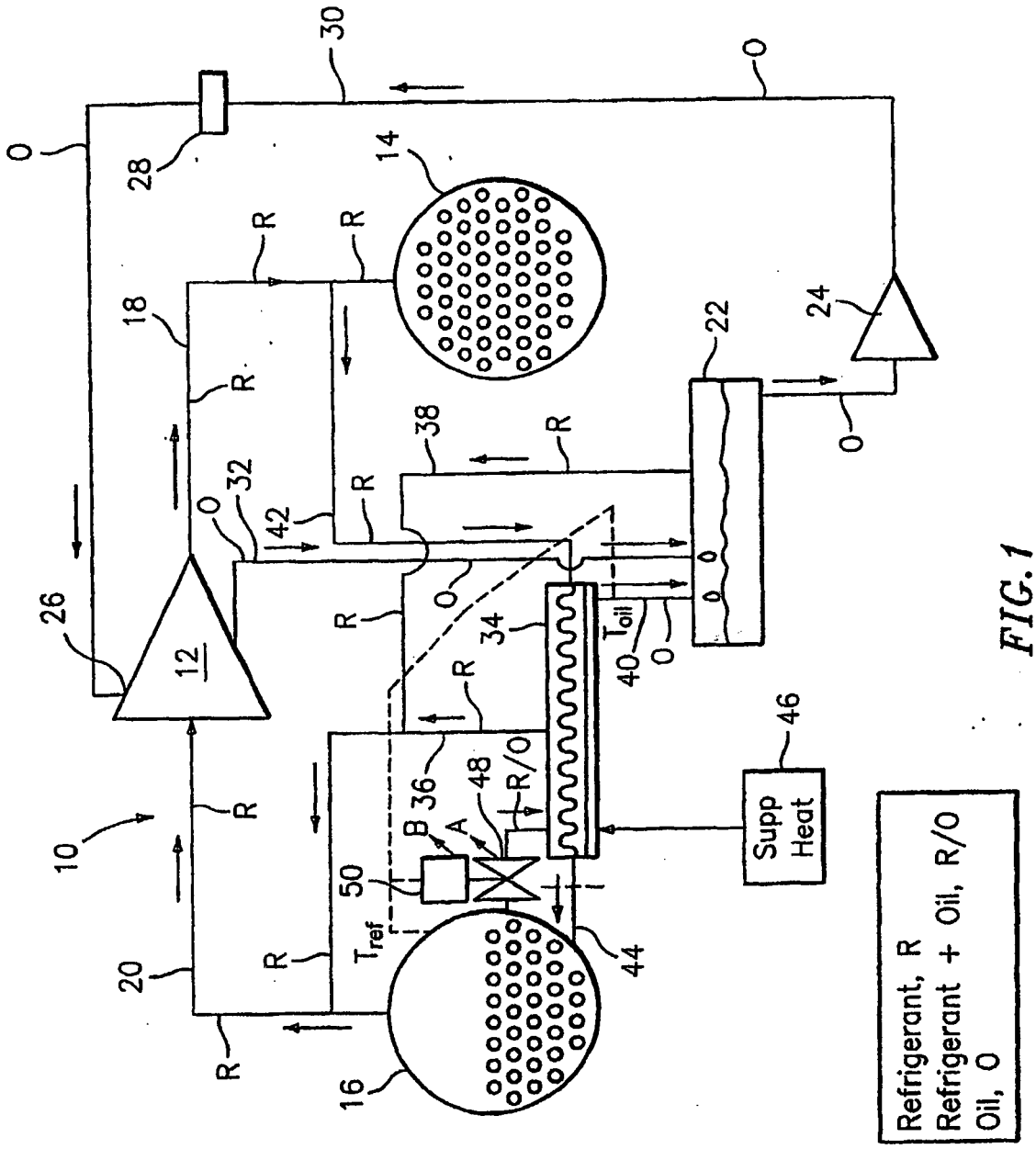
30
28
14
18
22
24
38
32
42
26
12
34
40
T_{oil}
46
Supp Heat
10
48
R/O
B
A
36
50
T_{ref}
20
44
16
Refrigerant, R
Refrigerant + Oil, R/O
Oil, O

FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6082982 A **[0009]**
- US 6672102 B, Huenniger **[0016]**