(19) Europäisches Patentamt
European Patent Office
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(11) **EP 2 990 739 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.03.2016 Bulletin 2016/09

(51) Int Cl.:
F25B 1/02 *(2006.01)* ***F25B 31/00*** *(2006.01)*

(21) Application number: **15182677.3**

(22) Date of filing: **27.08.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(30) Priority: **29.08.2014 IT GE20140083**

(71) Applicants:
- **BI Freezer Srl**
  16162 Genova (IT)
- **Balocchi, Cristiano**
  16166 Genova (IT)

(72) Inventor: **Balocchi, Cristiano**
16166 Genova (IT)

(74) Representative: **Karaghiosoff, Giorgio Alessandro**
Studio Karaghiosoff e Frizzi S.r.l.
Via F. Baracca 1R 4° piano
17100 Savona (IT)

(54) PROCESS FOR THE EXTERNAL FORCE-FEED LUBRICATION OF REFRIGERATING COMPRESSORS

(57) Lubrication system in refrigerating reciprocating compressors facilitating the implementation of refrigerating units with compressors in parallel based on the use of a centralized hydraulic pump that provides the compressors to be force-feed lubricated without leaving oil reserve in their crankcase causing them to operate in semi-dry condition.

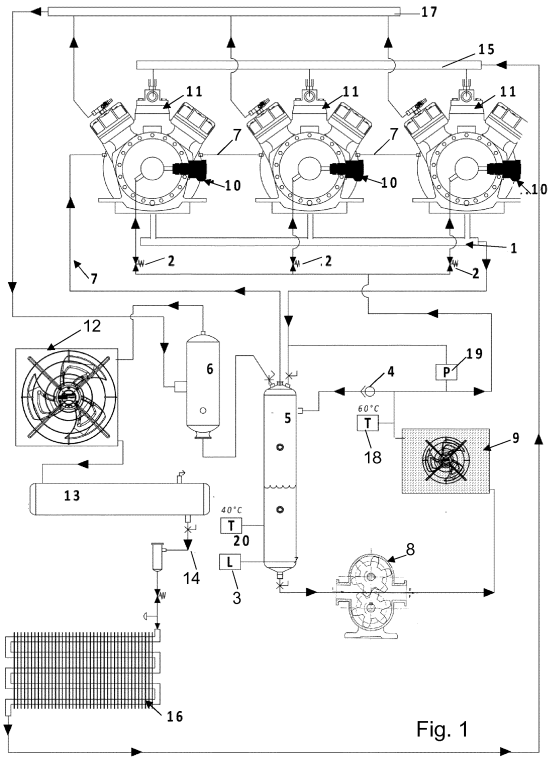

Fig. 1

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Description

[0001] The present plant relates to a new lubrication system in the refrigerating reciprocating compressors that facilitates the implementation of refrigeration units with compressors in parallel.

[0002] In current prior art the lubrication of the reciprocating compressor is considered as an event occurring inside it, both whether it has the pump or whether it occurs by mixing or gravity.

[0003] Because of such limit when multiple compressors are placed in parallel in order to achieve a higher capacity the designer has to take proper precautions so that oil can return within the crankcase of each compressor.

[0004] A medium-size compressor (30 hp) has internal oil contents of about 3/7 Kg, and a large part thereof is mixed with the refrigerant gas and is entrained within the circuit due to the following reasons:

- impact between the crankshaft and the connecting rods on the crankcase surface;
- effect of the entrainment occurring through the electric motor and the suction side;
- increase in the volume during the off-cycle of the compressor where gas remains captured within the oil of the crankcase with percentages reaching 30..40%.

[0005] More complicated problems occur when using several compressors in parallel or operating as inverter (variable speed) or operating at different pressures (Booster).

[0006] Information about other lubrication systems for reciprocating compressors relates to the inner circuit of the compressor both whether it has a force-feed lubrication (internal pump) and whether it occurs by splashing or gravity.

[0007] The article "Quando il liquido entra in un compressore" by Andrea Verondini, published in the issue of June 2015 of the specialist magazine ZeroSottoZero pages 50-56 and available on-line at the website www.zerosottozero.it, accurately describes the drawbacks related to problems both about the migration of the refrigerant fluid in the lubrication oil sump (tank) of the compressors and the subsequent mixing of said fluid with the oil and about the migration of the lubrication oil into the compression chambers of the compressor and about the penetration of oil into the refrigerant fluid circuit and in the condenser and evaporator. The article highlights the importance of the drawbacks caused by such phenomena and the fact that currently there are no technical expedients able to at least efficaciously limit these problems, except for a possible sizing of the plants that however is more related to contingent and personal experiences of people skilled in the art and do not guarantee a constant, repeatable and transferable effect.

[0008] The aim of the invention is to provide a lubrication plant for one or more reciprocating compressors for compressing gases or other fluids in refrigeration units comprising a plurality of compressors for the refrigerant fluid that, by means of relatively simple arrangements, is able to overcome the drawbacks described above of known multi-compressor refrigerating circuits.

[0009] The invention solves said drawback by a lubrication plant for refrigeration units comprising multiple reciprocating compressors, for compressing a refrigerant fluid, comprising the characteristics of claim 1.

[0010] The system according to the present invention is based on the use of a centralized hydraulic pump allowing compressors to be force-feed lubricated which therefore will not have anymore the oil reserve in their crankcase and that will operate in semi-dry condition.

[0011] Such innovation allows refrigerating efficiency of the plant to improve regardless of the refrigerant fluid employed and at the same time it guarantees a perfect lubrication in any operating conditions of the compressors.

[0012] By means of the characteristics of the present invention the oil amount mixing with the refrigerant fluid is reduced and the components intended to control the lubrication are considerably reduced while improving the mechanical performance of the compressor upon starting.

[0013] The use of an external lubrication circuit, according to the present invention, allows compressors without crankcases or internal reserves and oil pump to be used, overcoming the following drawbacks that have to be always faced by each manufacturer:

1. Mixing and migration of oil with gas;
2. Use of mechanical or electric devices for checking oil level of the crankcase in each compressor;
3. Use of differential pressure switches for controlling the pressure mounted on each individual compressor;
4. Use of the crankcase heater on each compressor to reduce mixing of gas with oil;
5. Liquid hammers upon starting due to gas mixed with oil in the crankcase;
6. Considerable size of the oil separator on the discharge line;
7. Start of compressors with a time delay of the lubrication pressure since the pump takes motion from the compressor itself.

[0014] In addition to overcome the drawbacks of the known system, the invention leads also to advantages that are:

1 Increase in the refrigerating efficiency by 10% due to the reduced amount of oil mixing with the refrigerant gas and it reduces the thermal transfer on the pipes of the evaporator;

2 Removal of the device controlling the oil level in the crankcase of each compressor;

3 Removal of the oil differential pressure switch in each compressor;
4 Removal of the oil pump in the compressor while reducing electrical load (the internal pump bypasses 50% of the oil since it has to guarantee efficiency even when there is considerable wear);
5 Reduced size of the oil separator (apparatus having a considerable cost depending on the size);
6 Removal of pipes for the connection between the compressors and the oil reserve;
7 Removal of pressure compensating valve on the oil tank;
8 Reduced oil amount on the plant (the one contained in the compressor crankcases);
9 Guaranteed and constant lubrication regardless of the gas operating pressure, of the wear condition of bushings, of the number of revolutions of the compressor if driven as inverter;
10 Start with already present lubrication and with constant pressure in any individual critical point, unlike the internal pump system that starts the lubrication with a not negligible time delay that is one of the reasons for seizure and wear of bushings.

[0015] Therefore from the above the great number of drawbacks solved by the invention and the further advantages resulting therefrom are clear.

[0016] The lubrication plant of the present invention is intended to be used in a multi-compressor refrigeration unit, comprising a plurality of reciprocating compressors placed in parallel.

[0017] According to a further characteristic of the present invention, there are provided means for adjusting the flow rate of the pump in a way corresponding to the requirement of lubrication oil.

[0018] These means are means controlling the electric motor driving the hydraulic pump that modify the rotation parameters of the electric motor by changing the flow rate of the pump depending on measurement values of the lubrication oil pressure in the centralized lubrication circuit.

[0019] According to one embodiment there is provided a nominal threshold value of the pressure that is equal to a pressure value corresponding to a lubrication oil pressure in the lubrication circuit higher than 1 to 5, preferably about 3 bar with respect to the inner pressure in the compressor crankcase.

[0020] This makes it possible that should a compressor have connecting rods more worn the pressure will remain always constant while the flow rate will change to compensate for the wear problem.

[0021] The invention also relates to a process for the lubrication of a plurality of compressors operating in a refrigeration unit in a reciprocating manner for compressing/circulating a refrigerant fluid, which process provides to feed the lubrication oil of compressors through an external circuit feeding said oil.

[0022] The process provides to bring the oil to a given feeding pressure in a feeding circuit and to feed said oil in parallel to the individual compressors.

[0023] According to a further characteristic the process provides to monitor the oil temperature and possibly to cool it to the operating temperature.

[0024] Still according to a characteristic the process provides to monitor the oil temperature and to generate an alarm or to stop the compressors if the detected temperature exceeds a predetermined maximum threshold value.

[0025] Still according to a further improvement the process provides to recover the oil possibly migrated within the refrigerant fluid.

[0026] According to an improvement, the process provides to change the flow rate of the lubrication oil within the circuit feeding said lubrication oil to the compressors depending on the requirement of lubrication oil.

[0027] One embodiment provides to change the flow rate of the lubrication oil in the circuit feeding said lubrication oil to the compressors depending on the pressure of the oil within the circuit.

[0028] Particularly the flow rate of the oil is changed such to keep a predetermined minimum pressure value of the oil in the circuit which is equal to the pressure present in the crankcases of the compressors plus a pressure difference incremental to said pressure in the compressor crankcases.

[0029] Further characteristics and advantageous improvements of the invention are the subject matter of the sub claims.

[0030] The characteristics of the invention and the advantages deriving therefrom will be more clear from the following description of a non limitative embodiment shown in the annexed drawing wherein:

Figure 1 is a diagram of a multi-compressor refrigeration unit provided with a lubrication device according to the present invention.

[0031] With reference to figure 1, in a multi-compressor refrigeration unit there are provided three reciprocating compressors denoted by 11.

[0032] The schematically shown refrigerating circuit comprises a tank for the refrigerant gas denoted by 13, a condenser 12 and an evaporator 16. The refrigerant gas flows between the condenser 12 and the evaporator 16 by the compressors 11, whose suction side is connected to a suction manifold 15 provided downstream of the evaporator (with reference to the fluid flowing direction). The discharge of the compressors 11 is connected to a discharge manifold 17 through which the compressed refrigerant gas is caused to pass into a separator 6 and therefore it is conveyed through the tank 13 and a dehydrator filter to the evaporator 16, from which it is again taken in the suction manifold 15 connected to the compressors 11, thus completing the refrigerating circuit.

[0033] In parallel with the refrigerating circuit there is provided a circuit feeding the lubrication oil to the indi-

vidual compressors 11 carried out according to the present invention.

[0034] Said lubrication circuit comprises an oil-hydraulic positive-displacement pump 8 in common to all the compressors and it is connected to the compressors through a lubrication circuit.

[0035] The pump 8 takes the oil from a reserve oil tank 5 and it feeds it to the compressors in parallel, an oil feeding valve 2 being provided for each compressor. Between the pump 8 and the feeding valves 2 the circuit is provided with an oil cooling radiator 9 and with an oil temperature adjusting thermostat.

[0036] For each compressor there is provided a safety pressure cut out 10 measuring the pressure of the oil circuit, and it stops the operation of the compressor or of the whole plant in case of malfunction.

[0037] The oil fed to the compressors 11 is recovered by a manifold 1 recovering the oil from the crankcases, and it goes back in the reserve tank 5.

[0038] The oil reserve tank 5 is also connected to the oil separator 6, from which it receives the oil taken from the refrigerating circuit. The oil separator 6 is inserted into the refrigerating circuit and it separates oil from the refrigerant gas.

[0039] A branch for the balance of circuit oil pressure is provided from the oil reserve tank 5 to the crankcase of each compressor 11, and it performs an adjustment of the pressure, necessary since the gas pressure in the crankcase of the compressor is variable. In order to keep a constant lubrication pressure therefore it is necessary also for the suction of the pump to be at the same pressure.

[0040] Downstream of the radiator 9 there is provided a differential pressure switch 19 for the oil, that is a switch that does not allow the compressor to be started if the lubrication pressure does not exceed a predetermined threshold.

[0041] Downstream of the radiator there is further provided a pressure adjusting bypass valve 4, which carries out pressure throttling, that is it adjusts the discharge pressure of the pump 8. The pump may easily reach even high pressures, while the plant needs a constant pressure on all the crank mechanisms and lubricatable points.

Circuit diagram

[0042]

1 Manifold recovering oil from the crankcase
2 solenoid valves feeding oil to the compressor
3 alarm indicator for minimum oil level
4 pressure adjusting by-pass valve
5 oil reserve tank
6 oil separator
7 oil pressure balance
8 oil pump
9 oil cooling radiator
10 safety pressure cut out
11 reciprocating compressors
12 condenser
13 gas tank
14 dehydrator filter
15 gas suction manifold
16 evaporator
17 discharge manifold
18 oil temperature adjustment thermostat
19 oil differential pressure switch
20 thermostat for adjustment of minimum oil temperature

Claims

1. Lubrication plant in a refrigeration unit comprising a plurality of compressors operating for compressing/circulating a refrigerant fluid such as a refrigerant gas,
characterized in that
it comprises a common oil-hydraulic positive-displacement pump connected to said compressors by an external lubrication circuit, said pump being composed of an operating unit separated and external to the compressors, and the compressors being free from oil reserve, that is with dry crankcase.

2. Lubrication plant according to claim 1, wherein the compressors of said unit are placed in parallel.

3. Lubrication plant according to one or more of the preceding claims, wherein said compressors work in a semi-dry condition.

4. Lubrication plant according to one or more of the preceding claims, wherein said pump (8) is inserted in a lubrication oil feeding circuit comprising an oil tank (5), means (4, 7, 10, 19) measuring and adjusting the oil pressure, means (9, 18, 20) measuring and adjusting the oil temperature and means measuring the oil level (3) in the tank (5).

5. Lubrication plant according to claim 4, wherein in the oil feeding circuit there is provided an oil cooling radiator.

6. Lubrication plant according to one or more of the preceding claims, wherein said pump feeds lubrication oil with a constant operating pressure to each compressor upon the start thereof there being provided a differential pressure switch (19) for the oil pressure that denies/permits the compressors to switch on if the lubrication oil pressure does not exceed a predetermined minimum pressure threshold.

7. Plant according to one or more of the preceding claims, wherein the lubrication circuit comprises a branch for the balance of the oil pressure that is pro-

vided from the oil reserve tank (5) to the crankcase of each compressor (11), for compensating the pressure of the lubrication oil with the pressure of the refrigerant fluid in the compressor crankcase.

8. Plant according to one or more of the preceding claims, comprising means for adjusting the flow rate of the pump in a way corresponding to the requirement of lubrication oil, particularly by a variable delivery pump feeding the lubrication oil.

9. Plant according to claim 8, wherein said means are a unit controlling the electric motor driving the hydraulic pump that change the rotation parameters of the electric motor by changing the flow rate of the pump as a function of measurement values of the lubrication oil pressure in the centralized lubrication circuit measured by a pressure sensor and that provide said measurement value to said motor control unit.

10. Lubrication process for a plurality of compressors operating in a refrigeration unit in a reciprocating manner for compressing/circulating a refrigerant fluid, which process provides to feed the lubrication oil of the compressors through a circuit feeding said oil that is independent and external to said compressors, while the compressors are free from lubrication oil reserve.

11. Process according to claim 10, **characterized in that** the process provides to monitor the oil temperature and to possibly cool it to the operating temperature and to possibly generate an alarm or to stop the compressors in case the detected temperature exceeds a predetermined maximum threshold value.

12. Process according to claim 10 or 11, **characterized in that** it provides to recover the oil possibly migrated into the refrigerant fluid.

13. Process according to one or more of the preceding claims 10 to 12, wherein it is provided to compensate the lubrication oil pressure fed to the compressors with the pressure of the refrigerant fluid present in the compressor crankcases.

14. Process according to one or more of the claims 10 to 13, **characterized in that** it provides to change the flow rate of the lubrication oil in the circuit feeding said lubrication oil to the compressors depending on the requirement of lubrication oil.

15. Process according to claim 14, **characterized in that** it provides to change the flow rate of the lubrication oil in the circuit feeding said lubrication oil to the compressors depending on the oil pressure in the circuit.

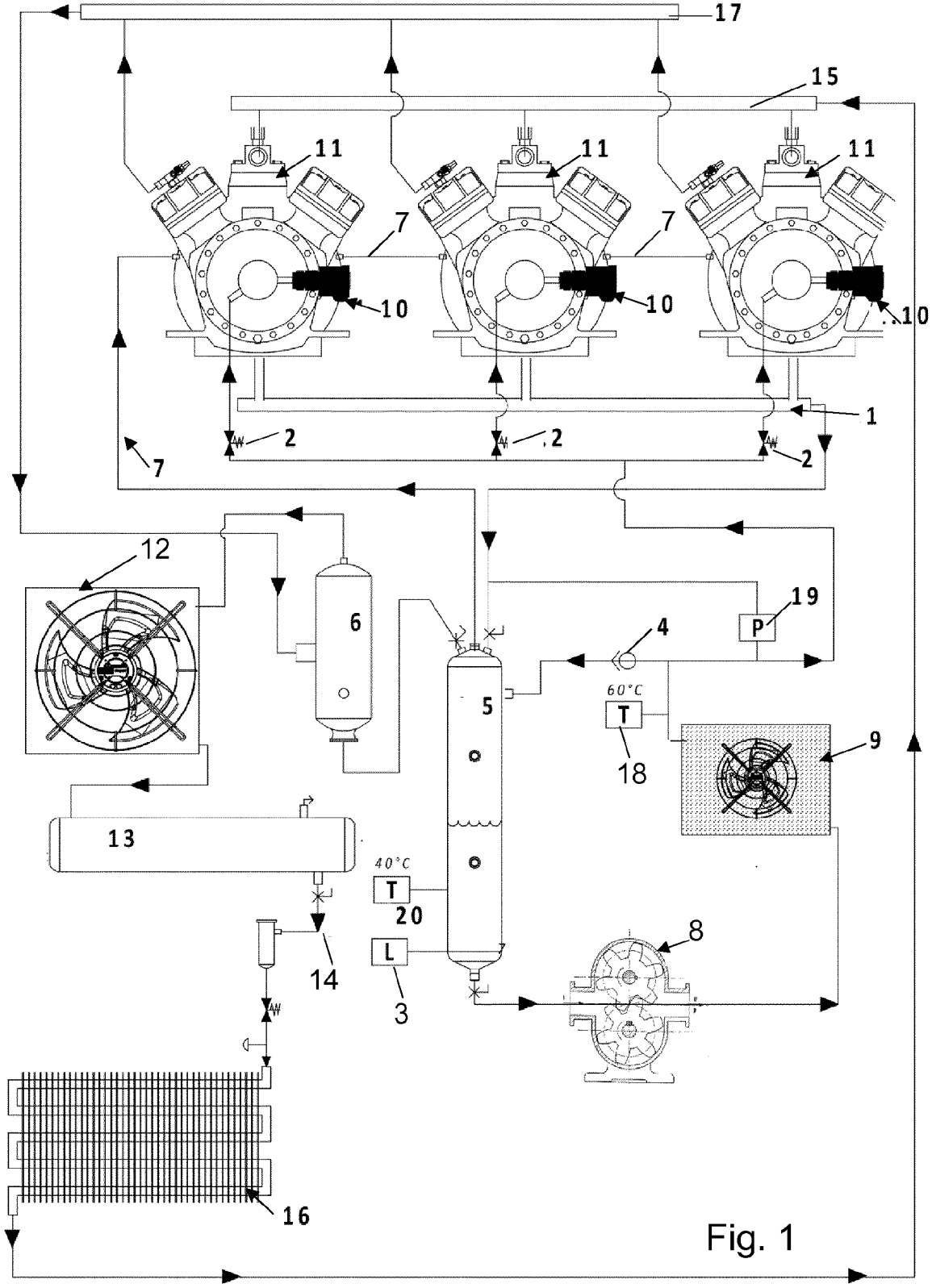
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Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 2677

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 January 2016	Lucic, Anita

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REFERENCES CITED IN THE DESCRIPTION

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