(12) STANDARD PATENT (11) Application No. **AU 2014408863 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Refrigeration cycle apparatus

(51) International Patent Classification(s)
F25B 1/00 (2006.01) ***C10M 107/24*** (2006.01)
C09K 5/04 (2006.01) ***C10M 107/34*** (2006.01)
C10M 105/38 (2006.01)

(21) Application No: **2014408863** (22) Date of Filing: **2014.10.16**

(87) WIPO No: **WO16/059697**

(43) Publication Date: **2016.04.21**
(44) Accepted Journal Date: **2019.01.03**

(71) Applicant(s)
Mitsubishi Electric Corporation

(72) Inventor(s)
Maeyama, Hideaki

(74) Agent / Attorney
FPA Patent Attorneys Pty Ltd, ANZ Tower 161 Castlereagh Street, Sydney, NSW, 2000, AU

(56) Related Art
WO 2012157764 A1

(12) 特許協力条約に基づいて公開された国際出願

(19) 世界知的所有権機関
国際事務局

(43) 国際公開日
2016 年 4 月 21 日(21.04.2016)

WIPO | PCT

(10) 国際公開番号
WO 2016/059697 A1

(51) 国際特許分類:
F25B 1/00 (2006.01) *C10M 107/24* (2006.01)
C09K 5/04 (2006.01) *C10M 107/34* (2006.01)
C10M 105/38 (2006.01)

(21) 国際出願番号: PCT/JP2014/077522

(22) 国際出願日: 2014 年 10 月 16 日(16.10.2014)

(25) 国際出願の言語: 日本語

(26) 国際公開の言語: 日本語

(71) 出願人: 三菱電機株式会社(MITSUBISHI ELECTRIC CORPORATION) [JP/JP]; 〒1008310 東京都千代田区丸の内二丁目７番３号 Tokyo (JP).

(72) 発明者: 前山 英明(MAEYAMA, Hideaki); 〒1008310 東京都千代田区丸の内二丁目７番３号 三菱電機株式会社内 Tokyo (JP).

(74) 代理人: 特許業務法人きさ特許商標事務所(KISA PATENT & TRADEMARK FIRM); 〒1050001 東京都港区虎ノ門二丁目１０番１号 虎ノ門ツインビルディング東棟８階 Tokyo (JP).

(81) 指定国 (表示のない限り、全ての種類の国内保護が可能): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

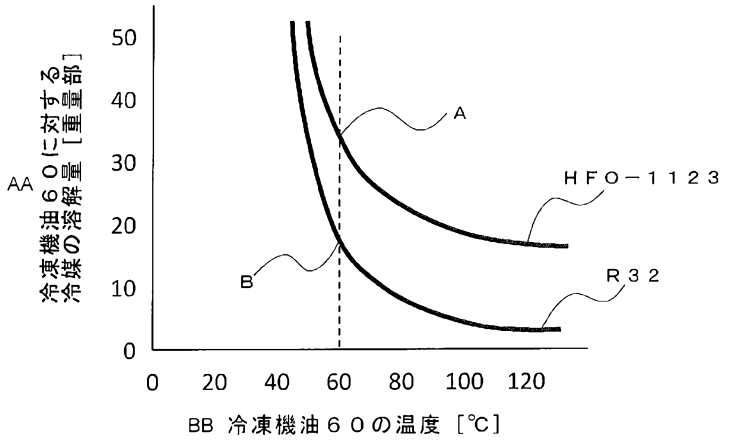
(84) 指定国 (表示のない限り、全ての種類の広域保護が可能): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), ユーラシア (AM, AZ, BY, KG, KZ, RU, TJ, TM), ヨーロッパ (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

添付公開書類:
— 国際調査報告（条約第 21 条(3)）

(54) **Title**: REFRIGERATION CYCLE DEVICE

(54) 発明の名称 : 冷凍サイクル装置

[図4]



AA Amount (parts by weight) of refrigerant dissolved in refrigerator oil 60
BB Temperature (°C) of refrigerator oil 60

(57) **Abstract**: The present invention makes it possible to obtain a refrigeration cycle device that uses HFO-1123, said device making it possible to suppress disproportionation reactions. This refrigeration cycle device 10 is provided with: refrigerant circuits 11a, 11b in which a high-pressure shell-type compressor 12, an exterior heat exchanger 14, an expansion valve 15, and an interior heat exchanger 16 are connected; a mixed refrigerant including 1,1,2-trifluoroethylene and another refrigerant apart from 1,1,2-trifluoroethylene, and circulating in the refrigerant circuits 11a, 11b; and a refrigerator oil 60 being adjusted such that 1,1,2-trifluoroethylene is more soluble therein than the other refrigerant, and being enclosed inside the refrigerant circuits 11a, 11b.

(57) 要約: ＨＦＯ－１１２３を使用する冷凍サイクル装置において、不均化反応を抑制することが可能な冷凍サイクル装置を得る。冷凍サイクル装置１０は、高圧シェル型の圧縮機１２、室外熱交換器１４、膨張弁１５及び室内熱交換器１６が接続された冷媒回路１１ａ，１１ｂと、１，１，２－トリフルオロエチレンと該１，１，２－トリフルオロエチレン以外の他の冷媒とを含み、冷媒回路１１ａ，１１ｂを循環する混合冷媒と、前記他の冷媒よりも１，１，２－トリフルオロエチレンの方が溶けやすく調整され、冷媒回路１１ａ，１１ｂ内に封入された冷凍機油６０と、を備えた。

WO 2016/059697 A1

DESCRIPTION

Title of Invention

REFRIGERATION CYCLE APPARATUS

Technical Field

[0001]

The present invention relates to a refrigeration cycle apparatus.

Background Art

[0002]

In recent years, there has been demand to reduce greenhouse gasses from a perspective of preventing global warming. Regarding refrigerants used for refrigeration cycle apparatus such as air-conditioning apparatus, those with a lower global warming potential (GWP) are being considered. The GWP of R410A widely used for air-conditioning apparatus at present is as high as 2088. Difluoromethane (R32) that has begun to be introduced recently has a considerably high GWP value of 675.

[0003]

Examples of refrigerant with a low GWP include carbon dioxide (R744: GWP = 1), ammonia (R717: GWP = 0), propane (R290: GWP = 6), 2,3,3,3-tetrafluoropropene (R1234yf: GWP = 4), and 1,3,3,3-tetrafluoropropene (R1234ze: GWP = 6).

[0004]

These low-GWP refrigerants are difficult to apply to typical air-conditioning apparatus because of the following problems.

- R744: There is a problem in securing withstanding pressure because of very high operating pressure. Also, because critical temperature is as low as 31 degrees C, there is a problem of how to secure performance in application to air-conditioning apparatus.
- R717: Because of high toxicity, there is a problem in ensuring safety.
- R290: Because of high flammability, there is a problem in ensuring safety.

2014408863 07 Mar 2017

- R1234yf/R1234ze: Because a volume flow rate increases at low operating pressure, there is a problem of performance deterioration due to increases in pressure loss.

[0005]

A refrigerant capable of solving the above problems is 1,1,2-trifluoroethylene (HFO-1123) (see, for example, Patent Literature 1). The refrigerant has the following advantages, in particular.

- Because of its high operating pressure and low volume flow rate, the refrigerant involves a reduced pressure loss and can readily ensure performance.
- The refrigerant has a GWP of less than 1 and has an edge in countermeasures against global warming.

Citation List

Patent Literature

[0006]

Patent Literature 1: International Publication No. 2012/157764

Non-patent Literature

[0007]

Non-patent Literature 1: Andrew E. Feiring, Jon D. Hulburt, "Trifluoroethylene deflagration", Chemical & Engineering News (22 Dec 1997) Vol. 75, No. 51, pp. 6

[0007A]

Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment or any form of suggestion that this prior art forms part of the common general knowledge in any jurisdiction or that this prior art could reasonably be expected to be understood, regarded as relevant and/or combined with other pieces of prior art by a person skilled in the art.

Summary

[0007B]

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and

2014408863 07 Mar 2017

"comprised", are not intended to exclude further additives, components, integers or steps.

[0008]

HFO-1123 has the following problem.

(1) An explosion occurs if ignition energy is applied under high-temperature, high-pressure conditions (see, for example, Non-patent Literature 1).

[0009]

To apply HFO-1123 to a refrigeration cycle apparatus, it is necessary to solve the above problem.

[0010]

Regarding the above problem, it has become clear that an explosion will occur due to a chain of disproportionation reactions. This phenomenon will occur under the following two conditions.

(1a) Ignition energy (hot portion) is produced in the refrigeration cycle apparatus (especially, a compressor), causing disproportionation reaction.

(1b) Under high-temperature, high-pressure conditions, disproportionation reaction spreads in chains.

[0011]

Disclosed within the following is a refrigeration cycle apparatus capable of inhibiting disproportionation reaction that uses HFO-1123.

[0012]

A refrigeration cycle apparatus according to a first aspect of the present invention comprises: a refrigerant circuit in which a high pressure shell compressor, a condenser, an expansion device and an evaporator are connected; a mixed refrigerant containing 1,1,2-trifluoroethylene and an other refrigerant different from the 1,1,2-trifluoroethylene and circulating through the

2014408863 12 Dec 2018

refrigerant circuit; and a refrigerating machine oil enclosed in the refrigerant circuit, wherein

the other refrigerant comprises at least one of difluoromethane, 2,3,3,3-tetrafluoropropene, trans-1,3,3,3-tetrafluoropropene, cis-1,3,3,3-tetrafluoropropene, 1,1,1,2-tetrafluoroethane, and 1,1,1,2,2-pentafluoroethane,

the refrigerating machine oil comprises at least one of polyol ester, polyvinyl ether, and polyalkylene glycol,

wherein solubility of the 1,1,2-trifluoroethylene to the refrigerating machine oil is higher than solubility of the other refrigerant to the refrigerating machine oil.

[0013]

By using a mixed refrigerant made up of a mixture of 1,1,2-trifluoroethylene and another refrigerant other than the 1,1,2-trifluoroethylene, the refrigeration cycle apparatus according to one embodiment of the present invention keeps down an amount of 1,1,2-trifluoroethylene in the refrigerant circuit. This makes it possible to keep 1,1,2-trifluoroethylene from causing disproportionation reaction. Furthermore, the refrigeration cycle apparatus according to the embodiment of the present invention uses a refrigerating machine oil adjusted such that 1,1,2-trifluoroethylene will be more soluble therein than the other refrigerant. Consequently, during operation of the refrigeration cycle apparatus, in the mixed refrigerant circulating through the refrigerant circuit, the mixing ratio of the 1,1,2-trifluoroethylene relative to the other refrigerant does not become greater than at a time when the mixed refrigerant is enclosed in the refrigerant circuit. Thus, the refrigeration cycle disclosed within the following can keep 1,1,2-trifluoroethylene from causing disproportionation reaction even during operation of the refrigeration cycle apparatus.

2014408863 06 Nov 2018

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a circuit diagram of a refrigeration cycle apparatus 10 according to an embodiment of the present invention (during cooling).

[Fig. 2] Fig. 2 is a circuit diagram of the refrigeration cycle apparatus 10 according to the embodiment of the present invention (during heating).

[Fig. 3] Fig. 3 is a longitudinal sectional view of a compressor 12 according to the embodiment of the present invention.

[Fig. 4] Fig. 4 is a diagram showing amounts of refrigerants dissolved in refrigerating machine oil 60 according to the embodiment of the present invention.

Description of Embodiments

[0015]

Embodiment.

Figs. 1 and 2 are circuit diagrams of a refrigeration cycle apparatus 10 according to an embodiment of the present invention, where Fig. 1 shows a refrigerant circuit 11a during cooling and Fig. 2 shows a refrigerant circuit 11b during heating.

[0016]

According to the present embodiment, the refrigeration cycle apparatus 10 is an air-conditioning apparatus. Note that the present embodiment is also applicable when the refrigeration cycle apparatus 10 is other than an air-conditioning apparatus (e.g., a heat pump cycle apparatus).

[0017]

In Figs. 1 and 2, the refrigeration cycle apparatus 10 includes refrigerant circuits 11a and 11b through which refrigerant circulates.

[0018]

The refrigerant circuits 11a and 11b are connected with a compressor 12 which is a high pressure shell compressor (compressor adapted to discharge the refrigerant compressed by a compression element into an airtight container), a four-way valve 13, an outdoor heat exchanger 14, an expansion valve 15, and an indoor heat exchanger 16. The compressor 12 compresses the refrigerant. The four-way valve 13 changes a flow direction of the refrigerant between cooling mode and heating mode. The outdoor heat exchanger 14 operates as a condenser during cooling and causes the refrigerant compressed by the compressor 12 to reject heat. The outdoor heat exchanger 14 operates as an evaporator during heating, and exchanges heat between outdoor air and the refrigerant expanded by the expansion valve 15 and thereby heats the refrigerant. The expansion valve 15 is an example of an expansion mechanism. The expansion valve 15 expands the refrigerant caused to reject heat by the condenser. The indoor heat exchanger 16 operates as a condenser during heating, and makes the refrigerant compressed by the compressor 12 to reject heat. The indoor heat exchanger 16 operates as an evaporator during cooling, and exchanges heat between indoor air and the refrigerant expanded by the expansion valve 15 and thereby heats the refrigerant. Note that when the refrigeration cycle apparatus 10 does only one of cooling and heating, the four-way valve 13 is not necessary.

[0019]

The refrigeration cycle apparatus 10 further includes a controller 17.

[0020]

The controller 17 is, for example, a microcomputer. Although only a connection between the controller 17 and compressor 12 is shown in Figs. 1 and 2, the controller 17 is connected not only to the compressor 12, but also to various

elements connected to the refrigerant circuits 11a and 11b. The controller 17 monitors states of the elements and controls the elements.

[0021]

In the present embodiment, mixed refrigerant made up of a mixture of 1,1,2-trifluoroethylene (HFO-1123) and an other refrigerant different from the HFO-1123 is used as the refrigerant circulating through the refrigerant circuits 11a and 11b (in other words, the refrigerant enclosed in the refrigerant circuits 11a and 11b).

[0022]

As a preferred refrigerant, a mixed refrigerant of HFO-1123 and difluoromethane (R32) can be used. Note that other than R32, refrigerants available for use as the other refrigerant include 2,3,3,3-tetrafluoropropene (R1234yf), trans-1,3,3,3-tetrafluoropropene (R1234ze (E)), cis-1,3,3,3-tetrafluoropropene (R1234ze(Z)), 1,1,1,2-tetrafluoroethane (R134a), and 1,1,1,2,2-pentafluoroethane (R125).

[0023]

Also, in the refrigeration cycle apparatus 10 according to the present embodiment, refrigerating machine oil 60 is enclosed in the refrigerant circuits 11a and 11b. Most of the refrigerating machine oil 60 is accumulated at a bottom of an airtight container of the compressor 12 as described later. Furthermore, the refrigerating machine oil 60 used in the refrigeration cycle apparatus 10 according to the present embodiment, has been adjusted such that HFO-1123 will be more soluble therein than the other refrigerant.

[0024]

The refrigerating machine oil 60 used in the present embodiment, may be, for example, polyol ester. Polyol ester is a product of esterification of a fatty acid and polyhydric alcohol (polyol). Solubility (ease of dissolution) of the refrigerant in polyol ester can be adjusted by adjusting a carbon number of the fatty acid, a molecular structure of the fatty acid (whether to use a branched-chain fatty acid or an unbranched (straight-chain) fatty acid), a carbon number of the polyhydric

alcohol, and a molecular structure of the polyhydric alcohol (whether to use a branched-chain polyhydric alcohol or an unbranched (straight-chain) polyhydric alcohol).

[0025]

Note that the refrigerating machine oil 60 used in the present embodiment is not limited to polyol ester, and polyvinyl ether or polyalkylene glycol may be used alternatively. Polyvinyl ether is a compound in which alkyl groups are linked to side chains of a straight-chain hydrocarbon via ether linkages. By varying components of the alkyl group linked to the side chains via ether linkages, the solubility (ease of dissolution) of the refrigerant in polyvinyl ether can be adjusted. Polyalkylene glycol is a compound in which a propylene oxide and ethylene oxide are linked together in chains via ether linkages. By varying a ratio between the propylene oxide and ethylene oxide the solubility (ease of dissolution) of the refrigerant in polyalkylene glycol can be adjusted.

Of course, the refrigerating machine oil 60 may be prepared by mixing at least two of polyol ester, polyvinyl ether, and polyalkylene glycol.

[0026]

Also, regarding amounts of the mixed refrigerant and refrigerating machine oil 60 before enclosure in the refrigerant circuits 11a and 11b, the weight ratio of the mixed refrigerant is set between one and four times (both inclusive) the refrigerating machine oil 60.

[0027]

Fig. 3 is a longitudinal sectional view of the compressor 12 according to the embodiment of the present invention. Note that hatching used to indicate a section is omitted in Fig. 3.

[0028]

According to the present embodiment, the compressor 12, which is a high pressure shell compressor (compressor adapted to discharge the refrigerant compressed by a compression element 30 into an airtight container 20), is a single-

cylinder rotary compressor. Note that the present embodiment is also applicable even if the compressor 12 is a multi-cylinder rotary compressor or scroll compressor.

[0029]

In Fig. 3, the compressor 12 includes an airtight container 20, a compression element 30, an electrically-operated element 40, and a shaft 50.

[0030]

The airtight container 20 is an example of a container. The airtight container 20 is equipped with a suction pipe 21 adapted to suck the refrigerant and a discharge pipe 22 adapted to discharge the refrigerant.

[0031]

The compression element 30 is housed in airtight container 20. Specifically, the compression element 30 is installed in lower inner part of the airtight container 20. The compression element 30 compresses the refrigerant sucked by the suction pipe 21.

[0032]

The electrically-operated element 40 is also housed in airtight container 20. Specifically, the electrically-operated element 40 is installed at that position in the airtight container 20 through which the refrigerant compressed by the compression element 30 passes before being discharged from the discharge pipe 22. That is, the electrically-operated element 40 is installed inside the airtight container 20 and above the compression element 30. The electrically-operated element 40 drives the compression element 30. The electrically-operated element 40 is a concentrated winding motor.

[0033]

The refrigerating machine oil 60 configured to lubricate a sliding portion of the compression element 30 is accumulated at a bottom of the airtight container 20.

[0034]

Details of the compression element 30 will be described below.

[0035]

The compression element 30 includes a cylinder 31, a rolling piston 32, a vane (not shown), a main bearing 33, and a secondary bearing 34.

[0036]

An outer circumference of the cylinder 31 is substantially circular in shape in planar view. A cylinder chamber, which is a space substantially circular in shape in planar view, is formed inside the cylinder 31. The cylinder 31 is open at opposite ends in an axial direction.

[0037]

The cylinder 31 is provided with a vane groove (not shown) that extends radially, being communicated with the cylinder chamber. A back pressure chamber, which is a space shaped substantially circular in planar view and communicated with the vane groove is formed on an outer side of the vane groove.

[0038]

The cylinder 31 is provided with a suction port (not shown) through which a gas refrigerant is sucked from the refrigerant circuits 11a and 11b. The suction port penetrates into the cylinder chamber from an outer circumferential surface of the cylinder 31.

[0039]

The cylinder 31 is provided with a discharge port (not shown) through which compressed refrigerant is discharged from the cylinder chamber. The discharge port is formed by cutting out an upper end face of the cylinder 31.

[0040]

The rolling piston 32 is ring-shaped. The rolling piston 32 performs eccentric motion in the cylinder chamber. The rolling piston 32 slidably fits over an eccentric shaft portion 51 of the shaft 50.

[0041]

The vane is shaped as a flat substantially rectangular parallelepiped. The vane is installed in the vane groove of the cylinder 31. The vane is constantly

pressed against the rolling piston 32 by a vane spring provided in the back pressure chamber. Because high pressure is maintained in the airtight container 20, when the compressor 12 starts operating, a force caused by a difference between pressure in the airtight container 20 and pressure in the cylinder chamber acts on a back surface (i.e., a surface facing the back pressure chamber) of the vane. Therefore, the vane spring is used to press the vane against the rolling piston 32 mainly during startup of the compressor 12 (when there is no difference between the pressures in the airtight container 20 and cylinder chamber).

[0042]

The main bearing 33 is substantially inverse T-shaped when viewed from a side. The main bearing 33 slidably fits over a main shaft portion 52, which is that part of the shaft 50 that is located above the eccentric shaft portion 51. The main bearing 33 blocks upper part of the cylinder chamber and the vane groove of the cylinder 31.

[0043]

The secondary bearing 34 is substantially T-shaped as viewed from a side. The secondary bearing 34 slidably fits over a secondary shaft portion 53, which is that part of the shaft 50 that is located below the eccentric shaft portion 51. The secondary bearing 34 blocks lower part of the cylinder chamber and the vane groove of the cylinder 31.

[0044]

The main bearing 33 includes a discharge valve (not shown). A discharge muffler 35 is attached to an outer side of the main bearing 33. High-temperature, high pressure gas refrigerant discharged through the discharge valve enters the discharge muffler 35 once and then gets released into a space in the airtight container 20 from the discharge muffler 35. Note that the discharge valve and discharge muffler 35 may be provided on the secondary bearing 34 or on both main bearing 33 and secondary bearing 34.

[0045]

Material of the cylinder 31, main bearing 33, and secondary bearing 34 is gray iron, sintered steel, carbon steel, or other steel. Material of the rolling piston 32 is alloy steel containing, for example, chromium or other metal. Material of the vane is, for example, high-speed tool steel.

[0046]

A suction muffler 23 is provided on a side of the airtight container 20. The suction muffler 23 sucks low-pressure gas refrigerant from the refrigerant circuits 11a and 11b. When liquid refrigerant returns, the suction muffler 23 keeps the liquid refrigerant from getting directly into the cylinder chamber of the cylinder 31. The suction muffler 23 is connected to the suction port of the cylinder 31 through the suction pipe 21. A main body of the suction muffler 23 is fixed to a side face of the airtight container 20 by welding or another method.

[0047]

Details of the electrically-operated element 40 will be described below.

[0048]

According to the present embodiment, the electrically-operated element 40 is a brushless DC (Direct Current) motor. Note that the present embodiment is also applicable even if the electrically-operated element 40 is a motor (e.g., an induction motor) other than a brushless DC motor.

[0049]

The electrically-operated element 40 includes a stator 41 and a rotor 42.

[0050]

The stator 41 is fixed in abutment with an inner circumferential surface of the airtight container 20. The rotor 42 is installed inside the stator 41 with a gap about 0.3 to 1 mm in size provided therebetween.

[0051]

The stator 41 includes a stator core 43 and a stator winding 44. The stator core 43 is produced by punching plural flat rolled magnetic steel sheets 0.1 to 1.5 mm in thickness into a predetermined shape, laminating the steel sheets in an axial

direction, and fixing the steel sheets by calking, welding, or another method. The stator winding 44 is wound around the stator core 43 by concentrated winding via an insulating member 48. Material of the insulating member 48 is, for example, PET (polyethylene terephthalate), PBT (polybutylene terephthalate), FEP (tetrafluoroethylene hexafluoropropylene copolymer), PFA (tetrafluoroethylene perfluoroalkylvinylether copolymer), PTFE (polytetrafluoroethylene), LCP (liquid crystal polymer), PPS (polyphenylene sulfide), or phenol resin. The stator winding 44 is connected with lead wires 45.

[0052]

Plural notches are formed at substantially equal intervals in a circumferential direction on an outer circumference of the stator core 43. Each of the notches serves as a passage for the gas refrigerant released from the discharge muffler 35 into the space in the airtight container 20. Each of the notches also serves as a passage for the refrigerating machine oil 60 returning to the bottom of the airtight container 20 from a top of the electrically-operated element 40.

[0053]

The rotor 42 includes a rotor core 46 and permanent magnets (not shown). As with the stator core 43, the rotor core 46 is produced by punching plural flat rolled magnetic steel sheets 0.1 to 1.5 mm in thickness into a predetermined shape, laminating the steel sheets in an axial direction, and fixing the steel sheets by calking, welding, or another method. The permanent magnets are inserted into plural insertion holes formed in the rotor core 46. For example, ferrite magnets or rare earth magnets are used as the permanent magnets.

[0054]

Plural through-holes are formed, penetrating the rotor core 46 substantially in the axial direction. As with the notches in the stator core 43, each of the through-holes serves as a passage for the gas refrigerant released from the discharge muffler 35 into the space in the airtight container 20.

[0055]

A power supply terminal 24 (e.g., a glass terminal) for use to connect to an external power supply is attached to a top of the airtight container 20. The power supply terminal 24 is fixed to the airtight container 20, for example, by welding. The lead wires 45 from the electrically-operated element 40 are connected to the power supply terminal 24.

[0056]

The discharge pipe 22 with opposite ends in the axial direction open is attached to the top of the airtight container 20. The gas refrigerant discharged from the compression element 30 is discharged from the space in the airtight container 20 to the refrigerant circuits 11a and 11b outside through the discharge pipe 22.

[0057]

Operation of the compressor 12 will be described below.

[0058]

Electric power is supplied from the power supply terminal 24 to the stator 41 of the electrically-operated element 40 via the lead wires 45. Consequently, the rotor 42 of the electrically-operated element 40 rotates. As the rotor 42 rotates, the shaft 50 fixed to the rotor 42 rotates. Along with rotation of the shaft 50, the rolling piston 32 of the compression element 30 rotates eccentrically in the cylinder chamber of the cylinder 31 of the compression element 30. Space between the cylinder 31 and rolling piston 32 is divided into two by the vane of the compression element 30. Volumes of the two spaces change with rotation of the shaft 50. One of the spaces increases in volume gradually, thereby sucking the refrigerant from the suction muffler 23. The other space decreases in volume gradually, thereby compressing the gas refrigerant in the space. The compressed gas refrigerant is discharged once into the space in the airtight container 20 through the discharge muffler 35. The discharged gas refrigerant passes through the electrically-operated element 40 and gets discharged out of the airtight container 20 through the discharge pipe 22 on top of the airtight container 20.

[0059]

Here, the refrigeration cycle apparatus 10 uses the high pressure shell compressor 12. That is, the refrigeration cycle apparatus 10 uses the compressor 12 in which temperature and pressure inside the airtight container 20 are elevated. Also, the refrigeration cycle apparatus 10 uses HFO-1123 as the refrigerant. Consequently, HFO-1123 can cause disproportionation reaction, raising concerns that a chain of disproportionation reactions might result in an explosion. However, the refrigeration cycle apparatus 10 according to the present embodiment keeps down an amount of HFO-1123 in the refrigerant circuits 11a and 11b by using a mixed refrigerant made up of a mixture of HFO-1123 and a refrigerant other than the HFO-1123. Consequently, the refrigeration cycle apparatus 10 can keep HFO-1123 from causing disproportionate reaction. Furthermore, the refrigeration cycle apparatus 10 uses the refrigerating machine oil 60 adjusted such that HFO-1123 will be more soluble than the other refrigerant in the mixed refrigerant. Consequently, regarding the mixing ratio between HFO-1123 and the other refrigerant in the mixed refrigerant circulating in the refrigerant circuits 11a and 11b during operation of the refrigeration cycle apparatus 10, the ratio of HFO-1123 does not become greater than at a time when the mixed refrigerant is enclosed in the refrigerant circuit. Thus, the refrigeration cycle apparatus 10 can keep HFO-1123 from causing disproportionate reaction even during operation of the refrigeration cycle apparatus. That is, the refrigeration cycle apparatus 10 according to the present embodiment can prevent explosions caused by a chain of disproportionation reactions of HFO-1123 and ensure high safety even when HFO-1123 is used.

[0060]

Also, use of R32 as the other refrigerant, i.e., use of the mixed refrigerant made up of HFO-1123 and R32, for the refrigeration cycle apparatus 10, it is possible to further keep HFO-1123 from causing disproportionate reaction. This is because the mixed refrigerant of HFO-1123 and R32 becomes a pseudo-azeotropic

refrigerant, inhibiting separation between R32 and HFO-1123, and thereby making it possible to prevent partial increases in concentration of HFO-1123 caused by separation of the mixed refrigerant circulating in the refrigerant circuits 11a and 11b.

[0061]

In so doing, in a state before the mixed refrigerant of HFO-1123 and R32 is enclosed in the refrigerant circuits 11a and 11b, preferably the ratio of HFO-1123 in the mixed refrigerant is 60wt% or less. This is because the lower the refrigerant temperature, the more soluble the refrigerant is in the refrigerating machine oil 60. That is, during heating in which refrigerant temperature is lower than during cooling, an amount of refrigerant soluble in the refrigerating machine oil 60 becomes larger than during cooling. Here, the refrigerating machine oil 60 according to the present embodiment has been adjusted such that HFO-1123 will be more soluble therein than R32. Consequently, by setting the ratio of HFO-1123 in the mixed refrigerant of HFO-1123 and R32 at 60wt% or less, it is possible during heating operation to increase a proportion of R32 in the mixed refrigerant circulating through the refrigerant circuit 11b and improve a coefficient of performance (COP) of refrigeration cycle apparatus 10. Note that when the effect of reducing global warming potential (GWP) by the use of HFO-1123 is considered, preferably the ratio of HFO-1123 in the mixed refrigerant is 10wt% or above.

[0062]

Also, according to the present embodiment, the mixed refrigerant and refrigerating machine oil 60 are enclosed in the refrigerant circuits 11a and 11b such that the mixed refrigerant will be between one and four times (both inclusive) the refrigerating machine oil 60 in terms of weight ratio. When the mixed refrigerant and refrigerating machine oil 60 are enclosed in the refrigerant circuits 11a and 11b such that the weight ratio of the mixed refrigerant will be equal to or less than the refrigerating machine oil 60, the ratio of the mixed refrigerant to the refrigerating machine oil 60 is so low that an amount of change in the composition of the mixed refrigerant (change in a ratio between HFO-1123 and another

refrigerant) becomes too large, which makes the composition of the mixed refrigerant unstable and thereby makes it difficult to control the refrigeration cycle apparatus 10. On the other hand, if the mixed refrigerant and refrigerating machine oil 60 are enclosed in the refrigerant circuits 11a and 11b such that the mixed refrigerant will be four times or more the refrigerating machine oil 60 in terms of weight ratio, the ratio of the mixed refrigerant to the refrigerating machine oil 60 is so high that that the amount of change in the composition of the mixed refrigerant (change in the ratio between HFO-1123 and the other refrigerant) is decreased, reducing a COP improvement effect. According to the present embodiment, since the mixed refrigerant and refrigerating machine oil 60 are enclosed in the refrigerant circuits 11a and 11b such that the mixed refrigerant will be between one and four times (both inclusive) the refrigerating machine oil 60 in terms of weight ratio, the refrigeration cycle apparatus 10 can be controlled stably, making it possible to achieve a sufficient COP improvement effect and high-pressure reduction effect.

[0063]

Finally, an example of an amount of refrigerant dissolved in the refrigerating machine oil 60 will be introduced.

[0064]

Fig. 4 is a diagram showing amounts of refrigerants dissolved in the refrigerating machine oil 60 according to the embodiment of the present invention. Fig. 4 shows dissolved amounts of HFO-1123 and another refrigerant in the refrigerating machine oil 60, where HFO-1123 and the other refrigerant make up a mixed refrigerant and R32 is shown as an example of the other refrigerant. Also, the ordinate in Fig. 4 represents the amounts of soluble HFO-1123 and R32 dissolved per 100 parts by weight of the refrigerating machine oil 60.

[0065]

As shown in FIG. 4, the amount of HFO-1123 dissolved in the refrigerating machine oil 60 is larger than the amount of R32 dissolved in the refrigerating

machine oil 60. When attention is focused on conditions in which temperature of the refrigerating machine oil 60 in Fig. 4 is 60 degrees C (position of the broken line), if the refrigeration cycle apparatus 10 is operating under these conditions, dew point temperature of the mixed refrigerant is 40 degrees C and temperature of the refrigerating machine oil 60 accumulated in the compressor 12 is 60 degrees C (in other words, a degree of superheat of discharge from the compressor 12 is 20 degrees C). Under these operating conditions, the dissolved amount of HFO-1123 is 33 parts by weight (point A). Also, the dissolved amount of R32 is 17 parts by weight, which is 16 parts by weight less than the dissolved amount of HFO-1123. By adjusting the refrigerating machine oil 60 such that the dissolved amounts of refrigerants will be as described above, the effects (especially the COP improvement effect) described above can be achieved sufficiently. Under the above operating conditions, if the refrigerating machine oil 60 is adjusted such that the dissolved amount of HFO-1123 will be 30 parts or above by weight and that the dissolved amount of R32 will be 10 parts or more by weight less than the dissolved amount of HFO-1123, the effects described above (especially the COP improvement effect) can be achieved sufficiently.

[0066]

An embodiment of the present invention has been described above, but the embodiment may be implemented partially. For example, one or some of the elements denoted by symbols in the drawings may be omitted or replaced by other elements. Note that the present invention is not limited to the above embodiment, and various changes may be made as required.

Reference Signs List

[0067]

10 refrigeration cycle apparatus 11a, 11b refrigerant circuit 12 compressor 13 four-way valve 14 outdoor heat exchanger 15 expansion valve 16 indoor heat exchanger 17 controller 20 airtight container 21 suction pipe 22 discharge pipe 23 suction muffler

24 power supply terminal 30 compression element 31 cylinder 32 rolling piston 33 main bearing 34 secondary bearing 35 discharge muffler 40 electrically-operated element 41 stator 42 rotor 43 stator core 44 stator winding 45 lead wire 46 rotor core 48 insulating member 50 shaft 51 eccentric shaft portion 52 main shaft portion 53 secondary shaft portion 60 refrigerating machine oil

2014408863 12 Dec 2018

CLAIMS

[Claim 1]

A refrigeration cycle apparatus comprising:

a refrigerant circuit in which a high pressure shell compressor, a condenser, an expansion device and an evaporator are connected;

a mixed refrigerant containing 1,1,2-trifluoroethylene and an other refrigerant different from the 1,1,2-trifluoroethylene and circulating through the refrigerant circuit; and

a refrigerating machine oil enclosed in the refrigerant circuit, wherein

the other refrigerant comprises at least one of difluoromethane, 2,3,3,3-tetrafluoropropene, trans-1,3,3,3-tetrafluoropropene, cis-1,3,3,3-tetrafluoropropene, 1,1,1,2-tetrafluoroethane, and 1,1,1,2,2-pentafluoroethane,

the refrigerating machine oil comprises at least one of polyol ester, polyvinyl ether, and polyalkylene glycol,

wherein solubility of the 1,1,2-trifluoroethylene to the refrigerating machine oil is higher than solubility of the other refrigerant to the refrigerating machine oil.

[Claim 2]

The refrigeration cycle apparatus of claim 1, wherein the other refrigerant is difluoromethane.

[Claim 3]

The refrigeration cycle apparatus of claim 2, wherein a ratio of the 1,1,2-trifluoroethylene in the mixed refrigerant is 60wt% or less.

[Claim 4]

The refrigeration cycle apparatus of any one of claims 1 to 3, wherein a weight ratio of the mixed refrigerant enclosed in the refrigerant circuit is equal to or more than a weight ratio of the refrigerant machine oil, but not more than four times the weight ratio of the refrigerating machine oil.

2014408863 12 Dec 2018

[Claim 5]

The refrigeration cycle apparatus of any one of claims 1 to 4, wherein under operating conditions in which a dew point temperature is 40 degrees C and a temperature of the refrigerating machine oil accumulated in the high pressure shell compressor is 60 degrees C,

wherein solubility of the 1,1,2-trifluoroethylene to the refrigerating machine oil is 30 parts or more by weight to 100 parts by weight of the refrigerating machine oil; and

solubility of the other refrigerant to the refrigerating machine oil is 10 parts or more by weight to 100 parts by weight of the refrigerating machine oil.

FIG. 1

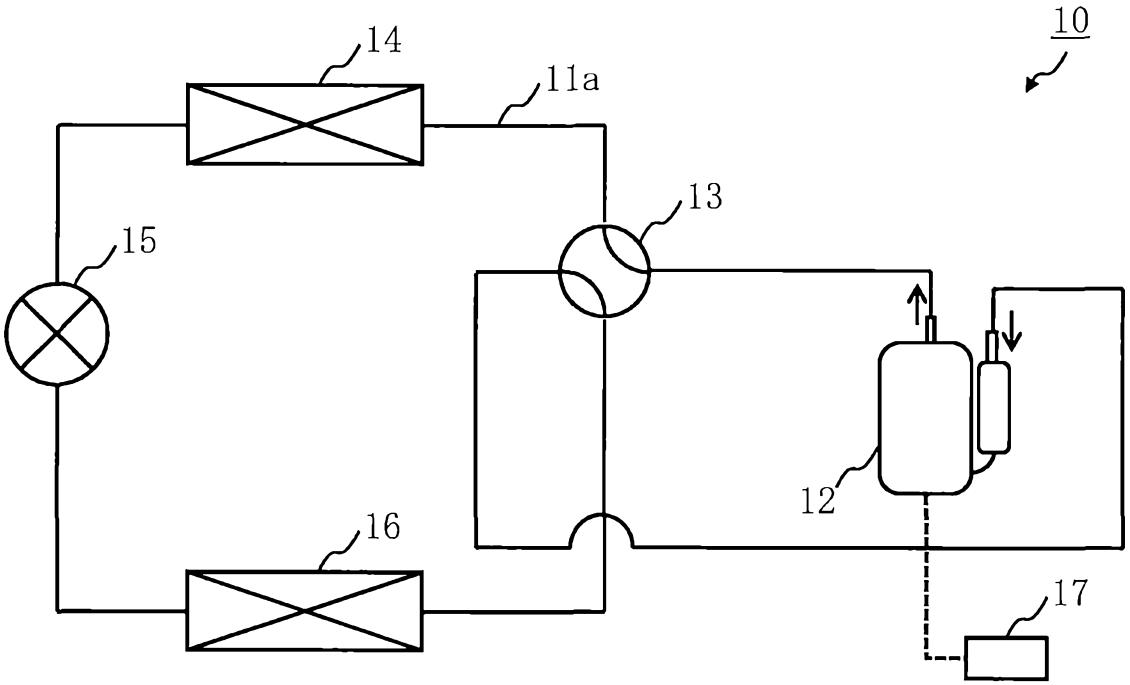


FIG. 2

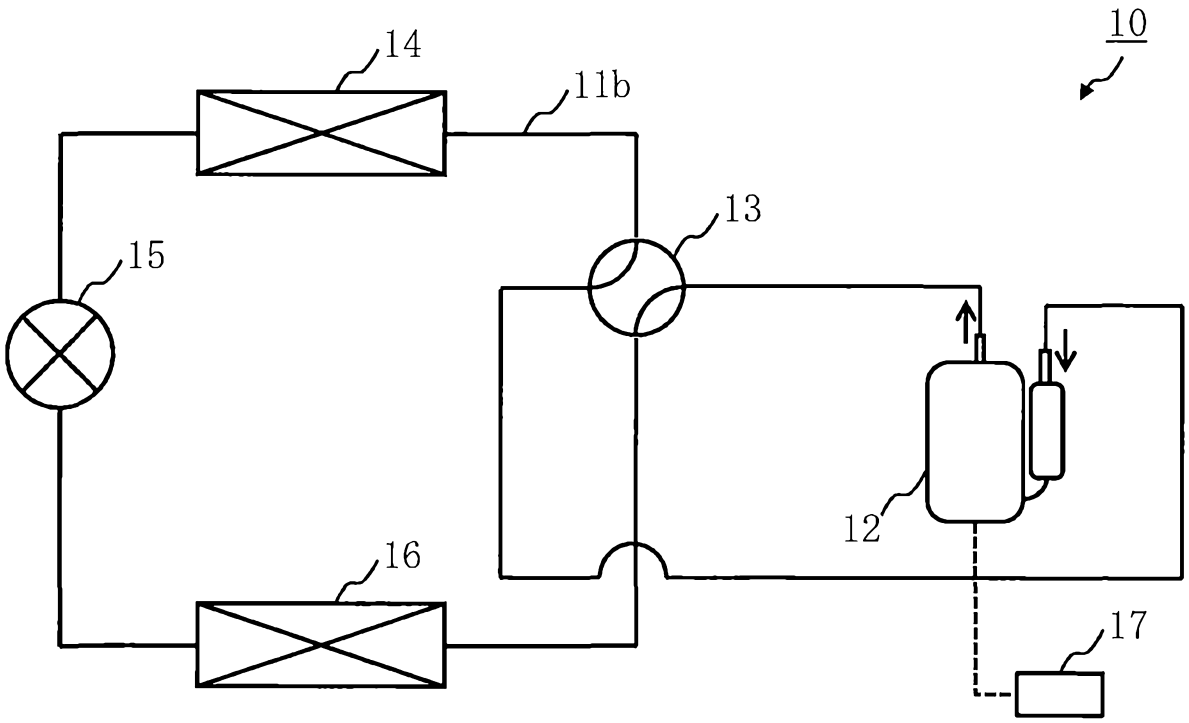


FIG. 3

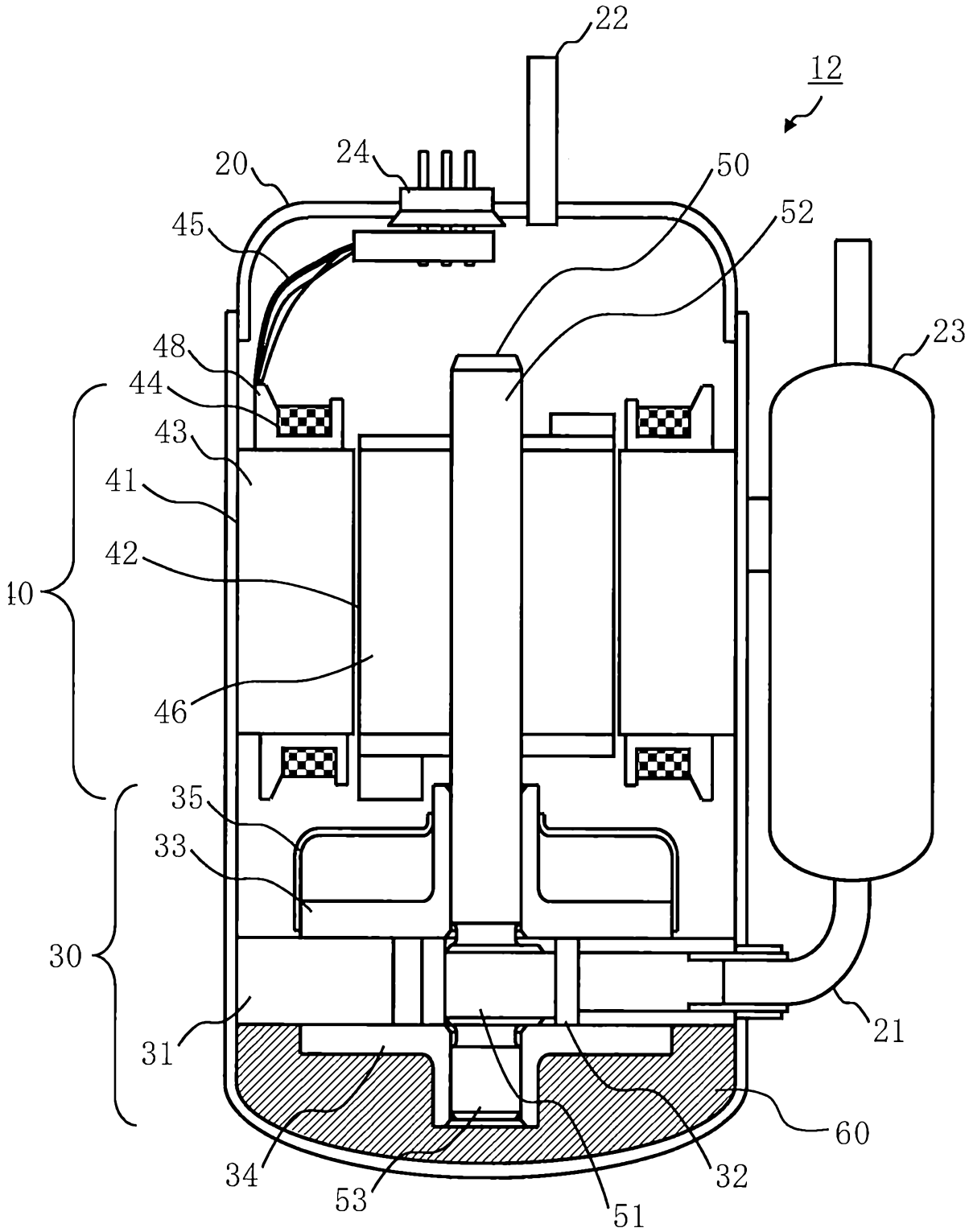
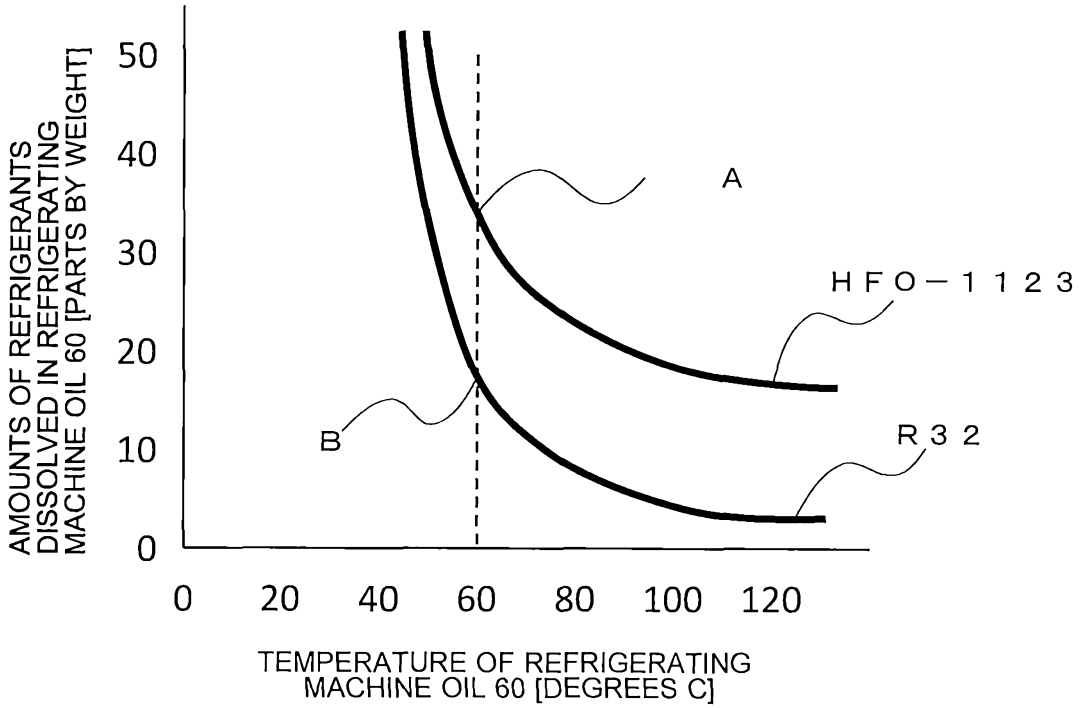

22
12
20
24
50
52
45
48
23
44
43
41
42
40
46
35
33
30
31
21
60
34
53
32
51

FIG. 4


AMOUNTS OF REFRIGERANTS DISSOLVED IN REFRIGERATING MACHINE OIL 60 [PARTS BY WEIGHT]
50
40
30
20
10
0
0
20
40
60
80
100
120
TEMPERATURE OF REFRIGERATING MACHINE OIL 60 [DEGREES C]
A
B
HFO−1123
R32