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REFRIGERANT COMPRESSOR

1 BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a refrigeration cycle and refrigerant compressor, and it relates to, in particular, a refrigeration-cycle-constituting material system comprising a refrigerating machine oil composition suitable for a flon type refrigerant containing no chlorine and having a critical temperature of 40°C or higher, for example, flon 134a, and electrical insulating materials and a drying agent which are hardly deteriorated by the refrigerating machine oil composition.

Prior Art

In recent years, chlorine-containing flons (chlorofluorocarbons, abbreviated as CFC) have been included in the list of compounds under regulation in use, all over the world because of the problems of environmental pollution, in particular, the ozone depletion and the global warming.

20 All of flons included in the list of compounds under regulation in use are chlorine-containing flons such as flon 11, flon 12, flon 113, flon 114, flon 115, etc. Flon 12 which has been exclusively used as a refrigerant in refrigerating apparatus such as

1 refrigerators, dehumidifiers, etc., has also been
included in the list.

Therefore, a refrigerant usable in place of
flon 12 is required. Hydrofluorocarbon (HFC) having a
5 low reactivity with ozone and a short decomposition
period in the air has recently been noted as a
substitute refrigerant. Flon 134a (1,1,1-tetrafluoro-
ethane, CH_2FCF_3) is a typical example of such a
refrigerant. In detail, when the ozone depletion
10 potential (ODP) of flon 12 (dichlorodifluoromethane
 CCl_2F_2) is taken as 1, that of flon 134a is zero. When
the global warming potential (GWP) of flon 12 is taken
as 1, that of flon 134a is 0.3 or less. Flon 134a is
noncombustible and similar to flon 12 in thermal
15 properties such as temperature-pressure characteristics.
Therefore, flon 134a has been said to be advantageous in
that it can be put into practical use without greatly
changing the structures of refrigerating apparatus such
as refrigerators and dehumidifiers and refrigerant
20 compressors in which flon 12 has heretofore been used.

Flon 134a, however, has a unique chemical
structure and hence very characteristic properties.
Therefore, it has a very poor compatibility with
refrigerating machine oils such as mineral oils and
25 alkylbenzene oils which have been used in conventional
refrigeration system using flon 12, and hence it cannot
be put into practical use at all. In addition, the
suitability including the improving effect on the

1 lubrication and the resistance to frictional wear of the
sliding portions of compression mechanical parts, the
influence on electrical insulating materials, the
influence on drying agents, etc. is a problem, and there
5 has been an eager desire for the development of a novel
material system constituting a compressor and a
refrigerating apparatus.

Therefore, before referring to the problem of
the miscibility of a refrigerant with a refrigerating
10 machine oil, conventional refrigerant compressor and
refrigeration apparatus which use a flon type
refrigerant are first explained with reference to Fig. 7
to Fig. 9.

Fig. 7 is a vertical cross-sectional view of
15 the principal part of a conventional closed rotary
compressor. Fig. 8 is a cross-sectional view for
explaining the displacement volume of the compressor
section of the compressor. Fig. 9 is a diagram showing
the structure of an ordinary refrigeration cycle.

20 In Fig. 7, numeral 1 shows a case used both as
a closed container and as a oil pan. In the case 1, an
electric motor section 22 and a compressor section 23
are accommodated.

The electric motor 22 is composed of a stator
25 19 and a rotor 20, and a rotating shaft 4A made of cast
iron is fitted in the rotor 20. The rotating shaft 4A
has an eccentric portion 3 and an shaft hole 17 is

1 formed in hollow form on the one side of the eccentric
portion 3.

The core wire of the winding wire portion 19a
of the stator 19 is coated with an ester imide film, and
5 an electrical insulating film of a polyethylene
terephthalate is inserted between the core portion and
the winding wire portion of the stator. The rotor 4A
has a surface finished by grinding.

The compressor 23 has as its chief mechanism
10 components a cylinder 2 made of an iron-based sintered
product; a roller 7 made of cast iron which is fitted in
the eccentric portion 3 of the rotating shaft 4A and
eccentrically rotated along the inside of the cylinder
2; a high-speed steel vane which is reciprocated in the
15 groove 8 of the cylinder 2 while one side of the vane is
in contact with the roller 7 and the other side is
pushed by a spring 9; and a main bearing 5 and a sub-
bearing 6 which are made of cast iron or an iron-based
sintered product, are provided on both ends of the
20 cylinder, and serve both as bearings for the rotary
shaft 4A and as the side wall of the cylinder 2.

The sub-bearing 6 has a discharge valve 27,
and a discharge cover 25 is attached thereto so as to
form a silencer 28. The main bearing 5, the cylinder 2
25 and the sub-bearing 6 are fastened with a bolt 21.

A pump chamber 12 is composed of a space and
parts surrounding the space, i.e., the back of the vane

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1 10, the groove 8 of the cylinder 2, the main bearing 5
and the sub-bearing 6.

The main bearing 5 has a suction piece 14
which can suck a naphthene type or alkylbenzene type
5 refrigerating machine oil 13A in which a refrigerant
flon gas stored in the bottom of the case 1 has been
dissolved, into the pump chamber 12. The sub-bearing 6
has a discharge port 16 which can discharge the
refrigerating machine oil 13A to an oil tube 15 from the
10 pump chamber 12. The oil tube 15 is designed to be able
to supply the refrigerating machine oil 13A to the shaft
hole 17 of the rotating shaft 4A and then to predeter-
mined sliding portions from the shaft hole 17 through a
branch opening 18.

15 The action of the rotary compressor thus
composed is explained below with reference to Figs. 7
and 8. When the compressor is operated to rotate the
rotating shaft 4A made of cast iron, a roller 7 made of
tempered cast iron is rotated with the rotation of
20 rotating shaft 4A, and the high-speed steel vane 10 is
reciprocated in the groove 8 of the cylinder 2 made of
cast iron or a iron-based sintered product while the
vane 10 is pushed by the spring 9 and its end is in
contact with the roller 7. Thus, the vane 10 compresses
25 a refrigerant (flon 12) which has flown in through a
refrigerant suction opening (not shown), and the
refrigerant is discharged outside the compressor from a
discharge pipe 29 through a refrigerant discharge

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1 opening 24. The winding wire portion 19a and the
electrical insulating film (not shown) of the stator 9
are immersed in the refrigerating machine oil containing
flon dissolved therein, or they are exposed to circum-
5 stances of spraying with mist of the refrigerant oil.

In the case of a combination of a conventional
refrigerating machine oil consisting of a mineral oil or
an alkylbenzene and flon 12, flon 12 is completely
miscible with the refrigerating machine oil in all use
10 ranges, so that it has been not necessary at all to care
about the various problems concerning the miscibility of
flon 134a with a refrigerating machine oil which are
hereinafter described in detail, namely, the separation
into two layers between the refrigerating machine oil
15 and the refrigerant in a compressor, and the residence
of the refrigerating machine oil in a heat exchanger.
However, in the case of fluorohydrocarbon type
refrigerants containing no chlorine which have unique
characteristics, for example, flon 134a, the miscibility
20 of the refrigerant with a refrigerating machine oil is
the most serious problem in practice because there is no
practical refrigerating machine oil which can easily
dissolve the refrigerant.

In general, for improving the performance
25 characteristics of a compressor, namely, the coefficient
of performance (COP) which indicates the energy
efficiency, it has been necessary to minimize the

- 1 mechanical loss of the compressor and maximize its
volumetric efficiency.

The mechanical loss of a refrigerant
compressor mainly includes the friction loss at the
5 journal bearing and thrust bearing in the mechanical
part and the power for agitating oil. In general, it
has been said that the best means is to minimize the
value of the coefficient of friction (μ) defined by the
following equation on the basis of the hydrodynamic
10 lubrication theory of a journal bearing:

$$\mu = 2\pi^2(D/C)\eta N/P \quad (9)$$

wherein N : revolution rate,
 P : pressure on surface,
 η : viscosity,
 D : diameter of shaft,
15 C : diametral clearance.

This fact indicates that in a refrigerant
compressor operated under hydrodynamic lubrication
conditions, not only the structural factors regarding
dimensions and shapes but also the actual viscosity of a
20 refrigerating machine oil containing flon dissolved
therein which is a factor influenced by operation
circumstances, have a close relationship to the
mechanical loss of the compressure.

On the other hand, for keeping the volumetric
25 efficiency highest, it is necessary that in a mechanical

1 chamber for compressing a refrigerant gas, the leakage
of the refrigerant gas from the high pressure side to
the low pressure side should be prevented by carrying
out sealing between parts which works to compress the
5 refrigerant gas. It should be noted that also in this
case, the actual viscosity of a refrigerating machine
oil containing the refrigerant dissolved therein has an
important function.

As described above, in a refrigerant
10 compressor heretofore used by the use of flon 12 and a
refrigerating apparatus using the refrigerant
compressor, it is important for the improvement of
performance characteristics of the compressor to
optimize the actual viscosity of a refrigerating machine
15 oil containing the refrigerant dissolved therein, at a
rated operation point under usual operation conditions.

A refrigerating apparatus such as a
refrigerator or a dehumidifier is operated, though in
rare cases, in a high-temperature circumstance much more
20 severe than usual operation conditions. In this case,
the lubrication in the apparatus gets into a so-called
boundary lubrication region in which a lubricating oil
layer is thinned, so that the metal surfaces of sliding
portions of a bearing are brought into contact with each
25 other. Consequently, the coefficient of friction is
increased at once, resulting in heat generation.
Therefore, scoring or seizing-and-adhesion phenomenon
occurs between the bearing and a rotating shaft and

1 deteriorates the reliability of a refrigerant
compressor. Therefore, some consideration is needed for
preventing a fatal problem from occurring even under
boundary lubrication conditions. In a conventional
5 refrigerant compressor using flon 12, chlorine in flon
12 acts effectively as an extreme pressure agent. In
detail, when scoring or seizing-and-adhesion phenomenon
takes place between a bearing and a rotating shaft, the
refrigerant flon 12 dissolved in a refrigerating machine
10 oil as bearing-lubricating oil is decomposed by
frictional heat generated by the scoring or the
phenomenon, and chlorine, i.e., the decomposition
product, reacts with iron on the surface of the bearing
to form iron chloride which acts as a lubricant.

15 As described above, in the case of a
refrigerating apparatus using a high-pressure vessel
type rotary compressor, for example, a refrigerator, a
refrigerant compressor and a refrigerating apparatus
which satisfy the operation conditions at an ambient
20 temperature of 30°C described below are satisfactory in
the coefficient of performance indicating energy
efficiency and the reliability of a product, and most
products have been used in such ranges. The discharge
pressure of the compressor: about 10 kg/cm²abs, oil
25 temperature: about 100°C, refrigerating machine oil: an
alkylbenzene oil or a mineral oil having a viscosity at
40°C of 56 cSt and a viscosity at 100°C of 6 cSt, the
actual viscosity of which becomes 1 to 4 cSt.

1 On the other hand, in the case of a refriger-
ating apparatus using a low-pressure vessel type
reciprocating compressor (the explanation of the
structure and operation is omitted), for example, a
5 refrigerator, there have been used a refrigerant
compressor and a refrigerating apparatus which satisfy
the following operation conditions at an ambient
temperature of 30°C; the suction pressure of the
compressor: about 1.6 kg/cm² abs, oil temperature: 85°C,
10 refrigerating machine oil: a mineral oil having a
viscosity at 40°C of 8 to 15 cSt and a viscosity at
100°C of 1.8 to 4.2 cSt, the actual viscosity of which
becomes 2 to 6 cSt.

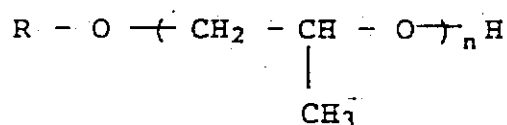
Next, a fundamental refrigeration cycle
15 provided with a refrigerant compressor which thus sucks,
compresses and then discharge a flon type refrigerant,
is explained below with reference to Fig. 9.

As shown in Fig. 9, a compressor 40 compresses
a low-temperature, low-pressure refrigerant gas,
20 discharges the resulting high-temperature, high-pressure
refrigerant gas and send the same to a condenser 41.
The refrigerant gas sent to the condenser 41 becomes a
high-temperature, high-pressure refrigerant fluid while
releasing its heat to the air, and then it is sent to an
25 expansion mechanism (e.g. an expansion valve or a
capillary tube) 42 while being freed from water by a
dryer 45. The high-temperature, high-pressure
refrigerant fluid which passes the expansion mechanism

1 becomes low-temperature, low-pressure wet vapor owing to
 squeezing effect and is sent to an evaporator 43. The
 refrigerant introduced into the evaporator 43 is
 evaporated while absorbing heat from the surroundings,
 5 and the low-temperature, low-pressure gas which has come
 out of the evaporator 43 is sucked into the condenser
 40. Thereafter, the above cycle is repeated.

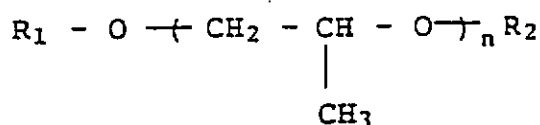
As there frigerant, flon 12 has heretofore
 been used. However, the employment of flon 12 is under
 10 regulations, as described above. The employment of flon
 134a in place of flon 12 involves many problems because
 conventional mineral oil type or alkylbenzene type
 refrigerating machine oils for flon 12 are very poor in
 miscibility with flon 134a. Therefore, refrigerating
 15 machine oils having a good miscibility with flon 134a
 have been vigorously developed and various refrigerating
 machine oils have been proposed. As typical examples of
 such refrigerating machine oils, there are known the
 compounds having ether linkages exemplified below.

20 For example, Japanese Patent Application Kokai
 No. 1-259093 discloses "a refrigerating machine oil for
 a flon compressor" which comprises as base oil a
 propylene glycol monoether represented by the general
 formula:

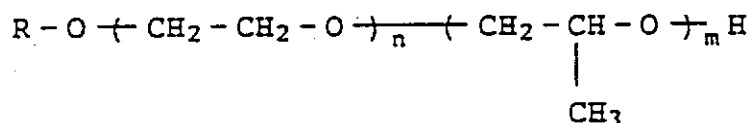


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- 1 wherein R is an alkyl group having 1 to 8 carbon atoms,
 and n is an integer of 4 to 19; Japanese Patent
 Application Kokai No. 1-259094 discloses a diether type
 compound obtained by etherifying one end of propylene
 5 glycol which is represented by the general formula:



- wherein each of R₁ and R₂ is an alkyl group having 1 to 8
 carbon atoms, and n is an integer (average molecular
 weight: 300 to 600); and Japanese Patent Application
 Kokai No. 1-259095 discloses a monoether type compound
 10 which is a copolymer of propylene glycol and ethylene
 glycol and is represented by the general formula:



- wherein R is an alkyl group having 1 to 14 carbon atoms,
 and m and n are integers, the ratio m: n being 6: 4 to
 1 : 9 (average molecular weight: 300 to 2,000).
 15 The difference of these polyalkylene glycols
 from conventional mineral oils and alkylbenzene oils
 have been reported as follows. By the introduction of
 ether linkages into the molecule, the affinity for flon
 134a is enhanced to improve the miscibility with flon
 134a greatly, refrigerant lubrication due to the
 20 phenomenon of separation into two layers (a phenomenon

1 that the refrigerant and the refrigerating machine oil
are insoluble in each other and separate; hereinafter
referred to merely as "two-layer separation") in the
sliding portions of a compressor can be prevented, the
5 return of the oil to the compressor which is induced by
residence phenomenon due to the adhesion of the oil to
the inner wall of a heat exchanger can be suppressed,
and there can be solved the problems concerning the
reliability of the compressor and a refrigerating
10 apparatus, for example, seizing and scoring in the
sliding portions of the compressor.

Such compounds thus containing a large number
of ether linkages (C-O-C), however, are disadvantageous
in that,

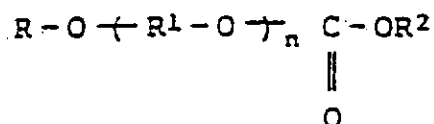
15 (1) they have a saturation water absorption
rate is high (they tend to absorb water).

(2) they have a low volume resistivity.

(3) they have a low oxidation stability, so
that the total acid value is apt to be increased.

20 Therefore, the compounds have been not suitable for
refrigerant compressors and refrigerating apparatus in
which a hermetic motor is used as an electric motor.
That is, although the compounds have an improved
miscibility with the refrigerant, they are dis-
25 advantageous in that they attack the insulating
materials of the motor to deteriorate the electrical
insulating characteristics. In all of the above
compounds, the end group having an ether linkage is

1 capped with hydrogen, and the hydrogen further increases
the hygroscopicity. Therefore, it has been proposed to
replace the hydrogen by an ester group to obtain a
refrigerating machine oil represented by the following
5 formula (see Japanese Patent Application Kokai No.
2-132178):



wherein R is a hydrocarbon group, R¹ is an alkylene R²
is an alkyl group, and n is an integer which is such
that the viscosity of this compound becomes 10 to 300
10 (at 40°C).

However, the improved miscibility with the
refrigerant of this compound is also brought about by a
large number of ether linkages in the molecule, like
that of the above compounds, and hence this compound
15 involves the same problems as in the case of the above
compounds.

Thus, the compounds having ether linkages tend
to absorb water because of the above problem (1), and
the compounds themselves are hydrolyzed by the water to
20 become unstable. Furthermore, the water freezes, chokes
the capillary of a refrigeration cycle, and disturbs the
pressure balance. The volume resistivity of the
compounds is low as described as the problem (2), so
that the electrical insulating properties are
25 deteriorated. When the total acid value is increased as

1 described as the problem (3), the compounds are hydrolyzed to become unstable.

As described above, flon 134a which is used as a substitute refrigerant for conventional refrigerant
5 flon 12 involves the following fatal problem. Because of its unique molecular structure, flon 134a has a low affinity for mineral oil type and alkylbenzene oil type refrigerating machine oils which have heretofore been used, and hence it lacks miscibility with the
10 refrigerating machine oils which is essential in a refrigerant compressor and a refrigerating apparatus.

Attempts have been made to improve the miscibility, but have been accompanied with, for example, the deterioration of the electrical insulating
15 properties, the water problem, and the unstability problems, such as the hydrolysis and the decomposition of the compound by an acid. Each problem is described below in more detail.

SUMMARY OF THE INVENTION

20 (1) A refrigerating machine oil having a bad miscibility cannot be put into practical use in a refrigerant compressor and a refrigerating apparatus from the viewpoint of performance characteristics and reliability, as described below.

25 In general, when the solubility of a refrigerating machine oil in a refrigerant is low, oil discharged from a compressor is separated in a heat

1 exchanger and the oil component adheres to the wall
surface to remain, so that the amount of oil which
returns to the compressor is decreased. Consequently,
the oil surface in the compressor is lowered and a so-
5 called oil drying-up phenomenon takes place, so that the
oiling level is lowered.

When a compressor is exposed to a low-
temperature circumstance in a refrigerating apparatus
enclosing a large amount of a refrigerant, the following
10 trouble is caused. In a so-called lying-idle state in
which liquid refrigerant is present preferentially in
the bottom of the compressor, low-viscosity liquid
refrigerant which is present in the bottom as a result
of two-layer separation is supplied to the sliding
15 surface of a rotating shaft, so that the assurance of a
lubricating oil film becomes difficult, resulting in
damage to the compressor.

On the other hand, as to the refrigerating
apparatus, a refrigerating machine oil which has
20 separated adheres to the inner wall of an evaporator
having a low temperature, to form a heat-insulating
layer, and therefore it inhibits the heat-transferring
capability seriously. Moreover, when this refrigerating
machine oil of wax form chokes an expansion mechanism (a
25 capillary tube) or a piping, the amount of the
refrigerant circulated is greatly decreased, resulting
in a lowered cooling power. As to the compressor, the
pressure of sucked gas is lowered and the pressure of

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1 discharged gas is increased. Therefore, the heat
deterioration of the refrigerating machine oil and
damage to bearings are caused, so that the long-term
reliability of the refrigerant compressor and the
5 refrigerating apparatus is greatly deteriorated.

Accordingly, a first object of the present
invention is to solve such conventional problems and
provide a refrigerating apparatus and a refrigerant
compressor which are provided with a refrigerating
10 machine oil which is highly miscible with and hence
suitable for flon type refrigerants containing no
chlorine a typical example of which is flon 134a. More
specifically, the present invention is fundamentally
intended to make improvements with respect to, for
15 example, (1) water absorption properties, (2) volume
resistivity, and (3) oxidative deterioration, and seek
for a novel refrigerating machine oil composition which
is miscible with flon 134a under all operation condi-
tions of a refrigerant compressor and a refrigerating
20 apparatus. It is also intended to provide a refrige-
ration system having excellent performance character-
istics, efficiency and reliability in refrigerating
apparatus and refrigerant compressors which are
different in purposes, by developing at least the
25 following two refrigeration oils: a refrigeration oil
for moderate-temperature refrigerating apparatus such as
dehumidifiers which achieves a first aim, i.e.,
attainment of a critical solution temperature of 0°C or

1 lower; and a refrigeration oil for low-temperature
refrigerating apparatus such as refrigerators which
achieves a second aim, i.e., attainment of a critical
temperature of -30°C or lower.

5 (2) In the long run, it is beneficial to the
prevention of global warming (GWP) to enhance the
coefficient of performance (COP) (which indicates the
energy efficiency, i.e., the ratio of the cooling power
of a refrigerant compressor to an input) under usual use
10 conditions under which refrigerant compressors and
refrigerating apparatus are usually operated.

For reducing the input to a compressor in
order to improve the performance characteristics of the
compressor, it is necessary to reduce the coefficient
15 of friction on the basis of the hydrodynamic lubrication
theory of coaxial bearing. For the reduction, it is
necessary to measure the solubility of flon 134a in the
refrigerating machine oil used in the present invention
and thereby determine the optimum value of the actual
20 viscosity of the oil used in the compressor. When the
actual viscosity is thus optimized, the coefficient of
friction of a bearing becomes minimum and the
coefficient of performance of the compressor and a
refrigerating apparatus using the compressor becomes
25 maximum.

Therefore, a second object of the present
invention is to attain high performance characteristics
and a high reliability by specifying a viscosity range

1 of the refrigerating machine oil which is most suitable
for a refrigerating apparatus using a high-pressure
vessel type rotary compressor or a low-pressure vessel
type reciprocating compressor, on the basis of the above
5 bearing theory.

(3) However, although very rarely in practice,
there is carried out an extremely severe operation such
as operation in a high-temperature circumstance or
overload operation which are more severe than expected
10 by a designer. Also in this case, a sufficient
reliability should be assured.

In a compressor using flon 134a, scoring or
seizing of the sliding portion of a bearing of the
compressor tends to take place more often than in a
15 compressor using a conventional refrigerant flon 12, in
a so-called boundary lubrication region (in which
contact between metal surfaces occurs) beyond the
hydrodynamic lubrication region of a coaxial bearing.

When contact between metal surfaces takes
20 place in the sliding portion of a bearing, flon 12
dissolved in an oil is decomposed to form a conversion
coating of iron chloride on an iron-based sliding
frictional surface. This iron chloride acts as an
extreme pressure agent to suppress the adhesion and
25 seizing.

On the other hand, since flon 134a is a
refrigerant containing no chlorine, chlorine cannot
possibly be supplied to a compressor using flon 134a..

1 Therefore, unlike flon 12, flon 134a is hardly expected
to have the above action as extreme pressure agent.

Accordingly, a third object of the present
invention is to provide a refrigerating apparatus and a
5 refrigerant compressor in which by using a flon type
refrigerant containing no chlorine represented by flon
134a and a refrigerating machine oil containing an
extreme pressure agent, the prevention of scoring and
seizing of the sliding portions and the assurance of
10 sufficient reliability can be achieved even when the oil
runs out in the sliding bearing of the compressor and
extremely severe operation is carried out.

(4) A fourth object of the present invention is to
provide a refrigerant compressor and a refrigerating
15 apparatus which use a composition comprising a flon type
refrigerant containing no chlorine represented by flon
134a and a refrigerating machine oil, and have an
electrical insulating system wherein electrical insulat-
ing materials such as an electrical insulating film and
20 an insulation-coated winding wire which constitute an
electric motor section have a sufficient long-term
reliability.

(5) Flon 134a has a high water absorption rate and
refrigerating machine oils miscible with flon 134a are
25 relatively hydrophilic though fairly improved. There-
fore, both of them tend to carry water into a refrigera-
tion cycle. Water in a refrigerating apparatus is
frozen in an evaporator on the low-temperature side and

1 chokes a pipe having a small diameter, such as a
capillary tube to lower the refrigerating capability.
Furthermore, in the long run, the refrigerating machine
oil, the refrigerant, electribcal insulating materials,
5 etc. undergo hydrolysis reaction, so that minus charact-
eristics are brought about, for example, the production
of an acidic substance and a lowering of the mechanical
strength are induced.

Accordingly, a fifth object of the present
10 invention is to provide a refrigerating apparatus in
which a flon type refrigerant containing no chlorine
represented by flon 134a and a refrigerating machine oil
coexists, and which has a dryer packed with a drying
agent effective in improving the reliability of the
15 refrigerating apparatus by separating and adsorbing only
water without absorbing the refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing a two-layer
separation temperature which illustrates the miscibility
20 of flon 134a with each refrigerating machine oil.

Fig. 2 is a graph showing a relationship
between the amount of water dissolved in each of various
refrigerating machine oils and its volume resistivity.

Fig. 3 is a graph showing a relationship
25 between the atual viscosity of each refrigerating
machine oil and the coefficient of performance during

1 rated operation of a high-pressure vessel type rotary
compressor.

Fig. 4 is a graph showing a relationship
between the actual viscosity and the coefficient of
5 performance during rated operation of a low-pressure
vessel type reciprocating compressor.

Fig. 5 is a graph showing a relationship
between FALEX test using an iron-based frictional
sliding surface and a high-pressure atmosphere friction
10 test using an oil containing flon 134a dissolved
therein.

Fig. 6 is a graph showing the abrasion loss
caused by a FALEX test.

Fig. 7 is a vertical cross-sectional view of
15 the principal part of a closed rotary compressor.

Fig. 8 is a vertical cross-sectional view of
the principal part of the compression mechanical part of
a rotary compressor.

Fig. 9 is a diagram showing the structure of
20 the refrigeration cycle of a refrigerating apparatus.

PREFERRED EMBODIMENT OF THE INVENTION

1. The above first object of the present
invention can be achieved by a refrigerating apparatus
comprising a refrigeration cycle comprising at least a
25 compressor, condensor, dryer, expansion mechanism and
evaporator, a refrigerant composed mainly of a
fluorocarbon type refrigerant containing no chlorine and

1 having a critical temperature of 40°C or higher, and a
refrigerating machine oil comprising as base oil an
ester oil of one or more fatty acids which contains at
least two ether linkages $(-O-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-)$ in the molecule and

5 has a viscosity at 40°C of 2 to 70 cSt and a viscosity
at 100°C of 1 to 9 cSt.

As described above, it is absolutely necessary
for the ester oil to be an ester of one or more fatty
acids which contains at least two ester linkages in the
10 molecule. Ester oils of one or more fatty acids which
have one ester linkage have a bad miscibility with the
refrigerant and hence cannot be used. The usable ester
oil of one or more fatty acids can be obtained by the
esterification reaction of an alcohol with one or more
15 fatty acids. As the alcohol, a polyhydric alcohol is
preferable. As the fatty acids, those having 1 to 6
carbon atoms are preferable. The fatty acids may be
either monobasic or polybasic. The ester oils include
hindered ester oils and complex ester oils. From the
20 viewpoint of the miscibility with the refrigerant, ester
oils having a branched-chain structure tend to be
preferable to ester oils having a straight-chain
structure. Examples of practical ester oils of one or
more fatty acids are given below by the general formulas
25 (1) to (5).

The ester oils represented by the formulas (1)
to (4) are hindered ester oils, and the ester oils

- 1 represented by the formula (5) are complex ester oils.

These ester oils may be used singly or in combination of two or more thereof. The refrigerating machine oil comprise at least 50 wt% of these ester oils as base oil, and the balance may be made up by other well-known refrigerating machine oils.



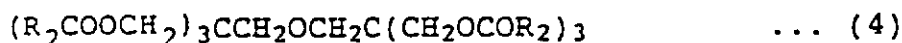
(examples of esters of neopentyl glycol (abbreviated as NPG) type alcohols which contain two ester linkages in the molecule).



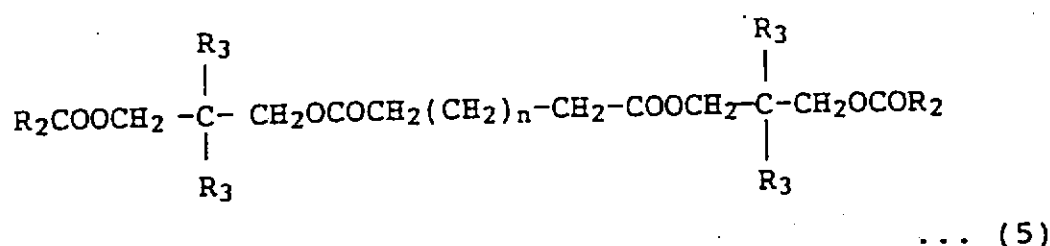
- 10 (examples of esters of trimethylolalkylpropanes (abbreviated as TMP) which contain three ester linkages in the molecule).



(examples of esters of pentaerythritol (abbreviated as PET) which contain 4 ester linkages in the molecule).



- 15 (examples of esters of dipentaerythritol (abbreviated as DPET) which contain 6 ester linkages in the molecule).



- 1 (examples of complex esters containing 4 or more ester linkages in the molecule).

In the above general formulas, R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight
 5 or branched-chain alkyl group having 5 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5.

- The esters represented by the above general
 10 formulas (1) to (4) are esters of polyhydric alcohols and monocarboxylic acids. As such esters, esters having a desired viscosity grade can be obtained by optionally choosing a combination of the alcohol and one or a plurality of the monocarboxylic acids and proportions of
 15 these components.

As the complex esters represented by the general formula (5), esters having a high viscosity and a wide critical solution temperature range can be obtained by selecting the chemical structure of the
 20 central dibasic acid (dicarboxylic acid) component from various chemical structures derived from succinic acid ($n = 2$), glutaric acid (abbreviated as Glut), adipic acid (abbreviated as AZP), pimelic acid, suberic acid,

1 azelaic acid, and sebacic acid ($n = 8$), selecting the
polyhydric alcohol component and the terminal
monocarboxylic acid component from various compounds,
and varying the blending proportions (molar fraction).

5 The monocarboxylic acids represented by the
formula R_2COOH may be straight- or branched-chain ones.
The latter includes 2-ethylhexanoic acid (2EH), 2-
methylhexanoic acid (i-C₇), 3,5,5-trimethylhexanoic
acid, 3,5-dimethylhexanoic acid (i-C₈), 2-methyl-
10 heptanoic acid. The monocarboxylic acids may be used
singly or in combination of two or more thereof.

 The base oil of the refrigerating machine oil
is prepared by adjusting the viscosity by using such
hindered ester oils and complex ester is singly or in
15 combination of two or more thereof.

 The refrigerant composed mainly of a fluoro-
carbon type refrigerant containing no chlorine and
having a critical temperature of 40°C or higher which is
used in the present invention includes hydrofluoro-
20 carbons and fluorocarbons. Specific examples of the
hydrofluorocarbons are difluoromethane (R32), penta-
fluoroethane (R125), 1,1,2,2-tetrafluoroethane (R134),
1,1,1,2-tetrafluoroethane (R134a), 1,1,2-trifluoroethane
(R143), 1,1,1-trifluoroethane (R143a), 1,1-difluoro-
25 ethane (R152a) and monofluoroethane (R161). Specific
examples of the fluorocarbons are hexafluoropropane
(C216) and octafluorocyclobutane (C318). Of these,
1,1,2,2-tetrafluoroethane (R134), 1,1,1,2-

1 tetrafluoroethane (R134a), 1,1,2-trifluoroethane (R143),
1,1,1-trifluoroethane (R143a) and hexafluoropropane
(C216) have a boiling point close to that of a
conventional refrigerant, dichlorodifluoromethane (R12),
5 and are preferable as substitute refrigerants. The
above-exemplified hydrofluorocarbon or fluorocarbon type
refrigerants can be used singly or as a mixture thereof.

The reason for the adjustment of critical
temperature of the refrigerant to 40°C or higher is that
10 there was required a refrigerating apparatus in which
the condensation temperature in a condenser was 40°C.

1) The above second object of the present
invention is, for one thing, achieved by a high-pressure
vessel type refrigerant compressor used in a
15 refrigeration cycle that comprises a closed vessel
stored with a refrigerating machine oil which
accommodates a motor composed of a rotor and a stator, a
rotating shaft fitted in the rotor, and a compressor
section connected to the motor through the rotating
20 shaft, and in which a high-pressure refrigerant gas
discharged from the compressor section resides, said
refrigerant being composed mainly of a fluorocarbon type
refrigerant containing no chlorine and having a critical
temperature of 40°C or higher, and said refrigerating
25 machine oil comprising as base oil an ester oil of one
or more fatty acids which contains at least two ester
linkages $(-O-\underset{\text{O}}{\underset{\parallel}{C}}-)$ in the molecule and has a viscosity

1 at 40°C of 2 to 70 cSt and a viscosity at 100°C of 1 to
9 cSt.

The constitution of the ester oil of one or
more fatty acids which contains at least two ester
5 linkages in the molecule is as described above in
detail.

In a high-pressure vessel type rotary
compressor, for example, is previously enclosed the
aforesaid refrigerating machine oil having a viscosity
10 at 40°C of 2 to 70 cSt, preferably 5.0 to 32 cSt, so
that the actual viscosity (at a gas pressure of 9 to 11
kg/cm² abs and an oil temperature of about 100°C) of the
oil which contains flon 134a dissolved therein may be
1.0 to 4.0 cSt.

15 2) In addition, the above second object of the
present invention is achieved by a low-pressure vessel
type refrigerant compressor that comprises a closed
vessel stored with a refrigerating machine oil which
accommodates a motor composed of a rotor and a stator, a
20 rotating shaft fitted in the rotor, and a compressor
section connected to the motor through the rotating
shaft, and from which a high-pressure refrigerant gas
discharged from the compressor section is directly
exhausted, said refrigerant being composed mainly of a
25 fluorocarbon type refrigerant containing no chlorine and
having a critical temperature of 40°C or higher, and
said refrigerating machine oil comprising as base oil an
ester of one or more fatty acids which contains at least

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1 two ester linkages $\left(\begin{array}{c} -O-C- \\ || \\ O \end{array} \right)$ in the molecule and has

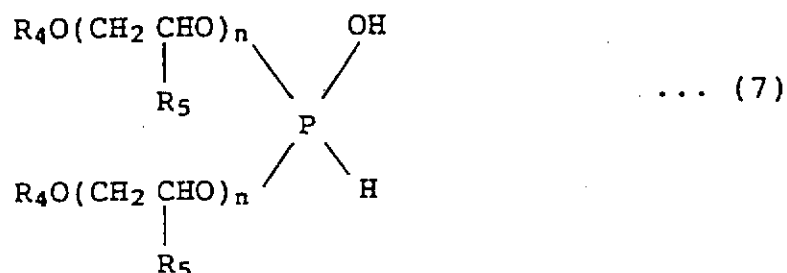
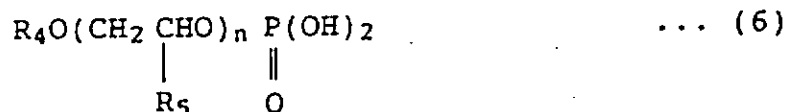
a viscosity at 40°C of 2 to 70 cSt and a viscosity at 100°C of 1 to 9 cSt.

5 The constitution of the ester oils of one or more fatty acids which contains at least two ester linkages in the molecule is as described above.

In a low-pressure vessel type reciprocating compressor, for example, is previously enclosed the aforesaid refrigerating machine oil having a viscosity at 40°C of 5.0 to 15 cSt and a viscosity at 100°C of 2.0 to 4.0 cSt, so that the actual viscosity (at a sucked gas pressure of 1.0 to 2.0 kg/cm abs and an oil temperature of 85°C) of the oil which contains flon 134a dissolved therein may be 2.0 to 4.5 cSt.

15 3) The above third object can be achieved by adding an extreme pressure agent to the aforesaid refrigerating machine oil.

The extreme pressure agent serves as an abrasion-preventing agent in sliding portions and includes, for example, alkylpolyoxyalkylene phosphate esters represented by the general formulas (6) and (7) and dialkyl phosphate esters represented by the general formula (8):



- 1 wherein R_4 is an alkyl group having 1 to 8 carbon atoms,
and R_5 is H or an alkyl group having 1 to 3 carbon
(molecular weight: 400 to 700).



- 5 wherein R_6 is an alkyl group having 8 to 16 carbon
atoms.

These phosphoric esters may be added singly or in combination of two or more thereof. The practical amount of the phosphoric esters added to the refrigerating machine oil is 0.05 to 10 wt%.

- 10 It is also effective to add an acid-capturing agent, antioxidant, defoaming agent, etc. together with the extreme pressure agent (the abrasion-preventing agent).

- 15 When an acid component is present in the refrigerating machine oil, the ester oil is decomposed

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1 by the acid component to become unstable. Therefore,
the acid-capturing agent is added for removing the acid
component. For example, compounds such as epoxy
compounds reactive with acids are preferable as the
5 acids-capturing agent. Particularly preferable examples
of the acid-capturing agent are compounds having an
epoxy group and an ether linkage, for example,
diglycidyl ether compounds such as polyalkylene glycol
diglycidyl ethers; monoglycidyl ether compounds such as
10 phenyl glycidyl ether; and aliphatic cyclic epoxy
compounds. The reason is that the epoxy group of such a
compound captures an acid and that the ether linkage
contributes to the improvement of the miscibility of the
refrigerating machine oil with the refrigerant to a
15 certain extent.

The other additives described above are, for
example, chlorine-capturing agents for preventing the
influence of residues of, for instance, a chlorine-
containing detergent used for producing the compressor
20 or the refrigerating apparatus, additives for preventing
oxidative deterioration during the circulation and
storage of the oil, and additives for preventing
foaming. These additives may be selected from those
used in the conventional general techniques and are not
25 critical in the present invention.

4) For achieving the fourth object, the
insulating film constituting an electric motor section
and the insulation-coated winding wire which are

1 described below are used in a refrigerating apparatus
and a refrigerant compressor which simultaneously use a
flon type refrigerant containing no chlorine represented
by flon 134a and a refrigerating machine oil comprising
5 as base oil the above-exemplified ester oil of one or
more fatty acids. As the insulating film, there is used
a crystalline plastics film having a glass transition
temperature of 50°C or higher, or a composite film
obtained by coating a film having a low glass transition-
10 temperature with a resin layer having a high glass
transition temperature. As the insulation-coated
winding wire, there is used an enameled wire having the
enamel coating of a glass transition temperature of
120°C or higher, or an enameled wire having a composite
15 coating consisting of a lower layer having a low glass
transition temperature and a upper layer having a high
glass transition temperature.

As the insulating film, for practical
purposes, it is preferable to use at least one kind of
20 insulating film selected from the group consisting of
films of polyethylene terephthalates, polybutylene
terephthalates, polypenylene sulfides, polyether ether
ketones, polyethylene naphthalates, polyamide-imides and
polyimides. As an enamel coating, it is preferable to
25 use at least one kind of insulating layer selected from
the group consisting of insulating layers of polyester
imides, polyamides and polyamide-imides.

1 5) For achieving the fifth object, a synthetic
zeolite composed of a composite salt consisting of
alkali metal silicates and alkali metal aluminates which
has a pore diameter of 3.3 angstrom or less and a carbon
5 dioxide gas absorption capacity (at 25°C and at a
partial pressure of carbon dioxide gas of 250 mmHg) of
1.0% or less, is used as a drying agent to be packed
into the dryer, in the aforesaid refrigerating apparatus
which simultaneously uses a flon type refrigerant
10 containing no chlorine represented by flon 134a and a
refrigerating machine oil comprising as base oil the
above-exemplified ester oil of one or more fatty acids.

In a refrigerating apparatus comprising at
least a compressor, condenser, expansion mechanism and
15 evaporator, and using a flon type refrigerant containing
no chlorine represented by flon 134a, the refrigerating
machine oil according to the present invention which
comprises at least one ester selected from the group
consisting of hindered or complex esters containing two
20 or more ester linkages in the molecule, and has a
viscosity at 40°C of 2 to 70 cSt, preferably 5 to 32
cSt, and a viscosity at 100°C of 1 to 9 cSt, preferably
2 to 6 cSt, has a good miscibility with the refrigerant
in the whole temperature ranges of the parts used in the
25 refrigerating apparatus. Therefore, there is no two-
layer separation between the refrigerant and the
refrigerating machine oil. Accordingly, no two-layer
separation is present in the oil-storing space in the

1 compressor, so that the supply of the oil to the sliding
portions of hearings is assured, and flon gas discharged
from the compressor is in a liquefied state by the
condenser, namely, in a state in which the oil is always
5 dissolved in flon 134a with a low viscosity in a low-
temperature circumstance of -30°C or lower in the
evaporator. Thus, on the whole, the flon gas is in a
low-viscosity state, so that the return of the oil to
the compressor is improved.

10 Therefore, the lowering of oil surface in the
compressor is prevented and hence the supply of the oil
to the sliding portions of hearings can be assured.
Thus, the problems causing scoring and seizing can be
solved.

15 Furthermore, unlike conventional
polyoxyalkylene glycol oils, the aforesaid refrigerating
machine oil has a low saturated water-content of one-
tenth or less as large as that of the conventional oils,
a large improving effect on the stability to oxidative
20 deterioration, and a volume resistivity of $10^{13} \Omega\text{cm}$
which is as high as that of an electrical insulating
oil. Therefore, in a refrigerant compressor comprising
a pressure vessel accommodating a motor section and a
refrigerating apparatus using the refrigerant compres-
25 sor, the refrigerating machine oil according to the
present invention do not separate from flon 134a and has
excellent characteristics with respect to both the
performance characteristics and reliability of the

1 compressor. Since the refrigerating machine oil has an
excellent miscibility also with conventional chlorine-
containing flon refrigerants such as flon 12 and flon
22, such conventional chlorine-containing refrigerants
5 can, if necessary, be used in place of a portion of flon
134a in admixture with flon 134a.

When the refrigerating machine oil according
to the present invention which had an oil viscosity at
40°C of 5 to 32 cSt was enclosed in a high-pressure
10 vessel type rotary compressor and the coefficient of
performance of the compressor was measured, the co-
efficient of performance reached a peak in the case of
using the oil which had a viscosity of 15 cSt. When the
oil which had a viscosity of 5 to 32 cSt was used, the
15 coefficient of performance was about 1.4 or more which
corresponds to a value of 0.95 to 0.93 when the co-
efficient of performance in the case of using a
conventional combination of a flon 12 and an alkyl-
benzene oil is taken as 1. Such a value indicates that
20 the oil involves no practical problem. The refrigerat-
ing machine oil according to the present invention which
had a viscosity at 40°C of 56 cSt was found to be
superior in the coefficient of performance of the
compressor to polyoxypropylene glycol oils. The reason
25 for this superiority is as follows. The ester linkages
contained in the oil itself undergoes molecular orienta-
tion mainly on the surfaces of iron-based sliding
portions of the shaft and bearings of the compressor to

1 improve the lubrication. Moreover, the oil is decreased
in actual viscosity owing to its high solubility in flon
134a, to reduce the mechanical loss. These effects are
synergistically brought about to improve the coefficient
5 of performance of the compressor.

On the other hand, in the case of a low-
pressure vessel type reciprocating compressor, the
amount of flon 134a dissolved and the actual viscosity
vary only in narrow ranges because the compressor is
10 operated at a low pressure in the vessel of 1 to 2
kg/cm² abs. Therefore, characteristics of a refrigerant
and a refrigerating machine oil are hardly dependent on
their kinds, and it was found that the oil which had a
viscosity at 40°C of 5 to 15 cSt and a viscosity of
15 100°C of 2 to 4 cSt was good in reliability and
performance characteristics.

When the refrigerating machine oil according
to the present invention is blended with an adequate
amount (0.05 to 10 wt%) of an extreme pressure agent
20 such as a strong primary or secondary phosphoric ester
retaining OH groups in the molecule, for example, an
alkylpolyoxyalkylene phosphate ester or a dialkyl
phosphate ester, the resulting blend can push away a
lubricating oil film having ester linkages undergoing
25 molecular orientation on the surfaces of iron-based
sliding portions constituting the shaft and bearings of
the compressor, and form a stronger chemical adsorption
film of the phosphoric ester. Therefore, the blend can

- 1 further improve the lubrication of the sliding portions
to prevent scoring and seizing.

When the lubricating properties of the
refrigerating machine oil according to the present
5 invention containing the extreme pressure agent were
examined, the critical seizing pressure on surface was
greatly increased in a FALEX test (a seizing test on the
oil) carried out without the dissolution of flon 134a in
the oil. In addition, when there was measured the
10 abrasion loss of an iron-based sliding member in the
case of employment of the refrigerating machine oil
containing the extreme pressure agent which further
contained 50% of flon 134a dissolved therein, as simula-
tion of the dissolution of a high concentration of flon
15 134a, the abrasion loss could be reduced to one-fifth or
less as large as that caused in the case of the oil
which did not contain the extreme pressure agent. The
suitable range of the amount of the extreme pressure
agent added is 0.05 to 10 wt% as described above. The
20 results of the abrasion loss test are as shown in Fig. 6
though specifically described in the examples herein-
after given. As shown in Fig. 6, the reducing effect of
the addition of the extreme pressure agent on the
abrasion loss is remarkable.

- 25 Conventional additives such as an acid-
capturing agent, antioxidant, defoaming agent, etc. can
be blended together with the extreme pressure agent.

1 Next, there are explained below electrical
insulating materials for the refrigerant compressor
using flon 134a together with the refrigerating machine
oil according to the present invention. As an insulat-
5 ing film used as electrical insulating material for the
motor section, a crystalline plastics film having a
glass transition temperature of 50°C or higher is used.
The insulating film includes films of polyethylene
terephthalates, polybutylene terephthalates, poly-
10 phenylene sulfides, polyether ether ketones, poly-
ethylene naphthalates, polyamide-imides and olyimides;
and composite films obtained by coating a film having a
low glass transition temperature with a resin layer
having a high glass transition temperature. These films
15 are hardly deteriorated in tensile strength character-
istics and electrical insulating characteristics and
involve no practical problem. This is because the films
carry in a much smaller amount of water and produce a
much smaller amount of an acid than do conventional
20 polyoxyalkylene glycol oils, and hence are hardly
deteriorated by hydrolysis of the films themselves.

 An enamel coating having a glass transition
temperature of 120°C or higher is used on a magnet wire
used in the motor section. The enamel coating includes,
25 for example, monolayers of polyester imides, polyamides,
polyamide-imides and the like, and composite enamel
coating films obtained by forming an upper layer having

1 a high glass transition temperature on a lower layer
having a low glass transition temperature. Like the
above-mentioned films, these enamel coatings hardly show
deterioration by hydrolysis, cracking, softening,
5 swelling, a lowering of breakdown voltage, etc. and
hence are useful for improving the reliability in
practical. In some cases, a self-lubricating agent or
an external lubricating agent is included in the enamel
coating on the magnet wire, for imparting self-
10 lubricating properties to improve the electrical
workability. Fundamentally, the above characteristics
of the enamel coating itself before the inclusion are
retained.

Lastly, a drying agent packed into the dryer
15 of the refrigerating apparatus in which flon 134a and
the aforesaid refrigerating machine oil according to the
present invention coexist is explained below. In this
invention, it is preferable to use a synthetic zeolite
composed of a composite salt consisting of alkali metal
20 silicates and alkali metal aluminates which has a pore
diameter of 3.3 angstrom or less, a carbon dioxide
absorption capacity at 25°C and at a carbon dioxide
partial pressure of 250 mmHg of 1.0% or less. As such a
synthetic zeolite, XH-9 and XH-600 (trade names, mfd. by
25 UNION SHOWA K.K.) can be exemplified. Both of them have
a small fluorine ion adsorption. The same synthetic
zeolite as above except for having a carbon dioxide gas
adsorption capacity of 1.5% or more has a fluorine

1 adsorption of as large of 0.24% or more and hence
possesses deteriorated adsorption characteristics and
breaking strength as molecular sieves. Moreover,
corroded crystal disintegration product of such a
5 synthetic zeolite chokes the piping of the refrigeration
cycle or injures the sliding portions of bearings of the
compressor. When the pore diameter in the present
invention is specified in relation to the above carbon
dioxide adsorption capacity in consideration of such
10 conditions, the troubles described above are not caused
and it becomes possible to compose a highly reliable
refrigerating apparatus.

Examples of the present invention are
explained below with reference to Figs. 1 to 6 and
15 Tables 1 to 4.

Examples 1 to 17

These examples show embodiments for achieving
the above first object of the present invention. In a
closed rotary compressor concerned with a refrigeration
20 cycle and a refrigerant compressor, flon 134a was used
as a refrigerant, and as a refrigerating machine oil,
there was used each ester oil listed in Table 1 which
contained two or more ester groups in the molecule and
had a viscosity at 40°C of 2 to 70 cSt and a viscosity
25 at 100°C of 1 to 9 cSt. For comparison, data on
conventional refrigerating machine oils are also shown
in Table 1.

1 Fig. 1 is a graph showing two-layer separation
temperature which illustrates the miscibility of flon
134a with each refrigerating machine oil. The graph was
obtained by enclosing flon 134a and the refrigerating
5 machine oil in a high-pressure glass vessel, observing
visually the two-layer separation state at each tempera-
ture and at each concentration of the refrigerating
machine oil, and summarizing the observation results.
The axis of abscissa refers to the concentration of the
10 oil in flon 134a, and the axis of ordinate to tempera-
ture. The first target value shown in Fig. 1 is a lower
critical solution temperature necessary for a refrige-
rating apparatus such as a dehumidifier, which has a
moderate evaporator temperature (0°C or lower). The
15 second target value is a lower critical solution tem-
perature necessary for a refrigerating apparatus such as
a refrigerator, which has a low evaporator temperature
(-30°C or lower). Both of the evaporator temperatures
are specified values.

20 From Table 1, it can be seen that SUNISO 4GSD
(a trade name, naphthene type) and Z300A (a trade name,
alkylbenzene type) both manufactured by JAPAN SUN OIL
Co., Ltd. were not dissolved. A polyalkylene glycol,
PAG56 (a trade name, mfd. by JAPAN SUN OIL Co., Ltd.)
25 had a lower critical solution temperature (shown by L1)
of -60°C and an upper critical solution temperature
(shown by U1) of 35°C . The ester oils containing two or
more ester groups in the molecule according to the

1 present invention are so excellent in critical solution
temperatures that their lower critical solution tempera-
ture (shown by L2) is -70°C and their upper critical
solution temperature (shown by U2) 70°C or higher. The
5 lower critical solution temperatures is an important
factor for practical purposes in the heat exchanger of a
refrigerating apparatus, and the upper critical solution
temperature is an important factor for practical
purposes in a refrigerant compressor.

10 Fig. 9 is a diagram showing the structure of
the refrigeration cycle of a refrigerating apparatus.
The refrigerating apparatus comprising a refrigerant
compressor 40, a condenser 41, a dryer 45, an expansion
mechanism 42 and an evaporator 43 was operated by using
15 each of the above-mentioned refrigerating machine oils
together with flon 134a. Consequently, in the case of
SUNISO 4GSD (a naphthenic mineral oil) and Z300A (an
alkylbenzene oil) (trade names, mfd. by JAPAN SUN OIL
Co., Ltd.), when the refrigerant was present in a large
20 amount and lay idle in the compressor, a refrigerant
layer having a high density and a refrigerating machine
oil layer having a low density were present merely as a
lower layer and an upper layer, respectively, owing to
two-layer separation. Therefore, as shown in Fig. 7,
25 i.e., the vertical cross-sectional view showing the
principal part of a refrigerant compressor (an example
of closed rotary compressor), oil supply to a shaft 4A,
a main bearing 5 and a sub-bearing 6 is carried out by

1 suction of the refrigerant layer present merely as the
lower layer through the suction opening 14 of a pump.
The refrigerant layer has a lower viscosity than does
the refrigerating machine oil. Therefore, when the
5 refrigerant layer is supplied to the bearings, the
resulting oil film is thin, so that contact between
metal surfaces tends to occur. In addition, since the
temperature of sliding frictional surfaces rises at
once, the refrigerant was gasified, resulting in more
10 severe conditions. When this phenomenon is repeated,
damages due to scoring and seizing are caused in the
shaft and the bearings, so that the performance
characteristics of the refrigerant compressor are lost.

When the conventional refrigerating machine
15 oil is used in the heat exchanger of the refrigerating
apparatus shown in Fig. 9, for example, the evaporator
43 used at 0° to -60°C, the refrigerating machine oil
which has been discharged together with gas of the
refrigerant from the compressor 40 undergoes two-layer
20 separation in the evaporator 43 and adheres to the inner
wall of the piping of the heat exchanger, and there is
caused the residence of the refrigerating machine oil or
the heat insulation of the heat exchanger. Therefore,
the conventional refrigerating machine oils greatly
25 deteriorate the cooling capability of the refrigerating
apparatus and are of no practical use. In this point,
the polyalkylene glycol listed as Conventional Example 3
in Table 1 is advantageous because it has a lower

1 critical solution temperature of -60°C and hence does
not undergo two-layer separation in the evaporator 43.
But, owing to its upper critical solution temperature of
35 $^{\circ}\text{C}$, it completely undergoes two-layer separation
5 because the temperature of the compressor 40 during
operation becomes at least 80 $^{\circ}\text{C}$. As in the case of
Conventional Examples 1 and 2, when the polyalkylene
glycol is supplied to the bearings, damages due to
scoring and seizing are caused in the shaft and the
10 bearing, so that the refrigerant compressor loses its
performance characteristics.

In a refrigerant compressor having a hermetic
motor, for example, the rotary compressor shown in Fig.
7, a refrigerating machine oil is, of course, required
15 to have characteristics as an electrical insulating oil.

Fig. 2 shows the relationship between the
water absorption and the volume resistivity of each of
the ester oils according to the present invention and
conventional mineral oil and polyalkylene glycol. Even
20 in a condition in which the water content is controlled
to be 500 ppm or less, the polyalkylene glycol as
conventional example has a low volume resistivity of
10¹² Ωcm or less owing to the ether linkages in the
molecule and hence is not preferable.

25 On the other hand, the refrigerating machine
oil having ester linkages introduced therein according
to the present invention has a high volume resistivity
(a high insulating capability) of 10¹³ Ωcm or more which

1 is in accordance with the standard value of electrical
insulating oil prescribed in JIS C2320. Therefore, it
can be sufficiently put to practical use. Although the
mineral oil as conventional example has a high insulat-
5 ing capability, it has a bad miscibility with flon 134a
and cannot be put to practical use.

Next, the relationship among the kind,
chemical structure and lower critical solution tempera-
ture of ester oils suitable for flon 134a is explained
10 below in detail with reference to Table 1.

The ester oil containing two or more ester
groups in the molecule which is used in the present
invention includes esters of monobasic or polybasic
organic acids and polyhydric alcohols. Typical examples
15 of the ester oil are hindered ester oils and complex
ester oils which are represented by esters of neophentyl
glycol, esters of trimethylolpropane or trimethyl-
olethane, and esters of pentaerythritol. Table 1 shows
the relationship amount the name, viscosity and critical
20 solution temperatures of typical chemically synthesized
products.

Table 1

	Sample refrigerating machine oil	Viscosity (cSt)		Critical solution temperature (°C)	
		40°C	100°C	U (upper)	L (lower)
Conventional Example	Naphthenic mineral oil (SUNISO 4GSD)	55.1	5.9	-	>40
	Alkylbenzene oil (SUNISO Z300A)	60.1	6.0	-	>40
	Propylene glycol monoether (PAG56)	54.0	10.0	35	-60
Example 1	Note 1	4.8	1.7		-29
		2.8	1.2		-61
		7.0	2.1	>80	-60
		5.5	1.8	>80	-70
		14.9	3.8	>80	-40
6		13.9	3.4		-20
7	Note 2	10.8	2.8		-62
8		32.2	5.2		-27
9		22.0	4.2		-33
10		14.9	3.4	>80	-60
11	Note 3	17.5	3.7		-44
12		52.0	6.7		-8
13		28.0	4.8		-40

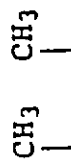
- Cont'd -

Table 1 (Cont'd)

14		NPG/Glut/n-C6		32.6	5.9	>80	<-75
15	Note 4	NPG/i-C7 +					
		AZP/NPG/n-C10		29.5	5.0	>80	-45
16		AZP/NPG/n-C10		54.5	7.3	>80	-60
17		Glut/NPG/i-C6		56.6	8.6	>80	-60

Note 1 NPG: esters of neopentyl glycol, i-C7: $\text{CH}_3(\text{CH}_2)_3\text{CHCOOH}$, n-C7: $\text{CH}_3(\text{CH}_2)_5\text{COOH}$,

i-C11: $\text{CH}_3(\text{CH}_2)_7\text{COOH}$



Note 2 TMP: esters of trimethylolpropane, i-C8: $\text{CH}_3 - \text{CHCH}_2\text{CHCH}_2\text{COOH}$, n-C6: $\text{CH}_3(\text{CH}_2)_4\text{COOH}$

Note 3 PTE: esters of pentaerythritol

Note 4 : complex esters, n-C10: $\text{CH}_3(\text{CH}_2)_8\text{COOH}$, i-C6: $\text{CH}_3(\text{CH}_2)_2\text{COOH}$

1 Of the sample names in Table 1, the names of
chemically synthesized ester oils are abbreviated. For
example, in the case of NPG/n-C₈, NPG is an abbreviation
of neopentyl glycol, n-C₈ is an abbreviation of a normal
5 organic acid (a straight-chain fatty acid) having 8
carbon atoms, and NPG/n-C₈ denotes an ester of neopentyl
glycol and the normal organic acid (the straight-chain
fatty acid) having 8 carbon atoms. In the case of
NPG/2EH, 2EH is an abbreviation of 2-ethylhexanoic acid
10 and NPG/2EH denotes an ester of neopentyl glycol and 2-
ethylhexanoic acid.

1) As shown in Examples 1 to 4, the esters of
neopentyl glycol (NPG) are esters of neopentyl glycol as
dihydric alcohol and a monocarboxylic acid as monobasic
15 organic acid, and are characterized by containing two
ester groups in the molecule. Such a chemical structure
has an important bearing on the miscibility with flon
134a and the viscosity characteristics of the oils.

That is, ester oils of a monocarboxylic acid
20 having 7 to 8 carbon atoms were satisfactory and had a
lower critical solution temperature of -29°C to -70°C
and a viscosity at 40°C of 2.8 to 7.0 cSt.

The smaller the number of carbon atoms of the
monocarboxylic acid (the fatty acid), the lower the
25 lower critical solution temperature. It was found that
the lower critical solution temperature of the ester of
2-ethylhexanoic acid (2EH) of Example 3 and the ester of
isooheptanoic acid (i-C₇) of Example 4 which have a

1 branched chain in the molecule is advantageously lower
than that of the esters of Examples 1 and 2, respec-
tively. The case of increasing the number of carbon
atoms of the carboxylic acid to 11 for increasing the
5 viscosity is Example 5. The ester of Example 5 was
found to have a viscosity at 40°C of 14.9 cSt and a
lower critical solution temperature of -40°C at the
lowest.

2) Next, the esters of trimethylolpropanol (TMP)
10 containing three ester linkages in the molecule are
explained below with reference to Examples 6 to 10.

The ester oils obtained by the condensation of
trimethylolpropane (TMP) as trihydric alcohol and a
monocarboxylic acid as monobasic organic acid contain
15 three ester groups in the molecule, and the mono-
carboxylic acid has 6 to 8 carbon atoms. The ester oils
have a viscosity at 40°C of 10.8 to 32.2 cSt and a lower
critical solution temperature of -20°C to -60°C. Of
these ester oils, ester oils having a lower critical
20 solution temperature of -20°C or lower are the ester oil
of heptanoic acid (n-C₇) of Example 6, the ester oil of
octanoic acid (n-C₈) of Example 8 and the ester oil of
2-ethylhexanoic acid (2EH) of Example 9. Ester oils
having a lower critical solution temperature of -60°C or
25 lower are the ester oil of hexanoic acid (n-C₆) of
Example 7 and the ester oil of isoheptanoic acid (i-C₇)
of Example 10. The ester oils of Examples 6 to 10 are
also characterized in that the smaller the number of

1 carbon atoms, the lower the lower critical solution
temperature, and that the lower critical solution
temperature of the ester oils containing a branched
chain is lower than that of the ester oils containing no
5 branched chain even when the former ester oils and the
latter ester oils have the same number of carbon atoms.

3) As shown in Examples 11 to 13, the ester oils
obtained by the condensation of pentaerythritol (PET) as
tetrahydric alcohol and a monocarboxylic acid contain 4
10 ester groups in the molecule, and the monocarboxylic
acid has 6 to 8 carbon atoms. The ester oils have a
high viscosity at 40°C of 17.5 to 52.0 cSt and a lower
critical solution temperature of -8°C to -44°C. Thus,
the lower critical solution temperature is shifted to
15 higher temperatures, as compared with the above-
mentioned ester oils of dihydric alcohols and trihydric
alcohols. Of the ester oils of Examples 11 to 13, ester
oils having a lower critical solution temperature of
-40°C or lower are the ester oil of hexanoic acid (n-C₆)
20 of Example 11 and the ester oil of isoheptanoic acid (i-
C₇) of Example 13. The ester oils of Examples 11 to 13
are also characterized in that the smaller the number of
carbon atoms, the lower the lower critical solution
temperature, and that the lower critical solution
25 temperature of the ester oils containing a branched
chain is lower than that of the ester oil containing no
branched chain.

1 4) As a method for introducing 4 ester groups
into the molecule, there is a method in which
esterification is carried out by condensing a polyhydric
alcohol and a monocarboxylic acid with a dicarboxylic
5 acid (i.e. a typical dibasic organic acid) as the
central constituent. By this method, the lower critical
solution temperature can easily be lowered and the
viscosity can easily be increased. Esters obtained by
such a molecular design are complex esters and are
10 explained with Examples 14 to 17 of the present
invention.

Example 14 shows a complex ester of glutaric
acid (abbreviated as Glut) as dicarboxylic acid,
neopentyl glycol (NPG) as dihydric alcohol, and hexanoic
15 acid (C₆) as monocarboxylic acid. This complex ester
had a viscosity at 40°C of 32.6 cSt, a viscosity at
100°C of 5.9 cSt, and a lower critical solution
temperature of -75°C or lower.

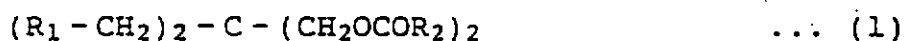
Example 15 shows the case where an ester
20 having moderate viscosity grade was prepared by mixing
the esters of Examples 4 and 16. This ester was also
found to possess a lower critical solution temperature
not much changed.

Example 16 shows a complex ester of adipic
25 acid (abbreviated as AZP) as dicarboxylic acid,
neopentyl glycol (NPG) as dihydric alcohol, and decanoic
acid (n-C₁₀) as monocarboxylic acid. Example 17 shows a
complex ester of glutaric acid (Glut) as dicarboxylic

1 acid, neopentyl glycol (NPG) as dihydric alcohol, and
 isohexanoic acid (i-C₆) as monocarboxylic acid. These
 complex esters were found to be so excellent that they
 had a viscosity at 40°C of 54.5 to 56.6 cSt, a viscosity
 5 at 100°C of 7.3 to 8.6 cSt, and a lower critical
 solution temperature of -60°C. These results indicate
 that a complex ester having a suitable viscosity can be
 synthesized by determining properly the number of carbon
 atoms (C₂ to C₁₀) of a dicarboxylic acid as dibasic
 10 organic acid and the number of carbon atoms (C₅ to C₁₀)
 of a monocarboxylic acid as monobasic acid, and
 condensing the dicarboxylic acid, the monocarboxylic
 acid, and a polyhydric alcohol in a properly chosen
 molar ratio.

15 When these Examples are arranged, the esters
 can be represented as follows by general formulas:

Esters of neopentyl glycol:



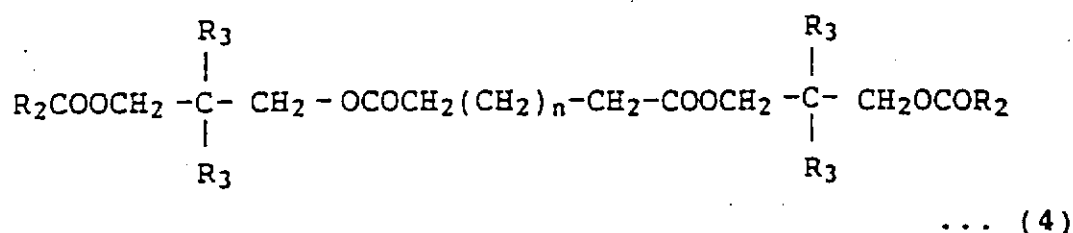
Esters of trimethylolalkane:



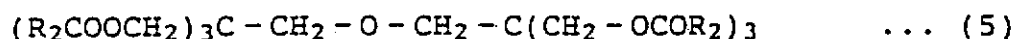
Esters of pentaerythritol:



Complex esters:



1 In addition, examples of easily obtainable esters are esters of dipentaerythritol:



5 In the above formulas (1) to (5), R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight-or branched-chain alkyl group having 5 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5.

10 The viscosity could be optionally determined by choosing the kinds of the polyhydric alcohol and the carboxylic acid(s).

 A moderate viscosity could easily be attained by blending a low-viscosity oil and a high-viscosity oil.

15 In the case of a refrigerating apparatus using a flon type refrigerant containing no chlorine, for example, flon 134a, a refrigerating machine oil capable of imparting fundamentally satisfactory performance characteristics and reliability to a compressor and the refrigerating apparatus can be obtained by selecting an oil having a lower critical solution temperature of 0°C or lower (the first target value) or an oil having a

20

- 1 lower critical solution temperature of -30°C or lower
(the second target value) both of which have a viscosity
at 40°C of 2 to 70 cSt, preferably 5 to 32 cSt and a
viscosity at 100°C of 1 to 9 cSt, preferably 2 to 6 cSt,
5 from the hindered esters and the complex esters which
contain two or more ester linkages in the molecule.

It was confirmed that these ester type
refrigerating machine oils have a good miscibility not
only with flon 134a but also with all flon type
10 refrigerant gases containing no chlorine, for example,
flon 152a (difluoroethane CH_3CHF_2). The refrigerating
machine oils were effective in imparting high
performance characteristics and a high reliability to a
refrigerating apparatus.

- 15 In addition, it was confirmed that since these
ester oils according to the present invention are highly
soluble also in conventional chlorine-containing flon
type refrigerants (chlorofluorohydrocarbon type
refrigerants) such as flon 12 and flon 22, they are
20 effective also when used in part in admixture with these
refrigerants.

However, since the conventional chlorine-
containing flon type refrigerants are included in the
list of compounds under regulation in use because of the
25 problem of environmental disruption, it is preferable to
adjust the proportion of the refrigerants to 50% or less
and that of the ester oil according to the present
invention to 50% or more.

1 Next, an example of refrigerating apparatus
for achieving the second object of the present invention
is given below.

Example 18

5 The rotary compressor shown in Fig. 7 which
was a refrigerant compressor was incorporated into a
refrigerating apparatus having the constitution shown in
Fig. 9. At a compressor temperature of 100°C and a
discharged gas pressure of 9.5 to 10 kgf/cm²G which were
10 conditions of examining the reliability of a refrige-
rator, a relationship between the viscosity of a
refrigerating oil stored in the compressor and the
coefficient of performance (COP), i.e., the ratio of the
refrigerating capacity of the compressor to an input,
15 was measured by using some of the ester oils with a
typical viscosity grade exemplified in Table 1. The
results obtained are shown in Fig. 3.

Fig. 3 shows a relationship between the actual
viscosity of each refrigerating machine oil and the
20 coefficient of performance (COP) which was determined
for the ester oils according to the present invention
having a viscosity at 40°C of 5 to 56 cSt and
conventional examples, i.e., a polyalkylene glycol and
an alkylbenzene oil (SUNISO Z-300A) used in combination
25 with flon 12. In Fig. 3, the axis of abscissa refers to
the actual viscosity of each refrigerating machine oil
stored in the rotary compressor, and the axis of

1 ordinate to the coefficient of performance (expressed in
terms of a relative value) of the compressor.

According to Fig. 3, when refrigerating
machine oils are compared in the coefficient of
5 performance by taking the coefficient of performance
attained by the conventional combination of flon 12 and
Z-300A (an alkylbenzene oil) having a viscosity at 40°C
of 56 cSt, as 1.0, the coefficient of performance
attained for the combination of the polyalkylene glycol
10 (PAG56) of Conventional Example 3 and flon 134a is as
small as 0.859, indicating that the energy efficiency is
lowered by about 14%.

On the other hand, the complex ester according
to the present invention with a viscosity at 40°C of
15 56.6 cSt of Example 17 gave a satisfactory coefficient
of performance of 0.906. It can be speculated that this
result is attributable to a reducing effect on friction
loss caused on the basis of the journal bearing theory
represented by the theory of the formula (9), a reducing
20 effect on oil-agitating power, a heat-dissipating
effect, etc. which are brought about because the
viscosity of the refrigerating machine oil which
contains flon 134a dissolved therein becomes as low as
4.35 cSt under the same operation conditions.

25 When the ester oils according to the present
invention which had a still lower viscosity of 5 to 32
cSt (at 40°C) were compared in the coefficient of

1 performance under the same conditions, the ester oil
with a viscosity of 32.6 cSt (at 40°C) of Example 14,
the ester oil with a viscosity of 14.9 cSt (at 40°C) of
Example 5 and the ester oil with a viscosity of 14.9 cSt
5 (at 40°C) of Example 10 gave coefficient values of
0.926, 0.966 and 0.973, respectively. Thus, the
coefficient of performance was increased in that order.
On the other hand, in the case of the ester oil with a
viscosity of 5.5 cSt (at 40°C) of Example 4, the
10 coefficient of performance was 0.953, namely, it showed
a tendency to be decreased a little.

From these results, it can be seen that an
ideal ester oil suitable for the rotary compressor is an
ester oil which has a viscosity at 40°C in the range of
15 5 to 32 cSt (exactly, 5.5 to 32.6 cSt), i.e., a range
around the most suitable value of 14.9 cSt, and contains
two or more ester linkages in the molecule, as described
above.

Example 19

20 Flon 134a and each of the refrigerating
machine oils according to the present invention
exemplified in Table 1 were used in a low-pressure
vessel type reciprocating compressor, and the compressor
was incorporated into a refrigerator, i.e., a
25 refrigerating apparatus. The refrigerator was then
subjected to a high-temperature reliability test

1 (pressure in case 1.6 kg/cm² abs, case temperature 85°C,
100 V, 50 Hz).

Fig. 4 shows the test results. In this graph,
the axis of abscissa refers to the measured value of
5 viscosity of the refrigerating machine oil, and the axis
of ordinate to the coefficient of performance (COP).
The graph was obtained by plotting the coefficient of
performance against the actual viscosity in actual
operation of each of the sample refrigerating machine
10 oils with a viscosity at 40°C of 5.5, 14.9, 22.0, 32.6
and 56.6 cSt, respectively, shown in Examples in Table
1. The coefficient of performance is in linear relation
with the actual viscosity.

From the results shown in Fig. 4, it can be
15 seen that the lower the viscosity of the refrigerating
machine oil, the larger the coefficient of performance
of the low-pressure vessel type reciprocating
compressor. The refrigerating machine oils having an
actual viscosity of 2 to 4.2 cSt and a viscosity at 40°C
20 of 5.5 to 14.9 cSt can be said to be excellent. When
the actual viscosity is less than 2 cSt, a decrease of
the coefficient of performance and a lowering of the
reliability of bearings tend to be caused because in the
case of using a conventional material such as cast iron
25 or an iron-based sintered material for producing the
sliding parts of the compressor, the precision of
finishing the surfaces of the sliding parts is limited,
and therefore at too low an actual viscosity, the

- 1 lubrication on the surfaces gets into the so-called
boundary lubrication region in which the contact between
metal surfaces occurs.

Example 20

- 5 The lubrication in a refrigerating machine and
a refrigerant compressor for achieving the third object
of the present invention is explained below with
reference to the following example.

- For evaluating the lubrication, there were
10 carried out a FALEX test in which a seizing load was
measured in the air, and a high-pressure atmosphere
friction test in which a seizing load was measured in a
refrigerating machine oil containing 50% of flon 134a
dissolved therein. Fig. 5 is a graph showing the
15 correlation between the results of the two tests. The
seizing load is as follows. An increasing load was
applied to a rotating sample pin from both sides and a
load at which seizing was caused was expressed in pound
(lb).

- 20 In the present example, the ester oil of
trimethylolpropane (TMP) and isoheptanoic acid (i-C₇) of
Example 10 exemplified in Table 1 was employed as a
typical example of a refrigerating machine oil used in
the refrigerating apparatus of the present invention,
25 and there was determined a relationship between the kind
and amount of an extreme pressure agent added to the
ester oil and the lubricating characteristics. As to

1 materials for test pieces used for the evaluation of the
lubrication, the materials for the pin and a block were
standard materials, i.e., SNC-21 (nickel chrome steel)
according to the standard of JIS and SUM 41 (resul-
5 furized free-cutting steel) according to the standard of
JIS, respectively. On the other hand, in the high-
pressure atmosphere friction test, there was measured a
load at which seizing was caused by friction between
cylinders made of a material for shaft (eutectic
10 graphite cast iron) and a material for roller (eutectic
graphite cast iron tempered material), respectively,
which had given satisfactory results in rotary
compressors.

As shown in the case of sample No. 1 in Fig.
15 5, the ester oil (the oil of Example 10) containing no
extreme pressure agent gave a FALEX seizing load of 700
lb and a seizing load of as low as 90 kgf/cm² in a flon
134a atmosphere. On the other hand, in the case of
sample No. 2 and sample No. 3, the FALEX seizing load
20 was further increased by 400 lb to reach 1100 lb and the
seizing load in a flon 134a atmosphere was increased by
90 kg/cm² to reach 180 kg/cm², owing to addition of each
of the following extreme pressure agents. In the case
of sample No. 2, CHELEX H-10 (a trade name, mfd. by
25 SAKAI CHEMICAL INDUSTRY Co., Ltd.) which was an acidic
phosphoric acid containing an active OH group in the
molecule, was added in an amount of 1%. In the case of
sample No. 3, an ester compound of an alkylene glycol

1 and phosphoric acid (butylpolyoxypropylene phosphate
ester) was added in an amount of 1%.

That is, it was actually proved that the
phosphorus-containing compounds such as the acidic
5 phosphoric ester and the alkylene glycol phosphate ester
compound act effectively as extreme pressure agents for
preventing seizing, regardless of the presence of flon
134a.

Next, a FALEX test was carried out
10 continuously for a maximum time of 120 minutes while
keeping an applied load constant at 100 lb, and the
abrasion loss of a pin, i.e., an iron-based test piece,
was measured. The results obtained are shown in Fig. 6.
In the case of the oil of sample No. 4 which contained
15 no extreme pressure agent, the pin was worn in an amount
of 25 mg. On the other hand, in the case of both of the
oils containing each of the above-mentioned phosphorus-
containing compounds, the abrasion loss was as small as
0.4 mg as shown for sample No. 7 and sample No. 8,
20 namely, the abrasion loss could be reduced to one-fifth
or less. The amount of the phosphorus-containing
compound added is effective from about 0.05 wt% as shown
for sample No. 5. The effect of the compound is
increased with an increase of the amount. But when the
25 amount exceeds 10 wt%, the improving effect on the
lubrication hits the ceiling, so that the addition of
the compound becomes economically disadvantageous and
hence becomes unpractical.

1 The abrasion loss could be reduced by
increasing the viscosity of oil from 14.9 cSt (at 40°C)
of sample No. 4 to 56.6 cSt (40°C) of sample No. 6.

 From the facts described above, it was found
5 that the seizing load, abrasion resistance and lubrica-
tion of the iron-based sliding members could be greatly
improved by adding a phosphorus-containing compound such
as an acidic phosphoric ester, phosphoric ester,
alkylene glycol phosphate ester or the like as an
10 extreme pressure agent to the refrigerating machine oil
used in the present invention, in an amount of 0.05 to
10 wt%, or by adjusting the viscosity of the oil to a
high value instead of adding the extreme pressure agent.
The refrigerating machine oil which contains the extreme
15 pressure agent exhibits excellent performance character-
istics particularly in the presence of a flon type
refrigerant containing no chlorine, such as flon 134a.

Example 21

 An example for achieving the fourth object of
20 the present invention is described below. The behaviors
of electrical insulating materials used in the hermetic
motor of a compressor, in the presence of both flon 134a
and the refrigerating machine oil according to the
present invention were evaluated. The results obtained
25 are explained below with reference to Table 2 and
Table 3.

1 Flon 134a and refrigerating machine oils were
evaluated by observing the degree of deterioration of
characteristics of a magnet wire (an enameled wire) and
an insulating film material by a sealed tube test, for
5 preventing external influence.

(1) Insulating characteristics of a magnet wire (an
enameled wire)

As magnet wire test pieces, two kinds of test
pieces, i.e., 5% elongated products and twisted-pair
10 test pieces were subjected to a sealed tube test at
150°C for 40 days. An explanation is given below with
reference to the results shown in Table 2.

As a result of the sealed tube test carried
out for a combination of flon 134a and the polyalkylene
glycol listed as Conventional Example 3 in Table 1 which
15 is a refrigerating machine oil said to be suitable for
flon 134a, 5% elongated products of both the polyester
wire (PEW) of sample No. 9 and the ester imide wire
(EIW-R) of sample No. 10 in Table 2 were crazed, and the
20 retention of the dielectric breakdown voltage of
twisted-pair test pieces of these two kinds of wires was
greatly lowered to 30 to 32%.

On the other hand, the same evaluation as
above was carried out for a combination of flon 134a and
25 the composite ester oil composed of glutaric acid
(Glut), neopentyl glycol (NPG) and isohexanoic acid
(i-C₆) which is a refrigerating machine oil used in the
present invention and is exemplified in Table 1.

1 Consequently, the same polyester wire (whose glass
transition temperature is shown in Table 2) and
polyester imide wire as the wires which were described
above and deteriorated as conventional examples sample
5 No. 9 and sample No 10, showed no abnormality in
appearance, as shown for sample No. 11 and sample No.
12. The retention of the dielectric breakdown voltage
of these samples was as high as 95% or more, indicating
that the degree of deterioration of the magnet wires was
10 very low. The reason is as follows. The refrigerating
machine oil according to the present invention has a low
water content in the early stages and a high thermal
stability, and hardly produce an acidic substance
capable of accelerating hydrolysis, and these
15 characteristics bring about the improving effects.

Sample No. 13 was obtained by coating the
ester imide wire of sample No. 12 with a polyimide layer
to form a composite. Sample No. 14 was a wire coated
with a polyamide-imide alone (AIW). Both samples had
20 satisfactory characteristics. It was found that such a
magnet wire obtained by thus coating a layer with a high
glass transition temperature on a layer with a low glass
transition temperature contributes to the improvement of
the reliability of a compressor because the upper coat-
25 ing layer is effective as protective layer against an
attack of flon 134a and the refrigerating machine oil.

(2) Insulating characteristics of insulating films

As a sealed tube test on insulating films for

1 motor, an insulating strength test at 130°C for 40 days
was carried out, whereby the films were evaluated with
respect to the appearance and the retention of tensile
strength. The results obtained are shown in Table 3.

5 When a polyester film (Lumilar X₁₀, a trade
name, mfd. by Toray Industries, Inc.) conventionally
used in the hermetic motor of a compressor was used in
the conventional polyalkylene glycol oil shown for
sample No. 15, its oligomer component was precipitated
10 in the oil and the retention of tensile strength was
83%.

On the other hand, in a combination of the
complex ester oil of Example 17 according to the present
invention and flon 134a, no oligomer was precipitated
15 and the retention of tensile strength was as high as 89%
or more in the case of all of Lumilar X₁₀ of sample No.
16, PA-61M (a trade name, mfd. by Hitachi Kasei Co.,
Ltd.), i.e., the polyamide-imide-coated polyester of
sample No. 17, the polyphenylene sulfide (PPS) film of
20 sample No. 18, and the polyether ether ketone (PEEK)
film of sample No. 19. Thus, it was found that the
electrical insulating system of a compressor using flon
134a can be markedly improved in reliability.

That is, it was found that the insulation
25 system of a hermetic motor can be completed by properly
selecting a film from the group consisting of polyester
films, polyamide-imide-coated polyester films, PPS films
and PEEK films which have a glass transition temperature

1 of 65°C or higher, and using the same in the presence of
both flon 134a and the refrigerating machine oil con-
taining two or more ester groups in the molecule accord-
ing to the present invention. It was found that when
5 the insulation system is thus completed, there can be
solved the problem of precipitation of an oligomer
component (the problem described above for the oil of
Conventional Example 3 shown for sample No. 15), the
problems in the performance characteristics of a
10 compressor and a refrigerating apparatus which are
caused by the lowering of the film strength, and the
practical problems in the long-term reliability.

Table 2

Sample No.	Insulation-coated winding wire	Glass transition temperature (°C)	Results of evaluating performance characteristics with respect to resistance to an oil and flon 134a		
			Oil tested	Appearance change (Note 1)	Retention of dielectric breakdown voltage (Note 2)
9	PEW (Polyester)	120-140	Conventional Example 3	Clazed	30
10	EIW-R (Polyester imide)	190-210	"	"	32
11	PEW (Polyester)	120-140	Example 17	No abnormality	95
12	EIW-R	190-210	"	No abnormality	98
13	RFW-V (Upper layer polyamide/lower layer polyester imide)	Lower layer 190-210 Upper layer 250-310	"	No abnormality	98
14	AIW (Polyamide imide)	250-310	"	No abnormality	98

Sealed tube test: 150°C x 40 days

Note 1: 5% elongated wire

Note 2: A relative value obtained for a twisted pair test piece by dividing a value after the test by a value before the test (taken as 100).

Table 3

Sample No.	Insulating film	Glass transition temperature (°C)	Results of evaluating performance characteristics with respect to resistance to an oil and flon 134a		
			Oil tested	Appearance change	Retention of tensile strength (Note 1)
15	Lumilar x 10 (polyester)	65	Conventional Example 3	Oligomer was precipitated	89
16	Lumilar x 10	65	Example 17	None	89
17	PA-61M (Polyamide-imide-coated polyester)	65	"	None	90
18	PPS (Polyphenylene sulfide)	85	"	None	95
19	PEEK (Polyether ether ketone)	143	"	None	98

Sealed tube test: 130°C x 40 days

Note 1: A relative value obtained by dividing a value after the test by a value before the test (taken as 100).

1 Example 22

An example for achieving the fifth object of the present invention is described below.

It is known that particularly in refrigerating
5 apparatus using a heat exchanger at 0°C or lower, the control of water content in the refrigerating apparatus has an important influence on the cooling capability and the assurance of the quality of an electrical insulating material. Therefore, the establishment of a technique
10 for removing water is indispensable for the system of the refrigerating apparatus.

In a refrigeration cycle composed as shown in Fig. 9, flon 134a gas discharged from a compressor 40 is condensed into a liquid refrigerant by heat dispersion
15 in a condenser 41. This high-temperature, high-pressure liquid refrigerant is transformed into low-temperature, low-pressure wet vapor by an expansion mechanism 42 and sent to an evaporator 43. In this series of steps, the water in the refrigerating apparatus is adsorbed and
20 removed by a drying agent represented by synthetic zeolite in a dryer 45 provided between the condenser 41 and the expansion mechanism 42. It is important to choose the kind of the drying agent in consideration of a use environment in which the refrigerating machine oil
25 according to the present invention and flon 134a coexist. The suitability of the drying agent is explained below with reference to Examples shown in Table 4.

1 Drying agents tested are synthetic zeolites
having trade names of Molecular Sieves all manufactured
by UNION SHOWA K.K. These synthetic zeolites are
classified according to the adsorption capacity (%) at
5 25°C and at a carbon dioxide gas partial pressure of 250
mmHg which is used as an indication of the distribution
of the diameter of pores for adsorption.

 As to the suitability of the synthetic
zeolites for flon 134a and the refrigerating machine oil
10 according to the present invention, the results of a
sealed tube test shown in Table 4 are explained below.

 It was found that the synthetic zeollite
composed mainly of sodium aluminate and sodium silicate
shown as sample No. 20 (a conventional example; trade
15 name 4ANRG) has a fluorine ion adsorption of as large as
1.05%, so that problems due to the lowering of the
strength or formation into powder are caused by the
reaction of the synthetic zeolite. Sample No. 21 (a
comparative example; trade name 4AXH-6) and sample No.
20 22 (a comparative example; trade name XH-7) which are
composed mainly of sodium aluminate, potassium
aluminate, sodium silicate and potassium silicate have a
carbon dioxide gas adsorption capacity of 4.5 to 1.5%
and a reduced fluorine ion adsorption of 0.24%. But,
25 they cannot put into practical use because their
fluorine ion adsorption is still too large.

 Sample No. 23 (an example; trade name XH-600)
and sample No. 24 (an example; trade name XH-9) which

1 consist of a synthetic zeolite composed mainly of
potassium aluminate, sodium aluminate, potassium
silicate and sodium silicate have a carbon dioxide gas
adsorption capacity of 0.2% and a greatly reduced
5 fluorine adsorption of 0.04%. Since a fluorine ion
adsorption which permits practical use is 0.1% or less,
the value of 0.2% indicates that these samples are
sufficiently usable.

The deterioration of characteristics of a
10 synthetic zeolite itself by the adsorption of molecules
of flon 134a is dependent on the distribution of pore
diameter of the synthetic zeolite. It has been
confirmed that for adjusting the fluorine ion adsorption
to 0.1% or less, the employment of a synthetic zeolite
15 whose carbon dioxide gas adsorption capacity has been
adjusted to 1.0% or less is sufficient. That is, the
following was found. When a synthetic zeolite composed
of alkali metal silicates and alkali metal aluminates
whose carbon dioxide gas adsorption at 25°C and at a
20 carbon dioxide gas partial pressure of 250 mmHg has been
adjusted to 1.0% or less, for example, Molecular Sieves
XH-600 or XH-9 (trade names, mfd. by UNION SHOWA K.K.),
is used as a drying agent in a refrigerating apparatus
using flon 134a and the refrigerating machine oil
25 containing two or more ester linkages in the molecule
according to the present invention, which are placed
together, only water can be effectively removed and
fluorine ion adsorption hardly produce influences such

- 1 as formation into powder or a lowering of the strength of beads, and therefore such a drying agent is very excellent for practical purposes.

Table 4

Sample No.	Drying agent Name of sample	CO ₂ adsorption capacity (%) CO ₂ partial pressure 250 mmHg (25°C)	Sealed tube test*	
			Decomposition rate of refrigerant (%)	Fluorine ion adsorption (%)
20	4ANRG	12.0	0.028	1.05
21	4AXH-6	4.5	0.032	0.24
22	XH-7	1.5	0.035	0.24
23	XH-600	0.2	0.042	0.04
24	XH-9	0.2	0.04	0.04

Sealed tube test: 150°C, 7 days

1 The carbon dioxide gas adsorption capacity at
25°C and at a carbon dioxide gas partial pressure of 250
mmHg should be 1.0% or less, and it is preferably as
small as possible. When it is zero %, the drying agent
5 absorbs water alone selectively but not fluorine ions,
so that the drying agent becomes ideal molecular sieves.
The present invention is constituted as explained above
and hence has the following effects.

(1) By using the refrigerating machine oil
10 described below, in a refrigerating apparatus comprising
a compressor, condenser, dryer, expansion mechanism and
evaporator and using a flon type refrigerant containing
no chlorine and having a critical temperature of 40°C or
higher which is represented by flon 134a, the perform-
15 ance characteristics and reliability of the compressor
and the refrigerating apparatus can be markedly improved
because the refrigerating machine oil and the refrige-
rant are highly miscible with each other without their
separation into two layers in the whole temperature
20 range where the compressor and the refrigerating
apparatus are used, and hence a lubricating oil film on
the shaft and bearings of the compressor and the
refrigerant-heat-transferring capability of a heat
exchanger are assured. The refrigerating machine oil
25 comprises as base oil an ester oil according to the
present invention which contains two or more ester
linkages in the molecule and has a refrigerating machine
oil viscosity at 40°C of 2 to 70 cSt, preferably 5 to 32

1 cSt and a refrigerating machine oil viscosity at 100°C
of 1 to 9 cSt, preferably 2 to 6 cSt. The refrigerating
machine oil has a lower critical solution temperature of
0°C or lower or -30°C or lower, and is used in the first
5 target, i.e., a moderate-temperature refrigerating
apparatus such as a dehumidifier, or the second target,
i.e., a low-temperature refrigerating apparatus such as
a refrigerator, respectively.

(2) Moreover, the performance characteristics and
10 the reliability can be improved by an improving effect
on the lubrication in the sliding portions of bearings
of the refrigerant compressor which is obtained by
adding a phosphoric ester type extreme pressure agent
having OH groups in the molecule and other additives
15 such as an abrasion-preventing agent, acid-capturing
agent, antioxidant, defoaming agent, etc. to the above-
mentioned refrigerating machine oil.

(3) By simultaneous use of the refrigerating
machine oil containing two or more ester linkages in the
20 molecule according to the present invention described
below and flon 134a, the so-called performance characte-
ristics can be improved, namely, the coefficient of
performance indicating the performance characteristics
of the compressor can be increased, the power consump-
25 tion of the refrigerating apparatus using the compressor
can be reduced, and the refrigerating capacity can be
increased. In a high-pressure vessel type rotary
compressor, the refrigerating machine oil is one which

1 has a viscosity at 40°C of 2 to 70 cSt, preferably 5 to
32. In a low-pressure vessel type reciprocating
compressor, the refrigerating machine oil is one which
has a viscosity at 40°C of 2 to 70 cSt, preferably 5 to
5 15 cSt.

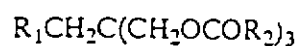
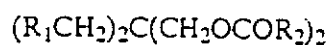
(4) The electrical insulating performance and
long-term reliability of the refrigerating apparatus can
be markedly improved by using an insulation-coated
winding wire with a glass transition temperature of
10 120°C or higher and an insulating film with a glass
transition temperature of 70°C or higher as insulating
materials for a motor, and a refrigerating machine oil
comprising as base oil the ester oil according to the
present invention, in a refrigerant compressor using a
15 flon type refrigerant containing no chlorine represented
by flon 134a.

(5) By using a synthetic zeolite composed of
alkali metal silicates and alkali metal aluminates
having a carbon dioxide gas adsorption capacity at 25°C
20 and at a carbon dioxide gas partial pressure of 250 mmHg
of 1.0% or less, in the dryer constituting the
refrigerating apparatus, water in the refrigeration
cycle can be efficiently separated and adsorbed, and
there can be prevented troubles caused by formation of
25 the drying agent into powder by deterioration of the
drying agent itself, namely, the problems caused by
clogging of a piping for refrigerant with the drying
agent and abnormal abrasion due to intrusion of the

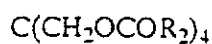
- 1 drying agent into the sliding portions of the compressor. Therefore, the employment of the synthetic zeolite has a marked improving effect on the performance characteristics and the long-term reliability.
- 5 (6) The refrigerating apparatus having the constitution explained above can reduce the ozone depletion potential (ODP) and the global warming potential (GWP) which are in question in the terrestrial environment to zero and 0.3 or less, respectively,
- 10 relative to values attained when a conventional chlorine-containing flon type refrigerant gas (e.g. flon 12) is used.

CLAIMS

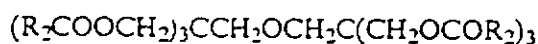
1. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant comprising a chlorine-free fluorocarbon and/or hydrofluorocarbon and having a critical temperature of 40° C. or higher, and said refrigerating machine oil consisting essentially of an ester oil obtained from a single alcohol and an acid component comprising one or more fatty acids having six to thirteen carbon atoms, wherein said ester oil has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the following general formulae (1) to (5):



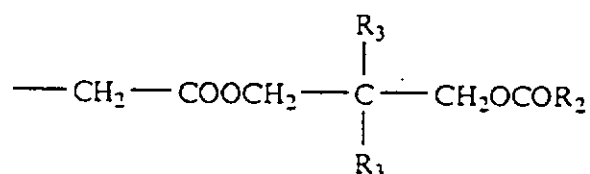
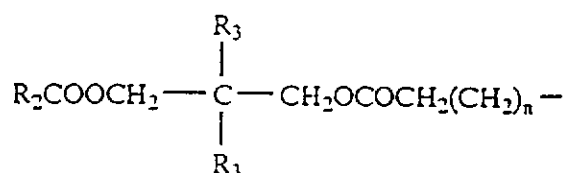
(3)



(4)



(5)



wherein R_1 is an alkyl group having 1 to 3 carbon atoms, R_2 is a straight or branched chain alkyl group having 5 to 12 carbon atoms, provided that in the formula (5) R_2 is a straight or branched chain alkyl group having 9 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

2. A refrigerant compressor according to claim 1, wherein said enamel coating comprises at least one insulating layer selected from the group consisting of layers of polyester imides, polyamides and polyamide-imides.

3. A refrigerant compressor according to claim 1, wherein the insulating film comprises a crystalline plastics film having a glass transition temperature of 50° C. or higher.

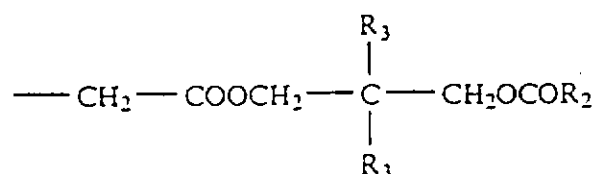
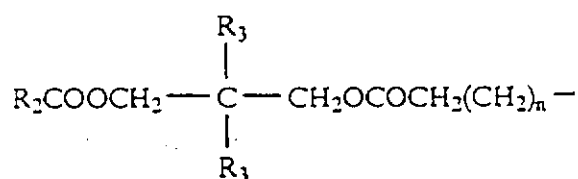
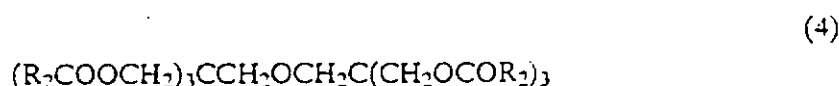
4. A refrigerant compressor according to claim 1, wherein said insulating film comprises at least film made of a material selected from the group consisting of polyethylene terephthalates, polybutylene terephthalates, polyphenylene sulfides, polyether ether ketones, polyethylene naphthalates, polyamide-imides, and polyimides.

5. A refrigerant compressor according to claim 1, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the general formulae (1) to (4).

6. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant comprising a chlorine-free fluorocarbon and/or hydrofluorocarbon and having a critical temperature of 40° C. or higher, and said refrigerating machine oil consisting essentially of an ester oil obtained from a single alcohol and an acid component comprising one or more fatty acids having six to thirteen carbon atoms, wherein said ester oil has a

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viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the following general formulae (1) to (5):



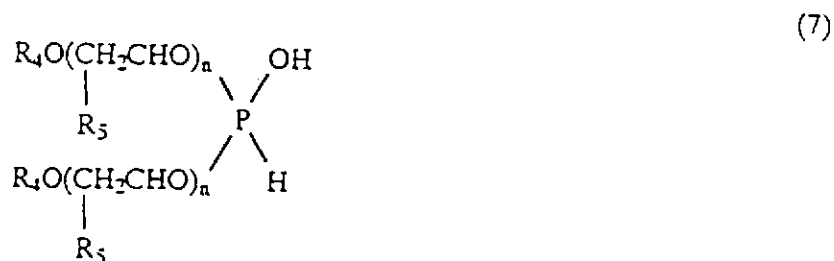
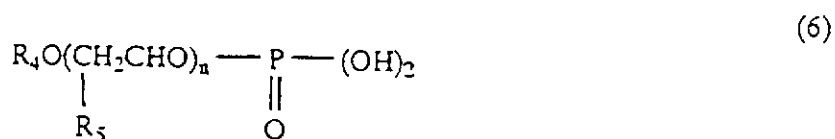
wherein R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight or branched chain alkyl group having 5 to 12 carbon atoms, provided that in the formula (5) R_2 is a straight or branched chain alkyl group having 9 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

7. A refrigerant compressor according to claim 1 or 6, wherein said chlorine-free hydrocarbon and/or hydrofluorocarbon is flon 134a.

8. A refrigerant compressor according to claim 1 or 6, wherein said refrigerant further comprises an extreme pressure agent.

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9. A refrigerant compressor according to claim 8, wherein the extreme pressure agent is at least one member selected from the group consisting of alkylpolyoxyalkylene phosphate esters represented by the following formulas (6) and (7):



wherein R_4 is an alkyl group having 1 to 8 carbon atoms, and R_5 is H or an alkyl group having 1 to 3 carbon atoms, and n is a value so as to make the molecular weight 400 to 700, and is contained in said refrigerant in an amount of 0.05 to 10 wt %.

10. A refrigerant compressor according to claim 8, wherein the extreme pressure agent is a dialkyl phosphate ester represented by the formula:



wherein R_6 is an alkyl group having 8 to 16 carbon atoms, and is contained in said refrigerant in an amount of 0.05 to 10 wt %.

11. A refrigerant compressor according to claim 8, wherein said refrigerant further comprises at least one member selected from the group consisting of acid-capturing agents, antioxidants and defoaming agents.

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12. A refrigerant compressor according to claim 6, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the general formulae (1) to (4).

13. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant comprising a chlorine-free fluorocarbon and/or hydrofluorocarbon and having a critical temperature of 40° C. or higher, and said refrigerating machine oil consisting essentially of an ester oil obtained from a single alcohol and single acid, the single acid being a fatty acid having six to eleven carbon atoms, said refrigerating machine oil having a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

14. A refrigerant compressor according to claim 13, wherein said single acid is a monobasic acid.

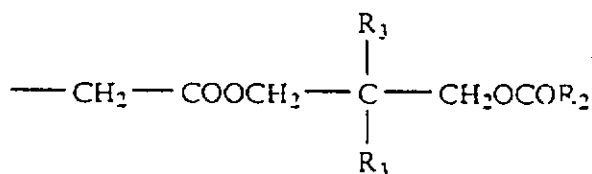
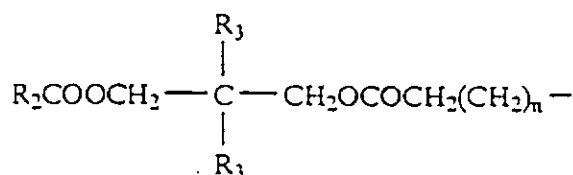
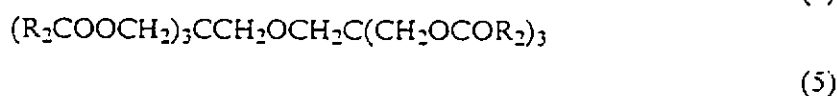
15. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant comprising a chlorine-free fluorocarbon and/or hydrofluorocarbon and having a critical temperature of 40° C. or higher, and said refrigerating machine oil consisting essentially of an ester oil obtained from a single alcohol and a single acid, the single acid being an acid having six to eleven

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carbon atoms, the refrigerating machine oil having a viscosity of 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

16. A refrigerant compressor according to claim 15, wherein said single acid is a monobasic acid.

17. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids, wherein the ester oil has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils which are represented by the following general formulae (1) to (5):



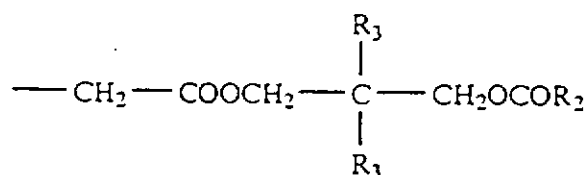
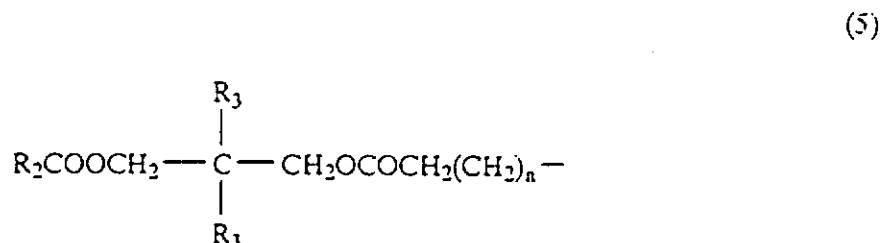
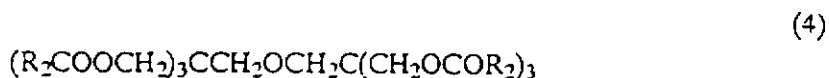
wherein R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight or branched chain alkyl group having 5 to 12 carbon atoms, provided that in the formula (5) R_2 is a straight or branched chain alkyl group having 9 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5, and said winding wire of the stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

18. A refrigerant compressor according to claim 17, wherein said enamel coating comprises at least one insulating layer selected from the group consisting of layers of polyester imides, polyamides and polyamide-imides.

19. A refrigerant compressor according to claim 17, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the general formulae (1) to (4).

20. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant being composed mainly of fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids wherein the ester oil has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils which are represented by the following general formulae (1) to (5):

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wherein R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight or branched chain alkyl group having 5 to 12 carbon atoms, provided that in the formula (5) R_2 is a straight or branched chain alkyl group having 9 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5, and said winding wire of the stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

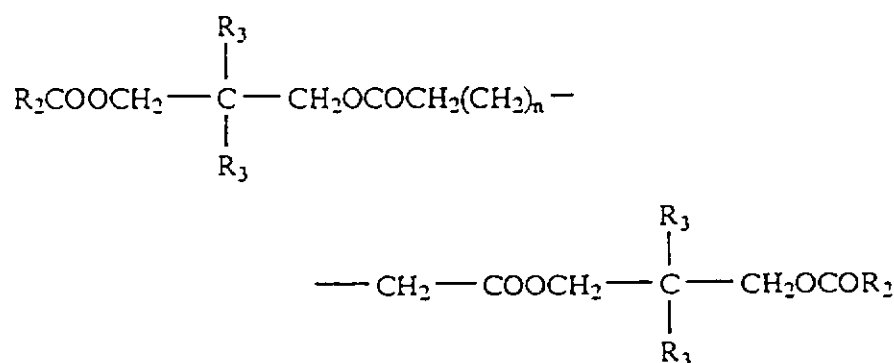
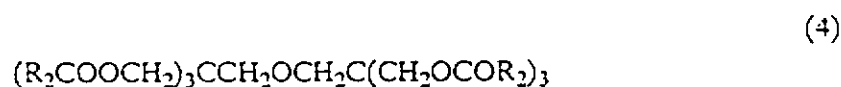
21. A refrigerant compressor according to claim 20, wherein said enamel coating comprises at least one insulating layer selected from the group consisting of layers of polyester imides, polyamides and polyamide-imides.

22. A refrigerant compressor according to claim 20, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the general formulae (1) to (4).

23. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a

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stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids wherein the ester oil has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils which are represented by the following general formulae (1) to (5):



wherein R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight or branched chain alkyl group having 5 to 12 carbon atoms, provided that in the formula (5) R_2 is a straight or branched chain alkyl group having 9 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon

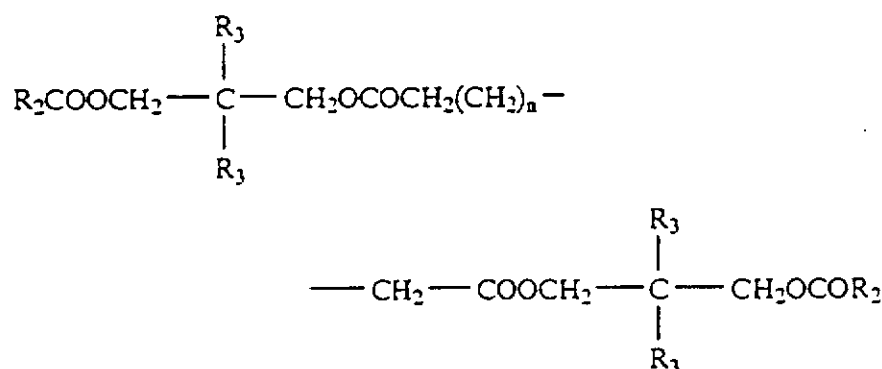
atoms, and n is an integer of 0 to 5, and said insulating film comprises a crystalline plastics film having a glass transition temperature of 50°C . or higher, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120°C . or higher.

24. A refrigerant compressor according to claim 23, wherein said insulating film comprises at least film made of a material selected from the group consisting of polyethylene terephthalates, polybutylene terephthalates, polyphenylene sulfides, polyether ether ketones, polyethylene naphthalates, polyamide-imides, and polyimides.

25. A refrigerant compressor according to claim 23, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils represented by the general formulae (1) to (4).

26. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant being composed mainly of fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40°C . or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids wherein the ester oil has a viscosity at 40°C . of 2 to 70 cSt and a viscosity at 100°C . of 1 to 9 cSt, wherein said ester oil comprises at least one member selected from the group consisting of the ester oils which are represented by the following general formulae (1) to (5):

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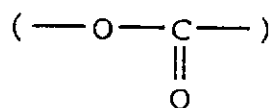


wherein R_1 is H or an alkyl group having 1 to 3 carbon atoms, R_2 is a straight or branched chain alkyl group having 5 to 12 carbon atoms, provided that in the formula (5) R_2 is a straight or branched chain alkyl group having 9 to 12 carbon atoms, R_3 is an alkyl group having 1 to 3 carbon atoms, and n is an integer of 0 to 5, and said insulating film comprises a crystalline plastics film having a glass transition temperature of 50° C. or higher, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C or higher.

27. A refrigerant compressor according to claim 26, wherein said insulating film comprises at least film made of a material selected from the group consisting of polyethylene terephthalates, polyethylene terephthalates, polyphenylene sulfides, polyether ether ketones, polyethylene naphthalates, polyamide-imides, and polyimides.

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28. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids having six to thirteen carbon atoms which ester oil contains at least two ester linkages

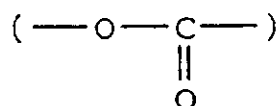


in the molecule and has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, said closed-vessel accommodating a motor composed of a rotor and a stator, a rotating shaft, and a compressor section connected to the motor through the rotating shaft, wherein a winding wire of the stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

29. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed-vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base

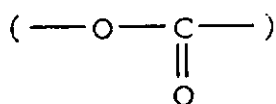
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oil an ester oil of one or more fatty acids having six to thirteen carbon atoms which ester oil contains at least two ester linkages



in the molecule and has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein an insulating film of the motor comprises a crystalline plastics film having a glass transition temperature of 50° C. or higher, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

30. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed-vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids having six to thirteen carbon atoms which ester oil contains at least two ester linkages

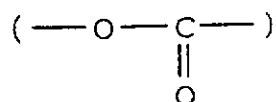


in the molecule and has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, said closed-vessel accommodating a motor composed of a rotor and a stator, a rotating shaft, and a compressor section connected to the motor through the rotating shaft, wherein a winding wire of

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the stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

31. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed-vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40° C. or higher, and said refrigerating machine oil comprising as base oil an ester oil of one or more fatty acids having six to thirteen carbon atoms which ester oil contains at least two ester linkages



in the molecule and has a viscosity at 40° C. of 2 to 70 cSt and a viscosity at 100° C. of 1 to 9 cSt, wherein an insulating film of the motor comprises a crystalline plastics film having a glass transition temperature of 50° C. or higher, and said winding wire of said stator comprises a core wire having an enamel coating having a glass transition temperature of 120° C. or higher.

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32. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40°C or higher, and said refrigerating machine oil comprising as base oil a hindered ester oil of one or more fatty acids which contains at least two ester linkages (-O-C-) in the molecule and has a



viscosity at 40°C of 2 to 70 cSt and a viscosity at 100°C of 1 to 9 cSt, and said winding wire of the stator comprising a core wire having an enamel coating having a glass transition temperature of 120°C or higher.

33. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a wiring wire and an insulating film, a rotating shaft fitted in the rotor, and a compression section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant being composed mainly of fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40°C or higher, and said refrigerating machine oil comprising as base oil a hindered ester oil of one or more fatty acids which contains at least two ester linkages (-O-C-) in the molecule and has a



viscosity at 40°C of 2 to 70 cSt and a viscosity at 100°C of 1 to 9 cSt, and said winding wire of the stator comprising a core wire having an enamel coating having a glass transition temperature of 120°C or higher.

34. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a high-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a winding wire and an insulating film, a rotating shaft fitted in the rotor, and a compressor section connected to the motor through the rotating shaft, and in which a high-pressure refrigerant gas discharged from the compressor section resides, said refrigerant being composed mainly of a fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40°C or higher, and said refrigerating machine oil comprising as base oil a hindered ester oil of one or more fatty acids which contains at least two ester linkages $(-O-\overset{\underset{\text{O}}{\parallel}}{\text{C}}-)$ in the molecule and has a

viscosity at 40°C of 2 to 70 cSt and a viscosity at 100°C of 1 to 9 cSt, and said insulating film comprising a crystalline plastics film having a glass transition temperature of 50°C or higher, and said winding wire of the stator comprising a core wire having an enamel coating having a glass transition temperature of 120°C or higher.

35. A refrigerant compressor used in a refrigeration cycle wherein the refrigerant compressor comprises a low-pressure closed vessel stored with a refrigerating machine oil which accommodates a motor composed of a rotor and a stator having a wiring wire and an insulating film, a rotating shaft fitted in the rotor, and a compression section connected to the motor through the rotating shaft, and from which a high-pressure refrigerant gas discharged from the compressor section is directly exhausted, said refrigerant

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being composed mainly of fluorocarbon refrigerant containing no chlorine and having a critical temperature of 40°C or higher, and said refrigerating machine oil comprising as base oil a hindered ester oil of one or more fatty acids which contains at least two ester linkages (-O-C-) in the molecule and has a



viscosity at 40°C of 2 to 70 cSt and a viscosity at 100°C of 1 to 9 cSt, and said insulating film comprising a crystalline plastics film having a glass transition temperature of 50°C or higher, and said winding wire of the stator comprising a core wire having an enamel coating having a glass transition temperature of 120°C or higher.