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WORKING FLUIDS IN REFRIGERATION APPARATUS

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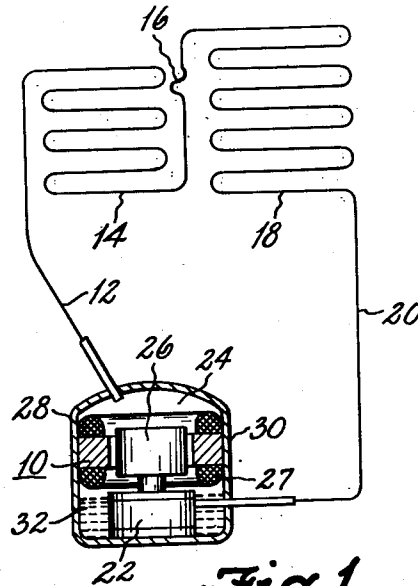
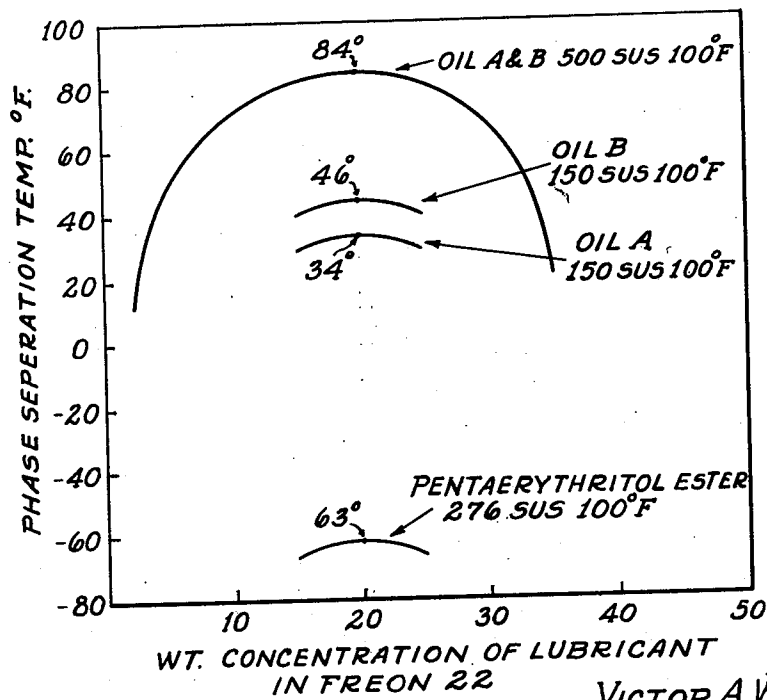


Fig. 2.

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WORKING FLUIDS IN REFRIGERATION APPARATUS

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6 Claims. (Cl. 62-117.7)

This invention relates to refrigeration apparatus and in particular to refrigeration apparatus of the sealed compressor type wherein the lubricant which lubricates the moving parts of the refrigeration apparatus comes into direct contact with the refrigerant, and relatively small portions of which are carried with the refrigerant throughout the refrigeration cycle.

It is an object of this invention to provide a working fluid for a refrigeration apparatus which includes a refrigerant capable of being in liquid and gaseous phases within the operating temperature range of the refrigeration apparatus and a wax-free lubricant which is completely soluble in the refrigerant and is highly thermally stable within the refrigeration apparatus in the range of the operating temperatures thereof.

It is another object of this invention to provide a working fluid for a refrigeration apparatus which includes a lubricant comprising an organic acid ester of pentaerythritol and a refrigerant wherein the refrigerant is completely miscible with the ester and is capable of existing in liquid and gaseous phases within the operating temperature range of the refrigeration apparatus.

It is a further object of this invention to provide a working fluid for a refrigeration apparatus which includes a fluoro halo substituted aliphatic hydrocarbon refrigerant capable of being in liquid and gaseous phases within the operating temperature range of the refrigeration apparatus and a lubricant comprising an organic acid ester of pentaerythritol.

It is yet another object of this invention to provide a refrigeration apparatus which includes a motor compressor, a condenser, an expansion device and evaporator in fluid flow relationship and a working fluid which includes a fluoro halo substituted aliphatic hydrocarbon refrigerant and a lubricant comprising an organic acid ester of pentaerythritol.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are clearly shown.

In the drawings:

Figure 1 is a diagrammatic representation of one type of refrigeration apparatus embodying this invention.

Figure 2 is a graph comparing "Floc" points or phase separation of various refrigeration lubricants and a pentaerythritol ester at various concentrations in Freon 22.

A refrigeration apparatus embodying this invention is diagrammatically indicated in Figure 1. A motor compressor unit 10 discharges compressed refrigerant, carrying some lubricant, through a pipe 12, to a condenser 14. The condensed refrigerant and lubricant then passes to an expansion device such as a capillary tube 16 and then to an evaporator 18. The vaporized mixture of refrigerant and lubricant flow through suction line 20 to the compressor 22 of the motor compressor unit 10 wherein the vapor is compressed and discharged into dome 24 of the motor compressor unit. The compressed

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vapor is then discharged through pipe 12 for recirculation through the refrigeration apparatus. The compressor 22 is driven by an electric motor comprising a rotor 26 operatively connected to the compressor 22 by shaft 27 and a stator 28 secured to the containing member 30 of the motor compressor unit. The compressor 22 is preferably partially submerged in a body of lubricant 32 held in containing member 30 for lubricating the moving parts of the compressor. As above indicated, circulating refrigerant comes in direct contact with the lubricant in the motor compressor unit and carries small amounts of lubricant therewith throughout the refrigeration cycle. In operation, the temperature in the refrigeration apparatus may vary from about -100° F. at the end of the capillary tube or expansion device to about 400° F. at the compressor outlet.

Although the refrigeration apparatus described is of the high side type, i. e., the refrigerant enters containing member 30 directly at the compressor so that the fluid in dome 24 is under considerable pressure, it will be obvious that the present invention is also applicable to low side or other types of refrigeration apparatus.

The refrigerant used in the present invention preferably comprises a fluoro halo derivative of an aliphatic hydrocarbon of the character disclosed in the patent to Midgeley et al., Re. 19,265, reissued August 7, 1934, as, for example, trichlorofluoromethane (Freon 11), dichlorodifluoromethane (Freon 12) and particularly difluoromonochloromethane (Freon 22).

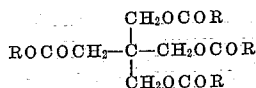
The lubricant which is associated with the refrigerant throughout the refrigeration cycle has presented serious problems to satisfactory refrigeration operation in connection with certain otherwise useful refrigerants.

Among the requirements of a satisfactory refrigeration lubricant which may be mixed with a refrigerant to constitute a working fluid in a refrigeration apparatus of the type described, is that the lubricant be completely soluble in the particular refrigerant used throughout the range of operating temperatures, and that the lubricant be substantially free of wax, so as to prevent the precipitation of wax or like substances with consequent blocking or restricting of the capillary tube and/or expansion valves at the low temperatures attained therein.

Various conventionally used mineral oils have been refined and dewaxed which have been effective in minimizing wax precipitation when used with certain refrigerants, such as Freon 12. However such oils are unsatisfactory to various degrees in this respect when used at very low temperatures with Freon 12 or with Freon 22 at any temperature in which such oils are only partially soluble.

Other important requirements of a refrigerant lubricant are that the lubricant have high chemical and thermal stability in the presence of the refrigerant used, the metals, motor insulation winding and other materials with which the lubricant comes into contact and is sealed.

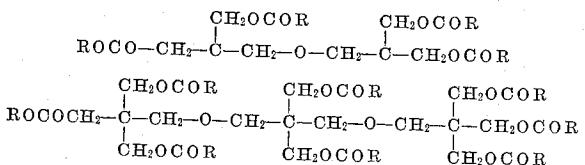
It has been found that a combination of properties which to a high degree meet the requirements of a refrigeration system of the type described exist in a class of compounds which may be broadly described as organic acid esters of pentaerythritol. More specifically the lubricant of the present invention may include esterified monomolecular pentaerythritol described by the following structural formula:



wherein the R represents a saturated aliphatic straight or branched hydrocarbon chain such as alkyl radicals, and alkyl radicals having substituted aromatic radicals, aromatic groups such as aryl radicals and aryl radicals

having substituted aliphatic radicals, the R groups having carbon atoms in the range of about 2 to 20 and preferably an average of from 6 to 10. The term alkyl as hereinafter used includes both unsubstituted and aromatic radical substituted alkyl radicals and the term aryl includes both unsubstituted and alkyl radical substituted aryl radicals.

The lubricant may also consist of or include the esterified polyethers diapentaerythritol and tripentaerythritol generally described by the following structural formulas:



wherein the R represents hydrocarbon groups as described above.

The pentaerythritol compounds may be produced by reacting acetaldehyde with formaldehyde in an alkaline medium under rigorously controlled conditions as is well described in chemical literature. The esters of the present invention may be formed by reacting the pentaerythritol compounds with organic acids having the desired hydrocarbon structures. Thus acids such as n-butyric, n-valeric and caprylic may be used to produce straight chained aliphatic R groups and acids such as isobutyric acid may be used to produce branched chain R groups. Similarly aromatic acids such as benzoic acid and paratoluic acid may be used to produce aryl R groups and acids such as phenylacetic acid may be used to produce aromatic radical substituted alkyl R groups. The acids used to produce the present esters are those having no reactive groups other than the carboxyl and preferably those having a single carboxyl group. The R groups mentioned in each molecule of the above-mentioned formulas may each be a different radical selected from the classes of radicals above described and are preferably varied. Further the lubricant preferably contains a mixture of different esters of the type described above selected so as to have a viscosity range from 50 to 2000 seconds Saybolt (SUS) measured as 100° F., the exact viscosity being dependent on the operating characteristics and the particular refrigerant of the refrigeration apparatus. Although it is not a strict requirement that all of the hydroxyl groups of the pentaerythritol compounds be esterified as shown in the above formulas, the compounds are preferably fully esterified.

The superiority of the present lubricant for refrigeration systems of the type described may be demonstrated by comparing the lubricant with conventionally used refrigeration mineral oil lubricants. The solubility of refrigeration lubricants is generally measured by mixing various percentages of the oil and a refrigerant in a glass pressure apparatus and externally cooling the same until phase separation or "Floc" point is noted. The graph of Figure 2 shows the temperature of the phase separation plotted against various concentrations of the oil and Freon 22 for lubricants of various viscosities. The refrigerant used in the comparison is Freon 22 since solution of the oil in this refrigerant is more difficult than in other refrigerants.

The oil designated as "A" is a commercial refrigerant type naphthenic oil having the following specifications:

	525 vis.	150 vis.	ASTM method
Flash point, ° F.	370 min.	330 min.	D-92-46
Fire point, ° F.	430 min.	370 min.	D-92-46
Viscosity at 100° F. SUS.	500-560	150-160	D-88-44
Pour point, not above	-10° F.	-35° F.	D-97-39
Color, not darker than	2 NPA.	1½ NPA.	D-155-45T
Specific gravity at 60° F.	.922-.934	.910-.922	D-287-39
Floc test (90% F. -12+10% oil by vol.)	-30° F.	-70° F.	

The oil designated as "B" is a commercial refrigerant type naphthenic oil having the following specifications:

	500 vis.	150 vis.	ASTM method
Flash point, ° F.	370 min.	330 min.	D-92-52
Fire point, ° F.	430 min.	370 min.	D-92-52
Viscosity at 100° F.	500-560	150-160	D-88-44
Viscosity at 210° F., min.	39	39	
Pour point, ° F., not above	-20	-40	D-97-47
Color NPA, not darker than	2	1½	
Specific gravity at 60° F.	.912-.919	.892-.910	D-287-52
Floc test (haze) (90% F. -12+10% oil by vol.) not above ° F.	-35	-60	

As shown in Figure 2 the "Floc" point of both oils A and B having a viscosity of 500 SUS at 100° F. is at 84° F. at a concentration of 20% in Freon 22. The "Floc" point of oils A and B having a viscosity of 150 SUS at 100° F. are at 46° F. and 34° F., respectively, at a concentration of 20% in Freon 22. In contrast the "Floc" point of a mono pentaerythritol ester having a viscosity of 274 SUS at 100° F. and an average of about 7 aliphatic carbon atoms in the acid portion of the ester groups, is -63° F. at a concentration of 20% in Freon 22.

The above described "Floc" tests are generally accepted as indicating low temperature performance of lubricants. Thus it is apparent that the use of the present pentaerythritol esters involve a substantial improvement in the operation of a refrigeration system at low temperatures, particularly with a refrigerant such as Freon 22.

The pentaerythritol esters of the present invention exhibit a high degree of thermal and chemical stability. The above A and B oils of comparable viscosity were compared by sealing the lubricant, Freon 22 and metal catalysts in pressurized glass tubes and exposing the combination to high temperatures the results of which are shown below.

Oil	Thermal exposure	Refrigerant decomposed in milligrams of released chlorine
A	2 weeks at 400° F.	100 to 385 in various tests.
B	do.	35.
Pentaerythritol ester	do.	7.5.

In a similar test involving di 2, ethyl hexyl sebacate, a di ester, 520 milligrams of chlorine were measured in the thermal exposure of 1 week at 400° F. The pentaerythritol ester used in the above tests involves esters formed by reacting aliphatic organic acids having an average carbon chain of about 7.

Laboratory tests also indicate that the ASTM viscosity index of the above pentaerythritol esters is 119.5 as compared to viscosity indexes of under 20 for the above A and B oils indicating that the subject lubricant varies considerably less with temperatures than conventionally used lubricants with obvious advantage.

While the embodiments of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In combination, a refrigeration apparatus including a compressor, condenser, and evaporator in refrigerant flow relationship, a difluoromonochloromethane refrigerant and a lubricant soluble in said refrigerant comprising an organic ester of pentaerythritol which is a reaction product of monopentaerythritol and an organic acid selected from the group wherein the carboxyl group is attached to a radical taken from a group consisting of alkyl and aryl radicals having an average of from 6 to 10 carbon atoms.
2. In combination, a refrigeration apparatus including a compressor, condenser, and evaporator in refrigerant flow relationship, a difluoromonochloromethane refrigerant and a lubricant soluble in said refrigerant comprising

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an organic acid ester which is a reaction product of a pentaerythritol selected from the group consisting of monopentaerythritol, dipentaerythritol and tripentaerythritol, and an organic acid selected from a group wherein the carboxyl group is attached to a radical taken from the group consisting of alkyl and aryl radicals having from 2 to 20 carbon atoms, said lubricant having a viscosity range of from 50 to 2,000 seconds Saybolt measured at 100° F.

3. In combination, a refrigeration apparatus including a compressor, condenser, and evaporator in refrigerant flow relationship, a difluoromonochloromethane refrigerant and a lubricant soluble in said refrigerant comprising an organic acid ester of monopentaerythritol, and an organic acid selected from a group wherein the carboxyl group is attached to a radical taken from the group consisting of alkyl and aryl radicals having an average of from 6 to 10 carbon atoms, said lubricant having a viscosity range of from 50 to 2,000 seconds Saybolt measured at 100° F.

4. In combination, a refrigeration apparatus including a compressor, condenser, and evaporator in refrigerant flow relationship, a fluorochloro substituted aliphatic hydrogen refrigerant capable of being in the liquid and gaseous phases within the operating temperatures of said refrigeration apparatus, and a lubricant soluble in said refrigerant comprising an organic ester of pentaerythritol which is a reaction product of monopentaerythritol and an organic acid selected from the group wherein the carboxyl group is attached to a radical taken from a group consisting of alkyl and aryl radicals having from about an average of 6 to 10 carbon atoms.

5. In combination, a refrigeration apparatus including a compressor, condenser, and evaporator in refrigerant flow relationship, a fluorochloro substituted aliphatic hydrogen refrigerant capable of being in the liquid and gaseous phases within the operating temperatures of said

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refrigeration apparatus, and a lubricant soluble in said refrigerant comprising an organic acid ester which is a reaction product of a pentaerythritol selected from the group consisting of monopentaerythritol, dipentaerythritol and tripentaerythritol, and an organic acid selected from a group wherein the carboxyl group is attached to a radical taken from the group consisting of alkyl and aryl radicals having from 2 to 20 carbon atoms, said lubricant having a viscosity range of from 50 to 2,000 seconds Saybolt measured at 100° F.

6. In combination, a refrigeration apparatus including a compressor, condenser, and evaporator in refrigerant flow relationship, a fluorochloro substituted aliphatic hydrogen refrigerant capable of being in the liquid and gaseous phases within the operating temperatures of said refrigeration apparatus, and a lubricant soluble in said refrigerant comprising an organic acid ester which is a reaction product of monopentaerythritol and an organic acid selected from a group wherein the carboxyl group is attached to a radical taken from the group consisting of alkyl and aryl radicals having an average of from 6 to 10 carbon atoms, said lubricant having a viscosity range of from 50 to 2,000 seconds Saybolt measured at 100° F.

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