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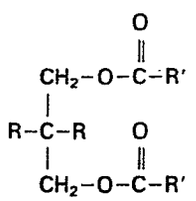
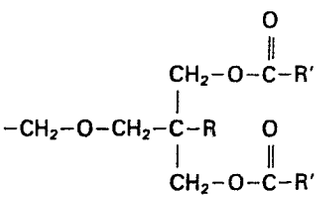
(54) Fluid-insulated switchgear.

(57) A liquid insulated tap-changer in which the dielectric liquid includes as a major constituent a monomeric or polymeric ester of the general formula:



wherein R′ are the same or different alkyl groups having five to ten carbon atoms, and R are independently H or

Me or Et or $-CH_2-O-C-R'$ or (in the case that the ester is polymeric)



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Fluid-insulated Switchgear

The present invention relates to switchgear, and in particular relates to fluid-insulated tap-changers.

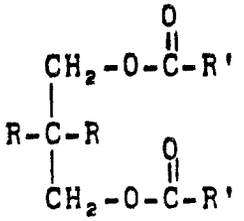
Fluid-insulated tap-changers are employed for light-duty switching in a variety of applications, such as distribution transformer installations, underground railways and the like, where repeated on-load switching of currents of up to about 500A at voltages of typically a few kV is required. Typically a tap-changer may perform 20,000 to 30,000 make and break cycles annually, and a working life of a minimum of 20 years is normally expected. Owing to their frequent make and break cycles, tap-changer electrodes are subject to considerable wear in use, and for the same reason the dielectric fluid in a tap-changer quickly becomes contaminated with carbon and other arcing products, which in turn tend to cause the electrodes to wear more rapidly. Consequently fluid-insulated tap-changers are distinguished from fluid-insulated switchgear in general by the requirement to renew their dielectric liquid at frequent intervals throughout their working life and also by the requirement that the dielectric liquid employed should be compatible with an absolute minimum of electrode wear. The problem of electrode wear is less severe in

heavy duty switchgear for example, even though such switchgear may switch currents of perhaps several kA at several tens of kV.

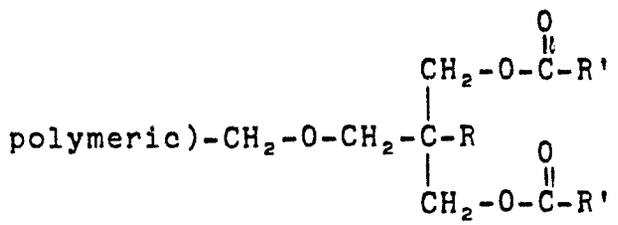
Thus although a fairly wide range of dielectric liquids have been used for switchgear in general the only insulating fluid found suitable for tap-changers and similar light-duty switching has been petroleum oil to BS148 insulating specification. However, BS148 petroleum oil has the following disadvantages; a) it is highly inflammable b) it can have poor lubricating properties c) it can freeze at -20^{o}C and d) being a natural petroleum product the molecular structure can contain various aromatic structures of questionable toxicity or carcinogeneticy. Also in operation in a tap-changer or switch, petroleum oil evolves large quantities of hydrogen and other flammable gases, and produces large quantities of colloidal carbon which requires periodic removal. Up to recently attempts to replace petroleum oil with an alternative less flammable fluid has not met with complete success. Dielectrics based on halogenated oils such as polychlorinated biphenyls fluorinated oils or mixtures of halogenated chlorofluoro compounds have resulted in the formation of large quantities of toxic or corrosive products such as hydrochloric acid or hydrolysable fluorides. Experience has also shown that there is in addition a marked increase in contact erosion with such fluids. Other fluids based on silicone materials such as dimethylsiloxane and phenylmethyl siloxanes have also been found to be unsatisfactory due to the formation of silica and gelatinous silicone polymers on arcing during switching which effectively abrade electrodes/contacts and can cause insulating films of fused silica to be formed on the contacts.

According to the present invention, a liquid insulated tap-changer incorporates a dielectric liquid

which includes as a major constituent one or more monomeric or polymeric esters of the general formula:

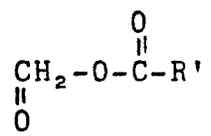


wherein R' are the same or different alkyl groups having five to ten carbon atoms, and R are independently H or Me or Et or $-CH_2-O-\overset{O}{\overset{\|}{C}}-R'$ or (in the case that the ester is



The dielectric liquid may comprise a single said ester or a mixture of such esters.

Preferably in an ester employed in a dielectric liquid according to the invention each R is



the other R is $CH_2-O-C-R'$. R' is preferably hexyl (C_6), heptyl (C_7) or octyl (C_8). R' may be a straight chain or a branched chain alkyl group. Preferred esters for use in accordance with the invention are esters (particularly tetra-esters) of pentaerythritol ($C(CH_2OH)_4$) and heptanoic or octanoic (particularly the n-heptanoic and n-octanoic) acid. Esters of trimethylol propane (particularly 1, 1, 1 trimethylol propane), di-trimethylol propane and dipentaerythritol ($(CH_2OH)_3C-CH_2-O-CH_2-C(CH_2OH)_3$) are also suitable, particularly when the acid is heptanoic or octanoic acid.

The use of certain aliphatic esters as insulating

fluids in fluid-insulated electrical apparatus in general is disclosed in our U.K. Patent No. 1602092, which is hereby incorporated by reference. Specifically, this patent disclosed the esters trimethylol-propane triheptanoate, trimethylol-propane tricaprylate and pentaerythritol tetrapelargonate and listed their viscosities, boiling points, electrical loss tangents ($\tan\delta$), resistivities, permittivities, electrical breakdown strengths, fire points and autoignition temperatures. However this patent did not suggest that any of the esters of the present invention were suitable for use in tap-changers and in particular did not disclose the amount of contact erosion or carbon production which arises when the esters are used in tap-changers. These two parameters are very important in tap-changer applications but are much less important in most other types of switchgear applications.

We have unexpectedly found that esters in accordance with the invention, when used as dielectric liquids in tap-changers, significantly reduce contact erosion in comprison with tap-changers which utilise petroleum oil (which has previously been considered the best dielectric fluid for tap-changers). Furthermore the esters of the present invention form only a small fraction of the carbon produced by petroleum oil in tap-changers, and the carbon produced by the esters of the present invention is less colloidal and separates more readily to leave a cleaner system. Thus, by using the esters of the present invention in tap-changers the overall life of the tap-changer may be increased and the required maintenance may be reduced.

The esters of the present invention are considered to be of low toxicity and have the following known advantages over petroleum oil:

a) the esters can be formulated to be fire resistant i.e. they can readily comply with

national fire specifications for a low flammability insulating fluid (fire point above 300°C).

b) smaller amounts of hydrogen and other flammable gases are produced on arcing.

An example of one ester mixture employed in a tap-changer in accordance with the invention consists of pentaerythritol tetra-heptanoate and pentaerythritol tetra-octanoate esters having a composition as follows:

48% $C(CH_2O-\overset{O}{\overset{\|}{C}}-nC_6H_{13})_4$

42% $C(CH_2O-\overset{O}{\overset{\|}{C}}-isoC_7H_{15})_4$

10% $C(CH_2O-\overset{O}{\overset{\|}{C}}-nC_7H_{15})_4$

The advantages of this ester mixture can be seen from the following table which lists comparative data for BS148 petroleum oil, fluoropentane, and the ester mixture.

TABLE

	BS148 Petroleum Oil	C_5F_{12}	ester mixture
Fire Point (°C)	170	-	310
Pour Point (°C)	-30	-	-50
Carbon/kJ (g)	0.023	<0.001	0.002
Hydrogen/kj (cm^3)	26	-	6
Contact erosion after type testing at up to 2kV (wt.%)	1	-	0.7
Contact erosion after type testing at 20kV (mm/kA)	0.04	0.09	0.02

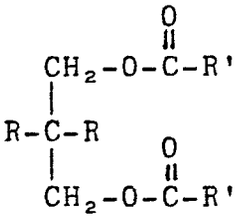
In each case, the fire point was determined by the method specified in the Institute of Petroleum handbook No. 36/63, the pour point was determined by

the method specified in the Institute of Petroleum Handbook No. 15/67 (ASTM Designation D97-66), and the type testing involved 20,000 make and break operations in a 33kV 500 amp High Speed Resistor Transition Tap-Changer.

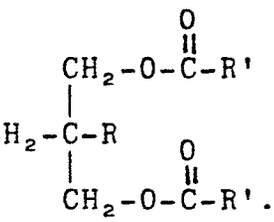
It will be appreciated that in practice, commercially available mixtures of aliphatic acids may be reacted with the alcohol to form the required esters, and that appropriate blending of esters produced from different batches of acid may be necessary in order to achieve the desired pour point, fire point, viscosity or other characteristics. In general the precise composition is not critical, but it should be noted that the electrical properties, especially the loss tangent and the resistivity, improve with increasing molecular weight and increasing symmetry of the ester molecule.

CLAIMS

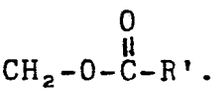
1. A liquid insulated tap-changer incorporating a dielectric liquid which includes as a major constituent one or more monomeric or polymeric esters of formula:



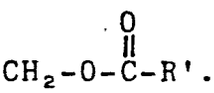
wherein R' are the same or different alkyl groups having five to ten carbon atoms, and R are independently H or Me or Et or $-CH_2-O-\overset{O}{\overset{\|}{C}}-R'$ or (in the case that the ester is polymeric)$-CH_2-O-CH_2-$



2. A liquid insulated tap-changer according to Claim 1 wherein the dielectric liquid incorporates a said ester, in which each R is



3. A liquid insulated tap-changer according to Claim 1 wherein the dielectric liquid incorporates a said ester in which one R is ethyl and the other R is



4. A liquid insulated tap-changer according to Claim 1 wherein the dielectric liquid incorporates a said ester, in which R' is hexyl (C_6), heptyl (C_7) or octyl (C_8).

5. A liquid insulated tap-changer according to Claim 4 wherein R' is a straight chain or a branched chain alkyl group.

6. A liquid insulated tap-changer according to any preceding Claim wherein the dielectric liquid incorporates, as a said ester, an ester of pentaerythritol and heptanoic or octanoic acids.

7. A liquid insulated tap-changer according to any one of Claims 1 to 5 wherein the dielectric liquid incorporates as a said ester an ester of trimethyl propane, di-trimethylol propane or dipentaerythritol and heptanoic or octanoic acid.

8. A liquid insulated tap-changer according to Claim 1 wherein the dielectric liquid comprises a mixture of pentaerythritol tetra-heptanoate and pentaerythritol tetra-octanoate esters.

9. A liquid insulated tap-changer according to Claim 1 wherein the dielectric liquid comprises an ester mixture having the following compositions:-

48% $C(CH_2O-\overset{O}{\overset{\|}{C}}-nC_6H_{13})_4$

42% $C(CH_2O-\overset{O}{\overset{\|}{C}}-isoC_7H_{15})_4$

10% $C(CH_2O-\overset{O}{\overset{\|}{C}}-nC_7H_{15})_4$.

10. A dielectric liquid suitable for use in a liquid insulated tap-changer according to any preceding Claim and comprising an ester or mixture of esters of pentaerythritol and heptanoic or octanoic acid.

11. A dielectric liquid suitable for use in a liquid insulated tap-changer according to any preceding Claim and comprising an ester or mixture of esters of trimethyl propane or dipentaerythritol with heptanoic or octanoic acid.

European Patent Office

EUROPEAN SEARCH REPORT

0202878
Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 86303735.4

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
X	US - A - 3 894 959 (GARDINER et al.) * Column 2, line 60 - column 9, line 10 * --	1-8, 10,11	H 01 B 3/20 H 01 F 29/02
X	"New Dielectric Fluids for Power Engineering" organised by Professionel Group Committee S2 (Materials, Science and Technology) 1980-03-12, Digest number 1980/14 * Pages 3/1-4/3 * --	1-8,	
D,A	GB - A - 1 602 092 (MICANITE) * Page 1, line 47 - page 2, line 55 * ----	1-8, 10,11	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

H 01 B 3/00
H 01 F
H 01 H 33/00
C 10 M 105/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	05-08-1986	KUTZELNIGG

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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