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COMPOUNDED LUBRICANT

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27 Claims. (Cl. 87—9)

This invention relates to new and useful compositions of the compounded mineral oil class. More particularly, it involves the provision of a lubricating oil containing metal salts of organic acids and an addition agent which inhibits undesirable effects of such compounds, as more particularly pointed out hereinafter, without destroying desired beneficial effects obtained therefrom.

Metal salts of organic acids are known as compounding ingredients for lubricating oils and have been added thereto for various purposes. For example, aluminum oleate is disclosed as a dispersing agent for graphite in the U. S. Patent to Burke #1,732,221; and various soaps have been disclosed as pour point depressing agents.

In its broader aspect this invention is applicable to compounded oils of the above types. However, the present invention is more particularly concerned with oils compounded with certain metal naphthenates such as aluminum or magnesium naphthenates to inhibit piston ring sticking.

An important property of lubricating oils is low corrosivity, especially with respect to modern bearing metals such as copper-lead mixtures or cadmium-silver alloy. Some lubricating oils which have been entirely satisfactory from the standpoint of corrosivity to high grade Babbitt bearing metals show a corrosion rate with cadmium-silver and copper-lead bearings which is greater than that permissible. Lubricating oils containing metal soap compounding ingredients have been found in general to show undesirable corrosive effects on such bearing materials. However, these metal soap compounding ingredients are highly desirable or even necessary for other purposes, such as inhibitors for piston ring sticking.

Accordingly, it is an object of the invention to solve the above difficulties by providing an improved compounded mineral oil having little or no corrosive action to machine parts and yet containing metal salts of organic acids.

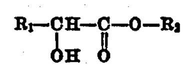
Another object of the invention is to inhibit corrosive effects of compounded lubricating oils containing metal salts of organic acids such as metal naphthenates.

A still further object of the invention is to improve the wear reducing value of mineral oils compounded with metal salts such as naphthenates.

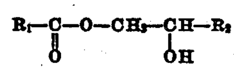
Another object of the invention is to increase the resistance to oxidation and discoloration of oils compounded with metal soaps.

In the investigation of lubricating oils containing metal salts of organic acids such as metal naphthenates, it has been found that oil-soluble organic compounds comprising an ester with a hydroxyl group in the alpha or beta position relative to the carboxyl group materially improve various properties of the compounded oils. These types of compounds may be represented generically by the following structural formulae:

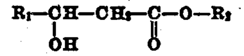
Alpha hydroxy ester



Beta hydroxy ester



or



In these formulae R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group. R_1 and R_2 may, of course, contain other active groupings and may be either of the same or different types.

Attention is directed to the fact that in the above types of compounds the hydroxyl group is no more than two carbon atoms removed from the carboxyl group. The addition of these types of esters to oils containing metal soaps effectively inhibits the corrosive action of oils so compounded, but where the hydroxyl group is further removed than two carbon atoms from the carboxyl group it has been our experience that the esters do not adequately inhibit the corrosive action of such oils. The inferior inhibiting effects obtained from these other types of hydroxy esters make it necessary to utilize an alpha or beta hydroxy ester in order to obtain the fullest benefits of this discovery and invention.

Specific examples of esters which have been found effective for reducing corrosive effects of mineral lubricating oils containing metal naphthenates comprise diethyl tartrate, dibutyl tartrate, diamyl tartrate, di-isoamyl tartrate, dibenzyl tartrate, dioctyl tartrate, dilauryl tartrate, amyl lactate, octyl lactate, tri-isoamyl citrate, and diethyl mucate.

To illustrate the effect of these esters as corrosion inhibitors, strip corrosion test data were obtained on several mineral oils compounded with 1% of a metal naphthenate to which had been added different esters as taught in this invention. A basic aluminum naphthenate containing 3 equivalent weights of aluminum to 2 equivalent weights of petroleum naphthenic acids, and magnesium naphthenate were used as the metal naphthenate addition agents in these tests. Likewise, petroleum naphthenic acids having an average molecular weight of 270, 340, and 370 were used in various of the different tests to illustrate the relative effects of the molecular weight of the naphthenic acids on corrosiveness and other properties of the oil.

The strip corrosion tests were carried out in the following manner: Glass tubes 2 inches in diameter and 20 inches long were immersed in an oil bath, the temperature of which was automatically controlled to within ±1° F. of the test temperature which was 300° F. Approximately 300 c. c. of oil under the test was placed in each tube and air was bubbled through it at the rate of 10 liters per hour. Strips of the different types of bearing metals were cut to size and placed in the oils; in most cases more than one type of metal was tested simultaneously in the same sample of oil. The weight loss of each strip was recorded at least once every 24 hours. Before weighing, each strip was washed in petroleum ether and carefully wiped with a soft cotton cloth. At the same intervals the oils were tested for viscosity, A. S. T. M. naphtha insolubles, and neutralization number to obtain their oxidation characteristics. The duration of the test was 72 hours. Summarized results are given in Table #1.

TABLE #1

Type of oil	Addition agents		72 hours at 300° F.				
			Weight loss in grams		Percent increase viscosity at 100° F.	A. S. T. M. naphtha ins.	Neut. No.
	Metal naphthenate	Ester	Copper-lead	Cadmium-silver			
Western oil (A) SAE 30	None	None	.0100	0	98	192	2.34
Do	1% Al dinaphthenate (270 M. W. acids).	do	.0670	.1134	320	670	4.04
Do	do	1% dibutyl tartrate	.0250	.0030	119	246	3.60
Do	do	½% dibutyl tartrate	.0258	.0055	94		
Do	do	1% dioctyl tartrate	.0584	.0449	123		3.39
Do	do	1% diamyl tartrate	.0176	.0064			
Do	do	1% diethyl tartrate	.0124	.0124	259	438	4.21
Do	do	1% dibenzyl tartrate	.0230	0	130	33	3.34
Do	1% Al dinaphthenate (370 M. W. acids).	None	.0475	.0001	165	293	3.06
Do	do	1% dibutyl tartrate	.0040	0	123	187	2.40
Pennsylvania motor oil SAE 20.	None	None	.1350	.1620	72	2	2.80
Do	1% Al dinaphthenate (270 M. W. acids).	do	.2087	.2315	118	5	4.30
Do	do	1% dibutyl tartrate	.0372	.2330	93	1	3.80
Penn. aviation oil SAE 60	None	None	.0874	.0458	20	0	
Do	1% Al dinaphthenate (270 M. W. acids).	do	.1495	.1702	74	4	
Do	do	1% dibutyl tartrate	.0299	.2225	56	3	
Western motor oil (A) SAE 30.	None	None	.0100	0	98	192	2.34
Do	1% Mg naphthenate (270 M. W. acid).	do	.1391	.1191	216	467	3.60
Do	do	+1% dibutyl tartrate	.0366	.1331	279	393	3.33
Do	1% Mg naphthenate (340 M. W. acid).	None	.2083	.0640	440	710	6.1
Do	do	+1% diamyl tartrate	.0122	.0003	329	447	5.8
Western motor oil (B) SAE 30.	1% Mg naphthenate (270 M. W. acid).	None	.1353	.0629	112	183	4.9
Do	do	1% diamyl tartrate	.0618	.0056	139	359	3.59
Blended Penn. and Western oil SAE 20.	None	None	.0523	0			
Do	¼% Mg naphthenate (270 M. W. acid).	do	.1843	.0070	42	59	2.9
Do	do	+1% diamyl tartrate	.0275	.0007	35	36	1.4

The results in Table 1 include a large number of combinations of different types of oils, various metal naphthenates and different types of esters on two different bearing metals. It will be noted that some esters are more effective than others, and that the effectiveness of a single ester varies with the mineral oil used, the naphthenate contained therein and the bearing metal being tested. The data illustrate the following facts:

(1) Oils from Western crudes are essentially non-corrosive.

(2) The addition of metal naphthenates such as aluminum dinaphthenate or magnesium naphthenate increases the corrosiveness of mineral oils to copper-lead and cadmium-silver bearing metals.

(3) The addition of hydroxy esters such as disclosed in this invention to oils containing these naphthenates markedly reduces their corrosiveness to these bearing metals.

It has also been found that oils containing naphthenates from the heavier acids and from the lighter acids do not differ greatly in corrosiveness but that the corrosive action of oils containing soaps of the heavy acids may be more effectively inhibited by the esters. The data in Table 2 are of interest in this respect.

TABLE #2

Oil	Weight loss (grams) in 72 hours at 300° F.	
	Copper-lead	Cadmium-silver
Western oil—SAE 30	.0100	0
Western oil—SAE 30+1% Al dinaph. (270 M. W. acid)	.0670	.1134
Western oil—SAE 30+1% Al dinaph.+1% diamyl tartrate	.0176	.0064
Western oil—SAE 30+1% Al dinaph. (340 M. W. acid)	.0475	.0001
Western oil—SAE 30+1% Al dinaph.+1% dibutyl tartrate	.0040	0
Western oil—SAE 30+1% mag. naph. (270 M. W. acid)	.1391	.1191
Western oil—SAE 30+1% mag. naph.+1% dibutyl tartrate	.0366	.1331
Western oil—SAE 30+1% mag. naph. (340 M. W. acid)	.2083	.0640
Western oil—SAE 30+1% mag. naph.+1% diamyl tartrate	.0122	.0003

Investigation also shows that addition of esters in accordance with this invention, to oils compounded with aluminum dinaphthenate very materially reduces the amount of wear and friction.

It should be noted that wear consists of corrosion and abrasion, and, strictly speaking, represents two different effects. Corrosion is the result of chemical attack of ingredients in the oil on the metal. This, of course, may occur on stationary parts and independently of abrasion. On the other hand, wear may result primarily from abrasion of the metal surface due to contact under load between moving parts. Similarly this phenomenon may occur in the absence of corrosion. Most generally both effects occur simultaneously in a running engine and in order to more closely simulate such conditions a series of tests was run on a General Motors connecting rod machine, in which both factors, that is, high temperatures causing accelerated corrosion and contact between moving surfaces, are present. The results of these tests are tabulated below.

TABLE #4

Effects of esters for inhibiting corrosivity and nates (General Motors connecting rod ma- abrasion with oils containing metal naphthe- chine) *

Mineral oil stock	Soap compound	Inhibitor (ester)	General Motors Machine weight loss in gms. after 54 hours at 300° F.	
			Copper-lead	Cadmium-silver
Western oil SAE 30			.9519	.1482
Do	1% Al dinaph. (270 M. W. acid)		3.3232	2.7410
Do	do	1% dibutyl tartrate	.4535	.2459
Highly refined Western oil SAE 30	do	1% diamyl tartrate	.7580	.7416
Do	1% Al dinaph. (340 M. W. acid)	0.2% diamyl tartrate	.5925	.5237
Do	1% magnesium naphthenate (340 M. W. acid).		6.1912	
Do	do	1% diamyl tartrate	2.0558	

*Described Nat. Pet. News, Nov. 11, 1936, Page 31.

Test results on 3 different types of laboratory machines are tabulated below:

As a check upon the above extensive laboratory tests, a series of engine tests was made and the data obtained are shown in Table 5.

TABLE #3

Effects of esters on oiliness of oils containing aluminum dinaphthenate

	Weeks machine,* steel on steel, 16 hours at 2 lbs. load		Timken machine,** steel on bronze, block temp., °F.	Kinetic machine,*** steel on bronze, 5 ft./min.—175° F.	
	Wear—Mg			Relative	
	Ball	Cup		Frict.	Wear
Test oil No. 1	0.4	0.7			
Test oil No. 1 + 1% Al dinaph. (270 M. W. acids)	1.5	.8			
Test oil No. 1 + 1% Al dinaph. + 1% diamyl tartrate	.7	.4			
Test oil No. 2			175		
Test oil No. 2 + 1% Al dinaph. (270 M. W. acids)			250+		
Test oil No. 2 + 1% Al dinaph. + 1% dibutyl tartrate			170		
Test oil No. 3				100	100
Test oil No. 3 + 1% Al dinaph. (270 M. W. acids)				140	160
Test oil No. 3 + 1% Al dinaph. + ½% diamyl tartrate				75	40

*A laboratory wear testing machine comprising a ½-inch steel ball pressed against a 1¾-inch steel cylinder which is rotated at 600 R. P. M. and which dips in the oil being tested.

**Described in S. A. E. Journal, volume 28, page 53, 1932.

***Described in A. P. I. Proceedings, mid-year 1932, section III, page 60 (published by Petroleum Institute).

TABLE #5

Mineral oil stock	Soap compound	Inhibitor (ester)	Engine tests, 1935 Plymouth engine laboratory tests, oil temp.: 108° and 279° F. Loss in weight per bearing for last 1,950 miles of a 2,925 mile run	
			Copper-lead, grams	Cadmium-silver, grams
Blended Penn. and Western oil SAE 30.			.041	.144
Do	1% Al dinaph. (270 M. W. acid)		.118	.778
Do	do	1% diamyl tartrate	.029	.338
Acid refined Western oil SAE 30	do	do	.048	.566
Do	1% Al dinaph. (340 M. W. acid)	0.5% diamyl tartrate	.082	.446

The tests in the 1935 Plymouth engine were made with the engine directly connected to an electric dynamometer, and the engine was run alternately hot and cold at the temperatures indicated in the table. In the cold part of the cycle the speed was 1500 R. P. M. (30 miles per hour), the load was 5.9 horsepower, and four ounces of distilled water were added at the start of the period to simulate conditions produced by condensation of moisture in the crankcase. During the hot period the speed was 2500 R. P. M. (50 miles per hour), and the load was 25 horsepower. Both copper-lead and cadmium-silver bearings were provided in the engine to obtain accurate comparative data. Only the weight losses of bearing metals during the last two-thirds of the run were considered, since the initial wear rate is entirely out of line with that of the greater portion of the run. The data thus obtained are more representative of long operating periods.

The results of these engine tests show that tartrates are very effective in inhibiting wear of bearings with oils containing aluminum dinaphthenate.

To ascertain the effectiveness of oils containing both naphthenates and esters for inhibiting piston ring sticking, tests were run in Lauson engines to determine the time necessary to cause piston ring sticking under highly adverse conditions. These engines are of the gasoline type and were loaded with fan dynamometers. The jacket temperature was maintained at 345° F. by the use of ethylene glycol in the water jackets and the crankcase oil temperature was maintained at 220° F. with an electric heater. The results in Table No. 6 illustrate clearly the beneficial effect in preventing piston ring sticking which these oils give as compared with the same original uncompounded crankcase lubricant.

TABLE #6

Effectiveness of oils containing aluminum dinaphthenate and esters, in inhibiting piston ring sticking

Oil	Naphthenate	Ester	Lauson engine, jacket temp., 345° F., oil temp., 220° F., hours to cause ring sticking
Western SAE 30	None	None	30
Do	1% Al dinaph. (270 M. W. acids)	1% diamyl tartrate	90+
Do	1% Al dinaph. (340 M. W. acids)	do	60
Do	1% Mg. naph. (270 M. W. acids)	do	90+
Do	1% Mg. naph. (340 M. W. acids)	do	105+

(Plus (+) sign indicates ring sticking had not yet occurred.)

The original uncompounded oil ran only 30 hours without ring sticking under the conditions of the test. The same oil compounded as taught by this invention prevented ring sticking for two, three or more times as long.

The chemical mechanisms by which the results of this invention are obtained have not been established and are not well understood. Metal naphthenates appear to catalyze corrosion effects in oils. The esters inhibit or offset this catalytic action by a phenomenon which has been discovered by the present inventors but which they are unable, definitely, to explain. The phenomenon of corrosion inhibiting appears to result from some peculiar action which converts the bearing metal to a passive state after an initial induction period. This latter fact is illustrated by the following comparative data:

Test No.	Oil	Naphthenate	Ester	Strip corrosion—total weight loss grams copper-lead at 300°		
				24 hours	48 hours	72 hours
1	Western oil SAE 30	1% Al dinaph.	None	.0189	.0359	.0578
2*	do	do	do	.0085	.0198	.0307
3	do	do	Dibutyl tartrate	.0158	.0170	.0158
4**	do	do	do	.0136	.0131	.0151
5***	do	do	do	.0138	.0758	.1092

*Strips dipped in straight dibutyl tartrate before start of test.
**Oil changed every 24 hours.
***Specimens changed every 24 hours.

Examination of the above data shows that dipping the specimen in dibutyl tartrate markedly reduced corrosion; that changing the oil every 24 hours had no effect on the corrosiveness of the oil containing both the naphthenate and the ester; and that when the bearing strip specimens were changed every 24 hours, the ester showed substantially no corrosion inhibiting action. These facts indicate that the metal surface must be converted to a passive state by some phenomenon of adsorption or coating by chemical action or the like. Although these effects offer a possible explanation of the action of esters in inhibiting corrosion as taught in this invention, it is to be understood that our invention is not limited to any theory or explanation of the action of the inhibitors.

A factor which should be recognized and considered when compounding oils according to this invention is the presence of free acid in the esters. Tests with tartrates indicate that best results are obtained when the free acid content of the ester is low. It is therefore preferred to use esters having a neutralization number of no more than approximately 20.

Measurable improvements in the properties of the compounded oil are obtained with as little as 0.1% of the ester, but approximately 0.5%, and preferably as much as 1.0%, is required to obtain adequate reduction of corrosivity in the compounded oil for the purpose of this invention. More than 10% is regarded as unnecessary.

The present invention is applicable in its broader aspects to oils compounded with many oil soluble metal salts of organic acids. The invention appears at present to find its greatest utility in oils containing metal salts of organic carboxylic acids, and particularly in oils containing metal naphthenates capable of inhibiting piston ring sticking. Such metal naphthenates are aluminum, zinc, magnesium, cobalt, cadmium and manganese naphthenates. It is apparent that the particular ester and the particular metal salts must be selected with various factors in mind, such as the service to be encountered and the type of bearings in engines to be lubricated if the maximum benefits of the invention are to be obtained.

While the character of the invention has been given in detail and numerous illustrative examples of the preparation and the compositions of the invention have been described, this has been done by way of illustration only and with the intention that no limitation should be imposed upon the invention thereby. It will be obvious to those skilled in the art that numerous modifications and variations of the above illustrative examples may be effected in the practice of the invention which is of the scope of the claims appended hereto.

We claim:

1. A compounded mineral oil containing an addition agent in an amount normally sufficient to substantially increase the corrosivity of a mineral oil, said addition agent being a metal salt of an organic acid and selected from the group of compounds which increase the corrosivity of hydrocarbon oils to bearing metals such as copper-lead mixtures and cadmium-silver alloys, and a small amount of an organic hydroxy ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester whereby the corrosivity of the compounded oil is materially reduced.

2. A compounded mineral oil as defined in claim 1, in which the ester is an alpha hydroxy ester of the type formula

$$R_1-\underset{OH}{\underset{|}{CH}}-\underset{O}{\underset{\|}{C}}-O-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

3. A compounded mineral oil as defined in claim 1, in which the ester is a beta hydroxy ester of the type formula

$$R_1-\underset{O}{\underset{\|}{C}}-O-CH_2-\underset{OH}{\underset{|}{CH}}-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

4. A compounded mineral oil as defined in claim 1, in which the ester is a beta hydroxy ester of the type formula

$$R_1-\underset{OH}{\underset{|}{CH}}-CH_2-\underset{O}{\underset{\|}{C}}-O-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

5. A compounded lubricating oil containing an oil-soluble metal salt of an organic carboxylic acid in an amount normally sufficient to substantially increase the corrosivity of said oil to bearing metals such as copper-lead mixtures and cadmium-silver alloys, and an organic hydroxy ester having at least one hydroxyl group no more than two carbon atoms from a carboxyl group of said ester, said hydroxy ester being present in an amount sufficient to materially inhibit the corrosivity of the compounded oil.

6. A compounded lubricating oil as defined in claim 5, in which the ester is an alpha hydroxy ester of the type formula

$$R_1-\underset{OH}{\underset{|}{CH}}-\underset{O}{\underset{\|}{C}}-O-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

7. A compounded lubricating oil as defined in claim 5, in which the ester is a beta hydroxy ester of the type formula

$$R_1-\underset{O}{\underset{\|}{C}}-O-CH_2-\underset{OH}{\underset{|}{CH}}-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

8. A compounded lubricating oil as defined in claim 5, in which the ester is a beta hydroxy ester of the type formula

$$R_1-\underset{OH}{\underset{|}{CH}}-CH_2-\underset{O}{\underset{\|}{C}}-O-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

9. A compounded lubricating oil containing a small amount of a naphthenate selected from the group consisting of aluminum, zinc, magnesium, cobalt, cadmium and manganese naphthenate, said naphthenate being present in an amount sufficient to substantially increase the corrosivity of the oil to bearing metals such as copper-lead mixtures and cadmium-silver alloys, and from approximately 0.1% to approximately 10% of an organic hydroxy ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester.

10. A compounded lubricating oil as defined in

claim 9, in which the ester is an alpha hydroxy ester of the type formula

$$R_1-\underset{OH}{\underset{|}{CH}}-\underset{O}{\underset{\|}{C}}-O-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

11. A compounded lubricating oil as defined in claim 9, in which the ester is a beta hydroxy ester of the type formula

$$R_1-\underset{O}{\underset{\|}{C}}-O-CH_2-\underset{OH}{\underset{|}{CH}}-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

12. A compounded lubricating oil as defined in claim 9, in which the ester is a beta hydroxy ester of the type formula

$$R_1-\underset{OH}{\underset{|}{CH}}-CH_2-\underset{O}{\underset{\|}{C}}-O-R_2$$

in which R_1 and R_2 represent an alkyl, aryl, aralkyl or cyclic non-benzenoid group.

13. A compounded lubricating oil as defined in claim 9, in which the ester is a tartrate.

14. A compounded lubricating oil as defined in claim 9, in which the ester is a tartrate, and the naphthenate is an aluminum naphthenate.

15. A compounded lubricating oil as defined in claim 9, in which the ester is a tartrate, and the naphthenate is magnesium naphthenate.

16. A compounded mineral oil containing an aluminum salt of a fatty acid in an amount sufficient to normally increase the corrosivity of said oil and an organic hydroxy ester, having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester, said ester being present in an amount sufficient to materially inhibit said increased corrosivity.

17. A compounded lubricating oil containing a metal salt of an organic carboxylic acid in an amount sufficiently to normally increase the corrosivity of said oil and an oil soluble tartrate, in an amount sufficiently to materially inhibit said increased corrosivity.

18. In a method of lubricating bearing surfaces which comprises maintaining between the bearing surfaces, one of which is a bearing metal selected from the group consisting of cadmium-silver alloy and copper-lead mixtures, a film of a compounded lubricating oil containing a small amount of a metal naphthenate which oil would normally tend to corrode said bearing metal, the step of inhibiting the corrosive action of the compounded oil on said bearing by incorporating therein a minor proportion of an organic ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester, said minor proportion of ester comprising at least 0.1% by weight of the lubricating oil.

19. In a method of lubricating bearing surfaces which comprises maintaining between the bearing surfaces, one of which is a bearing metal selected from the group consisting of cadmium-silver alloy and copper-lead mixtures, a film of a compounded lubricating oil containing a small amount of a metal naphthenate selected from the group consisting of aluminum, zinc, magnesium, cobalt, cadmium and manganese naphthenates which compounded oil would normally tend to corrode said bearing metal, the step of inhibiting the corrosive action of the oil on said bearing by incorporating therein a minor proportion of an organic ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester, said minor proportion of ester comprising at least 0.1% by weight of the lubricating oil.

20. A compounded mineral oil as defined in claim 1, in which the proportion of hydroxy ester is from approximately 0.1% to approximately 10% by weight based on the mineral oil.

21. A compounded lubricating oil as defined in claim 5, in which the proportion of hydroxy ester is from approximately 0.1% to approximately 10% by weight based on the mineral oil.

22. In a method of lubricating bearing surfaces which comprises maintaining between the bearing surfaces, one of which is a bearing metal selected from the group consisting of cadmium-silver alloys and copper-lead mixtures, a film of a compounded lubricating oil normally tending to corrode said bearing metal and containing an addition agent selected from the group of metal salts of an organic acid which substantially increase the corrosivity of said oil to said bearings, the step of inhibiting the corrosive action of the compounded oil on said bearing by incorporating therein a minor proportion of an organic ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester, said minor proportion of ester comprising at least 0.1% by weight of the lubricating oil.

23. A compounded lubricating oil containing a small amount of a metal naphthenate sufficient to substantially increase the corrosivity of the oil to bearing metals such as copper-lead mixtures or cadmium-silver alloys, and from approximately 0.1% to 10% of an organic hydroxy ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester.

24. A compounded lubricant comprising a mineral lubricating oil containing a small proportion of a metal salt of an organic acid in an amount sufficient to substantially increase the corrosivity of the lubricating oil to bearing metals, and from approximately 0.1% to 10% of an organic hydroxy ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester.

25. A compounded liquid lubricant comprising a mineral oil containing a metal salt of an organic acid in an amount sufficient substantially to increase the corrosivity of the lubricant to bearing metals, such as copper-lead mixtures and cadmium-silver alloys, and approximately 1% of an ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester.

26. A compounded liquid lubricant comprising a mineral oil containing an oil-soluble metal salt of an organic carboxylic acid in an amount sufficient substantially to increase the corrosivity of the lubricant to bearing metals, such as copper-lead mixtures and cadmium-silver alloys, and an ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester, said ester being present in an amount sufficient substantially to reduce the corrosivity of said compounded lubricant.

27. In a method of lubricating bearing surfaces which comprises maintaining between the bearing surfaces, one of which is a bearing metal selected from the group consisting of cadmium-silver alloys and copper-lead mixtures, a film of a compounded lubricating oil containing an oil-soluble metal salt of an organic carboxylic acid in an

amount which would normally increase the corrosivity of said oil to said bearing metal, the step of inhibiting the corrosive action of the oil on said bearing by incorporating therein from approximately 0.1% to approximately 10% of an ester having at least one hydroxyl group no more than two carbon atoms removed from a carboxyl group of said ester.

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