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3,017,359

LUBRICATING COMPOSITION

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This invention relates to a lubricating composition and more particularly to a lubricant adapted for the lubrication of industrial machinery wherein the lubricant, by the nature of its use, is subjected to extremely high pressures.

Various lubricating compositions have heretofore been disclosed for lubricating bearings operating under extremely high pressures but the prior compositions have not been entirely satisfactory. Some of the prior compositions have satisfactorily lubricated bearing operating under high pressures but they have not given the bearings and surrounding metal parts protection against rusting and corrosion, particularly when the bearings and parts are exposed to moisture. Other compositions have given good protection against rusting and corrosion in the presence of moisture, but said other compositions have not possessed good load-carrying properties.

The present invention is based upon a particularly effective lubricating composition having good load-carrying characteristics combined with resistance to oxidation and corrosion and rust-inhibiting properties.

The improved lubricating composition of this invention comprises a major proportion of a mineral lubricating oil and minor proportions of an alkyl phenol, a substantially neutral addition product of di oxo-octyl acid orthophosphate with primary fatty amines containing from 8 to 18 carbon atoms, and an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing from 6 to 22 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing from 12 to 24 carbon atoms and an alkitol anhydride. An improved lubricating composition can be prepared by incorporating in an oil an alkyl phenol and an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing from 6 to 22 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing from 12 to 24 carbon atoms and an alkitol anhydride. While the composition thus obtained has good oxidation stability and good rust-inhibiting properties, the composition does not possess good load-carrying properties such as those required to protect metal surfaces from wearing, seizing and galling when the oil is subjected to extremely high pressures.

We have found that an oil to which has been added an alkyl phenol and an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing from 6 to 22 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing from 12 to 24 carbon atoms and an alkitol anhydride can be improved with respect to its load-carrying properties by incorporating in the composition a small amount of a substantially neutral addition product of di oxo-octyl acid orthophosphate with primary fatty amines containing from 8 to 18 carbon atoms.

The lubricating oil to which the other constituents are added is advantageously a highly refined paraffinic oil. By the term "highly refined paraffinic oil" we mean a petroleum lubricating oil which has been refined by one of the more drastic refining methods known in the art, for example, by conventional aluminum chloride refining or by a solvent extraction adapted to remove all or substan-

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tially all of the unsaturated and naphthenic constituents of the oil. Aluminum chloride refined or solvent extracted paraffinic base oil, such as a Pennsylvania oil, provides an excellent base oil for the composition of the invention. However, drastically refined Mid-Continent and Gulf Coastal oil may also be used.

The alkyl phenol which is used in accordance with the invention is advantageously a di- or tri-alkylated phenol or cresol with at least one of the alkyl groups being a tertiary alkyl group. The alkyl groups are preferably those containing between 3 and 12 carbon atoms. Good results can be obtained with a tri-tertiary butyl phenol or a di-tertiary butyl cresol. Examples of the preferred alkylated phenols are 2,4,6-tri-tertiary-butylphenol and 2,6-di-tertiary-butyl-4-methylphenol. The alkyl phenols can be used in amounts of about 0.1 to about 5.0 percent by weight based on the weight of the total composition. The preferred amount, however, is between about 0.2 and about 1.25 percent by weight.

The acid esters employed in accordance with this invention are the reaction products resulting from the esterification of a dimerized unsaturated fatty acid with a partial fatty acid ester of an alkitol anhydride. The ratio of reactants may range from one mol of dimerized acid per mol of partial fatty acid ester up to the number of mols of dimerized acid that is equal to the number of free hydroxyl groups in the partial fatty acid ester, per mol of partial fatty acid ester.

The esterification reaction is effected in conventional manner and under conventional conditions. Thus, while esterification may proceed slowly at room temperature, the reaction is normally advantageously accelerated by heating the reactants, usually with refluxing, and/or by the use of conventional esterification catalysts, such as hydrogen chloride, sulfuric acid, or an aromatic sulfonic acid, such as p-toluene-sulfonic acid. The reaction may be driven to substantial completion by removing one of the products of the reaction. Since the herein disclosed dimeric unsaturated fatty acids, partial esters of alkitol anhydrides, and their reaction products boil at a temperature substantially above the boiling point of water, the reaction conveniently may be driven to completion by removal of the water of esterification by distillation. The removal of water from the reaction mixture may be facilitated by mechanical agitation, or by bubbling an inert gas, such as nitrogen, through the reaction mixture.

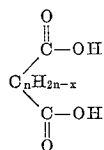
By way of illustrating the foregoing process, one, two or three mols of dimerized acid may be esterified with one mol of a partial fatty acid ester containing three free hydroxyl groups, under conventional reaction conditions, with the elimination, respectively, of one, two or three mols of water of esterification, to form, respectively, a mono-, di- or tri-acid or tricarboxylic ester of the dimerized acid and the partial fatty acid ester.

If desired, the reaction products may be prepared by effecting esterification of the reactants in mineral oil solution. This expedient is advantageous in that it prevents localized overheating of the reactants. Moreover, the resulting reaction products are in the form of mineral oil concentrates, the use of which often facilitates solution of the additives in their ultimate vehicles.

The dimerized acids referred to above are dimers, i.e., bimolecular addition products of conjugated or unconjugated dienoic or trienoic fatty acids having from 6 to 22 carbon atoms before dimerization. Dimeric acids derived from dienoic and trienoic fatty acids are well known and can be prepared by conventional methods which form no part of this invention.

More particularly, dimerized acids capable of forming the compounds utilized in the composition of this invention are prepared from dienoic or trienoic fatty acids having the generic formula $C_nH_{2n-x}COOH$, where n is

an integer of from 5 to 21 and x is 3 or 5. As will be evident, such monomeric acids contain from 6 to 22 carbon atoms and may contain 2 or 3 ethylenic linkages as the ratio of carbon to hydrogen increases, i.e., as x increases from 3 to 5. Dimerized acids corresponding to the addition products of the foregoing acids therefore may be defined by the generic formula:



where n is an integer of from 10 to 42 and where x is an even integer of from 6 to 10. These dimeric acids are therefore dibasic or dicarboxylic acids having from 12 to 44 carbon atoms.

Representative members of the class of dimerized acids capable of forming the compounds employed in the compositions of this invention are dimers of dienoic acids such as sorbic (hexadienoic), linoleic (octadecadienoic), humoceric (nonadecadienoic) and eicosinic (eicosadienoic) acids. Dimers of trienoic acids, for example, linolenic and eleostearic (octadecatrienoic) acids also may be used.

It is not necessary that both of the unsaturated fatty acid molecules of the bimolecular addition product be identical. Dimers of mixed composition such as those obtained by dimerizing mixed dienoic, mixed trienoic or mixed dienoic and trienoic acids such as may be derived from certain naturally occurring drying oils, e.g., linseed oil and soybean oil, are quite satisfactory.

Dienoic and trienoic acids having 18 carbon atoms, especially those having conjugated olefinic linkages, are preferred for reasons of economy of procurement, ease of reaction and the general excellence of the additives prepared therefrom.

The partial esters of alkital anhydrides and fatty acids adapted for use in the formation of the reaction products are those resulting from esterification with the desired fatty acid of at least one, but less than all, of the available hydroxyl groups of an alkital anhydride. By alkital anhydride is meant an intramolecular, mono- or di-anhydride of a polyhydric alcohol which contains at least 4 carbon atoms and at least 4 hydroxyl groups, or mixtures of said anhydrides. Representative of the class of alkital are erythritol; pentitols, such as arabitol, xylitol and adonitol; and hexitols such as mannitol, dulcitol and sorbitol, just as the xylitans and sorbitans are representative of the alkital anhydrides, or alkitalans.

Fatty acids capable of forming partial esters of alkital anhydrides suited to the preparation of the additives utilized in this invention are the fatty acids containing from 12 to 24 carbon atoms. These acids may be saturated or unsaturated, and they may be substituted with groups which do not adversely affect the oil-solubility or corrosion-inhibiting properties of the final reaction product. Representative of this group of acids are lauric acid, oleic acid, ricinoleic acid, stearic acid and lignostearic acid.

Partial esters capable of reacting to form the reaction products include those formed by reacting a fatty acid of the foregoing kind with the desired alkital anhydride in a molar ratio of at least 1:1, but less than that which would result in neutralization of all of the hydroxyl groups of the alkital anhydride. The use of mixtures of partial fatty acid esters of alkital anhydrides is also included within the scope of the invention. Specific examples of partial esters of alkital anhydrides capable of reacting with dimeric unsaturated fatty acids to form acid esters which can be used in the composition of the invention are xylitan and sorbitan mono-, sesqui-, di- and tri-oleates and stearates. Partial esters of hexitol anhy-

drides, i.e., anhydrides of polyhydric alcohols containing 6 carbon atoms and 6 hydroxyl groups, are preferred.

The partial esters of alkital anhydrides disclosed herein as well as the method of preparing the same are conventional and form no part of the present invention. Accordingly, they need not be described in detail.

Representative specific examples of acid esters of dimeric acids with partial fatty acid esters of alkitalans which can be used in the compositions of this invention are the mono- and poly-carboxylic acid esters of dimerized linoleic, linolenic and eleostearic acids with sorbitan and xylitan mono-, sesqui-, di- and tri-oleates and stearates. Included within the foregoing representative class of compounds are mono-, di-, and tri-acid dilinoleic mono-, di- and tri-esters of sorbitan monooleate, mono- and di-acid dilinoleic mono- and di-esters of sorbitan dioleate, mono-acid dilinoleic mono-esters of sorbitan trioleate, mono- and di-acid dilinoleic mono- and di-esters of xylitan monooleate, mono-acid dilinoleic mono-esters of xylitan dioleate, and corresponding acid esters made from dimerized linoleic and eleostearic acids, as well as those made from partial esters of stearic acid.

The preparation of the class of compounds useful in the compositions of the invention can be further illustrated by the following specific example:

EXAMPLE I

An acid ester of a dimeric unsaturated fatty acid and a partial fatty acid ester of an alkital anhydride is prepared by admixture and reaction of 428 parts by weight of sorbitan monooleate (manufactured by the Atlas Powder Company of Wilmington, Delaware, and marketed under the name "Span 80") with 560 parts by weight of dimerized linoleic acid (manufactured by Emery Industries, Inc. of Cincinnati, Ohio, and marketed under the name of Emery 955 Dimer Acid). The reaction mixture is heated under reflux, until 18 parts by weight of water are trapped off, the maximum temperature reached by the reaction mixture being 500° F. The dimerized linoleic acid of this example has the following typical characteristics:

Physical state	Straw-colored viscous liquid.
Molecular weight	564 (approx.).
Gravity, ° API	13.0.
Viscosity, SUV, 200° F.	597.
Flash, OC, ° F	510.
Fire, OC, ° F	575.
Color, NPA	+10.
Iodine No., Mod. Hanus	83.3.
Saponification No	186.
Neutralization No	182.
Dimer content	85% (approx.).
Trimer and higher	12% (approx.).
Monomer	3% (approx.).

Typical properties of sorbitan monooleate are as follows:

Molecular weight	428 (approx.)
Gravity, ° API	10.1
Sp. gr., 60°/60° F	0.999
Lb./gal., 60° F	8.32
Viscosity, SUV:	
100° F	1827
210° F	108.3
Flash, P-M, ° F	400
Flash, OC, ° F	410
Fire, OC, ° F	450
Pour, ° F	+10
Physical state, room temp	Viscous liquid
Color, ASTM Union	4.5
Water by dist'n, percent	nil
Carbon residue, Conradson, percent	2.94
Neutralization value, ASTM D974-51T, total acid	
No	6.15
pH value, glass-calomel electrodes	7.0

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Saponification No., ASTM D94-48T-----	149.0
Acetyl value, Gulf 433-----	142
Ash, percent-----	0.212

The product obtained in the above-described reaction is a clear, viscous liquid containing predominantly mono-acid esters of dimerized linoleic acid and sorbitan mono-oleate, having the following typical physical properties:

Gravity, ° API-----	13.4
Sp. gr., 60°/60° F-----	0.977
Lb./gal., 60° F-----	8.13
Viscosity, SUV, sec.:	
100° F-----	9936
210° F-----	498
Flash, P-M, ° F-----	425
Pour, ° F-----	0
Physical state, room temp-----	Viscous liquid
Color, ASTM Union-----	6.0
Neutralization value, ASTM D974-51T, total acid No.-----	70
pH value, glass-calomel electrodes-----	4.6

The acid esters of other dimerized unsaturated fatty acids and other partial fatty acid esters of alkitol anhydrides are similarly prepared.

The amount of the acid ester employed in the composition of the invention depends upon the characteristic of the base oil as well as upon the amounts of other additive agents present. Satisfactory results can be obtained when the amount of acid ester comprises about 0.001 to about 1.0 percent by weight based on the weight of the total composition. A preferred range, however, comprises about 0.01 to about 0.2 percent by weight.

The substantially neutral salt of a primary fatty amine containing 8 to 18 carbon atoms per molecule and di oxo-octyl acid orthophosphate can be prepared in any suitable manner. The amine salt of the di oxo-octyl acid orthophosphate per se and its method of preparation is not a part of the present invention inasmuch as this compound and its preparation are fully set forth in U.S. Patent No. 2,863,904, which issued on December 9, 1958, to Troy L. Cantrell and John G. Peters. According to a preferred procedure, as disclosed in U.S. Patent No. 2,863,904, a di oxo-octyl acid orthophosphate is substantially neutralized by addition thereto of an approximately equimolar amount of a primary fatty (n-alkyl) amine containing 8 to 18 carbon atoms per molecule. The reaction proceeds spontaneously at room temperature with evolution of heat. The temperature of the reaction should be maintained below about 200° F. and preferably below about 180° F., in order to prevent water from splitting out of the addition salt reaction product. Control of the reaction temperature may be achieved, for example, by controlling the rate of addition of n-alkyl amine, or by external cooling, or both. The overall time required to complete the reaction will vary somewhat according to the method by which the temperature is controlled and according to the temperature at which the reaction is carried out. Normally, it will be desirable to continue to stir the reaction mixture after amine addition is complete for about the same length of time as required to add the amine, in order to insure completion of the reaction. Toward the end of the addition of the amine, it may be found convenient to measure the pH in order to insure that the reaction product will be substantially neutral, i.e., that it will have a pH of about 5.5 to about 7.5, and preferably about 7.

The di oxo-octyl ester of orthophosphoric acid used in making the amine salts for use in the composition of this invention also may be prepared in any suitable manner. For example, a preferred method involves addition of P₂O₅ to the oxo-octyl alcohol in a mol ratio of about 1:4, again maintaining the reaction temperature below about 180° F. by controlling the rate of addition of P₂O₅, or by external cooling, or by both. After addition of P₂O₅ is complete, the reaction mixture should be

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stirred until the product is clear. Some external heating, below about 180° F., may be desirable toward the end of the reaction in order to accelerate completion.

Amines that form suitable addition salts with the di oxo-octyl phosphates for use in the composition of the invention are primary n-alkyl amines containing 8 to 18 carbon atoms per molecule. An example of a preferred primary n-alkyl amine that forms suitable salts with the di oxo-octyl acid orthophosphate is n-dodecyl (lauryl) amine. It is not necessary that the amine be in pure form, and other amines can be present. In fact, excellent results have been obtained with addition salts prepared from mixtures of primary n-alkyl amines of the class disclosed. An example of a commercial mixture of amines that forms outstandingly effective addition salts with di oxo-octyl acid orthophosphate is cocoamine, which is a mixture of primary n-alkyl amines derived from coconut oil fatty acids. Cocoamine normally has a mol combining weight of about 210, a melting point of about 21° C., and is composed principally of n-dodecyl amine, together with lesser amounts of homologous, primary straight chain amines containing an even number of carbon atoms ranging from 8 to 18.

Examples of other amines within the disclosed class are n-octyl amine (caprylyl amine), n-decyl amine (capryl amine), n-tetradecyl amine (myristyl amine), n-hexadecyl amine (palmityl amine), and n-octadecyl amine (stearyl amine).

Diocetyl acid orthophosphates that form suitable compounds for the purposes of this invention are those derived from so-called "oxo-" octyl alcohols, which, as is known, are highly branched chain saturated aliphatic monohydric octyl alcohols prepared by the Oxo process. Briefly, this process involves the hydroformylation of olefinic hydrocarbons, followed by hydrogenation of the carbonylic compounds thus obtained. Normally, the olefinic hydrocarbons used in the manufacture of oxo-octyl alcohols are prepared by condensation of C₃ and C₄ olefins in the usual proportion in which they occur in refinery process gases. In this case, oxo-octyl alcohols normally will contain a mixture of branched chain isomers of octyl alcohol, and the mixture will consist mostly of isomeric dimethylhexanols. Although the above-indicated composition is the most common for oxo-octyl alcohols, it will be appreciated that the nature and proportions of the isomeric mixed alcohols can be varied to some extent by varying the proportions of the C₃ and C₄ olefins used in preparing the C₇ olefin to be hydroformylated.

The substantially neutral salt of a primary n-alkyl amine containing 8 to 18 carbon atoms per molecule and di oxo-octyl orthophosphate is preferably used in an amount between about 0.01 and about 0.2 percent by weight based on the weight of the total composition. However, improved results can be obtained with an amount between about 0.001 and about 1.0 percent by weight. In any event, the amine salt of di oxo-octyl orthophosphate is used in an amount sufficient to improve the load carrying capacity of the composition and to simultaneously overcome the deleterious load-decreasing effect caused by the addition of the alkyl phenol and the acid ester.

The preparation of a substantially neutral salt of a primary n-alkyl amine containing 8 to 18 carbon atoms per molecule and di oxo-octyl orthophosphate can be further illustrated by the following specific example:

EXAMPLE II

To 260 g. (2 mols) of oxo-octyl alcohol, which are placed in a 3-necked 2-liter flask equipped with a stirrer, thermometer and reflux condenser, are added 71 g. (0.5 mol) of phosphorus pentoxide and 110 g. of a light mineral oil. The reaction mixture thus formed is stirred for about 1 hour while maintaining the temperature of the mixture at 180° F. or below.

The oxo-octyl alcohol used in the reaction is obtained

by the hydrogenation of a hydroformylated mixture of heptene isomers. Typical properties of the oxo-octyl alcohol are as follows:

Specific gravity, 20°/20° C.....	0.8324
Viscosity, kinematic, cs., 20° C.....	12.43
Refractive index, n_D^{20}	1.4313
C ₈ alcohol content, percent by wt.....	99.3
C ₈ carbonyl content, percent by wt.....	0.06
Distillation, isooctyl alcohol, ASTM D1078-49T, ° C.:	
Over point.....	184.0
Dry point.....	188.5
10%	185.5
50%	186.4
90%	187.5

The product of the foregoing reaction is a mineral oil concentrate of di oxo-octyl acid orthophosphate. To 441 g. (1 mol) of the di oxo-octyl acid orthophosphate-oil solution thus obtained are slowly added 210 g. (1 mol) of cocoamine (Armeen CD, Armour & Co.), with stirring, the temperature of the reaction being maintained below about 180° F. to avoid splitting out water from the mixture. The mixture is brought to the desired pH of about 6.0 by the addition of sufficient cocoamine. The final mixture consisting principally of an oil solution of the n-dodecyl amine salt of di oxo-octyl acid orthophosphate is then stirred for about 1 hour.

The lubricating oil composition of this invention can contain other additive agents if desired to improve other specific properties without deleteriously affecting the beneficial properties of the composition. For example, the oil can contain a pour point depressor, a viscosity and viscosity index improver, a dye, a sludge inhibitor and the like. Also, if desired, the oil can contain a foam inhibitor such as organo-silicon oxide condensation products, organo-silicol condensation products and the like.

In preparing a compounded turbine oil, the lubricating composition, for example, also advantageously contains a metal alkyl thiophosphate. The metal component of the alkyl thiophosphate is a metal of group II of Mendeleeff's periodic arrangement of the elements. Included within this group are magnesium, calcium, zinc, strontium, cadmium and barium. However, other metals including aluminum, copper, lead, tin, iron and manganese can be employed. The alkyl substituents are preferably those containing between 3 and 12 carbon atoms. Examples of the alkyl groups which can be used are butyl, particularly tertiary butyl, amyl, isoamyl, tertiary amyl, hexyl, cyclohexyl, octyl, isooctyl, nonyl, decyl, dodecyl, and the like. While the mono-alkyl esters can be used, the di-alkyl esters are particularly suitable in preparing a turbine oil. Examples of the preferred compounds are zinc salts of dihexyl, dicyclohexyl and diisooctyl thiophosphoric acids. Such salts, when used, comprise about 0.01 to about 0.1 percent by weight of the total composition.

The individual constituents of the composition of this invention may be added to the lubricating oil base in any order or simultaneously, either per se or in the form of a mineral oil concentrate. The latter practice is desirable in order to facilitate compounding of the compositions.

The advantages obtained by using the improved lubricating composition of this invention as compared with similar compositions containing less than all of the addition agents are illustrated by the following specific examples. In these examples, the improved load-carrying properties are demonstrated by subjecting the various lubricating compositions to the 4-ball film breakdown test. The apparatus used in this test is the same as that used for the 4-ball wear test described in the Military Specification VV-L-791, Method 6503. This test unit contains a ball pot assembly in which three steel balls are securely fastened so that rotation of these balls is impossible. The ball pot assembly also acts as the lubricant reservoir. A fourth steel ball, in a rotating spindle,

is placed so that it is evenly supported by the other three balls forming a pyramid. The spindle speed is selected and an electrical heating unit heats the lubricant in the reservoir to the desired temperature. A load is applied to the lever arm which exerts a pressure on the three stationary balls and one rotating ball. At the end of a test run, the scar diameters on the three stationary steel balls are measured by a microscope with a calibrated scale. The actual pressure exerted on each point of contact is calculated as a function of the lever load and the scar diameter. The ultimate load-carrying capacity of the lubricant can be found by increasing the lever load until the oil film ruptures which is noted by a large increase in the scar diameter. The load-carrying capacity of a lubricant is the maximum load or pressure which can be sustained by the lubricant when used in a given system, under specific conditions, without permitting contact of surfaces as evidenced by adverse physical changes such as seizure, galling or welding. The tests reported hereinafter were run under the following conditions:

Spindle speed.....r.p.m.....	1800
Temperature of lubricant.....° F.....	266
Duration of test.....minutes.....	60

In conducting the foregoing test a base oil suitable for use in industrial machinery was used. It consisted of a blend of 51.3 percent by volume of a highly refined solvent-extracted Mid-Continent special oil having an API gravity between about 28.0° and 30.0° and having a viscosity of about 640 SUS at 100° F., 38.6 percent by volume of a solvent extracted Coastal B-1 oil having an API gravity between about 23.5° and 25.5° and a viscosity of about 1250 SUS at 100° F., and 10.1 percent by volume of a highly refined aluminum chloride treated paraffinic oil having an API gravity between about 26.5° and 28.5° and a viscosity of about 1156 SUS at 100° F. The oil in each instance also contained 3 p.p.m. of Dow-Corning silicone fluid 200 as a foam inhibitor.

The results of the foregoing tests are presented in Table I.

Table I

Composition, Percent by Wt.	A	B	C	D	E
Base Oil.....	100	98.875	99.875	98.750	98.812
2,6-di-tertiary-butyl-4-methylphenol.....		1.000		1.000	1.000
Dimerized linoleic acid-sorbitan monooleate acid ester.....		0.125		0.125	0.063
Cocoamine di oxo-octyl orthophosphate.....			0.125	0.125	0.125
Inspection: 4-Ball Film Breakdown.....					
Lever load at breakdown, kg.....	36	30	21	28	30
Scar diameter, mm.....	0.62	0.76	0.49	0.33	0.33
Specific pressure, p.s.i.....	69,800	38,300	64,000	187,000	204,100

From the foregoing specific pressure data, it will be seen that the cocoamine di oxo-octyl orthophosphate in combination with the base oil, alkyl phenol and dimerized linoleic acid-sorbitan monooleate acid ester (Compositions D and E) gave lubricating compositions having extremely high load-carrying properties. It will be noted from the specific pressure data that Composition B comprising the base oil, alkyl phenol and dimerized linoleic acid-sorbitan monooleate acid ester had only about one-half the load-carrying capacity of the base oil alone. It will be noted further that Composition C comprising the base oil and the cocoamine di oxo-octyl orthophosphate did not have an improved load-carrying capacity when compared with Composition A even though the scar diameter for Composition C was less than that for Composition A. It is therefore quite surprising that Compositions D and E which contain a combination of the alkyl phenol, dimerized linoleic acid-sorbitan monooleate ester and cocoamine di oxo-octyl orthophosphate should have

load-carrying capacities which are more than 2½ times the load-carrying capacity of the base oil alone. The load-carrying capacity of Composition D is about 5 times the load-carrying capacity of an otherwise identical composition (Composition B) but containing no cocoamine di oxo-octyl orthophosphate. In addition to their load-carrying property, Compositions D and E also have excellent rust-preventing, corrosion inhibiting and oxidation stability. Compositions similar to Compositions D and E which also contain from 0.01 to 0.1 percent by weight of a metal alkyl thiophosphate such as, for example, zinc dihexyl thiophosphate have properties which make them especially suitable for use as turbine oils.

While the invention has been described above with reference to certain specific embodiments thereof by way of illustration, it is to be understood that the invention is not limited to such embodiments except as hereinafter defined in the appended claims.

We claim:

1. An improved extreme pressure lubricating composition comprising a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to about 5.0 percent by weight of an alkyl phenol, said alkyl phenol containing at least one alkyl group containing between 3 and 12 carbon atoms, about 0.001 to about 1.0 percent by weight of an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing from 6 to 22 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing from 12 to 24 carbon atoms and an alkitol anhydride and about 0.001 to about 1.0 percent by weight of a substantially neutral addition product of di oxo-octyl acid orthophosphate and a primary fatty amine, said amine being a mono-alkyl amine containing from 8 to 18 carbon atoms per molecule.

2. An improved extreme pressure lubricating composition comprising a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to about 5.0 percent by weight of an alkyl phenol, said alkyl phenol containing at least one alkyl group containing between 3 and 12 carbon atoms, about 0.001 to about 1.0 percent by weight of an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing 18 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing 18 carbon atoms and a hexitol anhydride and about 0.001 to about 1.0 percent by weight of the cocoamine salt of di oxo-octyl acid orthophosphate.

3. An improved extreme pressure lubricating composition comprising a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to

about 5.0 percent by weight of a tertiary alkyl phenol, said tertiary alkyl phenol containing at least one alkyl group containing between 3 and 12 carbon atoms, about 0.001 to about 1.0 percent by weight of an acid ester of a dimer of linoleic acid and sorbitan monooleate and about 0.001 to about 1.0 percent by weight of the cocoamine salt of di oxo-octyl acid orthophosphate.

4. An improved extreme pressure lubricating composition comprising a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to about 5.0 percent by weight of 2,6-di-tertiary-butyl-4-methylphenol, about 0.001 to about 1.0 percent by weight of an acid ester of a dimer of linoleic acid and sorbitan monooleate and about 0.001 to about 1.0 percent by weight of the cocoamine salt of di oxo-octyl acid orthophosphate.

5. An improved turbine oil comprising a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to about 5.0 percent by weight of an alkyl phenol, said alkyl phenol containing at least one alkyl group containing between 3 and 12 carbon atoms, about 0.001 to about 1.0 percent by weight of an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing from 6 to 22 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing from 12 to 24 carbon atoms and an alkitol anhydride, about 0.001 to about 1.0 percent by weight of a substantially neutral addition product of di oxo-octyl acid orthophosphate and a primary fatty amine, said amine being a mono-alkyl amine containing from 8 to 18 carbon atoms per molecule and about 0.01 to about 0.1 percent by weight of a metal alkyl thiophosphate, said alkyl group containing between 3 and 12 carbon atoms.

6. An improved turbine oil comprising a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to about 5.0 percent by weight of 2,6-di-tertiary-butyl-4-methylphenol, about 0.001 to about 1.0 percent by weight of an acid ester of a dimer of linoleic acid and sorbitan monooleate, about 0.001 to about 1.0 percent by weight of the cocoamine salt of di oxo-octyl acid orthophosphate and about 0.01 to about 0.1 percent by weight of zinc dihexyl thiophosphate.

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