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LUBRICATING COMPOSITION

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7 Claims. (Cl. 252-48)

This invention relates, as indicated, to lubricants and more particularly to lubricating compositions capable of providing efficient lubrication under extreme pressure conditions, that is, of satisfactorily maintaining a lubricating film 5 between bearing or other metallic surfaces operating under such extremely high pressures as would ordinarily cause seizing or scoring of such surfaces if a plain mineral lubricating oil, for example, were employed. These lubricating com- 10 positions are characterized by the fact that they are generally more effective and at the same time more stable than those used heretofore.

This application is a continuation in part of December 4, 1934 and co-pending application Serial No. 737,070, filed July 26, 1934.

This invention further relates to a method of preventing seizing or scoring of relatively moving bearing surfaces and of reducing the wear or 20 friction between such surfaces. The addition of certain agents to lubricating compositions generally for the purpose of improving their extreme pressure characteristics is not new. It is generally recognized that the degree of effective- 25 ness of extreme pressure addition agents is usually directly proportional to their chemical or physico-chemical action on the bearing surfaces in producing a film which usually has an antifluxing function in preventing actual metal to 30 metal contact, and in addition, sometimes the function of producing a film which is more strongly attached to the metal surfaces than plain lubricating oils. Also, the action of the addition agents is to provide a film characterized 35 by the fact that the coefficient of friction between the surfaces where such film is maintained is generally lower than when ordinary lubricants are employed.

While a certain amount of chemical or phys- 40ico-chemical action by the addition agent upon the bearing surfaces is necessary and desirable in order that an extreme pressure film may be produced, the addition agent must, nevertheless, be sufficiently stable and relatively inactive so 45 that its activity along this line remains dormant under ordinary conditions and is only activated under the conditions of extreme pressure where its effectiveness is required for the stated purpose. In certain types of use, such as in crank- 50cases of internal combustion engines, and in lubricants added to motor fuels and thus introduced into the apparatus to be lubricated through the combustion zone, such relatively high temperatures are encountered that the re- 55 convenience, hereinafter be referred to as the sultant conditions tend to either decompose or render undesirably active many types of addition agents which are accordingly not usable in such an environment.

lubricating compositions such as refined mineral oil, due either to naturally occurring constituents in the base material or constituents in the finished product produced by refining processes, are relatively corrosive, particularly when used in conjunction with certain sensitive metals or alloys.

It is a principal object of this invention to provide a lubricating composition characterized by the fact that it contains an addition agent which may be effective not only for the purpose of imparting extreme pressure characteristics to the lubricant, but at the same time likewise effective as a corrosion inhibitor for certain active conmy copending application Serial No. 755,987, filed 15 stituents which may either be originally present or added to the composition for certain specific

results and which will otherwise be detrimentally active. It is a further object of this invention to pro-

vide a lubricating composition which may be characterized by the fact that all of the above named desirable characteristics are imparted thereto by means of a single addition agent.

Other objects of this invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the features hereinafter fully described, and particularly pointed out in the claims, the following description setting forth in detail certain embodiments of the invention, these being illustrative, however, of but a few of the various ways in which the principle of the invention may be employed.

Broadly stated, this invention comprises the use as and in lubricants of organic compositions containing phosphorus and sulphur. These compositions are generally of the type which may be produced by reacting organic compositions with phosphorus and sulphur-containing reagents.

More specifically, this invention contemplates the use for the above purposes of organic compositions which (before reacting with the above referred to reagents) may desirably contain an organic oxygen compound and preferably a compound including a hydroxyl group which may advantageously be attached to a benzenoid ring structure.

Throughout the ensuing description of this invention, the above described material indicated as usable either by itself as a lubricant or in minor amounts as an addition agent to other lubricating compositions for the purpose of improving the characteristics of the same will, for addition agent.

As above indicated, the addition agent is of the type produced by reacting an organic composition with certain reagents which contain either It is also generally accepted that many plain 60 separately in combined or elemental form, or in combination, phosphorus and sulphur. The addition agent thus produced may, in most cases, be described as an organic composition contain-

ing both the elements, phosphorus and sulphur. The type of organic base composition contemplated for use in the reaction above described, by which the addition agents are produced, is represented by the following examples:

represented by the following examples:		
I. Hydrocarbons, preferably containing more than four (4) carbon atoms	e 10	
A. Chain type (acyclic)		
(1) Paraffins, e. g.		
Pentane Hexane		
Octane	15	
Decane		
Acyclic terpenes		
(2) Olefines, e. g.		
Hexylene Di-butylene	20	
Di-iso-butylene		
Amylene		
(3) Acetylenes, e. g.		
Butine, crotonylene		
Pentine, valerylene	25	
Hexine, hexoylene Heptine, oenanthylidene		
Octine, caprylidene		
Decine, menthene		
Dodecylidene	30	
B. Cyclic	·	
(1) Cyclo-aliphatic, e. g.(a) Naphthenes, e. g.		III.
Cyclopentane		
Cyclohexane	35	
Cyclo-octane		
(b) Cyclo-olefins, e. g.		
Cyclobutene		
Cyclopentene Cyclohexene	40	
(c) It will be noted that certain of		
the above, i. e., cyclohexane		
and cyclohexene, are also hy-		
dro-aromatic compounds, of	45	
which the following are ad- ditional examples:	40	
The hydro-diphenyls		
The hydro-naphthalenes,		
e.g., hexa- and dodeca-		
hydro-naphthalenes tet-	50	
ra- and decahydronaph-		
thalenes The hydro-anthracenes		
The hydro-phenanthrenes		
The hydro-retenes	55	·
(2) Aromatic, e. g.		
Benzene		
Di-phenyl Naphthalene		
Anthracene	60	
Phenanthrene		
Bridged ring hydrocarbons, e. g.		
aromatic terpenes such as		
pinene Homology of the shore well	65	
Homologs of the above such as alkylated aromatic hydrocar-		
bons, e. g. methyl, ethyl, propyl		
and iso-propyl, butyl, ampl. etc.		
benzenes, diphenyls, naphtha-	70	
lenes, anthracenes, phenan-	10	
threnes-more specific exam-		
ples are toluene, xylene, ethyl- benzene, cumene, cymene α		
methyl naphthalene, retene		
	75	

Aromatic hydrocarbons with one or more unsaturated sidechains, such as phenyl ethylene (styrene)

- 5 II. Naturally occurring, or commercially available complex compositions consisting principally of hydrocarbons
 - A. Petroleum and petroleum derivatives, such as crude mineral oils of paraffinc. naphthenic, or asphaltic character and from various sources including the Penna., Mid-Cont., and Coastal fields; and products refined from them, e.g. Bright stock
 - Neutral or pale oils
 - Steam refined oils
 - Fuel oils
 - Kerosene
 - Gas oils

 - Gasolines
 - Paraffin wax (or petroleum wax) Petrolatum
 - Solvent extracted fractions, e. g. Edeleanu extract
 - **Furfural** extract
 - B. Hydrocarbon materials of non-mineral origin, e. g. hydrocarbon products of vegetable origin such as certain oils obtained from the distillation of wood, etc., e. g.
 - Retene oil
 - Turpentine
 - Oxygen-bearing organic compounds (including oxygen-bearing derivatives of hydrocarbons in Groups I and II above) may be classified according to the nature of attachment of the oxygen atom, viz:
 - (a) Directly attached to one or more carbon atoms, as in the case of:
 - (1) Ethers and analogous compounds,
 - (2) Compounds containing the
 - -с-оп

radicle, such as the alcohols and other derivatives of carbinol (including phenols, cresols, naphthols, etc.)

- (3) Compounds containing the carbonyl
 - C=0

radicle, such as amides, aldehydes, ketones, organic acids, esters and salts of organic acids, thio-acids and esters of thio-acids.

- (4) Compounds in which oxygen forms a part of the ring structure, e. g. furan and its derivatives, etc.,
- (5) Compounds with an inorganic radicle where the oxygen is directly attached to a carbon atom Arsenite Hypochlorite Phosphite Thiophosphate Thiophosphite β-Hydroxylamines

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(b) Indirectly attached through the		Aliphatic	Aromalic
means of some other atom, i. e., in		Et	hers
the form of an inorganic radicle, e.g.;		Di-ethyl ethers	Diphenyl ethers
Arsenate	5	Propyl and isopropyl ethers	Dixenyl ethers
Chlorate		Butyl and isobutyl	Dinaphthyl ethers
Chlorite		ethers	
Cyanate «-Hydroxylamine		Amyl ethers	
Nitrate	10	Mireo	l ethers
Nitrite			
Nitro		Ethyl propyl ethers Methyl butyl ethers	Phenyl naphthyl ethers
Nitroso Oxime		Methyl Dutyl ethers	Phenyl ethyl ethers Phenyl propyl ethers
Perchlorate	15	Hadron	y ethers
Phosphate	10	*1907.02	y ethers
Sulphate		Glycol ether	Mono-methyl ethers of
Sulphite		(diethylene-glycol) Mono-alkyl esters of	dihydroxy phenols,
Sulphinic acid Sulphone	20	dihydric alcohols, e. g	e.g. 3. Methoxy phenols
Sulphonic acid	20	Mono-methyl ester	, monthly protons
Sulphoxide		of ethylene	
Thio-sulphate		glycol	
The following are specific examples of suitable	25	Ket	ones
oxygen-bearing compounds:	20	Acetone	Benzophenone
Aliphatic Aromatic		Di-ethyl ketone	Naphthyl ketones
Alcohols		Di-propyl ketones	• • ····
Methyl alcohol Benzyl alcohol	90	Mirod	ketones
Ethyl alcohol Phenyl ethyl alcohol	30		
Propyl and iso-propyl			Acetophenone Ethyl phenyl ketone
alcohols			Propyl phenyl ketones
Butyl and iso-butyl	05		Mixed long chain aryl
alcohols Amyl alcohols	35		ketones, such as
Lauryl alcohol			Dibenzofuryl hep-
Cetyl alcohol			tadecyl ketone Dibenzofuryl undecyl
Polyhydroxy alcohols;			ketone as described
Dihydroxy alcohols, e. g.	40		in U.S. Pat. No. 2,-
Ethylene glycol			033,548
Di-ethylene glycol		Cyclo-	ketones
Tri-hydroxy alcohols,	15	Cyclohexanone	Quinone
e. g. Glycerine	40		Anthraguinone
-		4130	hudaa
Phenols			hydes
Monohydroxy, e. g.	50	Acetaldehyde Propyl aldehydes	Benzaldehyde
Phenol Alkyl phenols, e. g.	90	110py1 aluenydes	Salicyaldehyde Naphthyl aldehydes
Cresols			
Xylenols			cids
Ethyl phenols		Fatty acids, e. g.	Monocarboxylic, e. g.
Propyl and iso- propyl phenol	55	Saturated: Acetic	Benzoic Phenyl acetic
Amyl phenols		Propionic	Phenyl propionic
Phenyl phenols		Butyric	Phenyl acrylic
Naphthols		Lauric	(cinnamic)
Polyhydroxy, e. g. Dihydroxy, e. g.	60	Palmitic Stearic	Salicylic Polycorrboyylic o g
Dihydroxy benzenes		Unsaturated:	Polycarboxylic, e. g. Phthalic
Pyrocatechin		Oleic	Hydroxy:
(catechol)		Hydroxy:	Salicylic
Resorcinol	65	Lactic Bisingleig	
Hydroquinone Dihydroxy diphenyls		Ricinoleic	
Tri-hydroxy, e. g.		Est	ters
Tri-hydroxy benzenes		Esters of an aliphatic	Esters of a phenol (such
Pyrogallol	70	alcohol (such as those	as those listed above
Hydroxy-hydro-		listed above under "Al-	
quinone Phloroglucinol		cohols") and a fatty acid; (such as those	a fatty acid (such as those listed above under
Others, e. g.		listed above under	"Acids") e. g.
Rufigallol		"Acids") e. g.	

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Esters Aliphatic	Aromatic		Hydrocarbon materials Petroleum derivatives, particularly mineral oll,
MethylPhenylEthylAcetateandPropylPropionateAcButylButyratePrAmylLaurateLaCetylPalmitatePaEthyleneOleateSt	l, phenyl-phenyl, naphthyl: etate opionate ityrate urate lmitate earate	5 10	for example Bright stock (preferably Pennsylvania) Neutral or pale oils Oxygen-bearing organic compounds Phenol Cresols Diphenyl ether Stearic acid Benzyl alcohol
Glyceryl Glyceryl Esters alcoho listed a cohols' acid listed	eate of an aromatic l (such as those above under "Al- ') and a fatty (such as those above under ") e. g.	15	Lauryl alcohol Oxidized hydrocarbons including oxidized mineral oils Naphthenic acid Methyl stearate Butyl stearate Methyl salicylate Oleic acid
Benzyl a Acet Prop	nd phenyl-ethyl ate pionate yrate	20	Fatty oils such as lard oil Halogen-bearing organic compounds Mono- and dichlor xylene Mono- and dichlor cresol Para- and orthochlorphenol
Paln Stea Olea Esters	nitate rate te of an aliphatic	25	Monochlor pentane (chlor amyl phenol) Chlorinated diphenyl ether, for example tri- chlor diphenyl ether and hexachlor di- phenyl ether Mono- and dichlor benzyl alcohol
listed a cohols' matic those	l (such as those above under "Al- ") and an aro- acid (such as listed above "Acids") e.g.	30	Methyl dichlor stearate The reagents which may be employed with the above defined organic base compositions in pro- ducing the so-called addition agents, according to this invention, are, as previously indicated,
Methyl Ethyl Propyl Butyl Amyl Lauryl Cetyl	Benzoate Phenyl acetate (Salicylate Phthalate	35 40	characterized by their containing free or com- bined phosphorus and sulphur, either present in the same or different compounds and either in elemental or combined form. Those containing the above-named elements in combined form may generally be classified as follows: <i>Reagents</i>
Ethylene Diethylene			A. Phosphorus compounds
Glyceryl Esters of fatty acids derived fro curring fatty oils and waxes, an genated acids derived from like) om naturally oc- ad of the hydro- sources, e. g.	45	1. Compounds of phosphorus and halogen Phosphorus chloride—P2Cl4 Phosphorus tri-chloride—PCl3 Phosphorus pentachloride—PCl5 Phosphorus dichlor trifluoride—PCl2F3
Methyl, ethyl, butyl, etc. er fatty acid, palm fatty acid after hydrogenation. Naturally occurring, or comme complex oxygen-bearing organ	id, or the same ercially available	50	2. Compounds of phosphorus and oxygen Phosphorus trioxide—P4O6 (or P2O3) Phosphorus tetraoxide—P2O4 Phosphorus pentoxide—P2O5 (or P4O10)
such as: Non-mineral oils and waxes, e. g Fatty oils, including: Animal oils, Fish oils	3.	55	3. Compounds of phosphorus, oxygen and halogen Phosphorus oxychloride POCl ₃ Phosphorus trioxytetrachloride—P ₂ O ₃ Cl ₄
Lard oil		60	4. Elemental phosphorus
Vegetable oils, Cottonseed oil			B. Sulphur compounds
Rape seed oil Corn oil Castor oil	· .	65	1. Sulphur and halogen Sulphur monochloride—S ₂ Cl ₃ Sulphur trichloride—SCl ₂
Soya bean oil Waxes of animal or vegetable Carnauba wax Palm wax	origin:		2. Sulphur and oxygen Sulphur dioxide—SO ₂ Sulphur trioxide—SO ₃ Sulphur heptoxide—S ₂ O ₇
Beeswax Japan wax Of the foregoing named organ tions, the following are among		70	3. Sulphur, oxygen and halogen Sulphur monoxytetrachloride—S2OCl4 Sulphur pentoxydichloride—S2O5Cl2 Sulphuric oxychloride—S02Cl2
able:		75	Sulphurous oxychloride—SOCl ₂

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4. Elemental sulphur

C. Phosphorus and sulphur compounds

- 1. Compounds of phosphorus and sulphur alone
 - Phosphorus disulfide-P3S6 (or PS2) Phosphorus trisulphide-P4Ss (or P2S3) Phosphorus sesquisulphide-P4S3 Phosphorus pentasulphide— P_2S_5 (or P4S10) 10

Phosphorus heptasulphide-P4S7

- 2. Compounds of phosphorus, sulphur and halogen
 - Phosphorus thiochloride—PSCl3 Phosphorus thiobromide—PSBr3 Phosphorus thiobromide-P2S3Br4
- 3. Compounds of phosphorus, sulphur and oxygen
 - Phosphorus sulphoxide-P4S4O6
- 4. Compounds of phosphorus, sulphur and elements other than oxygen or halogen Phosphorus thiocyanate-P(CNS) 3
- D. Reagents containing elements equivalent to 25 phosphorus and/or sulphur
 - 1. Compounds of phosphorus and equivalents of sulphur, e. g. Se, for example P₂Se

P₂Se₃

P2Se5

It will be noted that since the so-called addition agent produced by the above referred to reaction shall contain both phosphorus and sul- 35 phur, and advantageously phosphorus, sulphur and oxygen, organic compounds and the reagents selected shall be such as to produce the addition agent of the desired character.

The following is a list of particularly suitable 40 addition agents. Since the addition agents in the list are identified according to the organic compounds and reagents used in their preparation, it includes typical examples of suitable organic compounds and reagents. 45

A. Reaction products of the following organic compounds with phosphorus pentasulphide (P2S5):

(2	205)		
	Stearic acid		
	Lauryl alcohol	50	
	Benzyl alcohol		
	Phenol		_
	Butyl stearate		B.
	Methyl salicylate		
	Naphthenic acid	55	
,	Diphenyl ether		
	Cresylic acid (cresol)		
•	Mineral oils such as bright stocks and neutrals (preferably Penn.)		
	Oxidized mineral oils	60	
	Fatty oils such as lard oil	•	
	Chlorinated diphenyl ether, particularly		
	trichlor diphenyl ether and hexachlor		
	diphenyl ether		
	Mono- and dichlor benzyl alcohol	65	
	Para- and orthchlor phenol		
B. Read	ction products of the following organic		
CO	mpounds with phosphorus sulphochloride		المحم
(P	SCI3)	-	wh
		70	ors

Mineral olis such as bright stocks and neutrals (preferably Penn.) Oxidized mineral oils Naphthenic acid Methyl stearate 75

Fatty oils such as lard oil Methyl salicylate Stearic acid Oleic acid Diphenyl Dichlor xylene Dichlor cresol Orthochlor phenol Monochlor amyl phenol Methyl dichlor stearate Chlordiphenyl

- C. The reaction products of thiophenol and chlorinated thiophenol with phosphorus **trichloride**
- D. The reaction products of thiophenol and chlorinated thiophenol with phosphorus oxychloride
- 20 E. The reaction products of chlorinated tricresyl phosphate (one or more chlorine atoms on one or more methyl groups) with sodium polysulphide.
 - F. The product produced by reacting with phosphorus oxychloride (POCl₃)
 - (a) The reaction product of phenol with phosphorus pentasulphide (P2S5) and
 - (b) The reaction product of orthochlorphe-

nol with phosphorus pentasulphide.

The foregoing typical examples will be sufficient for those skilled in the art in utilizing the named reagents as well as their equivalents in producing the addition agents of this invention.

The foregoing method of preparing the addition agent contemplated herein involves the use of reagents containing both phosphorus and sulphur or separate reagents which include both phosphorus and sulphur. Methods of preparing these addition agents other than that described above may be used, for example, by reaction of the following:

- A. Organic sulphur compounds with phosphorusbearing reagents, e.g.
 - (1) Mercaptans (including thio-alcohols and thio-phenols) with (a) POCla

(b)	PCl ₃		
(C)	PSCl ₃		
(d)	P2O5		
(e)	PC15		
nio phoenteres			

Organic phosphorus compounds with sulphurbearing reagents, e.g.

- (1) Chlorinated organic phosphates or phosphites, (preferably with chlorine attached to aliphatic radicle) with Inorganic sulphide or polysulphide
- (2) Organic phophates and phosphites (preferably containing unsaturated organic radicles or products of incomplete reaction of organic hydroxy compounds with phosphorus-bearing reagents such as POCl3 and PCl3) with
 - (a) SCl₂

(b) SCl₂
(c) Elemental sulphur

Certain of the addition agents themselves, hich have been previously generically defined as organic compounds containing both phosphorus and sulphur, may be generically, subgenerically and specifically classified in the following manner:

(1) Organic compounds containing both phosphorus and sulphur

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- (2) Organic compounds containing phosphorus, sulphur and oxygen
- (3) Any of the foregoing compounds which contain a halogen.

A slightly different classification for certain 5 types of the compounds usable as so-called addition agents, in accordance with this invention, is

- (1) Esters of phosphorus- and sulphur-containing acids, e.g.
 - Esters of tri-thiophosphorus acid and
 - Tetrathiophosphoric acid
- (2) Esters of phosphorus-, sulphur- and oxygen-containing acids, e. g.,
 - Esters of thiophosphorus, thiophosphoric and
 - Tri-thiophosphoric acids
- (3) Any of the previously mentioned compounds which contain a halogen.

Among the specific examples of addition agents contemplated for use in accordance with this invention which have been previously somewhat more generically defined, the following compounds may be mentioned, viz:

Tri-butyl thiophosphate

Triphenyl thiophosphate

Tri-benzyl thiophosphate

Tri-cresyl thiophosphates, e.g., tri-(ortho-cresyl) thiophosphate

Tri-butyl tri-thiophosphate

Triphenyl trithiophosphate

Tricresyl trithiophosphate Tributyl trithiophosphite

Triphenyl trithiophosphite

Tricresyl trithiophosphite

Tri-(chlor ethyl) thiophosphate

Tri-(orthochlor phenyl) thiophosphate

Tri-(orthochlor phenyl) trithiophosphate

Tri-(dichlor xylyl) thiophosphate

Tri-(dichlor cresyl) thiophosphate

Tri-(monochlor amyl phenyl) thiophosphate

Tri-(chlorbenzyl) thiophosphate

Tribenzyl trithiophosphate

Tri-lauryl trithiophosphate

Tri-(orthochlor phenyl) trithiophosphite

As previously indicated, the above named addition agents are usable either by themselves as lubricants or advantageously in small amounts as 50 found to very materially improve the viscosity addition agents to other lubricating compositions. Their particular effectiveness in very small amounts for the purposes previously specified and hereafter explained in greater detail makes the so-called addition agents especially desirable for 55 use in lubricating compositions comprising any of the well known oils usually used as lubricants, such as mineral oil, non-mineral oils such as animal and vegetable oils e. g. rape-seed oil, castor oil, or, for certain uses, desirable combinations of 60such oils.

It has been found that when a refined mineral lubricating oil base is used, the previously named desirable properties may be imparted thereto by the use of the named addition agents in amounts 65 upwards of 0.10%. The amount of addition agent used in excess of the stated minimum depends of course upon the particular use for which the resultant composition is designed; in preparing a lubricant for use in the crank case of 70 of the addition agents as will not react chemiinternal combustion engines, the composition will be found to give superior results if it contains from about 0.10% to about 2% of the addition agents.

conditions of higher pressure where generally temperatures lower than those in a crank case are encountered, for example in lubricating heavily loaded gears and bearings, the addition agent may be present in greater amounts, i. e., up to 5 and, in certain cases, desirably up to 10 and 20%

may be employed. The principal advantages resulting from the

use of the named addition agents in lubricating 10 compositions of the character described are as follows: The addition agents will be found to impart substantial extreme pressure characteristics to the lubricant. The addition agents containing phosphorus, sulphur, halogen and oxy-15 gen will be found, in general, to be more effective than those containing only phosphorus, sulphur and oxygen, and the latter will generally be found to be more effective as extreme pressure addition agents than those which contain only 20 phosphorus and sulphur.

Certain of the addition agents have an inherent property of inhibiting corrosion of metallic surfaces by such constituents as are usually present either by virtue of being contained in the mineral

- 25 oil, created in the mineral oil during the refining process, or intentionally added thereto for the purpose of producing a particular result. The addition agents which contain halogen thus have the remarkable combination of desirable properties of imparting unusually high extreme pres-30 sure values to the composition, while at the same time rendering the same particularly stable and non-corrosive under ordinary conditions.
- The oiliness factor of a lubricant, to which 35 certain of the named addition agents have been added, has been found to be measurably improved over similar untreated lubricating compositions with which they have been compared.
- The tendency of the lubricating composition to 40 form sludges resulting either from oxidation on standing or under conditions of use is generally considerably reduced by the presence therein of the addition agent. If any sludge constituents are formed in the lubricating composition con-
- taining the addition agents, the latter have a 45 marked tendency to render harmless such constituents so that even so formed, their presence in the composition is not objectionable.

Certain of the named constituents have been index and cold test characteristics of mineral

lubricating oils to which they have been added. The stability and volatility of the addition agents should be such that under conditions encountered in service the concentration of the addition agent in the lubricant will not be substantially reduced because of its loss by evaporation or by decomposition.

For most uses the addition agent should have a vapor pressure less than atmospheric at a temperature of 140° C.; and if the lubricant is to be subjected to elevated temperatures in use, less than atmospheric at 170° C.

The stability of the addition agent should be such that decomposition shall be negligible at temperatures to which the lubricant will be exposed in service.

By the term "non-corrosive" as used herein and in the appended claims is meant such forms cally to a substantial and continuing extent with the bearings and other metallic parts exposed to the lubricant excepting under conditions of extreme pressure and the like, nor cause damaging If the resultant composition is to be used under 75 corrosion of such metallic parts.

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The foregoing statements as to non-corrosiveness, stability and volatility of the addition agents applies particularly to compositions made in accordance with this invention and used as lubricants and especially when such lubricants are employed under conditions of extreme stress such as imposed by high temperature, extremely high pressure and the like. There are, however, certain uses such as in metal working, die drawing and the like where relatively more active, i. e., 10 relatively corrosive, addition agents of the character referred to herein may be employed to advantage.

While the lubricating compositions which have been described herein as illustrating one embodi- 15 portion of tri(orthochlorphenyl) thiophosphate. ment of the invention have been generally referred to as "oils," i. e., liquids, this invention is, however, also applicable to the solid and semisolid types of lubricants commonly referred to in the trade as greases, bodied oils, etc. In this 20 jor proportion of mineral oil and a minor amount connection, it should be noted that certain of the addition agents contemplated for use herein for the purpose of imparting extreme pressure characteristics to the lubricant may be employed for the additional purpose of bodying or thicken- 25 ing the lubricant to which they are added.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the materials employed in carrying out the process, provided the ingredient or ingredients stated in any of the following claims or the equivalent of such stated ingredient or ingredients be employed.

I, therefore, particularly point out and distinctly claim as my invention:

1. A lubricating composition comprising a halogenated aromatic thiophosphate.

2. A lubricating composition comprising a major proportion of mineral oil and a minor amount of a halogenated aromatic thiophosphate.

3. A lubricating composition comprising a major proportion of mineral oil and a minor pro-

4. A lubricating composition comprising a major proportion of mineral oil and a minor amount of tri(monochlor amyl phenyl) thiophosphate.

5. A lubricating composition comprising a maof a chlor-phenyl thiophosphate.

6. A lubricating composition comprising a major proportion of mineral oil and a minor amount of a chlor-benzyl thiophosphate.

7. A lubricating composition comprising a major proportion of mineral oil and a minor amount of tri(chlor-benzyl) thiophosphate.

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