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(54) **A gear oil composition with improved properties**

(57) A lubricating oil composition containing an additive composition comprising an alkali metal borate; an

oil-soluble sulfur-containing compound; and a trialkyl phosphite, which improves the high temperature load-carrying properties in gears.

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Description

[0001] The present invention relates to a novel lubricating oil composition having improved extreme pressure and antiwear properties. The novel lubricating oil composition comprises an alkali metal borate, an oil-soluble sulfur-containing compound, and a trialkyl phosphite. The unique combination of compounds provides improved load-carrying performance, especially at high temperatures, in gears.

BACKGROUND OF THE INVENTION

[0002] The need to increase truck productivity (reduce maintenance) has forced the original equipment manufacturers (OEMs) to update their specifications and increase their drain intervals. For example, in recent years, most of the U.S. heavy-duty axle and transmission OEMs updated their specifications for rear axles and transmission lubricants (extended warranty) from a 250,000-mile drain interval to a 500,000-mile drain interval.

[0003] Among the many requirements in these updated specifications, surface fatigue protection, oxidation and thermal stability are key performance areas for oils intended for extended drains. For example, Eaton in its rear axle 250,000-mile specification evaluated the load-carrying capacity of the gear oils using two test procedures: the CRC L42 (load-carrying capacity under conditions of high-speed shock loading) and the CRC L37 (load-carrying capacity under conditions of low speed and high torque). Currently, in Eaton's updated rear axle specification (500,000-mile), the load-carrying capacity of the gear oils is evaluated using five test procedures. Among these five performances, which evaluate the capacity of the oil to protect the gears, the load-carrying capacity under conditions of elevated temperatures, low speed and high torque (evaluated using the Eaton High Temperature L37) is one of the most difficult to meet.

[0004] The present invention relates to extreme pressure lubricating oils that meet the newer, more stringent load-carrying capacity requirements of OEMs.

[0005] Alkali metal borates are well known in the lubricant industry for their usefulness as extreme pressure agents. See, for example, U.S. Patent Numbers 3,313,727; 3,565,802; 3,819,521; 3,846,313; 3,853,772; 3,907,691; 3,912,639; 3,912,643; 3,912,644; 3,997,454; and 4,089,790.

[0006] U.S. Patent Number 4,459,215 discloses a lubricating composition containing an alkali metal borate, a sulfur-containing compound and a zirconium salt.

[0007] U.S. Patent Number 4,575,431 discloses a lubricating oil containing a mixture of phosphates said phosphates being essentially free of monothiophosphates.

[0008] U.S. Patent Number 4,089,790 discloses a synergistic lubricant mixture containing: (1) a hydrated potassium borate; (2) an antiwear agent selected from

(a) zinc dihydrocarbyl dithiophosphate, (b) C₁-C₂₀ ester, C₁ to C₂₀ amide or C₁ to C₂₀ amine salt of a dihydrocarbyl dithiophosphoric acid, (c) zinc alkyl aryl sulfonate, and (d) mixture thereof; and (3) oil soluble antioxidant organic sulfur compound.

[0009] U.S. Patent Number 4,171,268 discloses lubricant compositions containing a zirconium salt of a carboxylic acid and oil-soluble sulfur-containing extreme pressure agent.

[0010] U.S. Patent Numbers 4,563,302 and 4,204,969 disclose sulfurized olefins useful in lubricating oils. These patents teach that it is one object of the inventions to therein provide an alkali metal borate-containing lubricant which has superior load-carrying properties.

[0011] U.S. Patent Number 4,717,490 discloses an alkali metal borate-containing lubricating oil containing: (1) an alkali metal borate; (2) an oil-soluble sulfur compound; (3) a dialkyl hydrogen phosphite; and (4) a mixture of neutralized phosphates, said phosphates being essentially free of monothiophosphates which provides a lubricant with superior load-carrying properties. However, this lubricating oil fails to provide high temperature load-carrying performance unless the dialkyl hydrogen phosphite is at 4 wt %. However, at 4 wt %, there are compatibility problems with sediment formation, haze, and floc.

[0012] Accordingly, there is a need to have available a lubricating oil composition that can meet modern high temperature load-carrying performance required by OEMs.

SUMMARY OF THE INVENTION

[0013] It has been found that a lubricating oil containing an alkali metal borate, an oil-soluble sulfur-containing compound, and a trialkyl phosphite provides surprisingly improved load-carrying capacity, especially at high temperatures, thus reducing wear on the gears commonly found, for example, in transmissions, axles, trans-axles and industrial machinery, such as stationary gear boxes.

[0014] In its broadest embodiment, the present invention relates to a lubricating oil composition comprising:

- a) a major amount of an oil of lubricating viscosity,
- b) a hydrated alkali metal borate,
- c) an oil-soluble sulfur-containing compound, and
- d) a trialkyl phosphite.

[0015] The present invention also relates to a lubricating oil additive composition comprising a mixture of:

- a) a hydrated alkali metal borate,

- b) an oil-soluble sulfur-containing compound, and
- c) a trialkyl phosphite.

[0016] Furthermore, the present invention also relates to an additive concentrate containing a diluent and the lubricating oil additive composition of the present invention.

[0017] A minor but effective amount of the concentrate of the present invention may be incorporated into a major amount of lubricating oil to improve the high temperature load-carrying performance by the lubricating oil composition.

[0018] This invention further provides a method of producing the lubricating oil of the present invention by blending a mixture of a major amount of an oil of lubricating viscosity and effective amount of a hydrated alkali metal borate, an oil-soluble sulfur-containing compound, and a trialkyl phosphite to improve the high temperature load-carrying properties.

[0019] Among other factors, the present invention is based on the surprising discovery that the high temperature load-carrying performance of gears can be improved by lubricating the gears with the lubricating oil composition of the present invention. Additionally, the lubricating oil composition of the present invention is more cost-effective than other lubricating oil compositions containing dialkyl phosphites because trialkyl phosphites are less expensive.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The lubricating oil composition of the present invention comprises a major amount of a base oil of lubricating viscosity, a hydrated alkali metal borate, an oil-soluble sulfur-containing compound, and a trialkyl phosphite.

Definitions

[0021] Prior to discussing the present invention in detail, the following terms will have the following meanings unless expressly stated to the contrary.

[0022] The term "gears" generally refers to a toothed wheel, cylinder, or other machine element that meshes with another toothed element to transmit motion or to change speed or direction. Examples of gears are, but are not limited to, spur, bevel, hypoid, spiral bevel, worm, helical, and herringbone.

[0023] The term "hydrocarbyl" refers to an organic radical primarily composed of carbon and hydrogen which may be aliphatic, alicyclic, aromatic or combinations thereof, e.g., aralkyl or alkaryl. Such hydrocarbyl groups are generally free of aliphatic unsaturation, i.e., olefinic or acetylenic unsaturation, but may contain minor amounts of heteroatoms, such as oxygen or nitrogen, or halogens, such as chlorine.

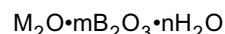
[0024] The term "base oil of lubricating viscosity" gen-

erally refers to an oil having a viscosity of 3 to 45 cSt at 100°C in the case of lubricating oil compositions and may be a single oil or a blend of oils.

The Hydrated Alkali Metal Borates

[0025] Hydrated alkali metal borates are well known in the art and are available commercially. Representative patents disclosing suitable borates and methods of manufacture include: U.S. Pat. Nos. 3,313,727; 3,819,521; 3,853,772; 3,907,601; 3,997,454; and 4,089,790, the entire disclosures of which are incorporated herein by reference.

[0026] The hydrated alkali metal borates can be represented by the following formula:



where M is an alkali metal of atomic number in the range 11 to 19, i.e., sodium and potassium; m is a number from 2.5 to 4.5 (both whole and fractional); and n is a number from 1.0 to 4.8. Preferred are the hydrated potassium borates, particularly the hydrated potassium triborate microparticles having a boron-to-potassium ratio of about 2.5 to 4.5. The hydrated borate particles generally have a mean particle size of less than 1 micron.

The Oil-Soluble Sulfur Compounds

[0027] Any of the known types of organic sulfur compounds which have heretofore been suggested as being useful as extreme pressure (EP) agents may be used as a sulfur-containing agent in the present invention. These include organic sulfides and polysulfides, sulfurized oils and esters or fatty acids, and mixtures thereof. These sulfur compounds may contain other groups which are beneficial and these include halogen groups.

[0028] Examples of organic sulfides and polysulfides which are useful as EP agents include aliphatic and aromatic sulfides and polysulfides such as hexyl sulfide, octadecyl sulfide, butyl disulfide, amyl disulfide, hexyl disulfide, octadecyl disulfide, diphenyl sulfide, dibenzyl sulfide, dicyllyl sulfide, diphenyl disulfide, dinaphthyl disulfide, diphenol disulfide, dibenzyl disulfide, bis(chlorobenzyl) disulfide, dibenzyl trisulfide, dibutyl tetrasulfide, sulfurized dipentene and sulfurized terpene.

[0029] A preferred class of sulfur-containing additives are those made by reacting sulfur and/or sulfur monochloride with an olefin such as isobutylene. Particularly preferred are the sulfurized olefins disclosed in U.S. Pat. Nos. 4,563,302 and 4,204,969, the entire disclosures of which are incorporated herein by reference.

[0030] Halogenated derivatives of the above sulfides and polysulfides are useful and examples include the chlorinated and fluorinated derivatives of diethyl sulfide and disulfide, dioctyl sulfide and disulfide, diamyl sulfide and disulfide, diphenyl sulfide and disulfide, and diben-

zyl sulfide and disulfide. A more exhaustive listing of sulfur and halogen EP agents which may be used is found in U.S. Pat. No. 2,208,163. Examples of sulfurized oils include sulfurized sperm oil, sulfurized methyl ester of oleic acid, and sulfurized sperm oil replacements. Other examples of sulfurized oils include sulfurized methyl linoleate, sulfurized animal and vegetable oils, sulfurized lard oil, and sulfurized cottonseed oil.

The Phosphites

[0031] Trialkyl phosphites useful in the present invention include $(RO)_3P$ where R is a hydrocarbyl of 4 to 24 carbon atoms, more preferably 8 to 18 carbon atoms, and most preferably 10 to 14 carbon atoms. The hydrocarbyl may be saturated or unsaturated. Representative trialkyl phosphites include, but are not limited to, tributyl phosphite, trihexyl phosphite, trioctyl phosphite, tridecyl phosphite, trilauryl phosphite and trioctyl phosphite. A particularly preferred trialkyl phosphite is trilauryl phosphite, such as commercially available Duraphos TLP® by Albright and Wilson, Inc. Preferred are mixtures of phosphites containing hydrocarbyl groups having 10 to 14 carbon atoms. These mixtures are usually derived from animal or natural vegetable sources. Representative hydrocarbyl mixtures are commonly known as coco, tallow, tall oil, and soya.

Base Oil of Lubricating Viscosity

[0032] The base oil of lubricating viscosity used in such compositions may be mineral oils or synthetic oils of viscosity suitable for use in gears. The base oils may be derived from synthetic or natural sources. Mineral oils for use as the base oil in this invention include, for example, paraffinic, naphthenic and other oils that are ordinarily used in lubricating oil compositions. Synthetic oils include, for example, both hydrocarbon synthetic oils and synthetic esters and mixtures thereof having desired viscosity. Useful synthetic hydrocarbon oils include liquid polymers of alpha olefins having the proper viscosity. Especially useful are the hydrogenated liquid oligomers of C_6 to C_{12} alpha olefins such as 1-decene trimer. Likewise, alkyl benzenes of proper viscosity, such as didodecyl benzene, can be used. Useful synthetic esters include the esters of monocarboxylic acids and polycarboxylic acids, as well as mono-hydroxy alkanols and polyols. Typical examples are didodecyl adipate, pentaerythritol tetracaprate, di-2-ethylhexyl adipate, dilaurylsebacate, and the like. Complex esters prepared from mixtures of mono and dicarboxylic acids and mono and dihydroxy alkanols can also be used. Blends of mineral oils with synthetic oils are also useful.

The Lubricating Oil Composition

[0033] The lubricating oil composition of the present invention is useful for imparting improved load-carrying

capacity, especially at high temperatures of gears such as commonly found, for example, in transmissions, axles, trans-axles and industrial machinery, such as stationary gear boxes. Such a lubricating oil composition comprises a base oil of lubricating viscosity and an effective amount of the above compounds.

[0034] In its broadest embodiment, the lubricating oil composition would contain:

- a) a major amount of a base oil of lubricating viscosity,
- b) from 0.5 to 6.0 wt % of a hydrated alkali metal borate,
- c) from 0.5 to 5.0 wt % of an oil-soluble sulfur-containing compound, and
- d) from 0.5 to 6.0 wt % of a trialkyl phosphite.

[0035] The alkali-metal borate will generally comprise 0.5 to 6.0 wt % of the lubricating oil composition, more preferably 2.0 to 5.0 wt %, and most preferably 3.5 to 4.5 wt %. The oil-soluble sulfur compounds will comprise 0.5 to 5.0 wt % of the lubricating oil composition, preferably 2.0 to 4.0 wt %, and more preferably 2.5 to 3.5 wt %. The phosphites will comprise 0.5 to 6.0 wt % of the lubricating oil composition, preferably 2.0 to 5.0 wt %, and more preferably 3.0 to 4.5 wt %.

[0036] The lubricating oil composition of the present invention can be made by addition of the additive composition to a lubricating base oil, as will be described in the following section.

[0037] The lubricating oil composition of the present invention is useful in a method of improving the high temperature load-carrying performance of gears. In that method, an lubricating oil composition is used to lubricate gears.

[0038] The lubricating oil composition of the invention can be prepared by successively or simultaneously adding the additive components to a base oil, or by beforehand preparing an additive composition or as a concentrate, as herein described below, and then mixing it with a base oil.

[0039] In a further embodiment, a lubricating oil composition is produced by blending a mixture of the above components. The lubricating oil composition produced by that method might have a slightly different composition than the initial mixture, because the components may interact. The components can be blended in any order and can be blended as combinations of components.

Lubricating Oil Additive Composition

[0040] Lubricating oil additive compositions within the scope of the present invention comprise

- a) from 31 to 50 wt % of a hydrated alkali metal borate.
- b) from 24 to 40 wt % of an oil-soluble sulfur-containing compound, and
- c) from 25 to 40 wt % of a trialkyl phosphite.

[0041] The product produced by blending the above additive composition would also be included within the scope of the present invention.

[0042] The lubricating oil composition described in the previous section can be made by the addition of the lubricating oil additive composition to a base oil. Generally, the lubricant will contain 1.0 to 15.0 wt %, more preferably 5.0 to 14.0 wt %, and most preferably 10.0 to 14.0 wt % of the lubricating oil additive composition.

Additive Concentrates

[0043] The additive concentrate of the present invention usually include the product produced by blending: 20

- a) from 1.0 to 15 wt % of an organic liquid diluent
b) from 27 to 38 wt % of a hydrated alkali metal borate;
c) from 19 to 30 wt % of an oil-soluble sulfur-containing compound, and
d) from 27 to 38 wt % of a trialkyl phosphite.

[0044] The concentrates contain sufficient organic liquid diluent to make them easy to handle during shipping and storage. Typically, the concentrate will contain from 1.0 to 15 wt % of the organic liquid diluent, preferably 2.0 to 10 wt %.

[0045] Suitable organic diluents which can be used include, for example, solvent refined 100N, i.e., Cit-Con 100N, and hydrotreated 100N, i.e., Chevron 100N, and the like. The organic diluent preferably has a viscosity of about from 1.0 to 20 cSt at 100°C.

[0046] The components of the additive concentrate can be blended in any order and can be blended as combinations of components. The concentrate produced by blending the above components might be a slightly different composition than the initial mixture because the components may interact.

Other Additives

[0047] The following additive components are examples of some of the components that can be favorably employed in the present invention. These examples of additives are provided to illustrate the present invention, but they are not intended to limit it:

1. Metal Detergents

Sulfurized or unsulfurized alkyl or alkenyl phenates, alkyl or alkenyl aromatic sulfonates, sulfurized or unsulfurized metal salts of multi-hydroxy alkyl or alkenyl aromatic compounds, alkyl or alkenyl hy-

droxy aromatic sulfonates, sulfurized or unsulfurized alkyl or alkenyl naphthenates, metal salts of alkanolic acids, metal salts of an alkyl or alkenyl multiacid, and chemical and physical mixtures thereof.

2. Anti-Oxidants

Anti-oxidants reduce the tendency of mineral oils to deteriorate in service which deterioration is evidenced by the products of oxidation such as sludge and varnish-like deposits on the metal surfaces and by an increase in viscosity. Examples of anti-oxidants useful in the present invention include, but are not limited to, phenol type (phenolic) oxidation inhibitors, such as 4,4'-methylene-bis(2,6-di-tert-butylphenol), 4,4'-bis(2,6-di-tert-butylphenol), 4,4'-bis(2-methyl-6-tert-butylphenol), 2,2'-methylene-bis(4-methyl-6-tert-butylphenol), 4,4'-butylidene-bis(3-methyl-6-tert-butylphenol), 4,4'-isopropylidene-bis(2,6-di-tert-butylphenol), 2,2'-methylene-bis(4-methyl-6-nonylphenol), 2,2'-isobutylidene-bis(4,6-dimethylphenol), 2,2'-methylene-bis(4-methyl-6-cyclohexylphenol), 2,6-di-tert-butyl-4-methylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,4-dimethyl-6-tert-butyl-phenol, 2,6-di-tert-butyl-4-dimethylamino-p-cresol, 2,6-di-tert-butyl-4-(N,N'-dimethylaminomethylphenol), 4,4'-thiobis(2-methyl-6-tert-butylphenol), 2,2'-thiobis(4-methyl-6-tert-butylphenol), bis(3-methyl-4-hydroxy-5-tert-butylbenzyl)-sulfide, and bis(3,5-di-tert-butyl-4-hydroxybenzyl). Diphenylamine-type oxidation inhibitors include, but are not limited to, alkylated diphenylamine, phenyl- α -naphthylamine, and alkylated- α -naphthylamine. Other types of oxidation inhibitors include metal dithiocarbamate (e.g., zinc dithiocarbamate), and methylenebis(dibutylthiocarbamate). The anti-oxidant is generally incorporated into an engine oil in an amount of about 0 to 10 wt %, preferably 0.05 to 3.0 wt %, per total amount of the engine oil.

3. Anti-Wear Agents

As their name implies, these agents reduce wear of moving metallic parts. Examples of such agents include, but are not limited to, phosphates, carbamates, esters, and molybdenum complexes.

4. Rust Inhibitors (Anti-Rust Agents)

- a) Nonionic polyoxyethylene surface active agents: polyoxyethylene lauryl ether, polyoxyethylene higher alcohol ether, polyoxyethylene nonyl phenyl ether, polyoxyethylene octyl phenyl ether, polyoxyethylene octyl stearyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitol monostearate, polyoxyethylene sorbitol mono-oleate, and polyethylene glycol mono-oleate.
- b) Other compounds: stearic acid and other fatty acids, dicarboxylic acids, metal soaps, fatty acid amine salts, metal salts of heavy sulfonic

acid, partial carboxylic acid ester of polyhydric alcohol, and phosphoric ester.

5. Demulsifiers

Addition product of alkylphenol and ethylene oxide, polyoxyethylene alkyl ether, and polyoxyethylene sorbitan ester.

6. Extreme Pressure Anti-Wear Agents (EP/AW Agents)

Zinc dialkyldithiophosphate (primary alkyl, secondary alkyl, and aryl type), diphenyl sulfide, methyl trichlorostearate, chlorinated naphthalene, fluoroalkylpolysiloxane, lead naphthenate, neutralized phosphates, dithiophosphates, and sulfur-free phosphates.

7. Friction Modifiers

Fatty alcohol, fatty acid, amine, borated ester, and other esters.

8. Multifunctional Additives

Sulfurized oxymolybdenum dithiocarbamate, sulfurized oxymolybdenum organo phosphorodithioate, oxymolybdenum monoglyceride, oxymolybdenum diethylate amide, amine-molybdenum complex compound, and sulfur-containing molybdenum complex compound.

9. Viscosity Index Improvers

Polymethacrylate type polymers, ethylene-propylene copolymers, styrene-isoprene copolymers, hydrated styrene-isoprene copolymers, polyisobutylene, and dispersant type viscosity index improvers.

10. Pour Point Depressants

Polymethyl methacrylate.

11. Foam Inhibitors

Alkyl methacrylate polymers and dimethyl silicone polymers.

12. Metal Deactivators

Disalicylidene propylenediamine, triazole derivatives, mercaptobenzothiazoles, and mercaptobenzimidazoles.

EXAMPLES

[0048] The invention will be further illustrated by the following examples, which set forth particularly advantageous specific embodiments of the present invention. While the examples are provided to illustrate the present invention, it is not intended to limit it.

Example I

[0049] The following example provides the efficiency of the composition of the present invention to impart high temperature, load-carrying performance to a lubricating oil. Two blends were evaluated (A and B). Both blends in this example contain a detergent, dispersant, metal deactivator, a multifunctional gear oil component, and a foam inhibitor. Additionally, Blend Number A contains an

alkali metal borate and a sulfur-containing compound. Blend Number B (invention) also contains an alkali metal borate, a sulfur-containing compound, and a trialkyl phosphite.

[0050] The results that were generated by the Eaton High Temperature L37 Test are shown in Table I. It is part of the Eaton PS-163 specification (drive axles - 500,000-mile extended drain). This test procedure evaluates the following: load-carrying, wear, and extreme pressure properties of a gear lubricant in an axle under conditions of elevated temperature, high-speed and low torque, and low-speed and high-torque operation. The lubricating oil must pass this test in order to meet the Eaton specification.

Table I

Component	Blend Number	
	A	B
Wt % Component		
Alkali Metal Borate	4	4
Sulfur-Containing Compound	3	3
Trialkyl Phosphite	-	4
Results	Fail	Pass

Comparative Example A

[0051] Each of the blends in this example contain a detergent, dispersant, metal deactivator, a multifunctional gear oil component, and a foam inhibitor identical to Example I with the following differences. Blend Number C contains an alkali metal borate, a sulfur-containing compound, and a dialkyl phosphite. Blend Number D is similar to Blend Number C except the concentration of the dialkyl phosphite is 4 wt %. Results from the Eaton High Temperature L37 Test are shown in Table II.

Table II

Component	Blend Number	
	C	D
Wt % Component		
Alkali Metal Borate	3	4
Sulfur-Containing Compound	2	3
Dialkyl Phosphite	0.3	4
Results	Fail	Pass
Compatibility	Yes	No

[0052] The above results shown in Table I clearly indicate that the trialkyl phosphite provides high temperature load-carrying capacity performance. Without the trialkyl phosphite, the lubricating oil fails the test. Furthermore, as shown in Table II, using a dialkyl phosphite does not yield acceptable results. At low concentrations,

using a dialkyl phosphite clearly fails to provide high temperature load-carrying capacity performance. At higher concentrations equivalent to the present invention, using dialkyl phosphite passes the test but at the higher concentration, it is not compatible with the other components of the lubricating oil.

[0053] Although this invention has been illustrated by reference to specific embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made which clearly fall within the scope of this invention.

Claims

1. A lubricating oil composition comprising:

- a) a major amount of a base oil of lubricating viscosity,
- b) from 0.5 to 6.0 wt % of a hydrated alkali metal borate,
- c) from 0.5 to 5.0 wt % of an oil-soluble sulfur-containing compound, and
- d) from 0.5 to 6.0 wt % of a trialkyl phosphite.

2. The lubricating oil composition of Claim 1 wherein said lubricating oil composition comprises:

- a) a major amount of a base oil of lubricating viscosity,
- b) from 2.0 to 5.0 wt % of a hydrated alkali metal borate,
- c) from 2.0 to 4.0 wt % of an oil-soluble sulfur-containing compound, and
- d) from 2.0 to 5.0 wt % of a trialkyl phosphite.

3. The lubricating oil composition of Claim 1 wherein said lubricating oil composition comprises:

- a) a major amount of a base oil of lubricating viscosity,
- b) from 3.5 to 4.5 wt % of a hydrated alkali metal borate,
- c) from 2.5 to 3.5 wt % of an oil-soluble sulfur-containing compound, and
- d) from 3.0 to 4.5 wt % of a trialkyl phosphite.

4. The lubricating oil composition of Claim 1 wherein said hydrated alkali metal borate is a sodium or po-

tassium triborate.

5. The lubricating oil composition of Claim 4 wherein said hydrated alkali metal borate is a potassium triborate.

6. The lubricating oil composition of Claim 1 wherein said sulfur-containing compound is a sulfurized isobutylene.

7. The lubricating oil composition of Claim 1 wherein said trialkyl phosphite is a mixture of C₄ to C₂₄ trialkyl phosphites.

8. The lubricating oil composition of Claim 7 wherein said trialkyl phosphite is a mixture of C₈ to C₁₈ trialkyl phosphites.

9. The lubricating oil composition of Claim 8 wherein said trialkyl phosphite is a mixture of C₁₀ to C₁₄ trialkyl phosphites.

10. The lubricating oil composition of Claim 9 wherein said trialkyl phosphite is a trilauryl phosphite.

11. A method of producing a lubricating oil composition comprising blending the following components together:

- a) a major amount of a base oil of lubricating viscosity,
- b) from 0.5 to 6.0 wt % of a hydrated alkali metal borate,
- c) from 0.5 to 5.0 wt % of an oil-soluble sulfur-containing compound, and
- d) from 0.5 to 6.0 wt % of a trialkyl phosphite.

12. A method of improving the high temperature load-carrying performance of gears, said method comprising lubricating said gears with the lubricating oil composition of Claim 1.

13. A lubricating oil additive composition comprising a mixture of:

- a) from 31 to 50 wt % of a hydrated alkali metal borate,
- b) from 24 to 40 wt % of an oil-soluble sulfur-containing compound, and
- c) from 25 to 40 wt % of a trialkyl phosphite.

14. A lubricating oil composition comprising a major amount of lubricating oil and a minor but effective

amount of said lubricating oil additive composition of Claim 13 to improve the high temperature load-carrying performance of the lubricating oil composition.

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15. The lubricating oil composition of Claim 14 wherein the composition contains 1.0 to 15.0 wt % of said lubricating oil additive composition.

16. The lubricating oil additive composition of Claim 13 wherein said hydrated alkali metal borate is a sodium or potassium triborate. 10

17. The lubricating oil additive composition of Claim 16 wherein said hydrated alkali metal borate is a potassium triborate. 15

18. The lubricating oil additive composition of Claim 13 wherein said sulfur-containing compound is a sulfurized isobutylene. 20

19. The lubricating oil additive composition of Claim 13 wherein said trialkyl phosphite is a mixture of C₄ to C₂₄ trialkyl phosphites. 25

20. The lubricating oil additive composition of Claim 19 wherein said trialkyl phosphite is a mixture of C₈ to C₁₈ trialkyl phosphite.

21. The lubricating oil additive composition of Claim 20 wherein said trialkyl phosphite is a mixture of C₁₀ to C₁₄ trialkyl phosphite. 30

22. The lubricating oil additive composition of Claim 21 wherein said trialkyl phosphite is a triaryl phosphate. 35

23. An additive concentrate suitable for improving the high temperature load-carrying performance of gears comprising: 40

a) from 1.0 to 15 wt % of an organic liquid diluent;

b) from 27 to 38 wt % of a hydrated alkali metal borate; 45

c) from 19 to 30 wt % of an oil-soluble sulfur-containing compound; and

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d) from 27 to 38 wt % of a trialkyl phosphite.

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