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# GEAR OIL COMPOSITIONS

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This invention relates to a mineral oil composition useful for lubricating mechanical elements subject to extreme pressures. More particularly, this invention relates to lubricating compositions useful under extreme pressure conditions such as are encountered in the transmissions and differentials of cars and trucks having hypoid and other types of gears.

In the lubrication of gear elements in automotive vehicles and various industrial machines, lubricating oils are generaly used which are fortified with additives to impart to the lubricating oils the ability to lubricate at high pressures. One such product which has been in successful use is a sulfurized-phosphorized lard oil such as that disclosed in Whittier et al., U. S. Patent No. 2,211,306.

More recently, sulfurized fatty bodies, such as sulfurized-phosphorized propylene glycol dioleate and glyceryl trioleate have been used, although they are some what more expensive. A stable, oil-soluble, sulfurized-phosphorized additive, which has the added feature of a low channel point making it suitable for use under low temperature conditions, comprises an additive of the sulfurized-phosphorized fatty-oil-type prepared by separately sulfurizing methyl esters of tall oil acids or other alkyl esters of tall oil acids and the lower straight-chain, saturated, monohydric aliphatic alcohols, and phosphorizing a substance from the group comprising glyceryl trioleate, ethylene, propylene or butylene glycol dioleate and the like, and commingling the two products. Thus phosphorus and sulfur appear in separate components of the additive; that is, the glyceryl trioleate carries the phosphorus and whatever sulfur is also incorporated in the phosphorization reaction from the treating agent, such as phosphorus sesquisulfide. Most of the sulfur of the formulation is present in the sulfurized methyl esters of tall oil acids or equivalent component of the additive. This is in contradistinction to one-component systems employing fatty bodies which have been sulfurized, and then phosphorized, so as to contain both sulfur and phosphorus, or phosphorized-sulfurized in one operation so as to contain phosphorus and a variable amount of sulfur.

The nature of conditions under which hypoid and other gears function during normal operations indicates that it is advisable not only to have a lubricant present which serves to cool the gears and prevent or inhibit welding effects under normal conditions, but which will also afford such protection under all possible conditions of operation, the extremes of which range from thick-film to boundary lubrication. Increased oiliness, or lubricity, over that normally furnished by unfortified mineral lubricating oils, is needed to reduce friction in that zone of lubrication referred to as semi-boundary lubrication where there is a transition from thick-film lubrication, requiring only mineral oil, to boundary lubrication where anti-weld protection is required.

It has been noted that when mineral lubricating oil is fortified with the usual extreme pressure additives



comprising sulfurized and/or phosphorized fatty bodies, a decrease in the overall lubricity of the composition may occur, probably due to the presence of the metalloid elements sulfur and phosphorus which restrict the orientation of the fatty materials at the oil-metal interface. This condition may be aggravated by the common practice of utilizing as the lubricating base oil, petroleum mineral oil fractions which have undergone refining to some degree, and, in many cases, to a high degree. It is known that the usual refining operations on the petroleum oil have a tendency to reduce the natural lubricity of the oil. It is therefore advantageous to incorporate, together with the extreme pressure additive, another component which will enhance the oiliness of the extreme pressure lubricating oil produced.

We now have discovered that the incorporation of a certain type of oiliness agent in a lubricating oil formulation also containing a certain type of extreme pressure additive unexpectedly produces a synergistic effect between the extreme pressure additive and the lubricity agent. This synergistic effect is manifested by an unusual improvement in the extreme pressure properties of the lubricating oil, as well as by superior oiliness properties. The formulation, therefore, not only exhibits increased lubricity and some degree of corrosion and rust inhibition because of the oiliness agent, but shows greatly improved load-bearing properties rendering it ideally suitable as an extreme pressure lubricant for use with gears and in other extreme pressure applications.

Accordingly, it is an object of this invention to provide an improved extreme pressure lubricant.

It is another object of this invention to provide an extreme pressure lubricating oil of improved lubricity and high load-bearing properties.

It is yet another object of this invention to provide an improved extreme pressure lubricating oil exhibiting high lubricity and load-bearing characteristics due to the presence of synergistically cooperating constituents.

In general, our invention discloses an extreme pressure lubricant of high load-bearing capacity and lubricity which incorporates a synergistically cooperating combination of a sulfur- and phosphorus-containing fatty body and an ester-type oiliness agent.

More particularly, our invention covers an extreme pressure lubricant comprising mineral oil and a synergistically cooperating combination of a sulfur- and phosphorus-containing fatty oil, and an ester of a high molecular weight hydroxy aliphatic acid and a low molecular weight aliphatic alcohol.

The first constituent of the present composition is an oleaginous material utilized as the base oil and present as the major constituent of the extreme pressure lubricant. The oleaginous constituent may be any mineral oil, or mineral oil fraction, or mixture of mineral oils or mineral oil fractions. The oleaginous constituent may also be a synthetic oil, or a mixture of one or more synthetic oils and/or one or more natural mineral oils. Synthetic oils such as polyalkylene glycols, marketed under "Ucon," may be used, as well as esters of dibasic acids, such as di-2-ethyl hexyl sebacate. The oil may be a petroleum hydrocarbon oil refined to any degree. Usually, a petroleum mineral oil boiling within the lubricating oil range is preferred. This includes any single component or combination of lubricating oils and extracts thereof. An example of a compounded oil is 200 viscosity (at 100° F.) neutral oil blended with (phenol) extract oil from the manufacture of bright stock and with 150 viscosity (at 210° F.) bright stock to an appropriate viscosity. Raffinate fractions obtained by extracting mineral lubricating oil with phenol, sulfur dioxide, or other solvent commonly used for such purposes, may be used alone or in combination, as indicated above, with one or more extract oils or with other lubri-

cating oil fractions. The lubricating oil fractions may be of high, medium, or low viscosity, and may be bright stocks, neutral oils, or combinations thereof.

The second constituent of the present composition is an "oiliness," or lubricity, agent capable of imparting added lubricity and anti-wear characteristics to a mineral oil lubricating composition. In addition, the oiliness agent has some anti-corrosion and anti-rust properties. The particular type of lubricity agent found to have a synergistic effect with the extreme pressure additive of this invention is an ester of the general formula:

RCOOX

where RCOO— is an acid radical derived by subtracting the acid hydrogen from a monohydroxy, monobasic, long-chain aliphatic acid having 8 to 24 carbon atoms per molecule, and X is an aliphatic substituent selected from the group consisting of:

(1) A $C_1$ to $C_5$ alkyl radical,

(2) A $C_2$ to $C_6$ hydroxy-substituted alkyl radical having one or more hydroxyl substituents, and

(3) Acyl derivatives of said $C_2$ to $C_6$ hydroxy-substituted alkyl radicals formed by substituting an acyl group derived from a $C_2$ to $C_{24}$ aliphatic monobasic carboxylic acid for at least one of the hydroxyl hydrogens of said hydroxy-substituted radical.

Examples of suitable long-chain hydroxy fatty acids from which the ester-type oiliness agents may be derived are the monohydroxy derivatives of long-chain fatty acids such as pelargonic, myristic, palmitic, stearic, behenic, hyenic, lauroleic, oleic, gadoleic and arachidonic. The aliphatic substituent is exemplified by such $C_1$ to $C_5$ radicals as methyl, ethyl, propyl, butyl, iso-butyl, amyl and iso-amyl; and the $C_2$ to $C_6$ hydroxy-substituted alkyl radicals are exemplified by those derived from ethylene glycol, propylene glycol, erythrol, glycerine, tetritols, pentitols, hexitols, and their acylated derivatives. Various esters having application in the instant invention are illustrated but not limited by the following specific examples: methyl ricinoleate, amyl 10-hydroxy palmitate, propylene glycol mono-10-hydroxy stearate, ethylene glycol 8-hydroxy myristate, ethylene glycol mono-ricinoleate monoacetate, propylene glycol di-9-hydroxy palmitate, glyceryl monoricinoleate, pentaerythritol monoricinoleate, glyceryl triricinoleate, erythritol mono-12-hydroxy hyenate monobutyrate, etc., or mixtures thereof.

A number of methods are available for the preparation of the lubricity agent of this invention. These include but are not limited to the acylation of suitable mono-, di- and polyhydric alcohols having not more than 6 carbon atoms per molecule by means of $C_8$–$C_{24}$ aliphatic acids, anhydrides and acid chlorides, as well as other syntheses not employing an alcohol as a reactant.

The oiliness agent may be utilized in the extreme pressure lubricant in any amount suitable to impart the desired synergism manifested by enhanced lubricity and extreme pressure properties. However, in general, at least about 0.3% by weight of the "oiliness" agent, based on total weight of the composition, may be advantageously employed. An amount of 2.5% by weight, based on total weight of the composition, of the "oiliness" agent exerts a strong synergistic effect when in the presence of a sufficient amount of the extreme pressure additive. The effect of the "oiliness" agent, with regard to its ability to cooperatively enhance the load-bearing characteristics of the lubricant, increases with increasing concentration in a non-linear manner, that is, small successive increases in the amount of the lubricity additive produce progressively greater than linear increases in the extreme pressure, load-bearing ability of the lubricant. An optimum amount of this agent per unit of extreme pressure additive is eventually reached and may be determined by experimentation, since it depends to some extent on the particular lubricity agent-extreme pressure additive combination used. The optimum amount of the oiliness agent-extreme pressure additive combination in the base oil may also be determined by routine experimentation.

The extreme pressure additive of this invention may be any fatty body which has been sulfurized and phosphorized under proper conditions of time and temperature to produce a suitable sulfur- and phosphorus-containing extreme pressure additive. Thus, lard oil, which is preferred, may be utilized, as well as other fatty oils, vegetable, animal, or marine oils, and waxes, such as sperm oil, tung oil, cottonseed oil, castor oil and rapeseed oil, menhaden oil, soya bean oil and the like.

The process of sulfurization and phosphorization of the fatty oil may, for example, be that disclosed in U. S. Patent 2,211,306 (William A. Whittier, Norman D. Williams and Harry L. Moir, August 13, 1940), or 2,211,231 (Henderson, August 13, 1940), but is not limited to such a method.

The method of U. S. 2,211,306 comprises adding, for example, about 5 parts petroleum lubricating oil and 0.5 part sulfur chloride together and adding the mixture to about 87 parts by weight of fatty oil at below 270° F. with agitation. Thereafter the combined mixture is slowly heated to about 270° F. and about 74 parts by weight finely ground flowers of sulfur are added over a period of about 10 minutes. The temperature is then raised to about 330° F. and the mixture agitated and kept at this level until a copper strip immersed therein for a period of 2 minutes shows no black coating. After heating for about 7 hours, the corrosion test is usually passed. The mixture is then rapidly cooled to about 150° F. and permitted to cool slowly to room temperature. Approximately all of the sulfur of the treating agent is incorporated into the fatty body thereby.

About 99.6 parts of the sulfurized oil are then mixed with about 0.4 part of finely divided phosphorus sesquisulfide, $P_4S_3$, although appropriate amounts of another phosphorus compound, such as phosphorus pentasulfide, $P_2S_5$, or elemental phosphorus, may be utilized instead, in accordance with appropriate modifications of reaction conditions. Heat is applied to the mixture during constant agitation. The temperature is raised to about 220–230° F. and kept there during a period of about 5 hours while agitation is continued. The mixture is then allowed to cool and the phosphorus- and sulfur-containing base is blended with petroleum lubricating oil. The temperature has to be kept below 230° F. during the reaction period in order to prevent phosphorus from vaporizing from the mixture and being lost. The product contains substantially all the sulfur of the sulfurization agent plus at least some of the sulfur of the phosphorization agent, that is, for the above example, about 7.5% by weight. Substantially all of the phosphorus of the phosphorization agent is incorporated into the fatty oil by this process.

The proportions of ingredients in the above method may be varied in order to produce sulfurized-phosphorized oil having incorporated therein different relative concentrations of sulfur and phosphorus.

Other methods may be employed for the introduction of phosphorus and sulfur into the fatty body; for example, preliminary sulfurization need not be employed, but the sulfur may be introduced solely under appropriate conditions by the phosphorus sulfide, so that the relative proportions of phosphorus and sulfur in the treated fatty body approximate the relative proportions of the respective elements in the treating agent. Other methods are contemplated and are well known to those skilled in the art.

All that is important concerning the extreme pressure agent is that it should be a fatty body, such as a fatty oil as described above, and that it must have both phosphorus and sulfur incorporated therein. Mixtures of fatty bodies are also contemplated, but each constituent must contain both phosphorus and sulfur. As will be

shown below, extreme pressure agents, for example, of the Metalyn-GTO type, which comprise combinations of two or more components, one component of which has been sulfurized and the other component of which has been phosphorized, are not satisfactory for use as the extreme pressure additive in the instant invention and may even be deleteriously affected by the lubricity agent.

The extreme pressure additive of this invention may be present in any suitable amount whereby it lends its extreme pressure properties to the lubricant and whereby it acts synergistically with the lubricity agent also present to provide the lubricant with greatly enhanced load-bearing properties. The optimal amount of the extreme pressure additive per unit of the lubricity agent depends on the particular extreme pressure additive and lubricity agent used and can be determined by routine experimentation. Such also is the case with the optimal concentrations of the synergistically cooperating extreme pressure additive lubricity agent combination in the lubricant. However, it has been found that a concentration of about 8–15% by weight, based on the total weight of the composition, of the extreme pressure additive in the lubricant functions synergistically with about 2.5% by weight, based on the total composition, of the lubricity agent present in the formulation to increase the extreme pressure characteristics of the lubricant.

A four-ball machine test was performed on sample compositions of extreme pressure lubricants to determine the extreme pressure characteristics of lubricant formulations. The four-ball machine test was performed in the following manner:

A four-ball extreme pressure lubricant tester consisting of four balls of metal, such as SAE 52100 steel, arranged in the form of an equilateral tetrahedron, was used. The basic elements of the machine are three lower balls held immovably in a clamp to form a cradle in which the fourth or upper ball is caused to rotate about a vertical axis under prescribed conditions of load and speed. The contacting surfaces on the apparatus are geometrically well-defined, thus providing obvious advantages in the study of wear and friction phenomena. The points of contact are lubricated by the test lubricant which is held in a cup surrounding the four-ball assembly. The diameter of the scar depends on the load, speed, temperature, time of test, and character of the lubricant. The scars are measured by a suitable microscope.

The mean Hertz load extreme pressure value is obtained by performing a series of 10 second runs at preselected loads ranging from 40 kg. on the first run to successively higher loads on successive runs until welding of the four balls occurs. A speed of 1800 R. P. M. is, for example, maintained, and a total of 20 runs is made. If the load at which verified welding occurs is below 355 kg., then additional runs at successively lower loads below 40 kg. are made until a total of 20 runs is obtained. A "corrected load" is obtained for each run by reducing the actual load in the proportion between the wear-spot diameter on the "Hertz line" at that load and the measured wear-spot diameter, i. e.,

$$\text{Corrected load} = \text{actual load} \times \frac{\text{Hertz line diameter}}{\text{measured diameter}}$$

The "Hertz line diameter" is calculated from the formula of H. Hertz for determining the diameter of the contact area between two spherical surfaces. This diameter is the static indentation caused by deformation of the balls under the load at the start of the test. The Hertz formula is as follows:

$$dh = 8.73 \times 10^{-2} \sqrt[3]{P}$$

where $dh$=Hertz diameter in mm., and $P$=applied vertical load in kg.

The mean Hertz load is obtained by adding the corrected loads for 20 runs below 355 kg., and dividing the total by 20.

The table below lists the results of tests on extreme pressure lubricants obtained through the use of the four-ball machine:

TABLE

*Four-ball machine evaluation*

| Constituents | Blend 1 Percent by wt. Composition | Blend 2 Percent by wt. Composition | Blend 3 Percent by wt. Composition | Blend 4 Percent by wt. Composition | Blend 5 Percent by wt. Composition | Blend 6 Percent by wt. Composition |
|---|---|---|---|---|---|---|
| Extreme Pressure Type A Additive (3 parts of Sulfurized Metalyn) (1 part of phosphorized GTO) | 13 | 13 | 13 | | | |
| Type B Additive (Sulfurized-Phosphorized lard oil) | | | | 12 | 12 | 12 |
| Methyl ricinoleate oilness agent | | 1.0 | 2.5 | | 1.0 | 2.5 |
| 150 Viscosity at 210° F., bright stock | 42.5 | 42 | 41.25 | 29 | 28.7 | 28.17 |
| 170 Viscosity at 100° F., neutral oil | 42.5 | 42 | 41.25 | | | |
| Aromatic extract oil [1] | | | | 29 | 28.7 | 28.17 |
| 200 Viscosity at 100° F., neutral oil | | | | 29 | 28.7 | 28.17 |
| Foam depressant [2] | 0.0001–0.001 | 0.0001–0.001 | 0.0001–0.001 | 0.0001–0.001 | 0.0001–0.001 | 0.0001–0.001 |
| Dibenzyl disulfide | 1 | 1 | 1 | 1 | 1 | 1 |
| Pour depressant and V. I. Improver [3] | 1 | 1 | 1 | | | |
| Mean Hertz load, kg. | 39.9 | 38.6 | 37.0 | 37.0 | 37.9 | 54.9 |

[1] Extract obtained in the solvent refining with phenol of a mineral lubricating oil stock to produce a low viscosity bright stock.
[2] The foam depressant is a silicone polymer of the polymethyl siloxane type.
[3] The combination viscosity index improver and pour point depressant is a high molecular weight (10,000–15,000) polymeric ester of methacrylic acid and higher fatty alcohols, e. g. lauryl, cetyl and octyl alcohols.

The test results as presented above in the table entitled "Four-Ball Machine Evaluation" show definitely that a synergistic effect is obtained by the addition of the lubricity agent, in this case methyl ricinoleate, to the blend-4-type of extreme pressure lubricant formulation. Thus, blend 4 containing type B extreme pressure lubricant, that is, a sulfurized-phosphorized fatty oil (in this case phosphorus- and sulfur-containing lard oil), exhibited a mean Hertz load of 37.0 kg. Upon addition of the lubricity agent to the formulation, as shown in blend 5 and blend 6, the mean Hertz load increased to 37.9 kg. for the blend 5 formulation containing 1% by weight of lubricity agent, and to 54.9 kg. for blend 6 containing 2.5% by weight of the lubricity agent. Thus, blend 6 showed approximately a 50% increase in the load-bearing capacity of the formulation. Members of the class of compounds defined above as the lubricity agent of this invention other than methyl ricinoleate function in the same manner as methyl ricinoleate. The small amount of lubricity agent utilized produced a dramatic increase in the load-bearing characteristics of the formulation when the extreme pressure additive present in the formulation contained a sulfurized-phosphorized fatty oil, such as sulfurized-phosphorized lard oil, as the extreme pressure agent.

Note, however, the lack of increase in the load-bearing capacity of the formulation when an extreme pressure additive other than a phosphorized-sulfurized fatty body type was utilized. Thus, in blend 1, blend 2, and blend 3, the extreme pressure additive was the double component additive, Metalyn-GTO, with the Metalyn component only sulfurized and the GTO component phosphorized. Blend 1 showed a mean Hertz load of 39.9 kg. when no lubricity agent of the type described for use in our invention was present. In blend 2, although 1% by weight of the lubricity agent was present, the mean Hertz load actually descreased from 39.9 kg. to 38.6 kg. This deleterious effect of the lubricity agent on the load-bearing properties of extreme pressure formulations not containing an extreme pressure additive of type B in the table above was even more pronounced when a larger amount of the lubricity agent was added to the lubricant containing the type A extreme pressure additive. Thus, the mean Hertz load further decreased from 38.6 kg. to 37.0 kg., again a substantial decrease in the extreme pressure properties of the lubricant. It is therefore seen that whereas the lubricity agent in combination with the type B extreme pressure agent produced greatly enhanced extreme pressure properties in the lubricant, the lubricity agent in combination with the type A extreme pressure additive produced a decrease in the extreme pressure, load-bearing capacity of the lubricant.

The type of lubricity agent as defined above for use in our invention, and as utilized in the formulations of our invention, is of itself not an extreme pressure additive. Indeed, it appears to usually function, as seen from blends 2 and 3, to depress the load-bearing capacity of an extreme pressure agent. Only when the type B extreme pressure additive is also present in the formulation does the lubricity agent exhibit new characteristics and synergistically cooperate with said type B additive to greatly increase the load-bearing capacity of the lubricant. Synergism is therefore demonstrated.

A further non-limiting example of the composition of our invention is as follows:

Approximately 120 gm. of cottonseed oil, which has been sulfurized to a sulfur content of approximately 7.2% by weight by the sulfurization step as disclosed in U. S. Patent 2,211,306 (William A. Whittier et al., August 13, 1940), and which has been further treated with phosphorus sesquisulfide by the process of U. S. Patent 2,211,306 (William A. Whittier et al., August 13, 1940), to a final sulfur content of approximately 7.3% by weight and a final phosphorus content of approximately 0.21% by weight, is blended with 840 gm. of base oil comprising the following proportions of components: 420 grams of 150 viscosity at 210° F. bright stock, and 420 grams of 170 viscosity at 100° F. neutral oil. To this mixture is then added 20 gm. of amyl 10-hydroxy palmitate with stirring. A pour point depressant-viscosity index improver of the type represented by polymeric esters of methacrylic acid and fatty alcohol is also present in 10.0 gm. amount, as is dibenzyl disulfide to the extent of 10.0 gm. A minute amount, 0.001 gm., of a silicone-type foam depressant is also added. Upon testing with a four-ball extreme pressure lubricant tester according to the procedure described above, the extreme pressure lubricant is found to have a mean Hertz load value of 61.0, and thus is superior for use in the lubrication of hypoid gears and other machine parts.

It is to be noted from the table of this specification and the above example that the viscosity index improver-pour point depressant, as well as the dibenzyl disulfide and foam depressant, exhibit in the formulation merely their own non-synergistic properties and are non-essential to the formulation. They may be dispensed with or replaced by other well-known, functional, non-synergistically cooperating additives. Thus, any number of viscosity index improvers may optionally be utilized. Examples of suitable V. I. improvers include the polyisobutylene derivatives, polymerized esters of the acrylic acids and higher fatty alcohols, and mixtures of these esters, said esters having a molecular weight of from about 5000 to 20,000, such as methyl alkyl methacrylate polymer, and the alkyl styrene polymers formed from styrene and olefins having 8–12 carbon atoms per molecule. Suitable pour depressants which may be utilized in the formulation include various polymerization and condensation products, such as the condensation product derived from the reaction between a phenol and a chlorinated wax ester, or polymerized esters of the acrylic acid series. Suitable anti-foam agents, such as those of the polyethylsiloxane or polymethyl phenylsiloxane type, may be utilized in the extreme pressure lubricant formulation. Rust inhibitors, inciuding metal salts of the petroleum sulfonic acids and similar metal-organic compounds, especially those having a basic reaction, as well as complex amines, may be blended in the formulation of the instant invention. Indeed, any known additive which does not inhibit the synergistic effect between the extreme pressure additive and the lubricity agent in the formulation of our invention may be utilized for its own properties in the instant extreme pressure lubricant. Such other compositions may be formulated employing the instant invention and such modifications are within the scope of the instant invention.

We claim and particularly point out as our invention:

1. An extreme pressure lubricant consisting essentially of a major proportion of a mineral lubricating oil having incorporated therein sulfurized and phosphorized fatty oil in an amount sufficient to enhance the load-bearing capacity of said lubricant and an oiliness agent consisting of a $C_1$–$C_5$ alkyl ester of a $C_{18}$ monohydroxy monobasic aliphatic acid in an amount sufficient to further increase, in synergistic co-operation with the sulfurized-phosphorized fatty oil, the load-bearing capacity of said lubricant.

2. A lubricant according to claim 1 which contains 8–15% by wt. of the sulfurized-phosphorized fatty oil and not less than about 1% by wt. of the ester.

3. A lubricant according to claim 1 in which the sulfurized-phosphorized fatty oil is of the group consisting of sulfurized-phosphorized lard oil, sulfurized-phosphorized sperm oil, and sulfurized-phosphorized cottonseed oil.

4. A lubricant according to claim 1 which contains 8–15% by wt. of the sulfurized-phosphorized fatty oil and not less than about 2.5% by wt. of the ester.

5. A lubricant in accordance with claim 2 in which said fatty oil is sulfurized-phosphorized lard oil and in which said oiliness agent is methyl ricinoleate.

6. A lubricant in accordance with claim 2 in which said fatty oil is sulfurized-phosphorized cottonseed oil and in which said oiliness agent is methyl ricinoleate.

7. A lubricant in accordance with claim 4 in which said fatty oil is lard oil which has been sulfurized and phosphorized, and in which said oiliness agent is methyl ricinoleate.

8. A lubricant in accordance with claim 4 in which said fatty oil is sulfurized-phosphorized cottonseed oil, and in which said oiliness agent is methyl ricinoleate.

9. An extreme pressure lubricant consisting essentially of the following composition:

| Component | Approximate Wt. Percent |
|---|---|
| Sulfurized-phosphorized fatty oil of class consisting of sulfurized-phosphorized lard oil, sulfurized-phosphorized sperm oil and sulfurized-phosphorized cottonseed oil | 12 |
| Dibenzyl disulfide | 1 |
| Mineral lubricating oil | 86 |
| Silicone polymer antifoamant | 0.0001–0.001 |
| $C_1$–$C_5$ alkyl ester of $C_{18}$ monohydroxy monobasic aliphatic acid | 1 |

10. An extreme pressure lubricant consisting essentially of the following composition:

| Component | Approximate Wt. Percent |
|---|---|
| Sulfurized-phosphorized fatty oil of class consisting of sulfurized-phosphorized lard oil, sulfurized-phosphorized sperm oil and sulfurized-phosphorized cottonseed oil | 12 |
| Dibenzyl disulfide | 1 |
| Mineral lubricating oil | 84.5 |
| Silicone polymer antifoamant | 0.0001-0.001 |
| $C_1$-$C_5$ alkyl ester of $C_{18}$ monohydroxy monobasic aliphatic acid | 2.5 |



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2,211,231 Henderson ---------- Aug. 13, 1940