This invention relates to new and useful lubricating compositions and to methods of preparing the same. In particular, it relates to the preparation of lubricating compositions of the type known generally as "extreme pressure lubricants," such, for example, as will satisfy the severe requirements demanded in the proper lubrication of hypoid and the like gears, and bearing surfaces, metal cutting tools, and the like, subjected to unusually heavy loads per unit area of bearing surface.

In general, the primary requirement of such an "extreme pressure lubricant" is that it shall possess high lubricating film strength; preferably it also has low rates of wear and low coefficients of friction, and it is an object of the present invention to disclose and provide a novel type of lubricating composition which fulfills these requirements. It is a further object of this invention to disclose and provide extreme pressure lubricants that do not suffer a loss or deterioration of high film strength, low rate of wear or low coefficients of friction in long continued use under severe conditions, and which have no tendency to cause gumming or fouling of the lubricated metal parts or surfaces under such long continued service.

As now known, one class of compositions designed for use as "extreme pressure lubricants" comprises mineral lubricating oils to which have been added, preferably in oil-soluble form, sufficient amounts of various active agents discovered to possess the properties of increasing the film strength and/or decreasing rate of wear and/or decreasing coefficients of friction of the mineral oil base to which they have been added. Mineral oil lubricants containing added metallic soaps, notably lead soaps, and/or sulfurized fatty acids or fatty oils, such as sulfurized animal or vegetable oils, are examples of such compositions.

Certain of the compositions of this type have the very serious defect that they tend to cause gumming of the metal parts; certain of them tend to separate into their constituent parts upon long continued subjection to severe operating conditions. Another class of compositions, designed for such service comprises mineral lubricating oils, either alone or in admixture with fatty oils, to which has been added sulfur in elemental or uncombined form. Compositions containing such uncombined sulfur have the serious defect that they cause undue corrosion and wear of the metal parts to be lubricated, or the parts adjacent thereto, such as bushings, etc., which result not only in deterioration of the said metal parts but lead directly to a short life of the lubricating compositions themselves.

We have now discovered that the addition of small amounts of thiacarboxates, in admixture with hydrocarbon or fatty lubricating oils, provide lubricating compositions, which satisfy all of the primary requirements of extreme pressure lubricants and, in addition, are stable in long continued use, do not separate into their constituent parts and do not tend to gum, foul or corrode metal surfaces.

The amounts of thiacarboxates required to be added to hydrocarbon or fatty lubricating oils for the preparation of the composition of our invention vary somewhat, depending upon the severity of the service for which they are designed and, to some extent, upon the character of the hydrocarbon or fatty lubricating stock used as a base; these amounts are in all cases small, however, compared with the amounts of active agents of the prior types, and in general vary between about 1% and about 5% of the oil base, by weight.

The thiacarboxates to be added to mineral or fatty lubricating oils may contain one, two or three sulfur atoms per thiacarboxate group, and may thus correspond to any one of the following type compounds:

\[
\begin{align*}
\text{R-O-O-C-R'} \\
\text{R-O-S-C-R'}
\end{align*}
\]

in which R and R' represent any aliphatic or aromatic radicals, which may or may not contain another thiacarboxate group such as is here described; the compositions may contain mixtures of any two or more compounds of these types.

In the preparation of compositions of our invention, and in order to point out the variety of thiacarboxates which we have found suitable in the preparation of compositions of this character, reference is made to the accompanying tabulation, in which R and R' of the above type formulas are shown as exemplified by ethyl, amyl, phenyl, benzyl and stearyl radicals. It will be ap-
parent that a wide variety of other aliphatic and aromatic radicals may be used in compounds of the above type, any and all of which, so long as capable of incorporation in a hydrocarbon or fatty oil base, are suitable for the practice of our invention, and will give results comparable to those shown in the specific examples below.

<table>
<thead>
<tr>
<th>Example</th>
<th>Sulfur content percent</th>
<th>Amount added percent by weight</th>
<th>Sulfur in final oil solution</th>
<th>Timken film strength on steel load 500 pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>25.3</td>
<td>2.0</td>
<td>0.07%</td>
<td>370</td>
</tr>
<tr>
<td>20</td>
<td>25.2</td>
<td>2.0</td>
<td>0.04</td>
<td>540</td>
</tr>
<tr>
<td>35</td>
<td>18.3</td>
<td>2.0</td>
<td>0.01</td>
<td>340</td>
</tr>
<tr>
<td>30</td>
<td>20.0</td>
<td>2.0</td>
<td>0.07</td>
<td>400</td>
</tr>
<tr>
<td>35</td>
<td>14.0</td>
<td>None</td>
<td>0.02</td>
<td>250</td>
</tr>
</tbody>
</table>

In the respective columns in the above tabulation there are set out: 1st, typical thiocarbonates, representative of a great number which may suitably be used in the practice of our invention; 2nd, the amount of combined sulfur in each of the several thiocarbonates, in percent by weight; 3rd, the amount of each of the thiocarbonates added to a mineral hydrocarbon lubricating oil base stock (kept uniform in amount here only for the purposes of exemplification); 4th, the amount of sulfur in each of the finished extreme pressure lubricants, in percent by weight; 5th, the film strength of the finished lubricating compositions, as measured on the Timken machine described by O. L. Maag in the National Petroleum News for November 16, 1932, page 53, article entitled "Extreme pressure lubricants", wherein the "O. K. load in pounds", or the "load carrying capacity" of the lubricant, is directly measured. In the above exemplifying tabulation the same mineral oil stock was used throughout.

In the preparation of the compositions of our invention, the desired thiocarbamate or mixture of thiocarbonates, in suitable amounts, is admixed with a hydrocarbon or fatty lubricating oil and the admixture merely agitated mechanically in order to obtain complete and homogeneous solution. We have found in general that the thiocarbonates are easily soluble in hydrocarbon and fatty oil, and that no difficulty is encountered in incorporating them therein.

A particular feature of our invention lies in the preparation of bases or concentrates containing relatively large amounts of thiocarbonates in admixture with hydrocarbon or fatty oils. Such concentrates may be stored or transported in this form and before actual use in extreme pressure lubrication service may be diluted with the same or other lubricating oil to any desired concentration. Admixtures of the thiocarbonates and lubricating oils containing upward of 50% of our active agents, by weight, may in this way be prepared. In preparing concentrates or bases of this character complete solution of thiocarbonate is not in all cases necessary, although most of them are freely oil-soluble to this extent. Blending agents, such as amyl or higher alcohols, may be employed as homogenizers in the case of those thiocarbonates not freely oil-soluble to this extent, if desired: incorporation of the less soluble active agents in suspended form, however, is sufficient to allow the thiocarbonates to function in decreasing film strength in actual use.

Obviously the character and viscosity of the lubricating oil to which the thiocarbonate is added will depend to some extent upon the character of service to which the composition is ultimately to be put, and we are not to be limited in the character of the lubricating composition used as a base in the preparation of our compositions. For example, we have found that the life of metal cutting tools is very remarkably lengthened by the incorporation of small amounts of thiocarbonates in either the mineral hydrocarbon or fatty oils used ordinarily in this service. Moreover, we have prepared miscible metal cutting oils in which the usual oil component is replaced with an oil containing small amounts of thiocarbonates in solution, and have found that the life of the cutting tools is greatly lengthened and the character of the metal surfaces cut much improved, especially in severe cutting service. Further, semi-solid and solid lubricating greases have been prepared in the usual manner, wherein small amounts of thiocarbonates have been incorporated in the hydrocarbon and fatty oils ordinarily used therein; the lubricating film strength is in all cases increased to a degree comparable to the increases pointed out in the examples tabulated above.

While we have described in detail the character of our invention and given numerous illustrative examples of the preparation and application of the composition of our invention, we have done so by way of illustration and with the intention that no limitation should be imposed upon the invention thereby. It will be obvious to one skilled in the art that numerous modifications and variations of the above illustrative examples may be effected in the practice of our invention, which, broadly, includes within its scope any composition containing thiocarbonates incorporated therein.

We claim:
1. A composition of matter comprising an admixture of a lubricating oil and a thiocarbonate.
2. A composition of matter comprising an admixture of a hydrocarbon oil and a thiocarbonate.
3. A composition of matter comprising a hydrocarbon oil containing between about one and about five percent of a thiocarbonate, by weight.
4. A composition of matter containing a hydrocarbon lubricating oil and an organic ester of a thiocarbamic acid.
5. A composition of matter containing a hydrocarbon lubricating oil and an organic ester of a monothiocarbamic acid.
6. A composition of matter containing a hydrocarbon lubricating oil and an organic ester of a dithiocarbamic acid.
7. A composition of matter containing a hydrocarbon lubricating oil and an organic ester of a trithiocarbamic acid.
8. A composition of matter containing a hydrocarbon lubricating oil and a compound of the type—

\[ R-O-C-O-R' \]

wherein \( R \) and \( R' \) may represent any aliphatic...
or aromatic radical and in which either or both oxygen atoms may be replaced by a sulphur atom.

9. An extreme pressure lubricant containing between about one and about five percent by weight of an ester of a thiocarbonic acid.

10. An extreme pressure lubricant comprising a mineral oil containing between about one and about five percent by weight of admixed amyl benzyl dithiocarbonate.

11. An extreme pressure lubricant comprising a mineral oil containing between about one and about five percent by weight of admixed dibenzyl monothiocarbonate.

12. An extreme pressure lubricant comprising a mineral oil containing between about one and about five percent by weight of admixed dibenzyl trithiocarbonate.

13. An extreme pressure lubricant base containing an oil and an organic ester of a thiocarbonic acid, capable of dilution with a lubricating oil to produce an extreme pressure lubricant containing between about one and about five percent by weight of the said ester of the said thiocarbonic acid.

14. An extreme pressure lubricant base containing fifty or more percent by weight of an organic ester of a thiocarbonic acid in admixture with an oil.

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