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LUBRICANT AND PROCESS OF MAKING SAME

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This invention relates to lubricants and to methods of making the same.

The lubrication of bearings, gears, cylinders, and other parts of machines is dependent in a broad and general sense upon the mechanical construction and speed and load on the bearing surfaces to be lubricated, on the supply of lubricant, and on the kind and properties of the lubricant. In prior applications Serial Number 209,256 filed July 9, 1927 and Serial Number 256,308 filed February 3, 1928, of which applications, the present one is a continuation in part, certain principles of lubrication and lubricants have been set forth, and mechanisms, processes and lubricants disclosed for securing novel results in the lubrication of machines, particularly for street railway cars which illustrate the application of these discoveries and inventions. These inventions and discoveries are of broad application and extend to any case where one solid material is caused to pass over another, and where it is desirable to reduce friction to a minimum. The conditions under which these two surfaces pass over one another vary from the high speed and high temperatures of the pistons of an internal combustion engine to the swivel plates of a railroad turn table. As indicated in the prior applications, the lubrication of a bearing, to take a typical case, is dependent upon first, the supply of lubricant; second, the viscosity of the lubricant; and third, the "oiliness" of the lubricant. The present invention is more directly concerned with the nature and properties of the lubricant and the methods of obtaining desired lubricants having the most desirable properties as to viscosity and "oiliness" and other features as will more fully appear below.

Petroleum oil and oils of related nature such as those obtained from shale and coal by distillation are the main supply of lubricants the world over. These oils vary a good deal among themselves but in general as the viscosity of the oil increases, the "oiliness" also increases. Consequently it has become the practice to specify the lubricant in terms of its viscosity thereby more or less loosely fixing the "oiliness" property desired. But in using these mineral and related oils by themselves, it is necessary to use oils of relatively high viscosity, in order to obtain the required degree of oiliness.

The use of heavy or viscous lubricating oils is well illustrated in the specifications set out in Technical Paper No. 323A issued by the Bureau of Mines and entitled "United States Government specification for lubricants and liquid fuels and methods of testing". On page 28 of this paper, the names and grades of the various lubricants are given. In this paper, the lightest grade of oil suggested for lubrication is called "Class A extra light", having viscosity of 135 seconds at 100° F. On page 9 of this paper the whole Class A embracing oils with viscosities of from 135 to 360 seconds is given as used for very light machinery. The use of an oil of viscosity below 135 seconds at 100° F. is not contemplated.

This reference to the paper of the Bureau of Mines is sufficient to show what the attitude of the entire industry is and the use of relatively heavy lubricants is universally followed. Oils with a viscosity below 135 seconds at 100° F. are known as the so-called spindle oils, but these relatively light oils do not enter into the ordinary lubrication program.

It is customary, for example, in oils for use in the lubrication of automobile engines, where the speed and load are high, to mix with the lighter oil, large percentages of cylinder stock or other very heavy oils in order to obtain the desired adhesiveness; so much is this the custom that petroleum lubricating oils are generally sold on the basis of their viscosity only, it being well known that the adhesiveness is in this way secured to a greater or lesser extent.

This prior art practice is further illustrated by the practice in connection with lubrication of street railway journals or axles, where oils of the viscosity of from 250 to 600 Saybolt have been used prior to the present invention. Further in this as in analogous cases where the operating temperatures of the bearing or related mechanism might be about 100° F. or even higher, the viscosity of the lubricant was chosen with this temperature in mind. The variation in viscosity with change in temperature over the usual operating range was quite marked in these prior art lubricants so that when the lubricant operated at the higher temperatures, it had to be that more viscous at the lower temperatures. In fact in many instances, these lubricants in order to give the requisite viscosity at the higher temperatures were actually solid at temperatures such as those frequently reached in this climate during the winter season.

But the choice of heavy or viscous materials in order to secure adequate adhesiveness, results in a tremendous loss of power due to the internal friction of the lubricant, and these losses in power were either not recognized or not appreciated in the prior art.

One of the objects of the present invention is the use of lubricants of the lowest possible vis-

cosity consistent with the heat conditions under which they are to be used. That is while the lowest possible viscosity material is chosen, regard must be had for its flash point, fire test, etc. where these factors come into play. For example these factors are important in connection with the lubrication of an internal combustion engine where in order to secure the necessary flash point etc. in the oil, its viscosity would have to be higher than in lubrication of an ice machine where such factors would be of little importance. But in any event, in accordance with the present invention, the oil of lowest possible viscosity is chosen having in mind the heat conditions under which it is to be used. The use of these low viscosity oils is evidently advantageous and particularly when full fluid or viscous friction is to be utilized, as the amount of friction under these conditions is dependent upon the viscosity only, and the lower the viscosity, the more economical is the lubrication.

But while the viscosity should be as low as possible, the adhesive properties should be as high as possible. When a bearing for example, comes to a stop, or when for any other reason the so-called greasy-layer has to take up the work for a short time, the lubricant must have the power of forming a greasy layer sufficiently thick to act as a cushion between the metallic surfaces and must be sufficiently adherent to remain on the surfaces of the metals under severe conditions of service.

It has been known for some years that the property of "oiliness" of the ordinary petroleum oil is improved by the addition of saponifiable oil or fatty acids of saponifiable oil.

The principle on which an oily or greasy agent is added to the petroleum or other stock is based upon the fact that bearing surfaces by their surface energy preferentially attract from the lubricant to themselves certain portions of the lubricant, and it has been shown that the first layer of molecules so attracted may be held to the bearing surfaces with great tenacity. This initial layer upon the surfaces is almost infinitely thin, and though useful, is not sufficiently thick to protect the metallic or other surfaces against rupture of this thin oily film; such rupture though in parts only giving rise to undue friction and possible injury to the bearing surfaces. Further the building up of the first layer involves a time interval that must be considered and when the amount of material such as fatty acid which is readily adsorbed by the bearing surface is present in the lubricant in small proportion only, the disturbance created by the relative motion of the journal and bearing or other parts being lubricated may interfere with the formation or reformation of the first layer sufficiently to cause injury during the interval of its formation. The use of but small quantities of the oily or greasy agent, say up to 2 percent as has been suggested is therefor considered to be too low as a general rule.

These adsorbed substances may be termed "polar" bodies since there is present in them at one end of the molecule, a substituent group that changes the character of the hydrocarbon and the surface forces of the metals have a particular attraction for these substituent groups, the molecule apparently standing on end with the substituent group attached to the metal, and the remainder of the molecule extending out into the body of the fluid.

Among the further objects of the present invention are accordingly the use of low viscosity lubricating oils with added components giving oiliness or greasiness, the addition of such added components in substantial amounts, and the extension of the field of choice of such added ingredients and components.

But while as pointed out above, it is desirable to place in the stock a substance or substances which will be readily adsorbed by the surface, it is more important to build up this initially formed thin layer into a relatively thick one to protect the surface against any possible injury during the interval when this primary layer is being formed or at any time that this primary layer becomes ruptured. This may be done for example by adding substances which are attracted preferentially to the adsorbed primary layer or readily commingles with the substance or substances forming the primary layer. These additional layers are called "mush" layers and a lubricant which has the property of building up these so-called "mush" layers may be referred to as having the property of "mushiness". These "mush" layers are more resistant the closer they are to the initial or adsorbed layer and fade off gradually into the average composition of the lubricant. The total depth or thickness of the mush layers can be made within reason as great as requisite.

A further object of this invention therefore is the production of lubricants, particularly of low viscosity, that have the property of building up these "mush" layers and thus extending the effectiveness of the initial or primary adherent layer.

In addition, it may be noted, that when high temperatures prevail, the oils oxidize rather readily with the formation of gummy materials that are disadvantageous in practice. Some of the animal and vegetable oils and their derivatives used as the greasy or oiliness components, oxidize less readily than others, but all of them even when mixed with mineral oils oxidize to a greater or lesser extent and some like cotton oil and corn oil are seldom or never used either alone or mixed with mineral oil on account of this ease of oxidation.

Among the further objects and advantages of the present invention is the introduction of substances into the lubricant that lessen or prevent the oxidation of the oil under the conditions of service, so that undesirable changes in the oil due to oxidation rendering them undesirable from many points of view, are avoided or eliminated. The use of anti-oxidants evidently broadens the field and use of vegetable oils and mineral oils, as mineral oils also oxidize to a lesser extent than the vegetable and animal oils.

Other objects and advantages of this invention will appear from the more detailed description set forth below, it being understood however that various changes within the scope of this invention may be made by those skilled in the art without departing from the spirit and scope of this invention as herein disclosed.

And as set forth above, the most desirable form of the lubricant will be a compounded oil that possesses low viscosity, high adhesiveness, the ability to build up "mush layers", and that is not changed by oxidation to any extent that renders it undesirable for lubrication.

The present invention is therefore broadly concerned with the use of lubricating oil stock whether derived from petroleum or the products of distillation of coal and shale, that has the lowest

possible viscosity for the condition under which the machine operates; that is the lowest viscosity that is obtainable with the requisite flash point to withstand the temperature prevalent during use, and this applies whether the lubricant stock is derived from a straight paraffin stock or from a so-called asphaltic or semi-asphaltic base oil. For cold conditions or climates the non-paraffin base oils having lower freezing points than the paraffin base oils are in general more desirable for this reason.

The low viscosity stock may be used for lubrication by itself in those cases where it is pumped about a bearing, by external means, as in the case of turbines; but its use in the ordinary bearing where no pumping action is present aside from that produced by the rotation of the bearing itself or the journal, is preferable in conjunction with the added ingredients for improving its properties as to oiliness and mushiness.

It is a significant fact that such low viscosity material could not be secured on the open market as inquiry among the various oil companies and refineries developed. So that such low viscosity material had to be made for the first time and methods were developed for its production.

For example, a desirable stock may be made as by distilling off about 75 percent of the lighter material from kerosene oil and using the remainder in the still as "stock" for the preparation of the finished lubricant. There results a product of requisite fire point and cold test with much lower viscosity than those commercially available today, and these products may in general be said to have a viscosity of less than 150 seconds at 100° F. A specific product obtained by distilling off 75 percent of ordinary coal oil tested as follows:

Specific gravity at 60° F	38.3° Bé.
Flash point	240° F.
Fire point	275° F.
Viscosity at 40° F	74 sec. (S.U.)
Viscosity at 60° F	56 sec.
Viscosity at 80° F	45 sec.
Viscosity at 100° F	40 sec.
Viscosity at 210° F	31 sec.
Cold test	Below 0° F.
Total saponifiable matter	11.3%
Free fatty acids	1.2%

Similar products as to viscosity may be prepared from any of the other distillates of like boiling point, petroleum, coal tar or shale oil.

In general it may be stated that the viscosity of a hydrocarbon stock should not be so low that the product has a flash point of below about 225 to 230° F. But as pointed out in connection with the more general considerations set forth above, these factors are variable depending on the use to which the lubricant is to be put.

As indicative further of oils that may be used, products having the following characteristics may be noted:

	I	II	III
Gravity at 60° F	24.8	24.8	----
Flash point ° F	290	280	235
Fire point ° F	340	340	265
Viscosity at 100° F. (seconds)	72	60	44+

Such products as those indicated above are particularly desirably used in connection with the present invention, and in the case of the product III above, in view of the further fact that this material has a substantially uniform viscosity over the usual working scale, it is all the more desirable.

T. C. Thompson in his standard work on this subject lists eighteen oils with viscosity numbers of from 1 to 18 and ranging in viscosity as follows:

Viscosity numbers	Saybolt seconds		
	100° F.	130° F.	212° F.
1	65	45	29
2	80	50	31
3	95	60	32
4	125	70	34
5	160	81	36
6	180	86	38
7	240	115	43
8	350	160	50
9	500	230	55
10	700	320	65
11	----	----	80
12	1400	470	90
13	1800	600	100
14	----	----	130
15	----	----	165
16	----	----	190
17	----	----	700
18	Blown oils		1400

Of these, numbers 1–5 are the so-called spindle oils not generally considered in the lubrication program, but they will be used in accordance with the present invention when properly compounded for relatively heavy machinery; in addition to oils running from 65 seconds down as low as can be obtained—probably around 35 seconds.

The proposed low viscosity material discussed above emphasizes the use in accordance with the present invention of the lowest possible viscosity material. Take for example the first five oils of the Thompson tabulation. These oils if used in the prior art are limited for lubrication purposes to use on textile spindles where the load is almost zero and the speed is rather high. They have not been used in lubricating heavy machinery. However when compounded in accordance with the present invention in order to give them the requisite oiliness and mushiness, but still retaining their low viscosities, they will be used for such heavy machine lubrication. This is a phenomenal departure from prior art practice.

These low viscosity oils not hitherto available in the art for lubrication, are desirably compounded as set forth above with an agent forming the primary layer. As stated, fatty acids and particularly the higher fatty acids may be used. Further, the higher the fatty acid, the better its effect. Also, the presence of the hydroxyl group in the molecule with the carboxyl group yields a better lubricant. As an example, attention may be called to the fatty acids of castor oil. But these bodies which may be referred to as indicated above as "polar" bodies are not limited to the fatty acids, and non-fatty acid polar bodies or compounds or materials may be used. The higher alcohols and ketones are advantageous and work almost as well as the fatty acids; sulphides and some of the metallic salts are also efficient though in general due to the ready availability of the fatty acids and their cheapness, they are more generally used.

In some cases, however, the use of fatty acids may be objectionable due to the effect on the metal of the bearing or journal. Accordingly the "polar" body will be chosen with such considerations in mind.

The higher alcohols and ketones may be readily obtained from the oxidation products obtained during the air blowing of petroleum and related materials particularly under pressure and at elevated temperatures, or from the residues remaining in the still during such air blowing processes. The sulphides may be prepared by direct treatment of petroleum oil with sulphur, the products being somewhat complex, but the polar bodies appear and their effect is available.

The "mush" layers may be obtainable with various substances. The best effect is obtained with a material that is soluble in the polar body and quite, or totally insoluble in the petroleum oil, so that when a portion of the fatty acid or other polar body adheres to the metal surface to form the primary layer, a very considerable quantity of the mush substance will be withdrawn and a thicker and more coherent mush layer will be brought up. Saponifiable oils or fats that contain some fatty acid to act as the polar body serve in this connection. If the amount of fatty acid is small, the polar fatty acid will be withdrawn and will act to take up but a comparatively small quantity of the mush ingredient, namely the neutral glycerides or fats, and a comparatively thin and soft coating results. The presence of comparatively large quantities of substances more attracted to the polar body will assist in building up a better mush layer. A good example is castor oil dissolved in oleic acid, the castor oil being substantially insoluble in petroleum oil stock used. Two parts of castor oil to one part of oleic acid may be used. The oleic acid acting as the polar body carries down with it large quantities of the castor oil and the mush layer consists largely of oleic acid and castor oil. This artificial or synthetic composition builds up a better layer than does an ordinary animal oil consisting of a mixture of some free acid and natural glycerides.

Insofar as the formation of the mush layer is concerned, it does not appear to be material whether the substances are in solution or in colloidal condition, and both are available. Any method by which molecular attraction, i. e., the clinging together of molecules by either known chemical attraction or residual chemical forces, may be made use of. It is well known that substances used in lubrication build up a surface film on the metallic surface of considerable tenacity. Other substances may also form or build up such films but they are not of value as lubricants. In those cases where the fatty acids are objectionable in a lubricant, the substituted ammonias that have little value as lubricants but build up films on the surface, can be used, if there is also added some material of high lubrication power that is selectively adsorbed by the substituted ammonia or forms molecular aggregates with it. In the lubrication of internal combustion engines where high temperatures prevail, the avoidance of such acidity is desirable. There may be used in such cases a mixture of diphenylamine and tallow oil (with little or no free acid). Good results are obtained when only 5 percent of this mixture is used.

Soaps which form an emulsion with the petroleum stock or which are soluble in the petroleum stock can also be used. For example, soaps with petroleum stock particularly the soda and lime soaps that are present as colloids.

The soaps that go into solution include lead oleate, copper oleate, and the oleates of the heavy metals generally, the alkalies and alkaline earth metals forming colloids. As apparently soluble compounds there may be mentioned copper oleate, zinc oleate and sodium sulphur oleate, while ordinary calcium and sodium oleate when used, are present as colloids.

Animal oils such as lard oil may be used in amounts as exemplified by 10 percent, but other oils such as tallow oil which contains some free acid is preferable to lard oil, and castor oil when in solution as illustrated above is superior to either lard oil or tallow oil.

In some cases, the body added to improve the mushiness characteristic may at the same time possess a polar property so that in this way two purposes can be secured at the same time. This is particularly true of some of the sulphur compounds in the nature of sulphides illustrated above, and the sulphonic acids. As exemplary of the sulphonic acids that may be used for this purpose, the following is given.

Sulphonic acids derived from the treatment of unsaturated petroleum compounds, that is to say those obtained from the residue of the purification of ordinary petroleum oil by treatment with sulphuric acid, may be used. These sulphonic bodies are of indefinite chemical composition. The sulphonic acid group HSO_3 in these bodies acts as the polar body. Sulphonic acids can also be prepared and used which are dye-stuff intermediates, and these compounds may be very complex or elaborate. The simple hydrocarbons and the more complex ring compounds including double and triple rings may serve in this connection for the production of these sulphonic derivatives. As an example of dyestuff intermediates utilizable in this connection, mention may be made of the naphthol sulphonic acids.

These bodies which serve as both the polar and the mushiness ingredients may of course be used as the polar ingredient alone, and in general it has been found more desirable to use two separate ingredients for this purpose rather than to accomplish both ends with a single substance.

The anti-oxidant may be any substance that in a general sense reduces the effect of oxidation or air upon the lubricant. As such there may be mentioned: tetra ethyl lead, phenol disulphide, amido and amide compounds, phenols such as pyrogallol, hydroquinone, and other substances such as elementary sulphur and malachite green.

The following specific example of a lubricant made in accordance with the present invention that has proved particularly advantageous in practice is given.

Two parts of castor oil are dissolved in commercial oleic acid, and the mixture heated to about 160° F. to insure solution. The resultant product is admixed or added to petroleum stock having the characteristics set forth above, the castor oil oleic acid mixture constituting 5 percent of the total admixture. When the oil is to be used at a relatively elevated temperature, one part of beta-beta-dinaphthylamine is added to the oil; while if the oil is to be used at normal temperature, one part of monomethylaniline is added in lieu of the dinaphthylamine. These products are superior to the lubricant made from oils such as I, II, and III given above to which 10 percent lard oil is added. However, the latter products may also be used and have given good results in practice.

The amount of the anti-oxidant is varied according to the time at which the lubricant is to be used and the conditions as to oxidation. At

very low temperature, the effect of the oxygen is very little feared, so that the amount of antioxidant used in such cases may be as low as .1 of 1 percent. The dinaphthylamine is desirable but tetra-ethyl lead has also proved to be moderately efficient.

While certain theoretical considerations have been given in the explanation of the present invention, it should be noted that the tangible effects produced in accordance with the invention are not dependent on the theories stated, as the lubricants disclosed herein have been investigated under actual conditions of service and have proved a tremendous advance in the art. Even when such terms as "polar" are used these terms need not be considered as implying a certain theory of operation but may be taken as class or generic names.

As exemplary of the phenomenal results flowing from the present invention, attention may be called to the fact that it has been applied in the lubrication of a large railway system where about 30,000 bearings are under study. Whereas, it had been the custom to use oils of viscosity of about 250 seconds viscosity Saybolt prior to this application of the present invention, following the principles set forth above, the lubrication of bearings of the character of a street railway car is being made with oils of a viscosity of 35 seconds Saybolt universal viscosimeter, at 100° F. This lubrication with these oils of low viscosity has already resulted in the saving of approximately 15 percent of the costs in operating these cars, though the entire system is not yet fully equipped, and will result when full installation has been made, in a saving of approximately 25 percent of the original power costs, or a saving of hundreds of thousands of dollars annually.

Having thus set forth my invention, I claim:

1. A lubricating oil for heavy machinery containing a hydrocarbon oil having a viscosity considerably lower than that normally used for such purposes and within the range of 35 seconds to 65 seconds (Saybolt) at 100° F., and from 2 to 10% of an organic component increasing the oiliness and adhesiveness of the composition without substantial increase of viscosity.

2. A lubricating oil for heavy machinery consisting of a hydrocarbon oil having a viscosity considerably lower than that normally used for such purposes and within the range of 35 seconds to 65 seconds (Saybolt) at 100° F., and from 2 to 10% of a substance having high adhesive properties including oxidation products of petroleum type hydrocarbons which does not substantially increase the viscosity of the composition.

3. A lubricating oil for heavy machinery consisting of a hydrocarbon oil having a viscosity considerably lower than that normally used for such purposes and within the range of 35 seconds to 65 seconds (Saybolt) at 100° F., and from 2 to 10% of a substance having high adhesive properties containing a large proportion of saponifiable material which does not substantially increase the viscosity of the composition.

4. A lubricating oil for heavy machinery containing a hydrocarbon oil having a viscosity considerably lower than that normally used for such purposes and within the range of 35 seconds to 135 seconds (Saybolt) at 100° F., and from 2 to 10% of an organic component increasing the oiliness and adhesiveness of the composition without substantial increase of viscosity.

5. A lubricating oil for heavy machinery containing a hydrocarbon oil having a viscosity considerably lower than that normally used for such purposes, and within the range of 35 seconds to 135 seconds (Saybolt) at 100° F., and from 2 to 10% of an organic component containing a saponifiable glyceride, increasing the oiliness and adhesiveness of the composition, without substantial increase of viscosity.

6. A lubricating oil for heavy machinery containing a hydrocarbon oil having a viscosity considerably lower than that normally used for such purposes and within the range of 35 seconds to 135 seconds (Saybolt) at 100° F., and from 2 to 10% of an organic component containing a saponifiable glyceride oil and higher fatty acids increasing the oiliness and adhesiveness of the composition, without substantial increase of viscosity.

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