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LUBRICANT

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This invention relates to improvements in lubricants and has for a principal object the provision of a compounded hydrocarbon lubricating oil of highly improved "oiliness" characteristics.

Another object of the invention is to provide a lubricating oil having pronounced "non-sludging" characteristics.

Another object of the invention is to provide a lubricating oil of sufficiently high stability to prevent the formation of gummy and resinous oxidation and polymerization products.

Another object is to provide a novel and simplified method of preparing the desired compounded lubricating oil.

Further objects will become apparent as the invention hereinafter becomes more fully disclosed.

Lubricating oils for use in engines, particularly internal combustion engines, must have certain properties which tend to assure long continued operation of the engines by providing complete lubrication of the parts thereof, especially the cylinders, pistons and piston rings which are subject to severe heat conditions.

The above is particularly true of lubricating oils manufactured specifically for use in internal combustion engines of the Diesel type in which higher compression pressures and higher air-fuel ratios are essential operating factors.

To maintain such high compression for efficiency reasons the piston rings must function perfectly without sticking under the concomitant heat conditions to which the piston and piston rings are subject.

Also the above facts are true when applied to any type of internal combustion engine other than the Diesel type, even though in the ordinary spark ignition type of engine operating under relatively lower compression pressures than the Diesel type, the operating temperature range of the pistons and piston rings of said spark ignition type may be higher than that of similar parts of the Diesel type.

This is particularly true of the high speed Diesel type of engine equipped with aluminum pistons on account of the better heat conductivity of aluminum when compared to iron. However, the object of the invention is to design a compounded lubricating oil which will show the desired stability towards oxidation and polymerization over a wide range of heat and pressure conditions in order to fit into the service of any kind of internal combustion engine, as partially illustrated by,

- (1) Engines operating on spark ignition of compressed gaseous fuels (gas engines),
- (2) Engines operating on spark ignition

of vaporized liquid fuels (gasoline engines).

(3) Engines operating with compression ignition of atomized heavy liquid fuels (Diesel engines).

5 In all these services it is essential that the lubricant has good affinity for metal surfaces, which is maintained at the conditions prevailing on those surfaces under a wide range of temperatures and pressures.

10 In order to more fully comprehend the scope of the invention, it should be understood that mineral oils suitable for lubricating oils consists of a mixture of different series of hydrocarbons. Depending on the origin of the crude oil, such
15 mixture may include the saturated, the unsaturated, and the aromatic series of hydrocarbons, which are thus above defined for the purposes of the invention and any boiling range of finished lubricating oil may include one or more of the
20 above series.

Heretofore in refining lubricating crude oil, it has been considered advisable to so treat the oil that most of the unsaturates and aromatic hydrocarbons will be removed and leave only a body
25 of substantially saturated hydrocarbons for use as a lubricating oil. However such saturated oils are not only deficient in film strength or "oiliness," and adherence to metal surfaces, but upon exposure to air at high temperature and high
30 pressures, oxidation occurs in the cylinders of an engine, whereby acidic compounds are formed which is considered the initial step in their deterioration as lubricating oils.

Such oxidation products are of a resinous, oil
35 insoluble, type which gather around the piston rings in the ring grooves and cause piston ring sticking and thus the ultimate seizure and scoring of the piston in the cylinder.

Inasmuch as oxidation in general is largely a
40 function of temperature, there is a certain temperature range within which saturated hydrocarbons might function well as lubricating oil in internal combustion engines without deteriora-
45 tion, but outside of which oxidation will occur.

When the above deficiencies of saturated hydrocarbons as a lubricating oil are attempted to be remedied by the inclusion of unsaturated hydrocarbons the acidic compounds formed as
50 stated by oxidation of the saturated hydrocarbons cause secondary condensation reactions with the unsaturated hydrocarbons and thus cause the formation of an oil insoluble sludge detrimental to the function of the oil body as a
55 lubricating oil.

In order to obtain a lubricating oil combining freedom from piston ring sticking tendencies with non-sludging characteristics, this invention pro-

vides for the addition of certain metal compounds to a lubricating oil which has been processed sufficiently to remove undesired hydrocarbons and impurities, although it should be understood that a body of completely saturated hydrocarbons may be treated as herein set forth. The processing of the basic oil may be by well known methods, such as by selective solvents like liquid sulphur dioxide, phenol, dichlorethylether, furfural, nitrobenzene and the like, or by sulphuric acid, or by both, to any desired degree of refinement.

In the removal of the undesirable constituents of the oil by the above mentioned methods it may be desirable to retain in the oil certain compounds of acidic nature, as originally present in raw lubricating oil distillates. Reference is specifically made to the so-called naphthenic acids, which by proper application of the treating methods may be left in the refined lubricating oil. This will be further illustrated in the following description of the process herein disclosed.

There are two methods by which the invention may be practiced. In the first method a raw lubricating oil distillate containing organic acids normally present in such oil, such as naphthenic acids, is treated in the usual manner preferably with a selective solvent of the type liquid sulphur dioxide, phenol, dichlorethylether, furfural, nitrobenzene, or the like to yield a raffinate comprising substantially those hydrocarbons which have the desired characteristics of a lubricating oil. To such treated oil is added sufficient metal oxide or hydroxide, preferably calcium oxide or hydroxide, to form a metal soap in the oil; such soap comprising about between 0.01% and 1.0% by weight of the oil. The oxides or hydroxides are preferably selected from the group of the alkaline earth and earth metals, namely, calcium, strontium, barium, magnesium, zinc, aluminum, chromium. Most preferred of those enumerated is calcium oxide or hydroxide, not only by reason of economy, but also particularly because the calcium soaps are most effective for the purpose of imparting resistance to oxidation and non-sludging characteristics to the oil, but the invention is not limited thereto.

Alternatively the conversion of the free organic

acid to a metal soap, more specifically a calcium soap may be accomplished by adding instead of calcium oxide or hydroxide, the free calcium metal or even a suitable calcium salt, such as calcium acetate, in which the acetic acid radical can be easily displaced by that of the less volatile higher molecular weight organic acids.

Alternatively, where the organic acid content of the lubricating oil is insufficient to provide a desired percentage of incorporated soap as above described, sufficient organic acids may be added to the oil prior to saponification to obtain the required soap content, or a desired pre-formed metal soap may be added to an oil lacking in organic acidity in the desired proportions.

Again, in the event that the treated lubricating oil is lacking in contained organic acids, such acids may be added in the form of fatty acids together with equivalent portions of metal base to form the metal soaps.

In general, the higher molecular weight fatty acids are to be preferred where their calcium soaps are to be used and the type fatty acid to be used may include saturated or unsaturated, hydroxy, or polybasic fatty acids, or mixtures of the same. Carboxylic acids derived from cyclic nuclei in general are not particularly suitable for our purposes, primarily on account of their very low solubility but also on account of the relative instability of their metal soaps.

However, aryl-substituted fatty acids of the type $C_nH_{2n-2}(Ar)COOH$, resemble in their solubility and stability the ordinary fatty acids and therefore may be used in form of their alkylne earth metal soaps.

As examples of different organic acids, which have been tried, the following tabulation may be presented, showing the solubility characteristics, the stability of the compounded oil and the sludge inhibiting characteristics of each particular soap. The sludging test was carried out by heating a 100 gram sample of the oil, containing 1% by weight of the particular soap, to 330° F., for 24 hours in presence of a metallic catalyst, which contains all the metallic elements present in the oil circulation system of an internal combustion engine (iron, copper, lead) which are also known as accelerators for oxidation.

TABLE No. 1

Metal soap added to mineral lubricating oil	Solubility of soaps in mineral oil at room temperatures	Characteristics of compounded oil after heat test	
		Appearance	Thru color $\frac{1}{4}$ " cell Lovibond
None		Slight carbonaceous deposit	550
<i>Calcium soaps of saturated acids</i>			
Melissic acid, $C_{30}H_{60}O_2$	Slight ¹	Slight precipitate of soap	40
Montanic acid, $C_{28}H_{56}O_2$	do	do	45
Cerotic acid, $C_{26}H_{52}O_2$	do	Trace precipitate of soap	50
Lignoceric acid, $C_{24}H_{48}O_2$	do	do	60
Behenic acid, $C_{22}H_{44}O_2$	do	Very slight trace precipitate of soap	80
Arachidic acid, $C_{20}H_{40}O_2$	do	do	110
Stearic acid, $C_{18}H_{36}O_2$	Moderate ¹	Clear	130
Palmitic acid, $C_{16}H_{32}O_2$	do	do	180
Myristic acid, $C_{14}H_{28}O_2$	High ¹	do	240
Lauric acid, $C_{12}H_{24}O_2$	do	do	300
Capric acid, $C_{10}H_{20}O_2$	do	do	400
Butric acid, $C_4H_8O_2$	None	Slight carbonaceous deposit	Opaque
Acetic acid, $C_2H_4O_2$	do		
<i>Calcium soaps of unsaturated acids</i>			
Erucic acid, $C_{22}H_{42}O_2$	Moderate	Clear	110
Oleic acid, $C_{18}H_{34}O_2$	High	Slight precipitate of soap	90
Elaidic acid, $C_{18}H_{32}O_2$	do	Trace of soap	60
Linoleic acid, $C_{18}H_{32}O_2$	do	Heavy precipitate of soap	100
Telluric acid, $C_{18}H_{32}O_2$	do	do	120
Linolenic acid, $C_{18}H_{30}O_2$	do	do	200

TABLE No. 1—Continued

Metal soap added to mineral lubricating oil	Solubility of soaps in mineral oil at room temperatures	Characteristics of compounded oil after heat test	
		Appearance	Thru color $\frac{1}{2}$ " cell Lovibond
<i>Calcium soaps of saturated hydroxy acids</i>			
Mono-hydroxy stearic acid, $C_{17}H_{35}O_2(OH)$	Moderate	Clear	120
Di-hydroxy stearic acid, $C_{17}H_{33}O_4(OH)_2$	do.	do.	130
Tri-hydroxy stearic acid, $C_{17}H_{31}O_6(OH)_3$	Slight	Trace of soap	170
Tetra-hydroxy stearic acid, $C_{17}H_{29}O_8(OH)_4$	do.	do.	200
Hexa-hydroxy stearic acid, $C_{17}H_{25}O_{10}(OH)_6$	Very slight	Slight precipitate of soap	260
<i>Calcium soaps of unsaturated hydroxy acids</i>			
Ricinoleic acid, $C_{18}H_{33}O_2(OH)$	High	Gummy precipitate	200
<i>Calcium soaps of chlorinated acids</i>			
Chlorinated stearic acid	Moderate	Clear	200
Chlorinated oleic acid	High	do.	150
<i>Calcium soaps of cyclic acids</i>			
Benzoic acid, C_6H_5COOH	Very slight	CaO precipitate	500
Salicylic acid, $C_6H_4(OH)COOH$	do.	do.	500
Cinnamic acid, $C_6H_5CH:CHCOOH$	do.	do.	550
Hydrocinnamic acid, $C_6H_5CH_2CH_2COOH$	do.	do.	550
Phthalic acid, $C_6H_4(COOH)_2$	do.	do.	550
Naphthoic acid, $C_{10}H_7COOH$	do.	do.	550
Abietic acid, $C_{19}H_{31}COOH$	High	Clear	70
Naphthenic acid (extracted from petroleum)	do.	do.	55
<i>Soaps of metals other than calcium</i>			
Magnesium melissate	Slight	Slight precipitate of soap	150
Magnesium stearate	Moderate	Clear	130
Magnesium oleate	High	do.	100
Magnesium ricinoleate	do.	do.	250
Magnesium naphthenate	do.	do.	120
Strontium oleate	Slight	Heavy precipitate of soap	80
Strontium naphthenate	Moderate	do.	80
Barium stearate	Slight	Slight precipitate of soap	150
Barium oleate	Moderate	do.	110
Barium ricinoleate	do.	do.	220
Barium abietate	do.	do.	150
Barium naphthenate	do.	do.	90
Aluminum stearate	High	Clear	110
Aluminum oleate	Moderate	Slight precipitate of soap	350
Aluminum abietate	High	Heavy precipitate Al_2O_3	400
Aluminum naphthenate	do.	Clear	150
Zinc stearate	do.	do.	180
Zinc oleate	do.	do.	200
Zinc abietate	do.	do.	250
Zinc naphthenate	do.	Slight precipitate of ZnO	400
Chromium oleate	do.	Heavy precipitate of Cr_2O_3	220
Chromium naphthenate	do.	do.	250

¹ Up to 0.1% by weight.

² Up to 0.5% by weight.

³ More than 0.5% by weight.

The color of the original oil before heating and the addition of the soap, was between 10 and 20 in a $\frac{1}{2}$ " Lovibond cell. A darkening of the color is therefore indicated by through color substantially above 20.

In this mode of operation the formation of the soaps involves the formation of molecular equivalents of water by reaction. This water has to be removed from the system because it interferes with the homogeneity of the soap-oil mixture. To this end, during the formation or addition of the desired alkaline earth metal soap in the oil, the temperature should be maintained at or sufficiently above the boiling point of water or the pressure reduced to drive the same out of the oil. On the other hand, if a preformed desired soap is added to an oil, both the oil and the soap should be substantially dehydrated before mixing.

Within the percentage range of 0.01% to 1.0% by weight of alkaline earth metal soap to oil, it is found that the solubility of most of the soaps in the oil requiring stabilization is definitely limited and is in the lower brackets of the above percentages. Such solubility varies inversely with the carbon-hydrogen ratio of the oil, or with the degree of saturation of the oil. In consequence, the solubility of the alkaline earth metal soaps may be sufficient to retain the soap in a certain oil without precipitation up to a relatively high

percentage while, on the other hand, certain other desired hydrocarbon oils will precipitate out a portion of the stabilizing soaps desired to be retained.

As an instance of this, lubricating oils derived from asphalt or naphthene base crudes, whether treated or untreated, have a higher solvency power for alkaline earth metal soaps than oils derived from paraffine base crude. Also, an untreated lubricating oil distillate has a higher solvency power for these soaps than one which had been treated with either selective solvents or sulphuric acid.

The second method of treatment herein comprehends the incorporation and retention of alkaline earth metal soaps in a lubricating oil regardless of the origin or degree of refinement of the oil.

An increase in the solubility of alkaline earth metal soap and permanency of its solution in an oil may be accomplished by subjecting the mixture during formation of the soap or after the addition thereof to a temperature of at least about 400° F., for a period of time sufficient to drive off all water formed by the saponification. However, with this heat treatment of certain oils, undesirable darkening will occur, and therefore it is preferred to use an agent which has a dispersing and homogenizing effect on the soap at

lower temperature to make the same completely and permanently soluble in the oil and further to effect dispersal in such fashion that the soap remains in the oil as a clear solution without precipitation of any character whatsoever over an indefinite period.

These dispersing agents comprise two classes, either of which are effective.

(a) Agents which are of a boiling range lower than that of the oil and which are removed from the oil after having exercised their dispersing function.

(b) Agents which are of a boiling range not necessarily lower than that of the oil which will remain in the oil to serve as homogenizers for the compounded oil.

Agents of class *a* are solvents of an organic nature other than hydrocarbons, which have sufficient solvency power for both the oil and the alkaline earth metal soap used, and which have a boiling range lower than the oil but higher than that of water. Such solvents of class *a* which are found to be effective, include various alcohols, ketones, esters, ethers. Examples of such compounds found suitable, are compiled in Table No. 2 (Dispersing agents).

TABLE NO. 2
Group A—Dispersing agents

Material used	Dispersing action upon soap
Amyl alcohol.....	Poor.
Octyl alcohol.....	Fair.
Lauryl alcohol.....	Good.
Benzyl alcohol.....	Do.
Ethylene glycol.....	Poor.
Diethylene glycol.....	Do.
Phenol.....	Do.
Cresol.....	Do.
Hexahydrophenol.....	Good.
Amyl ether.....	Poor.
Methyl ether of ethylene glycol.....	Good.
Methyl ether of diethylene glycol.....	Fair.
Methyl phenyl ether.....	Good.
Benzyl ether.....	Do.
Butyric acid.....	Poor.
Lauric acid.....	Good.
Naphtenic acid.....	Do.
Amyl acetate.....	Poor.
Cellosolve acetate.....	Do.
Dimethyl phthalate.....	Do.
Butyl lactate.....	Do.
Diacetone.....	Fair.
Methyl propyl ketone.....	Good.
Dioxane.....	Poor.
Furfuraldehyde.....	Do.
Octyl aldehyde.....	Fair.
Citral.....	Good.
Benzaldehyde.....	Do.
Aniline.....	Poor.
Pyridine.....	Do.
Dichlorethyl ether.....	Do.
Tetrachlorethane.....	Do.
Chlorbenzene.....	Good.
Chloronaphthalene.....	Do.
Petroleum naphtha.....	Poor.
Coal tar distillate.....	Do.
Methyl naphthalene.....	Fair.
Tetrahydronaphthalene.....	Do.

Of these listed the methyl ether of monoethylene glycol is particularly useful in the process. This solvent has a boiling point of 285° F., and is especially adaptable to be mixed with an organic soap of calcium for permanent solution in hydrocarbon oil because of the solubility of both water and oil in the ether.

In consequence, when an organic alkaline earth metal soap, such as calcium oleate for instance, which has been made from hydrated lime and oleic acid, and the water formed therefrom is tenaciously retained, is mixed with the described ether, water of reaction is abstracted from the soap by the ether and thereby per-

mits the complete solution of the soap in the oil.

The mixing of ether soap and oil is preferably performed while under agitation with an inert gas, such as carbon dioxide, nitrogen or the like, which prevents darkening of the oil, and the mixture may thereafter be heated to a temperature corresponding to the boiling point of the solvent, in the presence of the inert gas, or a temperature sufficient to drive off all the solvent and all the water but insufficient to distill the oil.

Experiments confirm the fact that the desired dispersing agents of the type Class A should exercise the double function of dehydrating the soap while being soluble in the oil and by the mechanics of these functions it may readily be seen that an anhydrous soap is easily dispersed throughout the anhydrous oil to stay in permanent solution therein.

In order to render the solution of soap in oil permanent, it is preferred to subject the mixture to a prolonged heat treatment after the solvent (and water) has been driven off. Ordinarily there is a tendency for some of the soap to form a precipitate if suddenly chilled, or reduced in temperature immediately after removal of the solvent and water, but upon dilution of the precipitated mixture with further oil the precipitate will disappear. However, if a relatively concentrated solution of oil and soap, such as may be made by dispersing the soap in a relatively small portion of oil, is freed of its solvent and water and a temperature of about 150° F., and above is maintained on the mixture for a period of about 24 hours, a clear solution will result which will remain clear indefinitely.

In this respect, it is preferable to so mix the soap and solvent with a small portion of the hydrocarbon oil and to make a soap stock concentrate and then at a later period, when convenient, to distribute the same in larger amounts of oil to bring the percentage of soap in the final product within the stated limits. This will be better appreciated when it is known that the solubility of calcium oleate in a California motor oil of S. A. E. 30 grade at room temperature is between 0.1% and 0.5% by weight, whereas by following our specified procedure of dispersing and homogenizing as described under Class A, it is possible to maintain up to at least 10% of calcium oleate in solution, and hence more concentrated solutions may be reduced by dilution to the desired percentage.

Agents of Class B, which may be called homogenizing agents, include such types of compounds as the esters or ethers, or ester-ethers of high molecular weight fatty acids such as oleic or stearic acid, of which methylether of ethylene glycol oleate, diglycol laurate, diglycol oleate, may be illustrative. Also the esters of mono or polyhydric alcohols, partially or fully esterified, such as derivatives of amyl alcohol, glycerol or glycerol, of which butyl oleate and amyl stearate are illustrative. By this method it is possible to incorporate even higher percentages of alkaline earth soap into any type of lubricating oil. As an example, it is possible to make a solution of up to 30% by weight of calcium oleate in an S. A. E. 30 grade motor oil, which will stay permanently clear and fluid and which can be blended in with more mineral oil to give a permanent clear solution of any desired concentration between 0 and 30%. Examples of various homogenizing agents used are illustrated in Group B of Table No. 2A.

TABLE No. 2A
Group B—Homogenizing agents

Material used	Homogenizing action upon soap
Butyl stearate.....	Fair.
Amyl stearate.....	Good.
Biglycol stearate.....	Poor.
Ethyl oleate.....	Good.
Butyl oleate.....	Do.
Diglycol oleate.....	Fair.
Phenyl oleate.....	Good.
Olein.....	Do.
Methyl Cellosolve oleate.....	Do.
Butyl Cellosolve stearate.....	Fair.
Methyl ester of monochlor stearic acid.....	Good.
Methyl ester of monochlor oleic acid.....	Do.
Chlordiphenyl.....	Do.

Further agents of Class B include halogenated aromatic compounds such as chlorine substitution products of aromatic hydrocarbons and more specifically chlorinated diphenyl. Also certain aliphatic halogen compounds may be used advantageously as stabilizing agents for the compounded oils, such as halogen substitution products of high molecular weight fatty acids, or their esters. As an example may be given the methylester of monochlorstearic acid.

It is interesting to know that the use of homogenizing agents as above described has an added beneficial effect upon the film strength and metal affinity of the lubricating oil. This is particularly striking with the halogen containing ingredients.

As a special case of great interest we wish to emphasize the following, in which a metal soap, more specifically a calcium soap of a halogenated high molecular fatty acid is used as an oxidation inhibitor. We have found that metal soaps of a great number of halogen substituted fatty acids are not only readily soluble in mineral oils, but also impart very pronounced oxidation inhibiting characteristics to those oils.

It appears that the presence of the halogen in the fatty acid radical takes care of the desirable solubility characteristics as well as the film strength characteristics of the added ingredient, while the fatty acid radical still has preserved its oxidation inhibiting quality.

Metal soaps of the following halogen substituted fatty acids have been found effective.

Designation	Formula
Theta-chlorstearic.....	$\text{CH}_3(\text{CH}_2)_7\text{CH}(\text{Cl})(\text{CH}_2)_7\text{COOH}$
Iota-chlorstearic acid.....	$\text{CH}_3(\text{CH}_2)_7\text{CH}(\text{Cl})(\text{CH}_2)_8\text{COOH}$
Theta-iota dichlorstearic acid.....	$\text{CH}_3(\text{CH}_2)_7\text{CH}(\text{Cl})\text{CH}(\text{Cl})(\text{CH}_2)_7\text{COOH}$
Nu-chlor-erucic acid.....	$\text{CH}_3(\text{CH}_2)_7\text{C}(\text{Cl})=\text{CH}(\text{CH}_2)_{11}\text{COOH}$
Theta-iota-dichloroleic acid.....	$\text{CH}_3(\text{CH}_2)_7\text{C}(\text{Cl})=\text{C}(\text{Cl})(\text{CH}_2)_7\text{COOH}$

In compounding mineral lubricating oils in the various manners described, the general physical characteristics such as gravity, flash, and fire points, and viscosity, are not materially changed so that the desired stability features in these lubricating oils can be obtained without necessitating any changes in S. A. E. rating. The following table shows a comparison between a straight mineral oil and a compounded product made from the same oil by addition of a metal soap, using either dispersing agents or ho-

mogenizers, or by addition of metal soaps of chlorinated fatty acids.

TABLE No. 3

5 Comparison of straight mineral oil with oil compounded for stabilization

	Grav.	Flash	Fire	Viscosity S. U.		
				100	130	210
10 California lubricating oil as is.....	22.3	410	460	607	230	58
Same, containing 1% by weight Ca oleate incorporated, using methylcellosolve as dispersing agent.....	22.2	410	460	612	231	58
15 Same, containing 1% by weight of Ca oleate+0.5% of amylstearate as homogenizing agent.....	22.1	410	465	618	232	59
Same, containing 1% by weight of Ca soap of monochlorstearic acid.....	22.2	415	470	612	230	58
20						

In the above disclosure a number of preferred methods have been indicated for the manufacture of a compounded lubricant containing from relatively minute to large quantities of desired soaps. It should, however, be understood that this invention is not limited to the above examples, and it is possible to also manufacture compounded lubricants by a combination of these steps, and particularly within certain ranges of solubility, by the manufacture of a soap dissolved in a dispersing or homogenizing agent and the utilization of this mixture in compounding the oil. The scope of the invention is more clearly defined by the following claims.

35 This application is a division of our copending application Serial Number 119,158, filed January 5, 1937.

We claim:

1. A lubricating oil for severe service internal combustion engines comprising a naphthenic base mineral lubricating oil containing about 1% of an oil-soluble soap of abietic acid, the soap having the property of controlling ring sticking in heavy-duty internal combustion engines and free from the property of imparting substantial viscosity increase to the base oil in the stated amount.

2. A lubricating oil according to claim 1 wherein the soap is a calcium soap.

3. A lubricating oil for internal combustion engines comprising naphthenic base mineral lubricating oil from a California crude and an oil-soluble soap of abietic acid in quantity sufficient to lessen piston ring sticking but insufficient to increase materially the original viscosity of the naphthenic base oil.

4. A lubricating oil for internal combustion engines comprising a California mineral lubricating oil and about 1% of an oil-soluble soap of abietic acid, the soap being present in quantity to control ring sticking in heavy-duty internal combustion engines and free from the characteristic of imparting substantial viscosity increase to the base oil in the indicated proportions.

5. A lubricating oil according to claim 4 wherein the soap contains chlorine.

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