

12

**EUROPEAN PATENT APPLICATION**

21 Application number: **84301569.4**

51 Int. Cl.<sup>3</sup>: **C 10 M 3/12**

**C 10 M 3/10, C 10 M 3/20**

22 Date of filing: **08.03.84**

30 Priority: **09.03.83 US 473841**  
**09.09.83 US 531124**

43 Date of publication of application:  
**19.09.84 Bulletin 84/38**

84 Designated Contracting States:  
**DE FR GB IT NL SE**

71 Applicant: **UNIROYAL, INC.**  
**1230 Avenue of the Americas Rockefeller Center**  
**New York, New York 10020(US)**

72 Inventor: **Loveless, Frederick C.**  
**184 Towpath Lane Cheshire**  
**New Haven Connecticut 06410(US)**

72 Inventor: **Watts, Raymond F.**  
**14 Winchester Drive Califon**  
**Hunterdon New Jersey 07830(US)**

72 Inventor: **Nudenberg, Walter**  
**Route 3 Taunton Lake Road Newton**  
**Fairfield Connecticut 06740(US)**

74 Representative: **Harrison, Michael Robert et al,**  
**URQUHART-DYKES & LORD 11th Floor Tower House**  
**Merrion Way**  
**Leeds LS2 8PB West Yorkshire(GB)**

54 **Ethylene-alphaolefin lubricating composition.**

57 A lubricating composition is provided comprising a high viscosity ethylene-alphaolefin oligomer copolymer having a viscosity of over 3500 to 175,000 centistokes at 100°C; a low viscosity synthetic hydrocarbon and/or a low viscosity ester; and optionally an additive package to impart desirable performance properties to the composition.

ETHYLENE-ALPHAOLEFIN LUBRICATING COMPOSITION

This application is a continuation-in-part of copending application Serial No. 473,841 filed March 9, 1983, the entire disclosure of which is incorporated herein by reference and which is a continuation-in-part of application Serial No. 356,665 filed March 10, 1982, now abandoned.

This invention relates to compositions useful as lubricating oils having high viscosity index, improved resistance to oxidative degradation and resistance to viscosity losses caused by permanent or temporary shear.

According to the instant invention a lubricating composition is provided comprising (1) a high viscosity ethylene-alphaolefin oligomer having a viscosity of from more than 3500 to 175,000 centistokes at 100°C; (2) a low viscosity synthetic hydrocarbon, such as alkylated benzene or low viscosity polyalphaolefin and/or a low viscosity ester, such as monoesters, diesters, polyesters and, optionally (3) an additive package.

An object of the invention is to provide a lubricating composition with properties not obtainable with conventional polymeric thickeners.

A further object of the invention is to provide lubricating compositions exhibiting improved shear stability, oxidative stability and excellent temperature-viscosity properties.

The viscosity-temperature relationship of a lubricating oil is one of the critical criteria which must be considered when selecting a lubricant for a particular application. The mineral oils commonly used as a base for single and multigraded lubricants exhibit a relatively large change in viscosity with a change in temperature. Fluids exhibiting such a relatively large change in viscosity with temperature are said to have a low viscosity index. The viscosity index of a common paraffinic mineral oil is usually given a value of about 100. Viscosity index (V.I.) is determined according to ASTM Method D 2770-74 wherein the V.I. is related to kinematic viscosities measured at 40°C and 100°C.

Lubricating oils composed mainly of mineral oil are said to be single graded. SAE grading requires that oils have a certain minimum viscosity at high temperatures and, to be multigraded, a certain maximum viscosity at low temperatures. For instance, an oil having a viscosity of 10 cSt. at 100°C (hereinafter all viscosities are at 100°C unless otherwise noted) would be an SAE 30 and if that oil had a viscosity of 3400 cP. at -20°C, the oil would be graded 10W-30. An unmodified mineral oil of 10 cSt. can not meet the low temperature requirements for a 10W-30 multigrade rating, since its viscosity index dictates that it would have a viscosity considerably greater than 3500 cP. at -20°C, which is the maximum allowed viscosity for a 10W rating.

The viscosity requirements for qualification as multigrade engine oils are described by the SAE Engine Oil Viscosity Classification - SAE J300 SEP80, which became effective April 1, 1982. The low temperature (W) viscosity requirements are determined by ASTM D 2602, Method of Test for Apparent Viscosity of Motor Oils at Low Temperature Using the Cold Cranking Simulator, and the results are reported in centipoise (cP). The higher temperature (100°C) viscosity is measured according to ASTM D445, Method of Test for Kinematic Viscosity of Transparent and Opaque Liquids, and the results are reported in centistokes (cSt.). The following table outlines the high and low temperature requirements for the recognized SAE grades for engine oils.

SAE Viscosity Grade	Viscosity (cP) at Temperature (°C) Max.	Viscosity (cSt.) at 100°C	
		Min.	Max.
0W	3250 at -30	3.8	
5W	3500 at -25	3.8	
10W	3500 at -20	4.1	
15W	3500 at -15	5.6	
20W	4500 at -10	5.6	
25W	6000 at -5	9.3	
20		5.6	Less than 9.3
30		9.3	Less than 12.5
35		12.5	Less than 16.3
40		12.5	Less than 16.3
50		16.3	Less than 21.9

In a similar manner, SAE J306c describes the viscometric qualifications for axle and manual transmission lubricants. High temperature (100°C) viscosity measurements are performed according to ASTM D445. The low temperature viscosity values are determined according to ASTM D2983, Method of Test for Apparent Viscosity at Low Temperature Using the Brookfield Viscometer and these results are reported in centipoise (cP), where cP and cSt are related as follows:

$$cSt = \frac{cP}{\text{Density, Kg/dm}^3}$$

The following table summarizes the high and low temperature requirements for qualification of axle and manual transmission lubricants.

SAE Viscosity Grade	Maximum Temperature for Viscosity of 150,000 cP, °c	Viscosity at 100°C, cSt.	
		Minimum	Maximum
70W	-55	--	
75W	-40	4.1	
80W	-26	7.0	
85W	-12	11.0	
90	--	13.5	24.0
140	--	24.0	41.0
250	--		

It is obvious from these tables that the viscosity index of a broadly multigraded oil such as 5W-40 or 70W-140 will require fluids having considerably higher viscosity index than narrowly multigraded lubricants such as 10W-30. The viscosity index requirements for different multigraded fluids can be approximated by the use of ASTM Standard Viscosity-Temperature Charts for Liquid Petroleum Products (D 341).

If one assumes that extrapolation of the high temperature (40°C and 100°C) viscosities to -40°C or below is linear on chart D 341, then a line connecting a 100°C viscosity of, for example, 12.5 cSt. and a low temperature viscosity of 3500 cP at -25°C would

give the correct 40°C viscosity and permit an approximation of the minimum viscosity index required for that particular grade of oil (10W-40).

5 The 40°C viscosity estimated by linearly connecting the 100°C and -25°C viscosities would be about 70 cSt. The viscosity index of an oil having  $K.V._{100} = 12.5$  cSt. and  $K.V._{40} = 70$  cSt. would be about 180 (ASTM D 2270-74). Unless the -25°C viscosity of a fluid is lower than the linear relationship illustrated, then an oil must have a viscosity index of at least 180 to even potentially  
10 qualify as a 10W-40 oil.

In actual fact, many V.I. improved oils have viscosities at -25°C, which are considerably greater than predicted by linear extrapolation of the  $K.V._{100}$  and  $K.V._{40}$  values. Therefore, even having a V.I. of 180 does not guarantee the blend would be a  
15 5W-40 oil.

Using this technique minimum viscosity index requirements for various grades of crankcase or gear oils can be estimated. A few typical estimations are shown in the following table:

20	<u>Crankcase Oil Grade</u>	<u>K.V.<sub>100°C</sub> cSt.</u>	<u>Estimated K.V.<sub>40°C</sub> cSt.</u>	<u>Required Viscosity Index</u>
	10W-30	9.3	60	135
	5W-40	12.5	70	180
	5W-30	9.3	53	159
25	0W-50	16.3	75.5	232
	<u>Gear Oil Grade</u>			
	80W-140	24	270	112
	75W-140	24	200	149
	75W-250	41	318	184
30	70W-140	24	150	192

It can thus be seen that preparation of very broadly graded lubricants, such as 5W-40 or 75W-250 requires thickeners which produce very high viscosity indices in the final blends.

It has been the practice to improve the viscosity index of mineral oils or low viscosity synthetic oils by adding a polymeric thickener to relatively non-viscous base fluids. Polymeric thickeners are commonly used in the production of multigrade lubricants.

5 Typical polymers used as thickeners include hydrogenated styrene-isoprene block copolymers, rubbers based on ethylene and propylene, polymers produced by polymerizing high molecular weight esters of the acrylate series, polyisobutylene and the like. These polymeric thickeners are added to bring the viscosity of a base

10 fluid up to that required for a certain SAE grade and to increase the viscosity index of the fluid, allowing the production of multigraded oils. Polymeric V.I. improvers are traditionally high molecular weight rubbers whose molecular weights may vary from 10,000 to 1,000,000. Since the thickening power and V.I. increase are

15 related to the molecular weight of the V.I. improver, most of these polymers normally have a molecular weight of at least 100,000.

The use of these high molecular weight V.I. improvers, in the production of multigraded lubricants has some serious drawbacks:

1. They are very sensitive to oxidation, which results
- 20 in a loss of V.I. and thickening power and frequently in the formation of unwanted deposits.
2. They are sensitive to large viscosity losses from mechanical shear when exposed to the high shear rates and stresses encountered in crankcases or gears.
- 25 3. They are susceptible to a high degree of temporary shear.

Temporary shear is the result of the non-Newtonian viscometrics associated with solutions of high molecular weight polymers. It is caused by an alignment of the polymer chains with the shear field

30 under high shear rates with a resultant decrease in viscosity. The decreased viscosity reduces the wear protection associated with viscous oils. Newtonian fluids maintain their viscosity regardless of shear rate.

We have found that certain combinations of fluids and additives

35 can be used to prepare multigraded lubricants which outperform prior art formulations and have none or a greatly decreased amount of the above listed deficiencies found in polymerically thickened oils.

Certain specific blends of high viscosity synthetic hydrocarbons, low viscosity synthetic hydrocarbons and/or low viscosity esters form base fluids from which superior crankcase or gear oils can be produced by the addition of the proper additive "packages".

5 Besides exhibiting a broad range of viscosity the finished oils thus prepared exhibit an improved stability to permanent shear and, because of their nearly Newtonian nature, reduced temporary shear and so maintain the viscosity required for proper wear protection. The oils of this invention have remarkably better stability toward

10 oxidative degradation than those of the prior art. The unexpectedly high viscosity indices produced from our base fluid blends permit the preparation of broadly multigraded crankcase fluids, such as 0W-40 and gear oils such as 75W-250. Up to now it has been difficult if not impossible, to prepare such lubricants without

15 the use of frequently harmful amounts of polymeric VI improvers. In the instant invention, the high viscosity synthetic hydrocarbons have viscosities of 3500 to 175,000 cSt. may be polyalphaolefins, ethylene-alphaolefin oligomers (EP).

The high viscosity ethylene-alphaolefin oligomers of this invention (EAO) are conveniently prepared by Ziegler catalysis. Many references exist covering methods of producing liquid oligomers of ethylene and alphaolefins (particularly propylene). Polymerization is typically performed by subjecting the monomer mixture usually in a solvent to the combination of an organo aluminum compound and a

20 vanadium or titanium compound. The products formed can range from materials having viscosities as low as 20 cSt. to rubbery semi-solids depending on the choice of catalyst, the addition of molecular weight regulating species, temperature of polymerization and, especially, imposed hydrogen pressure. In some instances low

25 viscosity oligomers are prepared by the pyrolysis of high viscosity oligomers or rubbery solids. Typical preparations of liquid ethylene-alphaolefin copolymers can be found in references, such as:

30

United States Patent No.'s 3,634,249; 3,923,919; 3,851,011; 3,737,477; 3,499,741; 3,681,302; 3,819,592; 3,896,094; 3,676,521; Belgian Patent No. 570,843; United States Patent

35 No.'s 3,068,306, and 3,328,366.

While oligomers of ethylene and at least one other alphaolefin of this invention may be hydrogenated to increase their stability toward oxidation, the proper choice of polymerization catalysts in the presence of hydrogen often produces oligomers having very low  
5 levels of unsaturation directly. The alphaolefins which can be used, singly or in combinations, with ethylene include linear alphaolefins of  $C_3$  (propylene) to  $C_{14}$  (tetradecene) and branched alphaolefins of the same molecular weight range, provided that the branch point is at least in the beta position to the double bond  
10 (e.g. 4-methyl pentene-1). Inasmuch as the rate of polymerization of such olefins relative to ethylene decreases with monomer size, propylene and the lower molecular weight olefins are the preferred monomers in the preparation of the oligomers of ethylene and at least one other alphaolefin of this invention.

15 It is also possible to use in this invention oligomeric ethylene-alpha olefin polymers which contain controlled amounts of unsaturation introduced by copolymerization with certain non-conjugated diene such as dicyclopentadiene, 5-ethylidene-2-norbornene and 1,4-hexadiene. The introduction of unsaturation is sometimes  
20 desired if the oligomer is to be treated in any way to produce polar functionality thus giving the oligomer dispersant properties.

The low viscosity synthetic hydrocarbons of the present invention, having viscosities of from 1 to 10 cSt., consist primarily of oligomers of alphaolefins and/or alkylbenzenes.

25 Low molecular weight oligomers of alphaolefins from  $C_8$  (octene) to  $C_{12}$  (dodecene) or mixtures of the olefins can be utilized. Low viscosity alphaolefin oligomers can be produced by Ziegler catalysis, thermal polymerization, free radically catalyzed polymerization and, preferably,  $BF_3$  catalyzed polymerization. A host of similar processes involving  $BF_3$  in conjunction with a cocatalyst is known in  
30 the patent literature. A typical polymerization technique is described in United States Patent No. 4,045,508.

The alkylbenzenes may be used in the present invention alone or in conjunction with low viscosity polyalphaolefins in blends with  
35 high viscosity synthetic hydrocarbons and low viscosity esters. The alkylbenzenes, prepared by Friedel-Crafts alkylation of benzene with olefins are usually predominantly dialkylbenzenes wherein the

alkyl chain may be 6 to 14 carbon atoms long. The alkylating olefins used in the preparation of alkyl benzenes can be straight or branched chain olefins or combinations. These materials may be prepared as shown in U.S.P. 3,909,432.

5       The low viscosity esters of this invention, having viscosities of from 1 to 10 cSt. can be selected from classes of esters readily available commercially, e.g., monoesters prepared from monobasic acids such as pelargonic acid and alcohols; diesters prepared from  
10       dibasic acids and alcohols or from diols and monobasic acids or mixtures of acids; and polyol esters prepared from diols, triols (especially trimethylol propane), tetraols (such as pentaerythritol), hexaols (such as dipentaerythritol) and the like reacted with mono-  
15       basic acids or mixtures of acids.

      Examples of such esters include tridecyl pelargonate, di-2  
15       ethylhexyl adipate, di-2-ethylhexyl azelate, trimethylol propane triheptanoate and pentaerythritol tetraheptanoate.

      An alternative to the synthetically produced esters described above are those esters and mixtures of esters derived from natural  
20       sources, plant or animal. Examples of these materials are the fluids produced from jojoba nuts, tallows, safflowers and sperm whales.

      The esters used ought to be carefully selected to insure compatibility of all components in finished lubricants of this invention. If esters having a high degree of polarity (roughly indicated by  
25       oxygen content) are blended with certain combinations of high viscosity synthetic hydrocarbons and low viscosity synthetic hydrocarbons, phase separation can occur at low temperatures with a resultant increase in apparent viscosity. Such phase separation is detrimental to long term storage of lubricants under a variety of  
30       temperature conditions.

      The additive "packages" mixed with the recommended base oil blend for the production of multigraded crankcase fluids or gear  
35       oils are usually combination of various types of chemical additives so chosen to operate best under the use conditions which the particular formulated fluid may encounter.

      Additives can be classified as materials which either impart or enhance a desirable property of the base lubricant blend into which they are incorporated. While the general nature of the additives

might be the same for various types or blends of the base lubricants, the specific additives chosen will depend on the particular type of service in which the lubricant is employed and the characteristics of the base lubricants.

5           The main types of current day additives are:

1.    Dispersants,
2.    Oxidation and Corrosion Inhibitors,
3.    Anti-Wear Agents,
4.    Viscosity Improvers,
- 10    5.    Pour Point Depressants,
6.    Anti-Rust Compounds, and
7.    Foam Inhibitors.

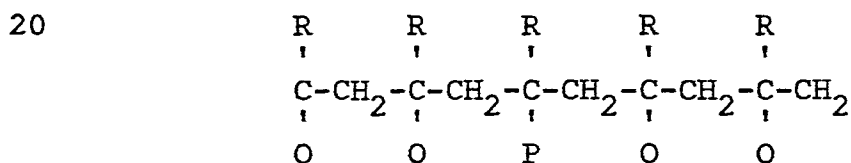
Normally a finished lubricant will contain several and possibly most or all of the above types of additives in what is commonly  
15    called an "additive package." The development of a balanced additive package involves considerably more work than the casual use of each of the additive types. Quite often functional difficulties arising from combinations of these materials show up under actual  
20    operating conditions. On the other hand, certain unpredictable synergistic effects of a desirable nature may also become evident. The only methods currently available for obtaining such data are from extensive full scale testing both in the laboratory and in the  
25    field. Such testing is costly and time-consuming.

Dispersants have been described in the literature as "deter-  
25    gents". Since their function appears to be one of effecting a dispersion of particulate matter, rather than one of "cleaning up" any existing dirt and debris, it is more appropriate to categorize them as dispersants. Materials of this type are generally molecules having a large hydrocarbon "tail" and a polar group head. The tail  
30    section, an oleophilic group, serves as a solubilizer in the base fluid while the polar group serves as the element which is attracted to particulate contaminants in the lubricant.

The dispersants include metallic and ashless types. The metallic dispersants include sulfonates (products of the neutraliza-  
35    tion of a sulfonic acid with a metallic base), thiophosphonates (acidic components derived from the reaction between polybutene and phosphorus pentasulfide) and phenates and phenol sulfide salts

(the broad class of metal phenates includes the salts of alkylphenols, alkylphenol sulfides, and alkyl phenol aldehyde products). The ashless type dispersants may be categorized into two broad types: high molecular weight polymeric dispersants for the formulation of multigrade oils and lower molecular weight additives for use where viscosity improvement is not necessary. The compounds useful for this purpose are again characterized by a "polar" group attached to a relatively high molecular weight hydrocarbon chain. The "polar" group generally contains one or more of the elements-- nitrogen, oxygen, and phosphorus. The solubilizing chains are generally higher in molecular weight than those employed in the metallic types; however, in some instances they may be quite similar. Some examples are N-substituted long chain alkenyl succinimides, high molecular weight esters, such as products formed by the esterification of mono or polyhydric aliphatic alcohols with olefin substituted succinic acid, and Mannich bases from high molecular weight alkylated phenols.

The high molecular weight polymeric ashless dispersants have the general formula:



where  
 O = Oleophilic Group  
 P = Polar Group  
 R = Hydrogen or Alkyl Group

The function of an oxidation inhibitor is the prevention of a deterioration associated with oxygen attack on the lubricant base fluid. These inhibitors function either to destroy free radicals (chain breaking) or to interact with peroxides which are involved in the oxidation mechanism. Among the widely used anti-oxidants are the phenolic types (chain-breaking) e.g., 2,6-di-tert.-butyl-para-cresol and 4,4'-methylenebis(2,6-di-tert.-butylphenol), and the zinc dithiophosphates (peroxide-destroying).

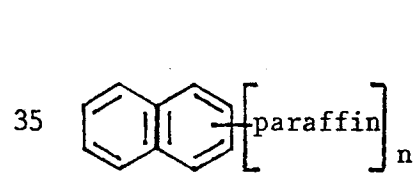
Wear is loss of metal with subsequent change in clearance between surfaces moving relative to each other. If continued, it will result in engine or gear malfunction. Among the principal factors causing wear are metal-to-metal contact, presence of abrasive particulate matter, and attack of corrosive acids.

Metal-to-metal contact can be prevented by the addition of film-forming compounds which protect the surface either by physical absorption or by chemical reaction. The zinc dithiophosphates are widely used for this purpose. These compounds were described under anti-oxidant and anti-bearing corrosion additives. Other effective additives contain phosphorus, sulfur or combinations of these elements.

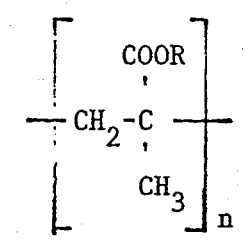
Abrasive wear can be prevented by effective removal of particulate matter by filtration while corrosive wear from acidic materials can be controlled by the use of alkaline additives such as basic phenates and sulfonates.

Although conventional viscosity improvers are often used in "additive packages" their use should not be necessary for the practice of this invention since our particular blends of high and low molecular weight base lubricants produce the same effect. However, we do not want to exclude the possibility of adding some amounts of conventional viscosity improvers. These materials are usually oil-soluble organic polymers with molecular weights ranging from approximately 10,000 to 1,000,000. The polymer molecule in solution is swollen by the lubricant. The volume of this swollen entity determines the degree to which the polymer increases its viscosity.

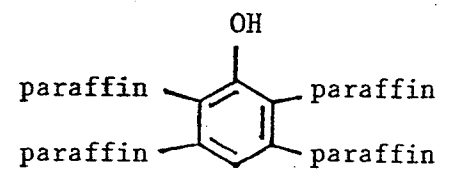
Pour point depressants prevent the congelation of the oil at low temperatures. This phenomenon is associated with the crystallization of waxes from the lubricants. Chemical structures of representative commercial pour point depressants are:



40 Alkylated Wax Naphthalene



Polymethacrylate



Alkylated Wax Phenol

Chemicals employed as rust inhibitors include sulfonates, alkenyl succinic acids, substituted imidazolines, amines, and amine phosphates.

5 The anti-foam agents include the silicones and miscellaneous organic copolymers.

Additive packages known to perform adequately for their recommended purpose are prepared and supplied by several major manufacturers. The percentage and type of additive to be used in each application is recommended by the suppliers. Typically available packages are:

1. HITEC [trademark] E-320, for use in automotive gear oils,
2. Lubrizol [trademark] 5002 for use in industrial gear oils,
3. Lubrizol [trademark] 4856 for use in gasoline crankcase oil, and
- 15 4. OLOA [trademark] 8717 for use in diesel crankcase oils.

A typical additive package for an automotive gear lubricant would normally contain antioxidant, corrosion inhibitor, anti-wear agents, anti-rust agents, extreme pressure agent and foam inhibitor.

20 A typical additive package for a crankcase lubricant would normally be comprised of a dispersant, antioxidant, corrosion inhibitor, anti-wear agent, anti-rust agent and foam inhibitor.

An additive package useful for formulating a compressor fluid would typically contain an anti-oxidant, anti-wear agent, an anti-rust agent and foam inhibitor.

This invention describes blends of high viscosity synthetic hydrocarbons, having a viscosity range of 3500 to 175,000 cSt. with one or more synthetic hydrocarbon fluids having viscosities in the range of 1 to 10 cSt. and/or one or more compatible ester fluids having a viscosity range of 1 to 10 cSt. Such blends, when treated with a properly chosen additive "package," can be formulated in broad range multigraded crankcase or gear oils having improved shear stability, improved oxidative stability, and nearly Newtonian viscometric properties. The blends of this invention also find uses in certain applications where no additive need be employed.

In discussing the constitution of the base oil blend, it is convenient to normalize the percentages of high viscosity synthetic hydrocarbons, low viscosity synthetic hydrocarbons, and low viscosity esters in the final lubricant so that they total 100%. The actual percentages used in the final formulation would then be decreased depending on the amount of additive packages utilized.

Each of the ingredients, high viscosity synthetic hydrocarbons, low viscosity synthetic hydrocarbons, and low viscosity esters are an important part of this invention. The high viscosity synthetic hydrocarbon provides thickening and VI improvement to the base oil blend.

The low viscosity synthetic hydrocarbon fluid is frequently the main ingredient in the base oil blend, particularly in finished lubricants having an SAE viscosity grade of 30 or 40. While certain low viscosity esters are insoluble in high viscosity synthetic hydrocarbons, the presence of low viscosity synthetic hydrocarbon, being a better solvent for low viscosity esters, permits greater variations in the type of esters used in base oil blends of high viscosity synthetic hydrocarbons, low viscosity synthetic hydrocarbons, and low viscosity esters.

Crankcase and gear oils consisting solely of hydrogenated polyisoprene oligomers and low viscosity synthetic hydrocarbons with the proper additives produce synthetic fluids having excellent oxidative and hydrolytic stability. Such fluids are exemplified in Examples 1 and 3.

The third component, low viscosity esters, can be added to produce the superior lubricants of this invention. High viscosity synthetic hydrocarbons and low viscosity synthetic hydrocarbons can be used alone to produce multigraded lubricants. The addition of low levels of low viscosity esters, usually 1-25% results in a base oil blend superior to blends of high viscosity synthetic hydrocarbons and low viscosity synthetic hydrocarbons alone in low temperature fluidity (see Examples 2 and 4).

The components of the finished lubricants of this invention can be admixed in any convenient manner or sequence.

An important aspect of the present invention is in the use of the properly constituted base oil blend in combination with the

proper compatible additive package to produce finished broad-range multigrade lubricants having:

1. Improved temporary shear stability
2. Excellent oxidation stability
- 5 3. High viscosity index.

The range of percentages for each of the components, i.e., high viscosity synthetic hydrocarbons, low viscosity synthetic hydrocarbons, low viscosity esters, and additive packages, will vary widely depending on the end use for the formulated lubricant, but the benefits of the compositions of this invention accrue when the base oil blend of high viscosity EAO, low viscosity synthetic hydrocarbons, and/or low viscosity esters contains (normalized):

From 1 to 99% EAO, from 0 to 99% low viscosity synthetic hydrocarbons, and from 0 to 99% low viscosity esters. It is preferred to blend from 10 to 80% EAO with correspondingly 90 to 20% of at least one low viscosity ester base fluid or hydrocarbon base fluid or mixtures thereof. The fourth ingredient, the additive package, may be used in from 0 to 25% of the total formulation.

The lubricants of this invention, when properly formulated, approach viscometrics of Newtonian fluids. That is, their viscosities are changed little over a wide range of shear rates. While the EAO of the invention may, in themselves, display non-Newtonian characteristics, particularly at low temperatures, the final lubricant products utilizing low viscosity oils as diluents are much more Newtonian.

The non-Newtonian character of currently used VI improvers is well documented. An excellent discussion can be found in an SAE publication entitled, "The Relationship Between Engine Oil Viscosity and Engine Performance--Part III." The papers in this publication were presented at a 1978 SAE Congress and Exposition in Detroit on February 27 to March 3, 1978.

The reference of interest is Paper 780374:

"Temporary Viscosity Loss and its Relationship to Journal Bearing Performance," M.L. McMillan and C.K. Murphy, General Motors Research Labs.

This reference, and many others familiar to researchers in the field, illustrates how commercial polymeric VI improvers of molecular weights from 30,000 and up all show a temporary viscosity loss when subjected to shear rates of  $10^5$  to  $10^6$   $\text{sec}^{-1}$ . The temporary shear loss is greater for any shear rate with higher molecular weight polymers. For instance, oils thickened to the same viscosity with polymethacrylates of 32,000; 157,000; and 275,000 molecular weight show percentage losses in viscosity at a  $5 \times 10^5$   $\text{sec}^{-1}$  shear rate of 10, 22 and 32%, respectively.

10 The thickening fluids of high viscosity synthetic hydrocarbons of this invention all have molecular weights below 10,000, and shear thinning of their solutions is minimal.

The shear rates developed in pistons and gears (equal to or greater than  $10^6$   $\text{sec}^{-1}$ ) is such that, depending on the polymeric thickener used, the apparent viscosity of the oils approaches that of the unthickened base fluids resulting in loss of hydrodynamic films. Since wear protection of moving parts has been correlated with oil viscosity, it is apparent that the wear characteristics of a lubricant can be downgraded as a result of temporary shear. The Newtonian fluids of the current invention maintain their viscosity under these use conditions and therefore afford more protection to and hence longer lifetime for the machinery being lubricated.

25 The currently used polymeric thickeners which show temporary (recoverable) shear are also subject to permanent shear. Extended use of polymeric thickeners leads to their mechanical breakdown with resultant loss in thickening power and decrease in V.I. Paper 780372 (op. cit), "Polymer Stability in Engines" by W. Wunderlich and H. Jost discusses the relationship between polymer type and permanent shear. The multigrade lubricants of this invention are not as susceptible to mechanical shear.

30 This same paper also recognizes an often overlooked feature of high molecular weight polymeric VI improvers, i.e., their instability toward oxidation. Just as these polymers lose viscosity by shear they are also readily degraded by oxygen with the resultant breakdown of the polymer and decrease in viscosity index. The lubricating fluids of this invention suffer much less change in viscosity index upon oxidation.

As mentioned earlier, the reduced temporary shear exhibited by the lubricants of this invention provides higher viscosity for the protection of moving parts where high shear rates are encountered. The importance of this feature is widely recognized. In the past, 5 SAE grading (e.g. SAE 30) relied only on a measurement of the viscosity of a fluid at 100°C under low shear conditions, despite the fact that in machinery such as a crankcase high temperatures and very high shear rates are encountered. This disparity has led to the adoption in Europe of a new grading system wherein viscosities 10 for a certain grade are those measured at 150°C and  $10^6 \text{ sec}^{-1}$  shear rate. This more realistic approach is currently being considered in the United States. The advantages a Newtonian fluid brings to such a grading system are obvious to anyone skilled in the art. The viscosity of a Newtonian fluid can be directly extra- 15 polated to 150°C under high shear conditions. A polymer thickened fluid, however, will invariably have a viscosity lower than the extrapolated value, frequently close to the base fluid itself. In order to attain a certain grade under high shear conditions, polymer thickened oils will require a more viscous base fluid. The use 20 of thicker base fluids will produce higher viscosities at low temperature making it more difficult to meet the low temperature (5W for crankcase of 75W for gear oil) requirements for broadly multigraded oils.

Stated another way, current high molecular weight VI improv- 25 ers "artificially" improve the viscosity index, since realistic high temperature high shear measurements are not utilized in determining V.I. Viscosity index is determined by low shear viscosity measurements at 40°C and 100°C. The nearly Newtonian lubricants of this invention not only produce high viscosity index multigraded fluids 30 which stay "in grade", but the V.I. and multigrade rating are realistic since they are not very sensitive to shear rate.

It should be noted that the invention uses a high viscosity ethylene-alphaolefin oligomer having a viscosity of 3500 to 175,000 cSt at 100°C. As the viscosity of the ethylene-alpha-olefin oligomer 35 used increases the oxidation a shear stability decreases. Nonetheless, the high viscosity oligomers of the invention exhibit an improvement over the V.I. improvers of the prior art. This is

particularly true for broadly graded lubricants such as 75W-250 gear oils and 0W-40 crankcase oils.

While the specific compositions exemplified in this patent are fairly precise, it should be obvious to anyone skilled in the art to produce even further combinations within the scope of this invention which will be valuable lubricants.

The following examples illustrate some of the blends encompassed by our invention:

Example 1

This example illustrates the preparation of automotive gear oils using an ethylene-propylene oligomer (EAO), having a kinematic viscosity @ 100°C of 25,700 cSt, with synthetic hydrocarbon.

	<u>INGREDIENT</u>	<u>WT %</u>
A.	EAO	11
	PAO-4 <sup>(1)</sup>	79
	ANGLAMOL [trademark] 6043 <sup>(2)</sup>	10
B.	EAO	13
	PAO-4	77
	ANGLAMOL 6043	10

The lubricants had the properties shown:

	<u>KV<sub>100</sub>, cSt</u>	<u>KV<sub>40</sub>, cSt</u>	<u>VI</u>	<u>VIS @ -40°C, cP</u>	<u>SAE GRADE</u>
A.	19.7	120.7	186	22,600	75W-90
B.	25.0	158.9	191	42,000	75W-140

(1) 4 cSt polyalphaolefin

(2) Additive package made by Lubrizol Corporation

Example 2

This example illustrates the preparation of crankcase lubricants using EAO's of the kinematic viscosities shown:

	<u>INGREDIENT</u>	<u>WT %</u>
5	A. EAO (KV <sub>100</sub> = 3850)	9
	PAO-4	53
	Di-2-ETHYLHEXYL AZELATE	20
	LUBRIZOL 3940 <sup>(1)</sup>	18
10	B. EAO (KV <sub>100</sub> = 25,700)	5
	PAO-4	63
	DI-2-ETHYLHEXYL AZELATE	20
	LUBRIZOL 4856 <sup>(1)</sup>	12
10	C. EAO (KV <sub>100</sub> = 149,000)	4.5
	PAO-4	57.5
	DI-2-ETHYLHEXYL AZELATE	20
	LUBRIZOL 3940 <sup>(1)</sup>	18

The lubricants had the properties shown:

	<u>KV<sub>100</sub>, cSt</u>	<u>KV<sub>40</sub>, cSt</u>	<u>VI</u>	<u>CCS, cP</u>	<u>SAE GRADE</u>
15	A. 13.3	74.3	180	3490 @ -25°C	5W-40
	B. 9.7	48.9	188	2710 @ -30°C	0W-30
	C. 14.9	84.0	188	2250 @ -25°C	5W-40

(1) Additive package made by Lubrizol Corporation

20

Example 3

This example illustrates the preparation of crankcase oil using EAO's of the kinematic viscosities shown in blends containing only synthetic hydrocarbon.

	<u>INGREDIENT</u>	<u>WT %</u>
25	A. EAO (KV <sub>100</sub> = 3850)	9
	PAO-4	79
	LUBRIZOL 4856 <sup>(1)</sup>	12
30	B. EAO (KV <sub>100</sub> = 25,700)	7
	PAO-4	81
	LUBRIZOL 4856	12

The lubricants had the properties shown:

	<u>KV<sub>100</sub>, cSt</u>	<u>KV<sub>40</sub>, cSt</u>	<u>VI</u>	<u>CCS, cP</u>	<u>SAE GRADE</u>
A.	13.5	79.5	174	3210 @ -25°C	5W-40
B.	13.9	81.3	177	2660 @ -25°C	5W-40

- 5 (1) Additive package made by Lubrizol Corporation

#### Example 4

This example illustrates the preparation of automotive gear lubricants using an EAO of the indicated kinematic viscosity in combination with ester and low viscosity hydrocarbon.

	<u>INGREDIENT</u>	<u>WT %</u>
10	A. EAO (KV <sub>100</sub> = 25,700)	9
	PAO-4	61
	DI-2-ETHYLHEXYL AZELATE	20
	ANGLAMOL 6043	10
15	B. EAO (KV <sub>100</sub> = 25,700)	14
	PAO-4	56
	DI-2-ETHYLHEXYL AZELATE	20
	ANGLAMOL 6043	10
20	C. EAO (KV <sub>100</sub> = 25,700)	17.5
	PAO-4	52.5
	DI-2-ETHYLHEXYL AZELATE	20
	ANGLAMOL 6043	10

The lubricants had the properties shown:

	<u>KV<sub>100</sub>, cSt</u>	<u>KV<sub>40</sub>, cSt</u>	<u>VI</u>	<u>CCS, cP</u>	<u>SAE GRADE</u>
25	A. 14.7	78.0	197	109,700 @ -55°C	70W-90
	B. 28.5	172.3	205	58,000 @ -40°C	75W-140
	C. 44.0	288.3	211	121,750 @ -40°C	75W-250

Example 5

This example illustrates the preparation of crankcase lubricants using EAO's having the kinematic viscosities shown:

	<u>INGREDIENT</u>	<u>WT %</u>
5	A. EAO ( $KV_{100} = 3850$ )	9
	DI-ISODECYL ADIPATE	78
	LUBRIZOL 4856	12
	B. EAO ( $KV_{100} = 25,700$ )	7.5
	DI-2-ETHYLHEXYL AZELATE	80.5
10	LUBRIZOL 4856	12

The lubricants had the properties shown:

	<u><math>\frac{KV_{100}}{cSt}</math></u>	<u><math>\frac{KV_{40}}{cSt}</math></u>	<u>VI</u>	<u>CCS, cP</u>	<u>SAE GRADE</u>
A.	13.2	66.3	205	1915 @ -30°C	OW-40
B.	13.5	65.2	215	1665 @ -30°C	OW-40

## CLAIMS:

1. A lubricating composition characterised in that it comprises:

(A) an ethylene-alphaolefin oligomer having a viscosity of from more than 3500 to 175,000 centistokes  
5 at 100°C and

(B) a synthetic hydrocarbon or ester having a viscosity of 1-10 centristokes at 100°C, or mixtures thereof.

2. A composition according to claim 1 characterised  
10 in that (B) is a synthetic hydrocarbon.

3. A composition according to claim 1 characterised in that (B) is an ester.

4. A composition according to the preceding claims characterised in that it further comprises an additive  
15 package comprising at least one additive selected from dispersants, oxidation inhibitors, corrosion inhibitors, anti-wear agents, pour point depressants, anti-rust agents, foam inhibitors and extreme pressure agents.