(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 927 754 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.07.1999 Bulletin 1999/27

(21) Application number: **98309433.5**

(22) Date of filing: **18.11.1998**

(51) Int Cl.6: **C10M 143/00**, C10M 145/14, C10M 149/04, C10M 149/06, C10M 149/10 // (C10N20/02, 20:04, 30:02, 40:26, 70:00)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **31.12.1997 US 1553**

(71) Applicant: **Chevron Chemical Company LLC**
San Francisco, CA 94105 (US)

(72) Inventors:
- **Logan, Mark Remmers**
San Ramon, California 94583 (US)
- **Smrcka, Nancy**
Point Richmond, California 94801 (US)

(74) Representative: **Nash, David Allan et al**
Haseltine Lake & Co.,
Imperial House, 15-19 Kingsway
London WC2B 6UD (GB)

(54) **Minimizations of viscosity variations in medium-speed diesel engines by the use of polymeric additives in lubricating compositions**

(57) Zinc-free medium-speed diesel engine lubricating oils containing a polymeric shear agent to minimize the variation in viscosity due to oxidation and soot thickening. The medium-speed diesel engine lubricating oil composition comprises:

(a) a major amount of a zinc-free baseline oil; and
(b) a minor amount of a polymeric shear agent, which gives from 1.0 to 2.7 cSt at 100°C incremental increase in viscosity over that baseline oil; and

wherein the medium-speed diesel engine lubricating oil composition meets the SAE 40 specification. The polymeric shear agents which may be used are those which can be dissolved in a mineral oil, such as ungrafted and grafted carbon-carbon polymers or copolymers.

EP 0 927 754 A1

Description

FIELD OF THE INVENTION

[0001] This invention relates to a zinc-free medium-speed diesel engine lubricating oil composition and more particularly to a zinc-free medium-speed diesel engine lubricating oil composition containing a baseline oil and a polymeric shear agent to minimize variations in viscosity.

BACKGROUND OF THE INVENTION

[0002] Medium-speed diesel engines are used in applications where several thousands of horsepower are needed. This includes locomotives operating in freight and passenger service, workboats operating in the inland and coastal waterways, and stand-by or continuous electrical power generation for a variety of applications including offshore drilling platforms and industrial facilities and buildings. Typically, these engines run at a speed of about 600 to 1,200 rpm. Such engines include those manufactured by the Electro-Motive Division of General Motors (EMD), and General Electric, and those manufactured by the American Locomotive Company (ALCO), Montreal Locomotive Works (MLW), Bombardier, and Detroit Diesel (DD). All these engines are often lubricated with zinc-free medium-speed diesel engine lubricating oils when used in similar applications.

[0003] In medium-speed diesel engines, it is essential to maintain control over the engine oil viscosity. If it is too low, bearing failures and scuffing will result from inadequate oil film thickness. If it is too high, fuel is wasted because of excessive frictional losses. Single-grade lubricating oils formulated with modern zinc-free medium-speed additive systems suffer an increase in viscosity over the life of the oil when applied to medium-speed diesel engines. Engine manufacturers specify the viscosity for new oil based on the optimum for their engine design. But once in service, the oils are subjected to a number of factors that increase viscosity including oxidation and soot thickening. Once the oil reaches a maximum viscosity specified by the manufacturer, the oil must be drained and replenished. Typically, the maximum viscosity specified may be 15-30% above the initial viscosity of fresh oil. Higher viscosity not only shortens the useable life of the lubricating oil but also causes more fuel to be consumed because of frictional losses. For example, over a typical railroad duty cycle, an increase in viscosity of 1 cSt will cost 0.4% in fuel consumption. A thorough discussion of the mechanisms and control of variations in viscosity by conventional methods in railroad diesel engine lubricants is provided by Logan et al. in *Lubricant Engineering,* Vol. 42, 6, pp. 350-356.

[0004] Variations in viscosity are caused by a number of mechanisms that either increase it or decrease it. Oxidation and soot thickening cause the viscosity to increase. This increase is conventionally controlled with oxidation inhibitors and dispersants. Another source of variation in viscosity results from the deterioration of viscosity index improvers, which are used to control changes in viscosity due to temperature.

[0005] The viscosity index is a property of the oil that provides a measure for the loss in viscosity that oil exhibits when it is heated. Most base oils used in engine oils do not have a high enough viscosity index as produced and require polymeric additives to reach the higher viscosity indices required to formulate multigrade oils. These polymeric additives are called viscosity index improvers (V.I. improvers). As their name implies, V.I. improvers are used to improve the viscosity index of lubricating oils. Oil with a high viscosity index will not lose as much viscosity when heated as one with a low viscosity index. High viscosity index oils are used as engine oils because they can be designed to minimize the oil's viscosity at low temperatures so that an engine can be started, yet provide adequate viscosity at operating temperatures to lubricate the moving parts. High viscosity index oils are exemplified by multigrade oils, which were originally introduced to improve low-temperature starting characteristics.

[0006] Typical V.I. improvers are the high molecular weight polymers and copolymers which may be grafted or ungrafted. They must have on one hand a sufficient thickening effect on a light lubricating oil at high temperatures to make the lubricating properties of said oil similar to those of a heavier lubricating oil and, on the other hand, they must have a limited thickening effect on a light lubricating oil at low temperatures to avoid impairing the viscometric properties of said oil at said low temperatures. Stated differently, the purpose of V.I. improvers is to minimize the changes in viscosity of an oil composition when it is exposed to a variety of temperatures.

[0007] In use, the high molecular weight V.I. improvers makes them susceptible to degradation as a result of shearing forces, resulting in lower lubricant viscosity. In other words, the shearing of V.I. improvers causes the viscosity to decrease. This mechanism for viscosity decrease is generally associated with multigrade lubricants, which are formulated with high molecular weight polymeric V.I. improvers. The shear stability of V.I. improvers varies and is a major consideration in their selection. Polymers that exhibit a high degree of shear have been regarded as undesirable because, at the high dosages of polymer normally required to formulate multigrade oils, they could shear in service to damage bearings because of inadequate lubricating oil viscosity. As a result the V. I. improver manufacturers have designed improved polymers that shear less in service.

[0008] In the present invention, V.I. improvers are used as shear agents to minimize variations in viscosity over time.

Rather than being used to improve an oil's viscosity index, they are used at low dosages to balance viscosity increase from oxidation and soot thickening by shearing in service.

[0009] Presently, V.I. improvers are being used in multigrade zinc-free medium-speed diesel engine lubricating oils at higher concentrations than specified in the present invention. For instance olefin copolymers (OCP), such as an ethylene propylene copolymer, may be used at a dosage of about 3.0 to about 6.2 weight percent. However, the weight percentage dosages for different types of polymers can vary depending on their thickening efficiency.

[0010] Another way to express their dosage that helps eliminate differences between polymer thickening efficiencies is to represent it on the basis of the increases in viscosity provided by the polymer at 100°C relative to that of the oil prior to the addition of the polymer. This is referred to as the incremental viscosity. On this basis, the OCP is normally added to give about 2.8 to about 5.5 incremental cSt at 100°C. Polymethacrylate (PMA) polymers have stronger thickening efficiencies. For instance SAE 20W-40 oils are normally used at about 2.8 to about 4.8 incremental cSt at 100°C. At these higher dosages of the V.I. improvers, prescribed in accordance with multigrade oil specifications, the oil shears excessively, causing its viscosity to drop considerably below its initial value. The dosages are too high to minimize any variation in viscosity and in fact, cause an excessive viscosity loss. This may lower the margin of safety against bearing, ring, and liner failures related to an inadequate oil film.

[0011] On the other hand, single-grade oils do not contain polymers of sufficient molecular weight for much shearing to occur. Because of this, the viscosity of single-grade lubricating oils can increase quite quickly during normal service due to lubricant oxidation and soot thickening. Aside from increasing fuel consumption, in extreme cases, viscosity increase in the oil can cause severe damage to medium-speed diesel engines by reducing oil flow to critical bearings and oil-cooled parts, such as pistons. It can also contribute to oil filter plugging.

[0012] In this invention, much lower amounts of V.I. improvers are used. They are used as polymeric shear agents to minimize variations in viscosity due to oil oxidation and soot thickening.

[0013] A variety of polymeric materials are known as V.I. improvers for lubricants. For example:

[0014] U.S. Patent No. 3,607,749, issued September 21, 1971 to Forbes et al., discloses V.I. improvers for lubricating oils comprising a polymer of molecular weight above 100,000, e.g., a polymethacrylate, and a polymer of molecular weight below 25,000, e.g., a polyisobutylene. The combination of polymers is used in an attempt to make the V.I. improvers more shear stable.

[0015] U.S. Patent No. 4,092,255, issued May 30, 1978 to Chapelet et al., discloses a lubricating composition containing a major proportion of a lubricating oil and a minor proportion of an oil-soluble specific nitrogenous polymer additive. The additive improves the oil viscosity index while increasing the dispersancy of the final lubricating composition.

[0016] U.S. Patent No. 4,922,045, issued May 1, 1990 to White et al., discloses polymer additives for improving oil consumption in a lubricating oil composition for heavy-duty engines, as used in tractor trailer trucks in over-the-road service. The polymer additives described in that patent may be carbon-carbon polymers, copolymers, and graft copolymers, from about 0.02% to about 3.0 wt % in single-grade SAE 30 or 50 heavy-duty diesel engine lubricating oil.

[0017] The lubricating oil requirements for heavy-duty engines and medium-speed diesel engines differ significantly. The most obvious difference between these engines is their size. Medium-speed diesel engines are much larger, producing about ten times more power than heavy-duty engines in over-the-road-service. Medium-speed diesel engines also operate at one-half to one-third the engine speed, and apply a greater number of power assemblies per engine. These design differences require different lubricating oils. Moreover, one major medium-speed diesel engine manufacturer, General Motors, used silver bearings in their engines until 1994, precluding the use of zinc dithiophosphate additives because they are corrosive to silver. This class of additive is used in heavy-duty engines for anti-wear protection. It has lead to the development of entirely different lubricating oils for medium-speed diesel applications based on zinc-free formulations. Most major oil blenders in fact provide separate blending and storage facilities for medium-speed diesel and heavy-duty engine oils to prevent contamination of their medium-speed diesel engine lubricating oils with zinc dithiophosphate. Heavy-duty engine lubricating oils will destroy medium-speed diesel engines containing silver because of the zinc dithiophosphate content of the lubricating oil.

[0018] This inventor is aware of application wherein a low dosage of a V. I. improver, similar to those defined in the present invention as polymeric shear agents, was used to formulate a zinc-free medium-speed diesel engine oil. In this application, the oil was severely hydrotreated, providing a multigrade 20W-40 oil without the need for any V.I. improver. However, a minimal dosage of V. I. improver providing an incremental viscosity of about 0.9 cSt at 100 °C was added so that the oil would have a composition including this conventional additive. In this case, the V.I. improver was used for conventional reasons rather than to minimize variations in viscosity, and it was dosed at a level below the useful range of this invention.

SUMMARY OF THE INVENTION

[0019] This invention involves zinc-free medium-speed diesel engine lubricating oils containing a polymer to minimize variations in viscosity. The medium-speed diesel engine lubricating oil composition comprises:

(a) a major amount of a zinc-free baseline oil; and
(b) a minor amount of a polymeric shear agent, which gives from 1.0 to 2.7 cSt at 100°C incremental increase in viscosity over that baseline oil; and

wherein the medium-speed diesel engine lubricating oil composition meets the SAE 40 specification.

[0020] Preferably, the polymeric shear agent gives about 1.5 to 2.5 cSt at 100°C incremental increase in viscosity over said baseline oil.

[0021] Preferably, the TBN of the lubricating oil composition is about from 10 to 20 TBN and has greater than about 1% sulfated ash content.

[0022] The polymers may be ungrafted polymers, such as polyethylene, polypropylene, polybutylene, polyisoprene, ethylene-propylene copolymer, polymethylacrylate, ethylene-butylene copolymer, styrene-isoprene copolymer, ethylene-propylene diene monomers, ethylene-propylene terpolymer, or styrene-butadiene copolymer.

[0023] Alternatively, the polymers may be polyethylene, polypropylene, polybutylene, polyisoprene, ethylene-propylene copolymer, polymethylacrylate, ethylene-butylene copolymer, styrene-isoprene copolymer, ethylene-propylene diene monomers, ethylene-propylene terpolymer, and styrene-butadiene copolymer, wherein nitrogen-containing compounds are grafted onto those polymers. The grafted compounds can be N-vinyl imidazole, N-vinyl pyridine, N-vinyl pyrrolidone, an alkyl amine, an alkyl amide, or an alkyl imide.

[0024] In one preferred embodiment, the polymer is a polymethylacrylate, wherein monomers are grafted onto the polymer, and wherein the grafted polymer has a number average molecular weight of at least 450,000. In another preferred embodiment, the polymer is ethylene-propylene copolymer, wherein monomers are grafted onto the copolymer, and wherein the grafted polymer has a number average molecular weight of from 100,000 to 450,000.

[0025] This invention provides for a method of minimizing variations in viscosity of a medium-speed diesel engine lubricating oil, comprising adding a polymeric shear agent to a baseline oil, thereby forming the medium-speed diesel engine lubricating oil; then using the medium-speed diesel engine lubricating oil to lubricate a medium-speed diesel engine.

[0026] In an alternative method of minimizing variations in viscosity of a medium-speed diesel engine lubricating oil, the base oil of lubricating viscosity and an additive package containing the polymeric shear agent and other additives can be added together, thereby forming the medium-speed diesel engine lubricating oil. That medium-speed diesel lubricating oil is then used to lubricate the medium-speed diesel engine.

[0027] The medium-speed diesel engine lubricating oil composition can be produced by blending a mixture of a major amount of a zinc-free SAE 40 baseline oil; and a minor amount of a polymeric shear agent, which gives from 1.0 to 2.7 cSt at 100°C incremental increase in viscosity over said SAE 40 oil.

BRIEF DESCRIPTION OF DRAWINGS

[0028] Figure 1 shows the effect of a polymethacrylate polymeric shear agent when added to a railroad diesel engine lubricating oil in a General Motors EMD SD50 locomotive.

[0029] Figure 2 shows the averaged viscosity history profiles for the test locomotives referred to in Figure 1, and the calculated viscosity profiles for 1.0 cSt, 1.9 cSt, and 2.7 cSt at 100°C incremental increase in viscosity.

[0030] Figure 3 shows the effect of an olefin copolymer as a shear agent when added to a railroad diesel engine lubricating oil in a General Motors EMD SD50 locomotive

[0031] Figure 4 shows the averaged viscosity history profiles for the test locomotives referred to in Figure 3, and the calculated viscosity profiles for 1.0 cSt, 2.2 cSt, 2.7 cSt at 100°C incremental increase in viscosity

[0032] Figure 5 shows the effect of an olefin copolymer as a shear agent when added to a railroad diesel engine lubricating oil in a General Electric C30-7 locomotive

[0033] Figure 6 shows the averaged viscosity history profiles for the test locomotives referred to in Figure 5, and the calculated viscosity profiles for 1.0 cSt, 1.7 cSt, 2.7 cSt at 100°C incremental increase in viscosity.

DETAILED DESCRIPTION OF THE INVENTION

[0034] As mentioned above, the invention relates to the discovery that addition of a polymeric shear agent minimizes the variation in viscosity due to oxidation and soot thickening.

[0035] Prior to discussing the invention in further detail, the following terms will be defined.

DEFINITIONS

[0036] As used herein the following terms have the following meanings unless expressly stated to the contrary.

[0037] The term "medium-speed engine" refers to an engine having an engine speed of about 600-1,200 rpm, corresponding to a cylinder bore size range of about 200-350 mm (about 8 to 13 inches).

[0038] The term "zinc-free" refers to less than 10 ppm of zinc in the lubricating oil composition from zinc dithiophosphate.

[0039] The term "incremental increase in viscosity" refers to the increase in viscosity of an oil relative to its initial viscosity value as a result of adding a polymeric shear agent.

[0040] The term "polymer" refers to a long-chain compound composed of recurring structural units called monomers.

[0041] The term "carbon-carbon polymer" refers to a polymer having all carbon atoms along the backbone of the polymer.

[0042] The term "copolymer" refers to a polymer with different repeating units in the backbone of the polymer.

[0043] The term "grafted copolymer" refers to a polymer produced by grafting a nitrogen-containing compound onto a polymer or copolymer to produce a branched-chain polymer.

[0044] The term "Total Base Number" or "TBN" refers to the amount of base equivalent to milligrams of KOH in 1 gram of sample. Thus, higher TBN numbers reflect more alkaline products and therefore a greater alkalinity reserve. The TBN of a sample can be determined by ASTM Test No. D2896 or any other equivalent procedure. In general terms, TBN is the neutralization capacity of one gram of the lubricating composition expressed as a number equal to the mg of potassium hydroxide providing the equivalent neutralization. Thus, a TBN of 10 means that one gram of the composition has a neutralization capacity equal to 10 mg of potassium hydroxide.

[0045] The term "sulfated ash" refers to a metal-containing compound wherein the metal can be zinc, sodium, potassium, magnesium, calcium, lithium, barium, and the like, as measured by ASTM D874.

[0046] The term "viscosity index" refers to the amount of change for a given oil compared to two reference oils over the range 40-100°C as defined by ASTM D2270.

[0047] The term "SAE 40" refers to an oil having a range of viscosity from 12.5 cSt at 100°C to less than 16.3 cSt at 100°C as defined by the SAE J300 specification.

[0048] The term "SAE 20W-40" refers to an oil having a range of viscosity of an SAE 40 oil at 100°C plus a maximum low temperature cranking viscosity of 4,500 cP at -10°C as defined by the SAE J300 specification.

BASELINE OIL

[0049] Baseline oils comprise a base oil of lubricating viscosity and a zinc-free medium-speed diesel engine dispersant-inhibitor additive system. Components of the baseline oil are further defined as follows.

Base Oil of Lubricating Viscosity

[0050] Suitable base oils of lubricating viscosity that can be used to prepare the baseline lubricating oil of this invention are oils derived from petroleum or synthetic sources. The oils can be paraffinic, naphthenic, synthetic esters, polyolefins, or combinations thereof.

[0051] Preferably, the base oil of lubricating viscosity is a fraction of a mineral oil such as petroleum, either naphthenic, paraffinic or as mixed naphthenic/paraffinic base, unrefined, acid-refined, hydrotreated, or solvent refined as required for the particular lubricating need. These base oils can either be from virgin, reclaimed, or re-refined sources. The oil of lubricating viscosity preferably will have a viscosity in the range from 5 to 20 cSt at 100°C. Suitable oils include low, medium, high, and very high viscosity index lubricating oils.

Medium-Speed Diesel Engine Dispersant-Inhibitor Additives

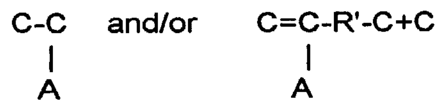
[0052] Metal detergents useful in zinc-free SAE 40 baseline oils are well known. They include, but are not limited to, alkyl or alkenyl phenates, alkyl or alkenyl sulfurized phenates, alkyl or alkenyl aromatic sulfonates, alkyl or alkenyl salicylates, alkyl or alkenyl sulfurized salicylates, alkyl or alkenyl napthenates, alkyl or alkenyl sulfurized napthenates, metal salts of alkyl or alkenyl multi-hydroxy aromatic compounds, metal salts of alkyl or alkenyl sulfurized multi-hydroxy aromatic compounds, alkyl or alkenyl hydroxy aromatic sulfonates, metal salts of alkanoic acids, metal salts of sulfurized alkanoic acids, metal salt of alkyl or alkenyl multiacids, metal salt of sulfurized alkyl or alkenyl multiacids, or chemical or physical mixtures thereof.

[0053] Other additives that may be present in the lubricating oil composition include dispersants, oxidation inhibitors, friction modifiers, rust inhibitors, foam inhibitors, corrosion inhibitors, metal deactivators, pour point depressants, wear inhibitors, and a variety of other well-known additives.

POLYMER

[0054] The polymeric shear agents of the present invention, which may be used to minimize the variation in viscosity due to oxidation and soot thickening, include polymers that traditionally have been used as V.I. improvers. Such polymers may be carbon-carbon polymers, copolymers, and graft copolymers dissolved in a mineral oil. Examples of such polymers are described in U.S. Patent No. 4,922,045, issued May 1, 1990 to White et al., which is hereby incorporated by reference for all it discloses.

[0055] These polymeric shear agents are typical carbon-carbon backbone polymers prepared from monomers bearing a polymerizable double bond and include homopolymers or copolymers prepared from a monomer:



where A may be: hydrogen; a hydrocarbon such as alkyl, aryl, etc.; phenyl; an acetate or less preferred acyloxy (typified by -COOR); halide, etc. R' may be divalent hydrocarbon typified by alkylene, alkarylene, aralkylene, cycloalkylene, arylene, etc. Examples of the above monomers include acrylates, methacrylates, vinyl halide (such as vinyl chloride), styrene, olefins such as butadiene, isoprene, hexadiene, ethylidene norbornene, etc. Homopolymers of olefins (such as polyethylene, polypropylene, polybutylene, etc.), dienes (such as hydrogenated polyisoprene), or copolymers of ethylene with e.g., butylene and higher olefins, styrene with isoprene and/or butadiene may be employed. The preferred carbon-carbon backbone polymers include those selected from the group consisting of olefin copolymers (OCP) and polymethacrylate (PMA). The molecular weight of the polymers may be about 10,000 to about 1,000,000.

[0056] In addition, nitrogen-containing compounds may be grafted onto the copolymer but are not necessary to the performance of the additive for this invention. The graft compounds that may be used include vinyl or alkyl compounds containing nitrogen (i.e., amides, imides, and amines) such as N-vinyl imidazole, N-vinyl pyridine, N-vinyl pyrrolidone, alkyl amine, etc.

[0057] The polymeric shear agents are generally polymers placed in diluent oil. The diluents that may be used are generally highly refined low viscosity (typically 50-120 SUS at 100°F.) naphthenic or paraffinic mineral oils such as solvent neutral or pale oils.

[0058] The levels of polymeric shear agent used in the present invention are lower than normally found in multigrade lubricating oils. The stabilizing effect of the polymeric shear agent will minimize the variation in viscosity of the lubricating oil due to oxidation and soot thickening. The lower amount of V.I. improver will also help meet GE's high temperature, high shear specifications. The addition of the polymeric shear agent may also reduce oil consumption.

LUBRICATING OIL COMPOSITION

[0059] The lubricating oil composition needs to meet the SAE 40 specification. SAE 40 oil is the only high temperature viscosity grade that meets General Motors (EMD) or General Electric (GE) medium-speed diesel engine builder's oil specifications. SAE 30 or 50 grade oils do not comply with medium-speed diesel engine builder's oil specifications. The characteristic properties of SAE 30, 40, and 50 differ solely on their viscosity specifications as defined by the SAE J300 standard. Oil blenders met these specifications by adjusting their base oil mixtures. For instance, a SAE 30 oil may be made with 40% of a light 150 Neutral oil and 60% of a heavier 600 Neutral oil, whereas a SAE 40 oil would have perhaps 10% of the 150 and 90% of the 600. To make a SAE 50 oil, most blenders would need to drop the light 150 neutral entirely and add a heavy component like a bright stock on to of the 600 Neutral oil.

[0060] The lubricating oil compositions can be conveniently prepared by simple blending or mixing of the polymeric shear agent with the baseline oil previously described above. The polymeric shear agent may also be pre-blended into a concentrate with various other additives in the appropriate ratios, then blending the concentrate into a base oil of lubricating viscosity, so that the base oil of lubricating viscosity and other additives form a baseline oil within the total composition. The lubricating oil composition of the invention contains only enough polymeric shear agent to give about from 1.0 to 2.7 cSt at 100°C incremental increase in viscosity over the baseline oil, preferably about from 1.5 to 2.5 cSt at 100°C incremental increase in viscosity over the baseline oil.

[0061] The lubricating oil composition should be free of zinc because the presence of zinc in the final product will be deleterious to silver-surfaced engine parts of certain medium-speed diesel engines, such as silver or silver-plated bearings. Silver, or silver-surfaced bearing parts, pose a special problem since many of the bearing protection additives are deleterious to silver bearings.

[0062] The lubricating oil composition has a TBN of about 10 to about 20, preferably about 13 to about 17. TBN is a measure of the alkalinity or neutralizing capacity and is typically provided by the addition of basic detergents or overbased materials. The function of the basic components is to neutralize acid and oxidation products, such as sulfuric acid or organic acids in the case of diesel fuels. Various types of overbased materials can be used, such as, for example, phenates, salicylates, and sulfonates.

[0063] The sulfated ash content of the lubricating oil composition is at least 1 wt.%, preferably about from 1 to 2.5 wt.%, which is commensurate with a TBN range of about from 10 to 20.

Process for Producing a Lubricating Oil Composition

[0064] The lubricating oil composition of the present invention is produced by blending a mixture of:

(a) a major amount of a zinc-free baseline oil; and
(b) a minor amount of a polymeric shear agent, which gives from about 1.0 to about 2.7 cSt at 100°C incremental increase in viscosity over that baseline oil; and

wherein the medium-speed diesel engine lubricating oil composition meets the SAE 40 specification.

[0065] The lubricating oil composition produced by that method might have a slightly different composition than the initial mixture, because the components may interact. The components can be blended in any order and can be blended as combinations of components.

[0066] To illustrate the advantages of using the present polymers as shear agents to control viscosity increase in medium-speed diesel engine lubricating oils, the following Examples are provided.

EXAMPLES

[0067] The following examples are presented to illustrate specific embodiments of the present invention. While these examples are provided to illustrate the invention, they are not intended to limit it.

[0068] To illustrate the ability of polymeric shear agents to minimize the variation in viscosity due to oxidation and soot thickening, three examples are provided. These data are taken from field tests designed to comply with the Locomotive Maintenance Officer's Association (LMOA) guidelines for evaluating engine oils in railroad applications. In each test, a group of locomotives were lubricated with multigrade oils containing polymeric engine oil additives, and their viscosity history compared with similar locomotives lubricated with SAE 40 oils that contained no polymeric shear agents. The locomotives were all operated together in commercial service hauling freight on Class I U.S. Railroads.

[0069] A summary of the test oil and locomotive details are provided in Table I. The three tests provide data from polymethacrylate (PMA) and olefin copolymer (OCP) polymers and include results from locomotives manufactured by the Electro-Motive Division of the General Motors Corporation (EMD) and the General Electric Company (GE).

[0070] In the examples that follow, the actual results from the field tests are shown in Figures 1, 3, and 5, in which the variation in viscosity over time is provided for the test units operating on the SAE 40 and multigrade oils. In all three examples, the typical multigrade oils were formulated with too much V.I. improver, which caused large variations in viscosity. These examples are followed in each case by the viscosity histories calculated by interpolation for the average SAE 40 and multigrade oil as well as oils formulated within the range of this invention, using dosages of V.I. improvers of 1.0 cSt and 2.7 cSt incremental viscosity. In addition, a viscosity history for the best dosage, calculated by minimizing the standard deviation in viscosity from the fresh oil value, is shown. All viscosities are in cSt at 100 °C.

EXAMPLE 1. THE USE OF POLYMETHACRYLATE IN EMD ENGINES

[0071] The results from a typical multigrade (SAE 20W-40) oil with a PMA polymer in EMD engines are shown in Figure 1. The SAE 40 oil with no polymer exhibited an increase in viscosity from about 15.0 to about 16.5 cSt at about 100°C within about 100 days of operation, as shown by the solid line. In contrast, the hatched line indicates a typical SAE 20W-40 oil with about 4.0 cSt incremental viscosity from the PMA polymer exhibited a decrease to about 13.5 cSt within about the first 30 days, after which it rose slightly to about 14.0 cSt by about 100 days.

[0072] This data demonstrates how such polymers in a typical multigrade oil effects the viscosity increase. In this example, the dosage of the shear agent was prescribed by the SAE 20W-40 specifications. That dosage was too high to minimize variations in viscosity.

[0073] Figure 2 shows the averaged viscosity history profiles for the test locomotives referred to in Figure 1, and calculated viscosity profiles for 1.0 cSt, 1.9 cSt, and 2.7 cSt at 100°C incremental increase in viscosity linear interpolation.

[0074] The table below shows that the variation in viscosity is minimized when the dosage rate of polymeric shear agent is from 1.0 to 2.7 cSt incremental increase in viscosity at 100°C of over the SAE 40 oil without the polymeric shear agent.

Incremental increase at 100°C (cSt)	standard deviation for viscosity (cSt)
0	1.28
1.0	0.63
1.9	0.26
2.7	0.60
4.0	1.42

EXAMPLE 2. THE USE OF OLEFIN COPOLYMER IN EMD ENGINES

[0075] The results from a similar test involving an OCP polymer in EMD engines are shown in Figure 3. As shown by the solid lines, the SAE 40 oil with no polymer exhibited an increase in viscosity from about 14.7 to about 16.0 cSt at 100°C within about 180 days of operation. In contrast, the SAE 20W-40 oil with about 5.5 cSt incremental viscosity from the OCP polymer exhibited a decrease in viscosity from an initial value of about 15.4 to about 14.0 cSt at about 100°C within about the first 60 days, and then rose slightly up to about 14.3 cSt by about 180 days, as shown by the hatched lines. This shows how different V.I. improvers can provide similar viscosity histories, and may therefore be used as polymeric shear agents to control viscosity increase. It also shows another example of how the 20W-40 dosage for the polymeric shear agent was too high to minimize variations in viscosity.

[0076] Figure 4 shows the averaged viscosity history profiles for the test locomotives referred to in Figure 3, and the calculated viscosity profiles for 1.0 cSt, 2.2 cSt, 2.7 cSt at 100°C incremental increase in viscosity

[0077] The table below shows that the variation in viscosity is minimized when the dosage rate of polymeric shear agent is from 1.0 to 2.7 cSt incremental increase in viscosity at 100°C of over the SAE 40 oil without the polymeric shear agent.

Incremental increase at 100°C (cSt)	standard deviation for viscosity (cSt)
0	0.80
1.0	0.48
2.2	0.23
2.7	0.28
4.0	1.13

EXAMPLE 3. THE USE OF OLEFIN COPOLYMER IN GE ENGINES

[0078] Finally, another example is provided using an OCP shear agent run in GE locomotives. The viscosity histories are shown in Figure 5. Because of their lower oil consumption rates, these locomotives exhibited a rapid rise in viscosity during the first 100 days as shown by the solid lines. In contrast, the SAE 20W-40 oil with about 5.5 cSt incremental viscosity from the OCP polymer exhibited a decrease in viscosity from an initial value of about 15.4 to a minimum value of about 13.0 cSt in about 50 days, and then rose back up slightly, as shown by the hatched lines. As with the EMD examples discussed above, the SAE 20W-40 oil shown in this example caused the oil viscosity to fall well below the initial oil viscosity during this period, and that it was dosed too high to minimize variations in viscosity.

[0079] Figure 6 shows the averaged viscosity history profiles for the test locomotives referred to in Figure 5, and the calculated viscosity profiles for 1.0 cSt, 1.7 cSt, 2.7 cSt at 100°C incremental increase in viscosity

[0080] The table below shows that the variation in viscosity is minimized when the dosage rate of polymeric shear agent is from 1.0 to 2.7 cSt incremental increase in viscosity at 100°C of over the SAE 40 oil without the polymeric shear agent.

Incremental increase at 100°C (cSt)	standard deviation for viscosity (cSt)
0	1.07
1.0	0.63

(continued)

Incremental increase at 100°C (cSt)	standard deviation for viscosity (cSt)
1.7	0.48
2.7	0.72
4.0	2.12

[0081] These examples show how relatively low dosages of polymeric shear agents can be applied to control viscosity in zinc-free medium-speed engine lubricating oils. Because of their natural tendency to shear in service, they can be prescribed at a dosage that will counter viscosity increase from oxidation and soot thickening. This will reduce fuel consumption and extend oil life relative to current SAE 40 oils while giving an improved margin of safety against bearing, ring, and liner failures as well as lower cost formulations relative to current multigrade oils.

Claims

1. A medium-speed diesel engine lubricating oil composition comprising:

(a) a major amount of a zinc-free baseline oil; and
(b) a minor amount of a polymeric shear agent, which gives from 1.0 to 2.7 cSt at 100°C incremental increase in viscosity over said baseline oil;

wherein the medium-speed diesel engine lubricating oil composition meets the SAE 40 specification.

2. A medium-speed diesel engine lubricating oil composition according to Claim 1, wherein said polymeric shear agent gives about 1.5 to 2.5 cSt at 100°C incremental increase in viscosity over said baseline oil.

3. A medium-speed diesel engine lubricating oil composition according to Claim 1, wherein said lubricating oil composition is about from 10 to 20 TBN and greater than about 1% sulfated ash content.

4. A medium-speed diesel engine lubricating oil composition according to Claim 1, wherein said polymeric shear agent is selected from a group consisting of polyethylene, polypropylene, polybutylene, polyisoprene, ethylene-propylene copolymer, polymethylacrylate, ethylene-butylene copolymer, styrene-isoprene copolymer, ethylene-propylene diene monomers, ethylene-propylene terpolymer, and styrene-butadiene copolymer.

5. A medium-speed diesel engine lubricating oil composition according to Claim 1, wherein said polymeric shear agent is a polymer selected from a group consisting of polyethylene, polypropylene, polybutylene, polyisoprene, ethylene-propylene copolymer, polymethylacrylate, ethylene-butylene copolymer, styrene-isoprene copolymer, ethylene-propylene diene monomers, ethylene-propylene terpolymer, and styrene-butadiene copolymer, wherein nitrogen-containing compounds are grafted onto said polymers, said nitrogen-containing compounds being selected from the group consisting of *N*-vinyl imidazole, *N*-vinyl pyridine, *N*-vinyl pyrrolidone, an alkyl amine, an alkyl amide, and an alkyl imide.

6. A medium-speed diesel engine lubricating oil composition according to Claim 5, wherein said polymer is a polymethylacrylate, wherein monomers are grafted onto said polymer, and wherein the grafted polymer has a number average molecular weight of at least 450,000.

7. A medium-speed diesel engine lubricating oil composition according to Claim 5, wherein said polymer is an ethylene-propylene copolymer, wherein monomers are grafted onto said copolymer, and wherein the grafted polymer has a number average molecular weight of from 100,000 to 450,000.

8. A method of minimizing variations in viscosity of a medium-speed diesel engine lubricating oil, said method comprising:

(a) adding a polymeric shear agent to a baseline oil, thereby forming said medium-speed diesel engine lubricating oil; and

(b) using said medium-speed diesel engine lubricating oil to lubricate a medium-speed engine.

9. A method of minimizing variations in viscosity of a medium-speed diesel engine lubricating oil, said method comprising:

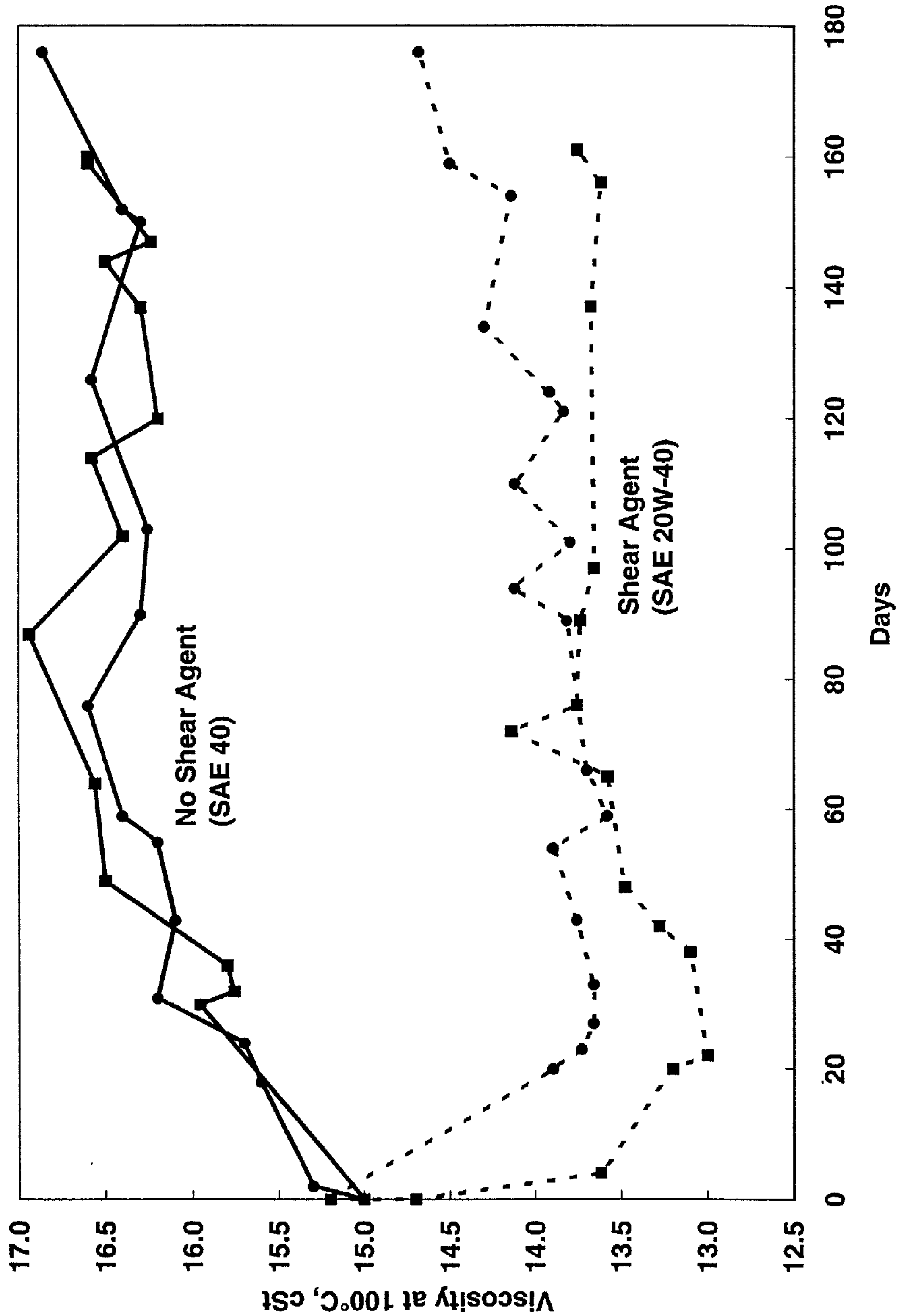
(a) adding an additive package comprising a polymeric shear agent to a base oil of lubricating viscosity, thereby forming said medium-speed diesel engine lubricating oil; and
(b) using said medium-speed diesel lubricating oil to lubricate said medium-speed engine.

10. A process for producing a medium-speed diesel engine lubricating oil composition comprising blending a mixture comprising:

(a) a major amount of a zinc-free SAE 40 baseline oil; and
(b) a minor amount of a polymeric shear agent, which gives from 1.0 to 2.7 cSt at 100°C incremental increase in viscosity over said SAE 40 oil.

11. A lubricating oil composition produced by the process according to Claim 10.

Figure 1



Viscosity at 100°C, cSt
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
Days
0
20
40
60
80
100
120
140
160
180
No Shear Agent
(SAE 40)
Shear Agent
(SAE 20W-40)

Figure 2

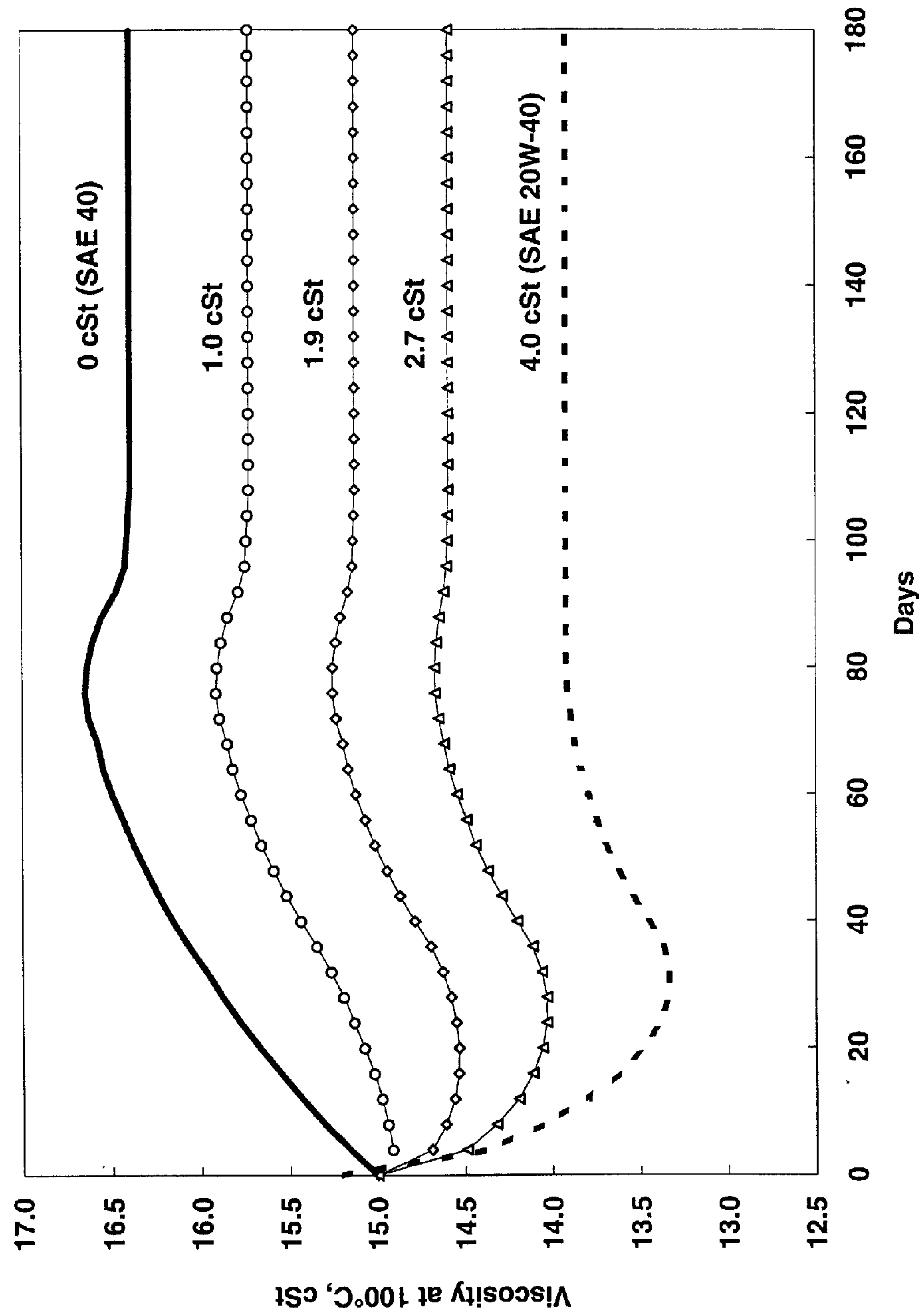

0 cSt (SAE 40)
1.0 cSt
1.9 cSt
2.7 cSt
4.0 cSt (SAE 20W-40)
Viscosity at 100°C, cSt
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
Days
0
20
40
60
80
100
120
140
160
180

Figure 3

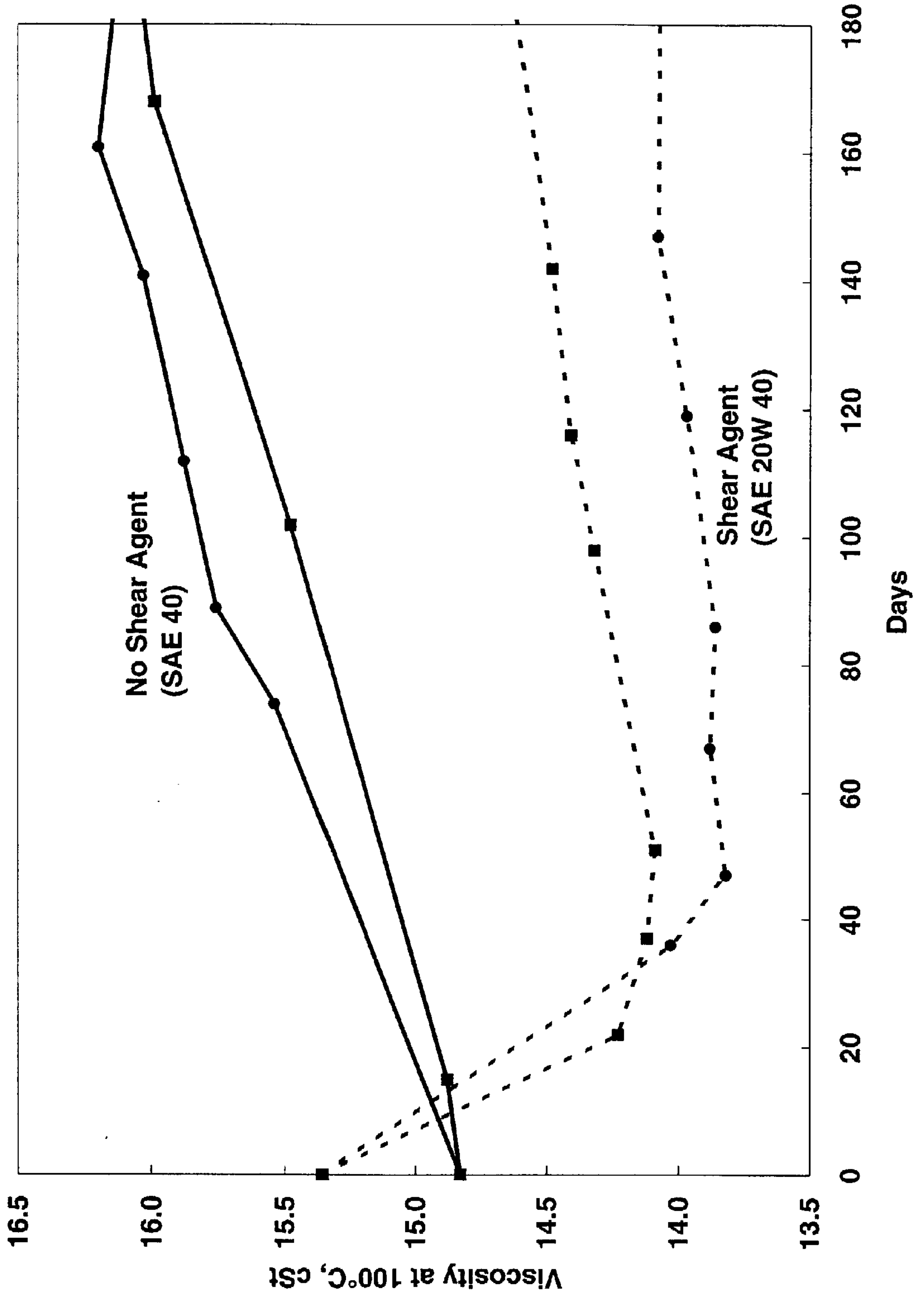

No Shear Agent
(SAE 40)
Shear Agent
(SAE 20W 40)
Viscosity at 100°C, cSt
16.5
16.0
15.5
15.0
14.5
14.0
13.5
Days
0
20
40
60
80
100
120
140
160
180

Figure 4

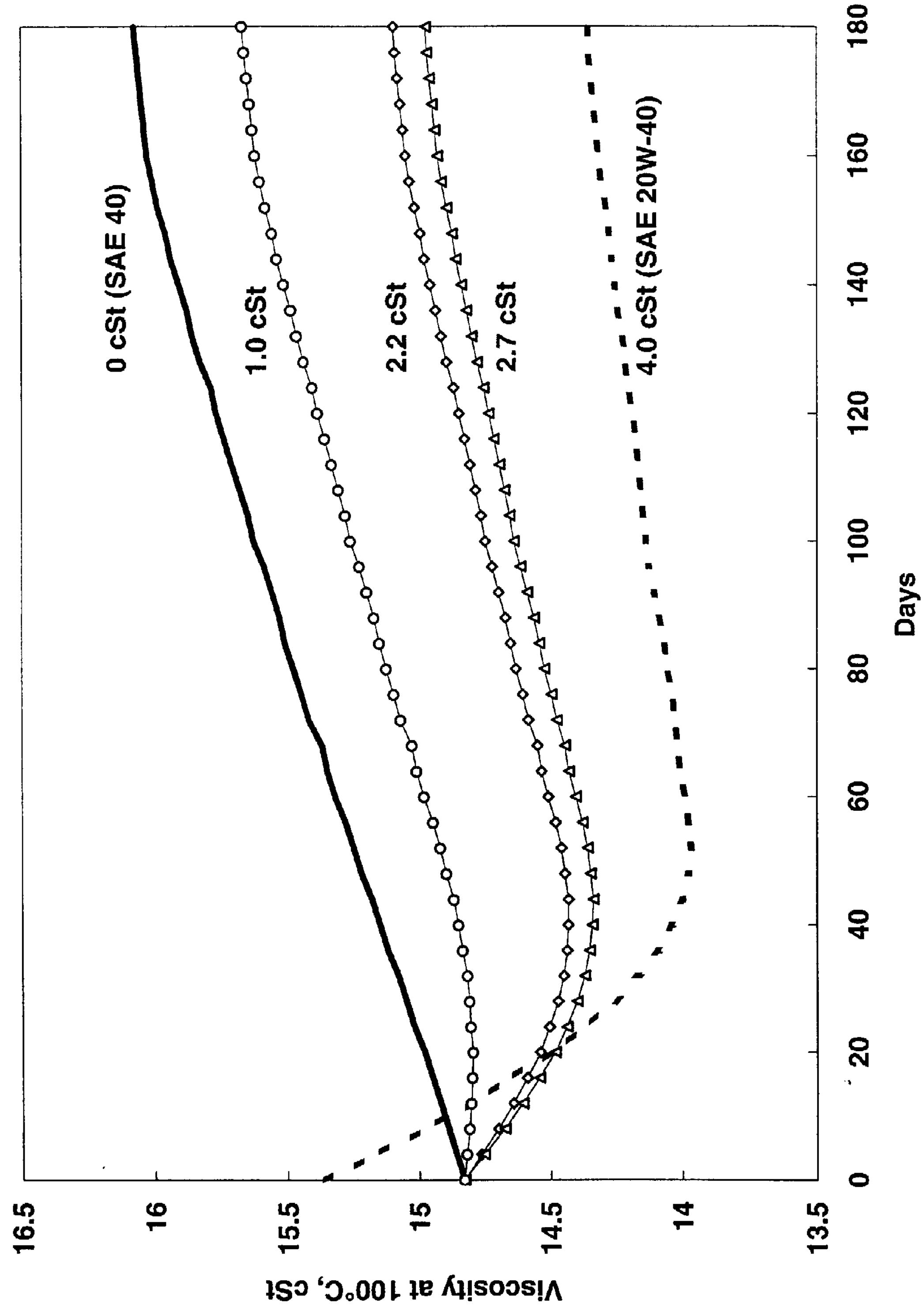

Viscosity at 100°C, cSt
16.5
16
15.5
15
14.5
14
13.5
Days
0
20
40
60
80
100
120
140
160
180
0 cSt (SAE 40)
1.0 cSt
2.2 cSt
2.7 cSt
4.0 cSt (SAE 20W-40)

Figure 5

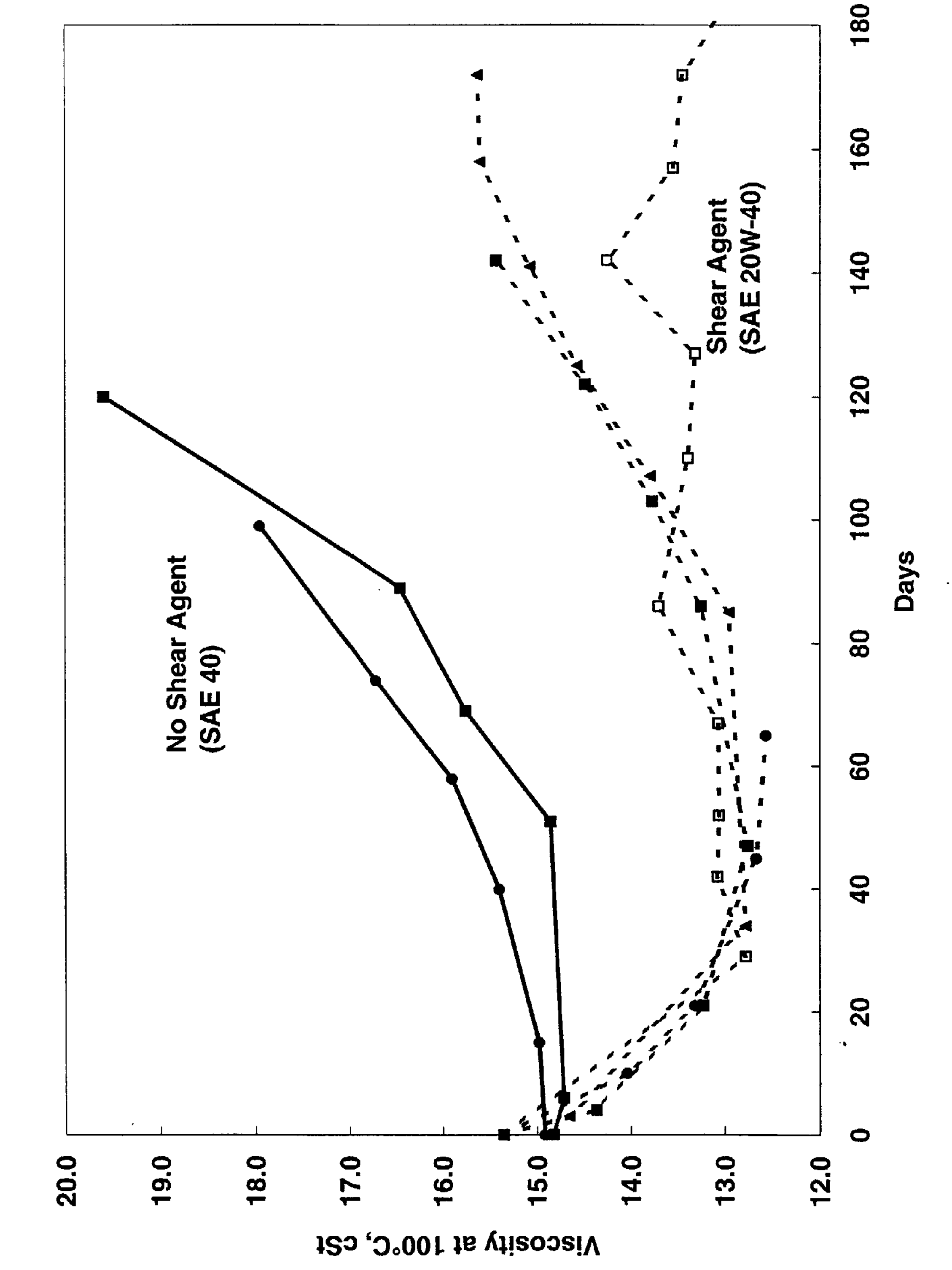
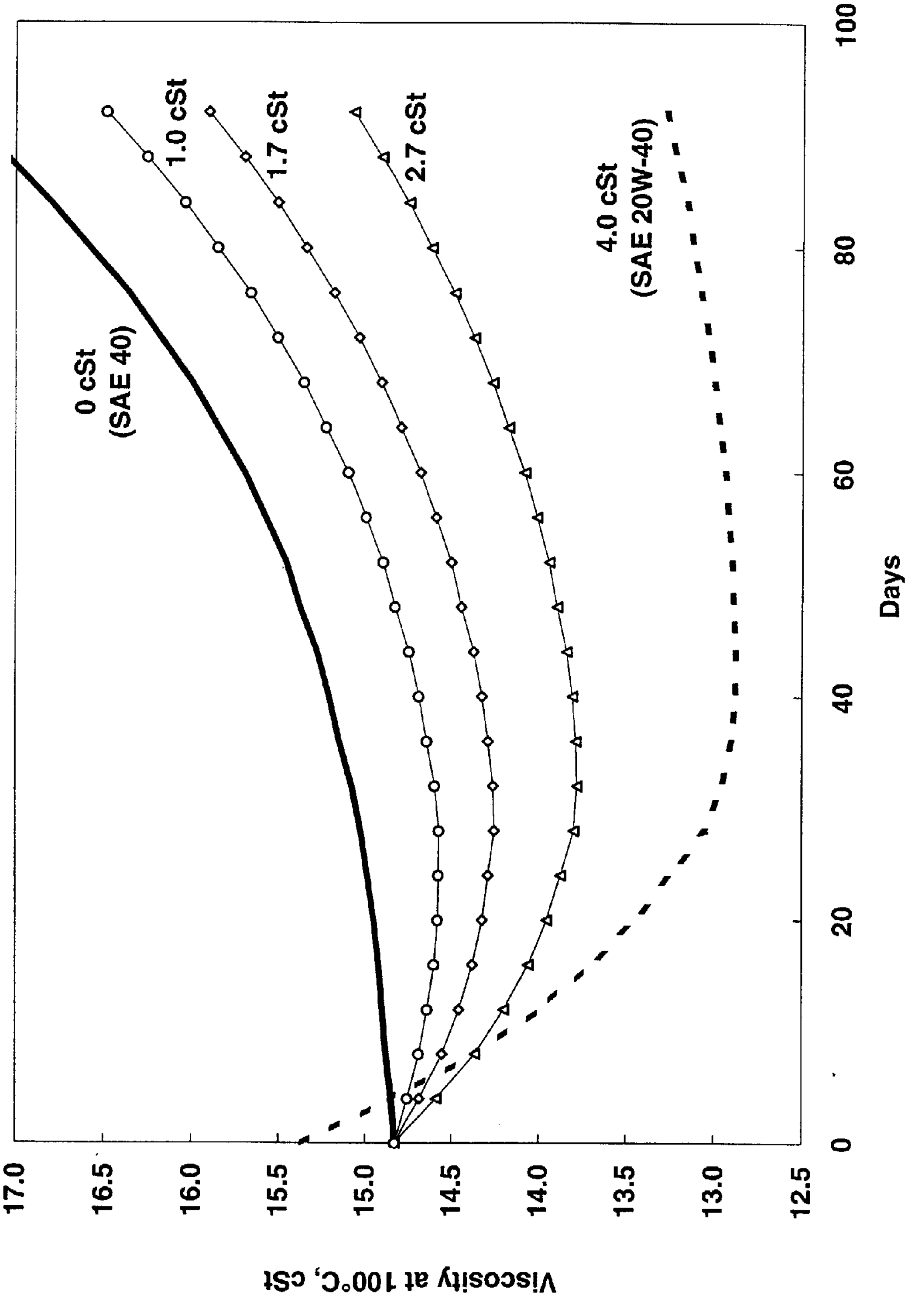

No Shear Agent
(SAE 40)
Shear Agent
(SAE 20W-40)
Viscosity at 100°C, cSt
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
Days
0
20
40
60
80
100
120
140
160
180

Figure 6


0 cSt
(SAE 40)
1.0 cSt
1.7 cSt
2.7 cSt
4.0 cSt
(SAE 20W-40)
Days
Viscosity at 100°C, cSt
0
20
40
60
80
100
12.5
13.0
13.5
14.0
14.5
15.0
15.5
16.0
16.5
17.0

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 9433

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 310 367 A (AMOCO CORP) 5 April 1989 * abstract * * page 2, line 17-19 * * page 2, line 60 - page 3, line 1 * * page 3, line 34-40 * * page 4, line 8 - page 5, line 43 * * examples 1-5 * * tables II-V * ---	1-5,8-11	C10M143/00 C10M145/14 C10M149/04 C10M149/06 C10M149/10 //C10N20:02, 20:04,30:02, 40:26,70:00
D,X	US 4 092 255 A (CHAPELET GILBERT ET AL) 30 May 1978 * examples 1,3,4 * * tables II,VII * ---	1-7,10, 11	
X A	EP 0 295 853 A (EXXON CHEMICAL PATENTS INC) 21 December 1988 * abstract * * page 2, line 1-11 * * page 3, line 14-18 * * page 3, line 24-35 * * page 4, line 15-16 * * page 4, line 40-49 * * page 10, line 41-44 * * page 12, line 17-18 * * page 13, line 16-22 * ---	8,9 1-7,10, 11	**TECHNICAL FIELDS SEARCHED (Int.Cl.6)** C10M
A	US 5 370 805 A (SMRCKA NANCY K ET AL) 6 December 1994 * abstract * * column 1, line 5-9 * * column 2, line 30-56 * * column 6, line 5-9 * -----	1-11	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	21 April 1999	Perakis, N

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 9433

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-04-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0310367 A	05-04-1989	AU 2331088 A	06-04-1989
		CA 1303599 A	16-06-1992
		DE 3867585 A	20-02-1992
		US 5174915 A	29-12-1992
US 4092255 A	30-05-1978	FR 2294229 A	09-07-1976
		FR 2294230 A	09-07-1976
		BE 836550 A	01-04-1976
		CA 1051857 A	03-04-1979
		DE 2556080 A	16-06-1976
		DK 563175 A	13-06-1976
		GB 1530321 A	25-10-1978
		IE 43403 B	25-02-1981
		JP 1299080 C	31-01-1986
		JP 51084804 A	24-07-1976
		JP 60019355 B	15-05-1985
		LU 73988 A	01-07-1976
		NL 7514546 A,C	15-06-1976
		US 4170561 A	09-10-1979
EP 0295853 A	21-12-1988	US 4803003 A	07-02-1989
		AT 71956 T	15-02-1992
		CA 1297605 A	17-03-1992
		DE 3867919 A	05-03-1992
		JP 1085246 A	30-03-1989
US 5370805 A	06-12-1994	AU 678249 B	22-05-1997
		AU 6749094 A	25-05-1995
		CA 2135702 A	19-05-1995
		ZA 9405149 A	24-05-1995

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82