Lubricant composition, method for its production, lubricant additive and method of using the lubricant composition

A lubricant composition is provided comprising a major amount by weight of a lubricant having dispersed therein a minor amount by weight of added abrasive particles having a hardness on the Mohs scale of at least 9, the abrasive particles having a size distribution such that the average particle size is less than 2 microns and the maximum particle size is less than 3 microns.

When used as a lubricant for, for example, vehicle engines and gear boxes, substantial economies in fuel consumption are obtainable.
This invention relates to lubricant compositions to methods for their production, to lubricant additives and to methods of using the lubricant compositions.

The presence of hard abrasive particles in a lubricant is generally considered to be undesirable since their presence may result in damage to the surfaces to be lubricated. Thus it is conventional to include an oil filter in the path of the circulating lubricant in an internal combustion engine to remove such particles.

French Patent Specification No. 977,834 describes the addition to a lubricant base of from 1 to 10% by weight of powdered, relatively soft minerals such as colcothar (polishing rouge or English rouge) aluminium, aluminium oxide or the siliceous material known as "Tripoli". It is stated that the lubricant composition so formed can reduce the running-in period of a vehicle and can help maintain fluid friction
between relatively moving surfaces. The particle sizes of the added mineral is not specified other than by indicating that it is less than the thickness of the lubricant film between the surfaces to be lubricated.

Lubricants have been incorporated in compositions containing abrasive particles which are intended for use in cutting and grinding metals. For example Russian Patent Specification No. 345,187 discloses a lubricating-cutting liquid for cutting copper and its alloys to which is added calcium oleate, kerosine and abrasive powder. Neither the particle size nor the hardness of the abrasive is specified. Similarly U.S. Patent Specification No. 3,078,227 discloses a cutting and grinding composition comprising molybdenum disulphide, various waxes and an abrasive and U S Patent Specification No. 2,157,379 discloses a lubricant to which is added hydrogenated castor oil wax, gel particles, and finely divided sulphur. This medium can be used to suspend particles of emery, carborundum, rouge or whiting to form grinding, lapping and polishing mixtures. The particle size of the abrasives is not given.
U.S. Patent Specification No. 3,399,145 discloses a dispersion of finely divided boron in mineral oil for use as an electroviscous fluid, but there is no mention of the use of the fluid as a lubricant. Also boron is not considered to be an abrasive.

U.S. Patent Specifications Nos. 3,213,024, 3,196,109, 3,658,709 and 2,980,475 disclose grease formulations comprising boron nitride. The boron nitride used in these specifications would be the hexagonal form, which is greasy (like graphite) and is not an abrasive.

It has now surprisingly been found that the addition to a lubricant of a minor amount of suitably finely divided particles of selected abrasives of a sufficient degree of hardness and having a precisely characterised size distribution has a beneficial effect on surfaces lubricated therewith, particularly when the resulting lubricant composition is used for lubricating during the "bedding in" of such surfaces, such as occurs for example to moving parts of vehicles during the running in period of the motor vehicle.
According to the present invention there is provided a lubricant composition comprising a major amount by weight of a lubricant having dispersed therein a minor amount by weight of added abrasive particles having a hardness on the Mohs scale of at least 9, the abrasive particles having a size distribution such that the average particle size is less than 2 microns and the maximum particle size is less than 3 microns. For the avoidance of doubt the term "micron" as used herein is used in the sense used in the diamond trade, that is to say 1 micron equals one thousandth of a millimeter.

The invention further provides a method of making a lubricant composition which comprises adding to a major amount by weight of a lubricant a minor amount of abrasive particles having a hardness on the Mohs scale of at least 9, the abrasive particles having a size distribution such that the average particle size is less than 2 microns and the maximum particle size is less than 3 microns.

Preferably the average particle size of the added abrasive particles is about 1 micron and most preferably the added abrasive particles have a fairly narrow size distribution, i.e. the maximum particle size is less than 2½ micron. It is also preferred that the shapes of the added
abrasive particles are generally regular or "blocky", i.e. in the form of minute blocks rather than in the form of spindles, irregular chips or plates. This preferred morphology may be expressed numerically by specifying that the ratio of the maximum transverse dimensions of the majority of the particles to minimum transverse dimension is less than 3:1, more preferably less than 2:1.

As indicated, the added abrasive particles should have a hardness on the Mohs scale of at least 9. Suitable abrasives include diamond, which has a hardness on the Mohs scale of 10, the so-called "cubical" form of boron nitride, otherwise known as borazon, which is said to be of similar hardness to diamond and boron carbide. The "cubical" form of boron nitride is to be distinguished from the so-called "hexagonal" form which is soft and is not an abrasive. The hexagonal form of boron nitride is thus not suitable for forming the abrasive particles used in accordance with the invention and the term "abrasive" as used herein is not to be construed as referring to "hexagonal" boron nitride.

Since the lubricants which form the base of the lubricant compositions according to the invention are generally oleaginous in nature it is preferred that the abrasive particles used in forming the lubricant compositions...
have a high surface affinity for oils (i.e. they are relatively hydrophobic) since it has been found that such particles may be dispersed in a particularly efficaceous manner in common oleaginous lubricant bases. In this regard it has been found that diamond particles possess a suitably high surface affinity for oleaginous substances and in view of this property and also because of the advantageous properties which they confer on lubricant compositions to which they are added diamond particles are the preferred abrasive particles for use according to the invention.

A particularly convenient source of diamond particles is the diamond dust produced during the grinding and crushing of diamonds, whether natural or synthetic. It is also produced during the production of synthetic diamonds. It is unimportant for the purposes of the invention whether use is made of dust from a natural diamond or whether it is synthetic in origin. A blend of natural and synthetic diamond particles may be used. Also mixtures of diamond particles (natural and/or synthetic) and other suitable abrasives, e.g. borazon may be employed.

Diamond dust is normally graded, e.g. by sieving, into several grades:

- Coarse: 16-72 mesh per linear inch
- Medium: 72-150 mesh per linear inch
- Fine: 150-400 mesh per linear inch
- Sub-seive: About 40 microns and smaller.
The coarse, medium and fine grades find uses in polishing and grinding of a variety of materials, including diamond itself, the material and type of operation determining the most suitable grade.

As their name suggests, it is generally not possible for sub-sieve grades of diamond dust to be classified by sieving methods. Instead they can be further graded by air sifting, centrifuging, elutriating (i.e. grading the particles by means of an upward current in a liquid), or by settling in a liquid, for example an oil (sedimentation). Typical grades (in microns) of sub-sieve diamond dust include 0/2, ½/3, 2/6, 4/8, 6/12, 8/12 and 20/40. In the practice of the invention it is preferred to use 0/2 micron diamond dust as the source of the particles which are added to the lubricant. 0/2 micron diamond dust is available commercially and hitherto has not found any significant commercial use. Consequently a further benefit accruing from the invention is the provision of a new use for a substance which hitherto has not been of much utility.

The preferred lubricating compositions according to the invention thus comprises a major amount by weight of a lubricant having dispersed therein a minor amount by weight of diamond dust whose particles do not exceed about 2 microns in size.
In formulating lubricating compositions according to the invention it is important that the abrasive particles are in a highly dispersed state. Microscopic examination of typical compositions has indicated that substantially all of the particles are separated from one another by lubricant.

It is preferred that compositions according to the invention display such characteristics. It has been found that diamond particles may be comparatively readily dispersed in oleaginous lubricants to the aforesaid degree of dispersion by firstly suspending the particles in the lubricant by conventional mechanical means and then subjecting the so-formed suspension to prolonged exposure to ultrasonic vibrations. For example an ultrasonic transducer may be suspended in the suspension or a vessel containing the suspension may be placed in an ultrasonic bath.

The extent of the required ultrasonic treatment will depend, of course, on the power input of ultrasonic energy to the suspension and also on the frequency of the ultrasonic vibrations. It will however be possible to readily determine that a satisfactory degree of dispersion has been obtained by microscopic examination as described above.
The amount of abrasive particles dispersed in the lubricant may vary within wide limits although generally only a very small proportion, for example less than 0.1% is required.

Preferably the abrasive particles are present in the lubricant compositions in concentration of from 4.0 to 800 mg/litre, more preferably 20 to 400 mg/litre. Most preferably the added abrasive particles are present in a concentration of from 25 to 100 mg/litre.

The invention also includes concentrate compositions for addition to a lubricant base to form lubricant compositions as defined above. Such concentrates may, for example comprise a dispersing medium which is miscible with and compatible with the lubricant base and at least 20 mg/litre, particularly from 20 to 4000 mg/litre, preferably from 100 to 2000 mg/litre of said abrasive particles. Most preferably the concentrates contain from 125 to 500 mg/litre of said abrasive particles. Expressed in terms of carats per 150 ml the concentrates preferably contain (in round terms) 0.1 to 20 carats/150 ml,
more preferably 0.5 to 10 carats/150 ml and most preferably about 1 carat/150 ml.

The dispersing medium used for preparing the concentrates preferably is an oil, but other lubricant-miscible liquids can also be used, for example isopropyl alcohol.

It is also envisaged that the lubricant compositions according to the invention may be prepared by adding to a lubricant base a solid composition comprising the abrasive particles and a lubricant-miscible dispersing agent and/or binder. Such solid compositions form a further aspect of the invention. The solid compositions may for example be in the form of tablets or other shaped bodies comprising the abrasive particles and a lubricant-miscible binder, for example a wax.

The lubricant used in formulating compositions according to the invention may be an oil of lubricant viscosity or it may be a grease.

The oil may comprise any of the kinds commonly employed in lubricating compositions or a blend of two or more
such oils. Thus it may be selected from mineral oils, vegetable oils, such as castor oil, and mixtures thereof. Typical mineral oils include paraffinic, naphthenic and aromatic mineral oils as well as blends of two or more thereof. Alternatively the oil may be a synthetic oil, a mixture of synthetic oils or a blend of a synthetic oil or oils with a mineral oil, with a vegetable oil or with a mixture thereof. Typical synthetic oils include those of the following types: silicone, organic ester, polyglycol, phosphate, polyisobutylene, polyphenyl ether, silicate, chlorinated aromatic, and fluorochemical. The oil may be, for example, an automotive oil (for example, an SAE 10W, 20W, 30, 40, 50, 10W-30 or 20W-50 automotive oil), a gear oil (for example an SAE 75, 80, 90, 140 or 250 gear oil) an automatic transmission oil, a light, medium, heavy or extra low temperature hydraulic oil, a machine oil, an aviation grade oil (for example an aviation grade 80 or 100 oil) or a refrigerator oil. Detergent oils may be used.

The oil may contain in conventional amount any of the usual additives or a mixture thereof. Such additives include dispersants, detergents, anti-wear additives, corrosion inhibitors, antioxidants, viscosity index improvers, varnish inhibitors, extreme pressure additives, pour-point
depressants, antifoam additives and the like. The choice and amount of any additive or additives will of course depend on the intended end use of the lubricating composition. The concentrate compositions according to the invention may be formulated using similar oils.

As mentioned above, the lubricant may alternatively be a grease. Any grease of the type conventionally used as a lubricant may be used. Thus, for example, the grease may comprise a petroleum oil thickened with a metallic soap. The grease may be, for example, an axle grease. The choice of grease will depend on the intended end use of the resulting composition. Silicone grease can also be used.

Compositions according to the invention have been found to be particularly useful for treating mechanical parts so as to reduce the frictional resistance to motion therebetween. In particular they may be used to treat such parts in situ in the mechanisms in which they are located by simply using the compositions in place of conventionally used lubricants for an extended period of time (which nevertheless may be short compared to the total working life of the mechanism) while causing the mechanism to perform its normal motions.

Thus according to a further aspect of the invention there is provided a method of reducing frictional resistance
to motion between relatively moving lubricated mechanical parts which comprises operating said mechanical parts for an extended period of time, continuously or intermittently, while lubricating said parts with a lubricating composition according to the invention.

The required period of operation will depend on a number of variables such as, for example, the nature of the relative motion, the material of the parts, the concentration of the abrasive and the rate of application of the lubricant. In practice it has been found that a significant reduction of frictional resistance to motion may be obtained if the treatment is continued for from 100,000 to 50,000,000, preferably from 1,000,000 to 25,000,000 cycles of the parts. The term "cycle" as used in this context is meant to refer to a single reciprocation of parts undergoing relative reciprocal motion or a single rotation of parts undergoing relative rotary motion. It will be appreciated that in carrying out the method of the invention, complementary low-friction surfaces are produced on pairs of said mechanical parts.

Lubricating compositions according to the invention have been found to be of particular use in treating internal combustion engines in the manner described above i.e. by replacing the normal engine oil by a lubricant composition according to the invention, and significant reductions in
fuel consumption have been observed after such treatment.
Similarly gear-boxes may be advantageously treated, in which
case the treatment has been observed to result in an increase
in gear-box efficiency. It will thus be appreciated that
by treating one or both of the engine and the gear-box of a
vehicle by the method of the invention, significant reductions
in fuel consumption may be obtained.

The treatment is preferably applied during the
initial "running-in" period of the vehicle engine during which
the bearings of the engine are "bedded-in". However the
treatment may be applied with beneficial results to vehicles
which have already been "run-in".

Following treatment in accordance with the invention,
lubrication with lubricant containing abrasive particles is
terminated and thereafter a normal lubricant is used. In
practice it has been found that a significant improvement in
fuel economy and running efficiency is attained if the treatment
of the invention is continued while running the vehicle for
about 500 miles (800 km).

The following test results further illustrate the
invention:-

Tests were carried out in which variable amounts of
diamond dust of different sub-sieve grades were added to a
variety of commercially available oils of lubricant viscosity. The diamond dust was dispersed in the oil using a rotary mechanical mixer. The dispersions so obtained were then exposed to ultrasonic energy in a commercially available ultrasonic cleaning bath for half an hour. At the end of this time, microscopic examination revealed that the diamond particles were totally dispersed in the oils, i.e. the particles were totally separated and completely surrounded by oil.

A commercial automotive oil to which has been added 1 carat per 3 Imperial pints of oil of 0/2 micron diamond dust (ca. 125 mg/litre oil of 0/2 micron diamond dust) was used to lubricate a car engine during the "running in" period of the engine. In this example, a production motor car with a 2000 cc (nominal) engine capacity was "run in" according to the manufacturers' recommendations, except that the recommended engine lubricant had had added thereto 1 carat per 3 Imperial pints of oil of 0/2 micron diamond dust. The petrol consumption was measured to be about 35 miles per gallon; this compared to the manufacturers' published figures of 24 - 27 miles per gallon. The engine ran extremely quietly and smoothly after this "running in" period.

Tests have also shown that the oils to which diamond dust had been added could be used for treating white metal
bearings in aluminium engines as well as in cast iron engines; they were also effective for treating plastics bearings. When such diamond dust-containing oils were used during "bedding in" of the bearings, the bearings thereafter ran extremely smoothly.

Inspection of bearings "bedded in" using a 0/2 micron diamond dust-containing lubricant oil shows a glass-like finish.

From these tests it would appear that the 0/2 micron diamond dust has a lapping effect on the bearing surfaces with which the lubricant oil comes into contact during "bedding in".

Preliminary experiments have further shown that similarly good results are obtained by the addition of 0/2 micron diamond dust to a commercial lubricant grease.

Results obtained in which diamond dust of larger particle size than 0/2 grade had been used were generally unsatisfactory and in particular the bearings showed a poor surface finish and had been worn away to an unacceptable degree. Several bearing had "sieved".

Although compositions according to the invention are generally intended for use during the initial period of use of mechanisms which are used to lubricate, e.g. during the initial running-in period of a vehicle, they may also be used for example to treat the engines, gear-boxes and differentials of vehicles which have been in operation for some time.
For example a Ford "Corsair" which had been running for 76,000 miles was treated in accordance with the invention in the following manner: A dispersion of 1 carat (200 mg) of 0/2 diamond dust in 1 pint (0.568 litres) of engine oil was added to the vehicle's sump. The vehicle was then run for 500 miles and the engine oil was then changed.

The fuel consumption before and after the treatment was as follows:

<table>
<thead>
<tr>
<th>Prior to treatment</th>
<th>After treatment</th>
</tr>
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<tbody>
<tr>
<td>28 miles/gallon</td>
<td>34 miles/gallon</td>
</tr>
</tbody>
</table>

This represented a decrease in rate of fuel consumption of 21%.

Similar tests were carried out on a Citroen "GS" (Vehicle A), an Audi which had been running for 20,000 miles (Vehicle B) and three new Audis which had already been "run in" (Vehicles C, D and E).

The results were as follows:

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Increase in distance travelled per unit volume of fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15%</td>
</tr>
<tr>
<td>B</td>
<td>10.8%</td>
</tr>
<tr>
<td>C</td>
<td>31%</td>
</tr>
<tr>
<td>D</td>
<td>30.2%</td>
</tr>
<tr>
<td>E</td>
<td>27.9%</td>
</tr>
</tbody>
</table>
For vehicles C, D and E, 1 carat (200 mg) of diamond dust in \( \frac{1}{2} \) pint (0.284 litre) of oil was added to the existing oil in the engine and \( \frac{1}{2} \) carat (100 mg) of diamond dust in \( \frac{1}{4} \) pint (0.142 litres) of oil was added to the existing oil in the gear box.
CLAIMS

1. A lubricant composition comprising a major amount by weight of a lubricant having dispersed therein a minor amount by weight of added abrasive particles, characterised in that the abrasive particles have a hardness on the Mohs scale of at least 9 and a size distribution such that the average particle size is less than 2 microns and the maximum particle size is less than 3 microns.

2. A lubricant composition according to Claim 1 wherein the average particle size of the added abrasive particles is about 1 micron.

3. A lubricant composition according to Claim 1 or Claim 2 wherein the maximum particle size of the added abrasive particle is less than 2½ microns.

4. A lubricant composition according to any preceding claim wherein the shapes of the added abrasive particles is such that the ratio of their maximum transverse dimension to their minimum transverse dimension is less than 3:1.

5. A lubricant composition according to any preceding claim wherein the added abrasive particles have a high surface affinity for oleaginous materials.
6. A lubricant composition according to any preceding claim in which the added abrasive particles consist of natural or synthetic diamond.

7. A lubricant composition according to any preceding claim wherein the degree of dispersion of the abrasive particles in such that substantially all of the particles are separated from one another by lubricant and each particle is completely surrounded by a lubricant layer.

8. A lubricant composition according to any preceding claim wherein the concentration of said added abrasive particles is from 4.0 to 800 mg/litre.

9. A lubricant composition according to Claim 8 wherein the concentration of said added abrasive particles is from 20 to 400 mg/litre.

10. A lubricant composition according to Claim 9 wherein the concentration of said added abrasive particles is from 25 to 100 mg/litre.

11. A concentrate for addition to a lubricant base to form a lubricant composition according to any preceding claim comprising a dispersing medium which is miscible with said lubricant base and having dispersed therein at least 20 mg/litre of said abrasive particles.
12. A concentrate according to Claim 11 containing from 20 to 4000 mg/litre of said abrasive particles.
13. A concentrate according to Claim 12 containing from 100 to 2000 mg/litre of said abrasive particle.
14. A concentrate according to Claim 13 containing from 125 to 500 mg/litre of said abrasive particles.
15. A solid composition for addition to a lubricant base to form a lubricant composition according to any of Claims 1 to 10 comprising said abrasive particles and a lubricant-miscible dispersing agent and/or binder.
16. A composition according to Claim 15 in the form of a tablet or other shaped body.
17. A method of reducing frictional resistance to motion between relatively moving lubricated mechanical parts which comprises operating said mechanical parts for an extended period of time, continuously or intermittently, while lubricating said parts with a lubricant composition according to any one of Claims 1 to 10.
18. A method according to Claim 17 wherein said mechanical parts are operated for from 100,000 to 50,000,000 cycles (as defined herein).
19. A method according to Claim 18 wherein said mechanical parts are operated for from 1,000,000 to 25,000,000 cycles (as defined herein).
20. A method according to any one of Claims 17 to 19 wherein at the end of said period, said lubricant composition is removed and thereafter the mechanical parts are lubricated with a lubricant not containing said added abrasive particles.
21. A method according to any one of Claims 17 to 20 wherein complementary low-friction surfaces are produced on at least one pair of said mechanical parts.
22. A method according to any one of Claims 17 to 21 wherein said mechanical parts are parts of an internal combustion engine.
23. A method according to any one of Claims 17 to 22 whether said mechanical parts are parts of a gear-box or differential.
24. A method of operating an internal combustion engine so as to reduce the fuel consumption thereof which comprises operating said engine for an extended period of time, continuously or intermittently, while lubricating said engine with a lubricant according to any one of Claims 1 to 10.
25. A method according to Claim 24 wherein the engine is operated for from 100,000 to 50,000,000 cycles (as defined herein).

26. A method according to Claim 25 wherein the engine is operated for from 1,000,000 to 25,000,000 cycles (as defined herein).

27. A method according to any one of Claims 24 to 26 wherein the engine is operated in the manner defined during the initial running-in period thereof.

28. A method of producing a lubricant composition according to any one of Claims 1 to 10 which comprises (1) mixing said abrasive particles with said lubricant to form a dispersion and (2) subjecting the so-formed dispersion to ultrasonic vibration.
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (Int. Cl.)</th>
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<tr>
<td>A,D</td>
<td>FR - A - 977 834 (F. SAUNIER)</td>
<td></td>
<td>C 10 M 1/10</td>
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The present search report has been drawn up for all claims.

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Date of completion of the search: 29-11-1979
Examiner: ROTSAERT