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LAPPING COMPOUND

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This invention, relating as indicated to a lapping compound, is particularly directed to a new and improved lapping compound involving a thixotropic gel, particularly an organophilic bentonite and the usual abrasives used in lapping compounds. This invention may be used with a great variety of surfaces, including steel, cast iron, bronze, brass, stainless steel, ceramics, some of the new structural alloys and sintered carbide compositions, i.e., all surfaces capable of being lapped. The lapping compound may be used with the abrasives in a thixotropic gel where the abrasive is suspended in the gel and the gel may be formed out of modified bentonite clays, which are particularly adapted for gelling with organic compounds, although other gelling agents may be used. These are known as organophilic bentonites.

Particular materials with which these gels are made include kerosene, hydrocarbons with a boiling point lower than 650° F. or light fraction, low viscosity hydrocarbons or synthetic esters, although it will be recognized that other low boiling point fluids, such as alcohol, ether, or emulsions of water and alcohol or water and kerosene, may be used. It is perhaps desirable to note that the gel used must have at least a minimal lubricating ability, which may be increased by deliberate addition of extreme pressure additives. The fineness of the abrasive particle used in connection with these lapping compounds is in the range of 80 grit to less than 1 micron.

An object of this invention is to produce a new and improved lapping compound which will improve lapping performance and will be less inclined to squeeze out between the lap and the lap surface.

A further object of this invention is to employ a thixotropic gel using materials such as organophilic bentonite and kerosene together with a suspended abrasive of usual form.

A further object of this invention is to employ a thin, thixotropic medium suitable for machine pumping with a limited evaporation rate and increased adhesion to or wetting with the metal surfaces by virtue of being thixotropic.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

In general, the greases, oils and soaps are the suspending media or carriers, and the abrasive compounds comprise a variety of grit sizes and include such materials as aluminum oxide (Al_2O_3), silicon carbide, boron carbide, zirconium carbide, tungsten, diamond bort, molybdenum, chromium and hafnium carbide. This invention includes all of the more common abrasive materials. These abrasive materials are held in a vehicle and a thixotropic gelling material, such as an organophilic bentonite. An ex-

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ample of one of these bentonites is dimethyl ammonium bentonite, sometimes hereinafter referred to as Bentone 34. This application is not limited to these particular gelling agents. These gelling agents would be used with a percentage of an abrasive compound, and the gelling agent would be employed over the entire range from 1 to 20% of the compound, and examples of compositions are 4% and 5% of gelling agents, the balance being substantially a low boiling point fluid, such as kerosene. These materials would be properly homogenized, and between 5 and 40% of the final compound would be abrasive, such as aluminum oxide. The narrower limits would be 10 to 30% of the compound, and examples of 20% have been used.

The lapping compound would consist of a suspending medium consisting of a mixture of the kerosene and possibly a low viscosity lubricating oil, such as 40-60 SUS at 75° F. This would be used and substituted into the vehicle to the extent of 20 to 70%, more specifically, 30 to 60%, with an example 50% oil and 50% kerosene. That is to say, we would take the vehicle or liquid of kerosene and oil and gel this with 4 to 5% of modified organophilic bentonites, add, such as, 20% aluminum oxide abrasive, and the balance would be gelled kerosene. However, we may substitute low viscosity lubricating oil for 50% of this kerosene.

In addition to the above lapping compound, 5% might be a chlorinated paraffin extreme pressure additive, particularly to prevent galling with abrasives below 1000 mesh. The limits for this additive would be ¼ to 20%, the preferred range being 2 to 10%, with 5% as an example.

One of the particular advantages of certain thixotropic gels is that they are non-melting and do not run out between the lap and the lap surface. Also, low boiling point materials are used to absorb the heat as these materials are boiled at the asperite point and thereby reduce the temperature by virtue of the phase change.

For a clearer understanding of this action, it should be explained that a gel is a lattice work somewhat similar to a sponge in which platelets of the gelling agent are bonded to the suspending medium and to the abrasive by true electrostatic forces. The thixotropic gel liquifies readily upon agitation to a fluid suspension of relatively low viscosity, and the gel reforms reversibly on standing. This has a particular desirability in that the abrasive compounds do not settle out as they may in low viscosity liquids, such as oils and the like. Though greases might be used, these provide excessive lubrication between the lap and the workpiece and prevent rapid cutting. The electrostatic forces mentioned above differ from the normal chemical forces, i.e., electrons, in their motion, set up electrostatic fields, and it is the attraction of these fields, rather than the actual chemical bond due to the exchange action of electrons, that forms a gel. This means that when the binding forces are easily broken by the application of a mechanical force, the order of magnitude of the mechanical force necessary to break an electrostatic bond is much less than that necessary to break a chemical bond. These gels are then thixotropic when they, by themselves or upon application of a small amount of shear force, remain stationary, i.e., there is no flow. If successive shear forces are applied, such as by shaking, the gels break down and any particle therein can be freely moved. By developing a gel that will keep large abrasive particles from settling appreciably, we have solved among others the problem of shelf life.

At the present time, many or most of the lapping compounds that are extremely low in viscosity are defective in that the abrasive of the substance settles to the bottom of the container within a relatively short time. It is extremely difficult to again mix the abrasive particles

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uniformly in the suspending medium once they have settled. This is so because the heavy particles settle first and when the cake at the bottom of the settled suspension is agitated, the smaller particles on the top are mixed in first and there is no uniformity of even mixture or even mixture of the large and small particles. In the alternative, if the lap compounder attempts to solve the problem of settling by the use of high viscosity greases or soaps, it is found that excessive lubrication is provided between the lap and the material being lapped and, as a result, it is found that there is a reduction in the cutting efficiency of the abrasive. In cases where the gel is non-melting, this characteristic prevents lubricant from flowing from between the surfaces.

Our objective in using a low boiling point fluid, such as kerosene, esters, or any of the other materials mentioned hereinabove, as a base in our compound was to lower the temperature at the point of fracture of the chip. Our past experience had shown that fracture was desirable rather than smearing or asperite tearing for metal removal. We therefore use kerosene or oils with a low boiling point as our most desirable media since the use of such material tends to carry the heat away.

In the prior art it has been known that kerosene is one of the better suspending media or carriers, but there have been a number of objections to the use of kerosene

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Boron carbide—.8 lb. per gal.
Titanium carbide—1.2 lb. per gal.
Zirconium carbide—2 lbs. per gal.
Molybdenum carbide—5 lbs. per gal.
Chromium carbide—5 lbs. per gal.
Zirconium oxide—1.7 lbs. per gal.
Magnesium oxide—1.44 lbs. per gal.
Diamond bort—1 to 4% by weight per gal.

It will be understood, of course, that the above proportions will be varied somewhat with grit size.

In connection with the suspending medium or carrier used in the lapping compound, kerosene is important, and it is also important to use an oil for wetting and lubricity, particularly with grit sizes finer than 1000 mesh. In connection with lapping machinery and the machine pumping of these fluids, it is important to have the correct viscosity, and the evaporation rate should be low enough to keep the fluid between the surfaces. This is accomplished by using a thixotropic gel. Studies show that the cutting rate under these conditions is greatly improved and metallographic examination of the surfaces shows reduced smearing.

Examples of the fluids we have tested are listed below in tabular form with the ranges of the gelling agents given for maximum, minimum and preferred for us:

	Fluid	Gelling Agent	Range			Other Components
			Min., Percent	Max., Percent	Preferred, Percent	
1.....	Kerosene..	Bentone 34 ¹	1	10	4½	Catronic SP wetting agent.
2.....	do.....	do.....	1	10	4½	
3.....	do.....	Silica gel.....	1	10	4	
4.....	do.....	Thixein (Baker Castor Oil).....	1	10	4	
5.....	do.....	Bentone 34 and Thixein.....	1-10	1-10	3/3	Amine O. Wetting agent.
6.....	do.....	Attapulugus Clay.....	1	12	5	
7.....	do.....	Aluminum Octoate.....	1	10	3	

¹ Dimethyldioctadecyl ammonium bentonite.

in lapping compounds because the particles of abrasive that would be employed therein settled out and the kerosene evaporated between the lap piece and left the lap dry. This invention employs a lapping fluid of ker-

The above compositions represent the variates we have tested on gelling agents for kerosene. Two more must be added for water which have proven satisfactory for non-metallic lapping:

	Fluid	Gelling Agent	Range			Other Components
			Min., Percent	Max., Percent	Preferred, Percent	
8.....	water.....	Bentonite.....	1	10	4	-----
9.....	water and ethyl alcohol.....	do.....	1	10	4	

osene or equivalent material, preferably below a boiling point of 650° F., in which abrasive particles are suspended with an organophilic bentonite. This is a non-melting gelling agent to prevent rapid evaporation of kerosene with the resultant drying out between surfaces. At the same time, the kerosene, because of its relatively high heat transfer, cools the workpiece and reduces the smearing action. In place of kerosene or low molecular weight hydrocarbons, we may use alcohol, ether or water, and emulsions of water and alcohol and water and kerosene.

Among the abrading compounds, we have found particularly successful in connection with the lapping compound the following and we use them in the proportions indicated:

Aluminum oxide—1 lb. of abrasive per gal. of suspension medium
Silicon carbide—1 lb. of abrasive per gal.

In dealing with various metals it become necessary to add agents to the kerosene to aid in wetting and lubricity. We chose 40-60 SUS light oils to add. We tried paraffinic and naphthenic base oils of the same viscosity and finally settled on a naphthenic oil from Sun Oil Company.

Viscosity, SSU, 160° F.
Flashpoint, 275° F.
Pour point, 50° F.
55-60 units
Firepoint, 305° F.
ASTM color #2

Our present base is 50% kerosene and 50% of the above named naphthenic oil plus the gelling agent, of course, as shown in the table above in the percentage indicated.

To this we would add our abrasive to make it up to 100%, i.e., 5-40% abrasive, generally 20% balance media, made up as above with fluid and gelling agent.

To eliminate metal to metal galling during lapping, we added to our standard base 50-50 kerosene and oil and 4% Bentone 34, with the following minimum and maximum percent in ranges, plus the best percent:

		E.P. Additive	Min., Percent	Max., Percent	Best
A	Base 1	Lard Oil	1/2	20	10
B	do	Sulphurized Lard Oil	1/2	10	4
C	do	Sulphurized Castor Oil	1/2	10	4
D	do	Tricresyl Phosphate	1/2	12	6
E	do	Triethyl Phosphate	1/2	10	5
F	do	Chloroparaffin	1/2	18	5
G	do	Lead Oleate	1	10	2
H	do	LC Base (chlorinated hydrocarbon) Sun Oil Company	1	20	5
I	do	LC Base (above)	1	20	10

¹ Base—50% kerosene—50% oil.

Of these we preferred C, E and H. The one we use mostly is H, this one is suitable for making gauge blocks. In general, however, no additives are needed until the grid size is finer than 1000 mesh. The finer the grit the more needed is the EP additive until for the finest lapping of gauge blocks composition "I" has proven useful on the last step.

To any of the above media we have added between 5-40% solid abrasive. Our present percent is 20% abrasive, 80% combined media except for the #220 grit (for finest polishing). Here we use 30-35% abrasive balance media "I" from table.

These lapping compounds are made by taking a gelling agent, such as bentonite or Bentone 34, and some kerosene, and making a slurry or paste, i.e., the ingredients are first mechanically mixed and then passed to a homogenizer, such as a Manton Gaulin, until the gel is formed, or until the strength of the electrostatic bond is at a maximum. Other gelling agents, such as those shown in the example, together with saponites, zeolites, fuller's earth, aryl ureas and phthalocyanine pigment, may be used. All of these may be mixed together to form a gel. They may be used at varying temperatures, up to the boiling point of the organic material used as a solvent.

It is somewhat a matter of dispute as to the actual mechanism of lapping, but sometimes the abrasive particles become embedded in the lap and the small tips extending outwardly tend to break. The larger the particle, the greater is the moment of force and, therefore, a constant shearing force caused by the action of the lap with respect to the lapped surface will break down these larger particles faster than it will break down smaller particles. We have found that there is a rolling action between the lap and the lap surface which causes the abrasive particle to gouge out cavities in the lapped surface. Our experience has shown that the top level of a gouged out surface can be lowered faster than that of a surface leveled by embedded particles.

In general, the lapping compounds above described may be used for both hand and machine lapping compounds. The advantage of these compounds is that they substantially reduce the time of lapping in order to accomplish a certain finish. As compared to lapping compounds suspended in oils or greases, lapping times of one-fourth of those previously needed have been produced. In other instances, in connection with a particular product, the time was reduced to one-sixth of the time ordinarily required. On an external shaft the time was reduced to one-third and on dies the time was reduced to a fourth or fifth of the time previously needed. Specific examples of compounds have been cited.

A further advantage of these lapping compounds is

that the lapping compounds do not work out from between the lap and the workpiece. This is quite important in preventing waviness in the surface, since the oozing out of material from between the pieces leaves a region in which there is a concentrated wear. Then the material is chased back on and still another area is uncovered, and, hence, again in this area there is excessive wear. This is a source of the waviness which is normally produced in lapped surfaces. It is not to be confused with irregularities that are caused by so-called asperities but this is a form referred to as macro-waviness. With these new lapping compounds we get a uniform metal cutting action and therefore by measurement we have a surface which exhibits considerable reduced waviness. This action is partially explained by the fact that the solvent does not run out from between the lap and the workpiece.

Another advantage of this combination is that the surface, upon completion of the lap, will be much easier to clean. Prior to this time, kerosene was employed to wipe the surface but since the suspending medium will probably be kerosene, all that is required is to wipe off the surface with a rag and there is no oil or other residue remaining.

This lapping compound, of course, suspends the abrasive particles and there is reduced settling of the particles because they are embedded in a gel.

Unless indicated to the contrary, all percentages are by weight.

Having thus described the specific nature of this suspending medium, the abrasive and the thixotropic gel, it will be appreciated that this invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by any of the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

We claim:

1. A metal lapping compound consisting essentially of from 1 to 20 percent by weight of an organophilic clay as a gelling agent and from 5 to 40 percent by weight of abrasive ranging in size from 80 grit to 1 micron, and the balance from 40 to 94 percent of low boiling point kerosene hydrocarbons.

2. The metal lapping compound of claim 1, in which from 20 to 70 percent by weight of the kerosene hydrocarbons have been replaced by a low viscosity lubricating oil.

3. The metal lapping compound of claim 1, in which from 0.25 to 20 percent of the kerosene hydrocarbons have been replaced by an extreme pressure lubricant.

4. The metal lapping compound of claim 3, in which the extreme pressure lubricant is a member of the group consisting of lard oil, sulphurized lard oil, sulphurized castor oil, tricresyl phosphate, triethyl phosphate, chloroparaffin, lead oleate and chlorinated hydrocarbon.

5. The metal lapping compound of claim 1, in which the gelling agent is from 2 to 10 percent of the mixture, and in which the extreme pressure additive is from 2 to 10 percent of the mixture.

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