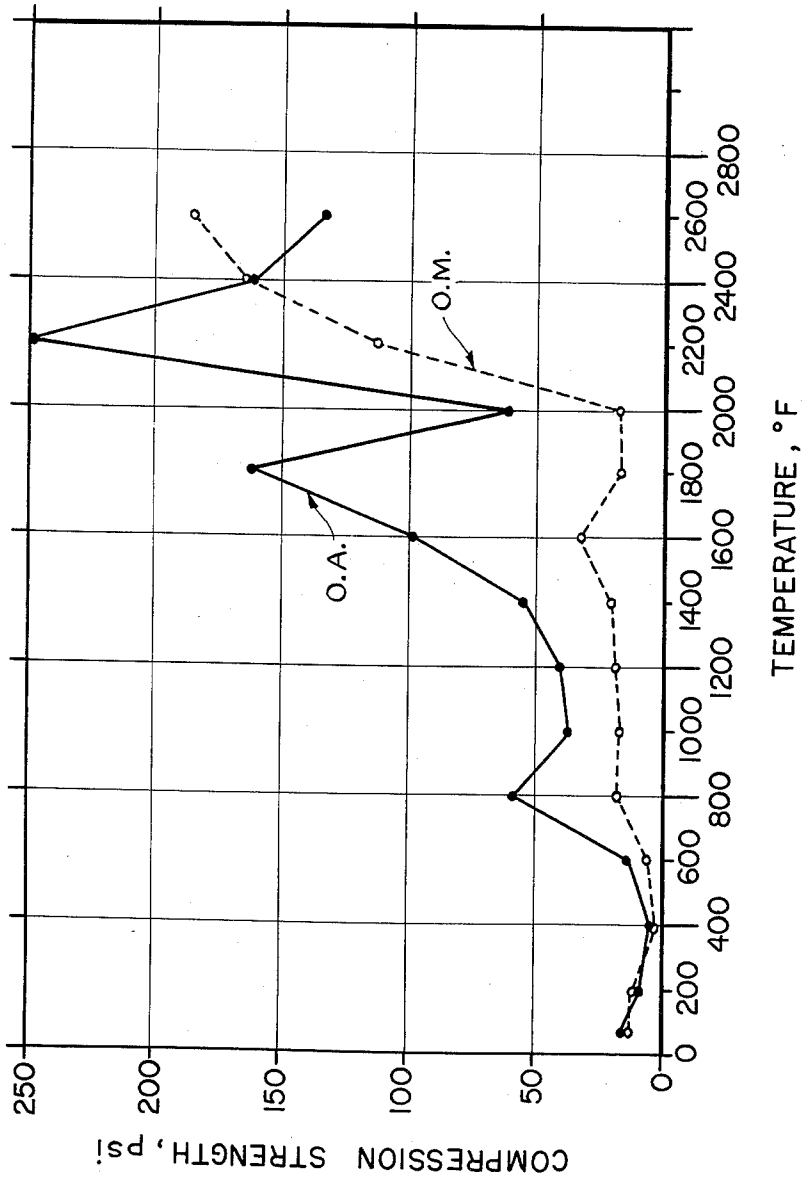
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MOLDING SAND

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MOLDING SAND

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This invention relates to molding sands such as are used for the casting of metals, and more particularly to molding sands which are bonded with materials other than ordinary clay as such, and liquids other than water.

In casting metals into a sand mold, the sand is commonly bonded with small amounts of clay moistened with water. Originally, sands were used which contained naturally occurring clay, but in recent decades the practice has arisen of adding specially selected clays to sands, particularly to sands which have been washed free of any clay or other contaminating material. The composition and use of such molding sands in the foundry art are well-known and will not be described further herein, except by reference to the literature, and in particular such monographs as "Metal Castings," by Harry L. Campbell, New York, 1936; and the U.S. Navy Bureau of Ships' "Foundry Manual," Bulletin No. Navships 250–0334, Washington, D.C., no date.

The properties of conventional molding sands such as have been described leave much to be desired, in spite of their wide and universal usage. Many problems arise from the fact that the properties of the conventional molding sands depend greatly upon their moisture content. Slight variations in moisture content can cause radical changes in their compressive strength, permeability, and flowability. These changes, if uncorrected, will cause surface and interior defects in castings and result in substantial scrapping. The moisture content of molding sands can vary appreciably during pouring, working, or storing, as a result of evaporation losses. Very little can be done to prevent the evaporation of water because of its relatively low boiling temperature, necessitating frequent and definite additions of water to the sand.

Conventional molding sands must be quite permeable, that is, must pass gas freely, in order to accommodate the large volume of water vapor evolved when the metal is poured. Since permeability is a function of pore diameter, which, in turn, is a function of average sand particle size, a definite lower limit is set on the fineness of sand which can be used in any particular type of casting, so that it is seldom possible to obtain as smooth a surface finish as desired when using conventional molding sands, because very fine sand cannot be used because of its low permeability.

Another factor influencing the smoothness of surface finish is the adherence or even bonding of sand particles to the metal, after the casting process has been completed. This quite common occurrence makes it necessary to clean up castings, as by sand blasting, wire brushing, grinding, and the like, so that a clean metal surface is presented by the casting, instead of one marred by sand grains and other tightly bonded residue from the face of the sand mold. The cleaning time and cost involved can be an appreciable portion of the total cost of the casting.

In order to avoid the disadvantages of sands containing water, many water-free molding sands have been tried in foundries over the years. These water-free sands contained oil as a bonding agent. Oil was believed to be

superior to water because it boiled at a higher temperature than water and evolved less gas, thereby requiring less sand control because of lower evaporation losses. The oil also caused less chilling of the molten metal. In spite of these advantages, the oil-sand sytsems were always found to be impractical because of their very low bond strength.

The proposal has been made to thicken the oil in systems of the type described with bentonite which has been made organophilic by treatment with certain organophilic materials. Alternatively, the proposal has been made to incorporate with the oil in such systems a clay known as attapulgite, although not previously placed in an organophilic state. There are certain disadvantages connected with both of these rather recent proposals, which the present invention avoids.

An object of the present invention is to provide a molding sand substantially free from water, and, hence, not subject to water evaporation losses.

Another object of the present invention is to provide a molding sand containing a bonding agent which is effective in an essentially non-aqueous lubricant vehicle.

Another object of the present invention is to provide molding sand compositions of such character that sand grain fineness can be much smaller than possible with conventional clay-water bonded sands, thus leading to the production of smoother castings.

Another object of the present invention is to provide a molding sand of substantially lessened adherence to castings formed therein, thus simplifying the problem of cleaning the castings from residual sand.

A further object of the present invention is to provide a molding sand exhibiting the superior properties obtainable with organophilic attapulgite produced in accordance with the invention.

Other and further objects of the invention will become apparent as the description thereof proceeds.

I have discovered that a satisfactory molding sand of improved properties can be obtained by using (*a*) sand which is bonded with a minor proportion of (*b*) organophilic attapulgite as hereinafter more particularly described and (*c*) a minor proportion of a liquid lubricant of non-aqueous and generally organic character. Optionally, I may include in the mix additionally (*d*) a finely divided, inert material of powdery character, and/or (*e*) an additive having the power of especially activating the grease thickening agent so as to increase its thickening or gelling characteristics in the particular lubricant used. Over and above these, I may optionally also add (*f*) other materials known to the molding sand art such as gelatinized starch and starchy flours, powdered gilsonite, powdered tar, lignosulfonate compounds, and the like.

The several components of the complete molding sand composition are mixed together by means well-known in the art, some of which will be alluded to in the examples which follow. The sand component will in general be by far the largest in percentage by weight of the total composition, generally from 85% to 98% thereof, while the other ingredients are used in relatively small percentages in the order of a few percent by weight of the total ingredients, as again will be more completely detailed hereinbelow.

(*a*) THE SAND COMPONENT

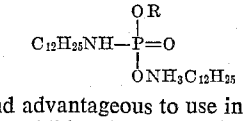
The sand most commonly used in molding sands, and

that which I prefer for general use and for the production of what may be termed an all-purpose molding sand composition, is a relatively pure silica sand. Such sands are available from a number of suppliers, and may be furnished in a considerable range of particle sizes and particle size distributions. The invention is not limited to the use of any particular particle size of sand, nor indeed to the type of sand used. For special work, particularly where very high temperatures are concerned, zircon sand may be used, and has been found to work very well in compositions made up in accordance with the invention. Olivine sand is likewise highly usable, and is preferred in some installations because of its freedom from any silicosis hazard in use. Other sands may likewise be used.

(*b*) THE ORGANOPHILIC ATTAPULGITE

It is known that it is possible to convert a certain clay known as attapulgite to an organophilic state in which the converted compounds have the property of thickening or gelling organic liquids, by treatment with a suitable organic compound in such a way that the surface of each colloidal particle of attapulgite is covered with an organic compound having as at least part of its molecule an organophilic, oleophilic, hydrophobic portion, such as a long hydrocarbon chain, an abietyl radical, or the like. Attachment of the organic compound (which may be termed organophilogenic, since it imparts organophilic character to the silicate in question) to the attapulgite particle may be by metathesis. It is generally most convenient to furnish the organophilogenic agent in the form of an organic cation which can be exchanged for the exchangeable cations normally present on the attapulgite.

A general procedure for forming organophilic organic-treated attapulgite is set forth in detail in Hauser Patent No. 2,531,427, the disclosure and teachings of which are made a part of this specification by reference thereto. The Hauser patent just mentioned set forth a number of possible clays, among which is attapulgite. Attapulgite is a clay mineral having substantial base-exchange capacity and particularly obtainable in northern Florida and southern Georgia. It is particularly effective if it has been freed of non-colloidal material, and to some extent mechanically dispersed by wet beneficiation including centrifugation prior to reaction with the chosen organophilogenic agent. Attapulgite is available from a number of suppliers, under such trade names as "Zeogel" and "Floridin." A suitable purified attapulgite is available under the trade names of "Permagel," and "Attagel." Various organophilogenic compounds may be used with attapulgite. A particularly effective organophilogenic agent for use with purified attapulgite is "Victamine C," which is the trade name for a cationic agent manufactured and sold reportedly under United States Patent No. 2,406,423, and having the following chemical formula, where R is a water solubilizing group:



It has been found advantageous to use in conjunction with Victamine C an additional organophilogenic agent such as that commercially available under the trade name of "Ethomeen 18/15," which is a tertiary amine in which a stearyl radical is bonded to the nitrogen atom together with two polyoxyethylene groups each representing the polymer of approximately five moles of ethylene oxide likewise bonded to the nitrogen atom. These two compounds may be used in the proportion of about 16% of Ethomeen 18/15 and 10% Victamine C based on the weight of the purified attapulgite.

The reaction, leading to the production of an organophilic organic-treated attapulgite material, may take place separately, that is, before the product is added to a molding sand mix; or the reaction may be caused to take place

by commingling the organophilogenic compound and the attapulgite in the molding sand mix itself, or at an intermediate stage thereof. For example, if the organophilogenic compound is dodecyl ammonium chloride, the latter may be reacted in substantially stoichiometric proportion, as taught in the Hauser patent noted, so as to form a dodecyl ammonium attapulgite. Alternatively, the dodecyl ammonium chloride may be added separately to the mixture of sand and liquid lubricant in the muller used to produce the final molding sand mix, of course together with any optional additional ingredients. Again, the attapulgite and the dodecyl ammonium chloride can be added to the liquid lubricant and then this mixture added to the molding sand in the muller. Such commingling of the organophilogenic compound and the attapulgite will result in the production of the organophilic organic-treated attapulgite material desired; the reaction is of course aided by heat and time, so that when the reactants are added separately as in the example just given, a few minutes extra mulling time should be allowed for the completion of the metathesis reaction in comparison to the mulling time allowed where the organophilic organic-treated attapulgite material is purchased as such, already formed, or otherwise made up ahead of time, and added as such to the sand mix in the muller or other sand mixing mechanism.

(*c*) THE LIQUID LUBRICANT

The liquid lubricant forming an important component of the molding sand compositions of the present invention may be chosen from a wide variety of non-aqueous liquids of substantial or even slight lubricating properties and of generally, although not necessarily always, organic character. I prefer ordinary lubricating oil, for example, coastal stock SUS 100 at 100° F., 24° A.P.I., but the invention is capable of being carried out successfully with many other liquids, such as, for example, kerosene, other hydrocarbon liquids of lubricating character about equal to kerosene or substantially greater in lubricating properties, such as medium and heavy petroleum lubricants, hydrogenated aryl compounds such as decahydronaphthalene, chlorinated naphthalene and the like, A resume of the more important broad groupings of suitable liquid lubricants which can be used is as follows:

Hydrocarbons

Kerosene	Diphenylethane, asymmetrical
Mineral lubricating oil	Decahydronaphthalene
Diesel Oil	Liquid polybutylene

Halogenated Hydrocarbons

Hexachlorobutadiene

Esters

Dioctyl sebacate	Hydrogenated soya oil
2-ethylhexyl sebacate	Linseed oil
Dioctylphthalate	Soya oil
Dibutylphthalate	Maize oil
Tricresyl phosphate	Jojoba oil
Hydrogenated cottonseed oil	Sperm Oil

Other "Synthetic" Lubricants

Water-soluble monoalkyl ethers of oxyethylene-oxy-1, 2 propylene copolymers (available as "Ucon" lubricants).

Silicon Derivatives

Various polymethyl siloxanes (available as Dow-Corning DC–200 series of silicone oils).

Various polymethyl phenyl siloxanes (e.g., Dow-Corning DC–550 silicone oil).

It will be understood that since the liquid lubricant may be characterized simply as a liquid lubricant of non-aqueous and generally organic character in which the treated attapulgite has the property of thickening or gelling, the number of such liquids is very large indeed, and the above listing is representative but not inclusive. A

convenient listing of liquid lubricants which may be used in the present invention occurs in Patent 2,625,508, column 6, line 23, to column 8, line 44. Reference may be made to this listing for additional liquid lubricants, and this portion of Patent No. 2,625,508 is hereby incorporated in this specification by citation. Additional information on the silicon derivatives which are also useful liquid lubricants for the purpose of this invention may be obtained in Chapter 4 of the book "An Introduction to the Chemistry of the Silicones," by E. G. Rochow, First Edition, New York, 1946; and chapters 5 and 6 of the Second Edition of this same book, New York, 1951.

It will be further understood that the liquid lubricant need be liquid only at the lower working temperatures involved. For example, hydrogenated cottonseed oil is a solid at 70° F., but liquefies at somewhat below about 100° F., which is a temperature readily obtained in the mulling operation and, indeed, maintained in normal foundry work where recycling of the molding sand is carried out.

(*d*) THE OPTIONAL FINELY-DIVIDED ADDITIVE

I have found that in some cases it is advantageous to add a relatively small amount of a generally inert, finely-divided material of particle size twenty to one hundred times or more smaller than the particle size of the sand component used. For example, ordinary commercial iron oxide, substantially all of which passes a 325 mesh screen, is suitable and is preferred since it is commercially available at relatively low cost and is quite inert. The iron oxide may be hematite or a less highly oxidized form such as magnetite. Silicon flour, of 250 or 400 mesh, may be used, as may likewise the commercial silica flour known as "800 mesh silica." Other silicates, ground barite, and the like can also be used, as the particle size is generally less than about 325 mesh, although feldspur, barite, synthetic zeolite fines and the like are not as desirable as silica or iron oxide since the former tend to flux at relatively low temperatures, which is not the case with silica or iron oxide. Finely-divided zircon and finely-divided alumina may be used with good results, except that these are considerably more expensive than either iron oxide or silica flour. As has been mentioned, these are purely optional additives, and the invention may be carried out without their use at all.

(*e*) THE OPTIONAL ACTIVATING ADDITIVES

The organophilic organic-treated attapulgite materials, when used with some of the liquid lubricants within the scope of the invention, will often give even better results from the standpoint of thickening or gelling the liquid concerned if a relatively small amount of an activating additive is used in conjunction with the treated attapulgite. Relatively small amounts of additives characterized by being of relatively low molecular weight and relatively high dielectric constant such as water, ethanol, methanol, acetone, propylene carbonate, and the like, will enable a reduction to be made in the total amount of the organophilic attapulgite necessary to achieve the same result as compared in the case when an additive is not used. In general, in addition to organic liquids having a dielectric constant of more than 10, liquids having an electric moment between 1.2×10^{-18} and 2.8×10^{-18} electrostatic units are suitable. Of such compounds, I prefer methanol, since it is effective, readily available, and inexpensive. The fact that such additives as have been described are relatively volatile does not at all preclude their use in accordance with the invention. Activating additives of the type just described, i.e., liquids having a dielectric constant of more than 10 or an electric moment between 1.2×10^{-18} to 2.8×10^{-18} electrostatic units will be termed "polar additives" herein and in the claims which follow.

(*f*) OTHER OPTIONAL ADDITIVES

It is well-known that in the art of compounding molding sands of the conventional water-clay-sand type, it is frequently advantageous to use relatively small amounts of extraneous materials, such as gelatinized starch and starchy flours, powdered gilsonite, powdered tar, lignosulfonate compounds, and the like. Generally speaking, such of these additives as are particularly adapted to a water system, such as lignosulfonate compounds, for example, find relatively little use in the present invention. On the other hand, with certain classes of castings, of course, it may in some cases be found advantageous to use additives of this optional and rather miscellaneous category, and such are therefore within the broad purview of the invention. Such of these materials as are inherently compatible with an oil system will be found preferable, when it is felt that such additional additives need be used. These are, for example, powdered gilsonite, powdered tar (especially coal tar), comminuted air-blown asphalt, hydrogenated castor oil, carbon black, lamp black, wood flour, and the like.

Relative Proportions of the Components

As has been mentioned, the sand component will be present in the largest proportion by weight, and in general from 85% to 98% by weight of the total composition. The sand is after all the basic structural unit of the molding sand composition, and the other additives are present essentially to enable the sand itself to be molded and to have desirable structural properties in the aggregate such as adequate green strength, adequate dry strength, adequate permeability, and the like. The quantities of organophilic attapulgite and lubricant are best considered together, since in a given composition if a larger amount of the former is used in general it will be found necessary to increase the amount of liquid lubricant proportionately. This is understandable in view of the fact that the organophilic attapulgite combines mechanically with the liquid lubricant, and the two together form a composition having the nature of a sticky paste. In general, the ratio of organophilic attapulgite to liquid lubricant will be much greater than the ratio of the former to a given lubricant when the two are compounded in the manufacture of lubricating grease. For example, in the lubricating grease art, it is usual to employ from 5% to perhaps 20% by weight of grease-thickening agent per total weight of grease. I have found that greases of this conventional type do not impart suitable molding properties to molding sand compositions. Rather, in carrying out my invention, I use more nearly equal amounts of organophilic attapulgite and lubricant, although these may be varied within rather wide relative limits. This is particularly so in view of the fact that different lubricants differ among themselves in the amounts necessary to impart plastic consistency to a given grease. Generally, however, it may be stated that the ratio of organophilic attapulgite to liquid lubricant is within the range of 1:1 to 2:1, that is, the former will outweigh the liquid lubricant. A representative range of percentages of the organophilic attapulgite is from 1% to 5% based on the total weight of the molding sand composition, but in some cases both of these limits may be exceeded. A representative range of percentages of liquid lubricants is from ½% to 4% by weight of total molding sand composition, but here again it will be understood that both of these limits may be exceeded.

When an optional finely-divided additive is used, such as, for example, powdered iron oxide or silica flour, the amount to be used is subject to considerable variation. In the first place, none at all need be used, although it is found that an increase in both hot and green strength of the molding sand is generally brought about by the use of small quantities of the aforesaid finely-divided material. If too much of the finely-divided material is used, it tends to reduce the permeability of the sand, and is in general wasteful, as it tends to absorb liquid lubricant and thus leads to the employment of a wasteful excess

of liquid lubricant. It will be found that with average mixes, approximately 1% by weight of iron oxide or silica flour based on the total weight of the composition will be suitable, although quantities of from 0% to 2% by total weight will still give workable molding sand compositions in most of the cases.

The optional activating additive may in general be used to obtain greater yield from the organophilic organic-treated attapulgite. Representative additives of this class have been described hereinabove; it is to be expected that they will differ among themselves in the amount which needs to be added for a given degree of activation or otherwise stated as a given degree of increase of thickening or gelation power of the organophilic attapulgite. In general, the quantity to be added will be of the same order of magnitude as the organophilic attapulgite itself, and more particularly, in general from about 50% to 100% of the weight of the latter. It is believed that activating additives of this type act by adsorption in the organophilic attapulgite-lubricant complex, so that it will be readily understood that an excess, for example, twice the optimum quantity, represents merely a waste and contributes material to the molding sand mix which in general will be flashed off at relatively high temperatures. On the other hand, using too little of the optional activating additive will merely have the effect of reducing the efficacy of the organophilic organic-treated attapulgite so that more of it will have to be used. Again, where an optional activating additive is used, it will be found that the optimum amount for use will vary with the type of lubricant chosen. It is best, therefore, to determine the amount of optional activating additive, if any, to be used by making a few preliminary tests with the mixture of the actual components at hand.

When other optional additives are used, their quantity will in general be small. As a matter of fact, they are not necessary for the production of a workable molding sand composition in accordance with the present invention, but may be used for special effects. In general, they will not be used in quantities of more than 1% or 2% of the total mix.

The method of mechanically compounding the various components into a molding sand composition in general follows standard practice. The ordinary foundry equipment for sand mixing and conditioning is well adapted to the exercise of the present invention without any change of equipment. Conventional mixing equipment in use in American foundries is alluded to in chapter 4 of the U.S. Navy Bureau of Ships "Foundry Manual" hereinbefore cited. A practice which has been found particularly suitable in carrying out the invention is to use a muller, for example, a "Simpson Intensive" mixer, pour the desired amount of sand into a clean dry muller, start the machine, allow it to make several revolutions to mix the sand, then add all the dry agents, such as, for example, the organophilic attapulgite and any other dry additives, mix for one to two minutes, depending upon the size and type of mixer and the load therein, and then add the liquid lubricant and any other liquid additives. Mulling is continued for an additional length of time sufficient to produce a homogeneous sand mix. This time may be as little as ten minutes more, but may in some cases be as long as thirty minutes. It will be appreciated that a dispersion of the organophilic attapulgite in the liquid lubricant takes place, or otherwise viewed, an adsorption of the liquid lubricant into the organophilic attapulgite takes place, and this is a process which takes some time, and in general takes a longer time for large particle size of the organophilic attapulgite granules or powder and high viscosity of the liquid lubricant, and conversely takes a shorter time when the former is very finely comminuted, and also with liquid lubricants of relatively low viscosity.

A number of examples of the employment of the invention in compounding molding sand mixes will now be given.

EXAMPLES

Table I

No.	Content (percent)	Hot Strength, p.s.i.					Gr. Str. (p.s.i.)	Perm.	Flowability	Impact Def. at 30 Blows	Dry Comp., p.s.i.	Sand
		1,500° F.			2,000° F.							
		2 Min.	4 Min.	6 Min.	2 Min.	4 Min.						
VV	4 Attapulgite 0.65 Eth. 18/15 0.4% Vic. C 2 Coast. (C.R.)	64	81.5	85	65.5	45	4.6	14.3	84.5	15	9.6	We. 10.
WW	4 Attapulgite 0.65 Eth. 18/15 0.4% Vic. C 1 Coast. (C.R.)	19	27.5	37	19.5	20	9.7	18.7	81	11	10.8	We. 10[1].
ZZ	2.9 O.A 3 Coast (C.R.) 0.5 M.A 1.1 FeO	[2] 54 [3] 99	-----	-----	[4] 39	-----	11.1	23	86	-----	14	We. 10.

[1] Sand preheated to about 190° F.
[2] 1400° F., 12 minutes.
[3] 1600° F., 12 minutes.
[4] 2000° F., 12 minutes.

In the above examples, the identifying letter for the individual mix is given in the first column, while in the second column are given the several additives to the sand whereby the molding-sand mixture is formed. These ingredients are in some cases abbreviated in the table above, the abbreviations used being given below. The sand used appears in the last column, again abbreviated as explained below. The various properties of the molding sand compositions of the several examples are set forth in the intermediate columns. In the columns headed "Hot Strength," a 1⅛ inch diameter by 2 inch long specimen was prepared with a Dietert No. 754 sand rammer and the compressive strengths at the elevated temperatures and after the period of time shown in the various columns were determined with a Dietert No. 753 "Thermolab," these being well known testing apparatuses in American practice. The hot strengths are given in pounds per square inch. The green strength test was performed on 2 inch specimens rammed with a Dietert No. 315 sand rammer, and measured with a Dietert No. 401 compression instrument. Dry compression strength was tested on this equipment as well, after drying at 220° to 230° for one hour. Permeability was measured with a Dietert No. 320 permeability meter with a standard 1.5 mm. orifice. Flowability was measured by a Dietert No.

730 flowability indicator attached to a Dietert No. 315 sand rammer, and the impact properties were determined on a Dietert No. 620 green core impact tester. All of these tests were carried out in accordance with precedures specified by the American Foundrymen's Society, and are well known tests in the foundry art, and hence will not be described in detail except by reference to the sand testing procedures of that society.

The abbreviations used for the ingredients in the second column and for the sands used in the last column are as follows:

O.A.: Organophilic attapulgite made by reacting commercial dimethyldioctadecylammonium chloride as "Arquad 2 HT" with attapulgite in the proportion of 35 milliequivalents of the quaternary compound per 100 grams of the attapulgite.

FeO: Commercial iron oxide, 95% minus 325 mesh, largely hematite.

M.A.: Commercial methyl alcohol.

Eth. 18/15: "Ethomeen 18/15," chemical composition given hereinabove.

Vic. C: "Victamine C," chemical composition given hereinabove.

Coast. (C.R.): Lubricating oil, coastal stock, conventional refined, viscosity index approximately 30, A.P.I. gravity 24.4.

We 10: Washed silica sand sold as "Wedron No. 10" sand, GFN (grain fineness number) 133.

Thus, for example, mix "VV" consists of 92.95 parts by weight of Wedron sand, 4 parts by weight of attapulgite, 0.65 part by weight of Ethomeen, 0.4 part by weight of Victamine C, and 2 parts by weight of lubricating oil of the type designated, the whole mix having been mulled in a muller for a time suitable for the appearance of the properties shown, which in general was about three (3) minutes.

In order to show the extraordinary and unexpected differences and superiority of a molding sand mixture made with organophilic attapulgite as contrasted with an otherwise similar molding sand mixture made with organophilic montmorillonite, the following tests were performed:

A molding sand mixture was made up in accordance with the formulation of example ZZ hereinabove. As the data accompanying this example show, this sand was made up with Wedron silica sand, a coastal stock oil, iron oxide in the proportion of 0.4 part of iron oxide to each part of organophilic attapulgite, and 0.5% methyl alcohol.

For purposes of comparison, an organophilic montmorillonite which had been prepared in the same fashion as the organophilic attapulgite of example ZZ, except that montmorillonite was used instead of attapulgite, was substituted in this control test. The organophilic montmorillonite, hereinafter abbreviated as "O.M.," was a stoichiometric reaction product of dimethyldioctadecylammonium chloride with montmorillonite, and thus in accordance with the base exchange capacity of the montmorillonite had 95 milliequivalents of the quaternary compound per 100 grams of the montmorillonite. The ratio of iron oxide to organophilic clay was maintained the same as in example ZZ, the percentage of methyl alcohol was the same, the sand was the same, and the oil and O.M. percentages were adjusted to give as nearly as possible the same dry compression strength. The amounts found necessary for this control were 2.5% O.M., and 2% oil.

The compression strength of the sands made up with the two organophilic clays in the fashion described was then tested over a range of temperatures from room temperature to 2600° F. It will be understood that separate samples were made up and heated in an oven for each test. The compression strengths obtained were as follows:

T, °F.	Compression Strength, p.s.i.	
	O.A.	O.M.
70	14.0	13.2
200	8.0	9.5
400	5.0	4.0
600	13.0	6.0
800	57	18.0
1,000	37	16.0
1,200	40	20.0
1,400	54	22
1,600	99	33
1,800	164	16.0
2,000	59	17.0
2,200	249	114
2,400	162	165
2,600	135	183

The compression strengths of the two sand mixes as a function of temperature are plotted in the drawing. The results are startling, in that they show that over the range of room temperature to 400° F. the two sand mixes are substantially alike in strength. At temperatures in excess of 400° F. and over a wide range up to somewhat greater than 2200° F., the compression strength of the organophilic attapulgite mix is much greater than that of the O.M. mix. On the other hand, at 2400° F. the compression strengths of the two mixes are substantially equal, and if this temperature is exceeded, up to 2600° F., for example, the compression strength of the organophilic attapulgite mix drops while that of the O.M. mix increases.

The effects demonstrated by these comparative tests are of great importance in casting technique, as mold washing is reduced for large magnesium and aluminum casting, for example, when the organophilic attapulgite mix is used because of the high compression strength over the wide temperature range just described. On the other hand, the loss of strength of the latter at the highest temperature shown, rather than being a disadvantage, is an advantage, as it permits easier shake-out when gray iron and steel, for example, are cast.

It will be appreciated that mulling time is greatly dependent upon the size and type of the muller or other mixing equipment used, and the size of the batch being mulled in relation to the capacity of the muller. Accordingly, optimum mulling time is best determined by an actual test on the batch in question and with the equipment at hand.

Throughout the specification and claims, quantities of additives present in the molding sand compositions in addition to the sand itself are expressed as percentages by total weight of the finished molding sand mixture, as is clear from the example immediately hereinabove.

In general, a molding sand composition having a green strength of less than 2.4 pounds per square inch, as determined by the standard procedure of the American Foundrymen's Society, is not a practicable molding sand composition for casting purposes. While the percentages of the various ingredients are subject to great variation within the broad scope of the invention, it will be self-evident that if so little of the necessary additives are present that the green strength of the finished composition falls below substantially 2.4 pounds per square inch, then the composition is not properly termed a molding sand composition within the meaning of this specification.

It will be apparent that the invention is a broad one, and much variation of ingredients, quantities and procedure is permissible within the broad scope of the invention and of the claims which follow.

The distinction is to be noted between attapulgite, and attapulgite which has been caused to become organophilic by treatment as hereinabove described. Attapulgite is a natural clay in which the ultimate particles are acircular, (i.e., needle shaped) and, hence, there is a loose resemblance between attapulgite and very short fibered asbestos or like asbestiform minerals. A finely

divided, needle-shaped mineral such as attapulgite or, for that matter, certain asbestos varieties, when incorporated with various liquids is often able to confer some structural viscosity on the system. An example is the incorporation of finely divided asbestos in paints in order to give them more apparent body. However, this is clearly to be distinguished from the peculiar property of an organophilic attapulgite in accordance with the invention of forming a sticky gel with a liquid lubricant as hereinabove exemplified and described. The sticky gel produced when using organophilic attapulgite in accordance with the invention functions in a superior fashion in forming molding sand compositions having desirable properties, whereas this is not the case if an ordinary attapulgite is used with a lubricating oil and a molding sand, for example.

This application is a continuation-in-part of my co-pending application Serial No. 537,069, filed September 27, 1955, now abandoned.

Having described the invention, I claim:

1. A molding sand composition, comprising sand, and a binder consisting essentially of organophilic attapulgite, and an organic liquid lubricant exhibiting the property of gelling when brought into admixture with said organophilic attapulgite in a weight ratio of between about one and about five parts of said organophilic attapulgite per part of said liquid lubricant.

2. A nonaqueous molding sand composition comprising sand and a binder consisting essentially of organophilic attapulgite and of a liquid lubricant exhibiting the property of gelling when brought into admixture with said organophilic attapulgite, said organophilic attapulgite and said liquid lubricant being present in proportions of between about 1:1 and 2:1 relative to each other.

3. A molding sand composition consisting essentially of from 85% to 98% by weight of sand, and from 2% to 15% of a mixture of organophilic attapulgite and an organic liquid lubricant exhibiting the property of gelling when brought into admixture with said organophilic attapulgite, said organophilic attapulgite and said liquid lubricant being present in a weight ratio of between about 1:1 and 2:1.

4. A molding sand composition according to claim 3, including from 0% to 2% of a finely divided inert material of particle size 20 to 100 times smaller than the particle size of said sand.

5. The composition in accordance with claim 3 wherein the organophilic attapulgite is a tetraalkyl quaternary ammonium attapulgite.

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