Jan. 3, 1933. M. G. FOWLER 1,893,023

METALLURGICAL APPARATUS

Filed March 8, 1930

Fig. 1.

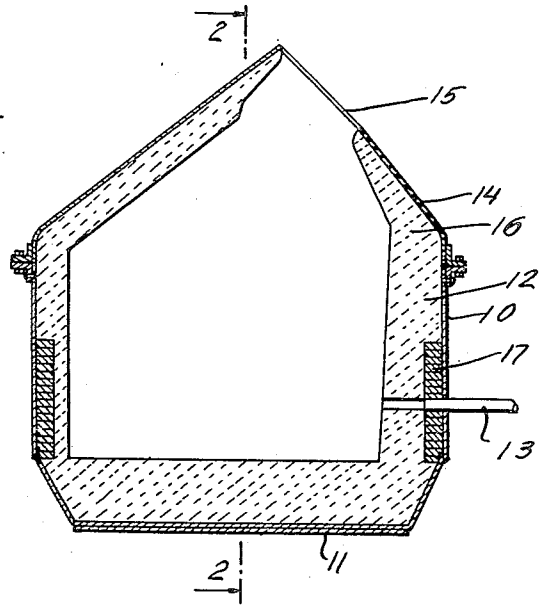
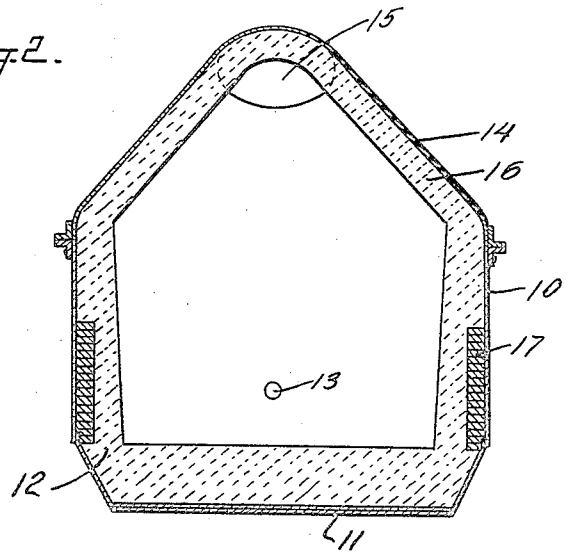



Fig. 2.




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# UNITED STATES PATENT OFFICE

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## METALLURGICAL APPARATUS

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This invention relates to metallurgy and has for an object the provision of improved basic lined metallurgical apparatus. More particularly, the invention contemplates the provision of an improved monolithic magnesite lining for metallurgical apparatus and an improved method of lining metallurgical apparatus. The invention further contemplates the provision of a copper converter provided with an improved monolithic magnesite lining. A further object of the invention is to provide improved material for forming monolithic linings.

Some metallurgical operations require the use of apparatus provided with basic linings for carrying out the processes involved and, in such cases, it is customary to employ linings formed of magnesite. Considerable difficulty is involved in forming satisfactory magnesite linings from commercially available products such, for example, as dead burned magnesite. This material does not bond readily except at high temperatures or when diluted with a binder which lowers its softening temperature. High temperatures cause shrinkage of the magnesite, and the addition of sufficient binder to form a suitable bond frequently causes a reduction in refractoriness which makes the resulting product unsuitable.

Satisfactory linings may be formed by applying the magnesite in the form of bricks which have been heated to the bonding temperature of the magnesite during the course of their manufacture. The preparation of such bricks is expensive, and, consequently, linings in which the bricks are employed are costly.

Lining costs are frequently sufficiently important that the type of process used in some metallurgical operations is governed thereby. Thus, in the case of copper converting, the cost of the linings in cases in which brick linings are used, determines the type of slag which is employed. The use of a relatively high-silica slag results in injury to basic linings, and, consequently, relatively low-silica slags are generally used.

While the use of a slag having a low silica content prolongs the life of a converter lining, such slags also produce certain harmful effects. Low-silica slags retain more copper than high-silica slags, the amount of copper carried by the slag being inversely proportional to the amount of silica contained therein. Considerable difficulty is experienced in handling low-silica slags in ladles and in introducing such slags into retreatment furnaces. Retreatment of low-silica slags also involves some difficulties. It is difficult to extract copper from such slags, and there is a tendency for magnetite contained therein to separate out and build accretions on the hearth of the retreatment furnace. It is therefore desirable to provide a lining at a sufficiently low cost that high-silica slags may be used economically.

Various attempts have been made to reduce lining costs by substituting monolithic linings for built-up linings of brick. Such linings have been formed by applying the magnesite in the form of a plastic mass of fine and coarse particles to the surfaces to be covered and drying and burning the resulting lining.

In providing monolithic linings for the usual commercial purposes, it is impracticable to heat the magnesite to temperatures sufficiently high to cause bonding of the particles because of the size and location of the monolith and because of the tendency of magnesite to shrink when heated. Accordingly in providing monolithic magnesite linings it is customary to employ binders which lower the softening point of the magnesite or which themselves provide mechanical bonds between the magnesite particles.

In forming monolithic linings, it is desirable to provide lining mixtures which may be tamped to provide dense structures which retain their forms until burned and which are sufficiently refractory to withstand the temperatures to which they are subjected in service. Dense structures are necessary to provide the necessary mechanical strength and, in some cases, to prevent the penetration of fluids such as molten minerals which cause disintegration of the lining.

In forming monolithic magnesite linings in accordance with the heretofore customary practices, it is frequently necessary to em-

ploy an amount of binder or a type of binder which so reduces the refractoriness of the resulting lining that it is unsatisfactory for the intended purpose in order to provide a mass of lining material which is sufficiently plastic that it may be readily moulded into the desired form. Considerable difficulty has been experienced in providing monolithic linings in which sufficiently good contact is obtained between the adjacent particles to give satisfactory density and strength while maintaining satisfactory refractory qualities. Frequently, segregation of the particles of different sizes or the less refractory particles of a lining mixture occurs during the installation of the lining with the result that a lining of non-uniform density having weak spots is produced.

The present invention facilitates the production of monolithic linings having dense, strong structures. The invention further provides for the production of monolithic linings of relatively uniform density without the use of excessive amounts of relatively non-refractory binders.

The present invention is based upon my discovery that particles of commercial magnesite may be made more adaptable for the manufacture of monolithic linings if subjected to the action of an acid prior to being incorporated in the lining structure. I have found that improved plasticity of a mixture of magnesite particles and a binder may be obtained by treating the mixture with an acid or by subjecting the magnesite particles to the action of an acid before the mixture is formed. I have also found that a more intimate contact of the particles may be obtained when magnesite is subjected to the action of an acid prior to being incorporated in the lining. In general, a substantially neutral mixture of magnesite particles and a suitable binder may be used advantageously to form highly satisfactory monolithic linings.

I attribute the increased plasticity to neutralization of the relatively strongly alkaline impurities contained in the commercial magnesite. The more intimate contacts of the particles may be attributed to the increased plasticity of the lining mixture which provides for better contact between the particles by permitting more uniform dissemination or distribution of the fine particles throughout the mass, and, in some measure, to the fact that the acid etches the surfaces of the magnesite particles and permits better contact of the fine material with the coarse.

As a result of the increased plasticity which may be achieved by treating magnesite with acid, lining mixtures containing relatively small amounts of binders may be used to produce satisfactory linings. Objectionable segregation of particles of various types is minimized with the result that weak spots which are sometimes present in linings formed according to heretofore customary practices are eliminated.

I have also found that improved results may be obtained whether or not the particles of magnesite are subjected to an acid treatment if the quantities of grains of different sizes which are present in the lining material are carefully proportioned so that a dense structure may be provided.

The magnesite may be treated with acid in any desired manner and at any appropriate time. The manner and time of treatment of the magnesite with acid will depend to some extent upon the natures of the acid and the magnesite. The acid may be of such a nature that the incorporation of an excess in the lining would produce harmful results, or a particular acid might react with pure magnesite or with impurities contained in commercial magnesite to produce one or more harmful reaction products. If the acid employed and the magnesite are of such natures that no reaction product which would produce harmful effects if incorporated in the lining is produced, the acid may be added directly to the lining mixture and no steps need be taken to remove any excess or the reaction products. On the other hand, if the use of any particular acid would result in the production of harmful reaction products, or if an excess of the acid would produce a harmful effect, it is advisable to first subject the magnesite to the action of the acid and then remove any excess acid and/or the harmful reaction products by washing, or otherwise, before incorporating the magnesite in the final lining mixture. All or any desired part of the grains to be incorporated in the lining may be subjected to the action of acid and the magnesite which is subjected to the action of acid may be completely or only partially neutralized.

Any desired amount of acid may be employed. The amount of acid employed will depend upon the nature of the acid and the results desired. If complete or partial neutralization of the impurities in the magnesite only is desired, an amount of acid only sufficient to accomplish the desired result should be employed. If etching of the grains is desired an amount of acid which is more than sufficient to neutralize the impurities in the magnesite being treated should be employed. In some instances it may be desirable to cause etching of the surfaces of the relatively coarse grains only, and, in such cases, the coarse grains may be treated separately.

In some instances, the acid employed and the magnesite may be of such natures that one or more reaction products which may be incorporated advantageously in the lining may be produced. For example, sulphuric acid may be employed as a means for neutralizing impurities and/or etching the sur-

faces of the particles and incorporating magnesium sulphate in the lining.

Most commercial magnesite products contain lime, and a mixture of the magnesite with water and a binder such, for example, as fireclay may be strongly alkaline. This is due to the slight alkalinity of the pure magnesite and the strong alkalinity of the lime. When such a mixture is treated with sulphuric acid, the acid acts as a flocculent, increasing the plasticity of the fireclay and permitting the use of less fireclay for bonding purposes. The amount of acid employed can be varied widely, as even a large excess will be completely neutralized by the magnesite to form magnesium sulphate. The use of excessive quantities of sulphuric acid is not advisable because such a practice would result in the incorporation of excessive quantities of relatively non-refractory magnesium sulphate in the lining.

Some of the important effects of sulphuric acid when used in the proper proportions are as follows:—

(1) It increases the plasticity of a binder, such as fireclay, by neutralizing the alkaline substances in the magnesite.

(2) It etches the surfaces of the particles and provides better contact of the fine material with the coarse, thus increasing the bonding effect of whatever additional bond is used with a consequent increase in mechanical strength.

(3) It forms hydrated magnesium sulphate which takes a very strong cold set. The magnesium sulphate may be very widely disseminated throughout the lining mixture.

The incorporation of magnesium sulphate in linings is sometimes desirable because of its property which will cause a lining in which it is incorporated to take a strong cold set. It loses some of its bonding strength at dehydration temperature, but still bonds magnesite fairly well up to a temperature of about 1500° F. It is particularly valuable as a bond when used with another bond such as fireclay which does not take a strong cold set and bonds with magnesite only at temperatures of from 2000° F. to 2200° F.

According to the present invention, granulated magnesite may be mixed with a suitable binder in the wet state and rammed or tamped into place between the receptacle or furnace wall and a suitable form to provide a wall of proper thickness. The magnesite may be treated with acid prior to its incorporation in the lining mixture, or, when the type of acid and the nature of the magnesite will permit the acid may be added to the mixture during the mixing operation. When the lining material has been rammed or tamped into place, the form is removed and the wet lining is subjected to heat at a low temperature for a sufficiently long period to drive off the major portion of the water contained therein. The lining is subsequently heated until it reaches a temperature approximating that to which it will be subjected in service or a temperature which is high enough that the charging of a bath or other charge of normal temperature will not cause material damage. It is unnecessary to bring the entire lining up to the maximum temperature. Good results can be obtained if only that portion of the lining immediately adjacent the inner surface is thus heated.

In order that the best results may be obtained in forming the refractory lining material of the invention, it is important that the particle sizes be carefully proportioned. The most satisfactory material comprises a mixture of relatively fine particles and relatively coarse particles. The coarse particles should form the major portion of the mixture. The fine particles should be sufficiently small to form a compact mass which is substantially impervious to, or capable of affording satisfactory resistance to penetration by, any molten mineral bath in conjunction with which the lining is to be used. The relative amounts of fine and coarse material to be used in each case will depend upon the character and sizes of the coarse grains. Sufficient fine material to fill the voids between the coarse particles should be used. It is desirable, though not necessary, to provide just sufficient fine material to fill the voids and permit at least one point of contact of each coarse particle with every adjacent coarse particle.

The fine material may consist substantially entirely of particles ranging from substantially colloidal particles to 100-mesh, and the coarse material may consist substantially entirely of particles ranging from 20-mesh to one-half inch or larger. In general, it is advisable to use mixtures of which twelve to twenty-two per cent of the particles are sufficiently small to pass a 100-mesh screen. A large proportion of the remaining particles should be too large to pass a 20-mesh screen. About eighty per cent of the minus 100-mesh material should pass a 200-mesh screen. The proportion of particles between 20-mesh and 100-mesh in size should be minimized. In fact, it is desirable to eliminate such sized particles. While any suitable mixture of grain sizes may be used, the best results may be obtained when no intermediate sizes are used and when twelve to twenty-two per cent of the particles pass a 100-mesh screen and the remaining particles are too large to pass a 20-mesh screen. Material in which ten to fifteen per cent of the particles are too large to pass a 3-mesh screen is very satisfactory. It is desirable to provide material in which the coarse particles are uniformly graded between 20-mesh and one-half inch.

Particle sizes have been given in terms

of the Tyler series. Percentages by weight are given throughout the specification. The term "magnesite" is used throughout in the accepted sense, that is, to denote the commercial calcined products commonly used for refractory purposes.

The mixtures of particles of different sizes may be formed in any desired manner. A number of different sizes may be separately formed and classified and subsequently mixed in the proper proportions, or crushing and grinding may be so conducted that very coarse material may be reduced to provide a mixture containing approximately the correct sizes and proportions in a single operation. The composition of the resulting mixture may be corrected by additions of separately classified particles of the proper sizes. Satisfactory coarse and fine products may be obtained by subjecting the raw or initial materials to types of treatment designed to produce particles having maximum sizes corresponding to the maximum sizes desired. In each case the grinding or crushing operations utilized will produce a mixture containing the maximum and minimum sizes as well as a variety of intermediate sizes. If the resulting products are not satisfactory separate additions and/or removal of particles of particular sizes may be made.

Owing to the fact that in crushing or grinding refractory materials an infinite variety of particle shapes may be produced, it is substantially impossible to predict that any mixture of particles of different sizes will result in the production of a lining which is perfect with respect to density. Mixtures of particles within the size limits hereinbefore set forth produce satisfactory linings, and the most satisfactory mixture for any particular material or for any particular purpose may be determined readily by means of a few simple tests. For example, small amounts of several different mixtures may be formed into bricks which may be subjected to conditions similar to those to which the lining will be subjected, and a comparison of the effects on the different bricks will indicate the mixture which is the more suitable.

Any suitable magnesite product may be used in forming linings in accordance with the invention. California magnesite may be used advantageously. Two commercial forms of magnesite, dead burned magnesite and periclase, have been found to be satisfactory for forming linings in accordance with the method of the invention.

Any suitable solid or liquid substance or combination of such substances may be used as a bonding agent. The binder may comprise a plastic mass of finely divided solid particles. When a binder comprising solid particles is used, the binder may provide a portion of the fine material required for the lining mixture.

The binder should be selected to avoid the incorporation of large amounts of fluxing materials in the lining. The following binders have been found to be satisfactory when used with granular magnesite in the amounts by weight noted:—

| | Per cent |
|---|---|
| Fireclay | 2– 5 |
| Bauxite | 2–10 |
| A mixture containing bauxite 3 parts and fireclay 2 parts | 2–10 |
| Molasses | 0.5–5.0 |
| Sulphuric acid | 0.1–0.5 |

The lining mixture should contain sufficient water or other fluid that a plastic mass capable of being tamped to form a dense structure is provided. A water or fluid content of about 3 to 5% by weight is ordinarily satisfactory.

The following examples illustrate lining mixtures which have been found to produce highly satisfactory results:—

*Example I*

| Ingredients: | Per cent |
|---|---|
| Maltby magnesite | 91.5 |
| Fireclay | 4.0 |
| Water | 4.0 |
| Sulphuric acid | 0.5 |
| Screen sizes: | |
| +100 mesh | 87.2 |
| −100 mesh | 12.8 |

*Analyses of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| Maltby magnesite | 6.88 | 0.69 | 7.72 | 2.4 | 81.6 |
| Fireclay | 66.94 | 21.3 | 3.58 | 0.8 | 1.2 |

Sulphuric acid—specific gravity 1.84

*Example II*

| Ingredients: | Per cent |
|---|---|
| Periclase | 96.7 |
| Molasses | 2.0 |
| Water | 1.0 |
| Sulphuric acid | 0.3 |
| Screen sizes: | |
| +100 mesh | 85.7 |
| −100 mesh | 14.3 |

*Analysis of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| Periclase | 2.6 | 0.3 | 2.42 | 2.48 | 91.2 |

Sulphuric acid—specific gravity 1.84

*Example III*

| Ingredients: | Per cent |
|---|---|
| Maltby magnesite | 86.7 |
| Crude bauxite | 4.3 |
| Calcined bauxite | 5.3 |
| Molasses | 1.6 |
| Sulphuric acid | .5 |
| Water | 1.6 |
| Screen size: | |
| +100 mesh | 88 |
| −100 mesh | 12 |

*Analyses of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| Crude bauxite | 8.26 | 60.81 | 3.4 | 0.3 | 0.53 |
| Calcined bauxite | 7.04 | 79.97 | 9.3 | 0.6 | 0.84 |
| Maltby magnesite | 6.34 | 1.84 | 7.7 | 2.2 | 81.9 |

Sulphuric acid—specific gravity 1.84

*Example IV*

| Ingredients: | Per cent |
|---|---|
| Sierra magnesite | 86.0 |
| Fireclay | 1.7 |
| Crude bauxite | 2.8 |
| Calcined bauxite | 4.6 |
| Water | 4.8 |
| Sulphuric acid | 0.1 |
| Screen size: | |
| +100 mesh | 78.0 |
| −100 mesh | 22.0 |

*Analyses of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| Sierra magnesite take at mud mill | 4.6 | 1.7 | 9.1 | 2.5 | 82.1 |
| Gallup fireclay take at mud mill | 62.4 | 18.6 | 7.0 | 1.0 | 1.6 |
| Calcined bauxite take at mud mill | 14.0 | 72.5 | 11.2 | 0.9 | 1.1 |
| Crude bauxite take at mud mill | 13.6 | 55.0 | 5.8 | 0.5 | 0.9 |

Sulphuric acid—specific gravity 1.84

*Example V*

| Ingredients: | Per cent |
|---|---|
| Periclase | 94.7 |
| Gallup fireclay | 3.0 |
| Water | 2.0 |
| Sulphuric acid | 0.3 |

*Analyses of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | $Mg_3O$ |
|---|---|---|---|---|---|
| Periclase | 3.2 | 0.6 | 2.40 | 0.7 | 92.3 |
| Fireclay | 67.3 | 21.0 | 3.68 | 0.6 | 2.6 |

Sulphuric acid—specific gravity 1.84

*Example VI*

| Ingredients: | Per cent |
|---|---|
| Sierra magnesite | 90.0 |
| Gallup fireclay | 5.5 |
| Sulphuric acid | 0.1 |
| Water | 4.4 |
| Screen size: | |
| +100 mesh | 83.4 |
| −100 mesh | 16.6 |

*Analyses of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| Sierra magnesite | 5.6 | 1.0 | 6.86 | 0.84 | 85.7 |
| Fireclay | 62.0 | 22.0 | 5.61 | 0.39 | 2.0 |

Sulphuric acid—specific gravity 1.84

*Example VII*

| Ingredients: | Per cent |
|---|---|
| Sierra magnesite | 86.2 |
| Fireclay | 5.3 |
| Calcined bauxite | 5.3 |
| Sulphuric acid | 0.1 |
| Water | 3.1 |
| Screen size: | |
| +100 mesh | 84.7 |
| −100 mesh | 15.3 |

*Analyses of materials*

| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
|---|---|---|---|---|---|
| Sierra magnesite | 4.8 | 2.8 | 6.95 | 1.68 | 83.6 |
| Fireclay | 63.4 | 22.6 | 3.69 | .50 | 4.4 |
| Calcined bauxite | 16.0 | 66.5 | 10.64 | .40 | 6.0 |

Sulphuric acid—specific gravity 1.84

In utilizing sulphuric acid in the production of monolithic linings, it is advisable to employ more than enough to neutralize the strongly alkaline impurities in the magnesite in order to etch the surfaces of the magnesite particles and provide sufficient magnesium sulphate to permit the lining to take a good cold set. The resulting lining mixtures will be neutral except for the slight alkalinity due to magnesite. When magnesite, a solid binder and an excess of sulphuric acid are employed the resulting lining material will consist essentially of magnesite, solid binder and magnesium sulphate.

Magnesite linings formed in accordance with the method of the present invention are particularly suitable for use in molten bath receptacles such as copper converters, and when so used give satisfactory service at a lower cost than brick linings of similar materials. A number of magnesite linings which served satisfactorily in copper converters showed matte and slag penetration varying from about one-half inch to about one and three-quarters inches.

Linings of the invention have been successfully used in copper converters, twelve feet in diameter, of the type illustrated in the accompanying drawing, in which

Fig. 1 is a sectional side elevation of a well-known type of copper converter provided with a monolithic lining; and

Fig. 2 is a section taken substantially along line 2—2 of Fig. 1.

The converter comprises a substantially cylindrical receptacle having sheet metal side walls 10 and a sheet metal bottom wall 11.

The side walls and bottom of the receptacle are provided with a monolithic lining 12. A tuyère pipe 13 extends through the side wall 10 and the lining 12 and provides means of communication between the interior of the receptacle and a source of supply of air under pressure (not shown). A layer or lining 17 of bricks is disposed between the sheet metal side wall 10 and the monolithic lining and extends around the receptacle in the vicinity of the tuyère pipe. A substantially conical cap 14 provided with an opening 15 in its side wall and having a monolithic lining 16 is removably mounted on the receptacle.

When the converter is to be lined, the cap is removed to permit the insertion of forms. The bottom is first provided with a layer of a suitable refractory mixture of the desired thickness which is tamped to provide a dense structure. When the bottom has been lined, forms having substantially vertical walls are placed within the receptacle with their vertical walls spaced the proper distances from the vertical side walls of the receptacle. The lining mixture is then placed between the form and the side walls in successive horizontal layers of suitable thickness. Each layer is thoroughly tamped and packed before the next succeeding layer is added. The best results have been obtained when the material has been inserted in layers varying from three to seven inches in thickness. Layers of greater thickness are difficult to tamp properly and their use might result in segregation of the coarse particles. The bricks 17 are placed in position in layers periodically as the lining mixture is inserted. The tuyère pipes are inserted when the lining has been built to the proper height. The lining mixture is tamped and packed around the sides and above the tuyère pipes. During the tamping, bars or heavy pipes may be inserted within the tuyère pipes to prevent distortion. The force used in tamping need only be sufficient to insure thorough packing and the production of a dense mass.

The cap is separately lined while inverted. The cap may be lined with the lining mixture of the invention or any other suitable refractory. The caps are not subjected to excessive wear and the cost of their linings is not of great importance. The joint between the cap lining and the shell lining when the cap is attached may be plastered with the lining mixture of the invention or any suitable plastic mass of refractorty material.

When the lining has been completed a slow wood fire is started in the receptacle and heating is conducted in this manner until the lining has been well dried. This requires from about eight to forty-eight hours depending probably upon the heat generated, the thickness of the lining, and the amount of moisture in the lining. When the lining has been dried satisfactorily in this manner, it is heated by means of a hot oil fire for a sufficiently long period to raise the temperature of the inner surface portion thereof to about 2000° F. This heating may be continued over a period of from eight hours to several days.

The converter should be put in service before any considerable drop in the temperature of the lining takes place. The usual procedure with respect to copper converters may be followed in putting the converter into service. A coating of magnetite may be provided or not as desired. Better service will be obtained if copper is not made within forty-eight hours after the converter is put into operation.

The monolithic linings of the present invention are not only satisfactory in service when new, but they may also be quickly and cheaply repaired when portions thereof are damaged. In patching a damaged monolithic lining it is only necessary to cut away a sufficient amount of the old lining to provide a rough surface for bonding purposes and apply a suitable amount of the lining mixture to build the damaged portion to the required thickness.

It is advisable to dry and burn patches in the same manner as new linings prior to putting the receptacles back in service.

Linings formed in accordance with the present invention are considerably cheaper than linings formed from refractory bricks according to the heretofore customary practices. Granular material can be obtained more cheaply than bricks at any desired location. The linings of the invention can be installed at a lower cost than brick linings. The installation of brick linings requires highly skilled labor while the installation of the linings of the invention may be made by relatively cheap common labor.

The relatively lower cost of monolithic magnesite linings of the invention permits the use of a more siliceous slag in copper converters even though the siliceous slag attacks the lining. The use of a siliceous slag is not only advantageous because of the lesser amount of copper carried thereby, but it is more advantageous because a relatively high-silica slag is easier to handle in ladles, easier to introduce into retreatment furnaces, and retreatment is more complete not only with respect to the copper extracted but also with respect to minimizing the segregation of the more or less infusible and refractory magnetite which, in the case of less siliceous converter slags, separates out in the retreatment furnaces and builds accretions on the hearth. Thus, the use of the linings of the invention permits not only saving in lining costs but a saving in the cost of retreatment and a higher recovery of copper as well.

I claim:

1. A molten bath receptacle having a monolithic refractory lining in which about twelve

to twenty-two per cent of the bonded particles are small enough to pass a 100-mesh screen, and the major portion of the remaining particles are too large to pass a 20-mesh screen.

2. A molten bath receptacle having a monolithic refractory lining in which about twelve to twenty-two per cent of the bonded particles are small enough to pass a 100-mesh screen, and the major portion of the remaining particles are too large to pass a 20-mesh screen and small enough to pass a one-half inch screen.

3. In a method of lining metallurgical apparatus involving the application of a wet mass comprising granular magnesite and a binder to the walls of the apparatus, the improvement which comprises subjecting the mass to the action of a mineral acid to neutralize alkaline impurities contained therein and thereby improve the plasticity of the mass.

4. In a method of lining metallurgical apparatus involving the application of a wet mass comprising granular magnesite and a binder to the walls of the apparatus, the improvement which comprises subjecting the mass to the action of an acid to improve the plasticity of the mass and thereby provide for better contact between the particles by permitting more uniform distribution of the fine particles throughout the mass, the amount of acid employed being not substantially in excess of that required to neutralize alkaline impurities contained in the mass.

5. In a method of lining metallugical apparatus involving the application of a lining mixture comprising granular magnesite and a binder to the walls of the apparatus, the improvement which comprises improving the plasticity of the mixture by the addition of an amount of sulphuric acid equal to not more than about 0.5% of the weight of the mixture.

6. In a method of lining metallurgical apparatus involving the application of a wet mass comprising granular magnesite and fireclay to the walls of the apparatus, the improvement which comprises subjecting the mass to the action of an acid to improve the plasticity of the mass and thereby provide for better contact between the particles by permitting more uniform distribution of the fine particles throughout the mass, the amount of acid employed being not substantially in excess of that required to neutralize alkaline impurities contained in the mass.

7. In a method of lining metallurgical apparatus involving the application of a wet mass comprising granular magnesite and bauxite to the walls of the apparatus, the improvement which comprises subjecting the mass to the action of an acid to improve the plasticity of the mass and thereby provide for better contact between the particles by permitting more uniform distribution of the fine particles throughout the mass, the amount of acid employed being not substantially in excess of that required to neutralize alkaline impurities contained in the mass.

8. In a method of lining metallurgical apparatus involving the application of a wet mass comprising granular magnesite and molasses to the walls of the apparatus, the improvement which comprises subjecting the mass to the action of an acid to improve the plasticity of the mass and thereby provide for better contact between the particles by permitting more uniform distribution of the fine particles throughout the mass, the amount of acid employed being not substantially in excess of that required to neutralize alkaline impurities contained in the mass.

9. In a method of lining metallurgical apparatus involving the application of a wet mass comprising granular magnesite and a binder to the walls of the apparatus, the improvement which comprises subjecting the mass to the action of sulphuric acid to improve the plasticity of the mass and thereby provide for better contact between the particles by permitting more uniform distribution of the fine particles throughout the mass, the amount of acid employed being not substantially in excess of that required to neutralize alkaline impurities contained in the mass.

In testimony whereof I affix my signature.

MORRIS G. FOWLER.