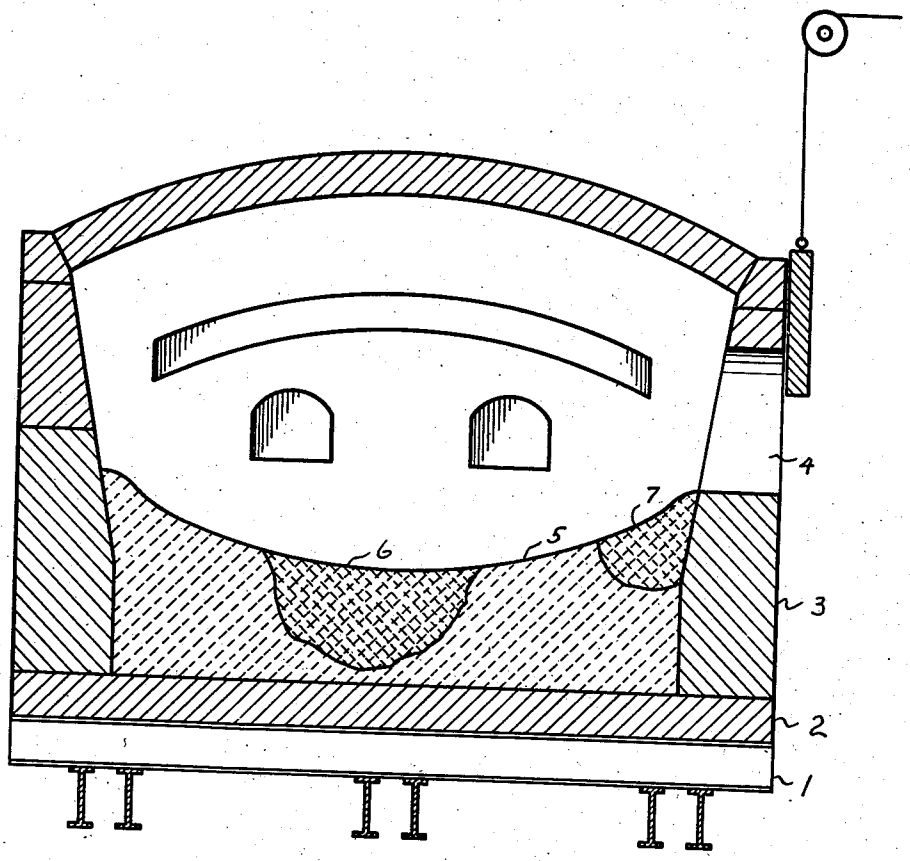
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METHOD OF MAKING BOTTOM OF HIGH TEMPERATURE BASIC FURNACE

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METHOD OF MAKING BOTTOMS OF HIGH TEMPERATURE BASIC FURNACES

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This invention relates to a method of making and repairing the bottoms of high temperature basic furnaces such as the well-known open hearth furnace, and it is among the objects thereof to lower the cost and reduce the time of such construction.

It is a further object of the invention to employ a lining material that will sinter when subjected to the normal temperatures of the furnace to such depth that the resulting upper crust will effectively support the charge of the furnace long before the remainder of the lining material has become an integral monolithic mass.

Bottom making of basic furnaces, as it is known in the steel industry, consists of building up superposed layers of refractory material, which may consist of a combination of magnesite, dolomite and slag, each layer being applied by spreading the material to a depth or from 1 to 2 inches and then subjecting the same to a fusing temperature. By this method, considerable time is consumed in building up each layer because of the intervening heating step. This same method of bottom making was also employed in repairing depressions or holes in the hearth or furnace lining.

In accordance with the present invention, the building up of successive layers of the refractory lining material is eliminated and the furnace bottom, if a new lining is required, will be built up by spreading a single layer of the refractory material to the desired thickness over the entire supporting hearth structure. Similarly, when making repairs, the depression in the lining is completely filled by a single charge of the refractory lining material. Where repairs on the banks adjacent furnace bottoms are needed, it has been found practical to patch such bank portions by a single charge of the lining material.

The invention will become more apparent from a consideration of the accompanying drawing in which the single figure is a cross-sectional view of a furnace illustrating the method of patching the furnace hearth in accordance with the principles of this invention. In the drawing numeral 1 generally designates the superstructure supporting the hearth 2. Refractory side walls 3 are supported on the hearth wall and numerous side openings 4 are provided as shown. In the case of an open hearth furnace, the hearth material for supporting the burden is of substantial depth and is designated by the reference character 5, and consists of magnesite, dolomite and slag, or other basic refractory materials.

The numeral 6 designates a patch of substantially the thickness of the hearth, made in accordance with the present invention, of a single layer of a basic refractory material which, in the main, comprises a dry-mixed batch of granular and powdered magnesite or a mixture of magnesite and ground chrome ore which completely fills the depression in the hearth to be patched as shown. The numeral 7 similarly designates a patch in the bank of the hearth bottom, the materials being built up to the normal level of the hearth by a single charge. The patches are then subjected to the normal temperature of the furnace in excess of 2600° F. for a sufficient time to form a crust capable of supporting the charge of the furnace, which requires only a fraction of the time needed to fuse the main body of the material into an integral monolithic mass. The furnace is then charged in the normal manner and operated at temperatures in excess of 2600° F., and during the normal operation of the furnace the main body of the patch will gradually become an integral mass. A surface layer of dead burned crushed dolomite or magnesite may be used where desired, or the entire batch may consist of the granular and powdered magnesite.

My improved method of bottom making and repairing basic furnace linings is made possible by the selection of materials of a proper grade to form a suitable refractory mixture consisting of certain grades of magnesite or artificially prepared magnesite, base refractory, and selected grades of chrome ore. The mixture may contain up to 75% magnesia (MgO) as compared with 85% magnesia in the pure grades of dead burned magnesite, the selection being based upon chemical analyses, preferably a quick setting magnesite obtainable by fully calcining a natural magnesite, brucite, dolomite or a combination of these materials. The relation in the analyses of these dead burned materials and the preferred analyses is shown in the following tabulation:

	Dead burned natural magnesites	Quick setting magnesites	Preferred analysis
Range in percent:			
Silica, SiO_2	4 to 7	4 to 7	4 to 5
Alumina, Al_2O_3	1 to 3	1 to 3	2 to 3
Ferric oxide, Fe_2O_3	2 to 7	5 to 12	8 to 12
Calcium oxide, CaO	2 to 7	10 to 25	12 to 16
Magnesia, MgO	80 to 85	55 to 75	65 to 75

If the dead burned magnesites or the quick-setting magnesites are used alone, as in the prior art practice, they must be subjected to high tem-

peratures of approximately 3000° F. to sinter or set the materials, and it is for this reason that the lining must be built up in layers of from one inch to two inches thick and then subjected to sintering temperatures for about a 2 to 4 hour heating period.

I have discovered that by adding chrome ore to the magnesite materials, the lining may be constructed of a single layer of any thickness, followed by a single period of heating no longer than for a thin layer of the quick-setting magnesites, and that by the use of this mixture the lining becomes harder instead of softer, up to the highest temperatures reached in open hearths, which may be nearly 3000° F.

The chrome ore is preferably selected for its low iron and high alumina content, and these constituents are found in the Rhodesian chrome ore and the Cuban chrome ores, the analyses of which are as follows:

	Rhodesian chrome ore	Cuban chrome ore
	Per cent	*Per cent*
Chromic oxide, Cr_2O_3	45.00	34.00
Silica, SiO_2	8.70	6.00
Alumina, Al_2O_3	16.00	25.00
Ferrous oxide, FeO	14.00	15.00
Calcium oxide, CaO	.70	1.00
Magnesia, MgO	15.00	18.00

Chrome ore represents mixtures of minerals consisting chiefly of chromite, $FeO.Cr_2O_3$, and serpentines, while the quick-setting dead burned magnesites consist mainly of periclase, that is, crystallized magnesium oxide, having high refractory properties, mixed with more easily fused constituents, such as calcium and magnesium silicate, iron calcium silicates, and calcium ferrite.

I have determined that it is possible by the method of my invention to make up a mixture composed of quick-setting magnesite and chrome ore of the grades, or composition, given above, which will set at the comparatively low temperatures of 2300° F. to 2600° F., and thereafter undergo transformations and changes, as the temperature rises, to form a hard, compact, coherent mass that will not soften below 3400° F. and will be more resistant to chemical action than either chrome ore or magnesite.

So, having selected the magnesite and chrome ore as described above, I next proceed to prepare each separately by crushing and screening or sieving to various sizes as follows:

Material	Per cent remaining on—		Sieves and percentages		
	¼" sieve	⅛" sieve	20 mesh	Per cent passing through—	
				20 mesh	100 mesh
Quick setting magnesite	None	30	25	45	10
Chrome ore	do	None	20	80	40

In practice it is difficult to hold the sizes exactly to the percentages stated, so that it is necessary to permit tolerances in the specifications as established by commercial practices. It is important to point out that the magnesite particles will vary in size from ¼" to dust and chrome ore from ⅛" to dust, so that when the materials are subsequently mixed in the proportions required by the method of my invention, the finer particles and the dust will fill the voids, or interstitial spaces, formed by the larger particles, the largest of which will consist of magnesite.

Having crushed and sized each of the materials separately as described, the next step in the method of my invention is to mix the ground quick-setting magnesite with the ground chrome ore, each consisting of all the sizes produced, in the proportion of 60 to 90 parts of the former and 10 to 40 parts of the latter, the exact proportions being varied to a certain extent to meet different requirements with respect to chemical action, temperature, and commercial considerations. Usually a mixture consisting of approximately 80 parts of the ground magnesite with 20 parts of the ground chrome ore will meet the requirements of repairs to the bottoms of open hearth furnaces and others presenting similar conditions. For this purpose I select and proportion the raw materials so that the average composition of the mixture is within certain limits with respect to the oxide radicles ordinarily determined by chemical analysis, as follows:

	Percent
Chromic oxide, Cr_2O_3	5 to 11
Total iron oxide as ferrous oxide, FeO	5 to 11
Aluminum oxide, Al_2O_3	3 to 9
Silica, SiO_2	4 to 7
Calcium oxide, CaO	9 to 17
Magnesium oxide, MgO	50 to 63

For other purposes I may change this analysis slightly, for example, to obtain a mixture that will set at low temperatures I may, if the refractory requirements will permit, raise the silica content to as high as 8 per cent. To obtain a mixture meeting high refractory requirements, I may increase the chromic oxide content to as high as 15 per cent and hold other constituents, except magnesia, to the lower limits of the ranges given.

The mixing may be carried out in various ways with different equipment, the chief requirement being that the mixing must be thorough. In practice I have found that concrete mixers may be used economically to produce a satisfactory mixture.

During the grinding and mixing operations, as well as the subsequent handling operations, I take special precautions to keep the materials dry. Also as a simple test to determine if the materials have been properly sized and mixed, I fill a container, such as a box, by adding the materials in shovelfuls dropped from a height of 2 to 3 feet, and weigh the contents of the box. If the grinding and mixing have been properly done, the contents of the box will have a definite and standard weight which varies somewhat, and may be determined experimentally for any mixture of the two classes of materials selected.

To complete the description of steps in the method of my invention for repairing an open hearth bottom, we assume that a section of the bottom has risen during the making of a heat of steel and that the metal has been tapped from the furnace. The depression in the bottom is filled with molten metal and slag, which I remove as quickly as possible by any convenient method known to those skilled in the art. I then fill the depression in the bottom with the mixture of my invention by adding it in shovelfuls thrown through the doors of the furnace, except the last portions, which may be added from a spoon, pushed through the door so as to smooth up the

work and bring the top surface of the patch flush with the top surface of the bottom. As the material tends to shrink, causing the surface to sink slightly, I may add a layer about 1" thick of dead burned crushed dolomite or magnesite as a top dressing over the patched area. This dressing also prevents liquid slag flowing from the banks and other parts of the furnace bottom from reaching the filling of my invention before it has been heated to a setting temperature. I then close the doors of the furnace and admit fuel to bring up and hold the temperature above 2600° F. for at least one hour, after which period the furnace may be charged with the raw materials required by the next heat of steel to be made.

I have carefully observed the behavior of the mixture of my invention after it has been used to fill depressions in the bottoms and banks of various basic furnaces, and have made numerous laboratory experiments to determine the changes the material undergoes under the conditions of service stated above. Under such conditions, the behavior of the material is described as follows:

As the depression in the bottom is filled by shovelling as described, the materials pack solidly therein to fill the depression completely. Then if, or as soon as, the temperature is sufficiently high, it begins to sinter or set on the surface, forming a hard compact crust or layer that becomes thicker and thicker with the time of heating, so that within the period of about one hour, provided the temperature is around 2900° F. by this time, this hard sintered layer is two to three inches thick and hard enough to permit the charging of the furnace. Thereafter, the setting continues throughout the mass of the material, which is best described as a monolithic cast completely filling the depression.

This initial setting is brought about by the melting of certain components of the mixture which are separated by the crushing and sizing operations from the more refractory components of my raw materials. These components are amongst the finest, and begin to soften or melt at temperatures below 2500° F. and become fluid, having a low viscosity at temperatures around 2700° F. Therefore, as the temperature rises above 2700° F. these components unite to form a new constituent, which becomes so fluid that it tends to flow downward, leaving the higher melting components of the mixture behind, each particle of which, however, is coated with the liquid formed by the low melting constituent. I have not succeeded in identifying positively the components of the physical mixture that form the low melting constituent, but they appear to be mainly calcium oxide, alumina, and silica—the latter probably combined as aluminum silicate, for the composition of the low melting constituent corresponds closely to the formula

$$4CaO.Al_2O_3.3SiO_2$$

plus a small proportion of chromic oxide, Cr_2O_3, which is possibly dissolved by the liquid.

On account of this characteristic, the mixture of my invention exhibits unusual behavior in brick form, the brick showing a tendency to sweat badly at 3100° F. to 3200° F., then setting to a hard compact mass, in which the original particles lose their identity entirely. This sweating changes the composition of the material, the silica (SiO_2) being 1½ to 2%, the alumina (Al_2O_3) ½ to 2%, and the calcium oxide (CaO) 3 to 5% lower in the bricks after they have been heated to temperatures above 3150° F. than before they are thus heated. For the chief objects of my invention this is a desirable characteristic, because all of the material is retained in the cavity or cavities filled by it.

Finally, to refer to the action of the material as it lies in the furnace bottom; as the temperature rises still higher, that is to between 3100° F. and 3200° F., certain chemical reactions begin to occur between the ingredients fusing at the lower temperature and the excess of bases in the magnesite, presumably the calcium oxide and magnesia, to form new minerals having highly refractory properties, since chromite particles can still be identified imbedded in the mass. Mineralogically, the hard mass appears to consist mainly of periclase containing some magnesioferrite and of chromite, bonded with calcium ferrite and a green glass-like constituent composed of the oxides of calcium, aluminum, silicon and chromium. Apparently, at these high temperatures sufficient chromite is dissolved to raise considerably the freezing temperature of the low melting constituent.

As the heating is continued to higher and higher temperatures, certin reactions may occur at the surface of the chromite and magnesite particles whereby the chromic oxide in the chromite particles reacts with the lime and periclase in the magnesite particles, thus bonding them with the rest of the mixture as if the whole of the matrix materials had been fused and the particles of these minerals, that is, of the chromite and periclase, had been dropped into and mixed with the liquid, which then reacted with the latter to form a mass, infusible at the highest temperatures of the open hearth.

It is to accomplish this result that I crush my chrome ore to much finer sizes than I crush the quick-setting magnesite, as I have found that by finely grinding the chromite, this effect is promoted, and the gangue of the ore is separated to be mixed with the fines from the magnesite to form the low melting constituent essential to accelerate the initial setting of the material when it is subjected to heat.

These results are brought about and accomplished by the materials and method of my invention, because of the physical and chemical properties of the materials, and the proportioning, sizing, and mixing in the manner I have just described. Thus the magnesite, having an extremely high coefficient of expansion, increasing as the temperature rises to 2800° F., helps to fill the voids not filled by dust and to bring all the particles into closer contact, thus at first promoting the setting reactions. At higher temperatures, near 3200° F., the magnesite rapidly contracts, but it does so as separate particles surrounded by a more or less plastic mass, so that there is no actual shinkage of the material away from the walls of the depression as a whole. Finally, as stated before, the mass is hard at these high temperatures and the chromite imparts the property of greater resistance to the action of acidic substances, such as silica, than magnesite alone, without reducing the resistance to the action of strongly basic slags. The reasons it is not necessary, in the use of the mixture of my invention, to sinter it in layers to build up or patch a furnace bottom, are now evident from the foregoing description.

If a complete new bottom is made, the mixture is spread upon the supporting brick to the desired depth of a foot or less and subjected to a

temperature of about 2600° F. or more until the upper surface has sintered to a depth of several inches. The furnace is then ready to be charged and the main body of the material will gradually become hard and set with continued use as described above.

Besides the specific example cited herein, I have applied the mixture and method of my invention to many other uses, such as the repairing of the banks of tilting furnaces used for making steel by the basic process, for the rebuilding and resurfacing of the bottom and banks of open hearth furnaces, and for the building up of bottoms of basic electric furnaces.

I claim:

1. The method of making bottom of basic furnaces which comprises spreading a relatively thick layer of a dry mixed batch of ground magnesite and ground chrome ore on the furnace hearth in the proportion of 60 to 90 parts magnesite and 10 to 40 parts chrome ore, adding a surface layer of dead burned crushed dolomite or magnesite, and subjecting the upper surface of the material to a fusing temperature in excess of 2600° F. to form a sintered crust for receiving the furnace charge.

2. The method of making bottom of basic furnaces as set forth in claim 1 in which the chrome ore is sized to pass through a one-eighth inch screen and the magnesite is sized to pass through a one-fourth inch screen with not more than half of the magnesite passing through a 20-mesh screen.

3. The method of lining or patching furnace hearths which comprises spreading on the hearth or in a depression of the hearth a relatively thick layer of basic refractory material which in the main comprises a dry mixed batch of granular and powdered magnesite of substantially the thickness of the hearth or the depth of the depression in the hearth, the magnesite being sized to pass through a one-fourth inch screen with not more than half passing through a 20 mesh screen and subjecting the exposed surface of the material to a setting temperature in excess of 2600° F. for a sufficient time to form a crust capable of supporting the charge of the furnace before the main body of the magnesite has become an integral monolithic mass.

4. The method of lining or patching furnace hearths which comprises spreading on the hearth or in a depression of the hearth a relatively thick layer of a dry mixed batch of ground magnesite and ground chrome ore in the proportion of from 60 to 90 parts magnesite and 10 to 40 parts chrome ore, the magnesite being sized to pass through a one-fourth inch screen with not more than half passing through a 20-mesh screen and the chrome ore being sized to pass through a one-eighth inch screen, and subjecting the upper surface of the material to the normal temperature of the furnace in excess of 2600° F. for a sufficient time to form a crust capable of supporting the charge of the furnace before the main body of the material has become an integral monolithic mass.

5. The method of lining or patching furnace hearths which comprises spreading on the hearth or in a depression of the hearth a relatively thick layer of basic refractory material which in the main comprises a dry mixed batch of granular and powdered magnesite of substantially the thickness of the hearth or the depth of the depression in the hearth, the magnesite being sized to pass through one-fourth inch screen with not more than half passing through a 20 mesh screen. adding a sufficient layer of dead, burnt, crushed material selected from the class consisting of dolomite and magnesite, and subjecting the exposed surface of the material to a setting temperature of 2600° F. for a sufficient time to form a crust capable of supporting the charge of the furnace before the main body of the material has become an integral monolithic mass.

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