

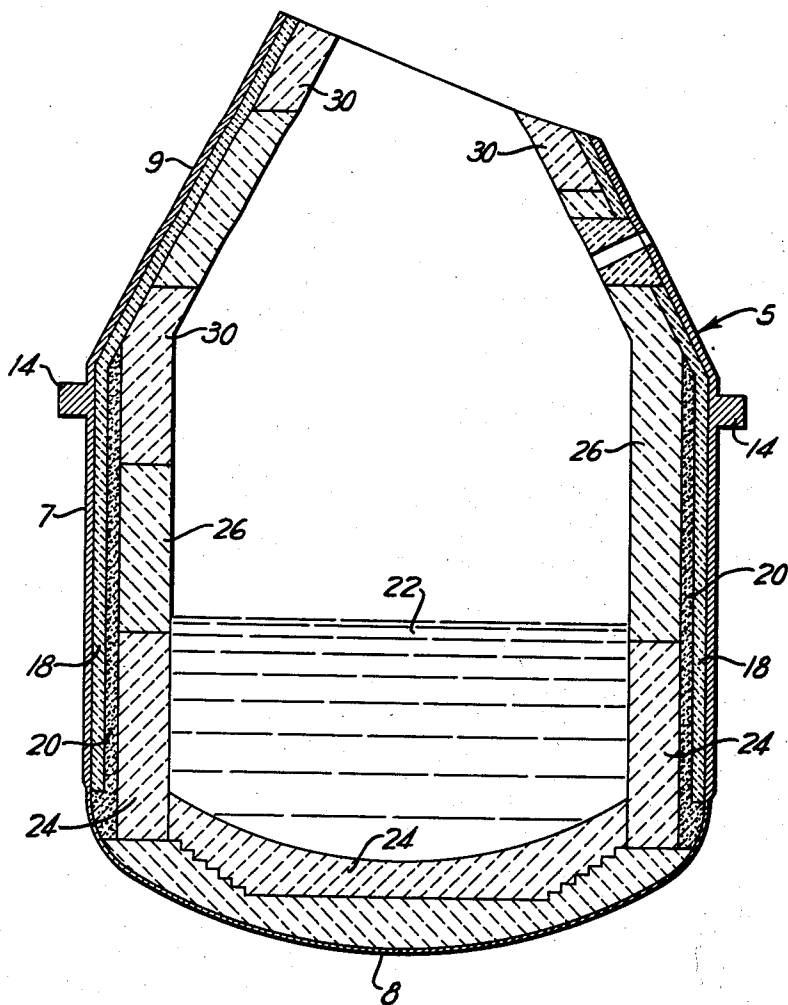
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OXYGEN CONVERTER LININGS

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OXYGEN CONVERTER LININGS

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This invention relates to furnace structure for the oxygen steel making process. More particularly this invention relates to the composition of the working lining for such structures.

In the oxygen steel making process, which has been variously designated as the LD process, oxygen Bessemer process, and the oxygen converter process, the furnace structure fundamentally consists of a metal shell having a refractory lining disposed therein. The lining for oxygen steel vessels has heretofore been extremely simple, consisting of an inner or "working" lining of tar-bonded, chemically bonded or burned basic brick, an exterior or tank lining of burned magnesite brick and usually an intermediate layer of a tar-bonded ramming mix of composition similar to that of the working lining.

During the evolution of the oxygen converter process, many different materials have been tried for the working linings, with varying degrees of success, in attempts to obtain an even longer service life. Because these processes operate with basic slags, the working lining materials have of necessity been constituted of basic materials, principally dolomite and magnesite in a variety of forms and combinations. Although many different types of lining materials have been tried in attempts to improve service life, it has been the general practice to use only one particular type in any given lining. In general, it appears that the greatest success from the standpoint of both service and economy has been with working linings consisting of tar-bonded lime-magnesite compositions of the chemistry disclosed by King et al., in United States patent application Serial Number 38,438, filed June 24, 1960 and now abandoned and by Davies in United States patent application Serial Number 108,989, filed May 10, 1961, where Cr₂O₃ is added to such compositions.

The object of King et al. is to provide a tar-bonded brick composed of grain of at least 96 percent combined magnesite (MgO) and lime (CaO) which has the maximum resistance to the siliceous early slag produced in oxygen converter operation. Davies teaches the addition of up to 5 percent chromic oxide to a composition as in King et al. in order to improve the resistance to iron oxide (Fe₂O₃) which is present in the slag at all times and is particularly high in the late slag. The following are typical analyses of the early and late slags just referred to:

	Early Slag, percent	Late Slag, percent
Silica (SiO ₂)	32.1	18.1
Lime (CaO)	40.9	36.0
Iron Oxide (Fe ₂ O ₃)	11.5	30.5
Manganese Oxide (MgO)	6.9	6.7
Magnesia (MgO)	5.7	5.7
Titania (TiO ₂)	1.4	1.4
Phosphorous Pentoxide (P ₂ O ₅)	1.5	1.5

Since both King et al. and Davies aim at achieving maximum resistance to the oxygen converter slags, it is apparent that these brick, while of high quality, might not be the most desirable for use in those portions of the lining where resistance to slag is not the most important consideration.

It is a major object of the present invention to provide an improved oxygen converter vessel characterized by an improved life in consequence of the use of a working lin-

ing most suited to the varying conditions experienced therein.

Other objects will be evident from the following description.

This and other objects are attained in accordance with this invention by providing an oxygen converter vessel with a working lining having a plurality of compositions. The specific compositions used and their location have been determined by extensive commercial size tests of different lining materials as well as mineralogical studies of samples from such tests. From these data and information, I have determined that the lining material that is normally below the usual surface of metal in the vessel is not particularly critical. Accordingly, I line such portion with a basic refractory, the composition of which normally is determined by economics. Typically, this portion of the lining is composed of brick made from stabilized dolomite, dead burned dolomite, dead burned lime, dead burned natural magnesite, and dead burned synthetic magnesite or any combination of the foregoing in various proportions and in each of which the essential chemistry is not particularly critical. The second major zone of a converter vessel in accordance with this invention is the mouth area of the cone section and a portion of the side wall generally near or at the area where the cone section joins the body portion of the converter. These areas of the linings have been found to be subject to severe abrasion and thermal shock. This is a primary result of the impact of the charging materials on this particular area. The impact, of course, can abrade the surfaces of the lining. Since the charged materials are usually at a temperature quite low relative to the temperature experienced by the lining during use, thermal shock also develops. In these zones, I provide burned, tar impregnated, magnesite brick having an MgO content of at least 96 weight percent. The remainder of the lining and, in all events, at least that portion thereof that extends from immediately below the metal line or level of metal to the top of the splash area above the slag level is lined with a refractory that is particularly slag resistant. For this purpose, tar bonded MgO.CaO brick and particularly those having a small Cr₂O₃ content are used. In this manner, each zone of the converter is characterized by the best combination of properties, as determined by operating conditions, that can be attained and, therefore, maximum life of the lining is achieved.

The invention will be described further in conjunction with the attached drawing which shows a sectional view of a converter vessel having a zoned lining in accordance with this invention.

Referring now to the drawing, the vessel comprises a metal tank indicated generally by the numeral 5. Usually, the tank is cylindrically shaped throughout most of its body portion 7 and has a rounded bottom zone 8. Above the main body portion 7 is a cone section 9 having a mouth cut on a bias. In the embodiment shown, the tank 5 is provided with lugs 14 whereby it can be moved as by tilting or the like for charging and discharging operations.

The immediate inside surface of the tank 5 is provided with a lining 13 of the conventional type, usually consisting of burned magnesite brick, and that is covered with a tar bonded ramming mix 20 of the same general character. Over the ramming mix 20 is the working lining that is zoned in accordance with the teachings of the present invention.

Referring to the lower portion of the vessel, the metal melt 22 normally covers about 40 percent of the height of the side wall of the cylindrical body portion 7. The portion of the working lining in the vessel below the melt, which includes the bottom of the vessel, and is indicated by the numeral 24 is, in accordance with this in-

vention, made with the conventional basic refractories. By the term "conventional basic refractories" I mean a refractory product that is basic in character without regard to the remainder of the composition. These conventional refractories are quite satisfactory for this portion of the working lining because there is no direct impingement of oxygen on it nor significant contact with the slags. Moreover, conditions are rather steady and neither abrasion nor spalling are significant problems. It is possible, therefore, to use tar-containing basic brick of a composition largely determined by economics. Dead burned dolomite, stabilized dolomite, dead burned lime, dead burned natural magnesite and the like, alone or in various combinations can be used. It should be understood, however, that under some operating conditions the use of the special refractories subsequently specified for the upper portion of the vessel may be required. Typical properties of two of the brick that can be used for this purpose are as follows:

Composition	A	B
	Stabilized Dolomite +5% Pitch	60% Stabilized Dolomite, 40% Synthetic Magnesite +5% Pitch
SiO ₂percent.....	1.2	2.2
Al ₂ O ₃do.....	0.8	0.9
TiO ₂do.....	0.5	
Fe ₂ O ₃do.....	4.8	3.0
CaO.....do.....	50.5	30.3
MgO.....do.....	37.1	58.4
Ignition Loss.....do.....	5.0	5.2
Density, p.c.f.....	175	185
Modulus of Rupture, p.s.i.....	1,250	1,500

The brick 26 in the working lining at and immediately above the level of the melt contact slag during most of the heat. Splashing extends this area to above the normal level of slag as well as to a course or two below the melt level. To resist the unusual conditions presented by slag, particularly that of the changing composition as noted above, this zone of the working lining is lined with tar bonded slag resistant brick, for example those made in the manner taught in the aforementioned King et al. application, Serial No. 38,438, or preferably those made in accordance with the teachings of Davies, Serial No. 108,989. Typically, compositions or refractory products of King et al. are at least 96 percent of MgO plus CaO, the MgO ranging from 50 to 95 percent and the CaO from 50 to 5 percent, and there being present no more than about 4 percent total of SiO₂, Al₂O₃, and Fe₂O₃. Preferably, the MgO plus CaO content is at least 97 percent and the remaining oxides are less than 3 percent. Those compositions can be prepared by normal refractory practices using a tar or pitch bonding agent in an amount of about 4 to 8 weight percent. Those products are frequently and advantageously made by first preparing high density grain from lime, magnesite, dolomite or mixtures of the foregoing. Such grain can be prepared by pressing calcined dolomite or lime or magnesite at a pressure of at least 20,000 p.s.i. and then burning at a temperature of at least 3400° F. Other procedures also can be used and will be apparent to those skilled in the art upon consideration of the copending application of King et al. mentioned above.

Brick for the slag splash area can also be made in accordance with the teachings of the copending application of Davies, Serial No. 108,989. Generally speaking, Davies' refractory shapes are similar to those of King et al. with the only major change being the incorporation of an amount of about 1 to 5 weight percent of chromic oxide. As set forth in the Davies application just mentioned, all the advantages of the King et al. application are obtained in that manner and the brick are further advantageous in that they are also particularly resistant to the late slag that is encountered in practicing the

oxygen converter process. Typical data on the composition of properties of these slag resistant tar bonded brick are as follows:

	King et al. Type	Davies Type
Composition.....	90% MgO, 10% CaO + Bonding Pitch.	90% MgO, 10% CaO, 1-5% Cr ₂ O ₃ + Bonding Pitch.
Bulk Density, p.c.f.....	184.....	187.....
Modulus of Rupture, p.s.i.....	2,000.....	2,100.....

The Davies compositions comprise 50 to 5 percent of CaO, 50 to 94 percent of MgO and 1 to 5 percent of Cr₂O₃, with the SiO₂, Al₂O₃, and Fe₂O₃ content not over 4 percent, and the MgO plus CaO being at least 94 percent.

It will be understood that besides the foregoing examples, large blocks or monolithic materials of these compositions are not excluded. The manufacture of large tar-bonded blocks by vibration, air ramming, jolting, and the like is well-known as is the practice of ramming or vibrating monolithic materials into place in the lining.

The third major portion, indicated generally by the numeral 30, of the working lining is that about the mouth of the vessel and at the side wall where charge materials impinge. This area is subject to change to various locations higher or lower in the vessel depending upon where the scrap and hot metal strike. That portion of the lining is subject to conditions that bring about substantial abrasion and spalling. For this portion of the lining, the brick used must be tar impregnated to avoid undue slag attack. Broadly, these brick are burned magnesite brick having an MgO content of at least 96 percent, and preferably higher. Brick for these locations can be made from high purity magnesite grain as disclosed in the copending application of Snyder et al., Serial No. 847,864, now U.S. Patent 3,060,000. In that process, dead burned magnesite is made through a series of steps whereby caustic calcined magnesite maintained at a temperature of at least 600° F. and under conditions where hydration is avoided, is pressed dry at a pressure of at least 20,000 p.s.i. The resulting dry compresses, and while still heated to at least 600° F., are briquetted under a pressure of at least 20,000 p.s.i., while recirculating to the feed at least 15 weight percent of the previously compressed material. Dead burning is then accomplished, without permitting the bodies produced from the second compression step to fall in temperature, at a temperature usually on the order of at least 2900° F. and preferably higher to produce a dead burned magnesite of at least 98 percent MgO of an extremely high bulk specific gravity, e.g. at least 3.30. That high bulk density dead burned magnesite upon crushing results in a minimum of platy grains that theretofore seemed to obstruct densification in the forming of refractory shapes. The crushed dead burned magnesite is used to form brick and are burned in the conventional manner. The burned brick are impregnated with tar, as by boiling in tar or by causing impregnation by application of pressure. Generally, about 8 percent of tar is used. Brick formed in this general manner are outstandingly resistant to abrasion under repeated impact as well as resistant to spalling brought about by rapid and frequent temperature changes. Typical physical properties of brick of this type are:

Density, P.c.f.	188
Modulus of rupture, p.s.i.	3100
Apparent porosity, percent	15.5
Linear change at 3140° F., percent	0.0
Loss in panel spalling (ASTMC/22) with 3000° F. preheat, percent	0.0
Load Test, 25 p.s.i. failures at 3000° F.	None

It is to be noted that the requirements of great strength

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and abrasion resistance for this portion of the lining indicates that brick must be used to the exclusion of other shapes such as monolithic linings.

With a working lining zoned in the manner disclosed, maximum life and best economy are experienced. Each zone is provided with characteristics best suited to the conditions that are experienced. Thus, maximum service life is attained by using the best possible lining materials at those locations, and using less expensive compositions in zones (i.e. the bottom) where lining wear or failure is not a significant threat.

All percentages in this specification are by weight unless otherwise indicated.

In accordance with the provisions of the patent statutes, I have explained the principle of my invention and have described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. An oxygen converter vessel comprising a metal vessel having a mouth at its top, a shell protective lining in contact with the inside surface of said vessel and a working lining having a surface exposed to the interior of said vessel, said working lining being constructed of three major zones, these three zones being the bottom zone, the barrel zone and the cone section zone, the bottom zone being generally dish shaped and of upwardly opening concave configuration, the barrel zone extending from the dish shaped bottom upwardly to the cone section zone, the barrel zone being of substantially uniform cross sectional dimension from the bottom zone to the cone section zone, the cone section zone being of downwardly opening truncated cross sectional configuration, the working lining of at least the upper peripheral lip area of the cone section zone being fabricated of tar impregnated, ceramically bonded magnesite brick having an MgO of at least 96%, substantially the remainder of the cone section zone, the barrel zone, and the bottom zone portions of the working lining being fabricated of tar bonded basic refractory, the basic refractory used to fabricate a limited circumferential band portion of the barrel zone being an especially slag resistant refractory composed of at least 96% MgO+CaO, the MgO ranging from 50 to 95% and the CaO from 50 to 5%, and there being present no more than 4% of SiO₂, Al₂O₃, and Fe₂O₃, said band being positioned in said barrel zone above its point of contact with the bottom zone, and just beyond molten metal in the vessel in the slag splash area of the vessel when it is in operation.

2. An oxygen converter vessel in accordance with claim 1, said barrel zone and bottom zone being lined with a basic refractory in which the basic constituents thereof are selected from the group consisting of dead burned dolomite, stabilized dolomite, dead burned lime, dead burned natural magnesite, and combinations thereof.

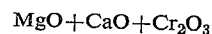
3. An oxygen converter vessel comprising a metal vessel having a mouth at its top, a shell protective lining in contact with the inside surface of said vessel and a working lining having a surface exposed to the interior of said vessel, said working lining being constructed of three major zones, these three zones being the bottom zone, the barrel zone, and the cone section zone, the bottom zone being generally dish shaped and of upwardly opening concave configuration, the barrel zone extending from the dish shaped bottom upwardly to the cone section zone, the barrel zone being of substantially uniform cross sectional dimension from the bottom zone to the cone section zone, the cone section being of a downwardly opening truncated cross sectional configuration, the major extent of the cone section zone and a limited upper portion of the barrel zone where it joins

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the cone section zone being lined with tar impregnated, ceramically bonded magnesite brick having an MgO content of at least 96%, that limited portion of the barrel zone working lining which is fabricated of the ceramically bonded brick arranged to oppose the charging of scrap to the vessel, both the remainder of the barrel zone and the cone section zone and the bottom zone portions of the working lining being fabricated of tar bonded basic refractory, the basic refractory used to fabricate a circumferential band portion of the barrel zone being an especially slag resistant refractory composed of at least 96% MgO+CaO, the MgO ranging from 50 to 95% and the CaO from 50 to 5%, and there being present no more than 4% of SiO₂, Al₂O₃ and Fe₂O₃, said band in the barrel zone being positioned in said barrel zone above its point of contact with the bottom zone, and just beyond molten metal in the vessel in the slag splash area of the vessel when it is in operation.

4. An oxygen converter vessel comprising a metal vessel having a mouth at its top, a shell protective lining in contact with the inside surface of said vessel and a working lining having a surface exposed to the interior of said vessel, said working lining being constructed of three major zones, these three zones being the bottom zone, the barrel zone and the cone section zone, the bottom zone being generally dish shaped and of upwardly opening concave configuration, the barrel zone extending from the dish shaped bottom upwardly to the cone section zone, the barrel zone being of substantially uniform cross sectional dimension from the bottom zone to the cone section zone, the cone section zone being of downwardly opening truncated cross section configuration, and there being a tap hole opening through the cone section which tap hole is lined with basic refractory, the basic refractory used to fabricate a circumferential band portion of the barrel zone being especially slag resistant refractory composed of at least 96% MgO+CaO, the MgO ranging from 50 to 95% and the CaO from 50 to 5%, and there being present no more than 4% of SiO₂, Al₂O₃, and Fe₂O₃, said band being positioned in said barrel zone just beyond molten metal in the vessel in the slag splash area of the vessel when it is in operation, and a major portion of the lining of the cone section zone being fabricated of ceramically bonded 96% MgO refractory impregnated throughout with tar.

5. An oxygen converter vessel comprising a metal vessel having a mouth at its top, a shell protective lining in contact with the inside surface of said vessel and a working lining having a surface exposed to the interior of said vessel, said working lining being constructed of three major zones, these three zones being the bottom zone, the barrel zone and the cone section zone, the bottom zone being generally dish shaped and of upwardly opening concave configuration, the barrel zone extending from the dish shaped bottom upwardly to the cone section zone, the barrel zone being of substantially uniform cross sectional dimension from the bottom zone to the cone section zone, the cone section being of downwardly opening truncated cross sectional configuration, the working lining of at least the upper peripheral lip area of the cone section zone being fabricated of tar impregnated, ceramically bonded magnesite brick having an MgO content of at least 96%, substantially the remainder of the cone section zone, the barrel zone, and the bottom zone portions of the working lining being fabricated of tar bonded basic refractory, the basic refractory used to fabricate a limited circumferential band portion of the barrel zone being an especially slag resistant refractory composed of at least 96%



the MgO ranging from 50 to 94% and the CaO from 50 to 5%, the Cr₂O₃ from 1 to 5%, and there being present no more than 4% of SiO₂, Al₂O₃ and Fe₂O₃, said band in the barrel zone being positioned in said barrel zone

above its point of contact with the bottom zone, and just beyond molten metal in the vessel in the slag splash area of the vessel when it is in operation.

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