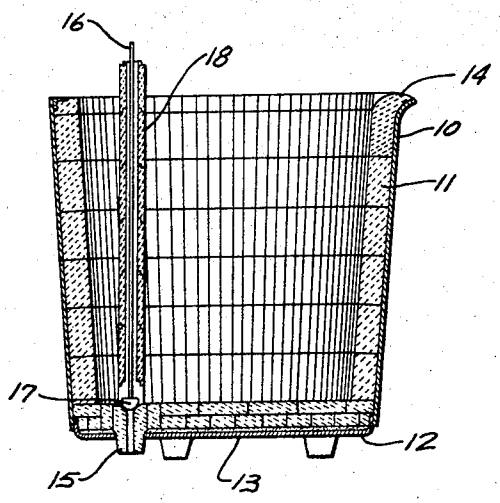
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BOTTOM POUR LADLE CONSTRUCTION

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BOTTOM POUR LADLE CONSTRUCTION

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ABSTRACT OF THE DISCLOSURE

Refractory sleeve mineralogically characterized by about 85 to 90% total of chromite and magnesium aluminate spinel and the remainder being for sterite and pyroxene type crystals in glass.

The present invention relates to bottom pour ladle construction and in particular to improved protective refractory sleeves for bottom pour ladle stoppers and stopper rods.

In the manufacture of steel and steel alloys, it is conventional to tap molten metal from a furnace into a ladle in a pouring pit. The pouring pit is usually at a lower elevation than the floor on which the metallurgical furnaces reside, so that the molten metal may flow by gravity from the furnace to the ladle. Spaced from the furnace are a plurality of ingot molds, and the ladle of molten metal is moved through the pouring pit into a position above these ingot molds. Molten metal is poured from the ladle into the ingot molds to form ingots. Usually the metal is poured from the ladle through a nozzle which opens through the bottom thereof. The metal is restrained from flowing through the nozzle by means of a stopper head which seals off the nozzle entrance. Attached to the stopper head is a stopper rod sheathed in short tubular lengths or sleeve segments of refractory which is generally longer than the depth of the ladle so that the stopper head can be moved in and out of position by means exterior to the ladle.

These stopper heads and rods are the source of many difficulties. The refractories which are used in these components, in the past, have worn at excessive rates or have had pieces crack and spall away by reason of heat shocking and contact with molten metal and slags. One of the primary problems is that these pieces of refractory may find their way into the castings and form foreign inclusions and flaws, which harm the quality of a final product made from that casting.

Accordingly, it is an object of this invention to provide protective refractory sleeves of improved composition for envelopment about bottom pour ladle stopper heads and rods.

Another object of the invention is to provide a refractory sleeve having relatively good thermal shock and spalling resistance. It is still another object of this invention to provide improved pouring pit refractory sleeves, basic in composition.

Briefly, in one embodiment of the present invention, there is provided an improved protective refractory sleeve for envelopment about the stopper head in a bottom pour ladle construction. The sleeve is fabricated of a basic refractory which resists attack by molten metal and particularly slags, and which does not crack or spall

away in contact therewith at operating temperatures. The sleeves are formed from a batch mixture of size graded chrome ore, preformed magnesia-alumina spinel grain and dead burned magnesite. The batch components are mixed in proportions, such that, after firing, the sleeves exhibit the mineralogical phases forsterite ($2MgO \cdot SiO_2$), pyroxene type crystals ($MgO \cdot SiO_2$) in glass, and spinel complex consisting essentially of the compounds MgO, FeO, Al_2O_3, Cr_2O_3 and Fe_2O_3. The spinel minerals are present as a solid solution and are bonded by the forsterite and pyroxene phase. In a weight relationship, these mineral phases are present in the final product in a range of about 85 to 90% of spinel complex, the remainder being the silicate phases.

Other features and advantages of ladle stopper head and rod construction, according to this invention, will become readily apparent to those skilled in the art from a study of the following detailed description, with reference to the drawing, the single figure of which is a side elevation in partial section of a bottom pour ladle according to the concepts of this invention.

In the drawing there is shown a bottom pour ladle having a stopper rod protective sleeve, according to this invention. Such a ladle normally includes an outer metal shell **10** lined with suitable refractory composition. It might be thought that the sidewalls **11**, for ferrous metals, such as, iron, steel and steel alloys, would be lined with a basic refractory composition, since the slags associated with production of the foregoing metals are themselves basic; but, in practice, it is far more common to use alumina-silica ladle brick, because they are cheap yet satisfactory in most instances. The bottom of the ladle includes an outer metal shell **12**, also lined with a refractory composition **13**, usually similar to that which is used to line the sides. A slag lip **14** opens through a portion of the upper periphery of the sidewall, and is usually fabricated of a refractory monolith.

Opening through the bottom, adjacent the sidewall, is a nozzle **15**. A downwardly extending stopper rod **16**, terminating in a stopper head **17**, is axially aligned with the nozzle inlet. The refractory sleeve **18**, of the invention, is disposed so as to envelop the stopper rod **16** and thereby protect it from extended contact with the molten metal and slag when the metal is being held and when it is poured from the ladle. The refractory sleeve **18** may consist of an integral unit or may be fabricated from a plurality of sleeve segments, as shown in the drawing, which are secured together with refractory mortar or the like, and may be held in compression by a clamp (not shown) disposed at the upper end thereof. The sleeve segments may be conveniently prepared by vibration casting, ramming and power pressing. As noted above, in the past, sleeves of the type shown in the ladle construction of the drawing have tended to crack, spall away, or to wear or irregularly erode at excessive rates by reason of contact with flowing molten metal and slags. Heretofore, the trade has almost exclusively used fireclay refractories for these sleeves as they did with the nozzles and stopper assembly. However, mineralogically, fireclay refractories are not best suited for contact with molten metal and slag. Such refractories are of relatively low refractoriness, and have tended to be very rapidly consumed during pouring with the danger of particles forming harmful inclusions within the metal.

A practical, workable range for the batch ingredients of this invention, by weight, is as follows:

	Percent
Chrome ore	At least 85
Preformed spinel grain	1–10
Dead burned magnesite	3–10

However, optimum results are obtained where the spinel grain and magnesite are present in amounts of 10% and 5% respectively.

In determining the delimiting ranges of composition of the refractory sleeves, a sample containing about 85% chrome ore, 9% preformed spinel grain and 6% dead burned magnesite was mineralogically examined. The composition consisted of angular to rounded chrome ore grains graded from about 4 mesh through fines and a heterogeneous silicate bonding system.

Microscopic and X-ray examination indicated that the silicate bonding system consisted predominantly of the crystal phase forsterite ($2MgO \cdot SiO_2$) with small amounts of fine lath shaped pyroxene type crystals and dendrites ($MgO \cdot SiO_2$) all contained in glass. This silicate material occurred as thin films surrounding and filling the microfractures in the chrome grains and in larger pools enveloping the fine chrome particles in the groundmass. The silicates were present as thin films around the chrome grains and in larger pools and irregular masses in the groundmass to form a continuous, well developed, silicate bonding system. The pores in the groundmass were relatively large and rounded to irregular. The larger pores were interconnected to form channel type networks while many of the intermediate and fine pores appeared isolated.

As the amount of dead burned magnesite is increased to amounts greater than about 10% in the chrome ore composition, the pyroxene type crystals will be converted to forsterite; however, an unreacted periclase phase will also be present. Such unreacted periclase in large amounts has been found to be deleterious to the bonding system of the invention. Accordingly, about 10%, by weight, dead burned magnesite is the preferred maximum.

A composition of the above type but containing about 12% dead burned magnesite, 3% preformed spinel grain and the balance chrome ore was prepared and examined. X-ray diffraction and microscopic examination revealed the mineral phases chrome spinel, periclase and forsterite. Bonding between the coarse grains and finer grains was poorly developed and discontinuous. Such a product would be considered unsuitable for the purposes of this invention.

A suitable magnesite material is one having a chemical analysis of about 95% MgO, the remaining 5%, by difference, being SiO_2, CaO, Fe_2O_3, alkalies and ignition loss. An exemplary preformed spinel analyzed about 73% Al_2O_3, about 18.5% MgO, about 0.5% SiO_2, about 0.7% Cr_2O_3, about 2.5% Fe_2O_3, the remainder, by difference, being alkalies, other impurities and ignition loss.

A typical preformed spinel grain contains magnesium aluminate spinel, beta alumina, and calcium aluminate as major phases, with lesser amounts of various impurities. For example, in the grain employed herein, the magnesium aluminate spinel was the single largest phase, amounting to about 60% of a representative sample studied. The beta alumina was present in an amount equal to about 8% of the sample, and calcium aluminate ($CaO \cdot 6Al_2O_3$) amounted to about 20%. Generally, in the grain, the magnesium aluminate spinel ranges between about 50 and 70% of the sample, the beta alumina being between about 5 and 10%, with the calcium aluminate being present in amounts between 15 and 25% and impurities ranging from 5 to 10%. The magnesium aluminate spinel occurs as massive to euhedral accumulations, developing cubic form particularly where embedded among well developed crystals of translucent calcium aluminate. The preformed spinel grain is substantially all in the fine −65 mesh fraction of the batch.

A preferred chrome ore material for use in the present

invention is Philippine or Moa chrome ore, the typical chemical analyses of which, are set forth in Table I below:

TABLE I

	Moa, percent	Philippine, percent
SiO_2	4.1	5.5
Al_2O_3	26.3	29.2
FeO	13.9	12.6
Cr_2O_3	35.6	32.1
CaO	0.3	0.6
MgO	17.2	18.8
Ignition loss	1.4	1.0

Preponderantly chrome ore brick bats may replace a portion of the chrome ore materials. The foregoing analyses, of course, are but typical. They are on the basis of an oxide analysis, in conformity with the conventional practice of reporting the chemical analysis of refractory materials.

Merely by way of example, a preferred size grading for the dry ingredients set forth in the preferred embodiment of the invention, is as follows: −4 +10 mesh, about 15%; −10 +28 mesh, about 20%; −28 +65 mesh, about 20%; and −65 mesh, about 45%. Of the 65 mesh fraction about 30% will pass a −150 mesh screen. The preformed spinel grain and the dead burned magnesite are substantially all −150 mesh, with the chrome ore being so size graded as to provide the desired total screen analysis for the batch.

A plurality of test samples illustrating the optimum composition were prepared as follows: the dry ingredients consisting of 85% chrome ore, 10% preformed spinel mineral, and 5% magnesite were mixed in a muller type mixer for about 5 minutes; about 4% of a tempering fluid was then added to the dry ingredients and mixing continued for a few more minutes. The tempering fluid employed in the laboratory was comprised of about 2 parts lignin and about 2.5 parts of water, both based on the total weight of the dry solids. Of course, other tempering fluids, well known to those skilled in the art, may be used. The wet batches were formed into shapes by power pressing at about 6000 p.s.i. and were burned to cone 23. The bulk density of the burned shapes made from the foregoing batch averaged 186 p.c.f. The cold crushing strengths of the shapes averaged 7360 p.s.i. and the modulus of rupture 2970 p.s.i. The temperature of failure of the shapes under load test at 25 p.s.i. was on the average, 3075° F.

In an actual bottom pour ladle service installation, in which burned fireclay refractory sleeves of prior composition had been used, and which were resulting in many leaking sleeves and failures, sleeves according to this invention were substituted. A 60 ton tea pot ladle was filled from a basic open hearth furnace operating at about 3000° F. Metal was poured from the tea pot ladle into a smaller ladle. The smaller ladle had a refractory protective sleeve around the stopper rod according to this invention. The metal was poured therefrom into a series of molds. The temperature at the beginning of the pouring was about 2900° F., and at the end was about 2850° F. The foregoing was repeated, and the small ladle was emptied and filled 10 times during this particular test. Visual examination of the sleeve after the test revealed no cracking, and no erosion.

Having thus described the invention in detail and with sufficient particularity as to enable those skilled in the art to practice it, what is desired to have protected by Letters Patent is set forth in the following claims.

We claim:

1. In vessels for handling molten metal, comprised of a shell, a stopper rod assembly including a metal rod, a stopper head and a protective sleeve, the improvement comprising a fired basic refractory protective sleeve made from a batch consisting essentially of at least 85% chrome ore, about 1 to 10% preformed spinel grain and about

3 to 10% dead burned magnesite, said sleeve being mineralogically characterized by about 85 to 90% of a solid solution of a spinel complex consisting of the compounds MgO, FeO, Al_2O_3, Cr_2O_3 and Fe_2O_3 and the balance forsterite and pyroxene crystals.

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