Sept. 22, 1970 R. K. MACK 3,529,753

PRESSURE POURING TUBE

Filed Jan. 13, 1969

FIG. 1

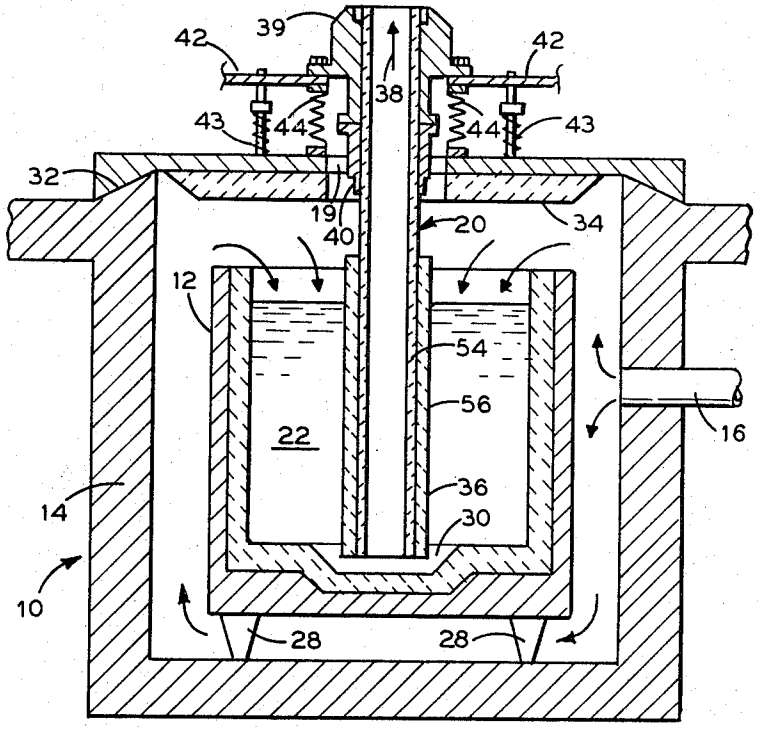


FIG. 2

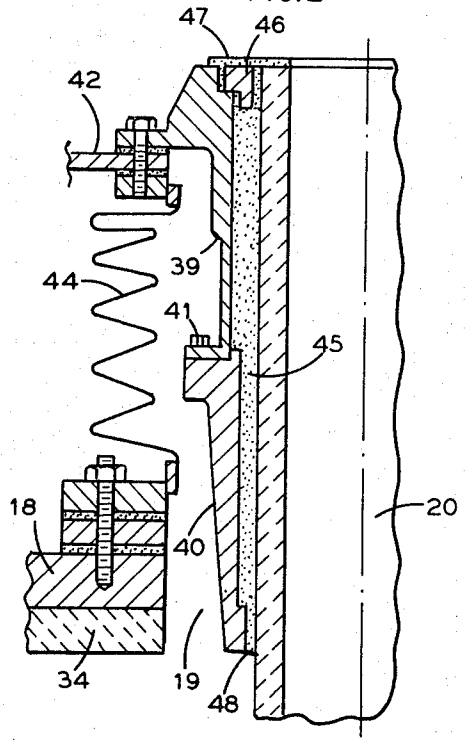


FIG. 3

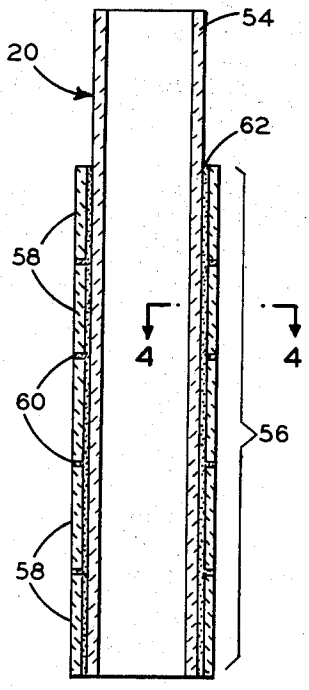
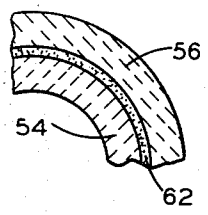


FIG. 4



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PRESSURE POURING TUBE

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Continuation-in-part of application Ser. No. 506,095, Nov. 2, 1965. This application Jan. 13, 1969, Ser. No. 790,712

Int. Cl. B67d 5/60

U.S. Cl. 222—464 11 Claims

ABSTRACT OF THE DISCLOSURE

A refractory pouring tube of the type employed in pressure casting molten steel from a melt thereof by applying a superatmospheric pressure to the surface of the melt to force it upwardly through the tube for discharge into a mold. The tube comprises a fired inner tubular member of refractory composition, a fired outer tubular member of refractory composition within which the inner member is receivable so as to form an annular space between them, and a refractory mortar in the annular space to join the members together. The outer member extends longitudinally of the length of the inner member for at least the length of the tube which is to be immersed in molten steel.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my prior filed copending parent application S.N. 506,095, filed Nov. 2, 1965 and claims an invention disclosed in said prior copending application. The benefit of the filing date of said prior application is hereby claimed.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to refractory pouring tubes of the type employed in pressure casting molten metals.

As is well known, controlled pressure pouring is a direct method of casting slabs from a ladle containing molten metal. A cap for sealing the open top of the ladle, or for sealing a container holding the ladle, is provided with a vertically extending, refractory pouring tube. In practice, the tube is oriented with the inlet, or lower end, of the tube immersed in the melt; and the outlet, or upper end, extending through the cap. Superatmospheric pressure applied to the surface of the melt forces the molten metal upwardly through the pouring tube for discharge into a mold.

The success of this pressure pouring method depends for efficiency and economy in no small measure on the durability and dependability of the pressure pouring tube. It is therefore a principal object of the present invention to provide a long-lasting refractory pouring tube which can be used for many heats to pour a large number of slabs before it must be replaced.

Ideally, a pressure pouring tube has a wall of dense, impermeable construction in order to resist flow therethrough of the pressurized air or gas used to force molten metal up the tube. In addition, the tube should be capable of withstanding not only the thermal shock of immersion in 2950° F. molten steel, but also chemical attack from hot slag on its exterior surface, as well as erosion of its internal surface from the flow of hot metal therethrough.

In the course of developing tubes for use with the pressure pouring process for pouring molten steel, it was found that a monolithically formed tube could not be used to pour more than 30 tons of molten steel. To increase the tonnage the wall thickness of the tube had to

be increased. However, when the wall thickness of the tube was increased, the tube could not withstand the thermal shock of being immersed in molten steel even after the tube was preheated to 1800° F. For example, assume a monolithically formed tube having a wall thickness of "*d*" inches can withstand the thermal shock of being immersed in molten steel, but if its wall thickness is increased beyond "*d*" inches it cannot withstand the shock. In an effort to increase the life of the tube I experimented with a composite tube comprising an inner cylindrically-shaped member of monolithic construction which was receivable within an outer cylindrically-shaped member of like construction, assembled them so as to form an elongated annular space between them, and filled the space with mortar. With the composite tube I found I could make the wall thickness of each of the members "*d*" inches in thickness. Thus the portion of the composite tube which was to be immersed in molten steel could have a wall thickness of "2*d*" inches and the pouring life of the tube thereby increased. I believe the reason the composite tube is able to withstand the thermal shock of being immersed in the molten steel is because the mortar joint between the inner and outer members allows for movement of the members relative to one another when they are immersed in molten steel. The outer member may be made of a plurality of annuli stacked in series as shown in my copending application S.N. 506,095, without departing from the spirit and scope of the invention. The composite tubes have been used to pour up to 200 tons of steel without being replaced.

Accordingly, the invention comprises, a refractory pouring tube of the type employed in pressure casting molten steel from a melt thereof by applying a superatmospheric pressure to the surface of the melt to force it upwardly through the tube for discharge into a mold. The tube comprises a fired inner tubular member of refractory composition, a fired outer tubular member of refractory composition within which the inner member is receivable so as to form an annular space between them, and a refractory mortar in the annular space to join the members together. The outer member extends longitudinally of the length of the inner member for at least the length of the tube which is to be immersed in molten steel. The outer tubular member may be made up for the desired height of a stacked series of annuli joined together with mortar to form an elongated annulus as described in my parent application.

Further, the invention may be said to comprise a tube made entirely of refractory materials and immersible in molten steel, comprising, a first annular member of ceramic refractory composition, a second annular member of ceramic refractory composition adaptable to receiving therewith the end of the first member which is to be immersed in molten steel, the members assembled so as to form an annular space therebetween which extends longitudinally of the length of the tube, and a refractory mortar entirely filling the annular space to join the members together.

The refractory compositions of the tube components including the inner and outer members and the mortar are described more fully in the detailed description which follows. The method of making the components and assembling the same are also described hereinafter in detail.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view of pressure pouring apparatus incorporating the pressure pouring tube of the present invention;

FIG. 2 is an enlarged view of a fragment of the apparatus of FIG. 1;

FIG. 3 is a vertical sectional view of an enlarged scale of the pressure pouring tube of FIG. 1 in another form; and

FIG. 4 is an enlarged, horizontal sectional view of the pressure pouring tube of FIG. 1, taken along line 4—4 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, pressure pouring apparatus incorporating the invention may comprise an airtight container **10** for a ladle **12**, the container including a vessel body **14** provided with a pressurized air inlet **16** and also a cover **18** having a central hole **19** fitted with a refractory tube **20**. The latter serves to conduct molten metal **22** under superatmospheric pressure, say 60 p.s.i., upwardly from the bottom of the ladle **12** through a suitable gate and passageway (not shown) to a mold (also not shown). It is the application of gas pressure to the surface of the melt **22** that forces molten metal up the tube **20** in the direction of the arrow **38** and into the mold.

The body **14** of the container **10** may be made of concrete and/or steel and of sufficient size to receive the ladle **12** therein on supporting legs **28**, with generous clearance on all sides of the ladle. Molten metal **22** may be supplied to the ladle **12** from one or more furnaces (not shown). The ladle **12** may be made of refractory and steel material in any suitable vessel shape which is open at the top, preferably with a sump **30** formed in the bottom thereof to provide a point from which molten metal may be withdrawn from the ladle **12**.

The mutually facing surfaces **32** of the body **14** and the cover **18** are preferably frusto conical in order that the cover **18** will seat centrally on the body **14** in registering, as well as sealing, relationship. In addition, an underside portion of the cover **18** positioned above the open top of the ladle **12** has a suitable insulating refractory lining **34**. Carried upright by a centrally apertured portion of the cover **18** is the pressure pouring tube **20**, with its lower or inlet end **36** being adapted for reception in the sump **30** and its upper or outlet end **38** extending upwardly through and beyond the cover **18**, as shown.

As shown in FIGS. 1 and 2, the tube **20** depends from a tubular pouring head **39** and a tapered tubular holder **40**. The latter two parts **39** and **40** are bolted together at **41** in axial alignment and they are carried on a supporting plate **42** which, in turn, rests on the cover **18** through resilient members **43**. Further provided is a metal bellows type of expansion joint **44** which effects a seal between the cover **18** and the pouring head **39**, thereby maintaining air or gas pressure within the container **10** despite the hole **19** in the cover **18**. A refractory mortar composition **45**, poured in the tapered annular space between the tube **20** and the assembly of the head **39** and the holder **40**, adheres to the outer surface of the tube **20** so that the holder **40** holds the tube **20** against downward movement by engagement with the mortar filler joint **45**. A metal ring **46** rests in the mortar composition **45** at the top thereof; and an annular asbestos gasket **47** rests on the top surface of the assembly. In addition, a fillet **48** of enamel glaze between the tube **20** and the annular lower end surface of the mortar joint **45** seals the interface and the end surface of the joint.

A plurality of molds may be used one after the other for pouring slabs by the introduction of molten metal thereto through a mold gate movable for controlling the flow of discharged molten metal from the tube outlet **38**. Opening the mold gate admits molten metal under pressure to the mold cavity until it is filled, after which the gate is closed to prevent further flow of molten metal into the mold cavity. Simultaneously with the closing of the mold, gate pressure is preferably reduced in the container **10** until the next mold is positioned and ready to be poured.

In one embodiment, the pressure pouring tube **20** of the present invention comprises an inner tubular member **54**, preferably of cylindrical shape, an outer tubular member **56** may be made up of ring collars or cylindrical annuli **58** stacked one above the other, and a mortar joint **60** between the ends of the annuli **58** and an annular mortar joint **62** between the inner and outer members **54** and **56** to join them all together. However, in the preferred embodiment the outer member **56** is made in the same form as the inner member **54**, an elongated annular member molded as a single section as shown in FIG. 1. In either embodiment the members **54**, **56**, **58** are of monolithic construction and of sufficient wall thinness to resist the thermal shock of being immersed in molten steel, at least after the composite tube formed thereby is preheated to aproximately 1000° F. However, it is understood that the commercial product need not be so preheated prior to shipment to the consumer. One embodiment or the other may be chosen depending on the availibility of capital equipment. An annular space of from $\frac{3}{32}$ to $\frac{3}{8}$ inches wide between the members **54** and **56** has been found suitable to permit the mortar to be introduced by making it in the consistency of a thin slurry which can be poured into the open top of the annular space. The entire tube **20** including the mortar for the joints **60** and **62** is made of refractory material which is resistant to erosion, slag attack, and thermal shock.

In the preferred embodiment, the inner and outer members **54** and **56** of the tube **20** are both preferably molded from a batch made in several steps. In the first step the following ingredients, in the indicated proportions by weight, are dry mixed in a muller-type mixer:

	Percent
4 mesh kaolin calcine, RC 193–1	34.8
4 mesh RASC bauxite, RC 260–1	17.7
35 mesh kaolin calcine, RC 376	17.2
35 mesh RASC bauxite, RC 376	9.1
—325 mesh A–2 alumina	7.6
Pulverized kaolin	8.5
Russell clay	4.0
Bentonite	1.1

Russell clay is present in the mixture as a bloating clay to compensate for shrinkage resulting from the presence of other ingredients such as pulverized kaolin, with the result that the tube wall is better able to resist the flow of pressurized air therethrough. Bentonite is a plastic clay which serves as a molding aid. And the main ingredients, kaolin calcine and bauxite, are refractory materials of high alumina content having a high resistance to erosion and chemical attack by molten slag.

To the above dry mix is added 6% water and 1.25% of lignon-sulfonate, a binder commercially available as Additive-A from suppliers of refractory materials, so that by further mixing the wet mixture is prepared. If necessary this mixture can be moisture sealed and stored for up to 48 hours before use, or it can be used immediately, by ramming it in an upright core mold which is rotating as the mixture is added and rammed as fed to a density sufficiently high to be gas impermeable and resistant to slag attack, yet without being so excessively dense as to be prone to thermal shock failure. The molded members **54** and **56** are air dried, then fired in a periodic kiln in which the temperature is increased over a 43 hour period to 2450° F. and held at this temperature for an additional 8 hours.

After firing and cooling, the tube components **54** and **56** are wetted with water and assembled as shown in FIG. 1 with $\frac{3}{32}$ and $\frac{3}{8}$ inch elongated annular space between them and the mortar slurry is poured from above into the annular space between the inner and outer members **54** and **56** to provide the mortar joint **62**. The assembly is then dried at 200 to 250° F., after which it is ready for use.

A suitable mortar is made by adding sufficient water for the desired consistency to a mixture of the following

ingredients, according to the weight percentages indicated:

	Percent
35 mesh kaolin calcine, RC 376	25.0
35 mesh RASC bauxite, RC 376	54.0
Hamilton No. 2 clay	11.0
Sodium silicate, brand GD	10.0

Optionally, 0.75% of Nodex–525 starch can be added to the mixture.

Although mixtures according to the percentage indicated are preferred, it is possible to deviate by using 10% more or less than the amount specified in making the tube **20** of the present invention, with acceptable results.

The pressure pouring tube hereinbefore described is seen to have an increased wall thickness for the length thereof which is to be immersed in molten metal. The finished tube is distinguishable over prior art pouring tubes of the type employed in pressure casting molten steel in that the portion thereof which is immersed in the melt is not monolithically formed although it is made entirely of refractory material. In addition, it should be noted that members **54** and **56** are fired after being dried, but after the members are assembled so as to form an annular space between them and a mortar slurry poured in the space to join the members together, the pouring tube thus formed is not again fired. That is, the mortar is not fired during the process of manufacturing the pouring tube.

It is well known in the art that a single specimen of known refractory composition shaped such as either member **54** or **56** and having a wall thickness of say two inches, is better able to withstand the thermal shock of immersion in a molten metal bath than a like member having a greater wall thickness. The maximum wall thickness of a monolithically formed tube is limited by the temperature of the melt and the material from which it is made. With the disclosed type of construction the wall thickness can be significantly increased thereby increasing the life of the tube, so long as the individual members **54**, **56** can individually survive the thermal shock of immersion in the melt. It is well known in the art that the finished tube is preheated to within approximately 1000° F. of the temperature of molten steel before being immersed therein. If the members **54** and **56** are of refractory composition and each is formed having a wall sufficiently thin to survive immersion in the steel melt, the assembled tube will also survive such immersion. Of course, it should be appreciated that preheating is not necessary in the process of manufacturing the tube; may not be necessary prior to insertion in molten metal other than steel; and may not be necessary if the tube is constructed of other refractory materials. It is considered that the reason the pouring tube hereinbefore described is better able to withstand the thermal shock is because the individual members **54** and **56** are able to move relative to one another. That is, the mortar flexes slightly or otherwise compensates for differential thermal expansion as the tube adjusts to the temperature of the molten metal bath.

As disclosed in my copending patent application Ser. No. 506,095, filed Nov. 2, 1965 for a Pressure Pouring Tube, the pressure casting apparatus hereinbefore described may be said to comprise a ladle for containing molten metal, an upright pouring tube having an inlet and its lower end in communication with a lower portion of the ladle and a discharge outlet at its upper end, and means for applying superatmospheric pressure to the molten metal within the ladle to force the molten metal upwardly through the pouring tube; the pouring tube comprising an inner cylindrical member of substantially constant cross-section throughout the length thereof, and at least one outer cylindrical member receiving therewithin the lower end of the inner cylindrical member and extending longitudinally of the tube from the lower end of the pouring tube to above the level of the molten metal within the ladle, the pouring tube having a double wall provided by the member over at least the length of the tube that is immersed in the molten metal. Further, this pressure pouring apparatus may be provided wherein at least one of the members of the pressure pouring tube is made by molding and subsequently firing a raw batch of finely divided dry ingredients consisting by weight essentially of about 33.3 to 40.3% of 4 mesh kaolin calcine, from 16.0 to 19.5% of 4 mesh bauxite, from 15.5 to 18.9% of 35 mesh kaolin calcine, from 8.2 to 10.0% of 35 mesh bauxite, from 6.9 to 8.4% of −325 mesh alumina, from 7.4 to 9.4% of pulverized kaolin, from 3.6 to 4.4% of Russell clay, from 1.0 to 1.2% of bentonite, plus sufficient water to render the batch flowable; the pouring tube, over the length thereof which is double-walled comprising an inner and outer tubular members joined together by a refractory mortar, the outer member being shorter than the inner member; and the refractory mortar may be made by mixing water to the desired consistency, with the following ingredients: from 22.5 to 27.5% of 35 mesh kaolin calcine, from 48.6 to 59.4% of 35 mesh bauxite, from 9.9 to 12.1% of Hamilton clay, and from 9 to 11% of sodium silicate.

The foregoing invention includes, in the process of forming a refractory pouring tube (made entirely of refractory materials) of the type employed in pressure casting molten metal from a ladle by applying superatmospheric pressure to the surface of the metal to force it upwardly into the tube for discharge into a mold, a method of increasing the wall thickness of the tube for the length of the tube which is to be immersed in molten metal. The method generally includes or comprises the steps of forming a tubular member of refractory composition within which the length of the aforesaid tube is receivable, firing the member so formed and assembling it with the tube so as to form an annular space between them, and pouring a refractory mortar in the annular space between the tube and member to join them together. The step of forming the tubular member may include the step of ramming the refractory composition in a rotating core mold to a density sufficiently high to be gas impermeable and resistant to slag attack without being so excessively dense as to be prone to thermal shock. The process may include the step of mixing a batch of refractory materials mainly consisting of bauxite and kaolin calcine with sufficient water to make the refractory composition.

The process may be described as a process for forming a tube made entirely of refractory material and immersible in molten steel, comprising, the steps of molding a first elongated annular member of refractory composition, molding a second elongated annular member of refractory composition and adaptable to receiving therewithin the end of the first member which is to be immersed in molten steel, assembling the members so as to form an elongated annular space between them which extends longitudinally of the length of the members and pouring a refractory mortar in the annular space to join the members together. The refractory mortar is preferably made by mixing a mortar mainly consisting of bauxite and kaolin calcines with sufficient water to make it pourable between the members.

What is claimed is:

1. A refractory pouring tube made of refractory materials, the tube being the type employed in pressure casting molten steel from a melt thereof by applying superatmospheric pressure to the surface of the melt to force it upwardly through the tube for discharge into a mold and comprising,

(a) a fired inner tubular member of refractory composition having its inner surface directly exposed to the melt,

(b) a fired outer tubular member of refractory composition within which the inner member is receivable so as to form an annular space between them, the outer member having its outer surface directly exposed to the melt, the outer member extending longitudinally of the length of the inner member for at least the length of the tube which is to be immersed in the melt, and

(c) a refractory mortar in the annular space to join the outer surface of the inner member and the inner surface of the outer member directly together along the full length of the outer member, said refractory mortar being of the type permitting differential thermal expansion between the inner and outer members,

(d) each of said members being of sufficient wall thinness to resist the thermal shock of being immersed in the melt.

2. The tube according to claim 1 wherein the refractory compositions each comprise a batch of ceramic refractory materials rammed to a sufficient density to be gas impermeable and resistant to slag attack without being so excessively dense as to be prone to thermal shock failure.

3. The tube according to claim 1 wherein the refractory composition of the outer tubular member is a rammed batch of refractory materials mainly consisting of bauxite and kaolin calcines with sufficient water to make said refractory composition.

4. The tube according to claim 1 wherein the refractory composition of the outer tubular member is a rammed batch of refractory materials having a high resistance to slag attack and thermal shock mixed with sufficient water to make said refractory composition.

5. A refractory pouring tube made of refractory materials, the tube being the type employed in pressure casting molten steel from a melt thereof by applying superatmospheric pressure to the surface of the melt to force it upwardly through the tube for discharge into a mold and comprising, a fired inner tubular member of refractory composition, a fired outer tubular member of refractory composition within which the inner member is receivable so as to form an annular space between them, and a refractory mortar in the annular space to join the members together, said refractory mortar being of the type permitting differential thermal expansion between the inner and outer members, the outer member extending longitudinally of the length of the inner member for at least the length of the tube which is to be immersed in molten steel and comprising a plurality of annular members arranged in series to receive the inner member therewithin.

6. A tube made entirely of refractory materials only and immersible in molten steel, comprising, a first annular member of ceramic refractory composition, a second annular member of ceramic refractory composition adapted to receive therewithin the end of the first member which is to be immersed in molten steel, the members assembled so as to form an annular space therebetween

which extends longitudinally of the entire length of the second member, and a refractory mortar entirely filling the annular space to join the members together, each of the annular members being of sufficient wall thinness to resist the thermal shock of being immersed in molten steel, said refractory mortar being of the type permitting differential thermal expansion between the inner and outer members, the wall thickness of the tube for at least the length thereof which is to be immersed in molten steel being greater than the maximum wall thickness of a monolithically formed refractory tube which is able to withstand the thermal shock of being immersed in molten steel.

7. The tube according to claim 6 wherein the annular members are fired members.

8. The tube according to claim 6 wherein the refractory composition of the second annular member is a fired batch of refractory materials rammed to a density sufficiently high to be gas impermeable and resistant to slag attack without being so excessively dense as to be prone to thermal shock failure.

9. The tube according to claim 6 wherein the refractory mortar is made from a mix of mainly bauxite and kaolin calcines with sufficient water to make the mix flowable.

10. The tube according to claim 6 wherein each of the members is a fired molded member of sufficient density to be gas impermeable without being so excessively dense as to be prone to thermal shock failure.

11. A tube made entirely of ceramic refractory materials and immersible in molten steel, comprising, a first annular member of ceramic refractory composition, a second annular member of ceramic refractory composition adaptable to receiving therewithin the end of the first member which is to be immersed in molten steel, the members assembled so as to form an annular space therebetween which extends longitudinally of the length of the tube, and a refractory mortar entirely filling the annular space to join the members together, said refractory mortar being of the type permitting differential thermal expansion between the inner and outer members, the outer member comprising a plurality of annular members arranged in series to receive the inner member therewithin.

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H. S. LANE, Assistant Examiner

U.S. Cl. X.R.

138—177; 164—306; 222—394