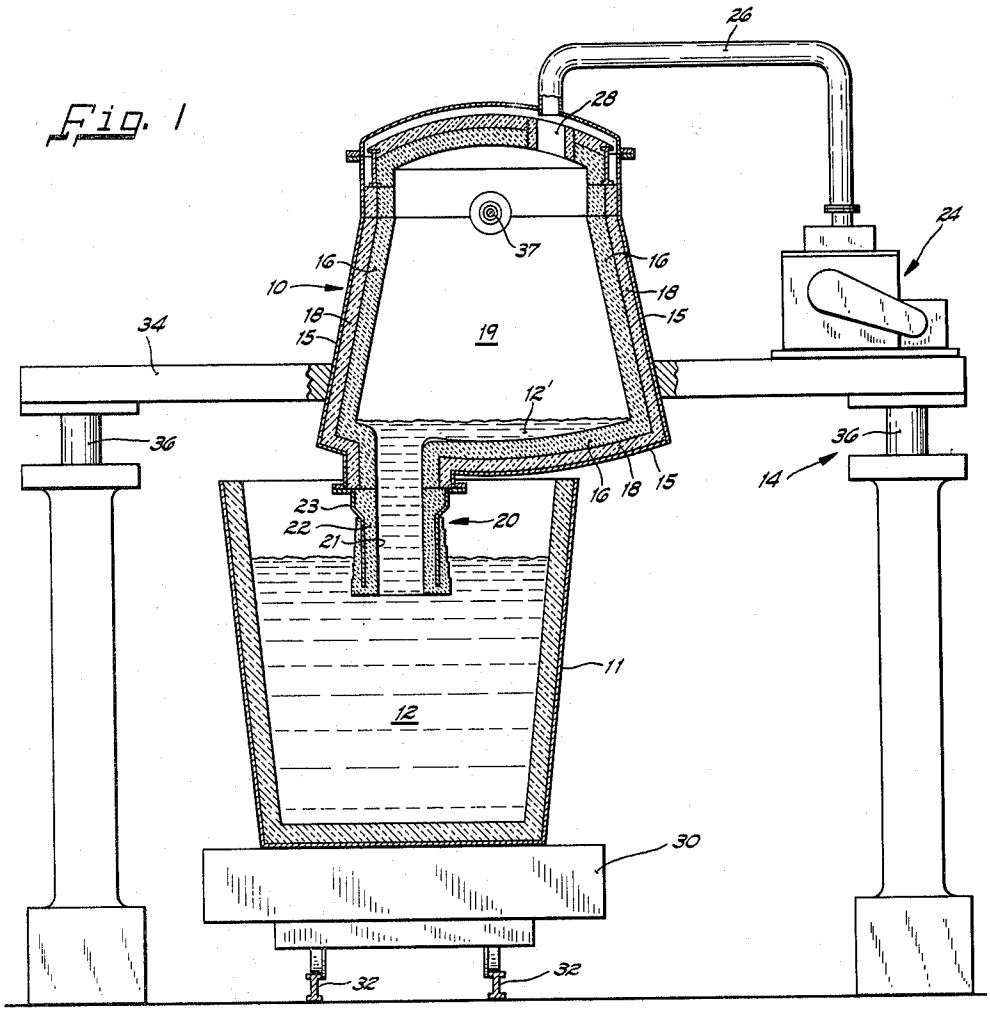
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APPARATUS FOR DEGASSING METALS

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Fig. 1



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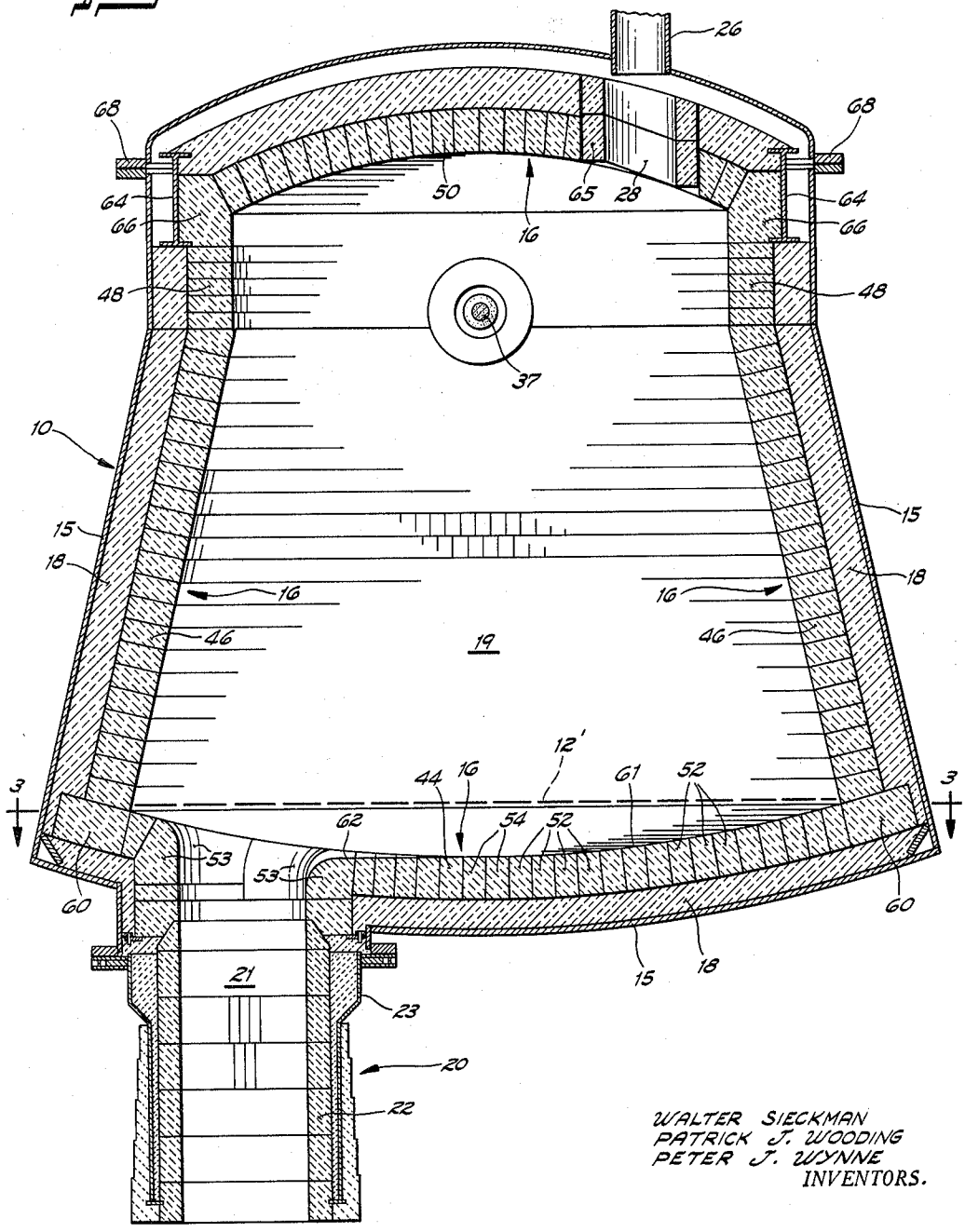
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Fig. 2



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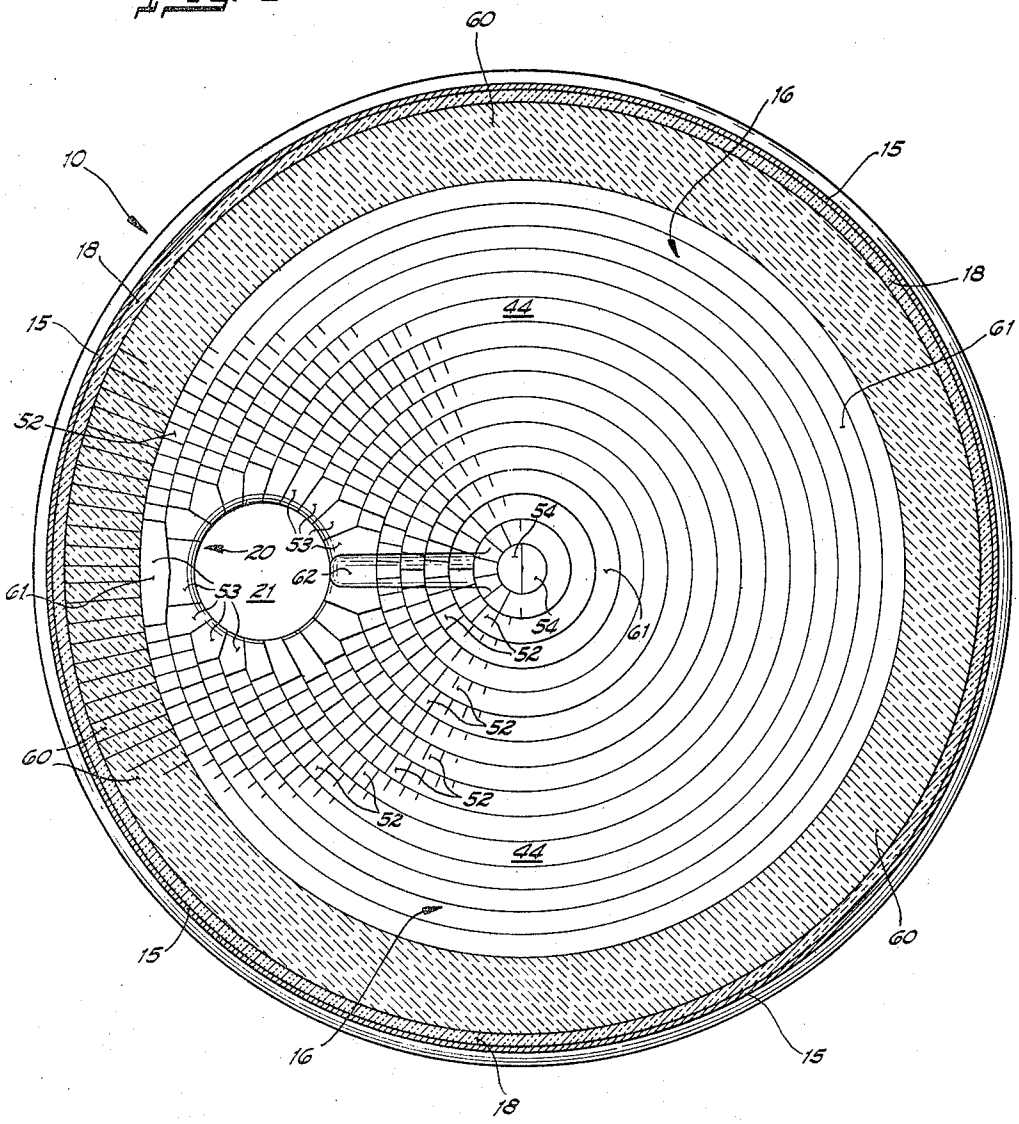
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Fig. 3



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3,246,889

APPARATUS FOR DEGASSING METALS

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2 Claims. (Cl. 266—34)

This invention relates to apparatus for the vacuum degassing of molten metals and, more particularly, to a refractory lining for a vacuum degassing vessel.

The production of certain steel alloys requires the reduction of oxygen, carbon and hydrogen. Because chemical reactions involving these elements have a gas phase and can be made to occur at reduced pressures, their removal can be accomplished expeditiously by treating the melt in a vacuum chamber.

The type of vacuum degassing apparatus to which the instant invention applies is one wherein a vacuum chamber is disposed above a ladle of molten metal and the two are arranged for relative movement toward and away from each other. A nozzle extends downwardly from the lower end of the vacuum chamber so that upon relative movement of the chamber and ladle toward each other, the reduced pressure in the chamber draws molten metal through the nozzle, whereupon degasification takes place due to the action of the partial vacuum therewithin. Upon relative movement of the chamber and ladle away from each other, the molten metal discharges from the nozzle to intermix with the main body of melt within the ladle. If desired, a new portion of melt may then be redrawn into the chamber by again relatively moving the vessel and chamber toward each other. This process is repeated until the desired degree of degasification has been achieved.

It is an object of the invention to provide a refractory lining for a vacuum degassing chamber wherein the exposed surface area of the molten metal within the chamber is very large relative to its volume.

Another object of the invention is to provide a refractory lining for a vacuum degassing chamber having sufficient inherent strength without additional structural members to support the weight of molten metal and to withstand the strains of expansion due to heating and the turbulence of the melt during treatment.

A further object of the invention is to provide a lining for a vacuum degassing chamber wherein maximum use of standard refractory shapes is possible.

Another object of the invention is to provide a refractory lining for a vacuum degassing chamber having a nozzle for conducting molten metal to and from a ladle wherein turbulence of the inrushing and discharging metal is minimized.

A still further object of the invention is to provide a refractory lined vacuum degassing chamber having a base portion which allows uniform heat radiation.

These and other objects and advantages of the invention will become apparent from the detailed description of the invention taken with the accompanying drawings in which:

FIG. 1 is a side elevational view, partly in section, of the vacuum degassing apparatus incorporating the instant invention;

FIG. 2 is a sectional view showing a vacuum degassing chamber according to the instant invention; and

FIG. 3 is a view taken along lines 3—3 of FIG. 2.

In general terms, the invention comprises a refractory lining for a vacuum degassing vessel having a nozzle extending from its lower end for drawing molten metal into said vessel for degasification from a ladle disposed therebelow. The refractory lining, according to one aspect

of the instant invention, includes a base portion comprising a plurality of refractories disposed in side-by-side abutment and substantially defining a spherical sector. According to another aspect of the invention the central bore of the nozzle opens into the vessel and is surrounded by a plurality of refractories in the base portion which have a curved surface terminating in said bore and the spherical surface of the base to provide a smooth transition therebetween.

The refractories at the center of the spherical base portion of the lining are preferably constructed and arranged so that the remainder of the refractories in the spheroidal configuration have standard shapes. In addition, the side walls of the lining may comprise a plurality of courses of standard refractories substantially defining the frustrum of a right circular cone intersecting the spherical sector. Also, in the preferred embodiment, the refractories at the intersection of the bottom and side walls of said lining have a skewback shape with intersecting surfaces defining the margins of said base portion and side walls.

Referring now to the drawings in greater detail, FIG. 1 shows vacuum degassing apparatus comprising a vessel **10**, a ladle **11** containing molten metal **12** and a lifting mechanism **14** for supporting the vacuum chamber **10** and for moving it vertically relative to the ladle **11**. The degassing vessel **10** includes a steel shell **15** which encloses an inner refractory lining **16**. Heat insulating material **18** is disposed between the metallic shell **15** and the refractory lining **16** to minimize heat radiation losses from the vessel **10**. The steel shell **15** provides a support for, and hermetically seals the chamber **19**, defined by the relatively porous refractory lining **16**.

A nozzle **20** is affixed to the lower end of vessel **10** and has a cylindrical bore **21** that communicates with the chamber **19**. The nozzle **20** is also provided with a refractory lining **22** and a metallic shell **23**. It will be noted that the lower end of nozzle **20**, which extends below the surface of melt **12** during a degassing operation, is also provided with a refractory jacket at its outer surface to prevent the contact of shell **23** with the molten metal **12**.

An evacuating apparatus **24** is connected to the chamber **19** by a conduit **26** which is connected to the shell **15** in a hermetically sealed relationship adjacent an aperture **28** in the refractory lining **16**. A car **30** movably mounted on rails **32** below vessel **10** is provided to support and position the ladle **11**. The lifting mechanism **14** includes a platform **34** upon which the vessel **10** is affixed, and a plurality of coordinated hydraulic rams **36** for moving the platform **34** and vessel **10** vertically. Control of the hydraulic rams **36** is effected by an operator stationed at a remote location. While the vessel **10** is shown to be vertically movable in the preferred embodiment, it will be appreciated that the device would operate equally as well if the vessel **10** were stationary and the ladle **11** movable.

Operation of the vacuum degassing apparatus will now be described. After the ladle **11** of molten steel **12** has been positioned below the vessel **10**, the latter is lowered until the nozzle **20** extends a predetermined distance below the surface of the melt **12**. The evacuating apparatus **24** is then activated to produce a partial vacuum within the chamber **19**. As a result of the difference between the pressure within chamber **19** and the atmospheric pressure acting on the surface of the melt **12**, a portion of said melt, identified by the reference numeral **12'** to distinguish it from the main body of the melt **12**, is forced upwardly through the nozzle **20** and into the chamber **19** where gases dissolved therein are drawn off by the operation of the partial vacuum. After this portion **12'** of the melt **12** has been degassed for a predetermined length of time, the vessel **10** is raised, thereby causing the melt **12'**

to discharge into the ladle 11 to produce a vigorous stirring with the remainder of the melt 12. The lower end of the nozzle 20, however, remains below the surface of the melt 12 to maintain the partial vacuum within the chamber 19. This process may then be repeated, by successively lowering and raising vessel 10, until the desired degree of total degasification has been achieved.

In order to replace the heat lost from the melt 12 during the degassing operation, heating means is provided, such as the carbon rod heating element 37 which is shown to extend across the upper end of vessel 10. It will be appreciated that the element 37 will be supplied by a suitable source of electrical energy (not shown). The disposition of element 37 in the upper end of chamber 19 protects it from damage by the turbulently inflowing melt 12' and also prevents the addition of any undesired carbon to melt 12' which might result if contact with the melt 12' were not prevented.

Referring now specifically to FIG. 2, the lining 16 of degassing vessel 10 is shown to be divided into four distinct structural portions. These consist of base portion 44 having a spherical configuration; side walls 46 having a frustro-conical configuration; a cylindrical neck portion 43; and a spherical roof or cover 50. The purpose for the particular geometric shape of each of these portions of the vessel 10 will be explained in detail in the ensuing paragraphs.

The base portion 44 of lining 16 consists of a plurality of refractories 52 which substantially define a spherical sector. The refractories 52 are laid in a plurality of substantially annular courses, except those 53 which define the throat of the nozzle 20 and those 54 at the center of the sector. In order to economize in the construction of a refractory lining, it is desirable to employ as many standard refractory shapes as possible. A standard shape, of course, being one which manufacturers regularly produce and stock. The spherical configuration of base 44 allows those refractories 52 in the annular courses to have such standard shapes. The configurations of these refractories as well as 53 and 54 are shown in FIGS. 2 and 3.

The spherical contour of the base portion 44, which has a radius of curvature much larger than the over-all height of the vessel 10, provides several distinct advantages. Before these can be fully appreciated, however, it should be recalled that when the vessel 10 is lowered into the ladle 11 a large mass of molten metal 12' will be drawn rapidly into the chamber 19 and in contact with the relatively cold lining 16. The spherical shape provides the strength required to support this large mass without the necessity of additional structural members beneath the vessel 10. Such structures would interfere with movement of the vessel 10 and ladle 11 into close proximity necessitated by the fact that the barometric height for molten steel is approximately 4 feet 8 inches which limits the stroke of vessel 10 to about 25 inches. In addition, the inrush of hot molten metal against the relatively cold lining 16 causes rapid expansion thereof. The additional strength necessary to withstand the strains of this expansion and those introduced by the turbulence of the molten melt 12' during the degassing process, is also provided by the spherical form of the base portion 44.

It should be appreciated, also, that the greatest degassing efficiency is achieved when the surface area of melt exposed to the vacuum is as large as possible for any given volume of melt 12' within chamber 19. This efficiency is obtained in the spherical configuration because it maintains the melt 12' in a shallow pool without a sacrifice in structural strength.

In addition, the spherical shape allows uniform heat loss from the lower end of vessel 10 so that the various portions of the melt within chamber 19 will have a substantially uniform temperature. Also, the smooth continuous surface of the base portion 44 of lining 16 reduces the amount of wear due to the turbulence of the melt 12. Another advantage results from the fact that the spherical shape of the base 44 causes each of the individual refractories 52, 53 and 54 to be slightly larger at its bottom than at its upper surface so that they are "locked" in place.

The roof 50 of lining 16 is also a spherical sector to facilitate the reflection of heat from the element 37. In addition, the side wall 46 of lining 16 is composed of a plurality of courses of standard refractories and has a truncated conical configuration to enhance the radiation of heat from the element 37 to melt 12' and to reduce heat loss. In addition, the shape of the side wall 46 allows the use of a shorter heating element. A course of special refractory shapes 60 is provided at the intersection of the conical side wall 46 and the spherical base 44 of lining 16. These members are called skewbacks and perform the function of supporting the side wall 46 and transferring the expansion of the lining 16 to the compactible layers of insulating material 18 between it and the steel shell 15.

As seen in FIG. 2, each of the refractory shapes 53 which surround the throat of nozzle 20 has a curved surface that terminates at one end in the bore 21 of nozzle 20 and at its other end in the upper surface 61 of the base 44 to produce a smooth transition therebetween. This reduces the turbulence of the melt 12 as it is drawn into chamber 19 thereby diminishing the wear on these shapes and also the refractories 52 and 54 which compose the base 44 of lining 16. In addition, a notch 62 is cut in base 44 from its lowest point to the throat nozzle 20 in order to insure complete drainage of chamber 19.

It will be appreciated that the molten metal 12' within chamber 19 acts almost exclusively on base 44 and the side walls 46 of lining 16. The roof 50 of lining 16, however, being relatively remote from the melt 12' is affected to a much smaller degree and, accordingly, will last several times longer than the remainder of the lining 16. As a result, the roof is constructed in such a manner that it may be lifted from the remainder of the vessel and replaced thereon after a new lining has been provided for the base 44 and the side walls 46. The roof of vessel 10 includes a circular I-beam 64 which holds an annular course of skewbacks 66 which, in turn, support the refractories that compose the arched roof 50 of the lining 16. In addition, a plurality of special refractory shapes 65 surrounds the vacuum flue 28. When it is desired to lift the roof 50, a flange coupling 68 connecting the roof portion of the shell 15 to the remainder thereof, is opened and a lifting means is applied to the circular I-beam 64.

While only a single embodiment of the instant invention has been shown and described, it is intended to cover in the appended claims all modifications that fall within its true scope.

We claim:

1. In a vacuum degassing vessel of the type having a nozzle extending from its lower end and means for producing relative movement of said vessel and a ladle of molten metal disposed therebelow so that a change in the relative distance between said vessel and ladle will draw molten metal through said nozzle and into said chamber for degasification, the improvement comprising a refractory lining for said vessel, the lower end of said lining forming a base portion and being defined by a plurality of refractories disposed in side by side abutment and substantially defining a spherical sector, the radius of curvature of said spherical sector being substantially larger than the height of said vessel so that the melt within said vessel will form a shallow pool having a large surface area, said nozzle having a central bore whose upper end opens into the lower end of said lining, a plurality of refractory shapes in said base portion and surrounding the upper end of said bore, each of said refractory shapes having a curved surface terminating in said bore and the spherical upper surface of said base to provide a smooth transition therebetween, the side walls of said lining comprising a plurality of courses of refractories substantially

defining the frustrum of a right circular cone intersecting said spherical sector, the course of refractories at the intersection of the base portion and side walls of said lining being of a skewback shape and having intersecting surfaces which abut the margins of the base portion and side walls of said lining.

2. In a vacuum degassing vessel of the type having a nozzle extending from its lower end and means for producing relative movement of said vessel and a ladle of molten metal disposed therebelow so that a change in the relative distance between said vessel and ladle will draw molten metal through said nozzle and into said chamber for degasification, the improvement comprising a refractory lining for said vessel, the base portion of said lining begin defined by a plurality of refractories disposed in side by side abutment and substantially defining a spherical sector, the radius of curvature of said spherical sector being substantially larger than the height of said vessel so that the melt within said furnace will form a shallow pool having a large surface area, said nozzle having a central bore whose upper end opens into said vessel through said base portion, a plurality of refractory shapes in said base portion and surrounding the upper end of said bore, each of said refractory shapes having a curved surface terminating in said bore and the spherical upper surface of said base to provide a smooth transition therebetween, the side walls of said lining comprising a plurality of refractories substantially defining the frustrum

of a right circular cone intersecting said spherical sector, the course of refractories at the intersection of the base portion and side walls of said lining being of a skewback shape and having intersecting surfaces which abut the margins of the base portion and side walls of said lining the roof of said lining also defining a spherical sector supported atop said side walls by a course of refractories having a skewback configuration, said roof being detachably mounted on said side walls.

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