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(54) **REFRACTORY ELEMENT, ASSEMBLY AND TUNDISH FOR TRANSFERRING MOLTEN METAL**

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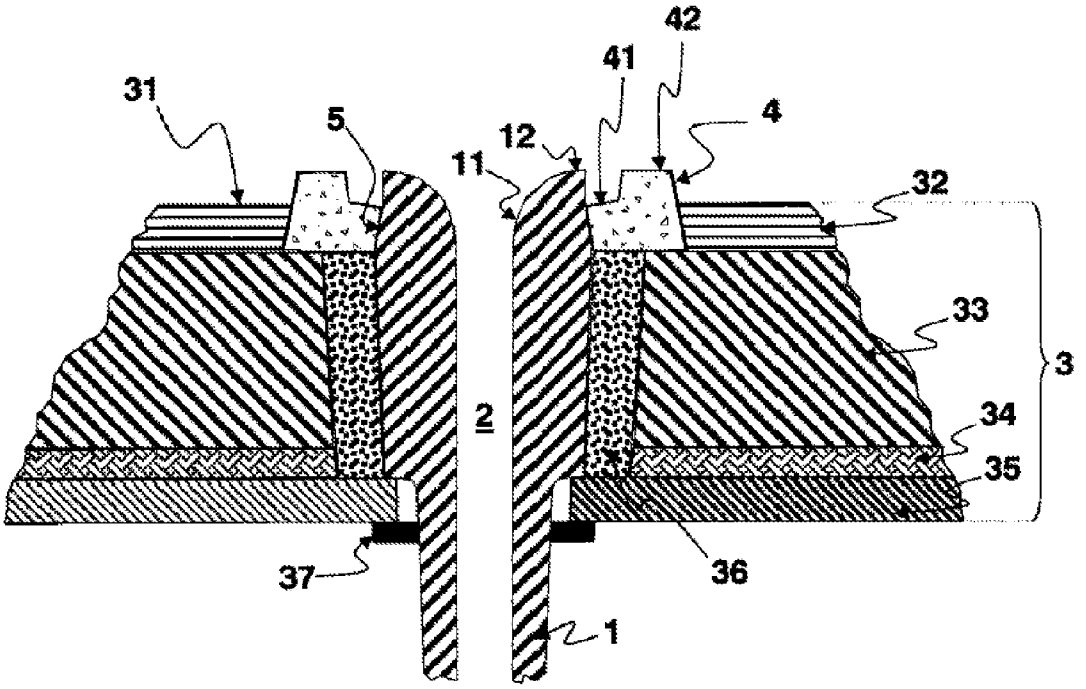
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(57) **ABSTRACT**

A refractory element is configured to prevent or limit steel reoxidation in a steel casting process. The refractory element contains a base surrounded by a periphery in a specified geometrical arrangement. The refractory element is constituted of a base surrounded by a periphery in a specified geometrical arrangement.



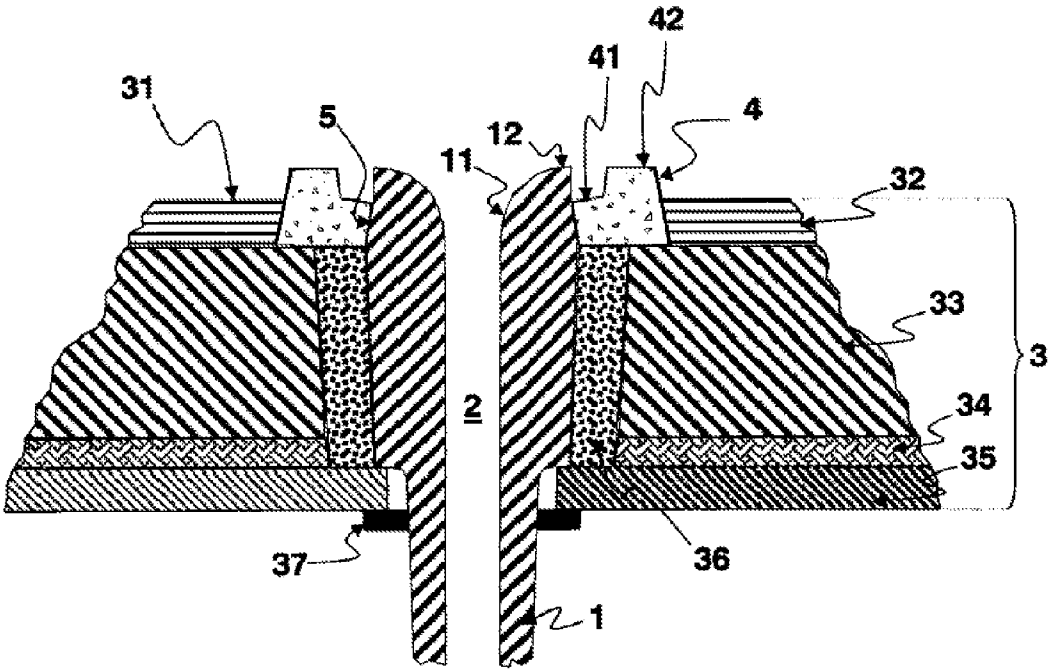


Fig. 1

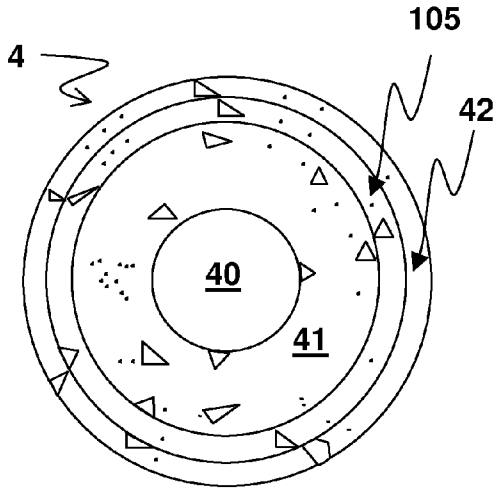


Fig. 2

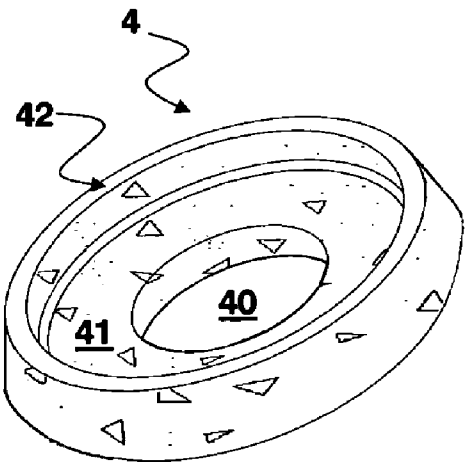


Fig. 3

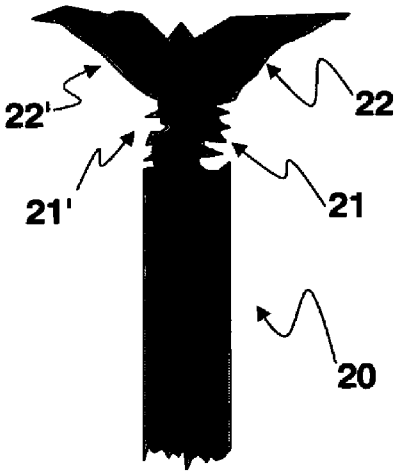


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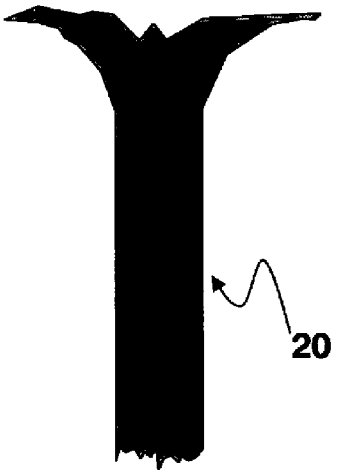


Fig. 5

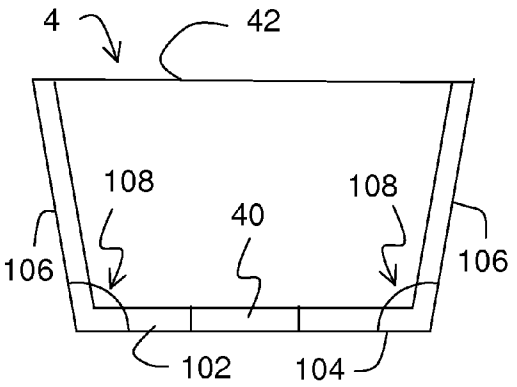


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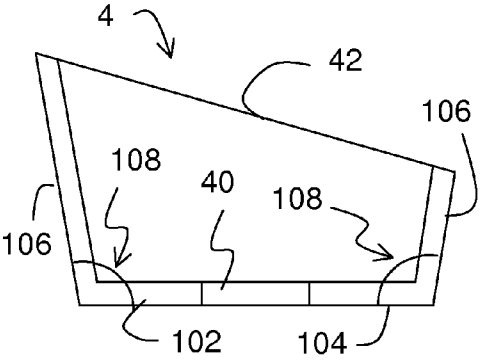


Fig. 7

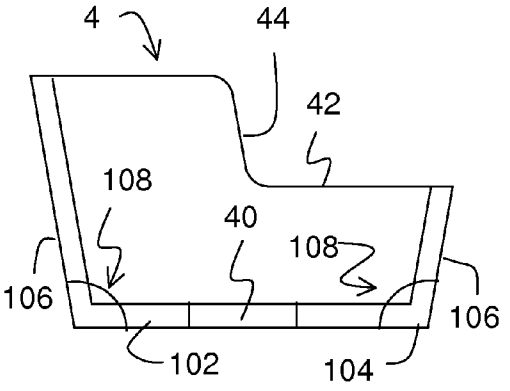


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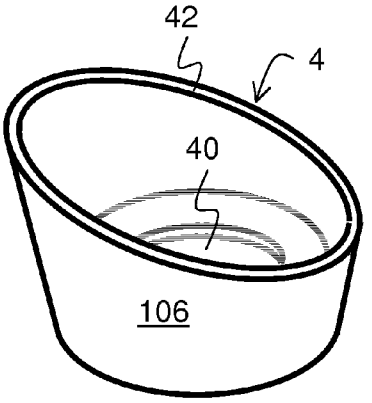


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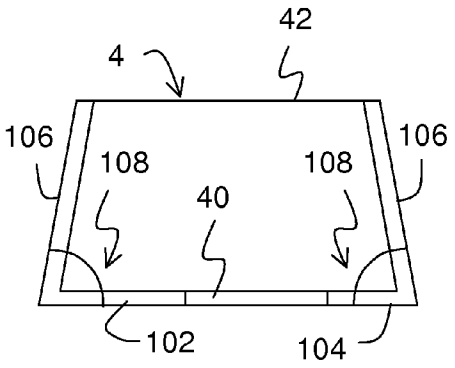


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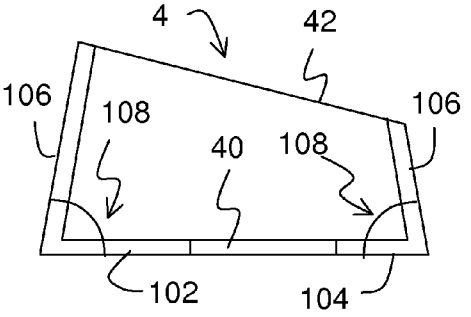


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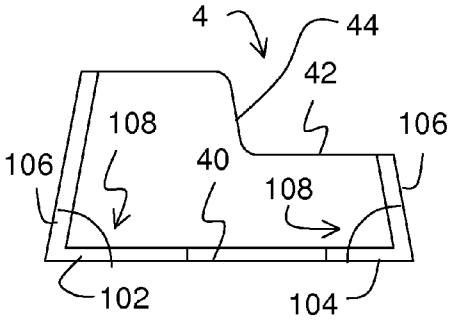


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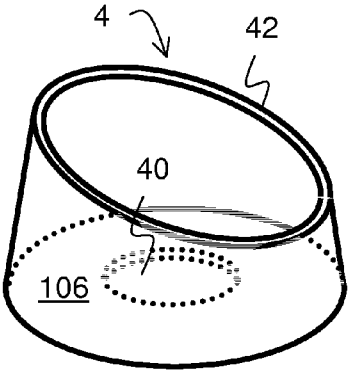


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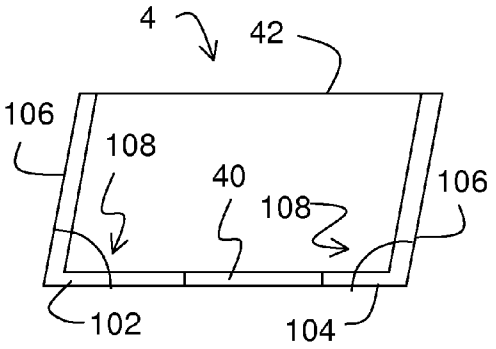


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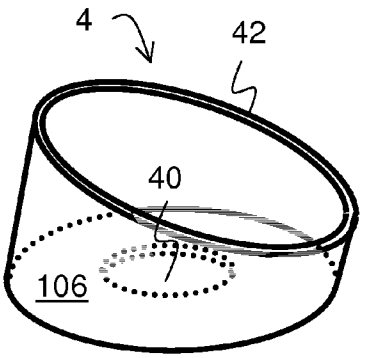


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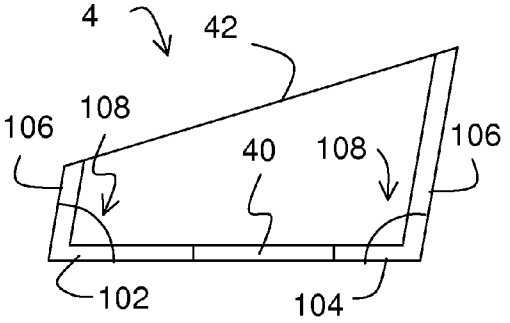


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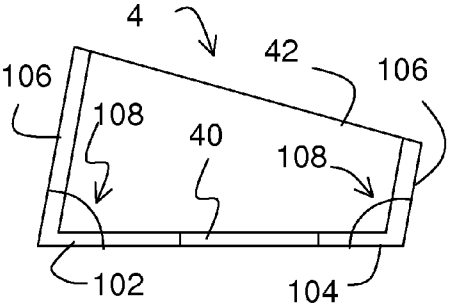


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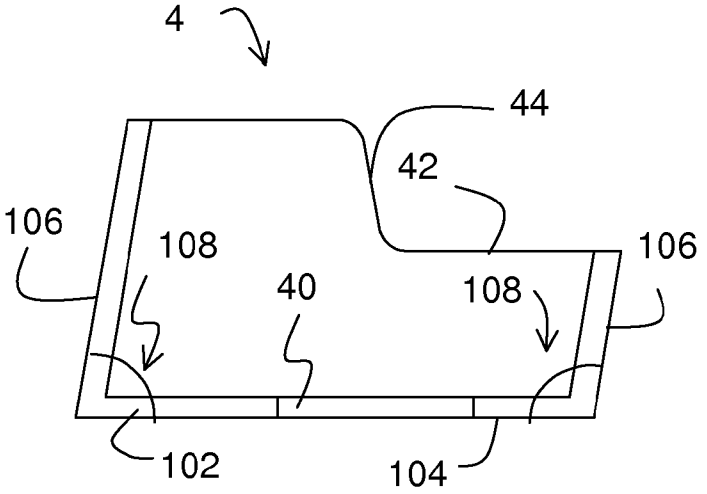

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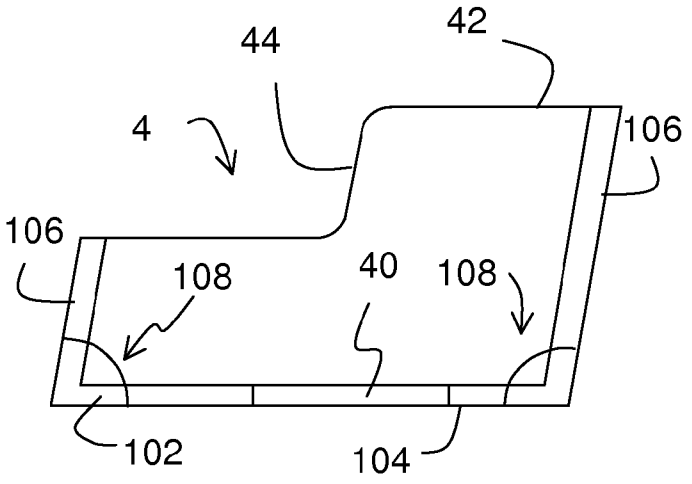

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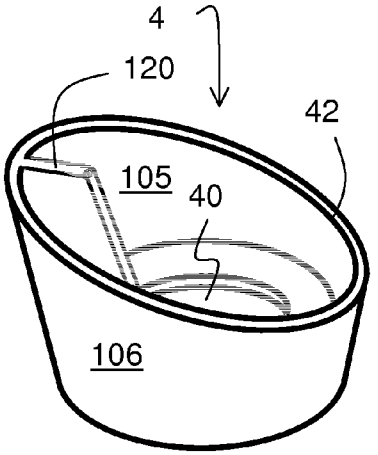


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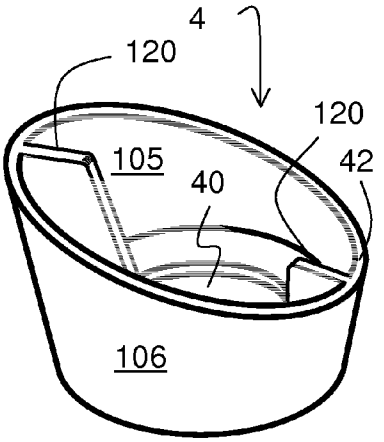


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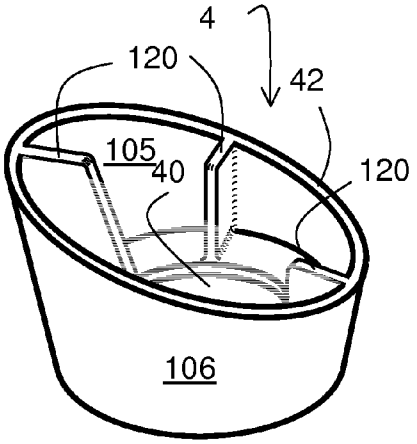


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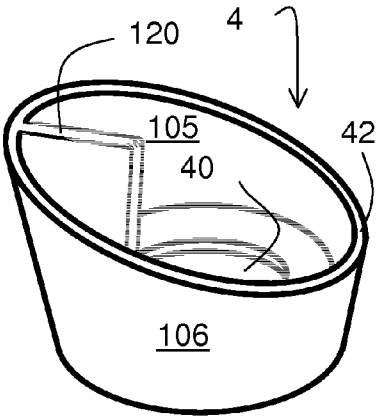


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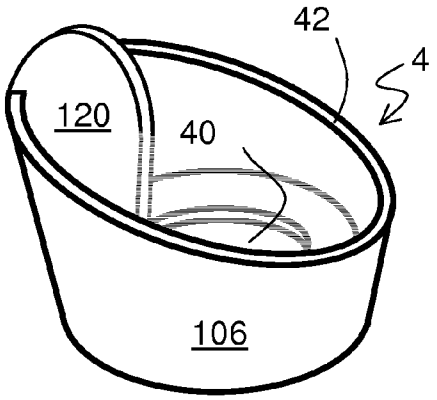


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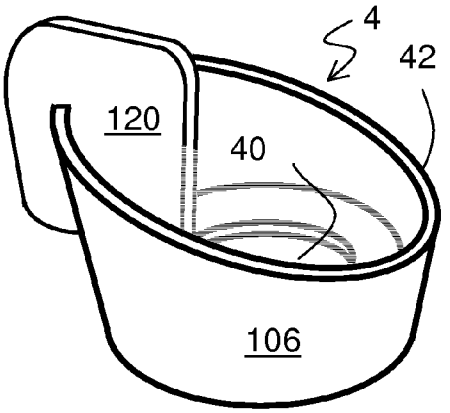


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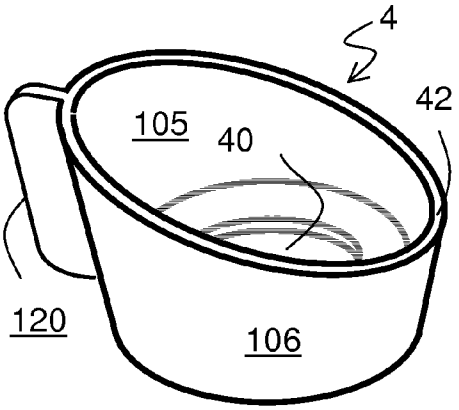


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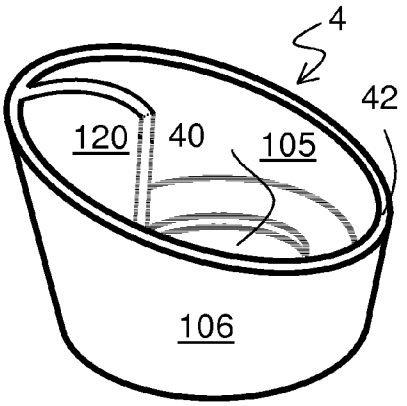


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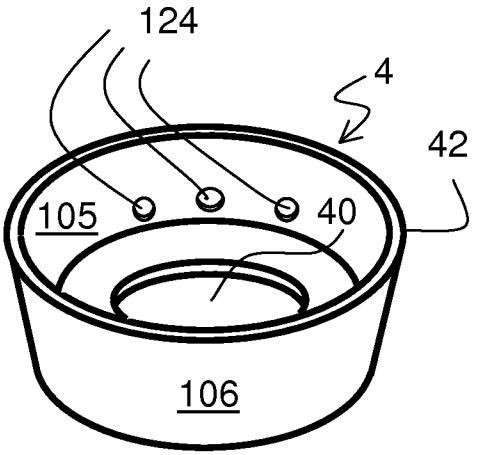


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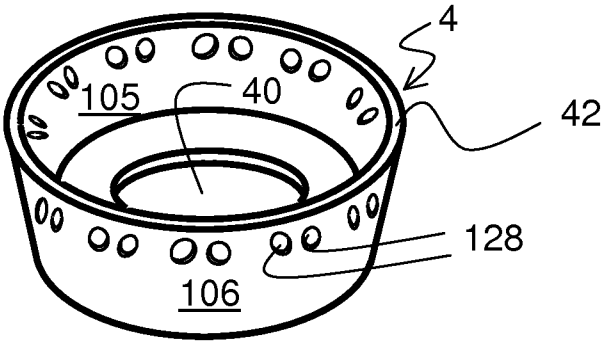


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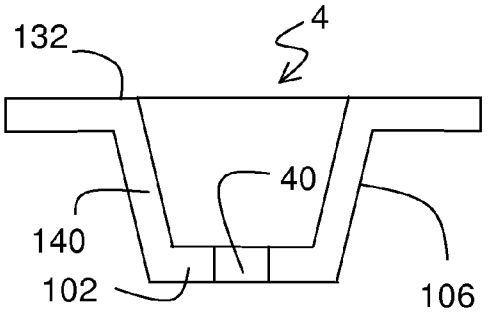


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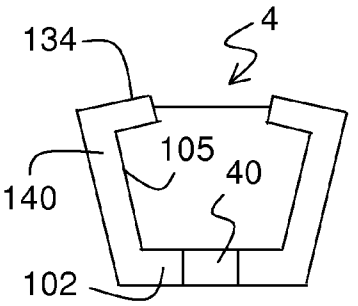


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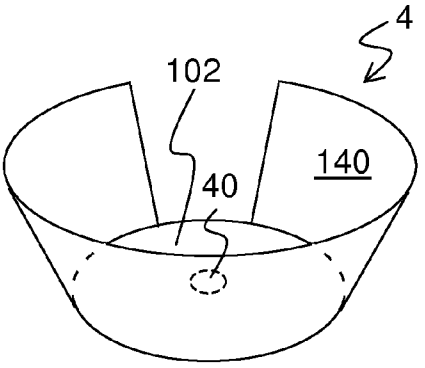


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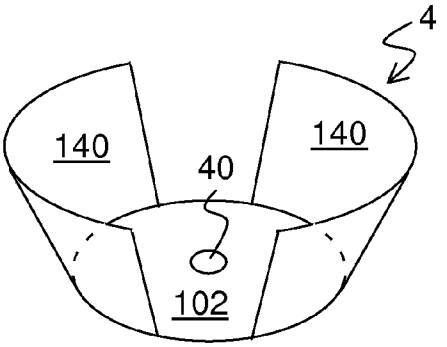


Fig. 33

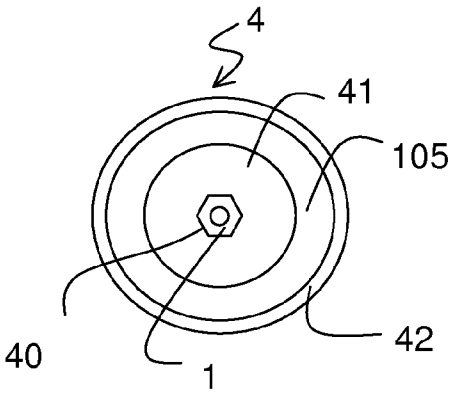


Fig. 34

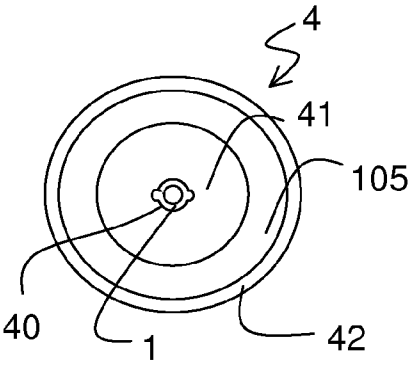


Fig. 35

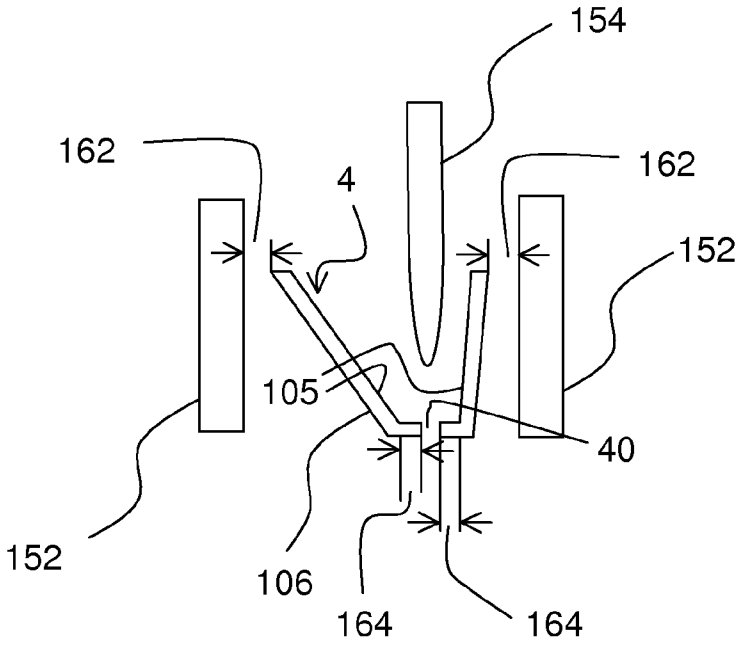


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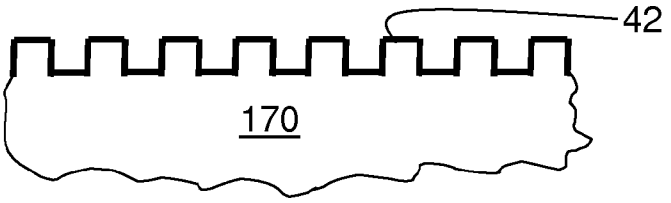


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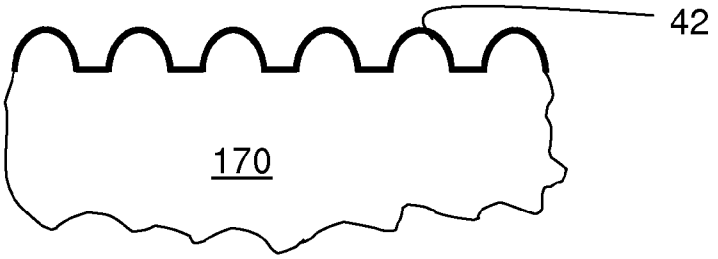


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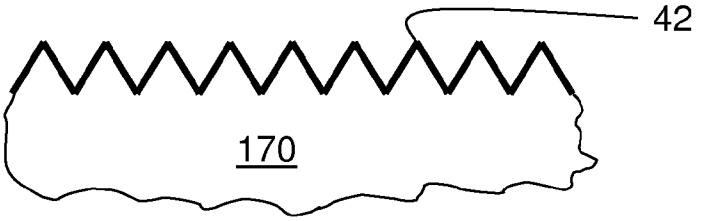


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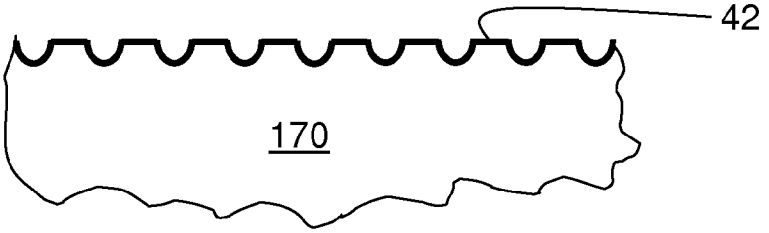


Fig. 40

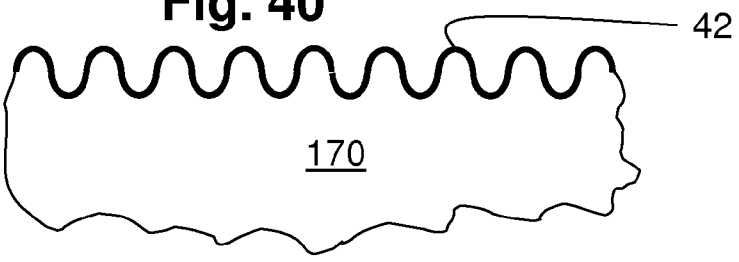


Fig. 41

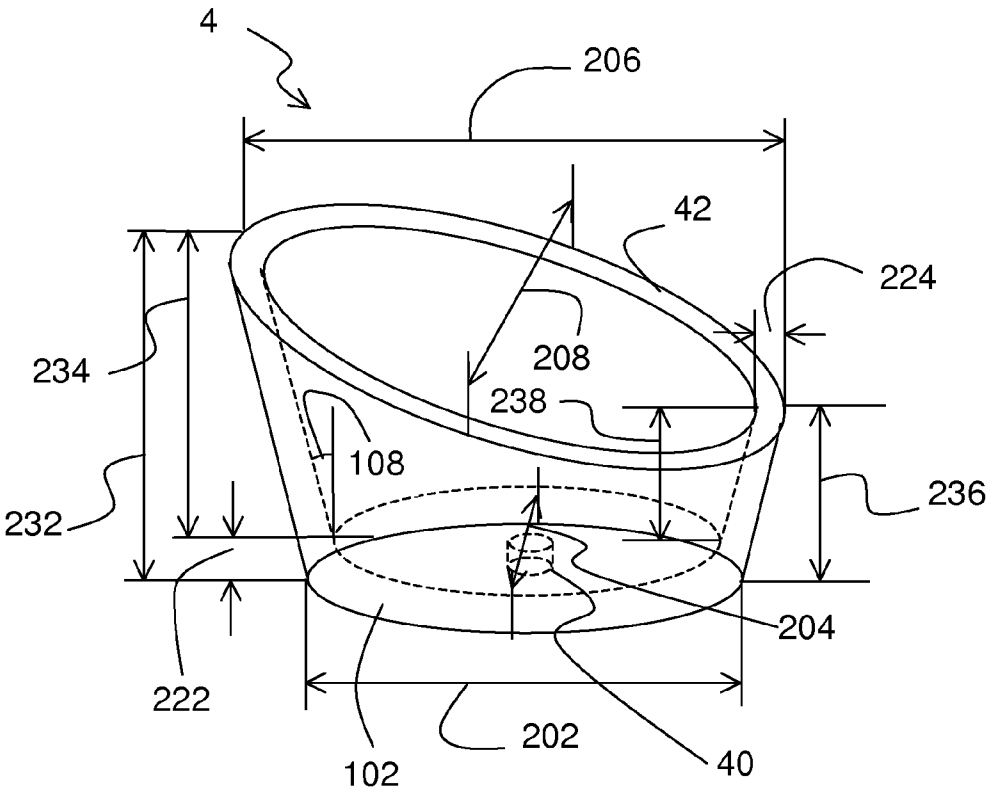


Fig. 42

REFRACTORY ELEMENT, ASSEMBLY AND TUNDISH FOR TRANSFERRING MOLTEN METAL

BACKGROUND OF THE INVENTION

[0001] (1) Field of the Invention

[0002] The present invention relates to the continuous casting of steel and particularly to the problem of steel reoxidation. In particular, the invention relates to a tundish comprising an assembly comprising a nozzle and a surrounding refractory element preventing or limiting steel reoxidation, and preventing oxidation products from entering a casting channel. The invention also relates to an assembly comprising a nozzle and a surrounding refractory element preventing or limiting steel reoxidation, and preventing oxidation products from entering a casting channel. According to other of its aspects, the invention also relates to such a surrounding refractory element and to a continuous steel casting process.

[0003] With growing demands for quality and property control, cleanliness of steel becomes more and more important. Issues like controlling the chemical composition and the homogeneity have been supplanted by concerns generated by the presence of non-metallic inclusions. Especially the presence of aluminum oxide and spinel inclusions is considered as harmful both for the production process itself as for the steel properties. These inclusions are mainly formed during the deoxidation of the steel in the ladle, which is necessary for continuous casting. Incomplete removal of the non-metallic inclusions during secondary metallurgy and reoxidation of the steel melt cause nozzle clogging during continuous casting. The layer of clogged material contains generally large clusters of aluminum oxide. Its thickness is related to the amount of steel cast as well as to the cleanliness of the steel. Nozzle clogging results in a decreased productivity, because less steel can be cast per unit of time (as result of the decreasing diameter) and due to replacement of nozzles with concurrent casting interruptions. Besides clogging, the presence of reoxidation products may give rise to erosion of the nozzle and to the formation of inclusion defects in the steel.

[0004] (2) Description of Related Art

[0005] Several solutions have been developed in the art to prevent steel reoxidation. In particular, the molten metal stream is generally shrouded with a pouring shroud during its transfer from a casting vessel to a downstream vessel (or mold) to prevent direct contacts between the poured steel and the surrounding atmosphere. Argon is often injected directly at the surface of a pouring nozzle so as to shield the molten metal stream. The surface of the steel melt in a metallurgical vessel (for example a tundish) is generally covered with a liquid slag layer so as to prevent direct contacts between the steel and the surrounding atmosphere. Alternatively (or in addition), the atmosphere above the tundish can be made inert (by the use of an oxygen scavenger or of an inert gas such as argon).

[0006] Further solutions have been developed in the art to remove non-metallic inclusions and reoxidation products when they are present in the tundish. These solutions consist generally in facilitating the flotation of these inclusions and reoxidation products so that these are captured by the floating slag layer. For example, dams, weirs, baffles and/or impact pads can be used to deflect upwardly the molten metal stream in the tundish. Inert gas bubbling devices can also be used to float out inclusions and reoxidation products.

[0007] Other solutions also exist for making the inclusions and oxidation product harmless. For example calcium based alloys can be used to eliminate some of the problems generated by the presence of aluminum oxide inclusions.

[0008] All these prior art solutions have contributed to improve the general cleanliness of the steel. However, some of the prior art solutions can, in turn, generate new defects in the steel (as in gas bubbling, or the use of a calcium-based alloy), can be expensive (as in the use of an inert atmosphere) or environmentally unacceptable. For these reasons, it would be desirable to propose an alternative solution which would solve the above problem, which would be economical and would not raise environmental problems.

BRIEF SUMMARY OF THE INVENTION

[0009] The present invention is based on the hypothesis that, even though the steel can be made relatively clean, it is impossible to keep it clean up to the mold in normal conditions. In particular, reoxidation of the steel by chemical reaction between the refractory elements (generally metal oxide) used in the continuous casting (vessel lining, slag, nozzles, stoppers, etc.) can also generate reoxidation products. Another potential source of reoxidation is the oxygen permeating through these refractory elements or through a permeable joint between the bottom wall lining and the nozzle inlet or even the oxygen desorbed from the refractory element.

[0010] An object of the present invention is therefore to solve the above problems by preventing the reoxidation products from reaching a casting nozzle and/or from forming in the immediate vicinity of or in the casting nozzle.

[0011] According to the invention, this object is achieved by the use of a surrounding refractory element, an assembly of a nozzle and a surrounding refractory element, or an assembly of a nozzle and a surrounding refractory element housed in a tundish, in which the element has a base having a main surface, a bottom and a periphery surrounding the main surface, in which the periphery has an exterior surface, and interior surface and an upper face, and the intersection of the bottom of the base and the exterior surface of the periphery contains at least one point at which the angle of intersection is not a right angle.

[0012] It is already known in the art to provide a surrounding element around the pouring orifice of a tundish. FR-A-2394348 for example discloses a ring intended to retain the steel in the tundish until a sufficient level and thereby a sufficient thermal mass is reached in order to avoid the entry of "cold" steel into the pouring orifice. The prior art however fails to disclose an element with a base and a periphery, and the intersection of the bottom of the base and the exterior surface of the periphery contains at least one point at which the angle of intersection is not a right angle.

[0013] JP-A1-2003-205360 discloses a tundish for the continuous casting of steel. The well block of this tundish is comprised of two elements. The nozzle is located inside the bottom part of the well block. An additional refractory element is positioned above the upper part of the nozzle to cover and protect the cement joint between the nozzle and the well block. However, this document fails to disclose a refractory element with a base and a periphery, and the intersection of the bottom of the base and the exterior surface of the periphery contains at least one point at which the angle of intersection is not a right angle.

[0014] WO2007/009667 discloses an element for use in conjunction with a nozzle in a metallurgical vessel. However,

this document does not disclose a refractory element with a base and a periphery in which the intersection of the bottom of the base and the exterior surface of the periphery contains at least one point at which the angle of intersection is not a right angle.

[0015] Thanks to the particular arrangement according to the present invention, the reoxidation products and/or inclusions present in the metallurgical vessel and which tend to accumulate on the bottom surface of the vessel and are carried down by the molten steel stream cannot reach the inlet of the nozzle.

[0016] It must be understood that the element surrounding the nozzle can be of any appropriate shape. In function of the metallurgical vessel design; it can be circular, oval or polygonal; its main orifice can be central or eccentric. In an alternate embodiment of the invention, appropriate shapes for the element may exclude circular shapes. The element surrounding the nozzle can also be cut off so as to accommodate those cases when one or more tundish walls are close to the pouring orifice. The main surface of the element can be planar or not (it can be frusto-conical, rippled, inclined). The nozzle can be an inner nozzle (for example in case the molten steel flow is controlled with a slide gate valve or if the installation is equipped with a tube or calibrated nozzle changer) or a submerged entry nozzle or SEN (for example in the case of stopper control). The metallurgical vessel or tundish can be equipped with one or more of such assemblies. The assembly can be supplied as a one-piece pre-assembled article (for example, co-pressed) or as separated articles.

[0017] As the element surrounding the nozzle need not be circular, and as the element may be placed in a vessel that does not have circular symmetry, it may be important to align the element with the nozzle, and therefore with the nozzle's surroundings, to produce desired flow patterns in the vicinity of the nozzle. Accordingly, the element and the nozzle may be constructed with matching visual indicators or markings that, when aligned or placed in contact, produce the desired geometrical arrangement of the element and the nozzle. Alternatively, the element and the nozzle may be constructed with mating geometries so that, when these geometries are mated, the desired geometrical arrangement of the element and nozzle, and of the combined element and nozzle with their surroundings, is produced. The mating geometries may be a matching recess and protrusion, a matching groove and lip, a matching peg and bore, a matching notch and protrusion, a matching dimple and mogul, a matching ridge and groove, aligned threaded receivers, aligned key or bayonet receivers, or matching non-circular surface geometries such as oval or polygonal faces. The mating geometry of the element may be placed within its main orifice or on the bottom of the base. The element, considered alone, may contain, within its main orifice or on its base, one or more orienting geometries, such as pegs, bores, protrusion, recesses, notches, bevels, dimples, moguls, ridges, grooves, housings for screw or bayonet fittings, or shaped or threaded receiver portions. The bore of the element may be asymmetric, oval or polygonal in shape.

[0018] In certain embodiments of the invention, the element and the nozzle may constitute a single piece.

[0019] According to the present invention, the refractory element comprises a base having a main surface and a periphery surrounding the main surface; the upper face of the periphery being higher than the main surface of the refractory element. Thereby, a kind of deflecting trap is created in the area surrounding the nozzle. It must be understood that the upper face of the periphery does not need to be planar. It can be waved or have different heights along the periphery (for example higher in area of the periphery close to a vessel lateral wall and lower on the other side). The periphery may contain one or more interruptions or openings. The periphery may contain stepped changes in height, or may contain gradual changes in height. The upper face of the periphery may have a sawtooth configuration, a semicircular notch configuration, a square notch configuration, a wave configuration, a semicircular protrusion configuration or may contain one or more steps. The upper face of the periphery may be in communication with an outwardly protruding lip. The upper face of the periphery may be in communication with an inwardly protruding lip. The upper face of the periphery may be in communication with a plate or dome structure containing at least one port. The periphery may contain one or more ports; these ports may be circular, oval or polygonal in shape, and the ports may have horizontal axes, axes directed upwards and inwardly, axes directed downwards and inwardly, or axes that are not perpendicular to the external surface of the periphery. The ports may be configured to have axes that are mutually tangent to a circle within the periphery. Pairs of ports may be configured to have axes that intersect each other at a circle within the periphery. The ports may be flared. In the inventive combination of a tundish, a nozzle and a refractory element, the level of at least one portion of the outer periphery of the refractory element is higher than the surface of the bottom wall of the tundish. Thereby, a second obstacle is created around the nozzle tundish preventing the inclusions or reoxidation products to reach its inlet. This type of arrangement is particularly advantageous.

[0020] The periphery of the refractory element of the present invention may take the form of a wall with measurements that are related to other measurements of the element by particular ratios or ranges of ratios. In certain embodiments, the maximum height of the wall, measured from the bottom of the base, has a ratio of 1:1 to 6:1, or 1.1:1 to 6:1, to the minimum height of the wall, measured from the bottom of the base. In certain embodiments, the maximum height of the wall, measured from the bottom of the base, has a ratio of 0.1:1 to 10:1, or 0.1:1 to 8.5:1, or 0.2:1 to 8.5:1, or 0.5:1 to 8.5:1, to the maximum exterior diameter of the base. In certain embodiments, the wall has a minimum thickness of 2 mm, 5 mm, or 10 mm. In certain embodiments, the wall has a maximum thickness of 60 mm, 80 mm, or 100 mm. In certain embodiments, the base has a maximum thickness of 100 mm or 200 mm.

[0021] The periphery of the refractory element of the present invention may take the form of a wall that has an exterior surface that has a portion that is not vertical. In certain embodiments, the entire exterior surface of this wall is not vertical. In certain embodiments, the entire wall forms an obtuse angle with the main surface, as measured from the interior of the element. In certain embodiments, the angle between the bottom surface of the base and the exterior surface of the wall has an angle lying within the ranges of 45 degrees to 89.5 degrees and 90.5 degrees to 135 degrees. In certain embodiments, the angle between the bottom surface of the base and the exterior surface of the wall may vary around the circumference of the element. In particular embodiments, the element has non-vertical outer walls, and the element partially encloses a volume with a cross-section that decreases in size with decreasing distance to the nozzle or to a port in which the nozzle may be located. The walls may

take the form of a cylinder with an axis that is not orthogonal to the horizontal plane. The walls may take the form of the radial surface of a truncated cone with a projected vertex below the plane of the main surface. The walls may take the form of the radial surface of a truncated cone with a projected vertex above the plane of the main surface. The upper face of the periphery may form a circle, oval, or polygonal figure in a plane that is not parallel to the plane of the main surface.

[0022] The interior of the wall of the refractory element and the base of the refractory element may communicate, separately or together, with one or more vanes. A vane may be disposed so that a projection of the plane of the vane intersects the axis of the nozzle. A vane may also be disposed so that no projection of a plane of the vane intersects the axis of the nozzle. The vanes may have surfaces and edges; the surfaces may be planar, may be curved in one or two dimensions, and may be smooth or have grooves. The edges of the vanes may be chamfered or have a sawtooth configuration, a semicircular notch configuration, a square notch configuration, a wave configuration, a semicircular protrusion configuration or may contain one or more steps.

[0023] The exterior of the wall of the refractory element may communicate with one or more vanes. A vane may be disposed so that a projection of the plane of the vane intersects the axis of the nozzle. A vane may also be disposed so that no projection of a plane of the vane intersects the axis of the nozzle. The vanes may have surfaces and edges; the surfaces may be planar, may be curved in one or two dimensions, and may be smooth or have grooves. The edges of the vanes may be chamfered or have a sawtooth configuration, a semicircular notch configuration, a square notch configuration, a wave configuration, a semicircular protrusion configuration or may contain one or more steps.

[0024] The surrounding refractory element may be made from a gas-impervious material. To be regarded as gas-impervious, such material has an open porosity (at the temperature of use) which is lower than 20% (thus lower than the open porosity of conventional lining material which is typically higher than 30%). For refractory materials, the permeability is generally related to the porosity. Therefore a low porosity material has a low permeability to gases. Such a low porosity can be obtained by including oxygen scavenger materials (e.g. antioxidants) in the material constituting the surrounding element. Suitable materials are boron or silicon carbide, or metals (or alloys thereof) such as silicon or aluminum. In certain embodiments, they are used in an amount not exceeding 5 wt %. Alternatively (or in addition), products generating melting phase (for example B_2O_3) can also be included in the material constituting the surrounding element. In certain embodiments, they are used in an amount not exceeding 5 wt. %. Alternatively or (in addition), materials forming more voluminous new phases (either upon reaction or the effect of the temperature) and closing thereby the existing porosity can also be included in the material constituting the preformed element. Suitable materials include compositions of alumina and magnesia. Thereby, steel re-oxidation in the area surrounding the nozzle is prevented. In certain embodiments of the invention, the refractory material has a permeability value less than 15cD, 20cD, 25cD or 30cD, according to standard ASTM testing. A material that may be used contains 0.5-1%, or 1-5% silica, 0.005% to 0.2% titania, 75% to 95% alumina, 0.1% to 0.5% iron (III) oxide, 0.5% to 1% magnesia, 0.1% to 0.5% sodium oxide, 0.25% to 2% boron oxide, and 1% to 10% of zirconia+hafnia. A suitable material may have a loss on ignition value of 0 to 5%.

[0025] The element, the nozzle or a layer of the element or the nozzle may be made from a gas-impervious material. The nozzle or element may be made from refractory oxides (alumina, magnesia, calcia) and may be isostatically pressed. To be regarded as gas-impervious in the sense of the present invention, a 100 g sample of the candidate material is placed in a furnace under argon atmosphere (a gentle stream of argon is continuously blown (about 11/min) into the furnace) and the temperature is raised to 1000° C. The temperature is then raised progressively to 1500° C. (in 1 hour) and is then left at 1500° C. for 2 hours. The loss of weight of the sample between 1000° C. and 1500° C. is then measured. This loss of weight must be lower than 2% for qualifying the material as gas-impervious. Thereby, not only the inclusion or reoxidation products cannot reach the nozzle but, in addition, they cannot form in the nozzle or the element. This particular combination provides thus a synergistic effect according to which a perfectly inclusion- and reoxidation product-free steel can be cast.

[0026] The material constituting the nozzle or element can be selected from three different categories of materials:

a) materials which do not contain carbon;

b) materials essentially constituted of non reducible refractory oxides in combination with carbon; or

c) materials comprising elements which will react with the generated carbon monoxide. Preferably, the selected material will present two or three of the above categories.

[0027] Examples of suitable material of the first category are alumina, mullite, zirconia or magnesia based material (spinel).

[0028] Suitable materials of the second category are for example pure alumina carbon compositions. In particular, these compositions should contain very low amounts of silica or of conventional impurities which are usually found in silica (sodium or potassium oxide). In particular, the silica and its conventional impurities should be kept under 1.0 wt. %, preferably under 0.5 wt. %.

[0029] Suitable materials of the third category comprise for example free metal able to combine with carbon monoxide to form a metal oxide and free carbon. Silicon and aluminum are suitable for this application. These materials can also or alternatively comprise carbides or nitrides able to react with oxygen compound (for example silicon or boron carbides).

[0030] In certain embodiments of the invention the selected material will belong to the second or third categories; in certain embodiments of the invention the selected material will belong to the second and third categories.

[0031] A suitable material constituting the layer which will not produce carbon monoxide at the temperature of use can comprise 60 to 88 wt. % of alumina, 10 to 20 wt. % graphite and 2 to 10 wt. % of silicon carbide. Such a material contains oxygen getters such as non-oxide species such as nitrides or carbides, or non-reducible oxides, which can react with any oxygen present.

[0032] In a variant, only a liner present at the steel contacting surface (inside and outside of the nozzle) is made from such a material. In another variant, the nozzle and the surrounding element are made integral (one-piece).

[0033] In case the joint between the surrounding element and the nozzle is not perfectly tight, it might be advantageous to provide a mortar joint which is made from a gas impervious

mortar. Conventional mortars have an open porosity of 30 to 50%. According to this advantageous embodiment, the mortar should have an open porosity of less than 20%. The mortar may be made of a composition similar to, and processed in similar fashion to, the element or nozzle.

[0034] According to another of its aspects, the invention relates to a particular surrounding refractory element which is used in the assembly according to the invention. This surrounding element comprises a main orifice adapted for matching engagement with at least a portion of the outer surface of the nozzle, a main surface surrounding the main orifice and an outer periphery surrounding the main surface, the level of the upper face of the periphery being higher than that of the main surface. Advantageously, the surrounding refractory element is made from a gas-impervious material. Thereby, steel re-oxidation in the area surrounding the nozzle is prevented. For example, a particularly suitable composition to this end is essentially comprised of a high alumina material comprising at least 75 wt. % of Al_2O_3, less than 1.0 wt. % of SiO_2, less than 5 wt. % of C, the reminder being constituted of refractory oxides or oxides compounds that cannot be reduced by aluminum (particularly aluminum dissolved in molten steel) at the temperature of use (for example calcia and/or spinel. A particularly suitable material is the CRITERION 92SR castable available from VESUVIUS UK Ltd. This material is a high alumina low cement castable material reinforced with fused alumina-magnesia spinel. A typical analysis of this product is the following:

Al_2O_3	92.7 wt. %
MgO	5.0 wt. %
CaO	1.8 wt. %
SiO_2	0.1 wt. %
Other	0.4 wt. %

[0035] According to yet another of its aspects, the invention is directed to a process for the continuous casting of steel which comprises pouring the molten steel through an element, or a combination of a nozzle and an element, as above described.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0036] The invention will now be described with reference to the attached drawings in which

[0037] FIG. **1** shows a cross-section of the bottom wall of a metallurgical vessel provided with an assembly according to the invention;

[0038] FIGS. **2** and **3** show respectively top and perspective views of a surrounding element according to the invention;

[0039] FIGS. **4** and **5** show skulls collected at the end of the casting operations in the upper part of the nozzle;

[0040] FIG. **6** is a cross-section of an element according to the invention;

[0041] FIG. **7** is a cross-section of an element according to the invention;

[0042] FIG. **8** is a cross-section of an element according to the invention;

[0043] FIG. **9** is a perspective view of an element according to the invention;

[0044] FIG. **10** is a cross-section of an element according to the invention;

[0045] FIG. **11** is a cross-section of an element according to the invention;

[0046] FIG. **12** is a cross-section of an element according to the invention;

[0047] FIG. **13** is a perspective view of an element according to the invention;

[0048] FIG. **14** is a cross-section of an element according to the invention;

[0049] FIG. **15** is a perspective view of an element according to the invention;

[0050] FIG. **16** is a cross-section of an element according to the invention;

[0051] FIG. **17** is a cross-section of an element according to the invention;

[0052] FIG. **18** is a cross-section of an element according to the invention;

[0053] FIG. **19** is a cross-section of an element according to the invention;

[0054] FIG. **20** is a perspective view of an element according to the invention;

[0055] FIG. **21** is a perspective view of an element according to the invention;

[0056] FIG. **22** is a perspective view of an element according to the invention;

[0057] FIG. **23** is a perspective view of an element according to the invention;

[0058] FIG. **24** is a perspective view of an element according to the invention;

[0059] FIG. **25** is a perspective view of an element according to the invention;

[0060] FIG. **26** is a perspective view of an element according to the invention;

[0061] FIG. **27** is a perspective view of an element according to the invention;

[0062] FIG. **28** is a perspective view of an element according to the invention;

[0063] FIG. **29** is a perspective view of an element according to the invention;

[0064] FIG. **30** is a cross-section of an element according to the invention;

[0065] FIG. **31** is a cross-section of an element according to the invention;

[0066] FIG. **32** is a schematic perspective view of an element according to the invention;

[0067] FIG. **33** is a schematic perspective view of an element according to the invention;

[0068] FIG. **34** is a top view of an element according to the invention;

[0069] FIG. **35** is a top view of an element according to the invention;

[0070] FIG. **36** is a cross section of an element and a metallurgical vessel according to the invention;

[0071] FIG. **37** is an elevation of a portion of a raised outer periphery of an element according to the invention;

[0072] FIG. **38** is an elevation of a portion of a raised outer periphery of an element according to the invention;

[0073] FIG. **39** is an elevation of a portion of a raised outer periphery of an element according to the invention;

[0074] FIG. **40** is an elevation of a portion of a raised outer periphery of an element according to the invention;

[0075] FIG. **41** elevation of a portion of a raised outer periphery of an element according to the invention; and

[0076] FIG. **42** is a perspective drawing of an element according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0077] The bottom wall **3** of a metallurgical vessel (here a tundish) is generally constituted of a permanent lining **33** made from refractory bricks or castable material. A working layer **32** of castable material is generally present above the permanent lining **33**. The surface **31** of the working layer will contact molten steel during the casting operations. A layer of insulating material **34** is normally present under the permanent lining **33** in order to protect the metallic envelope **35** of the metallurgical vessel.

[0078] A nozzle **1** goes through the bottom of the tundish and serves to the transfer of the molten steel from the tundish to the continuous casting mold. The nozzle is provided with an inlet **11** opening into a bore defining thus a passage **2** for the molten steel. The upper edge of the inlet is depicted as reference **12**. FIG. **1** shows a submerged entry shroud or SES but, as explained above other kind of nozzles (such as an inner nozzle) are also encompassed within the scope of the present invention. In the case of a SEN, the continuous casting operation is generally provided with a guillotine **37** to break the nozzle **1** and terminate casting operations. Generally, the SEN is maintained in position by a ramming mass **36**.

[0079] The surrounding refractory element **4** surrounds the inlet portion **11** of the nozzle **1**. The surrounding element **4** is comprised of a main surface **41** surrounding a main orifice **40**. The main surface has been represented frusto-conical at FIG. **1** and planar at FIGS. **2** and **3**, but, as explained above, other arrangements are possible. A raised outer periphery surrounds the main surface **41**; the raised outer periphery has an interior face **105**. The upper face **42** of the periphery is higher than the level of the main surface **41**.

[0080] As can be seen on FIG. **1**, it is advantageous to have the upper face **42** of the periphery rising higher than the surface **31** of the tundish.

[0081] A mortar or cement joint at the junction **5** between the refractory element **4** and the nozzle **1** can be provided for further tightness improvement.

[0082] A trial has been performed to illustrate the effect of the invention. The solidified steel skull remaining in the inner nozzle at the end of casting operations has been collected and cut vertically in the middle. FIG. **4** (given by way of comparison) shows such a skull collected in a conventional installation (without the surrounding refractory element) and FIG. **5** shows such a skull collected in an installation according to the invention.

[0083] The skull **20** of FIG. **4** shows significant disturbance in the region **21**, **21'** indicating the presence of alumina deposit on the inner wall of the nozzle. This alumina deposit is responsible for the clogging of the nozzle with all the detrimental consequences explained above. The skull **20** of FIG. **4** shows also an enlarged portion in the region **22**, **22'** indicating a severe erosion of the nozzle inlet.

[0084] The skull **20** shown on FIG. **5** corresponds to the inner shape of the nozzle indicating thereby that the nozzle has neither been subjected to erosion nor to alumina clogging.

[0085] FIG. **6** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, both of the angles shown in the cross-section representation are obtuse angles. In this embodiment, the height of the raised outer periphery is constant.

[0086] FIG. **7** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, both of the angles shown in the cross-section representation are obtuse angles. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference.

[0087] FIG. **8** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, both of the angles shown in the cross-section representation are obtuse angles. In this embodiment, portions of the raised outer periphery with a fixed height are joined by height transition segments **44**.

[0088] FIG. **9** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, all angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel.

[0089] FIG. **10** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, both of the angles shown in the cross-section representation are acute angles. In this embodiment, the height of the raised outer periphery is constant.

[0090] FIG. **11** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, both of the angles shown in the cross-section representation are acute angles. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference.

[0091] FIG. **12** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, both of the angles shown in the cross-section representation are acute angles. In this embodiment, portions of the raised outer periphery with a fixed height are joined by height transition segments **44**.

[0092] FIG. **13** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, all angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are acute. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel.

[0093] FIG. **14** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, one of the angles shown in the cross-section representation is an acute angle; the other angle shown is an obtuse angle. In this embodiment, the height of the raised outer periphery is constant around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are parallel.

[0094] FIG. **15** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are acute, obtuse and, at two points, are right angles. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel.

[0095] FIG. **16** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, one of the angles shown in the cross-section representation is an acute angle; the other angle shown is an obtuse angle. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel.

[0096] FIG. **17** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, one of the angles shown in the cross-section representation is an acute angle; the other angle shown is an obtuse angle. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel.

[0097] FIG. **18** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, one of the angles shown in the cross-section representation is an acute angle; the other angle shown is an obtuse angle. In this embodiment, the raised outer periphery has two portions of constant height; these portions are joined by two height transition segments **44**. The planes of the constant height portions of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are parallel.

[0098] FIG. **19** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40** and base bottom face **104**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. Angles **108** are formed between element base bottom face **104** and exterior face **106** of the raised outer periphery. In this embodiment, one of the angles shown in the cross-section representation is an acute angle; the other angle shown is an obtuse angle. In this embodiment, the raised outer periphery has two portions of constant height; these portions are joined by two height transition segments **44**. The planes of the constant height portions of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are parallel.

[0099] FIG. **20** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. An element fin **120** protrudes from the interior face **105** of the raised outer periphery of the element. The fin surface nearest main orifice **40** is at an angle from the vertical.

[0100] FIG. **21** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. Two element fins **120** protrude from the interior face **105** of the raised outer periphery of the element.

[0101] FIG. **22** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the

base of the element are not parallel. Three element fins **120** protrude from the interior face **105** of the raised outer periphery of the element.

[0102] FIG. **23** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. An element fin **120** protrudes from the interior face **105** of the raised outer periphery of the element. The fin surface nearest main orifice **40** is vertical.

[0103] FIG. **24** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. An element fin **120** protrudes from the interior face **105** of the raised outer periphery of the element. The fin extends upwardly above the maximum height of the upper face **42** of the raised outer periphery of the element.

[0104] FIG. **25** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. An element fin **120** protrudes inwardly from the interior face **105** of the raised outer periphery of the element as well as outwardly from the exterior face **106** of the raised outer periphery of the element. The fin extends upwardly above the maximum height of the upper face **42** of the raised outer periphery of the element.

[0105] FIG. **26** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. An element fin **120** protrudes outwardly from the exterior face **106** of the raised outer periphery of the element.

[0106] FIG. **27** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery varies around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are not parallel. An element fin **120** protrudes inwardly from the interior face **105** of the raised outer periphery of the element. The fin extends upwardly above the maximum height of the upper face **42** of the raised outer periphery of the element.

[0107] FIG. **28** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery is constant around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are parallel. A plurality of lateral ports **124** extends from interior face **105** of raised outer periphery of the element to the exterior face **106** of the raised outer periphery of the element. These ports may be cylindrical, or may be flared at one end or at both ends.

[0108] FIG. **29** shows a perspective view of an element **4** of the present invention having main orifice **40**. A raised outer periphery is joined to the base; the raised outer periphery has an exterior face **106** and an upper face **42**. In this embodiment, angles formed between the bottom face of the base of the element and the exterior face of the raised outer periphery of the element are obtuse. In this embodiment, the height of the raised outer periphery is constant around the course of the element's circumference. The plane of the upper face of the raised outer periphery and the plane of the bottom face of the base of the element are parallel. A plurality of paired lateral ports **128** extends from interior face **105** of raised outer periphery of the element to the exterior face **106** of the raised outer periphery of the element. These ports may be cylindrical, or may be flared at one end or at both ends. These ports may be directed so that the longitudinal axes of each of a pair of ports intersect at a circle within the volume partially enclosed by the element, i.e., the volume partially enclosed by the interior face **105** of the raised outer periphery of the element.

[0109] FIG. **30** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40**. A raised outer periphery **140** is joined to the base; the raised outer periphery has an exterior face **106**. In this embodiment an externally directed rim **132** is in communication with the exterior face **106** of the raised outer periphery of the element. In the embodiment shown, externally directed rim **132** is horizontal; it may be directed above or below the horizontal in other embodiments.

[0110] FIG. **31** shows a cross section of an element **4** of the present invention, in which base **102** contains main orifice **40**. A raised outer periphery **140** is joined to the base; the raised outer periphery has an interior face **105**. In this embodiment an internally directed rim **134** is in communication with the interior face **106** of the raised outer periphery of the element.

In the embodiment shown, the internally directed rim takes a truncated conical form; it may be horizontal in other embodiments.

[0111] FIG. **32** shows a schematic perspective view of an element **4** of the present invention, in which base **102** contains main orifice **40**. A raised outer periphery **140** is joined to the base. In the embodiment shown, the raised outer periphery has a gap.

[0112] FIG. **33** shows a schematic perspective view of an element **4** of the present invention, in which base **102** contains main orifice **40**. A raised outer periphery **140** is joined to the base. In the embodiment shown, the raised outer periphery has two gaps.

[0113] FIG. **34** shows a top view of an assembly of an element **4** of the present invention with a nozzle **1**. The top view depicts the main surface **41** of the element and the outer periphery surrounding the main surface of the element; the interior face **105** of the raised outer periphery is visible, as is the upper face **42** of the raised outer periphery. The interior of the main orifice **40** of the element has a non-circular geometry configured to mate with the exterior geometry of nozzle **1**. In the embodiment shown, the respective geometries are hexagonal. The corresponding geometries constrain the positioning of the element **4** about the nozzle, so that vertical and horizontal asymmetries of the element can be properly positioned within a metallurgical vessel.

[0114] FIG. **35** shows a top view of an assembly of an element **4** of the present invention with a nozzle **1**. The top view depicts the main surface **41** of the element and the outer periphery surrounding the main surface of the element; the interior face **105** of the raised outer periphery is visible, as is the upper face **42** of the raised outer periphery. The interior of the main orifice **40** of the element has a non-circular geometry configured to mate with the exterior geometry of nozzle **1**. In the embodiment shown, indentations on the interior of main orifice **40** accept protrusions on the surface of nozzle **1**. The corresponding geometries constrain the positioning of the element **4** about the nozzle, so that vertical and horizontal asymmetries of the element can be properly positioned within a metallurgical vessel.

[0115] FIG. **36** shows a cross section of an element **4** and the walls **152** of a metallurgical vessel according to the invention. The nozzle and the floor of the metallurgical vessel have been omitted for clarity. A stopper rod **154** is positioned to be moved vertically to permit or interrupt flow through main orifice **40**. The interior face **105** and the exterior face **106** of the raised outer periphery of the element are indicated. Gaps **162** between the element and the metallurgical vessel wall are indicated. The distance **164** between the interior face **105** and the main orifice **40** is also indicated. The asymmetric design on the element embodiment shown permits gaps of the same size between each metallurgical vessel wall **152** and the top of the element, as well as permitting constant, or nearly constant, distances between the interior face **105** and the main orifice **40**, while allowing the stopper rod **154** to be positioned closer to one metallurgical vessel wall than to the other.

[0116] FIG. **37** shows a portion **170** of the raised outer periphery of element **4**. The upper face **42** of raised outer periphery of the element contains a plurality of square notches.

[0117] FIG. **38** shows a portion **170** of the raised outer periphery of element **4**. The upper face **42** of raised outer periphery of the element contains a plurality of semicircular protrusions.

[0118] FIG. **39** shows a portion **170** of the raised outer periphery of element **4**. The upper face **42** of raised outer periphery of the element is formed in a sawtooth pattern.

[0119] FIG. **40** shows a portion **170** of the raised outer periphery of element **4**. The upper face **42** of raised outer periphery of the element contains a plurality of semicircular notches.

[0120] FIG. **41** shows a portion **170** of the raised outer periphery of element **4**. The upper face **42** of raised outer periphery of the element is formed in a wave pattern.

[0121] FIG. **42** is a perspective drawing of an element **4** of the present invention, in which base **102** contains main orifice **40** and in communication with raised outer periphery **140**. Raised outer periphery **140** houses upper face **42**. The maximum external dimension of the base of the element **202**, the minimum external dimension of the base of the element **204**, the maximum external dimension of the top of the element **206**, the minimum external dimension of the top of the element **208**, the thickness of the base of the element **222**, the thickness of the raised outer periphery of the element **224**, the maximum exterior height of the element **232**, the maximum interior height of the element **234**, the minimum exterior height of the element **236**, and the minimum interior height of the element **238** are indicated.

[0122] A refractory element according to the present invention, therefore, may comprise a base having a bottom and a main surface, a main orifice passing through the main surface, and a periphery surrounding the main surface, wherein the main orifice has an interior face, wherein the periphery has an interior face, an exterior face and an upper face, wherein the upper face of the periphery is higher than the main surface of the refractory element, wherein the periphery intersects the bottom of the base, and wherein the exterior face of the periphery forms an angle other than a right angle with the bottom of the base in at least one point in their intersection. The exterior face of the periphery may form a right angle with the bottom of the base at two points in their intersection, may form an acute angle with the bottom of the base at all points in their intersection, or may form an obtuse angle with the bottom of the base at all points in their intersection. The plane of the exterior face of the periphery and the plane of the bottom of the base may be non-parallel planes. The upper face of the periphery comprises an upper level and a lower level joined by two transitional non-vertical, non-horizontal portions. The main surface of the element may have a geometry selected from the group consisting of circular, oval, truncated circular, truncated oval, and polygonal geometry. The element may also comprise one or more fins extending from the inner face of the periphery, or one or more fins extending from the exterior face of the periphery. The element may comprise one or more ports passing from the exterior face to the interior face of the periphery. The element may comprise a feature on its surface, for example on the interior face of the main orifice or on the bottom of the base, which may be a marking, a recess, a protrusion, a groove, a lip, a peg, a bore, a notch, a dimple, a mogul, a ridge, a threaded receiver, a key receiver, a bayonet receiver, a bevel, and a non-circular geometry, or any other device or feature which would constrain movement of the element around an axis. The refractory element of the invention may be composed of single pieces or of multiple pieces. The refractory element of the invention may be produced from a high alumina material comprising at least 75 wt. % of Al_2O_3, less than 1.0 wt. % of SiO_2, and less than 5 wt. % of C. The refractory element may be constructed so that the

periphery of the element has a thickness equal to or less than 100 millimeters, and the base of the element has a thickness equal to or less than 100 millimeters.

[0123] An assembly of a refractory element and a nozzle according to the invention may be composed of a single piece or multiple pieces. The refractory element may comprise a main orifice having a non-circular geometry, and wherein the refractory nozzle comprises an exterior radial surface having a non-circular geometry configured to mate with the refractory element. The refractory element comprises a main orifice interior face having a mating feature, wherein the refractory nozzle comprises an exterior radial surface having a corresponding mating feature configured to engage with the main orifice interior face mating feature. The mating feature of the nozzle and the mating feature of the element, when engaged, may prevent rotational motion of the element around the longitudinal axis of the bore of the nozzle.

[0124] An assembly of a refractory element and a nozzle according to the present invention may be deployed in a metallurgical vessel for the casting of molten metal. In a typical deployment, the refractory nozzle may have an inlet portion forming a passage through the bottom wall of the metallurgical vessel and a refractory element as previously described surrounding the inlet portion of the nozzle, wherein the inlet portion of the nozzle has a top outer edge, wherein the inlet portion of the nozzle has a longitudinal axis, wherein the main orifice of the element is adapted for matching engagement with at least a portion of the outer surface of the nozzle, wherein the main surface of the base of the element has a lowest level, the lowest level being lower than the top outer edge of the nozzle inlet portion, and wherein at least a portion of the periphery of the refractory element is higher than the surface of the bottom wall of the tundish. The element may comprise a gas impervious refractory material. The nozzle or the element may comprise a gas impervious refractory material. A gas impervious mortar may be used between the nozzle and the refractory element.

[0125] A process for the continuous casting of steel may comprise pouring the molten steel from a ladle into a metallurgical vessel housing an assembly of a refractory element and a nozzle as described above, and thence into a casting mold.

[0126] Numerous modifications and variations of the present invention are possible. It is, therefore, to be understood that within the scope of the following claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. A refractory element for transferring molten metal comprising:

a base having a bottom and a main surface,

a main orifice passing through the main surface, and

a periphery surrounding the main surface,

wherein the main orifice has an interior face and a longitudinal axis,

wherein the periphery has an interior face, an exterior face and an upper face,

wherein the upper face of the periphery is higher than the main surface of the refractory element,

wherein the periphery intersects the bottom of the base, and

wherein the exterior face of the periphery forms an angle other than a right angle with the bottom of the base in at least one point in their intersection.

2. The refractory element of claim **1**, wherein the exterior face of the periphery forms a right angle with the bottom of the base at two points in their intersection.

3. The refractory element of claim **1**, wherein the exterior face of the periphery forms an acute angle with the bottom of the base at all points in their intersection.

4. The refractory element of claim **1**, wherein the exterior face of the periphery forms an obtuse angle with the bottom of the base at all points in their intersection.

5. The refractory element of claim **1**, wherein the element partially encloses a volume with a cross-section that decreases in size with decreasing distance to the bottom surface.

6. The refractory element of claim **1**, wherein the plane of the upper face of the periphery and the plane of the bottom of the base are not parallel.

7. The refractory element of claim **1**, wherein the upper face of the periphery comprises an upper level and a lower level joined by two transitional non-vertical, non-horizontal portions.

8. The refractory element of claim **1**, wherein the main surface has a geometry selected from the group consisting of circular, oval, truncated circular, truncated oval, and polygonal geometry.

9. The refractory element of claim **1**, further comprising a vane extending from the interior face of the periphery.

10. The refractory element of claim **1**, further comprising a plurality of vanes extending from the interior face of the periphery.

11. The refractory element of claim **1**, further comprising a vane extending from the exterior face of the periphery.

12. The refractory element of claim **1**, further comprising a plurality of vanes extending from the exterior face of the periphery.

13. The refractory element of claim **1**, further comprising at least one port passing from the exterior face to the interior face of the periphery.

14. The refractory element of claim **1**, further comprising a feature located at a position selected from the group consisting of the interior face of the main orifice and the bottom of the base, wherein the feature is selected from the list consisting of a marking, a recess, a protrusion, a groove, a lip, a peg, a bore, a notch, a dimple, a mogul, a ridge, a threaded receiver, a key receiver, a bayonet receiver, a bevel, and a non-circular geometry.

15. An assembly for the transferring of molten metal comprising

a refractory element according to claim **1**, and

a refractory nozzle in communication with the refractory element,

wherein the nozzle has a bore having a longitudinal axis, and

wherein the nozzle has an exterior radial surface configured to mate with the interior face of the main orifice.

16. The assembly of claim **15**, wherein the axis of the nozzle bore is aligned with the axis of the main orifice.

17. The assembly of claim **15**, wherein the main surface of the base of the element has a lowest level, the lowest level being lower than the top outer edge of the nozzle inlet portion.

18. The assembly of claim **15**, wherein the refractory element and the refractory nozzle together comprise a single piece.

19. The assembly of claim **15**, wherein the refractory element comprises a main orifice having a non-circular geom-

etry, and wherein the refractory nozzle comprises an exterior radial surface having a non-circular geometry configured to mate with the refractory element.

20. The assembly of claim **15**, wherein the refractory element comprises a main orifice interior face having a mating feature, wherein the refractory nozzle comprises an exterior radial surface having a corresponding mating feature configured to engage with the main orifice interior face mating feature.

21. The assembly of claim **20**, wherein the mating feature and the corresponding mating feature, when engaged, prevent rotational motion of the element around the longitudinal axis of the bore of the nozzle.

22. A metallurgical vessel for the casting of molten metal comprising

an assembly of a refractory nozzle having an inlet portion forming a passage through the bottom wall of the metallurgical vessel and

a refractory element according to claim **1** surrounding the inlet portion of the nozzle,

wherein the inlet portion of the nozzle has a top outer edge,

wherein the inlet portion of the nozzle has a longitudinal axis,

wherein the main orifice of the element is adapted for matching engagement with at least a portion of the outer surface of the nozzle,

wherein the main surface of the base of the element has a lowest level, the lowest level being lower than the top outer edge of the nozzle inlet portion, and

wherein at least a portion of the periphery of the refractory element is higher than the surface of the bottom wall of the tundish.

23. The assembly of claim **15**, wherein the element comprises a gas impervious refractory material.

24. The assembly of claim **15**, wherein the nozzle comprises a gas impervious refractory material.

25. The assembly of claim **15**, further comprising gas impervious mortar between the nozzle and the refractory element.

26. The element of claim **1**, consisting essentially of a high alumina material comprising at least 75 wt. % of Al_2O_3, and less than 1.0 wt. % of SiO_2, less than 5 wt. % of C.

27. Process for the continuous casting of steel comprising pouring the molten steel from a ladle into a metallurgical vessel according to claim **22**, and from the metallurgical vessel into a casting mold

28. The refractory element of claim **1**, wherein the periphery of the element has a thickness equal to or greater than 2 millimeters, and equal to or less than 100 millimeters.

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