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(54) **Gas permeable well nozzle.**

(57) The invention is directed to a gas permeable well nozzle for use in a metallurgical vessel such as in a well block of a tundish, ladle or like vessel. The well nozzle (40) is generally cylindrical in shape and includes a gas permeable refractory member (42) having an axial bore (44) therethrough. The gas permeable member is preferably formed of a pressed and fired ceramic refractory material having a high resistance to molten metal erosion such as alumina, zirconia or magnesia, present either as a single phase or as a carbon bonded system. A castable refractory member (46) is positioned around the outside of the gas permeable portion and defines an open gas annulus (48) therebetween. The castable portion contacts the gas permeable portion to form upper and lower gas impermeable joints around the gas annulus. A metal can (50) is preferably positioned around the castable member and includes a gas fitting (52) which communicates with a gas inlet channel (49) formed in the castable portion to permit introduction of pressurized inert gas therethrough. The major refractory constituents of the gas permeable member and the castable member are preferably identical so as to provide matched thermal expansion rates and thus lessen the opportunity for thermal induced cracking along the gas impermeable joints between the two members.

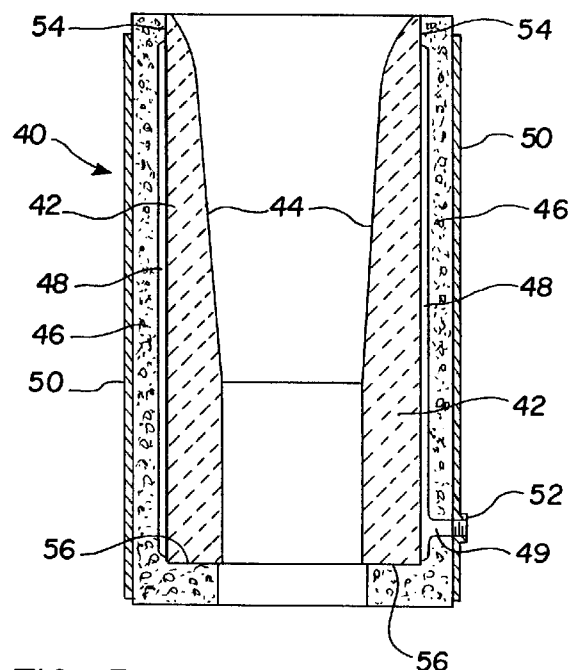


FIG. 3

The present invention relates generally to refractory elements used in metallurgical operations and more particularly to an improved well nozzle for use in a tundish, ladle or like vessel in the continuous casting of steel. Heretofore, the benefits of bubbling an inert gas such as argon through a porous refractory element in a tundish well nozzle have been recognized, particularly, as an aid in eliminating unwanted inclusions in the steel, preventing air aspiration and in minimizing the deposition of aluminum-type inclusions on the walls of the refractory casting elements. If unchecked, such aluminum oxide depositions will eventually cause complete blockage of the casting element.

In order to provide inert gas to the bore of the tundish well nozzle, it has been common practice to provide a pressed and fired porous refractory member of a generally cylindrical shape having an axial bore and an outer sidewall surface. The sidewall is machined to closely receive a metal can therearound. The outer sidewall of the porous refractory member and the inside surface of the steel can define an open annular region therearound for the introduction of a pressurized inert gas. The top and bottom portions of the porous refractory sidewall are joined to the can with a refractory cement along the contacting surfaces to prevent gas leakage therealong. When properly operating, inert gas introduced to the metal can enters the open annular region and permeates the porous refractory member to exit as a fine dispersion of bubbles in the molten metal stream passing through the axial bore of the well nozzle.

Unfortunately, it has been observed that the refractory cement seal at the joint between the porous refractory member and metal can eventually fails causing inert gas leakage along the top joint. When such a joint failure occurs, the inert gas takes the path of least resistance and generally flows along the failure path rather than permeating through the porous refractory to the bore, as required for proper operation.

The present invention solves the shortcomings of the prior art by providing a porous well nozzle for a metallurgical vessel such as a tundish in which the likelihood of inert gas leakage along the metal can is virtually eliminated. In addition, the well nozzle of the invention provides a novel construction in which the inert gas sealing joint is not dependent upon a refractory to metal cement seal, thus eliminating the problem caused by differing thermal expansion coefficients between ceramics and metals, which is inherent in prior art well nozzles. Still further, the present invention provides a gas permeable well nozzle which is less expensive to manufacture than prior nozzles because it employs less of the more costly porous refractory material, requires shorter firing times and requires no labor intensive external machining.

SUMMARY OF THE INVENTION

Briefly, the present invention is directed to a gas permeable inner nozzle or well nozzle for use in a metallurgical vessel such as in a well block of a tundish. The novel well nozzle is generally cylindrical in shape and includes a gas permeable or porous refractory member having an axial bore therethrough, defining an entry end at an upper end portion and an exit end at a lower end thereof. The porous member is preferably formed of a pressed and fired ceramic refractory material having a high resistance to molten metal erosion such as alumina, zirconia or magnesia, which may be present either as a single phase or as a carbon bonded system. A castable member of a pourable or castable refractory cement material is cast around the outside of the gas permeable member having an open gas annulus defined therebetween. The castable member has upper and lower end portions which extend beyond the gas annulus and directly contact and bond with the outer surfaces of the porous refractory member to form gas impermeable joints along the upper and lower end portions thereof. A transverse gas inlet channel extends through the castable member to communicate at one end with the gas annulus. A metal can, preferably of steel, is positioned around the castable member and includes a gas fitting which communicates with a second end of the gas inlet channel to permit introduction of pressurized inert gas therethrough.

The castable refractory member which defines the gas annulus along the porous refractory member forms a very tenacious chemical bond, upon curing, thus, creating a gas impermeable joint between the two refractory members. Preferably, the major refractory constituents of the porous member and the castable member are identical so as to provide matched thermal expansion rates and thus lessen the opportunity for thermally induced cracking along the gas impermeable joints between the two members. For example, the porous refractory member may be of a pressed and fired alumina material and the castable member may be a mixture of alumina and a cementitious material, preferably consisting of about 95% by weight alumina and about 5% by weight cementitious calcia, plus minor impurities. The predominant hydraulic bonding phase in this system is calcium aluminate. The castable mixture is poured around the porous refractory member with a wax sleeve previously applied on the outer surface of the porous member. After drying and moderate temperature curing at about 700°-800°F, the castable portion sets and forms a bond with the gas permeable refractory along the joint areas while the wax sleeve melts and vaporizes to form the open gas annulus in the region formerly occupied by the wax sleeve.

In addition to alumina, compatible matched refractory materials which may be used to form the gas

permeable member and castable member also include zirconia and magnesia, wherein the castable member contains preferably about 958 by weight of the matched refractory material and about 58 by weight cement, preferably calcium oxide, plus incidental impurities.

As a further embodiment, the above mentioned refractory materials, namely, alumina, zirconia and magnesia may be individually employed in a matched, carbon bonded system for manufacture of both the porous and castable or pourable members. A carbonaceous resin or pitch binder forms a strong carbon bond within and between the respective members. In the carbon bonded embodiment, volatile hydrocarbons in the castable or pourable member are driven off during a conventional preheating treatment of the tundish and the member undergoes a further firing treatment during normal use.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partially fragmented, cross-sectional side elevation view of a tundish, with a conventional sliding gate valve and attached submerged casting nozzle, showing a prior art well nozzle in place in the tundish;

Figure 2 is a cross-sectional side elevation view of a gas permeable well nozzle of the prior art, similar to that depicted in Figure 1; and

Figure 3 is a cross-sectional side elevation view of a gas permeable well nozzle according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, Figure 1 shows a partially fragmented section of a conventional tundish 2 which is used in continuous steel casting operations to hold molten metal prior to delivery to a continuous casting machine (not shown). The tundish has a well block area 4 and may include a cylindrical member 6 positioned around the discharge orifice of the tundish for the purpose of improving the quality of the metal being cast therefrom. A conventional well nozzle 8 is cemented into the well block area 4 and contains an axial bore 10 therethrough. A conventional sliding gate valve 12 is fitted to the bottom of the tundish 2 to control the flow of molten metal exiting therefrom. A slideable refractory plate 14 moves between two stationary refractory plates to control the metal flow, all in a well-known manner. A conventional collector nozzle 16 is fitted to the bottom stationary plate of the sliding gate valve 12 and directs the stream of molten metal to a submerged pouring nozzle 18 which, in turn, directs the molten metal to the continuous casting mold (not shown). A conduit 20 supplies pressurized inert gas, such as argon, to the well nozzle 8 for emission as a fine dispersion of inert gas bubbles to

the axial bore 10, all of which is well-known in the steelmaking art.

A porous well nozzle 8', typical of the prior art, is also depicted in Figure 2 and is similar to the nozzle 8 shown in Figure 1. The prior art well nozzle 8' includes a gas permeable, porous refractory portion 22 of a pressed and fired refractory material, such as alumina, for example. The porous portion 22 is encased by a metal can 24, usually of a steel material. An annular gas slot 26 is defined between the outside surface of the porous refractory portion 22 and the metal can 24. The metal can also includes a threaded fitting 28 which communicates at one end with the annular slot 26 and is adapted to be fitted to an inert gas supply line such as the conduit 20 of Figure 1 to supply pressurized inert gas to the annular slot 26.

The steel can 24 is joined to an upper end region of the porous refractory portion 22 by way of a joint 30 formed by a thin layer of refractory cement which creates a barrier to prevent the escape of inert gas from the annular slot 26. During operation, at elevated steel casting temperatures, it has been observed that the refractory cement joint 30 may begin to fail and thereafter permits the pressurized inert gas to leak from the annular slot 26 along the periphery of the steel can 24. Thus, instead of having the desired fine dispersion of inert gas bubbles around the bore 10', the inert gas will short circuit, taking the path of least resistance and escape around the upper edges of the steel can where the refractory cement 30 has failed. It is theorized that this premature and undesirable failure of the refractory cement joint 30 occurs because of the differences in the thermal expansion coefficients of the steel can 24 and the porous refractory portion 22, since the refractory material expands at a much lower rate than the steel material. Of course, when short circuiting of the inert gas flow occurs, the desired action of the inert gas along the axial bore 10' ceases and the well nozzle can no longer perform its intended gas distribution function.

This common problem is eliminated by the gas permeable well nozzle 40 of the present invention shown in Figure 3. The well nozzle 40 of the invention includes a gas permeable porous refractory member 42 of a generally cylindrical shape with an axial bore 44 formed therethrough. Due to the novel configuration of the present well nozzle 40, the porous refractory member 42 has a smaller wall thickness and diameter than its prior art counterpart depicted in Figure 2, previously identified as porous portion 22. Because of this decrease in physical size, less of the more expensive sized refractory grains are used in the manufacture of the porous member 42 and the time required for firing the refractory is also reduced. Thus, the porous refractory member 42 is less expensive to manufacture than the larger porous portion 22 of the prior art due to decreased material and energy costs.

A pourable or castable refractory member 46 hav-

ing a generally cylindrical shape surrounds the porous refractory member 42. An open gas annulus 48 is positioned intermediate the members 42 and 46 and includes a transverse channel 49 which is adapted to be placed into communication with a remotely positioned supply of pressurized inert gas. In operation, the pressurized inert gas fills the annulus 48 and permeates the porous refractory member 42. The gas exits along the sidewall of the axial bore 44 as a fine dispersion of inert gas bubbles in the molten stream of metal passing therethrough.

The annulus 48 is formed by the so-called "lost wax" method of casting, well-known in the refractory and foundry arts. A wax sleeve or coating of wax is applied around the outer surface of the fired porous refractory member 42 by hot dipping, for example, to form the gas annulus 48. The upper and lower joint areas 54 and 56 are preferably masked prior to wax application by taping the surface of the porous member 42, which prevents the wax from adhering to these areas. The wax coated piece 42 is then placed in a cylindrical mold having the configuration of the pourable or castable member 46. The tape covering the masked areas 54 and 56 is removed prior to pouring the castable material so as to provide a wax free bonding surface along the upper and lower areas 54 and 56. A wax core is also inserted into the mold in contact with the wax sleeve for formation of the transverse channel 49. The castable or pourable refractory material is poured into the mold and assumes the cylindrical shape of the mold, substantially as depicted in Figure 3. The castable member 46 sets in the mold and assumes a green strength after a given time period after which the green part is dried and then subjected to a thermal curing treatment to harden the castable member 46 and to form the bonded joints 54 and 56. During the curing treatment at about 700°-800°F, the previously applied wax melts and volatilizes off to produce the open gas annulus 48.

A metal closure or can 50, preferably of steel, is positioned around the cured castable member 46 and held in place by a mechanical fit. The can 50 includes a threaded gas conduit fitting 52 which communicates with the transverse channel 49 and is adapted to be attached to an inert gas supply conduit, such as a gas pipe 20 of Figure 1.

The gas permeable porous refractory member 42 is constructed of a pressed and fired refractory material such as alumina, zirconia or magnesia, all of which exhibit good erosion resistance in molten steel. After curing, the upper portions of the porous member 42 and castable member 46 form a high strength bonded joint 54 along their interface. A similar strong bonded joint 56 is formed along the lower portions of the contacting surfaces of the porous member 42 and castable member 46.

In a presently preferred embodiment, the porous member 42 is made from a refractory material select-

ed from alumina, zirconia or magnesia. The porous member is pressed and fired all in a well-known manner. The castable member 46 is constructed of a matched refractory system containing a high percentage of one of alumina, zirconia or magnesia plus, a small percentage of a refractory cement component. A preferred dry mix ratio for the castable member is about 95% by weight refractory material and about 5% by weight cement, preferably calcium oxide cement. In practice, the use of like refractory materials in the members 42 and 46 provides matched thermal expansion rates in the porous and castable members. Such matched thermal expansion properties serves to maintain the integrity of the gas impermeable joints 54 and 56 during service and prevents cracking and subsequent leakage of inert gas therebetween. It will be further appreciated, that the joint provided by the cementitious material in the castable member 46 creates a strong bond with the refractory material of the porous refractory member 42. The resulting joints 54 and 56 are much stronger than the prior art joint 30 between the refractory cement and the metal can. In addition, the close matching of thermal expansion rates of the members 42 and 46 provides further resistance to thermally induced cracking at the bonded joints 54 and 56.

Since castable member 46 is poured around the porous member 42, there is no need for time consuming and costly machining operations to fit the parts together as previously called for in the prior art. The castable refractory mixture making up member 46 in the wet, unset condition is flowable and conforms to any surface irregularities which may be present on the outer surface of the porous member 42. The wax sleeve employed to form the open gas annulus 48 likewise accommodates any surface imperfections or irregularities which may be present on the outer surface of the member 42.

It will be further appreciated that in the prior art construction of Figure 2, a gas seal is established by the application of a thin layer of refractory cement to joint 30 between the surface of the refractory portion 22 and the metal can 24. The improved gas impervious joint 54 of the present invention is robust because of the relatively great thickness of castable member 46, coupled with the concept of matching the thermal expansion coefficients of the refractory materials employed so as to permit the members 42 and 46 to expand and contract in unison without separating along the joint 54.

The present invention also contemplates the use of matched carbon bonded refractory systems, in which case the previously described cementitious constituent in the castable member 46 is not used. A resin or pitch carbonaceous binder in an amount of between about 2%-30% by weight is preferably employed in the refractory mix and formulated as a pourable material which is cast into place around a like

carbon bonded refractory porous member 42 which has been previously pressed and fired. Refractory systems such as carbon bonded alumina, carbon bonded zirconia and carbon bonded magnesia are well-known in the art and provide good steel erosion resistance and superior thermal shock resistance. The carbon bonded refractory systems also form strong joints 54 and 56 as previously described. The metal can 50 holds the unfired, pourable carbon bonded refractory in place and prevents handling damage to the pourable member 46 prior to thermal treatment which occurs during use. During conventional tundish preheat operations, the volatile hydrocarbon materials are driven off from the pourable member 46 such that the member 46 is cured as the tundish is preheated prior to start-up of metal teeming. The much higher temperatures which occur during continuous steel casting then provide a further firing treatment to the carbon bonded refractory pourable member 46. Such carbon bonded refractories also exhibit improved, longer life inert gas sealing along the joints 54 and 56 due to the fact that the refractories employed in the carbon bonded systems are matched. Therefore, the previously discussed balanced thermal expansion and contraction properties between the porous refractory member 42 and the pourable refractory 46 are likewise achieved in the carbon bonded refractories.

While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. The presently preferred embodiments described herein are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the appended claims and any and all equivalents thereof.

The features disclosed in the foregoing description, in the following claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. A gas permeable well nozzle for a metallurgical vessel comprising:
 - a porous member of a pressed and fired refractory material having an axial bore there-through; and
 - a castable refractory member surrounding said porous refractory member defining an annulus around an outer surface of said porous member, said castable member having channel means communicating with the annulus and adapted to be placed in communication with a supply of pressurized inert gas, said castable re-

fractory member contacting said porous refractory member along upper and lower end portions thereof to form gas impermeable joints there-around to permit said inert gas to permeate said porous refractory member and exit as a fine dispersion along the bore thereof.

2. The well nozzle of claim 1 wherein the castable member comprises a mixture consisting of a refractory material and a cementitious material, the refractory material of the castable member being the same as the refractory material of said porous member whereby substantially identical thermal expansion rates are present in said porous and castable members.
3. The well nozzle of claim 2 wherein the porous member is of an alumina refractory material and the castable member comprises a mixture of about 95% by weight alumina and about 5% by weight calcium oxide plus incidental impurities.
4. The well nozzle of claim 2 wherein the porous member is of a zirconia refractory material and the castable member comprises a mixture of about 95% by weight zirconia and about 5% by weight calcium oxide plus incidental impurities.
5. The well nozzle of claim 2 wherein the porous member is of a magnesia refractory material and the castable member comprises a mixture of about 95% by weight magnesia and about 5% by weight calcium oxide plus incidental impurities.
6. The well nozzle of claim 1 further including metal closure means surrounding said castable member.
7. The well nozzle of claim 6 wherein the porous member is of a carbon bonded refractory material and said castable member is formed of a pourable carbon bonded refractory composition consisting essentially of a like refractory material as present in said porous member.
8. The well nozzle of claim 7 wherein the porous member and castable member are made from a like carbon bonded refractory material selected from the group consisting essentially of carbon bonded alumina, carbon bonded zirconia and carbon bonded magnesia.
9. The well nozzle of claim 6 wherein the metal closure means includes a fitting means communicating with the channel means and adapted to interconnect with an inert gas supply conduit.
10. A gas permeable well nozzle for a tundish com-

prising:

a porous member of a generally cylindrical shape and having an axial bore formed there-through, said porous member comprising a pressed and fired refractory material selected from the group consisting of alumina, zirconia, and magnesia;

a castable member of a generally cylindrical shape surrounding said porous member, defining an annulus around an outer surface of said porous member, said castable member having channel means communicating with the annulus and adapted to be placed in communication with a supply of pressurized inert gas, said castable member including a refractory material selected from the group consisting of alumina, zirconia and magnesia and wherein the refractory material of the porous member and castable member are the same, said castable member contacting said porous member along upper and lower end portions thereof to form gas impermeable joints therealong to prevent inert gas leakage along said joints and to permit said inert gas to permeate said porous member and exit as a fine dispersion along the axial bore thereof; and

metal closure means surrounding said castable member.

11. The well nozzle of claim 10 wherein the refractory material of the castable member also includes an effective amount of a cementitious material, including calcium oxide.

12. The well nozzle of claim 11 wherein the castable member consists of about 95% by weight of one of said refractory materials and about 5% by weight calcium oxide plus incidental impurities.

13. The well nozzle of claim 10 wherein the refractory material of the porous member and castable member include a carbonaceous binder constituent.

14. The well nozzle of claim 13 wherein the carbonaceous binder is one selected from the group consisting of pitch and resin.

15. A method of making a gas permeable well nozzle comprising:

pressing and firing a porous refractory member of a generally cylindrical shape and having an axial bore therethrough;

applying a layer of wax around a selected outside surface area of said porous member, including forming a wax channel core means outwardly extending from said wax layer;

preparing a pourable refractory mixture containing a like refractory material as present in

said porous refractory member;

casting the pourable refractory mixture into a mold around the outside of said fired and wax coated porous member to form a generally cylindrical shaped castable member therearound and contacting upper and lower areas around said porous member continuously adjacent to said wax layer; and

drying and curing said castable member and enclosed porous member at an effective elevated temperature for a sufficient time to cure the castable member and to melt and vaporize said wax layer and channel core means whereby an open gas annulus is formed between said porous and castable members and wherein gas impermeable joints are formed along said upper and lower contacting areas continuously adjacent to said gas annulus.

16. The method according to claim 15 including the step of applying a metal closure means around an outside surface of said castable member.

17. The method of claim 15 wherein the like refractory material of the porous member and the castable member is one selected from the group consisting of alumina, zirconia and magnesia.

18. The method of claim 17 wherein the castable member includes an effective amount of calcium oxide as a cementitious constituent.

19. The method of claim 18 wherein the castable member consists of about 95% by weight refractory material and about 5% by weight calcium oxide and incidental impurities.

20. The method of claim 15 wherein the like refractory material of the porous member and the castable member include a carbonaceous binder.

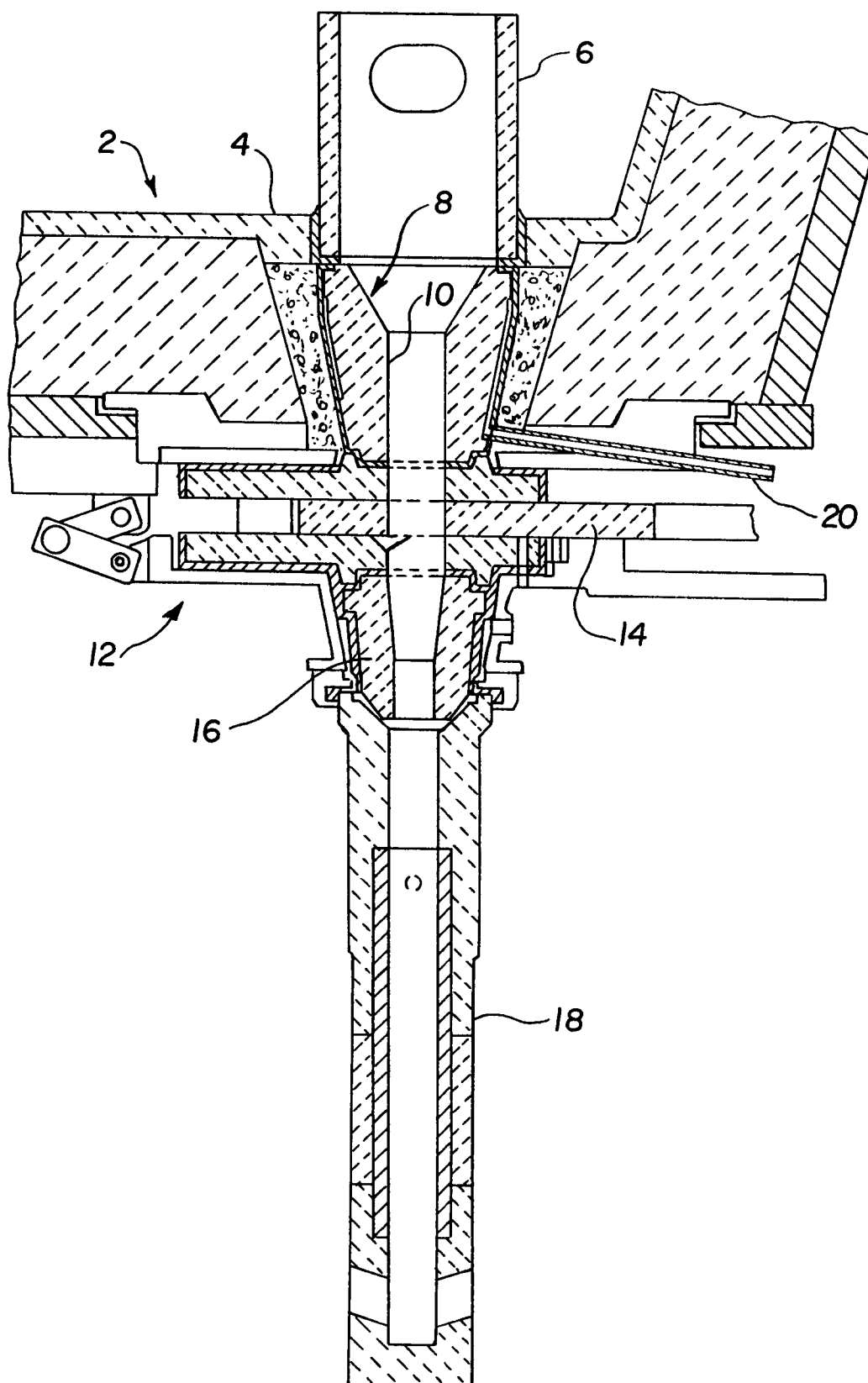
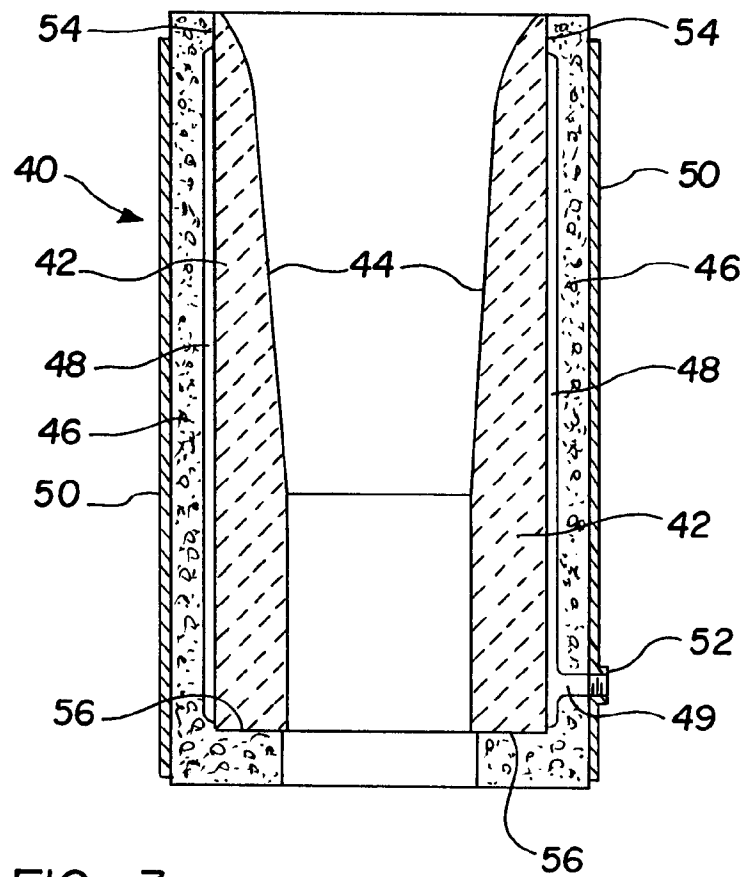
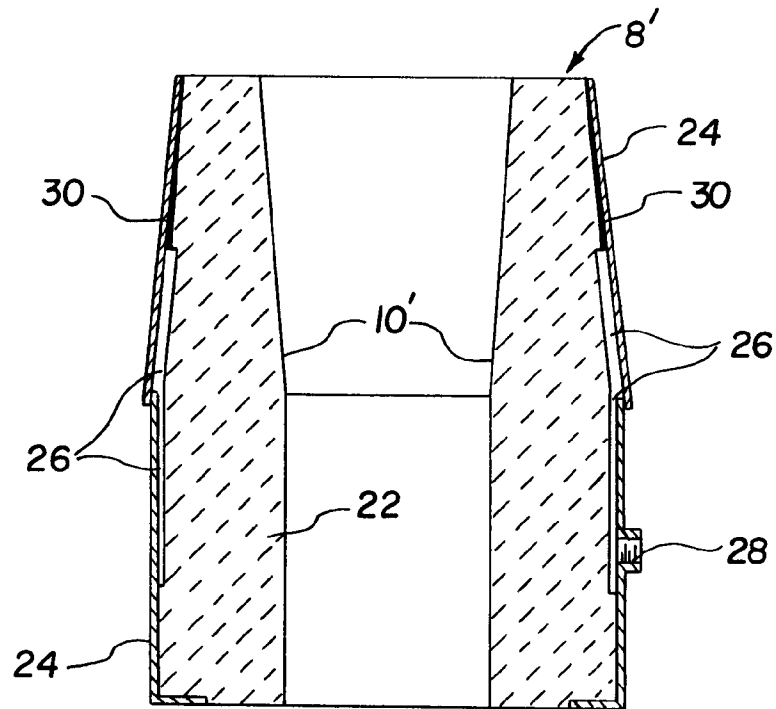


FIG. 1 PRIOR ART





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 3046

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN vol. 8, no. 234 (M-334)(1671) 26 October 1984 & JP-A-59 113 962 (HARIMA TAIKA RENG K) 30 June 1984 * abstract *	1, 10, 15	B22D41/58
X	--- PATENT ABSTRACTS OF JAPAN vol. 6, no. 142 (M-146)(1020) 31 July 1982 & JP-A-57 062 857 (KUROSAKI YOUNGIYOU KK) 16 April 1982 * abstract *	1, 15	
X	--- GB-A-1 575 602 (DIDIER-WERKE AG) * page 9, line 43 - page 10, line 28; figures 20, 21, 22 *	1	
A	--- WO-A-8 402 670 (VESUVIUS CRUCIBLE CY) * page 14, line 11 - page 15, line 16; figure 4 *	4, 6, 7, 8, 10, 13	
A	--- GB-A-1 492 534 (FLOGATES LTD) * page 3, line 82 - line 86; figure 3 *	9	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	--- US-A-4 691 844 (TOSHIBA CERAMICS LTD) * abstract *	4, 8, 11, 17-20	B22D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 16 JUNE 1992	Examiner MAILLIARD A. M.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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