United States Patent [19]

Voss

[11] **3,838,798**

[45] **Oct. 1, 1974**

[54] **POROUS TUNDISH NOZZLE**

[75] Inventor: **Wendell G. Voss,** St. Joseph, Mich.

[73] Assignee: **Leco Corporation,** St. Joseph, Mich.

[22] Filed: **Jan. 21, 1971**

[21] Appl. No.: **108,530**

[52] **U.S. Cl.** **222/148,** 222/566, 266/34
[51] **Int. Cl.** **B22d 37/00**
[58] **Field of Search** .... 266/34; 222/148, DIG. 1, 222/DIG. 19, DIG. 14, 566

[56] **References Cited**

UNITED STATES PATENTS

2,866,241	12/1958	Nirmaier et al.	222/DIG. 19
3,253,307	5/1966	Griffiths et al.	222/DIG. 14
3,330,645	7/1967	Moustier et al.	266/34 X
3,373,986	3/1968	Spire	222/DIG. 19
3,472,432	10/1969	Kilgore	222/DIG. 19
3,490,755	1/1970	Lutgen	222/DIG. 19

FOREIGN PATENTS OR APPLICATIONS

1,146,218	11/1957	France	222/DIG. 11

Primary Examiner—Allen N. Knowles
Assistant Examiner—David A. Scherbel
Attorney, Agent, or Firm—Price, Heneveld, Huizenga & Cooper

[57] **ABSTRACT**

A non-clogging tundish nozzle designed for the formation of a gas film in the bore thereof to keep the bore clean, and a preferred construction therefor.

15 Claims, 3 Drawing Figures

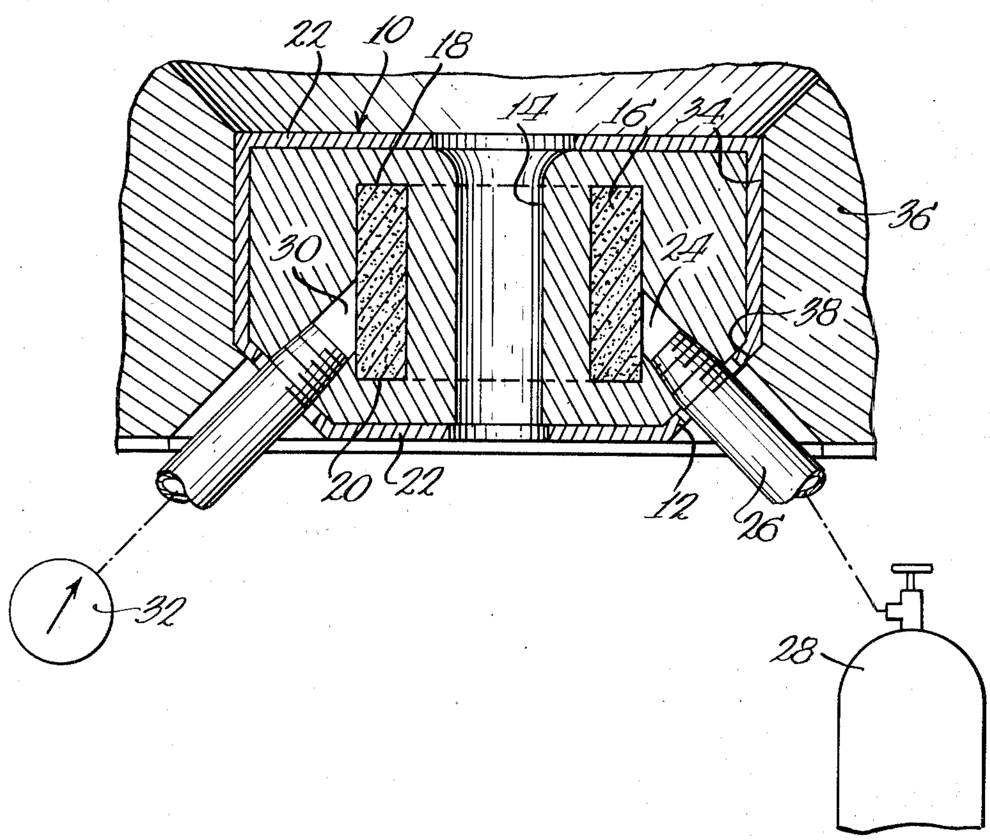


Fig. 1.

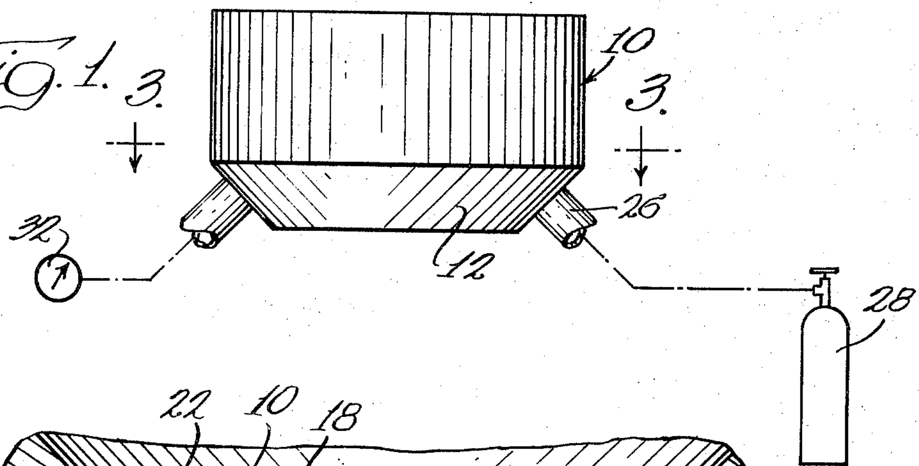
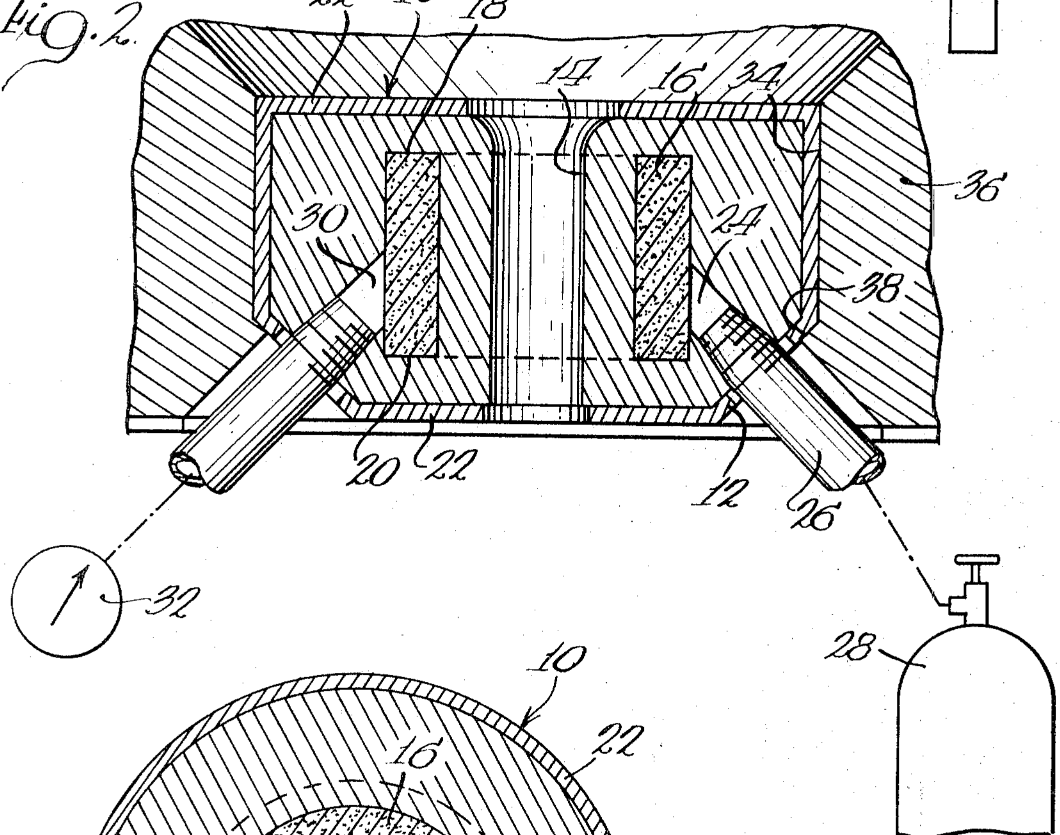


Fig. 2.



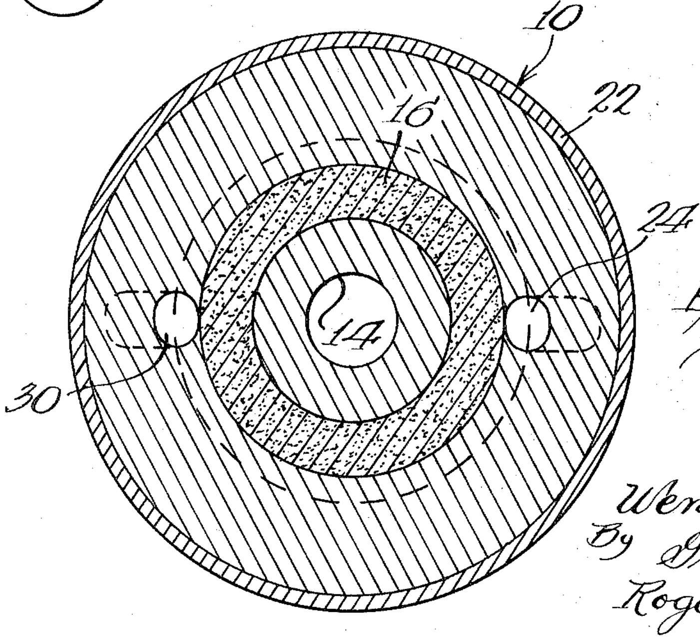


Fig. 3.

Inventor:
Wendell G. Voss
By Gradolph, Love,
Rogers & Van Sciver Att'ys

POROUS TUNDISH NOZZLE

BACKGROUND OF THE INVENTION

In the production of steel by the continuous casting method, it is desirable that the molten steel be poured into the mold from a ladle or tundish by bottom pouring through a metering nozzle. The flow rate must be adjusted to the cooling capacity of the molds and such a bottom delivery arrangement provides better control. Also, the steel must be delivered accurately to the center of the mold to avoid turbulence near the side walls. Such accurate placement is more easily achieved by the bottom delivery. In the pouring of aluminum killed steels, the experience has been that aluminum oxide accumulates within the bore of the nozzle and around its discharge end. The occurrence within the bore itself, of course, will progressively diminished flow to the point of shutting it off, and the accumulation around the end, or "snotting", will cause the stream to waver off the desired line of steel introduction into the mold so as to cause a weakening of the walls of the still interiorly molten billet as it emerges from the mold.

SUMMARY OF THE INVENTION

The tundish nozzle of this invention is one wherein means are provided for the generation of a blanket of an inert gas about the inside surface of the bore such that adhesion of aluminum slags is substantially whole avoided, both within the bore itself and about the discharge end thereof such that aluminum-killed steel may be poured through it at a substantially constant flow rate and in the desired steady stream. At the same time, the blanket substantially prevents nozzle erosion.

This invention is an improvement on and a contribution to the invention disclosed in application Ser. No. 809,723, to George F. Newton, and arose out of a joint experimental program with the assignee of that application.

Attention is directed to U.S. Pat. No. 3,253,307 issued to Griffiths et al. on May 31, 1966, as directed to a nozzle bearing a superficial resemblance to that to be described here, but differing actually in structure, function, and purpose widely.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevation of a tundish nozzle constructed in accordance with the present invention;

FIG. **2** is a vertical section therethrough; and

FIG. **3** is a horizontal section taken along the line 3—3 of FIG. **1**.

DESCRIPTION OF A PREFERRED EMBODIMENT

In the aforesaid application of Newton, the concept was invented of generating an inert gas film or blanket or screen on the surface of the bore of a tundish nozzle to eliminate above-stated difficulties of aluminum oxide accumulations within the bore and about the discharge end of the bore. Tundish nozzles are commonly formed of a zirconium oxide or zirconium silicate ceramic having a slight degree of porosity. Accordingly, the outside surfaces of the nozzle other than that of the bore itself were glazed with a nonporous glaze, a hole was drilled partially into the nozzle in the direction of the bore, but stopping short of the bore, and a gas pipe was connected to the bore for the delivery of an inert gas under pressure to the body of the nozzle. This expedient was found to be ineffective because the desired gas cushion developed only on that portion of the bore nearest the point of entry of the gas.

The invention here resides in the incorporation of a manifolding annulus concentric with the bore of the nozzle which communicates with the gas inlet. Referring specifically to the drawings, the illustrated nozzle of the present invention has a rather shallow, cylindrical body **10** having a bevel **12** about the lower periphery thereof and an axial bore **14** through the center thereof. A manifolding ring **16** is embedded in the body concentric with the bore **14**.

The ring is highly porous so as to offer near zero resistance to gas flow therethrough in comparison with the material of the body. The annulus should be so proportioned as to be spaced about a one-fourth inch on its top **18** and bottom **20** plane sides from the top and bottom surfaces of the body respectively and a like distance on its internal surface from the bore **14.** The nozzle may have an impervious glaze **22** on all surfaces thereof other than the bore **14** itself.

A hole **24** is drilled into the body from the beveled surface to extend to the annulus **16** and is internally threaded to receive a gas duct **26.** The gas duct in turn is connected to a source of inert gas, desirably argon, diagrammatically represented as at **28.** A second bore **30** may likewise extend from the bevel to the annulus at a point 180° spaced from the bore **24** to which is connected a pressure gauge **32** to monitor the condition of pressure within the annulus **16.**

In FIG. **2,** the nozzle is shown mounted in the bottom aperture **34** of a tundish **36,** the aperture having a lower inward slope **38** thereabout to conform to the bevel **12** to support the nozzle.

The exact shape of the nozzle and the means by which it is supported within a tundish may vary widely. The features of significance and of pertinence to this invention are the bore **14,** the annulus **16** closely surrounding the bore, and the means for supplying inert gas under pressure to the annulus.

The composition of the body of the mozzle is a zircon ceramic composed of zircon sand and milled zircon to result in an ultimate porosity of 17 to 18 per cent. This composition is entirely conventional and normal for tundish nozzles and has been employed for such purposes considerably before the concept of this invention. Such composition meets all the requirements of strength and resistance to erosion and at the same time is inexpensive. Other ceramics such as those based on zirconia might also be employed in this context. In any case, any ceramic having the necessary qualities of strength together with resistance to erosion and the same general order of porosity would meet the purpose. The above porosity is normal to the composition, but coincidentally serves well in the context of the present invention.

Once the concepts of providing the gaseous lining for the bore and of providing an annular manifold for insuring equal distribution of the gas to the whole surface of the bore were hit upon, the problem was the provision of the manifold. A void manifold was considered, using a vaporizable core such as wax or ice. However great difficulties were experienced in expelling the core material through the limited porosity of the ceramic mix while maintaining at the same time the integrity of the formed nozzle in its green or unfired condition.

Furthermore, it was determined that the wall of the bore, or more broadly the top, bottom and inner walls of the nozzle defining the manifolding annulus should be thin in order to obtain a substantially uniform gas flow into the bore over its enitre length. The top and bottom edges of the bore are obviously more remote from the annulus than the bore areas between, and to obtain a satisfactory cushion production at these extremities of the bore, such limited wall thickness is a necessity. Thus, a void annulus would result in a nozzle structure which is relatively fragil both in its unfired and fired condition.

A useful nozzle capable of commercial production and industrial use was formed by cutting an annulus from a K-28 fire brick. A part of the standard zircon nozzle mix was introduced into a nozzle die, the fire brick annulus set in place on this portion concentric with the bore punch of the die, and the remainder of the nozzle mix added on and around the annulus. After compression, the formed nozzle was dried and fired. Thereafter, the holes **24** and **30** were bored through the nozzle ceramic into the fire brick.

This nozzle functioned with a high degree of satisfaction. The rather remarkable results of experimental pourings are set forth in detail in the above referred application of Newton. To summarize some of the experimental results, a tundish was furnished with a conventional nozzle and the gas nozzle of the present invention and filled with an aluminum killed steel. The tundish was advanced along a double line of four companion molds. When one of the molds of a pair was filled, the tundish was advanced to the next pair. The pouring rates for the gas nozzle ran about 350 lbs. per minute each for the first three molds and diminished to 175 lbs. per minute for the fourth mold. This diminution is believed to be the result of a cooling of the metal and a consequent increase in viscosity. The pouring rates from the conventional nozzle ran in a steady succession downward, 315, 217, 137, and 103 lbs. per minute consecutively. In a test on a commercial scale, a tundish furnished with two gas nozzles as described herein containing 52,000 lbs. of steel was emptied in 61 minutes into two open-ended, water cooled molds. With conventional nozzles, the bores would have choked with alumina deposits well before a complete emptying.

The fire brick annulus, however, is not a complete success. The fire brick material is soft. With the very substantial pressure of 8 to 10 tons employed in compacting the nozzle mix within the die, the fire brick would frequently crush and lose porosity in some essential areas or shift or tilt so as to lose its concentricity with the bore of the nozzle. Furthermore, the fire brick differs from the body material in its coefficient of thermal expansion. As a consequence, there has been a rupturing or flaking of the inside surface of the bore. Both lack of concentricity of the annulus and defects in the surface of the bore will lead to unequal gas flow rates from increments of the surface of the bore and the latter leads to accelerated erosion.

A ceramic has been developed to meet the above difficulties of the fire brick annulus. While having a porosity of 60 per cent, it nevertheless is strong enough to withstand the compacting pressure referred to above, and it has a coefficient of thermal expansion substantially identical with that of the zircon body. The strength of the nozzle with the included annulus is substantially that of a nozzle without it.

The composition from which the annulus is made, by weight, is as follows:

- 14.59% fused mullite ($3Al_2 SiO_3 \cdot 2SiO_2$) − 14 + 28 mesh
- 65.01% fused mullite − 28 + 48 mesh
- 3.48% wood flour
- 11.11% Carbowax 4000, a trademark of Union Carbide and Chemical Co., indentifying a polyethylene glycol
- 3.32% old mine No. 4 clay
- 2.5% water

After mixing, the composition is molded into the annulus, dried, and fired to 2600° F. Although the wood flour amounts to only a small proportion of the composition by weight, by bulk it is equal to nearly half the composition. As it and the Carbowax burn out in the course of the firing, the desired porosity is created.

As stated above, the illustrated glaze is optional to a degree. The glaze, of course, prevents the loss of gas to any surface other than the bore surface, but the resistance to gas flow increases sufficiently with the thickness of the zircon to be traversed such that the loss of gas through surfaces other than the bore surface would be very slight. In short, the desirability of the glaze might well depend on the comparative thickness of the body portion between the annulus and the bore and the body thickness elsewhere. As they approach equality, the more desirable a glaze might be. This, in turn, will depend, in part, at least, on the tundish aperture into which the nozzle will seat.

I claim:

1. A ceramic article for pouring of molten metal therefrom comprising a homogeneous unitary ceramic body of uniform limited porosity having a bore therethrough defining the pouring passage for said metal, a porous ceramic annulus enclosed within said body to be concentric with and spaced from said bore, said annulus having insignificant resistance to the flow of a gas relative to the resistance of said body, and a passage between said annulus and the exterior surface of said body for delivering gas under pressure to said annulus for diffusion through said body to the surface forming said bore.

2. The combination as set forth in claim **1** wherein said annulus is close to and approximately equidistant from said bore and the top and bottom surfaces of said body.

3. The combination as set forth in claim **2** wherein said annulus is more remote from the outer periphery of said body.

4. The combination as set forth in claim **2** including an impermeable glaze on the exterior surface of said body other than said bore.

5. The combination as set forth in claim **1** wherein said body has a porosity on the order of 18 per cent.

6. The combination as set forth in claim **5** wherein said annulus is comprised of a material having a porosity on the order of 60 per cent.

7. The combination as set forth in claim **1** wherein said annulus is a porous fire brick.

8. The combination as set forth in claim **1** wherein said annulus is characterized by about the same coefficient of thermal expansion as that of said body.

9. The combination as set forth in claim **8** wherein said annulus is composed essentially of a crushed fused mullite.

10. The combination as set forth in claim **9** wherein said body is a zircon ceramic.

11. The combination as set forth in claims **1** wherein said annulus is spaced one-quarter to one-half inch from said bore and the top and bottom surfaces of said body.

12. A ceramic article providing a passage for the pouring of molten metal from a vessel comprising a homogeneous ceramic body of limited porosity having a bore therethrough, said bore defining the pouring passage for said metal, a porous ceramic annulus embedded in said body concentric with and radially spaced from said bore having insignificant resistance to the flow of a gas relative to the resistance of said body from whence gas under pressure will diffuse through said body to substantially the entire surface defining said bore, and means for delivering gas under pressure to said annulus.

13. The article as defined in claim **12** wherein said means for delivering gas under pressure to said annulus comprises a passage communicating between said annulus and the exterior surface of said body.

14. The article as defined in claim **13** and further including a second passage extending from said annulus to the exterior surface of said body on a side opposite said first passage.

15. The article as defined in claim **14** wherein said body is substantially cylindrical and the junction of the bottom and outer surfaces is beveled and said passages extend through the beveled surface thereformed.

* * * * *