Aug. 9, 1966 R. M. PARKE 3,264,692

INLET ORIFICE FOR CONTINUOUS CASTING APPARATUS

Filed April 29, 1964

Fig. 1.

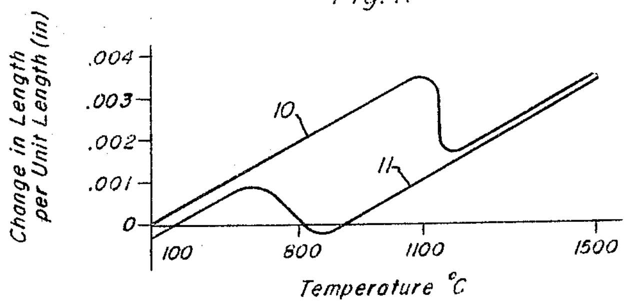


Fig. 2.

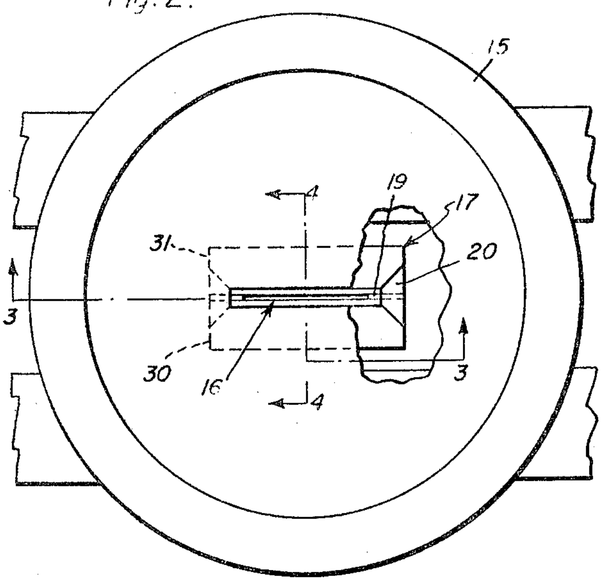


Fig. 4.

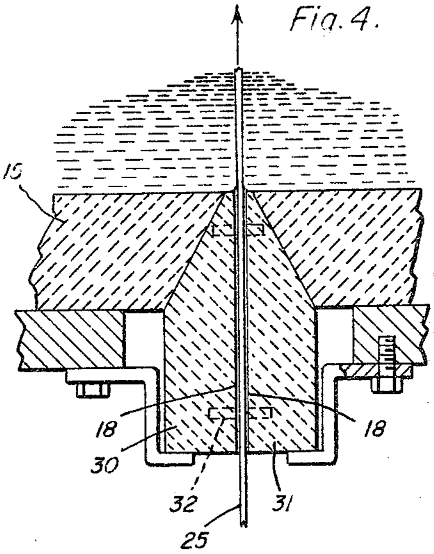
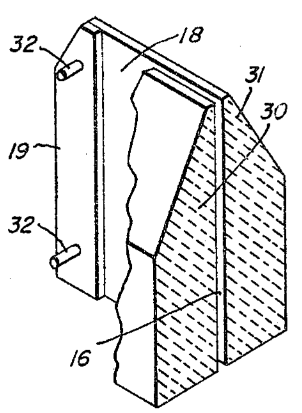


Fig. 5.



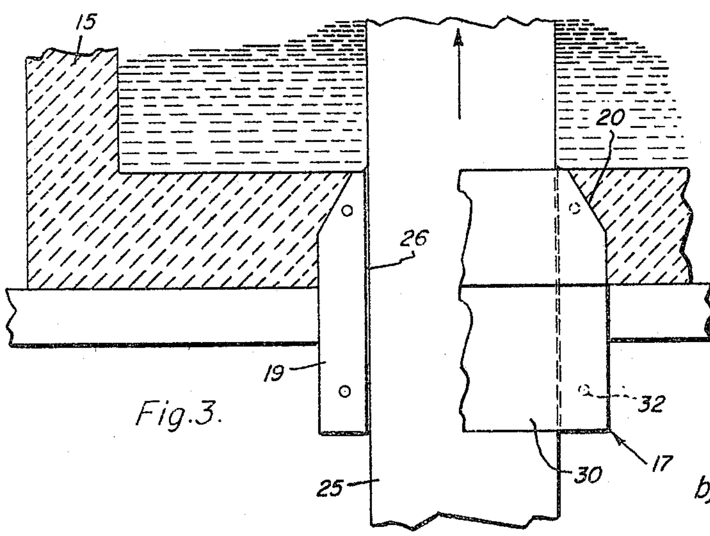


Fig. 3.

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INLET ORIFICE FOR CONTINUOUS CASTING APPARATUS

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4 Claims. (Cl. 22—57.2)

This invention relates to an apparatus for the continuous casting of metals and more particularly to an improved orifice construction for those continuous casting apparatus in which elongated strip material is fed upwardly into a crucible containing molten metal to freeze additional metal thereon.

Strip processing utilizing a vessel or crucible having an inlet orifice located below the surface of fluid contained within the crucible requires minimal clearances between the surfaces of the strip and the surfaces of the means defining the inlet orifice to prevent fluid from escaping. The required minimal clearances in turn necessitate comparatively accurate control of strip feeding to preclude, as much as possible, contact with the walls of the inlet orifice. Further, the clearances are of such limited natures that the thermal expansion and thermal contraction characteristics of the ceramic materials from which the orifice defining means is constructed should closely match those of the input strip. However, in the present instant, the ceramics must further be essentially insoluble in molten steel since this is the material that is located within the crucible into which the strip is passing.

It is a principal object of the invention to provide improved orifice construction for continuous casting apparatus in which elongated strip steel is fed upwardly into a crucible containing molten metal to freeze additional metal thereon.

It is another object of the invention to provide an improved orifice construction for apparatus of the class described wherein provision is made for differing thermal characteristics of the input strip and the material from which the orifice is constructed.

Other objects and advantages of this invention will be in part obvious and in part explained by reference to the accompanying specification and drawings.

In the drawings:

FIG. 1 is a graph of the thermal expansion and contraction in inches per inch versus temperature for the ceramic, zircon;

FIG. 2 is a top elevation of a continuous casting apparatus according to this invention with portions of the inlet orifice construction broken away for purposes of clarity;

FIG. 3 is a sectional view taken along the line **3—3** of FIG. 2;

FIG. 4 is a sectional view taken along the line **4—4** of FIG. 2; and

FIG. 5 is a partial perspective view of an inlet orifice construction according to the present invention.

Generally, the improved inlet orifice construction comprises comparatively elongated side walls constructed of high fired or high density zircon and end walls which are operatively associated with the elongated side walls and are comparatively shorter, which end walls are constructed of a material that can be readily abraded or machined by the passage of steel strip through the inlet orifice upwardly into the molten metal contained within a crucible.

It will readily be appreciated that the ceramic materials that are brought into contact with molten metals and especially with molten steel, must meet stringent requirements, particularly in that they do not react with or be seriously dissolved by the metal. Also, they must be thermally stable and strong to resist cracking, breaking, spalling and the like. I have found that zircon, which is zirconium silicate, $ZrSiO_4$, is admirably suited for contact with molten steel, both from the standpoint of relative insolubility and from the standpoint of mechanical strength characteristics over severe thermal cycling conditions.

However, as shown by the graph in FIG. 1, there is a hysteresis effect in the expansion and contraction which occurs when zircon is thermally cycled between room temperature and about 1500° C. The effect is largely an indirect result of the thermal dissociation of zircon into zirconia and silica, viz. $ZrSiO_4 \rightarrow ZrO_2 + SiO_2$, the zirconia then accounting for the predominant amount of volumetric change. Referring again to FIG. 1, the curve **10** represents the expansion of zircon on heating and clearly shows that it undergoes a drastic change in expansion characteristics at around 1100° C., when substantial amounts of zirconia are present. Further, it will be noted that a similar, although not precisely identical, change in contraction characteristics happens when the material is cooled, as shown by curve **11**.

Referring to FIG. 2, numeral **15** represents a crucible for holding the molten metal. In the center and at the bottom of the crucible can be seen the inlet orifice **16** and the means **17** which define the orifice. This means comprises elongated side walls **18** which taper downwardly away from orifice **16** and end walls **19** which define the lateral limits of orifice **16**. The orifice defining means is also provided with tapered faces **20** which serves to assist holding the orifice means **17** in its proper geometric location.

FIGS. 3 through 5 illustrate in more detail the physical construction of the orifice defining means. Referring to FIG. 3 specifically, the strip **25** moves upwardly through the orifice **16** with only a very minimal amount of clearance **26** between its lateral edges and the edges of end walls **19**. If both the end walls and the side walls were constructed of high fired or completely dense zircon, the space **26** would disappear when strip **25** was started upwardly through the crucible and it would gall or seize against walls **19** and completely stop further movement of the strip. The disappearance of space **26** is caused by the cooling effect which strip **25** has on the orifice **16**, the cooling causing a large contraction of the zircon (FIG. 1).

The orifice defining means may be constructed of two principal halves **30** and **31** (FIGS. 4 and 5) which constitute the side walls **18**. The end walls **19** are then held in position between the two principal halves by means of pins **32**. Obviously, any other suitable means for joining these various pieces into one integral unit may be equally effective.

I have now found that seizing of metal strip **25** within the inlet orifice can be effectively prevented by constructing the end walls **19** of a material which is comparatively softer than the high density zircon from which the side walls **18** are constructed. While the side walls **18** are high fired to a density of not less than 3.7 $gm./cm.^3$, a density of up to about 3.8 $gm./cm.^3$ has been found to be more desirable. On the other hand, I have now found that the end walls **19** can advantageously be constructed of ziron which has been low fired to a density ranging from about 3.45 to 3.55 $gm./cm.^3$. This low firing produces a body which in terms of macro-hardness is softer than the side wall zircon, and in fact is friable to the extent that a mild steel (SAE 1010) input strip **25** will readily abrade away any wall material that it comes into contact with. An additional material which is applicable under the operating conditions present in this type of apparatus is graphite. The graphite is slightly more soluble in molten steel than is zircon but the solubility rate is not sufficiently large to constitute an insurmountable difficulty.

Considering the overall operation, as strip **25** is passed upwardly through inlet orifice **16** when the zircon expansion ceases to coincide with that of the steel input strip, the strip will contact the surfaces of end walls **19** and rather than becoming lodged, will merely abrade away enough of the wall surfaces so that free passage onwardly into the interior of crucible **15** readily occurs.

Although the present invention has been described in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a continuous casting apparatus in which elongated strip steel is fed upwardly through an inlet orifice into a crucible containing molten metal to freeze additional metal thereon, the combination comprising means defining an inlet orifice having side walls and end walls which together define an inlet opening, said side walls being constructed of zircon having a density of not less than about 3.7 gm./cm.^{3} and said end walls being constructed of a material selected from the group consisting of zircon having a density no greater than about 3.55 gm./cm.^{3} and graphite.

2. An inlet orifice as defined in claim **1** wherein the density of the zircon in said end walls is in the range of from about 3.45 to 3.55 gm./cm.^{3}.

3. An inlet orifice as defined in claim **1** wherein said inlet opening is of generally rectangular cross-sectional configuration.

4. In a continuous casting apparatus in which elongated strip steel is fed upwardly through an inlet orifice into a crucible containing molten metal to freeze additional metal thereon, the combination comprising means defining an inlet orifice having side walls and end walls together defining an inlet opening of generally rectangular cross-sectional configuration, said side walls being constructed of zircon having a density of from about 3.7 to 3.8 gm./cm.^{3} and said end walls being constructed of a material selected from the group consisting of zircon having densities of from about 3.45 to 3.55 gm./cm.^{3} and graphite.

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