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**273, 281, 283 (recet), 337**

[56] **References Cited**

| <b>UNITED STATES PATENTS</b> |        |                   |          |
|------------------------------|--------|-------------------|----------|
| 1,298,035                    | 3/1919 | Gathmann.....     | 164/337X |
| 2,290,083                    | 7/1942 | Webster .....     | 164/337X |
| 3,340,924                    | 9/1967 | Ludwig.....       | 164/281  |
| 3,364,980                    | 1/1968 | Loewenstein ..... | 164/281  |
| 3,465,811                    | 9/1969 | Castelet.....     | 164/281  |
| 3,517,726                    | 6/1970 | Mills et al. .... | 164/281X |

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[54] **MOLTEN METAL SUPPLY APPARATUS FOR PREVENTING OXIDE CONTAMINATION IN CONTINUOUSLY CAST STEEL PRODUCTS**  
**7 Claims, 3 Drawing Figs.**

[52] U.S. Cl. .... **164/281,**  
**164/82, 164/337**

**ABSTRACT:** For continuous casting of steel, the steel is poured in free fall into a chamber having bottom below the surface level of the liquid steel in the mold and having lateral openings above the bottom to cause the poured-in steel to change the direction of flow at least twice before being introduced into the mold at a considerably reduced speed as compared with the speed of the poured, free falling stream.

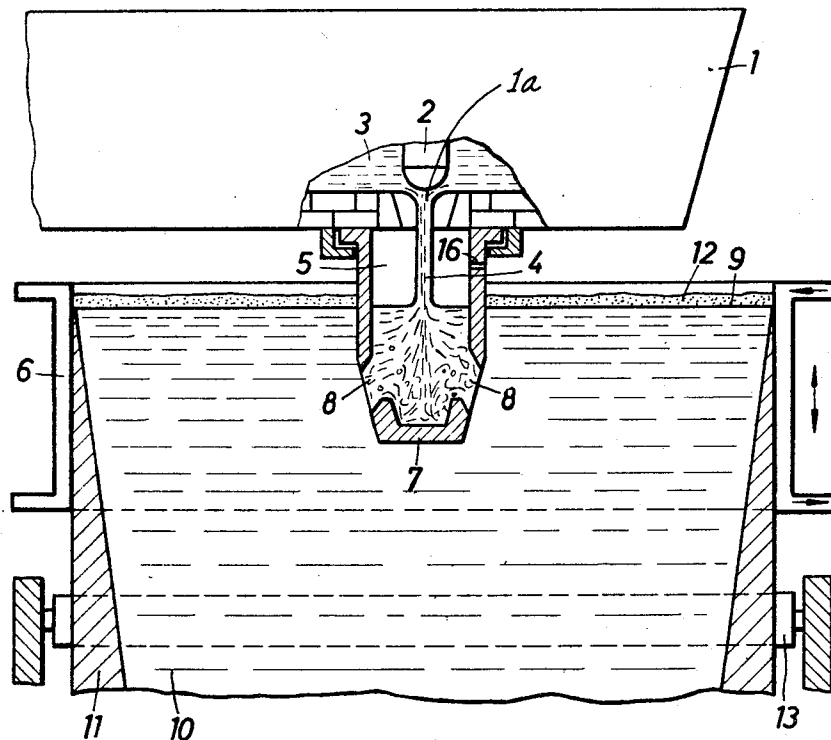


Fig. 1

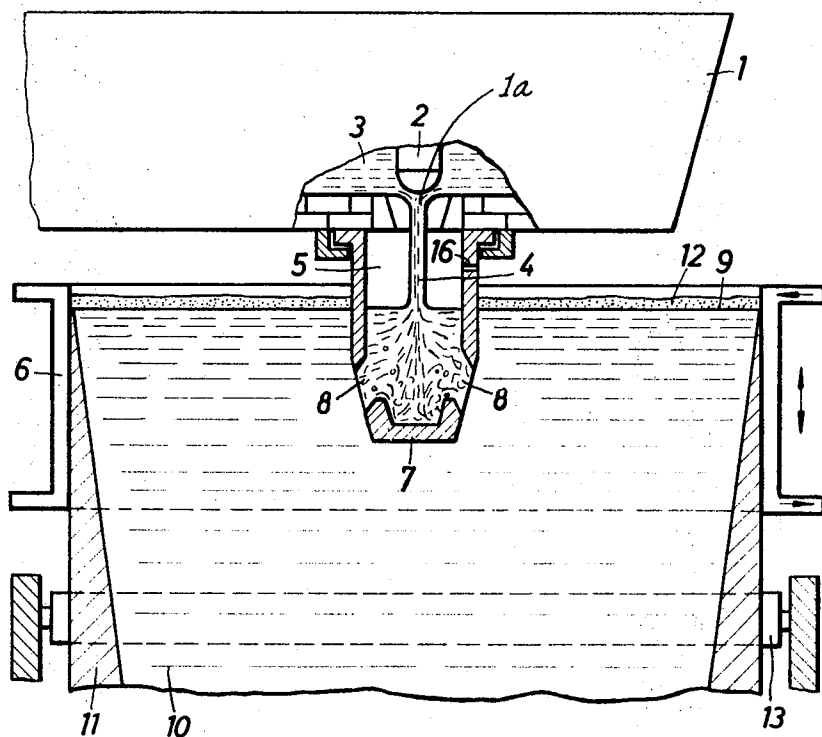


Fig. 2

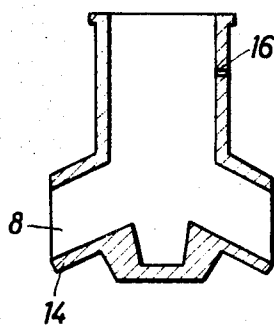
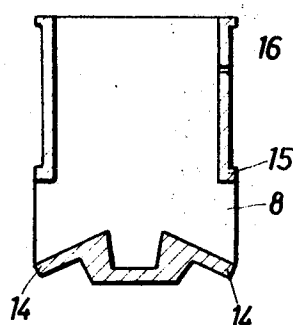


Fig. 3



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# **MOLTEN METAL SUPPLY APPARATUS FOR PREVENTING OXIDE CONTAMINATION IN CONTINUOUSLY CAST STEEL PRODUCTS**

The present invention relates to equipment for improving the purity of continuously cast steel products, and in particular to improvements in such equipment for separating oxide impurities from the melt during casting. Hanging of the casting ladle, flushing with argon, evacuating and casting in a protective atmosphere, are the known and conventional means employed to improve the purity of molten steel. Nevertheless, impurities cannot be entirely removed with these known methods. For example, (a) residual quantities of oxides resulting from oxidation of the flow of iron during casting will remain; (b) particles which separated from the material by erosion will also remain; (c) after incomplete deoxidizing reactions there remain some iron oxides which, in addition, may subsequently react with the metallic aluminum; (d) the metallic aluminum may have reacted with the silicone oxide of the ceramic lining in the distributor, outlet, stopper rod, and other parts of the casting equipment, the reaction producing additional impurities.

Improvements for continuous casting of steel have been attempted by using a pipe made of fireproof, refractory material which forces the poured stream of steel below the surface level of liquid steel in the mold. This type of arrangement has brought some advantages for casting, however, it changes the particle size and the structure of the oxide impurities to such an extent that these impurities now fail to rise to the surface level, at least not to a considerable and sufficient degree; instead, the impurities float in the interior of the molten material and are being caught by and in the regions where the molten material solidifies. This, of course, results in embedding of unacceptably large quantities of impurities.

The objects of the present invention are, therefore, as follows: (1) size and shape of the impurities should be controlled, particularly during flow into the mold for continuous casting, so that these impurities are capable of rising to the surface level of the molten material when entering the mold. (2) as the molten material is poured into the mold, turbulence is to be produced for causing coagulation of inclusions and for destroying a portion of the kinetic energy of the pouring material so that reaction products and impurities can separate and float to the surface.

In accordance with the present invention, in the preferred embodiment thereof, the molten material pours in free fall into a separate chamber in the mold. The chamber receives the poured material which flows in the chamber below the surface level of the molten material in the mold, whereby the direction of the average flow of the material in the chamber is changed at least twice prior to introducing the material into the mold at a speed of flow which is reduced, preferably to one-third or less of the initial velocity with which the free falling material hits the surface level.

The surprising result was obtained that in dependence upon the degree of oxidation of the melt, the kind and shape of the impurities could be kept under control by charging the mold in accordance with the features of the invention so that the probability of separation of impurities during casting was drastically increased. In particular, it was found that, for example, steel with not more than 0.1 percent carbon and not more than 0.15 silicon and not less than 0.15 percent metallic aluminum when cast with equipment constructed in accordance with the present invention resulted in a product of considerably improved degree of purity.

The inventive method can be improved further by controlling the atmosphere around the pouring steel, particularly as far as oxygen content and/or content of inert gases is concerned, so that the composition of the impurities in the cast materials and the cast produce can, in turn, be controlled to obtain most favorable consistency. The steps suggested to be taken cause precipitation of impurities in and along the walls of the auxiliary chamber. After the liquid material has left the chamber the larger particles rise to the surface level of the steel in the mold.

The equipment and apparatus, in accordance with the invention, is characterized by particular shape and contour of the auxiliary chamber to produce particular zones of turbulent flow to be continued in zones of laminar flow of steel into the mold whereby sufficient space is made available for reaction, and sufficient surfaces are available for depositing most of the impurities and inclusions. The auxiliary chamber is defined by a container disposed in the mold having an entrance opening which is above the top of the mold. This container may be connected with ladle or a tundish, below the opening thereof through which molten steel is poured toward the mold.

This container is provided with lateral exit or outlet openings through which the material leaves the chamber to flow into the mold. The lower edge of these openings is disposed somewhat above the bottom of the container. During operation these outlet openings are below the surface level of molten material in the mold, as well as in the container; preferably the upper edge of these outlet openings are 2 inches to 4 inches below the surface level of the molten steel.

For troublefree operation, particular dimensions of this container defining the auxiliary chamber were found to be of particular advantage. First of all, the molten steel is poured from a ladle, tundish or the like, in free fall into the auxiliary chamber. This chamber has cross section above its outlets which is at least about four times the cross section of the opening through which the steel is poured. The total cross-sectional area of all outlets of the chamber should be at least three times as large as the cross section of the opening for pouring. The horizontal cross section of the auxiliary chamber below the outlets is to be smaller than above, where the steel pours into the chamber, but is at least three times the cross section of the opening for pouring.

The lateral outlets of the container are preferably constructed as channels which are somewhat downwardly inclined. Inclination and length of these channels depends upon casting cross section and capacity. The molten material should flow toward the small side of the cast slab or ingot without, however, disturbing solidification. The contour of entrance, outlets and horizontal cross section of the auxiliary chamber should match the cross-sectional contour of the cast product. If the latter is rectangular, these cross sections of the auxiliary chamber should likewise be rectangular.

As the stream of molten steel pours into the auxiliary chamber, some of its kinetic energy is destroyed as the stream hits the bottom and reverses direction, while turbulence is created in the flow. The flow changes direction again when the material passes through the outlet openings and enters the mold in laminar flow. The reversal and deflection of direction of the flow of liquid steel causes the oxides to react and to coagulate, and as the flow speed is reduced, and the flow becomes laminar, these impurities separate from the steel as flowing towards the zones of solidification.

It is another feature of the invention that the length of the opening through which liquid metal pours toward the auxiliary chamber, does not exceed twice the diameter of that opening.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention and further objects, features and advantages thereof will be better understood from the following description taken in connection with the accompanying drawing in which:

FIG. 1 is a side elevation and partial cross-sectional view through casting equipment improved in accordance with the present invention; and

FIGS. 2 and 3 illustrate modifications of the container used in the equipment shown in FIG. 1.

Turning now to the detailed description of the drawings, in FIG. 1 thereof there is illustrated a metal supply vessel 1 such as a casting ladle or a tundish. In the present case the ladle is particularly provided to operate as a distributor, having a bottom opening 1a controlled by a stopper rod 2. The liquid metal 3 pours out of opening 1a in free falling stream 4 into a container defining an auxiliary chamber 5. Chamber 5 extends

below the surface level 9 of the molten material in a water-cooled mold 6. The bottom 7 of chamber 5, therefore, is below the liquid level in mold 6, so are outlet openings 8 of chamber 5. The slab or ingot to be produced by continuous casting is shown at 10 as it leaves the bottom of mold 6. The already solidified portion of the continuously cast product is denoted with reference numeral 11.

This particular embodiment should be used in particular for continuously casting slabs or ingots having rather small width, particularly a width between 32 inches to 52 inches (800 and 1300 mm.). The upper surface level 9 of the liquidous material in mold 6 is covered with material 12 as is known, per se, as a covering material. Under such circumstances, for example, it is slag. The slab 11 leaving the bottom mold 6 is supported and guided by means of rolls 13 or the like.

The casting metal is poured in free fall from the ladle 1 in form of a stream emerging from opening 1a, and the cross section of chamber 5 above the exit or outlet openings 8 should be at least about four times as large as the cross section of opening 1a. The downwardly directed, lateral outlet openings 8 together should have a cross section which is at least three times as large as the cross section of opening 1a. The cross section of chamber 5 below the lower edge of openings 8 where communicating with the interior of the chamber should be smaller than the cross section of chamber 5 above the openings 8. Preferably, the cross-sectional area of chamber 5 below openings 8 should be at least about three times as large as the cross-sectional area of the opening 1a.

FIG. 2 illustrates another configuration of the auxiliary chamber in accordance with the invention. In this case the outlet openings 8' are defined by channels 14. As one can see, the channels 14 are inclined, the inclination being more fully pronounced because of the channel configuration. The inclination and length of the channels will depend to some extent upon the cross section of the slab to be cast and upon the amount of material used per unit time. The cross section of the entrance opening of the chamber in FIG. 2 illustrates the situation where each side of chamber 5 is provided with an outlet. However, it is conceivable to provide several outlets, one above the other. The particular case illustrated here will be employed preferably for casting slab with a width above 52 inches. The channels 14 are comparatively long with an angle of 60° to 70° relative to the casting direction.

FIG. 3 shows still another embodiment for the invention. In this case chamber 5 has outlet openings defined by rather short channels, whereby the upper wall 15 of such a channel is actually at right angles, while the lower wall portions 14 are inclined. The inclination angle should not exceed 45° in this situation.

The inventive equipment can be used with particular advantage when the liquid metal is cast and the slab is guided along a curve below the cover 12; cover 12 binds the oxides rising in the molten steel. To control the atmosphere in the vicinity of the liquid metal pouring out of the ladle, chamber 5 is provided with additional entrance and exit openings 16 above level 9 to introduce gases containing oxygen and/or inert gases into chamber 5. The composition of the impurities in the cast material can be controlled through properly selecting and proportioning the constituents of the gas fed into that

particular chamber.

The invention is not limited to the embodiments described above but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be included.

We claim:

1. Apparatus for continuous casting of steel, there being a mold and equipment for introducing liquid steel into the mold, the steel in the mold having a surface level;
  - first means including a liquid steel supply vessel having an opening of particular cross section, for providing a free falling stream of liquid steel into the mold;
  - second means disposed in the mold defining a chamber open at the top and having side wall and closed bottom beneath said surface level, for receiving the free falling stream, the chamber having cross section area at least about four times the particular cross section of the opening of the vessel, so that the stream falls into a surface level of liquid steel in the chamber at a distance from the wall of the chamber above the surface level; and
  - third means included in the second means and defining at least one outlet opening for the chamber, above the closed bottom but beneath said level, for causing the average flow in the chamber to change directions at least twice prior to introducing the steel into the mold underneath said level, the outlet opening of the chamber having a cross-sectional area at least about three times larger than the cross section of the opening of the vessel, so that the speed of the liquid steel as introduced into the mold from the chamber is reduced to at least about one-third the speed of the free falling stream.
2. Apparatus as in claim 1, the chamber as defined by the second means, having at least one outwardly and downwardly directed outlet channel communicating with the chamber above the bottom thereof, the horizontal cross section of the chamber below the outlet channel being smaller than above the outlet channel, but at least about three times larger than the cross section of the liquid stream.
3. Apparatus as in claim 1, the chamber having horizontal cross section larger above the upper edge of the lateral opening than below the lower edge thereof.
4. Apparatus as in claim 1, the chamber having outlet channels for introducing the liquid steel into the mold, the upper edge of the outlet channels being 2 inches to 4 inches below the surface level of steel in the mold.
5. Apparatus as in claim 1, the third means as defining the lateral openings, directing the flow at an angle in downward direction and sideways away from the direction of the downflow in the chamber.
6. Apparatus as in claim 1, and including fourth means defining a second chamber between the first means and the first chamber; and
  - means for introducing a gas containing oxygen into the second chamber.
7. Apparatus as in claim 1, including fourth means defining a second chamber extending between the first means and the liquid level in the first chamber; and means for introducing a gas containing an inert gas into the second chamber.