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DEVICE FOR CHARGING A MOLD FOR CONTINUOUS CASTING
OF A HOLLOW INGOT

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Fig. 1

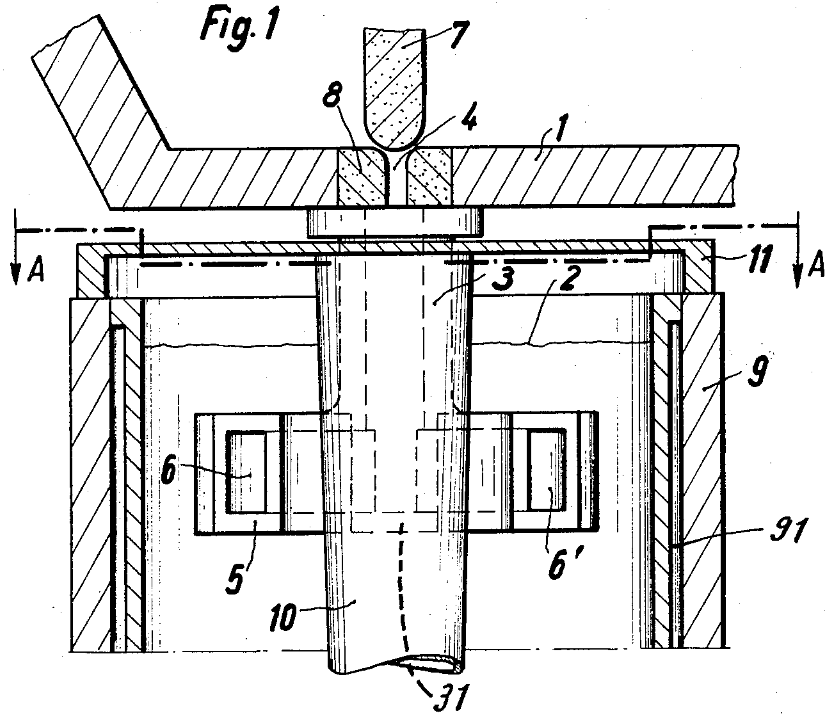
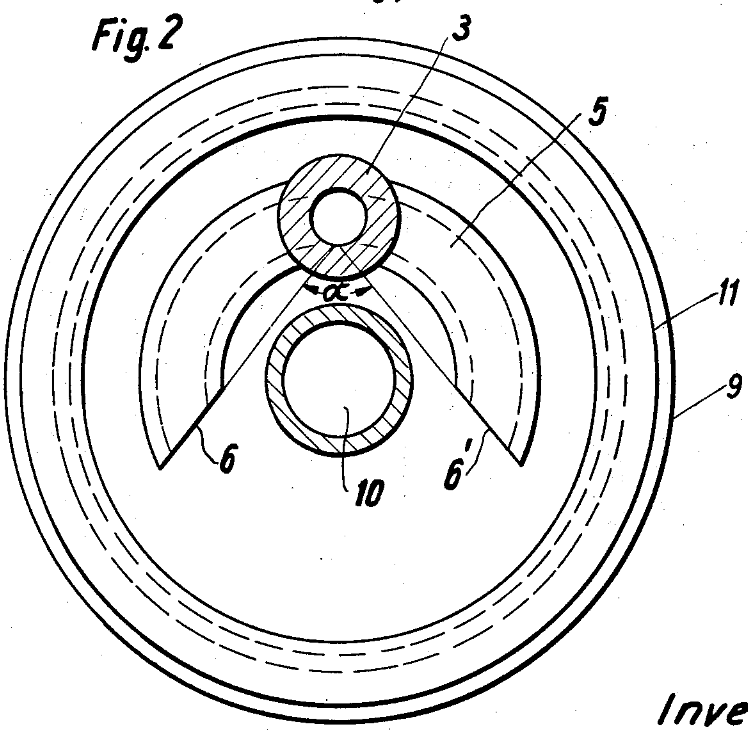


Fig. 2



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DEVICE FOR CHARGING A MOLD FOR CONTINUOUS CASTING OF A HOLLOW INGOT

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ABSTRACT OF THE DISCLOSURE

Device for charging an annular mold and having a cooled mandrel for continuous casting of a hollow ingot, there being a ladle or distributor with bottom opening from which molten metal pours in down direction into and through a hollow member, eccentric to the mandrel. The bottom of the hollow member is closed and submerged in molten metal in the mold. A two-arm, looping channel extends laterally from the hollow member near the bottom thereof, around the mandrel, the two arms respectively having at their ends discharge openings, disposed in planes that do not intersect in the mandrel axis but therebehind, near the hollow member.

The present invention relates to a device for charging a mold with molten metal, the mold being cooled and provided with a cooled mandrel for being used for continuous casting of hollow ingots. More particularly, the invention relates to introducing molten metal into an annular mold cavity, whereby the metal is poured from a ladle, distributor or the like, in independent operation, into the mold. Furthermore, a casting powder is used to cover the otherwise open surface level of the liquid in the mold.

A cylindrical mold with inserted mandrel provides an annular mold cavity. As liquidous metal is charged either from a ladle disposed above the mold or through a distributor, for example, for concurrently charging plural molds, a hollow ingot can be withdrawn from below the mold and advanced, transported and guided by means of rolls. It is known to pour the liquid metal from the distributor or ladle in free-falling streams into the mold cavity. As the surface of the molten metal in the mold is usually covered by a casting powder, there arises the danger that slag and powder particles are forcibly carried into the interior of the liquidous content of the mold, and impurities will precipitate in the withdrawn ingot. This is particularly disadvantageous or even dangerous, as vigorous internal flow in the mold may flush these impurities to the wall of mold or mandrel, to become embedded in the just forming skin along mold or mandrel wall. The particles so embedded near the surface of the withdrawn ingot may weaken the very thin skin that forms initially, so that the withdrawn ingot may rupture, and the still liquidous interior of the ingot may pour out.

If the liquidous metal pours in free-fall from the ladle from considerable height, vigorous flow is directly induced in the mold and continued underneath the surface level therein. That flow may reach considerable depth. Depending on the flow pattern, it may produce a wash out of the skin and destroy the thin skin that is being formed, for example, along the mandrel or along the cylindrical inner wall of the mold. Therefore, a strong flow within the mold as a continuation of the free-falling stream of pouring steel may locally impede the growth of the formed skin, which is again a source for damage or destruction of the ingot.

Generally, it has to be considered that any rupture, destruction, etc., of the skin may not only cause outpour of the still liquidous core of the ingot, but such rupture results actually in explosive spray and spattering into the vicinity, and there is immediate danger to the personnel manning the machine.

It has been suggested to use a particular charging pipe for introducing the liquidous metal from the ladle or distributor into the mold, the charging pipe being, for example, suspended from the ladle or distributor and having a vertically oriented outlet. The charging pipe opening dips into the liquidous metal in the mold so that the outlet is below the surface level of the metal in the mold, and extends into a region therein that is free from casting powder or slag particles. Therefore, these impurities will no longer be carried by the falling stream into the interior of the mold. The walls of that pipe additionally protect the enivronment from spattering of the poured metal. Thus, this pipe seems to offer a significant improvement. However, it was found that the down pouring stream as a whole actually penetrates and continues deeper into the mold than without this pipe, and, therefore, damage to the formed skin and wash out by forced flow conditions in the mold becomes even more probable. If particularly this charging pipe has one, downwardly directed exit opening, there will also be a nonuniform distribution of the casting material in the *annular* mold cavity, and that, in turn, will result in a nonuniform, axially asymmetrical solidification process.

The utilization of two such pipes for mold charging permits their disposing symmetrically to the axis of the hollow ingot. Even if they have vertically oriented discharge openings, the mold is now being charged in more uniform pattern as far as the annular distribution of molten material in the mold is concerned, but such an arrangement has also significant disadvantages of its own, which are particularly noticeable in case a distributor for charging plural molds is used. First of all, centering requirement for the charging pipes, as they are suspended from the distributor, becomes twice as difficult. Most importantly, however, it has to be considered that operational control for the stoppers that open and close the bottom openings of the distributor, must be carried out uniformly for the two discharge openings per ingot and mold. It was, therefore, found that, in fact, a uniform metal flow into the mold is not obtained, if metal can flow through two openings, and if the effective apertures thereof are not exactly the same (because, for example, one stopper is somewhat slower than the other or is lifted higher etc.) Conceivably, automatic control equipment could remedy the situation, but it is more desirable to provide for a single charge flow from ladle or distributor into a mold.

Casting and mold charging devices have been suggested wherein a pipe is provided with lateral exit openings. This is particularly useful for casting ingots with solid profile, slab ingots etc. The penetration depth of the free-falling metal flow into the mold as continued therein in down direction, is considerably reduced so that the above-mentioned disadvantages of a skin wash out by axial flow are avoided. However, it was observed that a strong tangentially effective flow component is included in the mold cavity so that the skin may still be eroded.

It can, therefore, be seen that the introduction of liquid metal into a mold for continuous casting is a difficult task and poses problems which are quite unforeseeable on basis of previously used structure. These deficiencies are usually observed only after the mold has been built and is tried. It is an object of the present invention to avoid the above-mentioned difficulties and to provide a particular device for charging a mold with molten metal in such a manner that the stream of pouring metal as a whole does not continue uniformly as downflow in the interior of the

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mold, but is uniformly distributed in an annular mold cavity, avoiding any erosion-producing wash out flow within the mold cavity, particularly directly underneath the surface level.

In accordance with the preferred embodiment of the present invention, the following arrangement is being improved. It is assumed that there is a cooled mold with centrally disposed mandrel for continuous casting of a hollow ingot, the width dimensions of the hollow ingot being determined by the annular gap between mandrel and mold. Liquidous metal is to be poured into the annular mold cavity, whereby generally the surface of the liquidous metal in the mold is to be covered by a casting powder. The improvement now is related particularly to the providing of a hollow member, e.g., a descending pipe, interconnecting the casting ladle or distributor with the liquidous metal in the mold and being disposed eccentric to mandrel and mold axis. The pipe member has a closed bottom underneath the surface level of the molten metal in the mold. A looping channel with open ends and substantially horizontal orientation is disposed underneath the surface level in the mold, partially circumscribing the mandrel. The pipe member ends in about the middle of the looping channel, so that two similar channel branches or arms extend in opposite directions from the lower end of the pipe member, in communication therewith, around the mandrel. The channel arms have particular outlet openings in planes that intersect near the pipe member. The annular looping channel may additionally be inclined to the horizontal in up or down direction by an angle up to 45°. Molten metal is poured from the ladle or distributor into the pipe member, hits the closed bottom and flows into the channel areas. Due to the deflection of the casting flow when entering the annular, looping channel, significant turbulence is developed so that the kinetic energy resulting from the free-fall is destroyed to a substantial degree. The velocity of the metal as flowing into the mold cavity from the exits of the looping channel is greatly reduced in relation to the speed of the metal when free-falling.

The descending pipe member has a cross-section that is a multiple of the cross-section of the discharge opening of the ladle, preferably the cross-section of the pipe member is three times as large as the cross-section of the discharge opening of the ladle. Therefore, the free-falling stream as pouring from the ladle remains at a distance from the wall of the pipe member throughout its length, so that the casting material *does* pour into the mold in free-fall. As a consequence, the flow is strongly turbulent already there. Preferably, the cross-section of that descending pipe member is circular, but could be rectangular, square-shaped, oval or the like. The combined cross-sections of the exit openings, are also to be larger than the cross-section of the opening in the ladle through which the liquid metal pours into the mold. Again, a threefold increase in cross-section, as far as that relation is concerned, is preferred.

As a direct consequence of the various dimensions chosen, the flow speed of the metal underneath the surface level in the mold is reduced to such an extent that solidification of the ingot and particularly the formation of skin adjacent mandrel and mold wall is not disturbed by any significant flow component that is directly attributable to the charge process of the mold. The angle between the two exit openings in relation to the axis of intersection of the planes in which the outlet openings are located is in between 45° and 180°, preferably between 60° and 100°, if this line of intersection is near the axis of the descending pipe member. It is particularly important that the metal flows from the looping chamber arms into the mold cavtiy proper without hitting directly the mold wall and without producing tangential flow erosion. Note also, that this angle is significantly smaller than the angle between the end points of the looping channel relative to the axis of the mandrel.

Another point to be made is that the looping channel does not have to be curved, but straight sections may be arranged in polygonal fashion, to establish the arms.

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 drawings in which:

FIG. 1 illustrates somewhat schematically a cross-sectional view through a mold cavity for continuous casting of a hollow ingot, and as improved in accordance with the preferred embodiment of the present invention; and

FIG. 2 illustrates a section along line A—A in FIG. 1.

Proceeding now to a detailed description of the drawings, in FIG. 1 there is illustrated a distributor or ladle **1** provided with a particular bottom opening **4** in the bottom insert **8** of the ladle. Opening **4** is controlled by a stopper **7**. The liquidous metal in the ladle will pour through opening **4** in down direction when the stopper is lifted, for charging the cavity of a mold **9** so as to sustain a pool of molten metal therein.

Mold **9** has cooling channel means **91** and is covered by a plate **11** from which extends a cooled mandrel **10** in down direction and in coaxial position to the mold **9**, to establish an annular mold cavity therein. The opening **4** of the ladle is disposed eccentrical to the mandrel to have position above the ring-shaped mold cavity.

A cylindrical, hollow member, i.e., a descending pipe **3** made of fireproof, refractory material, extends from ladle **1** from around opening **4** down into the annular mold cavity. Upon comparing cross-sections, one can see that the ladle opening **4** is significantly smaller than the inner diameter of the pipe **3**, so that the molten metal may fall inside of pipe **3** without establishing a retarding flow sheath along the wall of the pipe and in contact therewith. In FIG. 1 the pipe **3** is shown behind mandrel **10**. The pipe **3** is closed at the bottom (**31**). Near the bottom of the pipe, the two arms of a looping channel **5** extend symmetrically therefrom, around the mandrel. The channel member **5** is likewise made of fireproof, refractory material.

The channel member **5** is disposed clearly underneath the surface level **2** of the pool in the mold as sustained dynamically during continuous casting. The level proper is established by a layer of casting powder and slag. The material pouring down through opening **4** and in free-fall through pipe **3** hits the closed bottom **31**, and is distributed into two partial flows or branch streams flowing respectively into the two branches or arms of looping member **5**. The flow is arc-shaped in member **5** due to the curved structure thereof.

Each of these branches has an outlet opening, there being discharge or outlet openings **6** and **6'** accordingly. The liquid metal leaves the mold charging device **3–5** through these two openings and enters the annular mold cavity, as defined by mandrel **10** and mold **9**. Of course, due to the particular distribution, the actual charging process of the mold cavity occurs underneath the surface level in the pool so that slag and casting powder in the level region **2** is not disturbed at all by the flow.

The two outlet openings **6** and **6'** each are in planes that do not extend at right angles to the direction of the center line of channel **5** at the respective exit. As a consequence, the two planes intersect behind the axis of mold and mandrel, near the pipe **3**. The reason for this is that neither is there any charge flow directed towards the mold wall, nor against or along the mandrel. The two streams as leaving openings **6** and **6'** will meet in the annular cavity region remote from both, mandrel and mold, and set up vigorous turbulence, without any washout producing tangential component along mold wall or mandrel. In the illustrated example, angle α is about 80°, whereas the angle between the openings **6** and **6'** along a continued center line of the channel **5** around the axis of the mandrel is about 145°.

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.

What is claimed is:

1. Device for charging an annular mold and having a cooled mandrel for continuous casting of a hollow ingot, there being a ladle or distributor with bottom opening from which molten metal pours in down direction, there being casting powder in the surface level of molten metal in the mold, comprising:

a hollow member extending from the ladle or distributor, from around the bottom opening thereof in down direction and having a closed bottom submerged in molten metal in the mold, the member disposed eccentric to the mandrel; and

means defining a two arm, looping channel extending from the hollow member near the bottom thereof around the mandrel, the two arms respectively having at their ends discharge openings, the discharge openings lying in planes that do not intersect in the mandrel axis but therebehind, near the hollow member.

2. Device as in claim **1**, the angle between the planes being between 45° and 180°.

3. Device as in claim **2**, the angle being between 60° and 100°.

4. Device as in claim **1**, the sum total of the cross-section of the discharge openings being several times larger than the cross-section of the bottom opening of the ladle or distributor.

5. Device as in claim **1**, the inner cross-section of the hollow member being several times larger than the bottom opening of the ladle or distributor.

6. Device as in claim **1**, the inner cross-section of the hollow member being several times larger than the bottom opening, the sum total of the discharge openings being larger than the cross-section of the hollow member.

7. Device as in claim **1**, the looping channel means inclined in down direction.

References Cited

UNITED STATES PATENTS

2,305,477	12/1942	Junghaus	164—82 X
2,853,754	9/1958	Paddock	164—85
2,895,188	7/1959	Wiltmoser	164—85 X

FOREIGN PATENTS

748,709	5/1956	Great Britain	164—82
868,734	5/1961	Great Britain	164—85

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U.S. Cl. X.R.

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