CRYSTALLIZERS FOR VACUUM-MELTING INSTALLATIONS, PARTICULARLY ELECTRON-BEAM MELTING FURNACES

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FIG. 1 FIG. 2

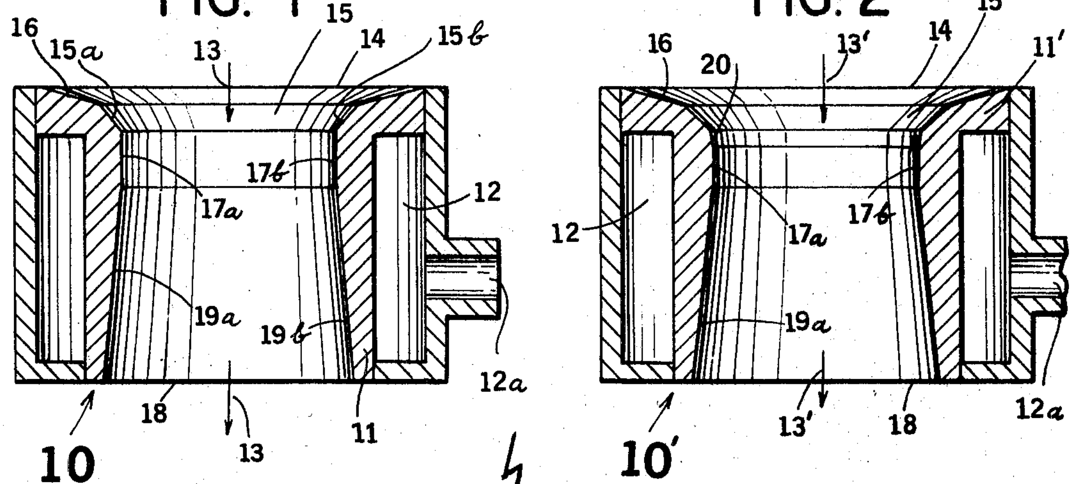
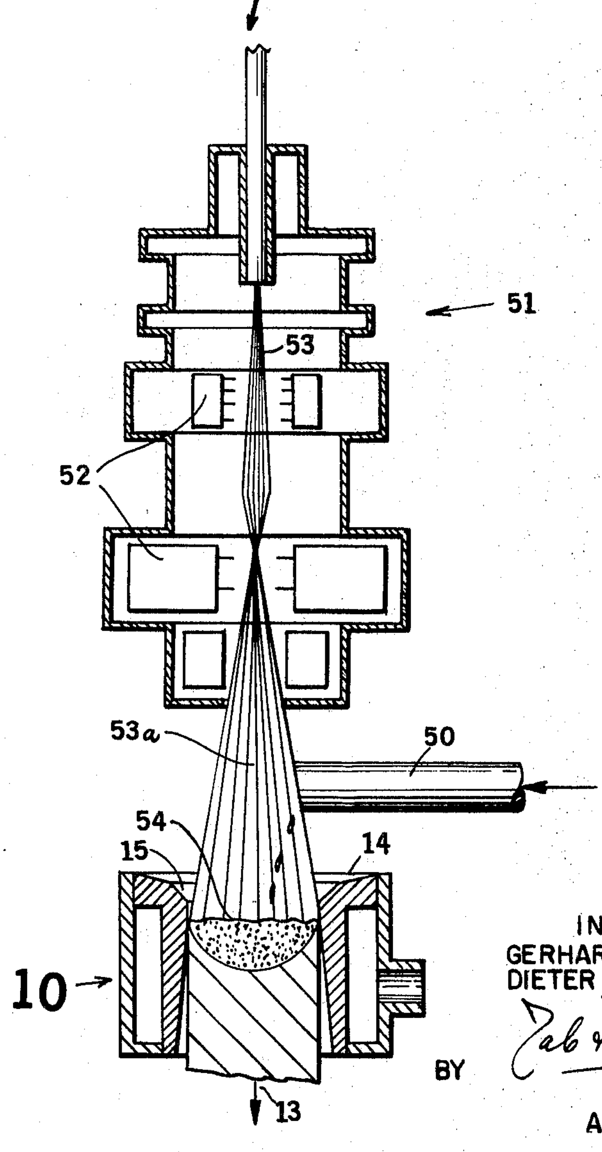


FIG. 3



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CRYSTALLIZERS FOR VACUUM-MELTING INSTALLATIONS, PARTICULARLY ELECTRON-BEAM MELTING FURNACES

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ABSTRACT OF THE DISCLOSURE

Crystallizers for vacuum melting of various metals and alloys, having a passage channel for the molten metal between the filling and the outlet apertures, wherein the filling aperture is followed by a run-off incline, another inclined wall portion, a substantially parallel section and slightly outwardly tapering walls adjoining the outlet aperture. According to the invention, the inclined wall portion diverges to a smaller degree than the walls of the run-off incline. The divergence is preferably of 45 degrees. An inflow incline may also be disposed between the inclined wall portion and the parallel section of the passage channel. Preferred and experimentally proven proportions, angles and relative lengths are disclosed in accordance with the invention.

The invention relates to crystallizers for vacuum-melting installations, particularly electron-beam melting furnaces where the liquid metals or alloys contained in the crystallizers are continuously heated at the bath surface.

In the melting of metals and alloys under vacuum, the block or ingot, intended for further processing, is usually built up by collecting the molten bath in a water-cooled crystallizer having a lowerable bottom. Due to the continuous supply of material from above and the lowering of the bottom plate, this leads to a block. In the extrusion melting of metals and alloys in water-cooled crystallizers, in particular of steel alloys, block surfaces suitable for the subsequent shaping are not readily obtained, that is, surfaces which would not require intermediate mechanical machining such as turning, planing or grinding.

Water-cooled copper crystallizers, called also chill molds, have become known in the extrusion casting process, with which a surface suitable for further processing is obtained. Chiefly one makes use for this of the chill-mold movement, the lubrication of the continuous casting, and the adjustment of suitable casting temperatures and casting speeds.

In extrusion melting under vacuum, which is characterized by continuous heating of the bath surface, for example, by arcs or electron beams, chill-mold movement is difficult to carry out as the chill mold is under a high vacuum and an arrangement for this movement involves considerable sealing problems.

Lubrication of the continuous casting is also not possible for several reasons, as due to the evaporation and combustion of even minute quantities of the lubricating substance an impermissible pressure increase occurs.

Variation of the bath temperatures and of the melting rates in the extrusion melting process, to influence the surface constitution of the blocks, is hardly possible as the bath temperature and melting rate are determined essentially by the degree of purity to be attained, or by the furnace parameters.

Further, crystallizers of copper have become known which are used in particular in a system operating by an extrusion melting process. Such crystallizers have a passage channel whose walls are parallel, the cross-sectional form of the passage channel being immaterial. At the filling aperture of the passage channel the cross-section increases greatly, resulting in a funnel-shaped run-off incline. The transition to the parallel walls is rounded by a radius to avoid edge formation. However, the bath level of the melt is usually below this transition.

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In the extrusion melting of steel or other metals containing readily volatile components, there occurs, at the bath level edge, and at the cold wall of the crystallizer, condensation of the metal vapor which is in plentiful supply precisely in this zone. The porous layer of condensate often does not detach from the rising bath, and due to notch effect in the as yet not very solid extrusion shell it forms the starting point for gaping discontinuities in the block. Such surface faults have a disadvantageous effect in the further machining of the blocks. To avoid subsequent rolling faults, therefore, intermediate machining by material removing or chipping processes is necessary to obtain a block surface which is suitable for further machining.

It is the object of this invention to obtain extrusion-melted blocks with a surface such that intermediate chipping machining is unnecessary.

The problem underlying the invention is to design crystallizers such as are used in extrusion melting in such a manner that the blocks produced exhibit a suitable surface. By suitable surface is meant that the produced blocks can be used for subsequent rolling or forging without intermediate treatment.

It has been found that this is achieved by diverging the walls between the passage channel, having parallel walls, and a run-off incline with a smaller inclination than the walls of the run-off incline, while the walls of the portion of the crystallizer which follow the parallel walls, viewed in the passage direction of the continuous casting, converge toward the filling aperture.

In contrast to continuous casting, in extrusion melting the transition of the bath level must have a concave form, and as the surface of the bath is maintained in the zone of the incline, the concave transition at the peripheral zones of the bath is thereby favored.

The slant between the parallel walls and the run-off incline is preferably around 45 degrees.

Another characteristic feature of the invention is an inflow incline, arranged between the parallel walls and the aforementioned incline. By the arrangement of this inflow incline the organic flow of some materials is favored so that suitable surfaces of the produced continuous casting can be obtained therewith.

Further it has been found that the length of the parallel walls may be different for different steel alloys. As a rule, the length of the parallel walls can be reduced with increasing carbon content of the steels.

It is one of the important features of the present invention that the wall portion of the crystallizers between the parallel section and the run-off incline diverges to a smaller degree than the walls of said run-off incline proper while the walls adjoining the outlet aperture converge toward the filling aperture or, in other words, taper outwardly toward the outlet aperture.

According to another noteworthy inventive feature an inflow incline is disposed between the substantially parallel section of the passage channel and the inclined wall portion.

The slanting or inclined wall portion has a divergence of preferably 45 degrees. These or the other inclined wall portions may have the form of a hyperbola, an ellipse or some other suitable curved area.

The various objects, features and attendant advantages of the present invention will become more apparent from the following detailed description of preferred exemplary embodiments of crystallizers for vacuum-melting installations when considered in conjunction with the accompanying drawing, wherein

FIG. 1 shows a longitudinal section through a first embodiment of the inventive crystallizers;

FIG. 2 shows a similar longitudinal section through a modified or second crystallizer embodiment having an inflow incline; and

FIG. 3 shows in a somewhat schematic, partly sectional view the general set-up of an inventive crystallizer in cooperation with an electron-beam melting furnace.

FIG. 1 illustrates a preferred embodiment of an inventive crystallizer, generally designated **10**, and consisting of a block **11** of copper or a suitable copper alloy. While outside cooling can be arranged in a conventional manner, the exemplary crystallizer **10** features an inner cooling space **12** with an inlet or outlet **12***a* (the other connection being omitted for the sake of clarity).

The copper block **11** is provided with a passage channel **13** which is given the cross-sectional form of the continuous casting to be produced. At its filling aperture **14**, the channel **13** terminates in an inclined section **15** having walls **15***a*, **15***b*. In the preferred exemplary embodiment, the inclination or divergence of section **15** is about 45 degrees. After a slight transitional rounding off the inclined section **15** is followed by a run-off incline **16** which forms a flat, funnel-shaped edge for the aperture **14**.

The portion of the passage channel **13** which actually determines the cross-section of the resulting continuous casting has substantially parallel walls **17***a*, **17***b*. According to the alloy to be melted, the length of this parallel section may be varied as a function of the thermal conductivity of the metal in question. The following correlation has been established on the basis of experimental and practical tests:

LENGTH OF WALLS 17*a* AND 17*b* DEPENDING UPON CARBON CONTENT OF MELTED ALLOYS

40 mm.	120 mm.
85 Cr Mo 7	CK 10
C 100	C 15
C 120	22 Cr Mo 4

As a matter of example, two length values are given, with the alloy designations, which proved to be best suited for the composition, thermal conductivity and other parameters of the alloys.

In the direction of the outlet aperture **18** of the passage channel **13** there follows a section of slightly increasing cross-section whose walls **19***a*, **19***b* converge toward the filling aperture **14**.

Concerning the general cross-section of the crystallizer **10** it should be noted that the inner form is not to be limited to a circular cross-section as can be assumed from the illustration. Extrusion forms such as squares, rectangles, hexagons and octagons may be used, and therefore the cross-section of the inventive crystallizer is not specified more particularly. The described wall portions and corresponding sections of the passage channel would of course be substantially the same for circular and other cross-sections, and the disclosed novel features would apply to all of them.

In FIG. 2 a modified embodiment of the inventive crystallizer is generally shown, designated **10'**, and consisting of a block **11'** similar to that shown in FIG. 1 at **11**. A somewhat modified passage channel **13'** results on account of the provision of an inflow incline **20** between the inclined section **15** and the parallel walls **17***a*, **17***b*. The inclination or divergence of incline **20** may be, for example, between 2 and 5 degrees. The incline increases in cross-section toward the filling aperture **14**, as shown.

The sections, wall portions and elements of the crystallizer **10'** not specifically mentioned, namely **12**, **12***a*, **16**, **18** and **19***a* are substantially identical with those shown in and described in connection with FIG. 1.

The surface of the molten bath is maintained, as a rule, in the zone of the inclined sections **15**. By this design of the crystallizer walls the concave transition of the bath at the peripheral zones is facilitated and thus condensate layers cannot have such effects on the surface of the produced continuous or extrusion casting that cracks or deep incisions could be formed.

The invention is not limited to the specific exemplary embodiments of crystallizers as illustrated herein where the inclined surfaces are all straight, e.g. in the region of the filling aperture **14**. The divergence of the wall portions, particularly of the run-off inclines **16** and/or the incline **20** of the modified embodiment, including the inclined sections **15**, may follow suitable curves, for example, a hyperbola or an ellipse. These modifications will be self-explanatory to those skilled in the art, and they are not illustrated herein.

The mode of operation or use of the inventive crystallizers **10**, **10'** is illustrated in the somewhat schematic, partly sectional view of FIG. 3, showing the general set-up of the crystallizers in cooperation with an electron-beam melting furnace, as a matter of example.

A melt-down rod **50**, fed continuously in a horizontal direction, is pushed laterally over the edge of the crystallizer **10** (it could, of course, also be the modified embodiment **10'**). An electron source **51** is disposed in axially aligned relationship above the filling aperture **14** of the crystallizer. By known electron-optical lenses **52**, and associated conventional elements of such furnace installations, the electron beam **53** is properly focused. The bundled and focused beam **53***a* is directed onto the bath surface **54** while it also impinges upon the continuously fed rod **50**. By the energy of the beam **53***a* the rod is heated at its end, is liquefied, and gradually drops or melts down into the crystallizer aperture **14**.

At this point the bath **54** forms by the collection of the molten material which is heated at the surface by the steadily impinging beam **53***a* so that it is maintained in a liquid state. When the melt bath has reached a certain height, for example the upper edges of the inclined section **15**, the bottom of the crystallizer is lowered until the bath surface approximately reaches the lower edges of section **15**. The conventional bottom plate of the crystallized has been omitted from the drawing.

As the crystallizers **10**, **10'** are cooled (externally or internally, as the case may be), heat is removed first from the melt adjacent the outer walls of the passage channels **13**, **13'**. Thereby a solid extrusion shell is formed which becomes thicker and thicker, viewed in the draw-off direction (that is, away from the electron beam). This is actually how the lower and removal of the continuous casting becomes possible at all.

Although a particular, known embodiment of an electron-beam furnace has been shown in FIG. 3, it will be understood that the crystallizers according to the invention would perform in substantially the same manner with other installations of vacuum-melting furnaces for continuous or extrusion casting. The arrangement of the electron source **51** and of the melt-down rod **50** is immaterial for the structure and performance of the crystallizers. Thus, for example, the rods may also be fed in or supplied vertically or at an angle; and instead of the illustrated electron source, several beam sources may be provided, for example those shown in French Pat. 1,249,096.

No particular reference has been made in the description to the metals or alloys that can be treated in the crystallizers. The alloy designations appearing in the table hereinabove, indicating preferred wall lengths as a function of the carbon content of the alloys, are but a few examples of a wide range of materials which can be, and are generally, processed in the crystallizers.

The foregoing disclosure relates only to preferred exemplary embodiments of the crystallizers, which is intended to include all changes and modifications of the examples described, within the scope and spirit of the invention as set forth in the appended claims.

What we claim is:

1. A crystallizer for vacuum-melting installations, particularly electron-beam melting furnaces, comprising a cooled block (**11, 11'**) defining therein an axial passage channel (**13, 13'**) for shaping the molten metal between filling (**14**) and outlet apertures (**18**), said channel being defined by a run-off incline formed by a wall portion (**16**) adjacent said filling aperture and tapering steeply inward, followed consecutively by an inclined wall portion (**15**) tapering less steeply than said run-off incline, a substantially parallel wall section (**17***a*, **17***b*), and by slightly outwardly tapering walls (**19***a*, **19***b*) adjoining said outlet aperture, wherein said inclined wall portion diverges to a smaller degree than said wall portion forming said run-off incline.

2. The crystallizer as defined in claim **1**, wherein said inclined wall portion defines an angle of approximately 45 degrees with respect to said axial passage channel.

3. The crystallizer as defined in claim **1**, wherein said passage channel has a substantially circular cross-section.

4. The crystallizer as defined in claim **1**, wherein said passage channel has a symmetrical, multi-angular cross-section.

5. The crystallizer as defined in claim **1**, further comprising an inflow incline between said inclined wall portion and said parallel section.

6. The crystallizer as defined in claim **5**, wherein the divergence of said inflow incline (**20**) defines an angle of between 2 and 5 degrees, increasing in cross-section toward said filling aperture (**14**).

7. The crystallizer as defined in claim **5**, wherein said inflow incline has a curved profile.

8. The crystallizer as defined in claim **1**, wherein at least one of said run-off incline and said inclined wall portion has a curved profile.

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