

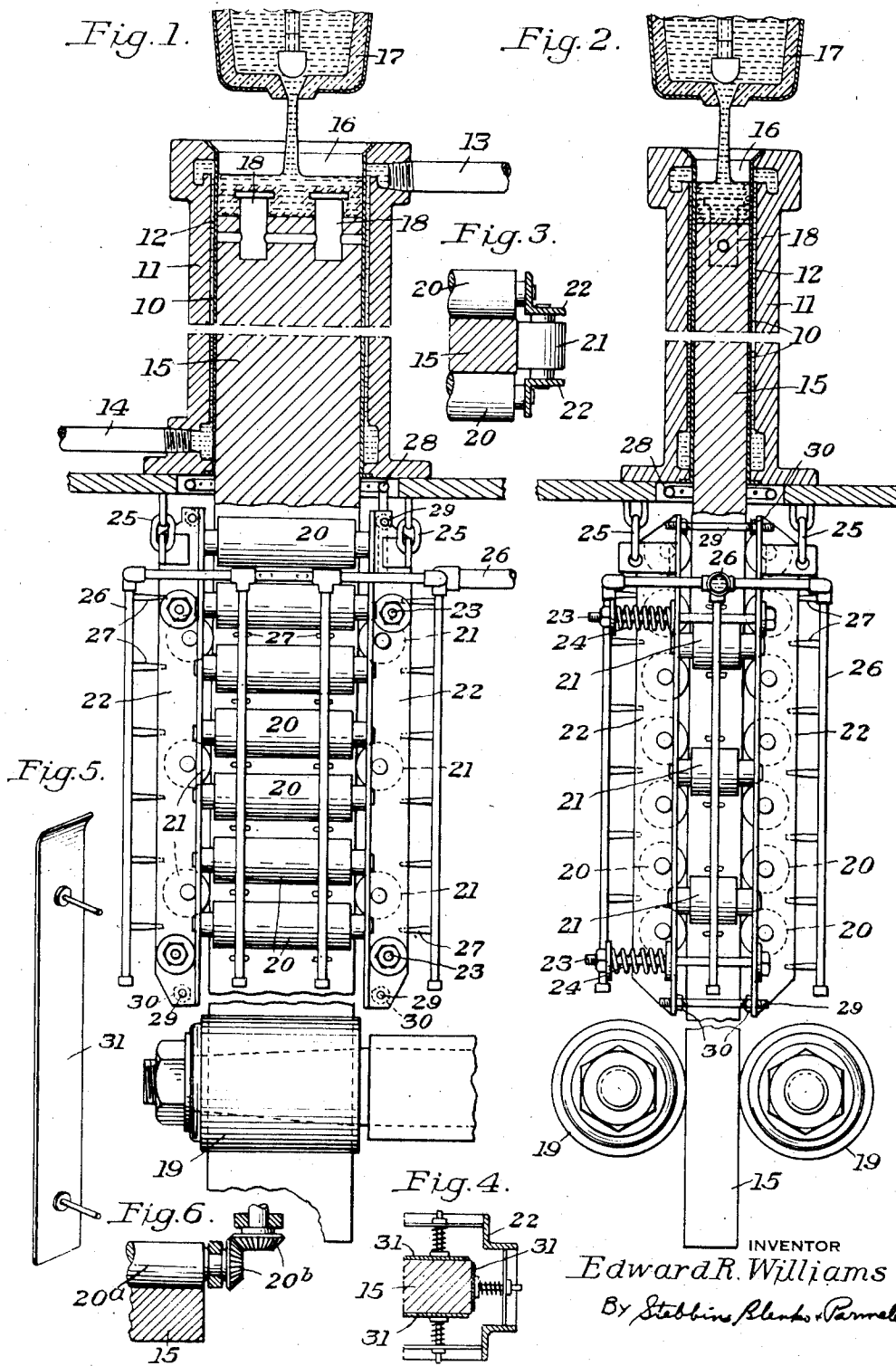
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E. R. WILLIAMS

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APPARATUS FOR CONTINUOUS CASTING

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INVENTOR  
Edward R. Williams  
By Stebbins, Plunk & Parnelle

ATTORNEYS

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## APPARATUS FOR CONTINUOUS CASTING

Edward R. Williams, Latrobe, Pa., assignor, by  
mesne assignments, to himself and Julia Lee  
Cox Williams, Latrobe, Pa.

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My invention relates to apparatus for casting fluid material, preferably fused metals or alloys in a definite shape and form and is particularly applicable to what is commonly referred to in the art as continuous casting of metal, and will be described in connection therewith. In the art of continuous casting, a supply of molten metal either ferrous or non-ferrous is continuously fed to one end of a mold cavity of suitable cross-section, the walls of which in contact with the poured metal are kept at a temperature, by a circulating fluid in contact with the outside of the mold wall, such as will cause rapid solidification of metal in contact with the walls. The cast metal, commonly called an ingot, having a uniform cross-section corresponding to that of the mold cavity throughout its length, is withdrawn by appropriate withdrawal mechanism from the opposite end without substantially interrupting the continuity of the ingot during the entire process. It is thus possible to produce ingots of any desired cross-section and of a length which is restricted only by the amount of metal available for pouring. Ingot produced according to the teachings of my invention have superior properties and may be cast in a more economical and expeditious manner.

In the continuous casting of ingots, for example, by the apparatus and process described and claimed in my Patent No. 2,079,644, issued May 11, 1937, I have found that it is desirable to provide means which contact the wall surface of the ingot directly after it is withdrawn from the mold, and thereby prevent the walls of the ingot from bulging outwardly due to the ferrostatic pressure or to warping of the metal. This is particularly desirable when ingots or slabs having a side wall in excess of about 6 inches are being poured. When the walls bulge outwardly to any appreciable extent, the ingot is very apt to have a poor internal structure.

To prevent appreciable bulging of the ingot walls, I provide supporting means such as rolls or plates which contact the ingot walls shortly after the ingot emerges from the mold tube. The rolls or plates are arranged so that the ingot is supported after it leaves the mold for a distance which allows the walls or skin to acquire such a thickness as to continue to be self-supporting. At the same time, I propose to continue the cooling of the ingot by the application of appropriate fluids to the surfaces, or the rolls or plates may themselves be cooled by appropriate means. The rolls or plates are preferably positioned close to the bottom of the mold tube and

above the withdrawal mechanism so as to contact the walls of the ingot directly after it emerges from the mold tube. The rolls may be driven so as to aid in the withdrawal or serve by themselves to withdraw the ingot from the mold. The rolls or plates can be arranged to bear against all the wall surfaces of the ingot, or against such sides or portions thereof as desired. For example, if a rectangular slab is being poured, it may be sufficient to support only the side walls, and in some instances only parts thereof.

In my aforesaid Patent No. 2,079,644 there is shown a mold tube of high thermal conductivity open at both ends. The tube is preferably made thin, so as to rapidly conduct the heat from the poured mold to the cooling fluid which is circulated in a thin stream at relatively high velocity along the outer wall of the tube. I have found that a tube having a thickness of from one sixteenth to one quarter of an inch and a water passage of from about thirty thousandths to about one eighth of an inch is satisfactory for carrying out my invention.

When rolls are used, they may simply serve to support the walls without exerting substantial pressure thereon or the rolls may exert pressure sufficient to deform and reduce the cross-sectional area of the ingot, as well as to control the speed of withdrawal of the ingot. The rolls may be driven either by external means or simply by contact with the passing ingot. The ingot may be withdrawn by its own weight, or by a pulling force exerted on the ingot. If withdrawn by its own weight, the rolls may even help to support the weight of the ingot. The rolls may be cylindrical in section or may be slightly convex or concave in contour and each pair of opposing rolls may be of such contour as to substantially embrace the whole surface of the ingot as it passes the rolls. I have found it advisable to keep the emerging slab or ingot flooded with water or an appropriate cooling fluid and this water serves to keep the rolls cool. However, it may be desirable, when pouring certain metals, to forego the use of a cooling fluid in direct contact with the ingot. In such instance the rolls or plates themselves may be cooled by appropriate means well known in the art, and they will in turn serve to cool the ingot.

By the use of the supporting members in conjunction with my continuous casting apparatus, beneficial results are obtained. By providing a casing around the partially solidified ingot after it emerges from the mold, which casing may con-

sist of rolls or restraining members, the ingot is prevented from enlarging or from undesirable changes in cross-section. The rolls may exert sufficient pressure to compensate for the natural volumetric shrinkage of the molten metal upon cooling and, if desired, sufficient pressure may be exerted to produce beneficial hot working of the solidified portion of the hot ingot, in which case the cross-sectional area will be changed.

In the drawing, I have shown for the purpose of illustration only the present preferred embodiment of my invention.

In the drawing:

Figure 1 is a side elevation view partly in section and more or less diagrammatic showing one form of apparatus which is suitable for carrying out my invention;

Figure 2 is an end elevation partly in section of the apparatus shown in Figure 1;

Figure 3 is a detail of the apparatus;

Figures 4 and 5 are views of details of a modification of the apparatus; and

Figure 6 is a view of a detail of still another modification of the apparatus.

In the drawing there is shown molding apparatus in which a continuous ingot of desired uniform cross-section can be formed and associated apparatus for supporting the ingot as it is being withdrawn from the mold tube. The molding apparatus consists of a thin wall mold tube 10 of uniform cross-section and made from metal such as copper or brass having high thermal conductivity. The tube is open at both ends and is housed within a metal casing or jacket 11 and spaced therefrom so as to provide a shallow cooling chamber 12 between the tube and the casing. The circulation at high velocity of a suitable cooling fluid is maintained through the cooling chamber by appropriate means connected to the pipes 13 and 14. A stool element or blank 15 is provided having a cross-sectional contour so that when it is inserted within the mold tube it will have a sliding fit therewith.

At the beginning of the pouring operation the blank is located at such a position within the tube 10 as to provide a pouring cavity 16 at the top thereof. The molten metal to be cast is poured from the ladle 17.

The molten metal contacts the upper part of the ingot blank or stool 15 and is bonded thereto by suitable means such as disconnectable lugs 18. The blank 15 is long enough so that when it is in position in the tube at the beginning of the pour the lower end of the blank will be engaged by suitable withdrawing rolls 19. The rolls 19 are pressed against the blank and driven in any suitable manner, for example, by a variable speed motor (not shown) so that the speed of withdrawal of the blank 15 and the ingot which is formed can be controlled at a rate such that the level of molten metal in the pouring cavity 16 will remain at a substantially constant height during the pour. The metal will be delivered to the pouring cavity 16 and the ingot withdrawn at such a rate that a skin of sufficient thickness may form around the edges of the molten metal in contact with the mold tube to enable the forming ingot to be withdrawn from the tube without rupture of the skin wall. The rate of formation of the skin will depend upon the ability of the cooling apparatus to carry away the heat transferred from the molten metal in the tube 10 through the tube and to the cooling fluid circulating through the chamber 12. I prefer to make the mold tube as thin as structurally possible and

I have found that thicknesses of from about one-sixteenth to about one-quarter inch are satisfactory for a brass tube. The cooling chamber must have a radial depth as slight as possible. I have found that a thickness of from about thirty-thousandths to about one-eighth inch is satisfactory.

Below the bottom of the molding tube and extending downwardly therefrom I provide supporting means including elongated members such as rolls or plates which contact and support the ingot walls directly after the ingot emerges from the tube 10 and for a substantial distance along the ingot. In Figures 1, 2 and 3 there is shown supporting means which consists of a series of rolls 20 disposed in pairs on opposite sides of the ingot. As many pairs of rolls are provided as are necessary to support the walls of the ingot and to insure that the ingot as it leaves the last roll will have a skin of sufficient thickness to prevent any breaking or substantial bulging of the walls of the ingot. In the drawing, I have shown 7 pairs of rolls disposed so as to contact opposite sides of the ingot, but it is to be understood that there may be more or less pairs of rolls than are illustrated. A number of pairs of rolls 21 are also provided for contacting the opposed end walls of the ingot, although it is possible in many instances to dispense with the end rolls 21. The rolls 20 and 21 are supported by or journaled in supporting members 22 here shown as angle bars. The angle bars are supported on bolts 23 and are resiliently urged toward one another by the springs 24. I have here shown the rolls 20 which contact only the side walls as being urged toward one another but it is obvious that the end rolls 21 can also be resiliently urged toward one another. It is also apparent that each pair of rolls 20 or each pair of rolls 21 may be independently urged toward each other. It is also within contemplation that all or any number of the rolls may be driven as shown by the roll 20<sup>a</sup> in Figure 6, which is driven by the gears 20<sup>b</sup>.

The upper rolls 20 of the supporting means are preferably disposed as closely adjacent the bottom of the mold tube as is structurally possible, so that the walls of the formed ingot are supported immediately after the ingot emerges from the bottom of the mold tube. The supporting apparatus is flexibly supported in operating relationship to the mold tube by flexible members here shown as links 25. This simplifies the problem of alignment. While I have shown the supporting means as being flexibly secured adjacent the bottom of the mold tube, I also contemplate that the ingot supporting means may be rigidly, as well as adjustably, fixed in position.

Associated with the rolls is a system of pipes 26 through which a cooling fluid such as water can be supplied and forced through jets 27 against the ingot walls and against the rolls for cooling purposes. The pipes of the cooling system 26 may be connected to the supporting apparatus or may be separately supported. Connected to the cooling fluid supply system 26 is an annular pipe 28 which is disposed immediately adjacent the bottom of the mold tube. The pipe 28 has openings through which the cooling fluid may be projected toward and against the ingot walls.

It may be desirable in some instances to exert pressure on the walls of the ingot by means of the rolls sufficient to deform the ingot and reduce the cross-section thereof, as well as suffi-

cient power to withdraw the ingot. Where this is done, it will be necessary to drive the rolls 20 and 21 or either of them, in which case the withdrawal rolls 19 could be dispensed with. The rolls 20 may be urged toward one another with sufficient force so as to compensate for the initial volumetric shrinkage from rolling or sufficient pressure may be exerted to produce beneficial hot working of the hot ingot. The amount of deformation accomplished by each pair of rolls or by a combination of rolls can be controlled by providing limit stops for such rolls or combination of rolls. Suitable limit stops are shown in Figures 1 and 2 and each consists of a threaded bar 29 which passes through suitable openings in the angle bars 22. Nuts 30 are threaded on the bars 29 and bear against the opposite legs of the angles.

In Figures 4 and 5 I have shown details of a structure for supporting the walls of the ingot in which plates 31 are provided instead of rolls. The pressure members or plates are arranged so as to be resiliently pressed into engagement with the walls of the ingot. When these plates are used, they may contact all sides of the ingot or only portions thereof or only the side walls and not the end walls.

Associated with the plates 31 a cooling system such as described in connection with the rolls may be employed. In some instances it will be desirable not to discharge a cooling fluid in any large amounts directly against the hot metal in which case the plates 31 can be cooled by an appropriate cooling fluid directly applied to the plates, or if rolls are employed as shown in Figures 1 and 2, the rolls themselves can be cooled and no fluid directed into contact with the hot walls of the ingot.

By the term, "ingot," I refer to a mass of metal having any desired area or cross-sectional dimensions, and of indefinite length.

While I have described suitable apparatus for supporting the walls of an ingot as the ingot emerges from the mold tube, it will be apparent that other types of apparatus may be employed to support the walls of the ingot as they leave the mold tube and for a distance sufficient to permit the formation of a skin or wall which will prevent substantial deformation of the walls of the ingot. It is also within contemplation to use casting apparatus of other construction as well as that herein described.

I claim:

1. Continuous casting apparatus comprising a vertical casting tube from the lower end of which the formed casting is drawn, means supported immediately below the discharge end of the casting tube for exerting a confining and rolling pressure against the walls of the casting while they are still in a deformable state, said means comprising a supporting frame having a yieldably mounted vertical series of closely spaced horizontal rollers therein arranged to engage opposite faces of the casting, and means providing a self-aligning transverse adjustment between said frame and the discharge end of the tube.

2. For use with apparatus for the continuous

casting of metal ingots, including a vertical casting tube from the lower end of which the formed ingot is drawn, supporting members positioned immediately below the casting tube, said supporting members having a plurality of elongated members extending for a distance along the ingot in the direction of the axis of the ingot yieldably supported for radial movement throughout their length and which are operative to exert a yieldable pressure against a substantial length of the ingot adjoining the casting tube, and means providing a universal self-aligning adjustment between the said supporting members and the discharge end of the casting tube.

3. For use with apparatus for the continuous casting of metal, including a casting tube from one end of which metal is drawn as an ingot having a thin deformable skin and a fluid interior, supporting members having a plurality of pressure plates extending along the ingot from a point adjacent the discharge end of the tube, the pressure plates being yieldably supported for radial movement throughout their lengths whereby the plates are yieldably pressed against a substantial length of the ingot, and means providing a universal self-aligning adjustment between the said supporting members and the discharge end of the casting tube.

4. For use with apparatus for the continuous casting of metal, including a casting tube from one end of which metal is drawn as an ingot having a thin deformable skin and a fluid interior, supporting members having a succession of transversely extending rolls supported therein in position to contact the emerging ingot for a substantial distance of its length, and means between the rolls and the supporting members for yieldably urging the rolls against the ingot.

5. For use with continuous casting apparatus comprising a vertical casting tube from the lower end of which the formed casting is drawn, means supported immediately below the discharge end of the casting tube for exerting a confining and rolling pressure against the walls of the casting while they are still in a deformable state, said means comprising a supporting frame having a yieldably mounted vertical series of closely spaced horizontal rolls therein arranged to engage opposite faces of the casting.

6. For use with apparatus for continuously casting molten metal in ingot form including a receptacle for molten metal, a thin wall open-end mold tube spaced below said receptacle said tube having a cooling chamber therearound of shallow radial depth, means for circulating cooling fluid through said chamber, the invention including supporting means comprising a plurality of spaced apart elongated members extending for a distance along the ingot in the direction of the axis of the ingot said members being yieldably supported for radial movement throughout their length, means for urging the members toward the ingot walls, and flexible members providing a self-aligning universal adjustment for supporting the members in ingot receiving relation to the end of the mold tube.

EDWARD R. WILLIAMS.