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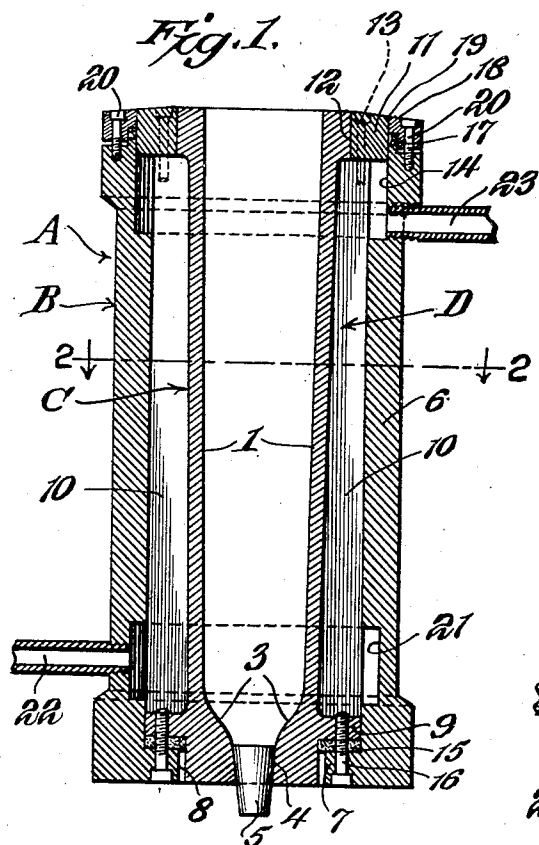
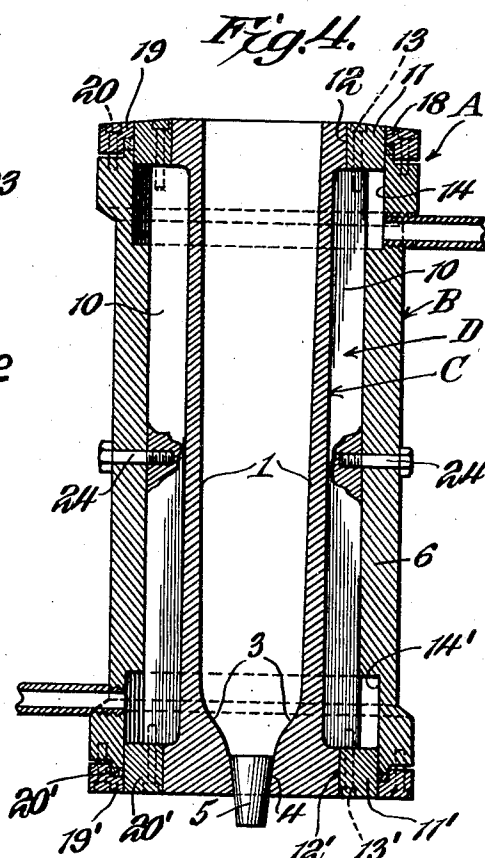
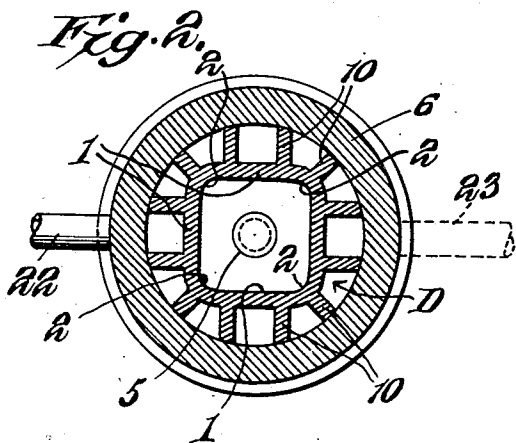
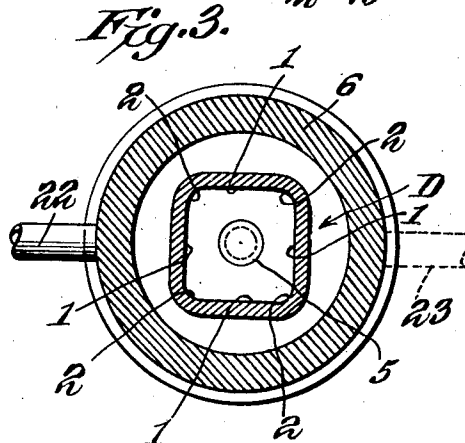
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INGOT MOLD

Filed Aug. 11, 1931

2 Sheets-Sheet 1



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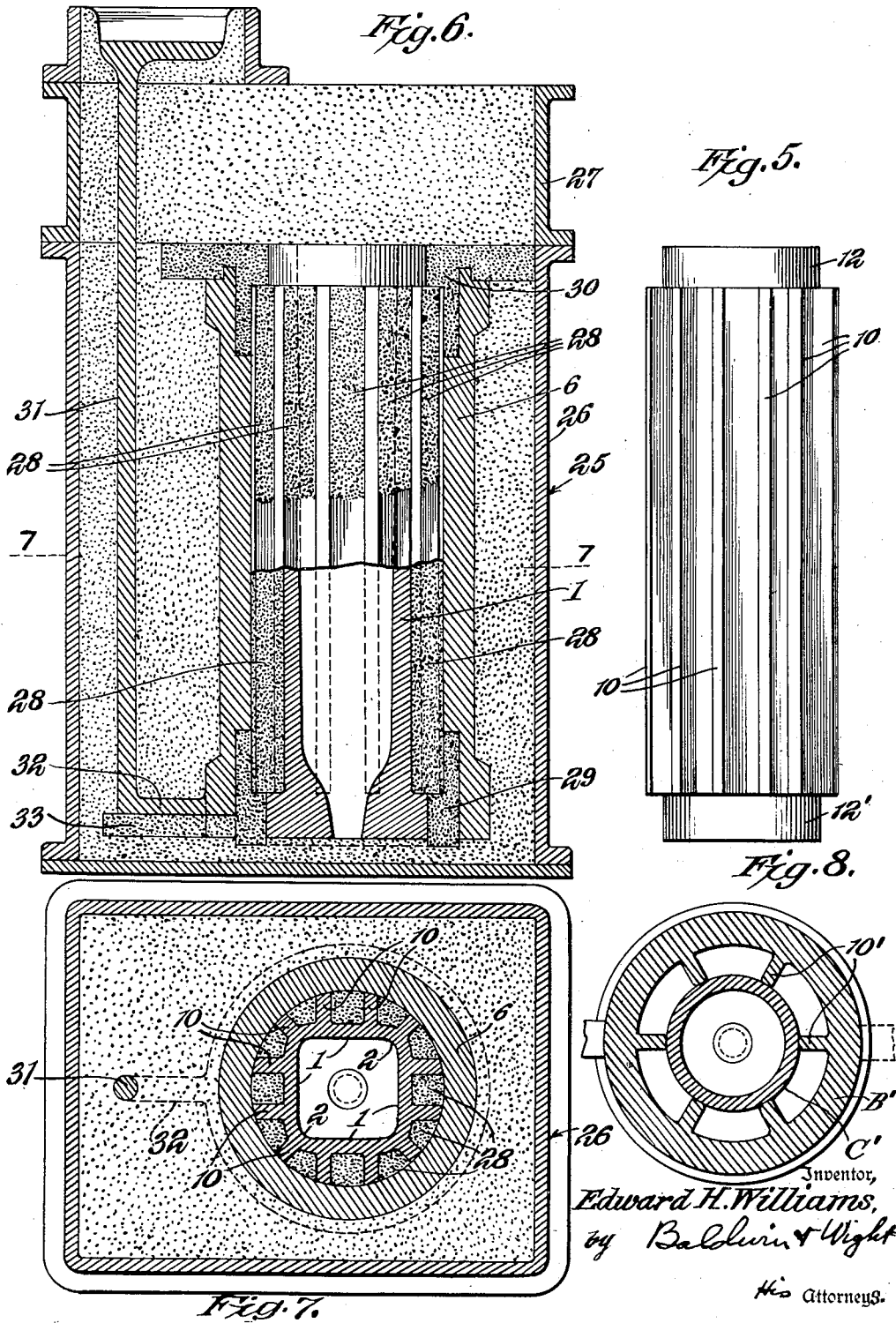
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UNITED STATES PATENT OFFICE

1,936,280

INGOT MOLD

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Application August 11, 1931. Serial No. 556,409

5 Claims. (Cl. 22—144)

This invention relates to ingot molds and more particularly to ingot molds of the kind provided with jackets through which cooling fluid is passed during the pouring or teeming of the molds.

When an ingot mold is poured or teemed, the hot molten steel entering the mold raises the temperature of the latter to such an extent as to cause the formation of fire cracks and cut-away portions of the mold walls and bottom, resulting in the early deterioration of the mold, so that only a limited number of ingots can be poured in each mold. In ingot molds of conventional design the formation of fire cracks is largely due to the unequal temperatures reached by different portions of the mold. In order to overcome this tendency, it has previously been proposed to provide ingot molds with jackets through which water or equivalent cooling fluid is passed during the teeming of the mold, the rate of flow of the cooling fluid being so regulated as to produce a cooling effect which both tends to increase the life of the mold and to so cool the ingot as to improve the physical properties thereof.

More particularly the potential advantages of the increased rate of solidification, and the better control of the rate of solidification made possible by the use of water jacketed molds may be set forth as follows:

1. Because of the rapid solidification produced by the cooling effect of the fluid circulating through the mold jacket space, the ingot may be stripped from the mold a much shorter time after teeming than in the case of the ordinary mold in which the cooling and solidification depends chiefly upon the thickness, configuration and initial temperature of the mold walls, and the pouring temperature of the metal;

2. Due to the shorter time which an ingot must be left in a fluid-jacketed mold before being stripped therefrom, the mold may be used for the pouring of a greater number of ingots within a given length of time, thus reducing the number of molds which must be maintained in a plant to receive a given size and number of heats;

3. Because of the rapid cooling of the ingot metal produced by the fluid circulating through the mold jacket, a more uniform grain structure of the ingot and, therefore, an ultimate product of higher quality can be produced.

In attempts to take advantage of the fundamentally superior characteristics of fluid-jacketed molds and of their ability to produce ingots of superior quality, a number of molds of this general character have heretofore been constructed. These molds have been found to be

subject to a number of difficulties which were basically due to the fact that the rapid heating of the inner section of the mold into which the molten ingot metal was poured and the almost negligible heating of the outer or jacket section caused unequal expansion of the two sections during pouring of the ingot and resulted in the formation of cracks or tears in the inner section occasioned by the inability of the latter to expand freely in a longitudinal direction relative to the outer section. In these prior molds the inner sections have been connected to the outer sections at both ends in order to seal the jacket space, and could not expand longitudinally during heating of the inner section, since the outer sections were not appreciably heated and underwent practically no expansion. Consequently, the inner sections of fluid-jacketed molds heretofore provided have been constrained to expand only in a horizontal direction, that is, transversely to the axis of a vertical mold and the severe strains thus set up in the inner mold sections have caused those sections to crack, rendering the molds useless.

An object of the present invention is to provide a fluid-jacketed ingot mold so constructed as to largely, if not entirely, eliminate the disadvantages exhibited by water-jacketed molds heretofore provided, whereby the fundamentally desirable characteristics of water cooled molds may be made use of without the mold's being susceptible to the early failures common to prior fluid cooled molds. I have found that a mold of the general character referred to but which is so constructed as to provide for relative movement between the inner and outer mold sections in a direction parallel to the mold axis and without breaking the jacket seal is free from the tendency to crack previously caused by the inability of the two sections to partake of relative longitudinal movement, and that such a mold will last much longer than molds heretofore provided.

The more detailed nature of the invention will be better understood from a reading of the following description, appended claims, and the accompanying drawings, in which:

Figure 1 is a central vertical sectional view of a mold embodying the invention;

Figure 2 is a horizontal sectional view taken on the line 2—2 of Figure 1;

Figure 3 is a view similar to Figure 2 but showing a modified form of mold;

Figure 4 is a view similar to Figure 1 but showing another modified form of mold;

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Figure 5 is a front elevation of an inner mold section of the kind shown in Figure 4;

Figure 6 is a vertical sectional view of a sand forming mold used for making an ingot mold in accordance with the inventions;

Figure 7 is a horizontal sectional view taken on the line 7—7 of Figure 6; and

Figure 8 is a horizontal sectional view of a further modified form of mold.

10 A practical embodiment of the invention is illustrated in Figures 1 and 2 in which a water-jacketed ingot mold A is shown as comprising an outer section B and an inner section C positioned within the outer section and being spaced from the latter to provide a jacket space D.

15 The inner mold section C, which defines the casting or ingot-forming cavity, is of generally rectangular cross section, and is preferably of the big-end-up Gathmann type, in the present instance including four side walls 1 which are connected by corner walls, 2 and a necked-in bottom portion 3 merging with a tapered bottom opening 4 closed by a plug 5. Preferably the mold walls are tapered from bottom to top so as to provide the well known big-end-up ingot forming chamber which is best adapted for the production of high quality steel, but it will be understood that the invention may be practiced with inner mold sections of various other specific forms.

20 The outer mold section B is shown as comprising a circular continuous wall 6 provided at its lower end with an inwardly extending flange 7 defining an opening 8 into which the bottom end portion of the inner section C extends, there being considerable clearance between the inner mold section and the opening 8. For centering the inner mold section within the outer section, the inner section is provided with spacing projections which, in the form shown in Figure 1, comprise a circumferential flange 9 on the lower end of the inner section and fitting within the outer section, a plurality of longitudinally extending ribs 10 formed on the inner section and engaging the inner wall of the outer section, and a separate ring 11 mounted snugly on a circumferential flange 12 at the top of the inner section and secured at the upper ends of the ribs 10 by means of bolts 13. The ring 11 is of a diameter to fit within a counter-bored portion 14 on the inner surface of the outer mold section, the counter-bore extending in a direction parallel to the mold axis to permit relative sliding movement between the ring 11 and outer mold section.

25 In accordance with an important feature of the invention, the space between the inner and outer mold sections is sealed and at the same time the two sections are left free to move relatively to each other so as to permit of expansion of the inner section in a longitudinal direction during pouring of the ingot. For sealing the jacket space at the bottom of the mold a compressible packing 15 of rubber or the like is interposed between the flange 9 of the inner section and the flange 7 of the outer section, and the two sections are secured together by means of bolts 16 which extend upwardly through the flange 7 and have threaded engagement with the flange 9 of the inner section, the bolts serving to draw flange 9 against the packing 15. At the upper end of the mold, the jacket space is sealed by means of a packing 17 of rubber or the like positioned in a channel 18 of a packing ring 19 secured to the top of the outer section by bolts 20 which serve to draw the ring down to compress

and maintain the packing 17 in place. The inner surface of this packing engages the outer surface of the ring 11 to seal the jacket space but at the same time permits relative movement between the ring 11 and the outer section in a direction parallel to the mold axis. It will be noted that the counter-bored portion 14 of the outer section constitutes an inner surface on which the outer or circumferential surface of the ring 11 is slidable. The part of the counter-bored portion extending below the ring 11 provides communication between the several spaces intervening between the ribs 10, and communication between these spaces is also provided at the bottom of the mold by an annular passage 21 formed in the outer mold section. The compressible packing 15 interposed between the flange 9 of the inner section and the outer section permits the two sections to be secured together at their lower ends so as to seal the joint between the sections against the passage of fluid, the compressible nature of the packing permitting alignment of the sections with the ribs on the inner section engaging the outer section evenly throughout.

A pipe 22 is connected to the bottom of the outer section and communicates with the annular passage 21 whereby water or other cooling fluid may be introduced into the jacket space, and a pipe 23 connected to the outer section adjacent its top and communicating with the counter-bored portion 14 provides for the outlet of water flowing through the jacket space.

In operation, water or other cooling fluid is introduced into the jacket space through the pipe 22 and is discharged from the jacket space through the pipe 23, it being understood that either of these pipes may be provided with a suitable valve for regulating the rate of flow of fluid, and hence, the rate of cooling of the mold and ingot. Preferably, the cooling fluid is caused to flow through the jacket space sometime before the mold is teemed and flow of cooling fluid is continued during and after teeming. When the molten metal is poured into the mold, the inner section will extract heat from the molten metal and the heat will in turn be extracted from the inner section by the cooling fluid passing through the mold jacket. In this way, the ingot will be rapidly chilled, and a more uniform grain structure obtained. When the inner mold section becomes heated during and after teeming, it will naturally tend to expand, especially in its longer or vertical dimension. The outer section, which is separated from the inner section by means of the water jacket space, will remain relatively cool and will not expand appreciably. However, the inner section will expand freely despite the relative non-expansion of the outer section because the ring 11 is freely slidable along the counter-bored portion 14, the packing 17 and the ring 19 without breaking the jacket seal.

The fluid flowing upwardly through the jacket space will become heated so that its temperature will at all times be progressively higher from bottom to top of the mold and the cooling effect will therefore be progressively less from bottom to top. For this reason the molten metal in the top of the mold will be the last to solidify and shrinkage of the ingot metal will be confined to the upper end portion of the ingot.

After the ingot has been teemed and stripped, the mold will be rapidly brought to the proper temperature before pouring another ingot by the continued flow of cooling fluid through the jacket space.

The modified form of mold illustrated in Figure 3 is the same as that shown in Figures 1 and 2 and described above except that the ribs 10 are omitted. In small molds it is sometimes not necessary to provide such ribs. In other respects the construction and manner of using the mold shown in Figure 3 is the same as that described above in connection with Figures 1 and 2.

Figure 8 illustrates a modified form of mold constructed in accordance with the invention and in which spacing ribs 10' are formed integrally with an outer or jacket section B'. In this form the center section C' is of circular cross section and is supported by the ribs 10'.

Figure 4 illustrates a further modification in which the inner section is fixedly connected to the outer section at an intermediate point by means of bolts 24 extending through the outer section and having threaded engagement with the longitudinal ribs 10 of the inner section, and both ends of the inner section are arranged for relative movement with respect to the outer section in a direction parallel to the axis of the mold. The construction of the inner and outer sections at the top of the mold is exactly the same as the construction of the corresponding parts in the form shown in Figure 1, and the construction at the bottom is likewise the same as the top construction of Figure 1, so that a further detailed description is not considered necessary. The reference characters applied at the bottom of the mold designate parts which are the same as correspondingly designated parts at the top and are the same as the characters used at the top with the exception that they are primed, i. e., the ring 11' at the bottom corresponds with the ring 11 at the top, et cetera.

In operation, the mold shown in Figure 4 is used in the same manner as that shown in Figure 1. However, during expansion of the inner mold section, both the upper and lower ends thereof will move relatively to the outer section so that the inner section will expand toward both ends from its intermediate point of connection with the outer section.

In constructing the improved forms of molds described above, it is sometimes desirable to machine the outer surface of the ribs 10 and other spacing projections so that they may be fitted snugly within the outer section. In many instances, however, this machining operation which results in an added cost in manufacture, may be dispensed with. I may form the inner mold section, for example, of the kind shown in Figures 4 and 5, by casting in the usual manner. A sand forming mold 25 of the kind illustrated in Figures 6 and 7, and comprising a drag 26 and a cope 27 is then prepared in any desired manner. The central core for this mold is formed from the inner mold section already prepared by inserting a plurality of cores 28 in the spaces between the ribs 10 of the inner section, the outer faces of the cores being flush with the outer faces of the ribs. The cores 28 and the ribs 10 together present a center core around which the outer mold section may be cast.

After the drag 26 of the forming mold is thus prepared, a core 29 having a shape adapted to form the counter-bored portion 14' of the outer mold section is lowered into the mold and the inner section C with the cores 28 attached thereto is positioned in the mold as shown in Figure 6. A core 30 shaped so as to form the upper counter-bored portion 14 of the outer mold sec-

tion is then positioned as shown in Figure 6 and the cope 27 then lowered and secured in place. The metal for forming the outer mold section is poured through a sprue 31 and gate 32 which extends over a runner or slab core 33. Risers or feeders, not shown, may be used if desired, and it will be understood that the manner of making the forming mold proper may vary in accordance with different foundry methods and with available pattern equipment, it being important however, that the inner section be provided with the cores 28 or their equivalent to enable the metal forming the outer mold section to contact with only the spacing projections of the inner sections.

When the outer section has been cast around the inner section in the manner described above and has solidified, the two sections are together removed from the mold and the sand comprising the cores 28 is removed through the counter-bored portions 14 at either or both ends of the mold. Thereafter the ring 11 is interposed between the flange 12 at the top of the inner section and the counter-bored portion 14 of the outer section, and the ring 19 secured in place. Similarly the ring 11' is interposed between the flange 12' and the counter-bored portion 14' at the bottom of the mold and the ring 19' secured in place.

Due to the considerable mass of the ribs 10 and their resultant chilling effect, the metal flowing into the forming mold cavity during pouring of the outer section will simply lie against the outer surface of the ribs and will not become fused thereto, so that the ribs will be longitudinally slidable with respect to the outer mold section, and expansion of the inner section during pouring of an ingot will take place without harmful restraint.

The method described above may also be employed for making molds of the general type shown in Figure 8, that is, molds in which the supporting ribs are formed integrally with the outer mold section. In such case the outer section B' may be prepared first and the spaces between the ribs 10' filled with cores in the manner described above, after which the inner section may be cast concentrically within the outer section so that the metal of the inner section will contact with the spacing projections only of the outer section.

From the foregoing it will be observed that an ingot mold constructed in accordance with my invention makes possible the efficient use of a cooling fluid by means of which ingots of high quality can be produced and at the same time the life of the mold considerably prolonged. The longer life of molds constructed in accordance with my invention as compared to water-jacketed molds heretofore known is due to the fact that the inner section of my mold is free to expand longitudinally with respect to the outer section without breaking the seal between the two. It will be understood that although the described forms of molds are considered practical embodiments of the invention, various modifications may be made in the construction and in the manner of making the molds without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. A fluid jacketed ingot mold comprising an outer section; an inner section positioned within the outer section in spaced relation thereto; spaced ribs on one of said sections extending lon-

- gitudinally of the axis of the mold and engaging the other section whereby said inner section is supported by said outer section; and means for sealing the space between said sections at the ends of the mold, said means at one end of the mold including a packing for providing for relative movement between the sections, said outer section being provided with a counter bore at each end of the mold to provide for flow of liquid into spaces intervening between said longitudinally extending ribs, and said outer section being provided with fluid passages communicating with said counter bores and adapted to communicate with fluid inlet and outlet pipes respectively.
2. A fluid jacketed ingot mold comprising an outer section; an inner section positioned within the outer section in spaced relation thereto; spaced ribs on one of said sections extending longitudinally of the axis of the mold and engaging the other section whereby said inner section is supported by said outer section; means for securing said sections together in sealed relation at one end of the mold, the outer section at the other end of the mold being formed with a counter bore extending longitudinally inward from said end; a flange on said inner section of less longitudinal extent than said counter bore and slidably engaging the wall of the latter; means for sealing the connection between said flange and said counter bore wall, said counter bore thereby providing for flow of fluid between the respective spaces intervening between said longitudinally extending ribs and said outer section, one of said sections at the other end of the mold being formed to provide for flow of fluid between the respective spaces intervening between said longitudinally extending ribs.
3. A fluid jacketed ingot mold comprising an outer section; an inner section positioned within the outer section in spaced relation thereto; spaced ribs on one of said sections extending longitudinally of the axis of the mold and engaging the other section whereby said inner section is supported by said outer section; a circumferential flange at one end of said inner section; compressible packing interposed between said flange and said outer section; means for drawing said sections together to compress said packing whereby the joint between said sections is sealed against passage of fluid while permitting alignment of said sections with the ribs on said one section engaging said other section evenly throughout; and means for sealing the space between said sections at their other ends including a packing held by one section and engaging the other to permit relative movement between said sections at said other end.
4. A fluid jacketed ingot mold comprising an outer section; an inner section positioned within the outer section in spaced relation thereto; a circumferential flange at one end of said inner section; compressible packing interposed between said flange and said outer section; means for drawing said sections together in a direction parallel to the axis of said sections to compress said packing whereby the joint between said sections is sealed against passage of fluid; and means for sealing the space between said sections at their other ends including a packing held by one section and engaging the other to permit relative movement between said sections at said other end.
5. A fluid jacketed ingot mold comprising an outer section; an inner section positioned within the outer section in spaced relation thereto, one of said sections comprising means arranged to cooperate with said other section for maintaining said sections in cooperative relation; a circumferential flange at one end of said inner section; compressible packing interposed between said flange and said outer section; means for drawing said sections together in a direction parallel to the axis of said sections to compress said packing whereby the joint between said sections is sealed against passage of fluid; and means for sealing the space between said sections at their other ends including a packing held by one section and engaging the other to permit relative movement between said sections at said other end.

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