

Aug. 16, 1938.

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2,127,407

APPARATUS FOR CASTING METAL

Filed Sept. 24, 1936

3 Sheets-Sheet 1

Fig. 1.

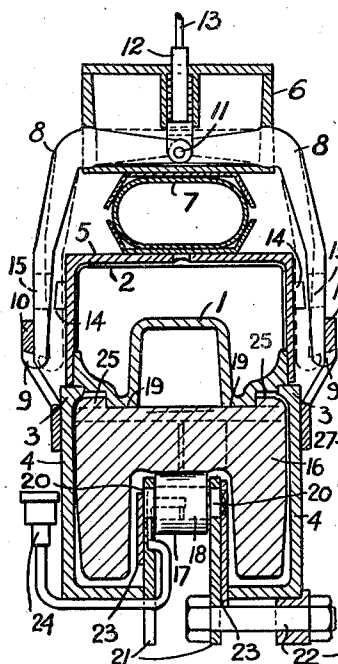


Fig. 2.

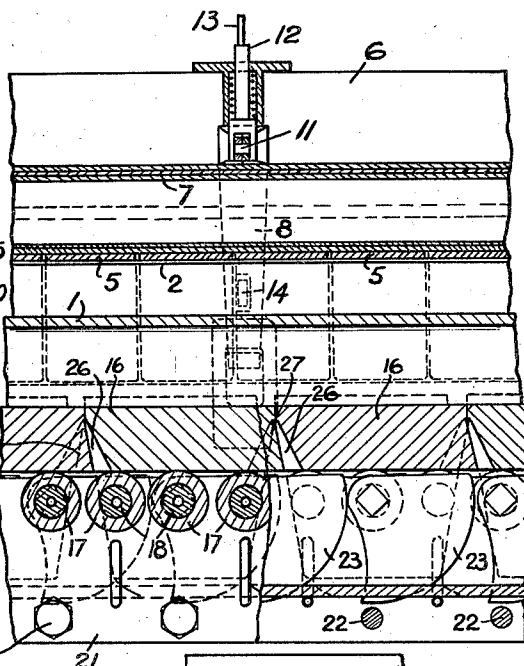
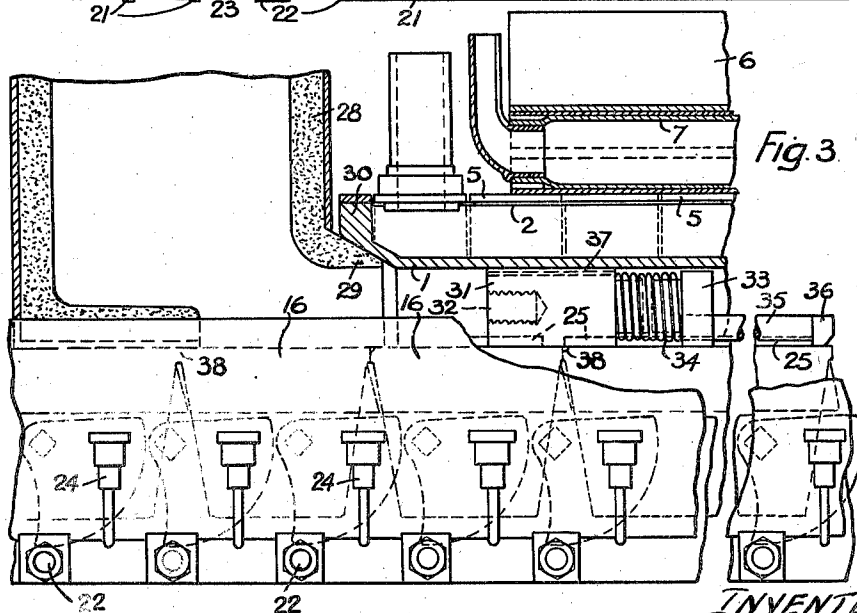


Fig. 3.

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3 Sheets-Sheet 2

Fig. 4.

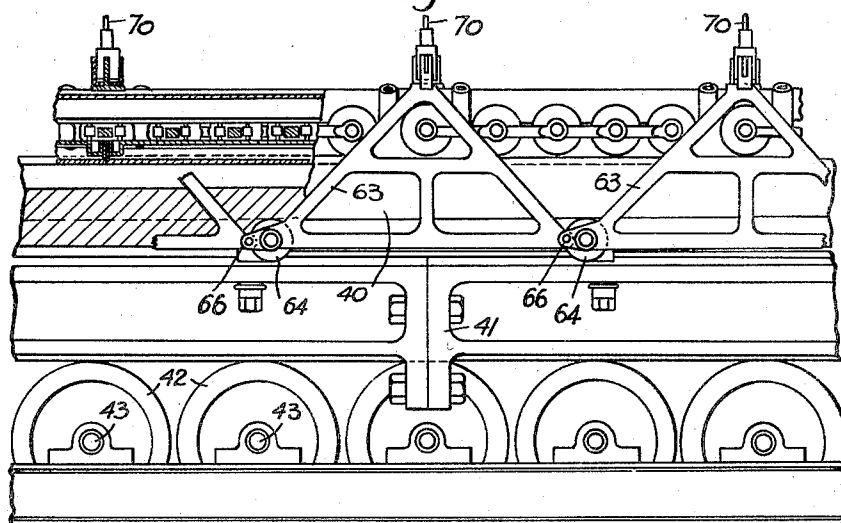


Fig. 5.

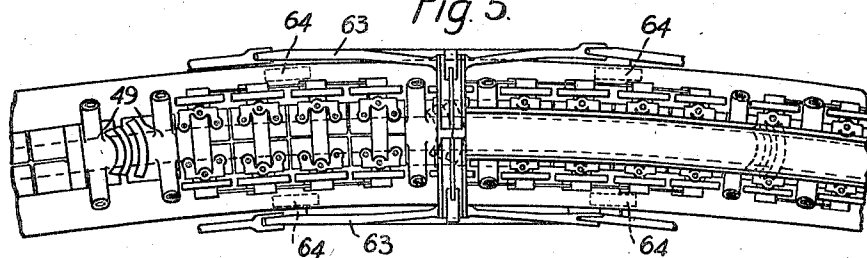


Fig. 11.

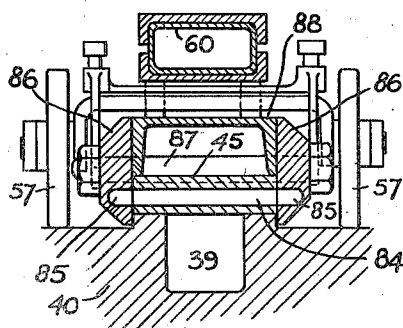
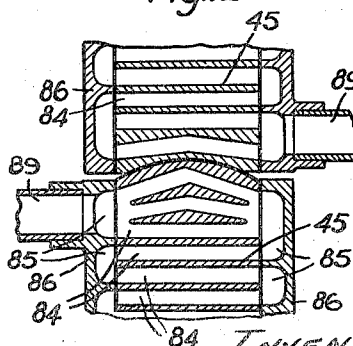


Fig.12



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3 Sheets-Sheet 3

Fig. 6.

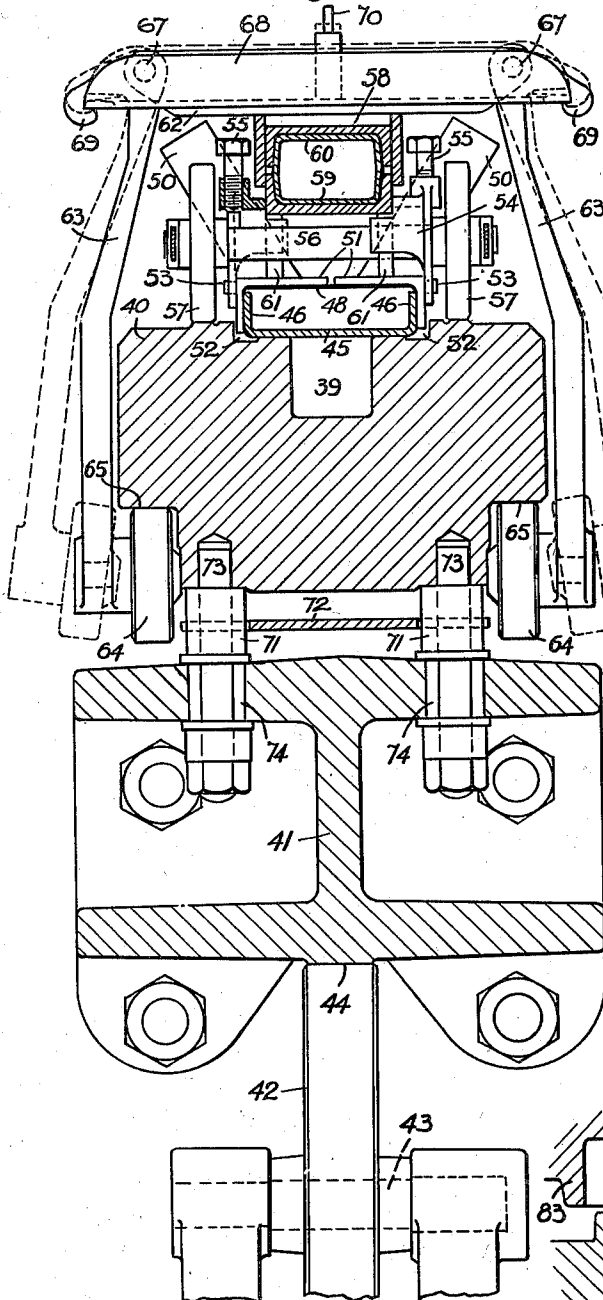


Fig. 7.

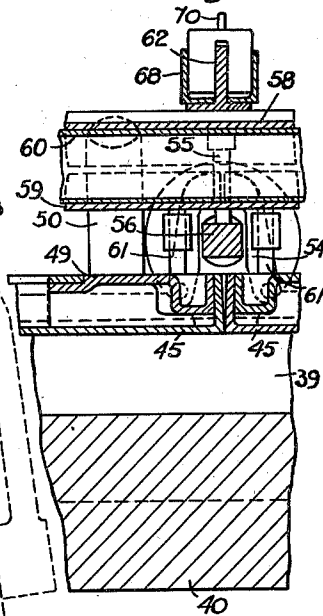


Fig. 8.

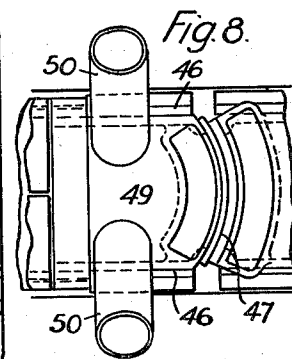


Fig. 10.

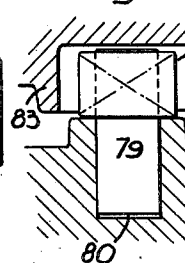
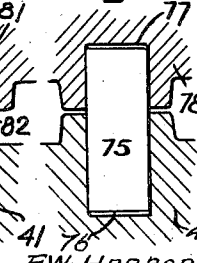


Fig. 9.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR CASTING METAL

Frank William Harbord and Vernon Harbord,
London, EnglandApplication September 24, 1936, Serial No. 102,435
In Great Britain October 9, 1935

10 Claims. (Cl. 22—57.3)

This invention relates to apparatus for the direct production from molten metal of billets, slabs, bars, and the like in forms suitable for use, and it has some features particularly useful when the metal is a non-ferrous alloy; the invention has other features which apply more especially to steel, and which have for their object the avoidance of costly reheating and rolling of large rectangular ingots in order to form the sections required.

Such apparatus, as described for example in the specifications of our prior Patent Nos. 1,891,813 and 1,928,562 usually comprises at least two members which co-operate to enclose a mould cavity and of which at least one is propelled longitudinally so that as molten metal poured into the cavity solidifies the billet thus formed is moved away from the casting point, causing continuously the formation of fresh mould cavity at the casting point.

The mould cavity may be in both members or in one only, and it may be in a fixed member or in a moving member or in both. A moving member may be rigid, as for example a long straight member moved in one path, or a circular ring revolving around a vertical or horizontal axis, or again it may be articulated and form an endless chain of rigid segments, or it may be a band of sheet metal thin enough to pass continuously round revolving cylinders or cones. The two members may be moving at the same or at different speeds.

To ensure the production of satisfactory billets it is necessary that the joints between the co-operating members shall be tight against the entry of a fin of molten metal, and in some cases pressure has been applied to one member by weights or springs which is resisted by the ultimate supports of the other.

According to one feature of the present invention a force is exerted upon one such member tending to press it on to its co-operating member, and acting across the surface of the joints between them by resilient means pressing one way upon one member and the opposite way upon an abutment or counter support, and the reaction upon this abutment is transferred to one or more parts acting directly upon the co-operating member, or upon a support which has no motion relatively to this member. This transference of the abutment reaction to the mould members may be effected by a link whose ends act upon the abutment and member directly or through levers as may be convenient.

In certain cases particularly when two co-operating members hereinafter called the mould and cover, are arranged to move at the same speed, they may be allowed to be in close contact with one another; in other cases when there is relative sliding of one over the other we may re-

duce friction and wear by using restraining means adapted to limit the approach of one to the other to within a clearance sufficiently fine to prevent the entry of molten metal.

According to another feature of the invention the mould and cover are arranged to be held in effective relation with each other by means of fluid pressure loading means throughout that part of them in which the mould cavity is closed by the cover.

According to another feature of the invention the mould cavity is formed in a stationary upper member hereinafter called the mould and the cavity is closed by a long or continuous closing member, which is caused to travel past the mould which, being stationary can conveniently be water jacketed. Three water-cooled sides of a mould of rectangular section, are thus enabled to have fresh molten metal continually passing over them near the casting point, and the rate at which they cool the casting compared with that of a single water-cooled cover is proportionately rapid. Each part of the travelling closing member of the cavity is in contact only momentarily with molten metal as this enters the cavity and in cases in which the closing member is formed by a chain of segments, it may be cooled during its return passage between the outlet end of the mould and the casting point in any convenient manner, as for example, by air or by immersion in water.

The jacket of the mould may be divided transversely into two or more separate sections each having its own inlet and outlet, and each inlet may be arranged to be supplied with a circulating medium at a suitable temperature, for example, water, oil, superheated steam or gas, so that the billet during its solidification as it passes through the mould can be subjected to controlled cooling and the crystalline structure of the metal can be thereby modified and controlled to a considerable extent.

The mould cavity being closed as described by a closing member moving longitudinally past the two horizontal bearing surfaces at the edges of the stationary mould, it is important to ensure that the closing member shall make close contact, or nearly so, with the inner edges of these bearing surfaces, and shall not be prevented from so doing by earlier contact with the outer edges which might cause a wedge-shaped gap into which molten metal could enter. For this purpose the mould and closing member are arranged to be pressed together by forces acting so that either the mould or the closing member, or both, tend to be deflected in cross section more toward the centre of the cavity than at its sides, each tending to present a convex surface to the other, with the result that contact between them begins at the bearing edges next the cavity and the molten metal. Thus where the surface of the closing

member is capable of readily assuming a convex cross-sectional form as in the case of a flexible closing member, the latter may be arranged to be pressed towards the mould by one or more lines of rollers acting between the sides of the mould cavity. In cases in which the closing member is constituted by a chain of rigid segments the more flexible mould may be pressed towards the closing member by forces exerted along lines within the mould cavity.

The invention is illustrated by way of example in the accompanying drawings of which Figure 1 is a view in vertical cross-section of the mould elements and their associated parts of apparatus embodying one form of the invention, Figure 2 being a view in sectional elevation of the mechanism shown in Figure 1.

Figure 3 is a view similar to Figure 2 of the portion of the mechanism adjacent to the casting point of the apparatus.

Figures 4 to 12 inclusive illustrate another form of the invention, Figures 4 and 5 being views thereof in side elevation and plan respectively.

Figure 6 is a view in vertical cross-section on an enlarged scale of the mechanism shown in Figures 4 and 5, Figure 7 being a view of a portion thereof in sectional elevation.

Figure 8 is a plan view of a portion of the mechanism of Figures 7, Figures 9 and 10 being sectional views of certain details of construction.

Figures 11 and 12 are views in vertical cross-section and sectional plan respectively of a modified construction of a portion of the mechanism shown in Figures 6, 7 and 8.

Referring now first to Figures 1 and 2 it will be seen that the moulding mechanism illustrated comprises an inverted mould member 1 provided with a flexible water-jacket 2 and mounted upon the upper edges 3 of supporting frames 4. Surrounding the water-jacket 2 and secured at their lower ends to the mould 1, sectional pressure members 5 are provided and interposed between the members 5 and an upper abutment frame 6 is a flexible tube 7 to which air under pressure is arranged to be supplied. The frame 6 and the lower frames 4 are arranged to be normally mechanically coupled to each other by a number of sets of stirrup levers 8 arranged at suitable intervals along the length of the mould 1, the upper ends of these levers being mounted in the frame 6 and their lower hooked ends 9 engaging with lugs 10 attached to the lower frames 4. The upper arms of each pair of levers 8 are connected as indicated at 11 to a spring-controlled plunger 12.

Each of the plungers 12 is connected to an operating cable 13 and it will be understood that by exerting a pull on the cables 13 after the compressed air has been released from the tube 7, the levers 8 will be moved into the position shown in dotted lines in Figure 1 in which lugs 14 on the sides of the pressure members 5 enter openings 15 in the levers 8. The continued pull exerted upon the cables 13 will then raise the mould 1 clear of the frames 9.

The lower end of the mould cavity in the mould 1 is closed by a chain of segments 16 guided transversely between the lower frames 4 and supported upon adjustable rollers 17, the supporting spindles 18 of which are arranged to be adjusted vertically so as to cause each segment 16 to be in contact with the bearing surfaces 19 of the mould 1 or to be separated therefrom by any desired clearance. This adjustment

is rendered possible by providing each of the spindles 18 with eccentric journals 20 by means of which the spindle is rotatably mounted in plates 21 secured to the frames 4 by means of bolts 22, one end of the spindle 18 being secured to a quadrant member 23. It will be evident that by loosening the bolt 22 and rotating the quadrant member 23 the corresponding roller 17 can be raised or lowered as desired so as accurately to determine the position of each of the segments 16 relative to the mould 1 while passing over the roller. The quadrant members 23 after adjustment are again locked in position by tightening the bolts 22 which, as shown in Figures 1 and 2, are arranged alternately on opposite sides of the apparatus. The spindles 18 of the rollers 17 are each provided with a lubricating device 24.

The segments 16 are of the cross-sectional form shown in Figure 1, which provides great rigidity and cooling surface and enables the segments to be supported upon the rollers 17 as closely as possible to the mould 1. The upper surface of each segment 16 is provided with ribs 25 for guiding the segment laterally relative to the mould 1 and the abutting ends of the segments are arranged only to engage with one another adjacent to the upper faces of the segments, as shown in Figure 2, so as to ensure close contact, the lower portions of the opposing ends of the segments being sloped away from each other as indicated at 26. A portion of each end of each segment 16 is, however, provided with a projection 27 for prolonging the support of the segment in passing over a roller 17. The chain of segments 16 is arranged to be caused to travel past the mould 1 by any suitable mechanism for this purpose.

It will be observed that the downward pressure on the mould 1 due to the compressed air in the tube 7 is exerted between the upper edges 3 of the supporting frames 4 so that any transverse deflection or distortion of the mould 1 due to this pressure will tend to cause the inner edges of the bearing surfaces 19 of the mould to engage closely with the upper faces of the segments 16 and thus effectively to seal the mould cavity.

Referring now to Figure 3 the pouring box 28, through which the molten metal is introduced into the moulding cavity, is provided with a spout member 29 adapted to fit closely within the coned end 30 of the mould 1 and to be pressed downwards into close engagement with the segments 16 during their travel, this being effected by a suitable spring-controlled or other mechanism not shown.

In starting the apparatus into operation the end of the mould cavity adjacent to the pouring box 28 is first closed by means of a plug member 31 provided with a screw-thread recess 32 and adapted to slide longitudinally within the mould 1. The plug member 31 is connected at its front end to a member 33 by means of a spring 34 secured at its ends to the members 31 and 33 and the latter member is connected to one end of a rod 35, the opposite end of which is connected to a cross-head 36 adapted to be engaged by the forward ends of the guide ribs 25 of a segment 16 ahead of the plug member end of the mould 1, as shown at the right-hand side of Figure 3.

The molten metal is introduced into the pouring box 28 and flows through the spout member 29 into the portion of the mould cavity in the

mould 1 in front of the plug member 31, the air contained in this portion of the mould cavity escaping through one or more holes 37 formed in the plug member 31. The molten metal enters the recess 32 in the plug member 31 and solidifying therein, keys the forward end of the continuous billet formed in the mould cavity to the plug member 31.

The chain of segments 16 is set into motion so as to travel past the mould 1 from left to right as viewed in Figures 2 and 3, and the billet formed in the mould cavity by the molten metal continuously supplied through the pouring box 28 is carried forward by the movement of the plug member 31 under the action of the cross-head 36. The billet contracts in cooling and this contraction is permitted by the spring 34.

The forward movement of the cast billet effected by the plug member 31 is assisted by the frictional engagement of the base of the billet with the segments 16, the upper faces of which, if desired, may be provided with serrations enabling the segments to grip the billet. As shown in Figure 3 the extreme upper ends of one of the opposing ends of each segment is slightly bevelled as indicated at 38 for this purpose, and this arrangement is usually found in practice to be sufficient for ensuring a satisfactory forward movement of the billet.

Referring now to the apparatus shown in Figures 4 to 12 inclusive it will be seen that the mould cavity is in this form of the invention constituted by an annular recess or channel 39 formed in the upper face of an annular mould member 40 of relatively large diameter mounted upon a turn-table 41 adapted to be rotated in a horizontal plane about a vertical pivot by any suitable mechanism (not shown). The turn-table 41 is supported adjacent to its periphery by rollers 42 rotatably mounted upon fixed pivots 43, the axes of which are slightly inclined so as to intersect the plane of the lower face 44 of the turn-table at the axis of the pivot of the turn-table thus ensuring that any distortion of the turn-table due to temperature variations shall not cause the turn-table to be raised or lowered.

The mould cavity 39 is closed at its upper end by a non-rotating cover 45 formed in a number of relatively short curved sections each having upwardly turned lateral flanges 46, adjacent sections of the cover 45 abutting against one another at cylindrically sliding joints as indicated at 47 in Figure 8. Each section of the cover 45 is provided with a water-jacket enclosed between the flanges 46 and a sheet metal or fabric covering 48 which at one end of the cover section extends into a hollow casting 49 provided with inlet and outlet pipe connections 50 for the cooling water.

Arranged above and enclosing the covering 48 are a pair of pressure members 51 for each cover section, the lower edges of the members 51 projecting within grooves 52 formed in the upper face of the mould member 40. The pressure members 51 are provided with lugs 53 engaging in corresponding holes in U-shaped clip members 54, which are adjustably supported by means of screws 55 upon a transverse bar 56 provided at each end with a rotatable roller or runner 57. The rollers 57 are carried on the upper face of the mould member 40 and it will be evident that by suitably adjusting the screws 55 the clearance between the cover 45 and the mould member 40 during the rotation of the mould member can be

caused to be of any desired value and positively determined with a high degree of accuracy.

Located above the pressure members 51 and enclosed between upper and lower channel members 58, 59 is a flexible tube 60 to which compressed air at a suitable pressure is arranged to be supplied in any suitable manner, spacer members 61 being interposed between the lower channel member 59 and the pressure members 51.

The upper channel member 58 is secured at intervals in its length to cross-bars 62 each of which is attached at each end, as hereinafter described, to the upper part of a triangular frame 63 provided with rollers or runners 64 adapted to roll on tracks 65 formed on the mould member 40. The several frames 63 on each side are pivotally connected together as indicated at 66 in Figure 4, and the upper end of each frame 63 is pivotally connected to the corresponding end of the cross-bar 62, as indicated at 67 in Figure 6. A cross-bar 68 is provided adapted to engage at each end with projecting lugs or arms 69 on the frames 63, the cross-bar 68 being adapted to be raised when desired by means of a cable 70. It will be seen that by releasing compressed air from the tube 60 and exerting a pull on the cables 70, the cross-bar 68 can be moved upwards and by its engagement with the lugs 69 will effect the outward movement of the frames 63 about their pivots 67 to the positions shown in dotted lines in Figure 6, whereupon the rollers 64 being thus moved clear of the tracks 65 on the mould member 40, the cover member 45 and its associated parts can be raised from the mould member 40 by means of the cables 70.

In order to protect the turn-table 41 from the heated mould member 40 so as to maintain the turn-table at as low and uniform a temperature as possible, the turn-table 41 and the mould member 40 are separated from each other by spacing members 71, a screen 72 of asbestos or other suitable thermal insulating material being also provided for the same purpose. Relative movement in the vertical direction between the mould member 40 and the turn-table 41 is prevented by stud bolts 73 secured to the member 40 and traversing the spacing members 71, the lower ends of the bolts 73 passing with considerable clearance through corresponding holes 74 in the turn-table 41.

The driving connection between the turn-table 41 and the mould member 40 is effected by a single pair of driving pins arranged at opposite ends of a diameter of the turn-table one of these pins as shown at 75 in Figure 9 fitting relatively closely in all directions in a corresponding recess 76 in the turn-table 41 and in a recess 77 formed in a boss 78 on the mould member 40. The other pin 79, as shown in Figure 10, fits closely within a recess 80 in the turn-table 41, the upper end of this pin being provided with a head or roller 81 fitting within a recess 82 in a boss 83 formed on the mould member 40, the recess 82 being elongated in the direction of the diametral line joining the axes of the pins 75 and 79 so as to permit expansion or contraction of the mould member 40 in a radial direction.

In operation it will be understood that as the mould member 40 containing the mould cavity 39 is caused to travel past the cover member 45 by the rotation of the turn-table 41 the cover member 45 is maintained in suitably close relation to the mould member 40 by the pressure due to the compressed air in the tube 60 and since the pressure thus exerted tending to cause the mem-

bers 40 and 45 to approach each other is transmitted through the frames 63, this pressure is balanced so that there is no external reaction. Furthermore the adjustable clips 54 enable any desired clearance between the mould member 40 and the cover member 45 to be established and maintained with great precision while the full air pressure is available to oppose any increase of this clearance.

Referring now to Figures 11 and 12 an alternative construction of the cover member is illustrated comprising modified water-cooling arrangements.

The cover member 45 in this construction comprises a casting provided with a number of internal channels or passages 84 extending transversely across the member. At each side of the member 45 the passages 84 are arranged to communicate with one another through cavities 85 formed in castings 86 which are secured to the member 45 by bolts 87 and spacing members 88, the castings 86 being provided with pipe connections 89 for the cooling water.

It will be seen that the water is thus caused to flow in a sinuous path through the cover member 45 thereby effectively cooling this member during the operation of the apparatus.

According to another arrangement a water jacket is so arranged and attached to the cover that the use of water under pressure tends to deflect the cover towards the mould cavity as desired.

According to another arrangement the two mould surfaces next the cover are not in one plane but are sloped so that the cover and mould have practically line contact on each edge of the mould cavity, and the cover is kept substantially flat on the face next the molten metal by the use of a rigid water jacket attached to it so as to resist its distortion in cross section.

It will be understood that the invention is not limited to the particular constructional forms or arrangements of the cooperating mould members and the various devices associated therewith which have been illustrated and described and various modifications in these and other respects may evidently be made without exceeding the scope of the invention.

We claim:

1. An apparatus for casting metal comprising a frame, at least one mould element carried by said frame, at least one counter mould element, said mould elements and counter mould elements being shaped and arranged to form a piece of a mould having a substantially cylindrical cavity of any cross-section when abutting against each other on a longitudinal surface, means for moving the said counter mould elements in an axial direction relative to the said mould elements, counter support means arranged at the rear of the counter mould elements, resilient means supporting against the said counter mould elements on the one hand and against the said counter support means on the other hand so as to press the counter mould elements against the mould elements, and connecting members flexibly connected at their upper ends to said counter support means and arranged to straddle the mould elements on both sides of the mould cavity for transferring without substantially bending stress the force exerted by the said resilient means from said counter support means to said mould elements.

2. An apparatus as claimed in claim 1, in which the connecting members are arranged to be tiltable out of engagement with the frame crosswise to the direction of thrust to be transmitted so as to become inoperative.

3. An apparatus as claimed in claim 1, in which the connecting members have cantilever rollers at their lower ends to engage the cooperating mould members so as to permit an axial movement of the latter with reference to the connecting members.

4. An apparatus as claimed in claim 1, further comprising additional supporting means for restricting the relative approximation between the cooperating mould members.

5. An apparatus as claimed in claim 1, in which the mould element is arranged to move with reference to the frame, further comprising rollers for supporting the mould elements, and means associated with each roller for individually adjusting its height relative to the connecting members.

6. An apparatus as claimed in claim 1, further comprising a turning table, rotatably connected with the frame, the mould element being arc-shaped and supported on the said turning table, further comprising a bolt connection between said mould element and said turning table at one point, and a radially slidable connection between said mould element and said turning table at a position diametrically opposite to said bolt connection.

7. An apparatus for casting metal comprising a frame, at least one pair of mould members supported by said frame and arranged cooperating to form a substantially cylindrical mould cavity of any cross-section, means for moving at least one of the mould elements in the direction of the axis of said cavity with reference to the frame, two connecting members arranged at opposite sides of the mould members closely adjacent said mould members and connected at their upper ends to said counter supporting means and to straddle said mould members and releasably connected at their lower ends to the frame to transmit forces from one mould member to the cooperating mould member, and elastic means comprising a container having collapsible walls and filled with fluid under pressure for pressing the cooperating mould members together.

8. In apparatus for casting metal, a frame, a plurality of mould members supported by said frame and arranged to cooperate in constituting a mould having a substantially cylindrical mould cavity, a plug or stopper member closing said cylindrical mould cavity, driving means for carrying said plug or stopper member in an axial direction with reference to the mould cavity, and spring means acting in the same direction for resiliently connecting said stopper member with said driving means.

9. Apparatus as claimed in claim 1, in which the elastic means comprise a collapsible tube filled with a gaseous fluid under pressure.

10. Apparatus as claimed in claim 1, in which the elastic means comprise a collapsible body filled with fluid under pressure and means for venting said body, and in which the connecting means are arranged readily to be detachable after venting of the collapsible body.

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