

July 5, 1966

K. REINFELD ETAL
CONTINUOUS CASTING MACHINE

3,258,815

Filed May 3, 1963

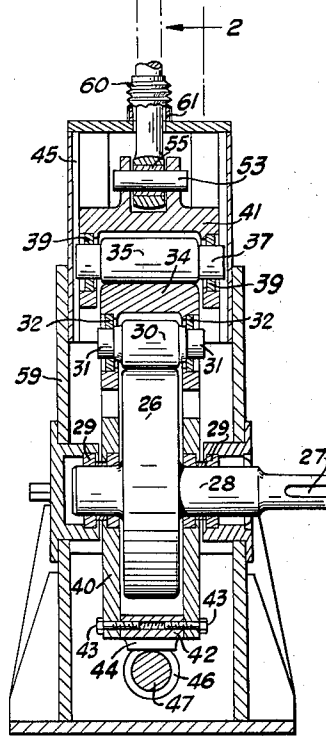
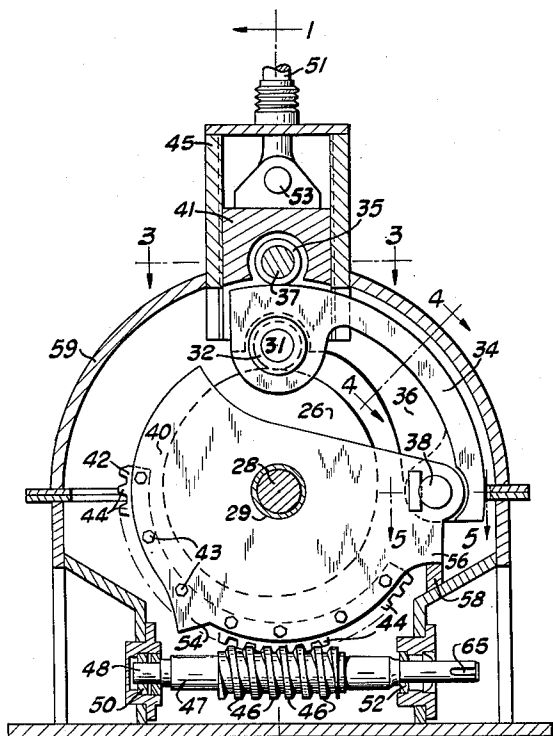
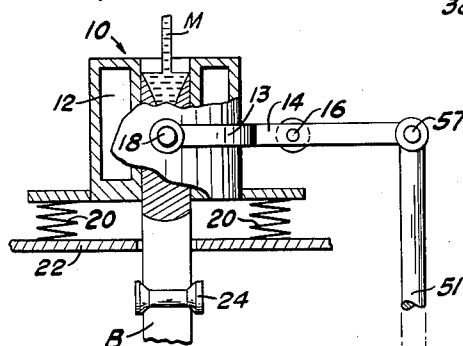
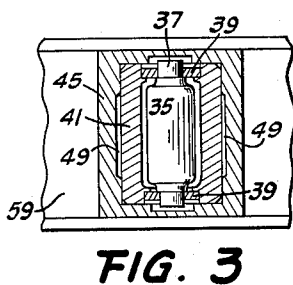
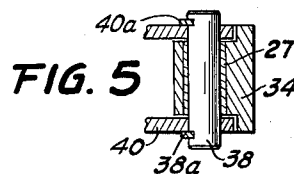
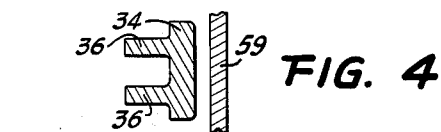


FIG. 2

FIG. 1

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3,258,815

CONTINUOUS CASTING MACHINE

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Filed May 3, 1963, Ser. No. 277,925

5 Claims. (Cl. 22—57.3)

This invention relates to continuous casting and more particularly to an improved apparatus for the vertical reciprocation of the mold of continuous casting apparatus.

In carrying out the continuous casting of metal into billets, there is conventionally employed an open-ended mold. The molten metal is poured into one end of the mold and an at least partially solidified billet having the contour of the mold is withdrawn from the other end. The mold is vertically reciprocated in an advance movement and a retracting movement.

The mold advance movement is usually synchronized with the rate of withdrawal of the billet such that there is no relative movement between the mold and the metal being cast. At the end of the advance movement the mold is rapidly retracted. This vertical reciprocation of the mold prevents adhesion of hot metal to the sides of the mold and minimizes the possibility of rupture of the partially solidified metal shell of the billet which would allow the core of molten metal to escape through the rupture.

In accordance with the present invention, an apparatus is provided for adjustment of the amplitude of reciprocation during the operation of the machine. By adjusting the machine during operation, a more precise adjustment can be made.

This invention contemplates a continuous casting unit wherein molten metal is poured into the top of a mold and removed from the bottom of the mold as a billet and provision is made for adjusting the amplitude of the reciprocation of the mold by way of a rotatable cam, a follower mounted on a pivot and actuated by the cam, a member actuated by the follower and restrained to reciprocate in a straight line, and means for changing the position of the pivot relative to the follower whereby the length of travel of reciprocation of the mold is adjustable.

The above and further objects and novel features will appear more fully from the following detailed description of the invention when the same is read in connection with the accompanying drawings. It is expressly understood however that the drawings are not intended to be a definition of the invention but are for purpose of illustration only.

In the drawings wherein like parts are marked alike:

FIGURE 1 is a vertical cross-sectional view of the apparatus of the present invention taken on lines 1—1 of FIGURE 2;

FIGURE 2 is a vertical cross-sectional view taken on lines 2—2 of FIGURE 1;

FIGURE 3 is a horizontal cross-sectional view taken on lines 3—3 of FIGURE 2;

FIGURE 4 is a cross-sectional view taken on lines 4—4 of FIGURE 2; and

FIGURE 5 is a cross-sectional view taken on lines 5—5 of FIGURE 2.

Referring now to the drawings, an embodiment of the invention is shown as incorporating a conventional continuous casting mold. As is conventional, molten metal M (FIGURE 1) is poured into the upper end of the mold 10 which is illustrated as tubular in shape. The mold 10 is formed with an outer jacket 12 through which cooling water is circulated by suitable means.

The mold 10 is mounted in a conventional manner for vertical reciprocation. A yoke 13 is attached to lever

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14 which is pivotally mounted on a pivot 16. The yoke 13 is attached to mold 10 by a pair of pivot pins 18 (only one shown) attached on either side of the mold 10 and urging the mold upwardly, or retracting the mold to its starting position, are compression springs 20 disposed between the stationary table 22 and the mold 10.

Frictionally engaging the periphery of the solidified or partially solidified billet B of metal are driven pinch rollers 24 which grasp and withdraw the billet B from the mold 10. The rate at which the billet B is withdrawn may be controlled by suitable means (not shown) such as a variable speed motor operable to drive pinch rollers 24 at varying speeds. The rollers 24 and drive means therefor are conventional. The speed of withdrawal of the billet B may be varied over wide limits, and in order to provide sufficient time for the metal to solidify within the mold, the mold 10 is normally advanced at the same speed the billet B is being withdrawn by the pinch rollers 24. This advance movement which is carried out at substantially the same speed as the casting rate assures that there be no relative movement between the constantly downwardly moving billet B and the mold 10. In this manner the molten metal solidifies into an at least partially solidified billet capable of withstanding handling.

In accordance with this invention the amplitude of the reciprocation of the mold 10 is adjustable during the continuous casting operation to allow the molten metal to solidify at least partially during the advance movement. To this end a cam 26 of predetermined configuration is mounted for rotation on drive shaft 28. The drive shaft 28 rotates on bearings 29 and is operatively connected by a drive end 27 to a variable speed drive means (not shown) whereby the speed of the mold advance movement can be synchronized with the casting rate. Rotation of shaft 28 rotates the cam 26 and thus imparts a rise and fall motion to follower roll 30 which is rotatably mounted on shaft 31 in bushings 32 in follower arm 34. Follower arm 34 is reinforced with ribs 36 to impart adequate structural strength thereto.

As follower arm 34 reciprocates it causes roll 35 to reciprocate. Roll 35 is mounted on shaft 37 which is rotatably supported in bearings 39, which are mounted in cross-head 41. As follower arm 34 forces roll 35 upwardly, cross-head 41 slides vertically within guide means 45 which restrains the motion of cross-head 41 to a vertical reciprocatory movement. Guide means 45 is provided with cut out portions 49 (FIGURE 3) to reduce friction between the sliding parts 41, 45. The cross-head 41 is attached to connecting rod 51 by means of a cross-head pin 53 and bushing 55. Connecting rod 51 is pivotally attached to lever 14 by pivot 57. Thus, rotation of cam 26 raises and lowers follower roll 30 which raises and lowers arm 34 which in turn reciprocates roll 35 and cross-head 41. This reciprocates the connecting rod 51.

In accordance with this invention the length of travel of cross-head 41 can be adjusted at any time while the novel continuous casting unit is in operation. To effect this adjustment without stopping the mechanism, follower arm 34 is pivotally mounted on pivot pin 38 which in turn is mounted on segment 40 and held in place by keys 38a, 40a. Pivot pin 38 is mounted in bushing 27 in follower arm 34. Segment 40 is rotatably mounted on shaft 28. A worm gear wheel segment 42 is attached by suitable means such as bolts 43 to segment 40. The worm gear wheel 42 is provided with teeth 44 which are driven by threads 46 on worm 47. The worm 47 is rotatably mounted on shaft 48 and bearings 50, 52 and is driven either by suitable means (not shown) or manually. As worm 47 is turned, the threads 46 thereon drive teeth 44 on worm gear segment 42 which rotates segment 40

around shaft 23. The degree of rotation of segment 40 is limited by abutment means 54, 56 in conjunction with a stop 58. By turning the worm 47 segment 40 is rotated and follower arm 34, attached to segment 40 through pivot 38, is driven around the cam 26. As the follower arm 34 is moved around the cam 26, the amplitude of reciprocation of that portion of the follower arm 34 which is disposed vertically above the shaft 28 will be continuously varied from a maximum to zero.

When follower roll 30 is at a twelve o'clock position, the amplitude of reciprocation of mold 10 is a maximum. When follower roll 30 is rotated to a nine o'clock position, roll 30 will reciprocate in a horizontal path (pivot 38 will now be at a twelve o'clock position) and no vertical movement of mold 10 will take place, i.e., roll 35 will not be lifted and no vertical motion of connecting rod 51 will occur. By turning worm 47 (as by placing a crank on drive end 65) the position of pivot 38 of the follower arm can be adjusted during operation of the machine to place the follower roll 30 in any position between nine o'clock and twelve o'clock thereby enabling adjustment of the amplitude of reciprocation of roll 35, connecting rod 51, lever 14, and mold 10.

Advantageously, the mold reciprocation apparatus is housed within housing 59 which completely encloses the mechanism whereby the atmosphere within the housing is maintained dust-free. To assure this dust-free condition, an expansion joint 60 is attached to the connecting rod 51 at the point at which the connecting rod passes through the housing 59. The expansion joint is attached to the housing through coupling 61.

In operation of the novel continuous casting mechanism of this invention molten metal M is poured into the upper end of tubular mold 10. The cooling water circulating through the mold solidifies the molten metal M at least partially during its travel through the mold. A solid skin forms over a core and this is the billet B which is withdrawn from the mold by pinch rollers 24. The mold is advanced vertically downward in the illustration at the same speed as the billet B is being withdrawn by the pinch rollers 24 to insure that there be no relative movement between the downwardly moving billet B and the mold 10. As explained above, relative movement tends to rupture the skin and release molten metal from the core. The mold 10 is then retracted and this cycle is continuously repeated whereby the mold 10 is vertically reciprocated at a predetermined speed. The extent of movement of the mold is adjusted to provide sufficient time for the metal to solidify within the mold 10. Vertical reciprocation of the mold 10 is caused by yoke 13 pivoted to mold 10 at 18 and attached to a lever 14 which is reciprocated by connecting rod 51.

For this reciprocation, a cam 26 rotates on shaft 28 and by its contour forces roll 30 to rise and fall. Roll 30 correspondingly raises and lowers follower arm 34 about pivot 38 and this in turn lifts and lowers roll 35 causing cross-head 41 to slide vertically within guides 45 which restrain cross-head 41 to a vertical reciprocatory movement. Cross-head 41 vertically reciprocates connecting rod 51 thereby reciprocating lever 14, yoke 13 and mold 10.

Under some circumstances as, for example, when it is found that the molten metal is not solidifying sufficiently within the period of mold advance movement, it is necessary to extend the length of travel of the mold 10 to increase the distance of the mold advance movement.

To adjust the amplitude of reciprocation of mold 10 under circumstances requiring such adjustment, such as if the molten metal is not solidifying sufficiently within the period of mold advance movement, worm 47 is turned, thus rotating worm gear segment 42 and segment 40 about shaft 23. This rotates pivot 38 about shaft 28 and changes the position of follower roll 30 relative to cross-head roller 35. As the follower arm 34 is moved around the cam 26, the amplitude of reciprocation

of that portion of the follower arm 34 which is disposed vertically above the shaft 28 and which therefore imparts motion to cross-head 41 can be continuously varied from a maximum to zero or vice versa. As the amplitude of reciprocation of this portion of the follower arm is changed, the amplitude of reciprocation of the mold is also changed.

In this manner, the length of travel of the mold 10 may be varied to obtain the required time for solidifying the molten metal during the advance stroke. This adjustment of the length of travel may be made during operation of the machine. The adjustment of length of travel during operation is of significance since it is difficult to predetermine with any degree of accuracy the precise time required to form a shell. As the hot strength of the metal being cast varies, the degree of reciprocation will also vary. It is thus of extreme importance to be able to adjust the length of reciprocation of the mold 10 during operation of the machine.

We claim:

1. A continuous casting apparatus comprising an open ended mold adapted to receive molten metal and to discharge the metal as a partially solidified billet, pinch rollers adapted to withdraw the billet from the mold at a predetermined rate, a cam mounted for rotation, variable speed drive means for said cam, a follower roll mounted for rotation in a follower arm which is adapted to rise and fall as said cam rotates, a second roll operatively associated with said follower arm and mounted to reciprocate as said follower arm rises and falls, said second roll being rotatably mounted in a cross-head, guide means for restraining the motion of said cross-head to a vertical reciprocatory movement, a connecting rod connected to said cross-head and a lever connected to said connecting rod and said mold, and means for adjustment of the length of travel of said mold without stopping the mechanism, said means for adjustment comprising means mounted to rotate said follower arm around said cam, whereby as the follower arm is moved around the cam the amplitude of reciprocation of said second roll will be continuously varied from a maximum to zero thereby varying the amplitude of reciprocation of said cross-head, said connecting rod, and said mold.

2. A continuous casting apparatus comprising an open ended mold adapted to receive molten metal and to discharge the metal as a partially solidified billet, a cam mounted for rotation, a follower roll mounted for rotation in a follower arm which is adapted to rise and fall as said cam rotates, a second roll operatively associated with said follower arm and mounted to reciprocate as said follower arm rises and falls, said second roll being rotatably mounted in a cross-head, guide means for restraining the motion of said cross-head to a vertical reciprocatory movement, a connecting rod connected to said cross-head and a lever connected to said connecting rod and said mold, means for adjustment of the length of travel of said mold without stopping the mechanism, said means for adjustment comprising means mounted to move said follower arm around said cam, whereby as the follower arm is moved around the cam the amplitude of reciprocation of said second roll will be continuously varied from a maximum to zero thereby varying the amplitude of reciprocation of said cross-head, said connecting rod, and said mold.

3. A continuous casting apparatus comprising an open ended mold adapted to receive molten metal and to discharge the metal as a partially solidified billet, a cam mounted for rotation, a follower roll mounted for rotation in a follower arm which is adapted to rise and fall as said cam rotates, a second roll operatively associated with said follower arm and mounted to reciprocate as said follower arm rises and falls, said second roll being rotatably mounted in a cross-head, guide means for restraining the motion of said cross-head to a vertical reciprocatory movement, a connecting rod connected to said cross-head

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and a lever connected to said connecting rod and said mold, and means for adjustment of the length of travel of said mold without stopping the mechanism, said means for adjustment comprising a worm gear mounted to move said follower arm around said cam, whereby as the follower arm is moved around the cam the amplitude of reciprocation of said second roll will be continuously varied from a maximum to zero thereby varying the amplitude of reciprocation of said cross-head, said connecting rod, and said mold.

4. A continuous casting machine comprising:

- (a) a casting mold for receiving molten metal continuously from which a partially solidified cast strand of said metal emerges;
- (b) means for continuously withdrawing said strand;
- (c) a cam journally mounted for rotation about an axis;
- (d) means for rotating said cam;
- (e) an arm pivotally mounted adjacent said cam;
- (f) a gear segment mounted to said arm and oscillatable about said axis;
- (g) a worm gear engaging said gear segment for oscillating said gear segment and moving the pivot of said arm relative to said cam;
- (h) a cam follower journalled to said arm and engaging said cam;
- (i) a crosshead mounted for movement in a plane substantially perpendicular to said axis;
- (j) resilient bias means engaging said mold urging the same in a first direction;
- (k) means connecting said crosshead to said mold for moving said mold in a second direction opposite to said first direction and against said resilient bias means;
- (l) means connecting said crosshead to said arm whereby said mold moves responsively in said second direction against said resilient bias means when said cam

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moves said crosshead in said first direction and said resilient bias means urges said cam follower means into engagement with said cam; and

(m) means to actuate said worm to move said gear segment and vary the location of said pivot and vary the amplitude of motion of said mold.

5. A continuous casting machine comprising:

- (a) a casting mold for receiving a stream of molten metal and discharging continuously a partially solidified strand of metal;
- (b) a rotatable drive means;
- (c) a cam driven by said drive means;
- (d) a follower actuatably engaging said cam;
- (e) an arm supporting said follower;
- (f) an adjustable pivot for said arm;
- (g) a crosshead adapted for reciprocation in a vertical plane;
- (h) linkage connecting said crosshead to said mold for reciprocating the same;
- (i) first operative means connecting said arm and said crosshead; and
- (j) second operative means for adjusting the position of said pivot relative to said crosshead whereby the amplitude of reciprocation of said crosshead and said mold is variable between maximum and minimum values.

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