Feb. 10, 1970 R. F. REIHMAN 3,494,411

CONTINUOUS CASTING METHOD

Original Filed Oct. 6, 1965 3 Sheets-Sheet 1

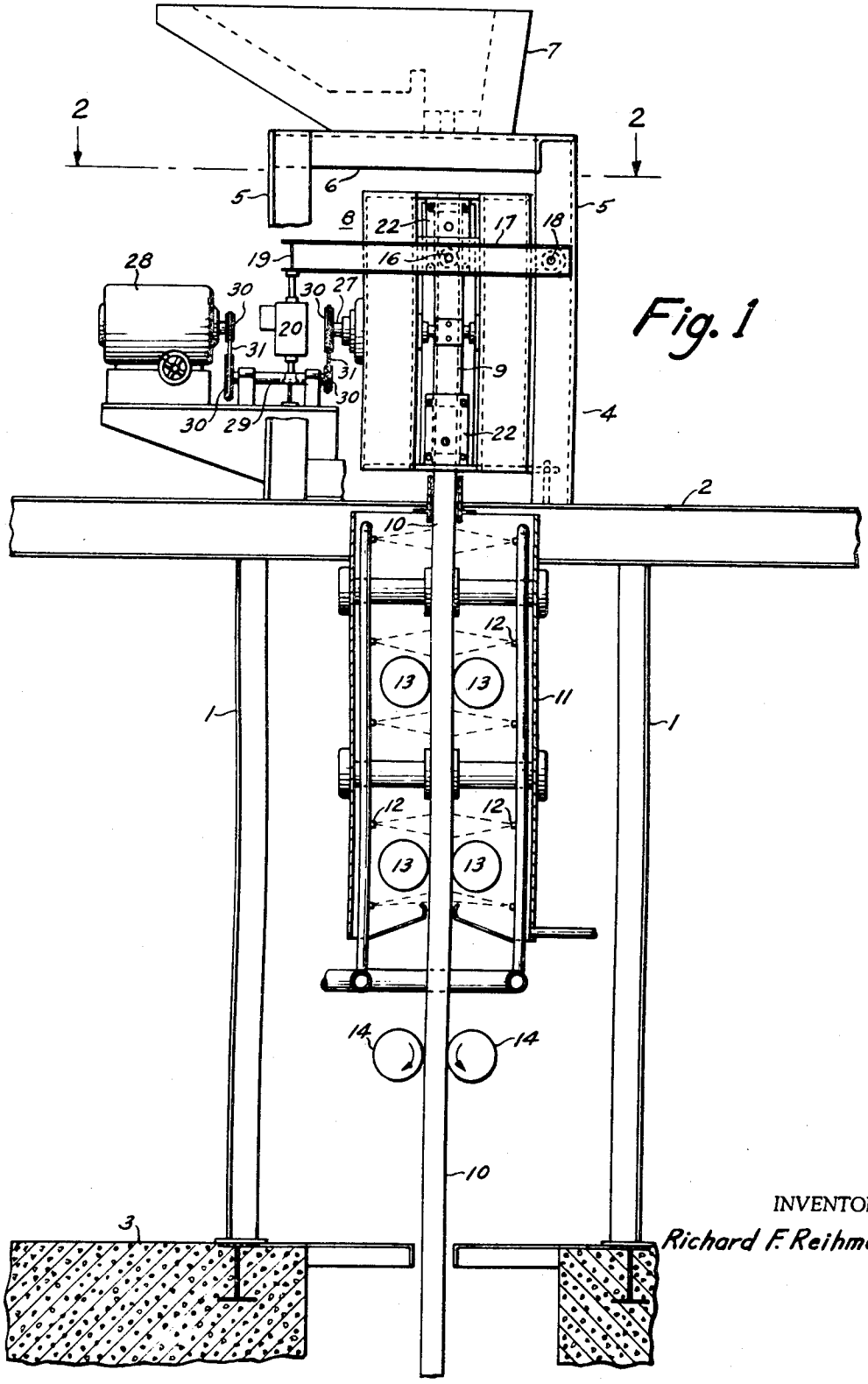


Fig. 1

INVENTOR

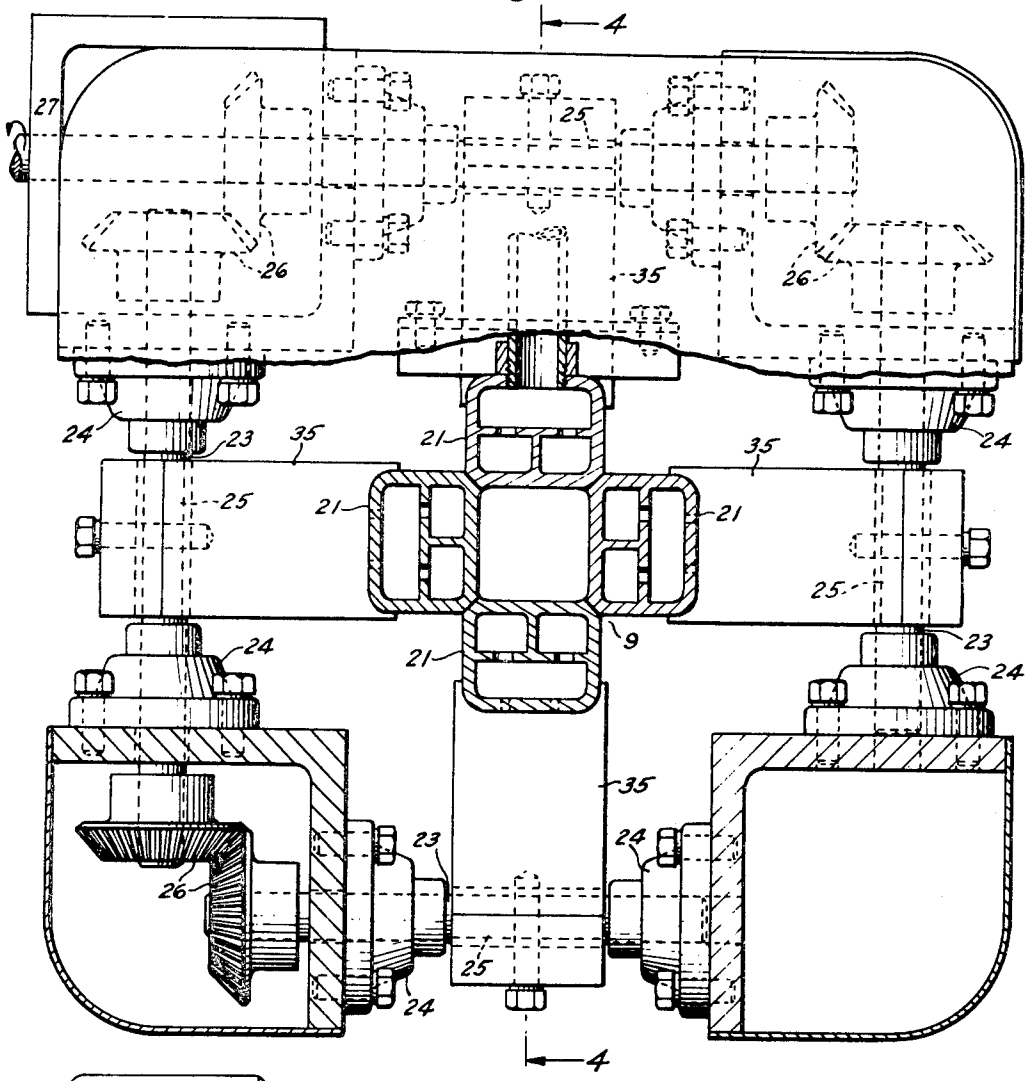
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CONTINUOUS CASTING METHOD

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Fig. 3



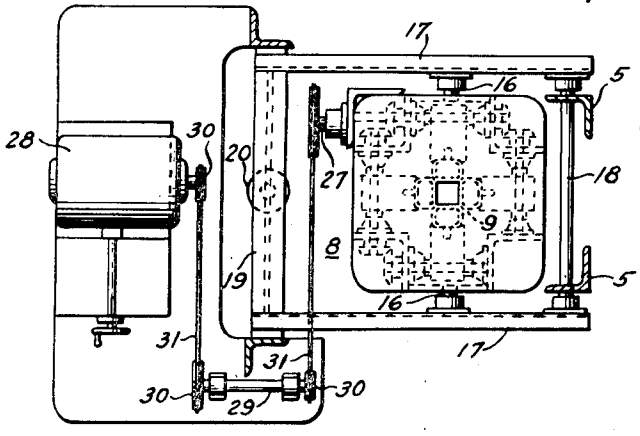


Fig. 2

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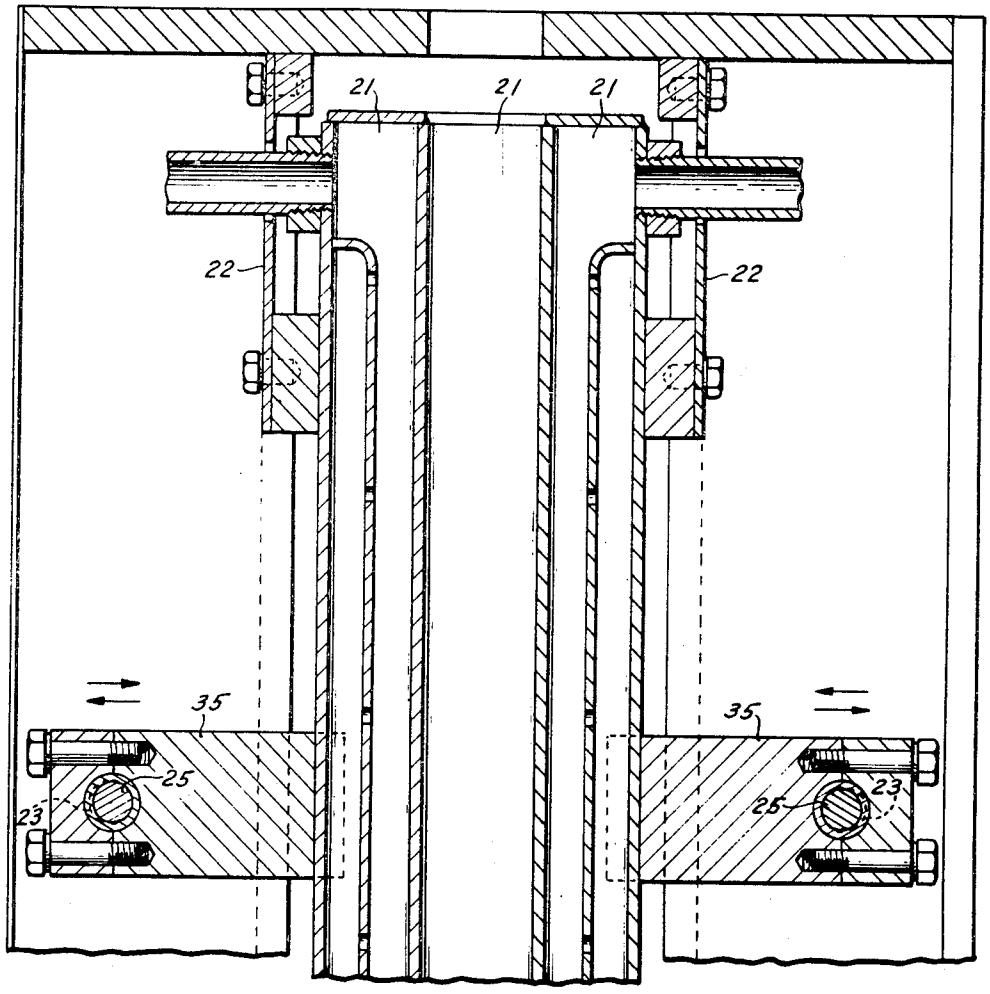
Richard F. Reihman

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Fig. 4



INVENTOR

Richard F. Reihman

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3,494,411

CONTINUOUS CASTING METHOD

Richard F. Reihman, Quakertown, Pa., assignor to Bethlehem Steel Corporation, a corporation of Delaware

Original application Oct. 6, 1965, Ser. No. 493,373, now Patent No. 3,421,572, dated Jan 14, 1969. Divided and this application Sept. 30, 1968, Ser. No. 763,714
Int. Cl. B22d 11/06
U.S. Cl. 164—83 6 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus and method for applying compressive and shear forces to the surfaces of a continuous casting in an open-ended continuous casting mold. Selected portions of the mold are reciprocated toward and away from each other in a transverse direction at a predetermined cyclic rate while the entire mold is reciprocated independently and at a different cyclic rate in a longitudinal direction.

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a division of application Ser. No. 493,373, filed Oct. 6, 1965 now United States Letters Patent No. 3,421,572, issued Jan. 14, 1969.

BACKGROUND OF THE INVENTION

This invention relates to the continuous casting of metals and metal alloys and more particularly to an improved mold assembly and an improved method of moving a mold assembly in continuous casting apparatus.

Heretofore, many different types of apparatus and methods have been tried in order to cast molten metals and alloys in a single elongated casting rather than in a number of individual castings or ingots. At first, various forms of an open-ended stationary mold were tried. The major difficulty with such a mold was that the solidified metal casting tended to stick to the walls of the mold making the withdrawal of the casting from the mold difficult. This practice was also very slow and usually resulted in castings of poor surface quality. It was then suggested to reciprocate an open-ended mold in a direction parallel to the longitudinal axis of the casting, such as shown by U.S. Patent No. 1,385,595 to Van Ranst. This practice not only reduced the friction between the mold walls and the casting but also permitted casting at a somewhat faster rate with improved surface quality.

It has also been suggested to use a vertically split open-ended mold in which the mold sections are vibrated at right angles to the longitudinal axis of the casting or oscillate about fixed points while keeping the mold stationary in a vertical direction. Generally, this practice was only suitable for casting at relatively slow rates.

SUMMARY OF THE INVENTION

It is therefore an object of my invention to provide continuous casting apparatus and a method of operating continuous casting apparatus which will enable one to cast molten metal and metal alloys at a relatively high rate of speed.

It is a further object of my invention to provide continuous casting apparatus and a method of using continuous casting apparatus which will produce metal castings having superior surface quality.

It is a still further object of my invention to provide an open-ended mold assembly for the continuous casting of metals and metal alloys which greatly reduces any tendency of the solidified metal casting to stick to the walls of the mold during the casting operation.

I have discovered the foregoing objects can be attained by using a longitudinally split open-ended water-cooled mold which is reciprocated in a longitudinal direction while opposed sections of the mold are reciprocated toward and away from each other in a transverse direction simultaneously with but independent of the reciprocation of the mold in the longitudinal direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings which illustrate an embodiment of my invention.

FIGURE 1 is a side elevation, partly in section, of continuous casting apparatus embodying my invention.

FIGURE 2 is a sectional view taken along line 2—2 of FIGURE 1.

FIGURE 3 is a top view, partly in section, of the mold assembly.

FIGURE 4 is a sectional view of the mold assembly taken along line 4—4 of FIGURE 3.

DETAILED DESCRIPTION

As shown in FIGURE 1, vertical structural columns **1** support a horizontal working platform **2** above the level of the shop floor **3**. Rigidly attached to the working platform **2** is a rectangular structural frame **4** comprised of vertical structural columns **5** and horizontal girders **6**. Structural frame **4** supports a tundish **7**, a mold housing **8** and the various drive means required to reciprocate the mold housing **8** and the mold **9**.

Molten metal from a ladle or holding furnace (not shown) is poured into tundish **7** from which the molten metal is then introduced into the top of an elongated cavity of an open-ended, water-cooled, mold **9**, where the molten metal is cooled until an elongated metal casting **10** having a solid exterior and a molten interior is formed. The partially solidified casting **10** is withdrawn from the bottom of the mold cavity and is guided into a cooling chamber **11** where high pressure jets of water **12** spray the surface of the casting **10**, cooling it further. Opposed pairs of guide rolls **13** contact the sides of the casting and guide the casting through the cooling chamber **11**. Immediately below the cooling chamber **11** is one or more pairs of driven pinch rolls **14** which control the speed of withdrawal of the casting. The casting **10** is then either deflected to a horizontal direction or, as shown in FIGURE 1, descends vertically to the shop floor **3** where it is cut off into suitable lengths by cutting torches or the like (not shown).

As best illustrated in FIGURES 1 and 2, the mold housing **8** is suspended within the rectangular structural frame **4** by trunnions **16**. The trunnions are attached to a pair of parallel arms **17** journaled at one end to the end of a shaft **18** attached to columns **5** of structural frame **4**. The other ends of arms **17** are joined by a cross-member **19**. The arms **17** are thereby free to pivot about shaft **18** in parallel vertical planes. Directly under the midpoint of cross member **19** are a hydraulic piston and cylinder **20** connected to a hydraulic pump and valve arrangement, not shown. It will be evident that raising and lowering of the piston in hydraulic cylinder **20** will cause arms **17** to pivot about shaft **18** and in turn reciprocate mold housing **8** in a longitudinal direction parallel to the longitudinal axis of the casting **10**. This results in a shearing force parallel to the longitudinal axis of the casting being applied to the surface of the casting **10**.

As shown in FIGURES 3 and 4, the mold **9** is set within the mold housing **8** and has its side walls split longitudinally along lines parallel to the longitudinal axis of the casting into pairs of opposed wall sections **21**. Sections **21** are hollow and water-cooled and preferably made of copper. While I have illustrated the mold **9** in FIGURE 3 as comprised of four wall sections of equal size for casting a square billet, it is apparent that the mold **9** may be

comprised of any even number of sections of any required dimension.

Each mold section **21** is attached to the mold housing **8** by flexible support members **22** attached both to the top and bottom of the rear faces of wall sections **21** as shown in FIGURE 4.

Also set within the mold housing **8** but surrounding the mold **9** is mechanical means for reciprocating a pair or pairs of opposed wall sections **21** toward and away from each other in a transverse direction simultaneously with but independent of the reciprocation of the mold **9** and mold housing **8** in the longitudinal direction.

This mechanical means includes for each wall section of the pair, a drive shaft **23** journaled on the mold housing **8** by suitable bearings **24**, an eccentric **25** mounted on each of the drive shafts **23** and a connecting rod **35** connecting the eccentric **25** to the rear face of the respective wall section **21** approximately midway between the top and bottom flexible support members **22**. As seen best in FIGURE 3 the drive shafts **23** all lie in a common plane which is perpendicular to the longitudinal axis of casting **10**. Drive shafts **23** are joined to one another by bevel gears **26** positioned at the corners of mold housing **8** and are driven at the same speed by shaft **27** driven by electric motor **28** through a jackshaft **29**, sheaves **30** and flexible belts **31**. Enough slack is maintained in the flexible belts **31** to permit the longitudinal reciprocation of the mold housing **8**.

The eccentrics **25** convert the rotary motion of drive shafts **23** into a rectilinear motion in a direction transverse to the longitudinal axis of the casting. This motion is imparted to the wall sections **21** which results in a progressively increasing and then decreasing compressive force being applied to the casting perpendicular to the longitudinal axis of the casting. Eccentrics **25** can be designed with a suitable dwell time so that the compressive force is held at a maximum for a predetermined period of time against the surface of the casting before the force begins to decrease.

With the arrangement of wall sections **21** as shown in FIGURE 3, I prefer to so position the eccentrics on drive shafts **23** so that as one pair of opposed walls sections **21** are moving towards each other and against the casting in the transverse direction, the other pair of opposed wall sections **21** are moving away from each other and the casting also in the transverse direction. For casting large rectangular slabs, it may be preferable for the wall sections **21** defining the narrow ends of the slab to move not at all. This may be done by replacing the respective eccentrics with circular bushings or by removing the respective connecting rods **35**.

As a result of the apparatus and methods of my invention, it is possible to continuously cast metal castings of superior surface quality at rates higher than has heretofore been possible.

As an example of my invention I have designed apparatus for casting a 2" x 2" square billet in which the mold is reciprocated in the longitudinal direction at a cyclic rate of less than 300 cycles per minute with the upstroke being at a speed at least twice as fast as the downstroke. The length of the longitudinal stroke is between ¾" and 1½". The opposed wall sections are reciprocated toward and away from each other in the transverse direction at a cyclic rate of 300–1700 cycles per minute and preferably at a cyclic rate approximately twice that of the longitudinal reciprocation. The length of the stroke in the transverse direction is 0.020 inch.

As many possible embodiments may be made of my invention without departing from the scope thereof, it is to be understood that all matter set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A method of producing an elongated metal casting comprising:

(a) introducing molten metal into an elongated cavity in an open-ended water-cooled mold,

(b) cooling the molten metal within said cavity until an elongated metal casting having a solid exterior and a molten interior has been formed,

(c) reciprocating said mold in a longitudinal direction substantially parallel to the longitudinal axis of said casting,

(d) moving opposed sections of said mold toward and away from each other against said casting in a transverse direction simultaneously with but independent of the reciprocation of said mold in the longitudinal direction,

(e) withdrawing said elongated metal casting from the bottom of said mold, and

(f) cooling said casting until the interior thereof is completely solid.

2. A method of producing an elongated metal casting comprising:

(a) introducing molten metal into an elongated cavity in an open-ended water-cooled mold,

(b) cooling the molten metal within said cavity until an elongated metal casting having a solid exterior and a molten interior has been formed,

(c) reciprocating said mold in a longitudinal direction substantially parallel to the longitudinal axis of said casting,

(d) moving one pair of opposed sections of said mold toward each other against said casting while moving a second pair of opposed sections of said mold away from each other and said casting, said movements occurring in a transverse direction simultaneously with but independent of the reciprocation of said mold in the longitudinal direction.

3. The method of claim **2** wherein the reciprocation in the longitudinal direction is at a different cyclic rate than the reciprocation of the mold sections in the transverse direction.

4. A method of producing an elongated metal casting comprising:

(a) introducing molten metal into an elongated cavity in an open-ended water-cooled mold,

(b) cooling the molten metal within said cavity until an elongated metal casting having a solid exterior and a molten interior has been formed,

(c) applying a shearing force parallel to the longitudinal axis of said casting to the surface of said casting,

(d) simultaneously but independently applying a progressively increasing and then decreasing compressive force perpendicular to the longitudinal axis of said casting to opposed surfaces of that portion of said casting contained within said mold,

(e) withdrawing said elongated metal casting from the bottom of said mold, and

(f) cooling said casting until the interior thereof is solid.

5. The method of claim **4** wherein the compressive force is held at a maximum for a predetermined length of time before decreasing said force.

6. The method of claim **4** wherein the shearing force is applied first in one direction and then in the opposite direction.

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J. SPENCER OVERHOLSER, Primary Examiner

R. S. ANNEAR, Assistant Examiner