Sept. 15, 1970 H. FASTERT 3,528,482

CONTINUOUS CASTING MACHINE

Filed Dec. 20, 1967 2 Sheets-Sheet 1

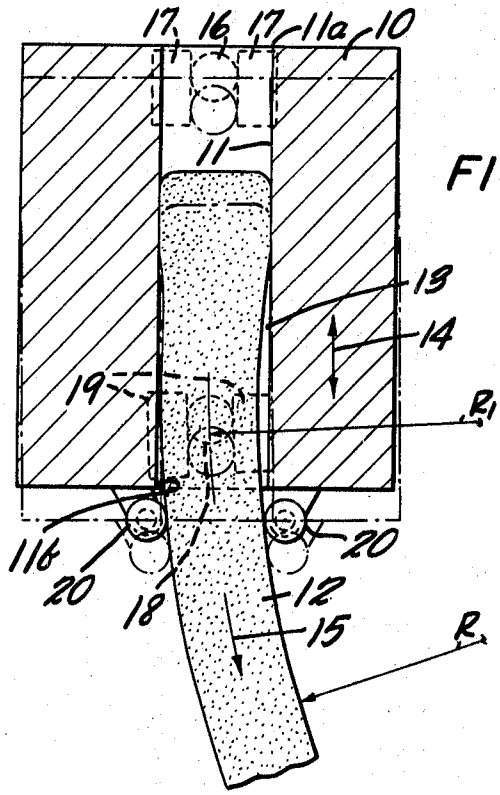


FIG. 1

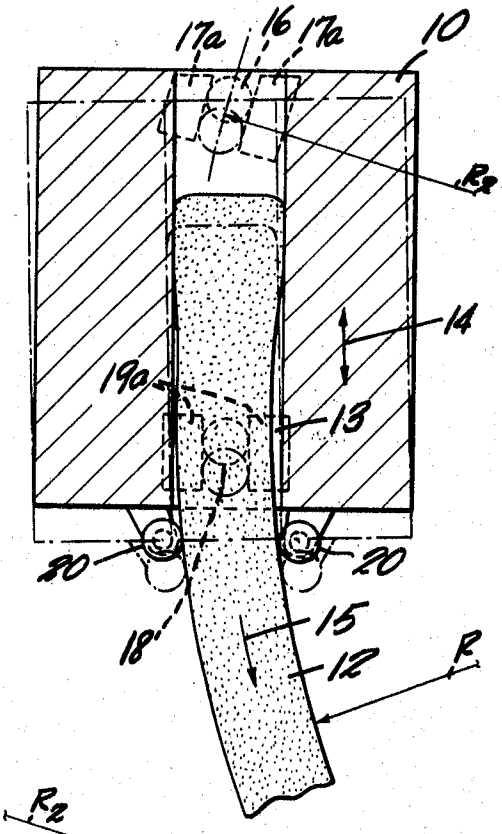


FIG. 2

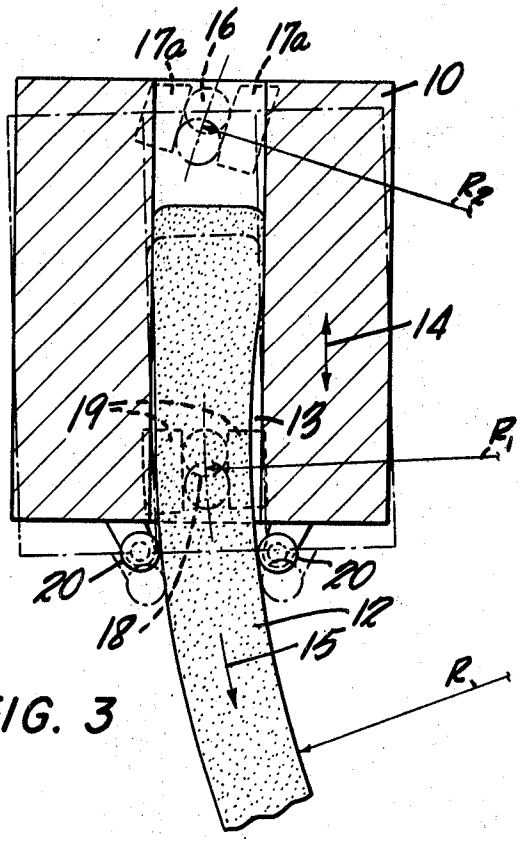
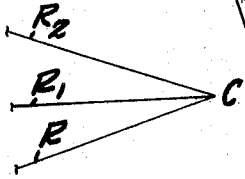


FIG. 3



INVENTOR.
HERBERT FASTERT

BY Sandoe, Hill, Schlatter & Wharton

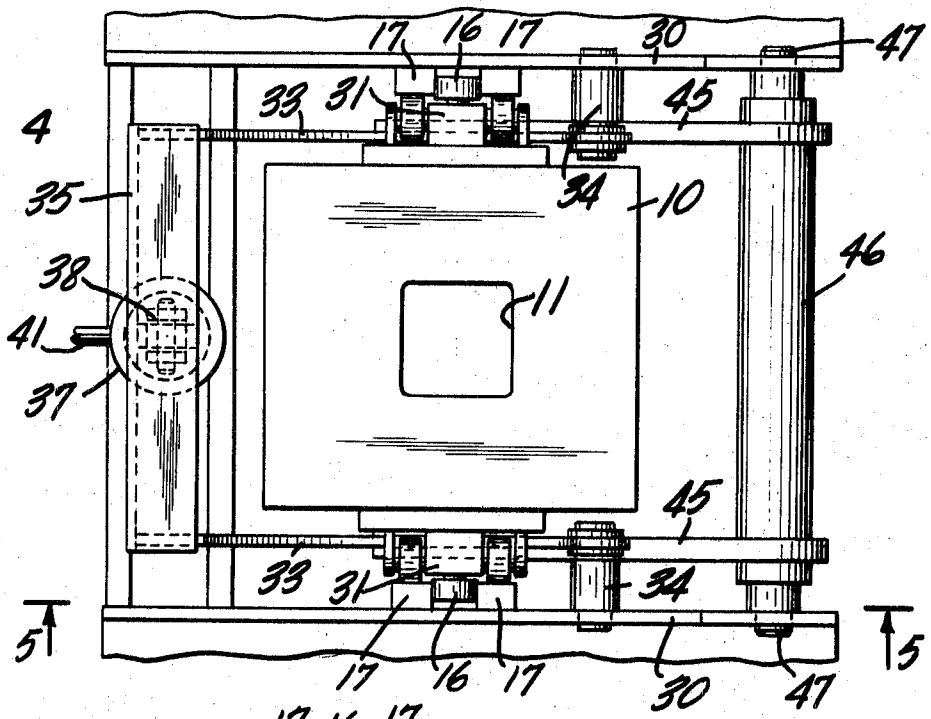
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FIG. 4



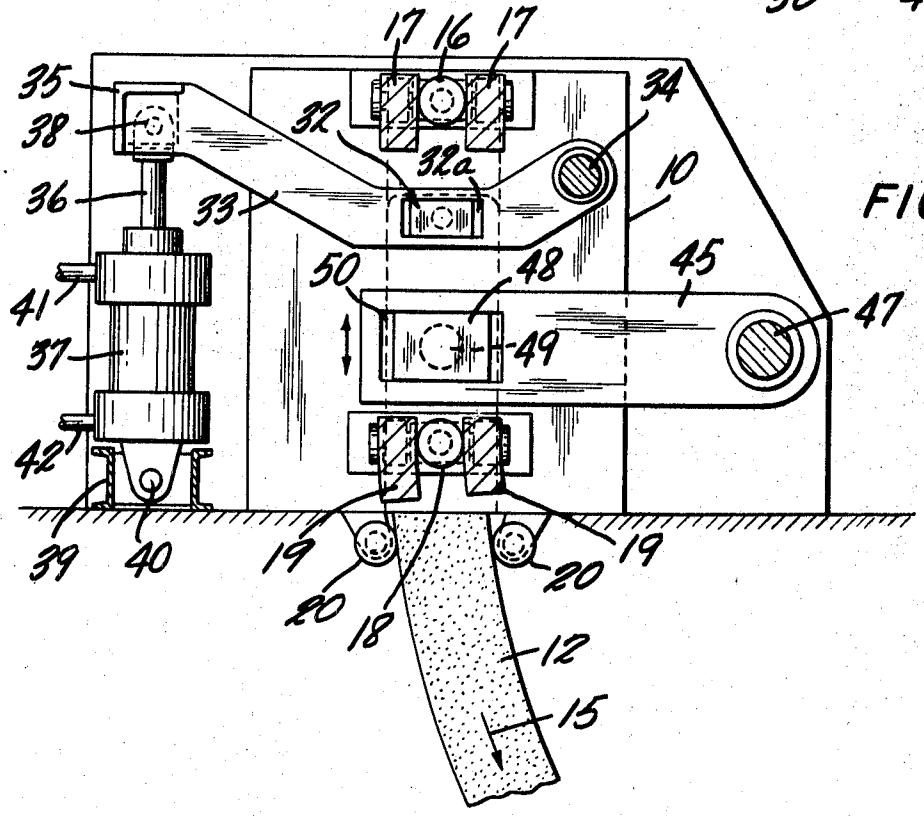


FIG. 5

INVENTOR.
HERBERT FASTERT

BY Hamburg, Niell, Schlatter & Wilkinson

ATTORNEYS

United States Patent Office 3,528,482 Patented Sept. 15, 1970

3,528,482

CONTINUOUS CASTING MACHINE

Herbert Fastert, Wyckoff, N.J., assignor to Concast Incorporated, New York, N.Y.

Filed Dec. 20, 1967, Ser. No. 692,090
Int. Cl. B22d 27/08, 11/00
U.S. Cl. 164—260 3 Claims

ABSTRACT OF THE DISCLOSURE

In a continuous-casting machine wherein the strand of cast metal is conducted from the mold along a curved path, an open-ended mold having a straight mold cavity is oscillated for the mold cavity to move in a direction generally tangent to the curved path of the strand, with at least one end portion of the mold moving in a curved path having substantially the same radius and center as the path of the strand.

The present invention relates to machines for the continuous casting of metal—especially steel—and particularly to the structure and operation of molds for continuous casting.

In the continuous casting of metal, molten metal is poured in one end of an open-ended mold that is continuously cooled to solidify the periphery of metal in the mold to form a strand of metal having a solidified shell. The strand is withdrawn from the other end and is thereafter further cooled and worked and/or cut into lengths. As the strand moves out of the mold, more molten metal is poured in to maintain an operative level of metal in the mold for continuous strand formation.

In a usual continuous-casting machine the mold is arranged vertically with the strand issuing from the bottom. In the early stages of the development of continuous casting the machines and the space in which they were operated had to be quite high because the strand moved down from the mold in a vertical path, through secondary cooling devices, such as water sprays, to a point at which it was cut into suitable lengths for further shaping or finishing operations.

Vertical factory space and the apparatus for performing mechanical operations in a vertical sequence are, however, much more expensive and inconvenient than horizontal space and mechanical operations in a horizontal plane. Consequently casting methods were developed wherein the strand emerging from the mold is conducted along a curved path to bend it to a horizontal path, and thereby reduce the height, and thus the expense, of the space and apparatus required.

A further reduction of height and overall length of casting machines has been achieved by making the mold cavity curved so that the strand emerges from the mold in curved condition conforming to the curved path. Molds with curved cavities, however, have not been completely satisfactory. Mold cavities are customarily provided with liners of copper because of its good heat conducting properties. The curved copper mold liners have higher fabricating and maintenance costs than straight copper liners for straight mold cavities. In addition, proper aligning of a mold with a curved cavity is more difficult than properly aligning a mold with a straight cavity. However, the strand which emerges in straight condition from a straight mold cavity must then be bent into the curved path and this bending operation requires additional vertical space as compared with the vertical space requirement for machines having curved mold cavities. Thus, in known casting machines the benefits of conducting the strand along a curved path from the mold warrant the continued use of curved paths, but these benefits

have been diminished by the above described problems with the molds.

In addition to efforts to reduce the vertical space required for continuous casting there has been a continuing effort to increase the casting speed. To date the most notable increase has been achieved by oscillating the mold along a short path in the casting direction. For casting steel a usual amount of oscillation of the mold is about 1/16 to 2 inches, for example. In known constructions, molds having curved mold cavities are oscillated in an arc corresponding to the curvature of the path along which the strand is conducted from the mold. If, however, a mold having a straight cavity is used—to avoid the above-mentioned difficulty with curved mold passages—the strand must be conducted from the mold in a straight vertical line for a sufficient distance to avoid rubbing of the lower edge of the mold against the portion of the casting at the inside of its arcuate path. But this involves increasing the vertical space required. In addition, tests have shown that at higher casting speeds a strand cast in a straight mold cavity and then bent to follow a curved path from the mold tends to develop internal defects and cracks. Therefore, on balance, the use of oscillating molds with curved cavities has, up to the present, been considered the most satisfactory arrangement for reducing the height of the apparatus and for increasing the rate of casting, despite the problems with curved mold liners, described above.

The present invention provides oscillating mold apparatus which eliminates the above problems in a continuous-casting machine in which the strand is conducted from the mold along a curved path.

In accordance with the invention, the mold for a continuous-casting machine has a straight mold cavity and the mold is oscillated in a manner such that the mold cavity oscillates in a path generally tangent to the curved path of the strand with at least one end portion of the mold moving in a curved path having substantially the same center and radius as the curved path of the strand. In one embodiment, the upper end of the mold, into which the molten metal is poured, oscillates in a straight line and only the bottom end, from which the strand issues, travels in a curved path. In another embodiment, both ends of the mold move along the curved path. In a third embodiment, the upper end travels a curved path while the bottom end moves in a straight line.

As in conventional casting machines, the mold in accordance with the present invention is quite short, being suitably between about 4 and 32 inches long. Also the length of the path along which the mold oscillates is quite short as in conventional machines.

Further objects, advantages and features of this invention will be apparent in the following description of illustrative embodiments depicted in the accompanying drawings wherein:

FIG. 1 is a view of a vertical cross section through one form of mold structure embodying the present invention and showing a metal strand being formed in the mold cavity and emerging from the bottom end thereof;

FIG. 2 is a view similar to the view of FIG. 1 illustrating another form of mold structure in accordance with the invention;

FIG. 3 is another view similar to the view of FIG. 1 illustrating a third embodiment of the invention;

FIG. 4 is a top plan view showing suitable means for oscillating a mold in accordance with the invention; and

FIG. 5 is a view along the lines 5—5 of FIG. 4.

Referring to the drawings, the mold **10**, as in conventional continuous-casting machines, has an open-ended mold cavity **11** therethrough and is cooled by usual means (not shown), such as by circulating water through pas-

sages in the body of the mold. Molten metal is poured in the top end **11***a* of the mold cavity and the cool mold surfaces solidify the periphery of the metal to form a strand **12**. As the metal in the cavity solidifies to form the strand, it shrinks away from the cavity wall as illustrated at **13**. The strand **12** then emerges from the bottom end **11***b* of the cavity and is conducted away from the mold along a curved path as illustrated by the strand **12** in the drawings. Guide rollers **20** are shown mounted on the bottom end of the mold respectively at opposite edges of the end **11***b* of the mold cavity for guiding the strand out the end of the cavity without being scraped by the edges of the cavity as the mold oscillates. A curved path for the emerging strand is customarily defined by suitable support means (not shown), such as a plurality of rollers arranged along the desired path in a manner known in the art.

In the drawings the radius of the curved path of the strand **12**, which it follows from the bottom of the mold, is indicated by radial line R, the center of curvature being indicated by the point C shown in FIG. 3.

In accordance with the present invention the mold cavity **11** is straight and the mold is oscillated so that the cavity **11** travels a path generally tangent to the radius of the curved path of the strand **12**. The relative paths of movement of the mold and strand are indicated respectively by arrows **14** and **15** in FIGS. 1, 2 and 3; the distance the mold oscillates is quite short—about ½ inch, for example—and the approximate limits of its oscillatory path are indicated respectively by the full and dash line positions of the mold **10**.

Referring to FIG. 1, as the mold thus moves in the general directions indicated by the arrow **14**, the mold is guided by cam rollers **16** riding between spaced ribs **17** at opposite sides of the top end of the mold and by cam rollers **18** riding between spaced ribs **19** at opposite sides of the bottom end of the mold so that at least one end portion of the mold cavity **11** moves along a curved path having substantially the same radius and center as the curved path of the strand **12**.

In the structure illustrated in FIG. 1, the ribs **17**, which define the paths of movement of cam rollers **16** at the upper end of the mold, are straight and arranged to guide the rollers **16** in straight paths that are tangent to the curved path followed by the portion of the strand **12** emerging from the bottom of the mold. The ribs **19**, which define the paths of movement of the cam rollers **18** at opposite sides of the lower end of the mold, are slightly curved and arranged to guide rollers **18** in curved paths which have the same radius, R1, and center C as the curved path of the strand **12**. Thus, as the mold **10** oscillates up and down, the points on the upper portion of the mold defined by the rollers **16** move in a straight line while the points on the lower portion defined by the rollers **18** follow an arcuate path, the rollers **16** and **18** providing pivot points around which the opposite end portions of the mold pivot to permit these movements. Oscillating and guiding the mold in this manner imparts a rocking motion to the mold cavity **11** that has the effect of shaping the portion being formed in the mold into a curve conforming approximately to the curvature of the path which the strand follows as it is conducted away from the bottom of the mold.

Similar rocking motion may be provided by an alternative arrangement illustrated in FIG. 2 in which ribs **17***a* engaging the cam rollers **16** at the top portion of the mold are slightly curved and aligned to guide the rollers **16** in curved paths which have the same radius, R2, and center C as the curved path of the strand. In this embodiment, as shown, the ribs **19***a* guiding the cam rollers **18** at the bottom portion of the mold may be straight and aligned to guide the rollers **18** in straight paths tangent to the curved path of the strand. Alternatively, as illustrated by the embodiment shown in FIG. 3, ribs **17***a* for the upper cam rollers **16** and ribs **19** for the lower cam rollers **18** may be curved and aligned to guide both sets of rollers, **16** and **18**, in arcuate paths having the same radii (R2 and R1, respectively) and center C as the curved path of the strand. Thus, in the arrangement shown in FIG. 3, the ribs **17***a* are the same, and in the same alignment, as the ribs **17***a* in FIG. 2, and the ribs **19** are the same, and in the same alignment, as the ribs **19** in FIG. 1; the difference between the respective embodiments are that in the first two (FIGS. 1 and 2) only one end portion of the mold moves in a curved path, while in the third (FIG. 3), both end portions do. But, in each of these three embodiments, the relative movements of the opposite end portions of the mold impart a rocking motion to the cavity **11** which produces the desired shaping effect described above.

FIGS. 4 and 5 show suitable operating means for oscillating a mold **10** having the structure and arrangement described with reference to FIG. 1. The mold **10** is received between parallel frame members **30** with the rollers **16** and **18**, which are rotatively mounted on the outward ends of bosses **31** on opposite sides of the mold at the top and bottom portions thereof, extending respectively into tracks defined by the pairs of ribs **17** and **19** on the opposed inner walls of the frame members **30**, respectively at their top and bottom portions. As previously described with reference to FIG. 1, the ribs **17** are straight and ribs **19** are curved to guide the rollers **16** in a straight path and the rollers **18** in a curved path. To adapt the mechanism of FIGS. 4 and 5 to operate the alternative mold arrangement illustrated in FIG. 2, the curved ribs **17***a* and straight ribs **19***a* of the latter figure would be substituted for the ribs **17** and **19**; for the mold arrangement illustrated in FIG. 3, curved ribs **17***a* of FIG. 3 would be substituted for the straight ribs **17**.

The mold **10** is supported between the frame members **30** and oscillated by means of sliding blocks **32** pivotally attached respectively to the opposite sides of the mold with each sliding block **32** carried in an opening **32***a* in one of a pair of lever arms **33** which are arranged respectively at opposite sides of the mold. One end of each lever arm **33** is pivotally supported on one of the frame members **30** by a stand-off pivotal mounting indicated at **34**; the other ends of the lever arms are attached respectively to opposite ends of a crossbar **35** that is across the upper end of a piston rod **36** of a conventional reciprocating piston motor **37** in which a piston (not shown) connected to the piston rod **36** is reciprocated in a cylinder by air, or other fluid, fed in alternatively through inlet pipes **41** and **42** and exhausted in sequence through alternate exhaust valves (not shown). The upper end of the piston rod **36** is pivotally connected to the crossbar **35** at **38**, and the bottom end of the cylinder **37** is pivotally connected to a frame element **39** as indicated at **40** to permit relative pivotal movement of the connected parts. When the piston rod **36** is moved up and down by the motor **37** it raises and lowers the lever arms **33** around their pivot points **34** so that the mold **10** is oscillated up and down by the action of the lever arms **33** on the sliding blocks **32** which are mounted on the mold. As the mold moves up and down, arcuate movement of one or the other or both end portions of the mold **10** is caused respectively by the curved ribs **19** in FIG. 1, the curved ribs **17***a* in FIG. 2, and the curved ribs **17***a* and **19** in FIG. 3. The up and down movement is stabilized by another pair of arms **45**. At one end the arms **45** are each attached respectively on end portions of a crossbar **46** which is pivotally supported between the frame members **30** as indicated at **47**; the other end of each arm **45** is pivotally and slidably connected to the side of the mold **10** by a slide block **48** that is slidably carried in an opening **50** in the arm and pivotally attached to the side of the mold as indicated at **49**.

It is to be understood that the embodiments of the invention shown in the drawings and described in detail

above are illustrative only and that some modifications and variations may be made in the structure and mode of operation thereof without departing from the scope of the invention defined by the following claims.

What is claimed is:

1. In a continuous-casting machine comprising a cooled mold having an open-end mold cavity for receiving molten metal in the top end and solidifying the periphery of metal in the mold to form a strand which is withdrawn from the bottom end and conducted therefrom along a curved path, the improvement comprising a mold having a straight cavity, and means for oscillating the mold for moving the mold cavity in a path generally tangent to said curved path, said means including a pair of pivot means on the mold between the mid portion of the length of the mold and the top and bottom ends respectively, means for guiding one of said pivot means in a straight path, and means for guiding the other in a curved path having substantially the same radius and center as the said curved path of the strand.

2. The machine of claim 1 in which the pivot means at the upper portion of the mold is guided in said straight path.

3. The machine of claim 1 in which the pivot means at the lower portion of the mold is guided in said straight path.

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J. SPENCER OVERHOLSER, Primary Examiner

R. S. ANNEAR, Assistant Examiner

U.S. Cl. X.R.

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