Nov. 5, 1968 J. J. CIOCHETTO 3,409,070

CONTINUOUS CASTING APPARATUS

Filed Aug. 5, 1966 3 Sheets-Sheet 1

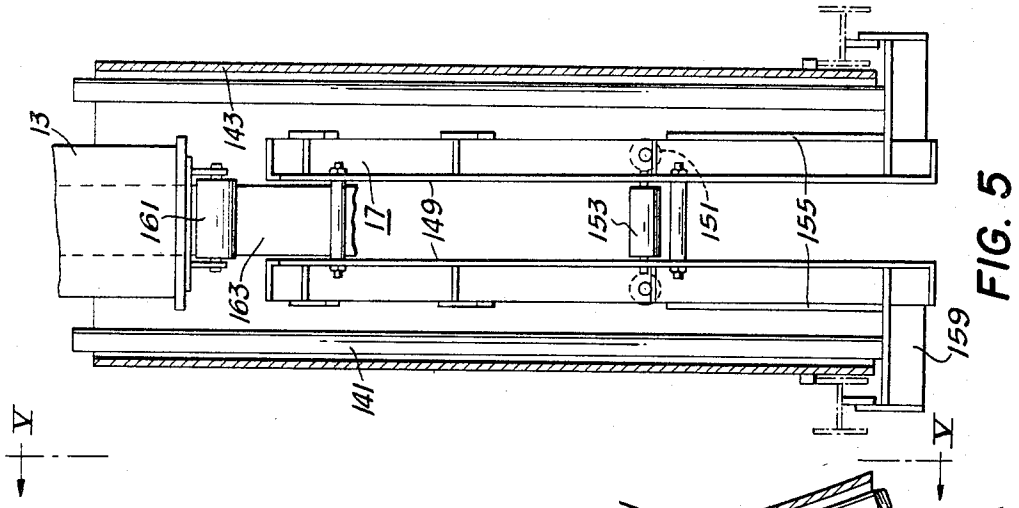


FIG. 5

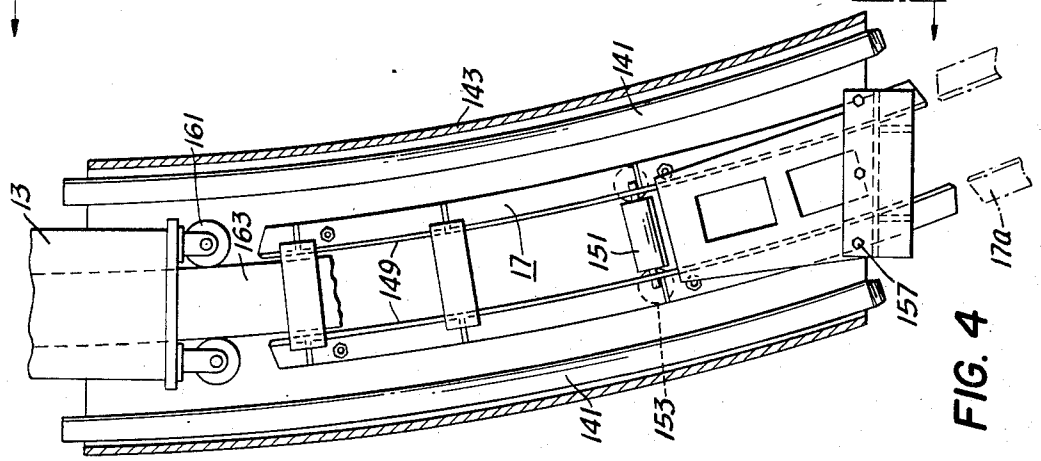


FIG. 4

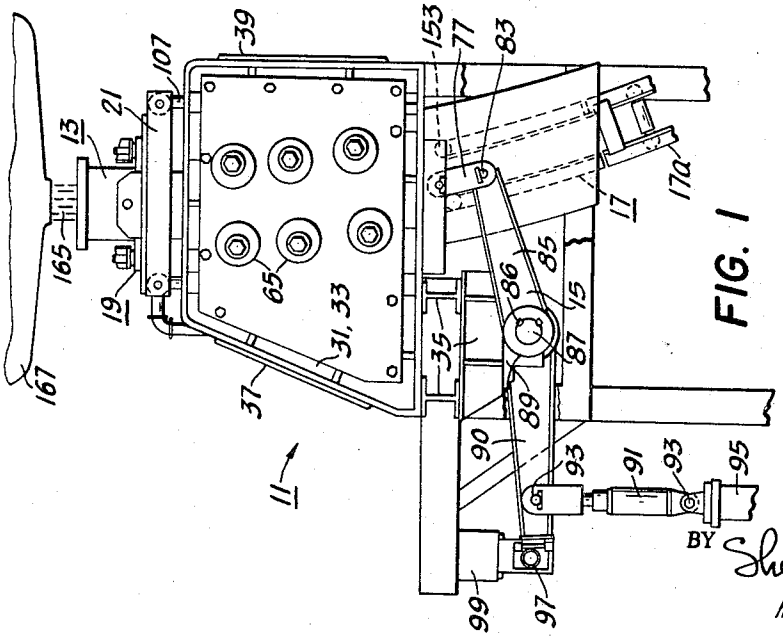


FIG. 1

INVENTOR.
JOSEPH J. CIOCHETTO
BY Sherman H. Barber
his Attorney

Nov. 5, 1968 J. J. CIOCHETTO 3,409,070

CONTINUOUS CASTING APPARATUS

Filed Aug. 5, 1966 3 Sheets-Sheet 2

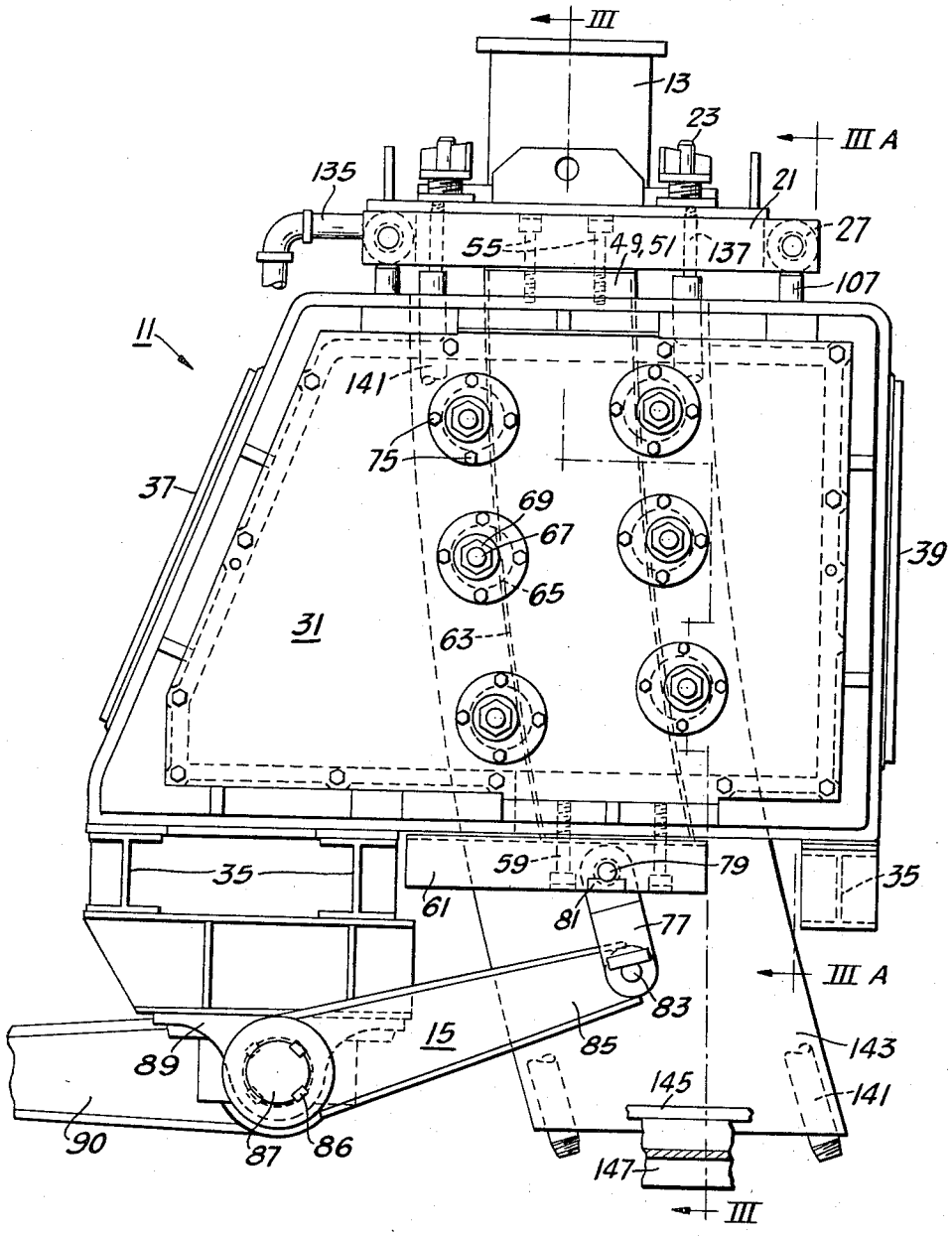


FIG. 2

INVENTOR.
JOSEPH J. CIOCHETTO
BY Sherman H. Barber
his Attorney

Nov. 5, 1968 J. J. CIOCHETTO 3,409,070

CONTINUOUS CASTING APPARATUS

Filed Aug. 5, 1966 3 Sheets-Sheet 3

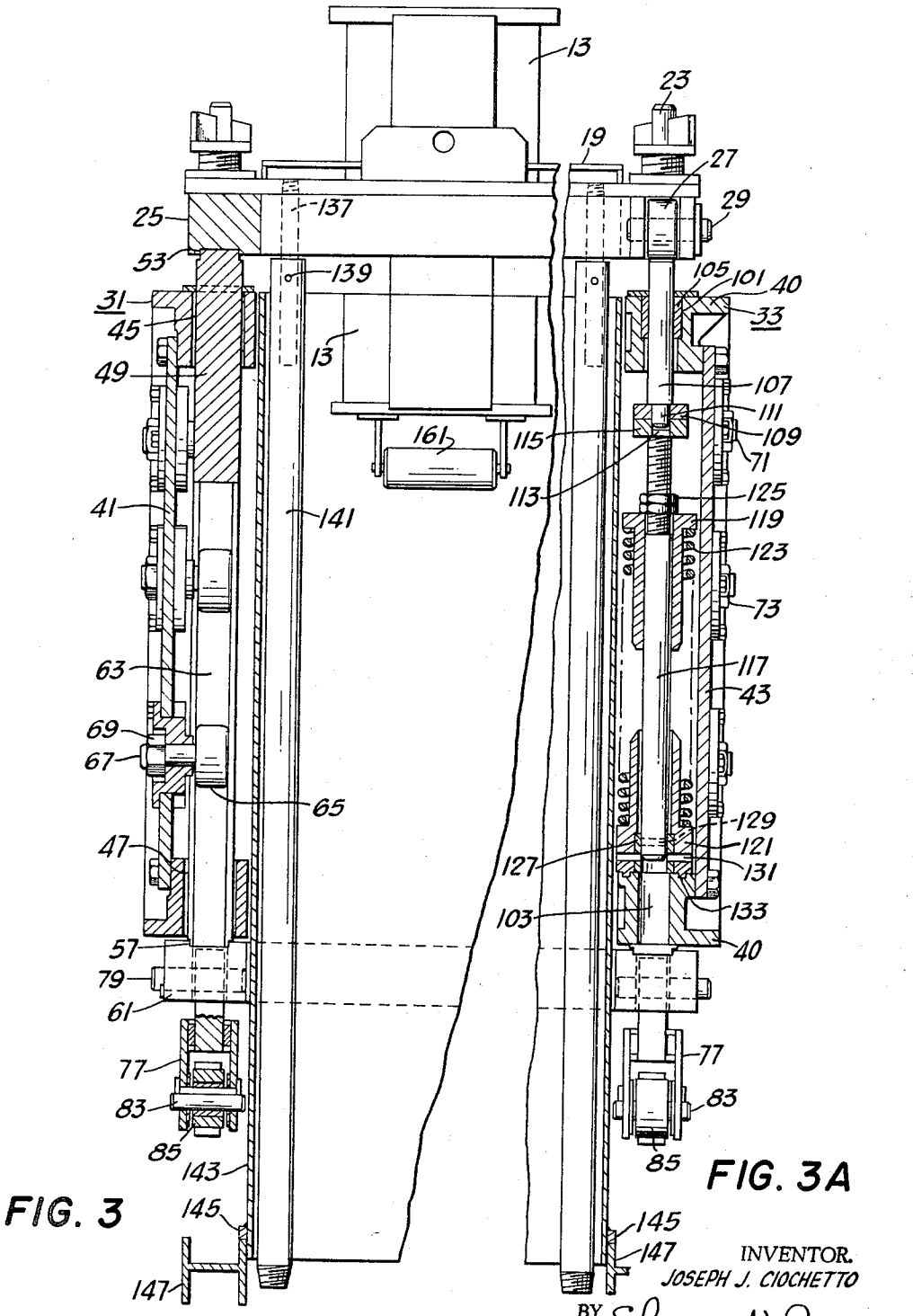


FIG. 3

FIG. 3A

INVENTOR.
JOSEPH J. CIOCHETTO
BY Sherman H. Barker
his Attorney

United States Patent Office 3,409,070 Patented Nov. 5, 1968

3,409,070

CONTINUOUS CASTING APPARATUS

Joseph J. Ciochetto, Allison Park, Pa., assignor to Koppers Company, Inc., a corporation of Delaware

Filed Aug. 5, 1966, Ser. No. 570,630
10 Claims. (Cl. 164—261)

This invention relates to continuous metal casting and more particularly to an improved arcuate continuous casting mold oscillating apparatus.

When molten metal is poured into a cooled casting mold during a continuous casting operation, the metal solidifies first in the marginal zones adjacent the cool mold walls, and forms a solid skin around a molten metal core. To prevent the solid skin from sticking to the walls of the mold, the mold customarily is oscillated upward and downward in a cyclical manner.

Various apparatus have been used heretofore for reciprocating the mold. One apparatus, used with a conventional vertical casting mold, includes cams and springs to move the mold downward and return the mold to the initial top position. Another apparatus, associated with the curved type of mold, includes a lever, pivotally mounted along its length, that is connected at one end to the mold and at the other end to a drive mechanism.

The feature of a lever connected to the mold and pivoted at the center of the casting radius, to restrain the mold in an arc, is generally applicable to small machines. In large machines, the driving lever becomes excessively long and, unless some additional structure is used to guide the mold along the prescribed arcuate path, the mold will not follow in a proper manner. The reciprocation equipment heretofore used in some applications comprises the usual driven cam and cam follower mounted to a lever which in turn is connected to the mold table. Such apparatus, however, has not proved to be entirely satisfactory.

The apparatus of the present invention, in contrast, comprises a continuous casting mold supported on a table that includes top and bottom separator members connected together by spaced apart arcuate side rails that engage and follow an arcuate path established by adjustable rollers. The side rails are linked to a lever system that is powered to move the mold and mold table downwardly. The mold table is resiliently biased against springs so that, at the bottom of its downward stroke, the springs are compressed sufficiently and they return the mold to the top of the stroke in a cyclical manner.

For a further understanding of the invention and for advantages and features thereof, reference may be made to the following description taken in conjunction with the accompanying drawings which show, for the purpose of exemplification, a preferred embodiment of the invention. In the drawings:

FIG. 1 is a schematic elevational view of the apparatus of the invention;

FIG. 2 is a schematic elevational view, at an enlarged scale, of a portion of the apparatus of FIG. 1;

FIG. 3 is a sectional view along line III—III of FIG. 2;

FIG. 3A is a view along line IIIA—IIIA of FIG. 2;

FIG. 4 is a schematic elevational view, at an enlarged scale, of another portion of the apparatus of FIG. 1; and

FIG. 5 is a view along line V—V of FIG. 4.

The apparatus **11**, illustrated in FIG. 1, comprises an arcuate continuous casting mold **13**, a mold oscillating mechanism **15**, and a cast strand guide and support structure **17**.

The continuous casting mold **13** is of the open-end, flow-through type and has a generally straight cylindrical outer shell and an arcuate internal casting cavity wherein molten metal is received to form a continuous strand or billet. The mold **13** is provided with the usual water-jacket cooling spaces and also a horizontal support shelf **19**. Preferably, the horizontal support shelf **19** is water cooled and is adjustably mounted to a top separator member **21** by means of a plurality of wedge key bolts **23**.

The top separator member **21** is comprised generally of four end-connected rectangular side bars **25** (FIG. 3) that form a rectangular opening through which the lower end portion of the arcuate casting mold **13** protrudes. The ends of two opposite parallel side bars **25** extend beyond the other interconnecting side members, and are slotted to receive rollers **27** that are journalled therein on pins **29** (FIG. 3A).

Beneath the top separator member **21**, there are two spaced apart parallel side-frame members **31**, **33**, each of which has a generally trapezoidal profile in elevation (FIG. 1). Each side-frame member **31**, **33** is fixed to a suitable supporting structure, such as an arrangement of I-beams **35** shown in FIG. 1, and the two spaced apart side-frame members **31**, **33** are fixedly connected together by means of tie plates **37**, **39** that may, of course, be connected to the side-frame members in any suitable manner, as by bolts or welding, or the like.

The side-frame members **31**, **33** are each comprised of a trapezoidal shaped skeletal frame **40** that is covered on the outside by a bolted cover plate **41**, **43**. The top and bottom skeletal frame members **40** are each slotted, as at **45**, **47** (FIG. 3), to pass therethrough a curved rail member **49**, **51** having the same general radius of curvature as the casting cavity within the mold **13**.

Each curved rail **49**, **51** has a tongue **53** projecting from the end for engaging a groove in the bars **25** comprising the top separator member **21**, and the rails **49**, **51** are fixed to the top separator member **21** by means of bolts **55** recessed in the side bars **25** (FIG. 2). In like manner, each curved rail **49**, **51** is also tongue-mounted as at **57**, and bolted as at **59**, in a bottom separator member **61** that is substantially identical to the top separator member **21**.

Of the two side rail members **49**, **51**, only the rail member **49** has, in each of its arcuate longitudinal edge surfaces, an elongate groove **63** for receiving a plurality of conventional oscillating cam followers **65**. Each cam follower **65** is mounted in an eccentric cartridge on a shaft **67**, and is provided with a self-locking nut **69** whereby the cam follower **65** may be adjusted to selectively position the rail member **49** with respect to the axis of both the casting mold **13** and the apron structure **17**. The other rail member **51**, however, does not have grooves in its arcuate edge surfaces. Similar cam followers (not shown) mounted on shafts **71** (FIG. 3A) are fixed in position by means of similar self-locking nuts **73**, and these other cam followers simply ride on and engage the arcuate edge surfaces of the rail member **51**, but do not operate in grooves in the arcuate rail member **51**.

As shown in FIG. 2, each oscillating cam follower **65** is fastened to the side-frame members **31**, **33** by means of bolts **75**, but, of course, other suitable fastening means may be employed if preferred.

The bottom separator member **61** is connected, adjacent each end, to adapting links **77** (FIG. 2) by means of pivot pins **79** journalled as at **81** to the separator member **61**. The other end of each adapting link **77** is pivotally connected, as at **83** to one end of a lever **85** that forms a part of the mold oscillating mechanism **15**. Thus, there are two spaced apart parallel levers **85**, each of which is connected to a side rail (FIGS. 3 and 3A) by means of a link **77** and pins **79, 83**. Each lever **85** also is keyed, as at **86**, to a common shaft **87** that is journalled in bearings **89** that may be fixed in any suitable manner to the support structure **35**. A single lever **90** is also keyed to the shaft **87** and extends in a direction away from, and generally parallel to, the levers **85**. That is, the lever **90** extends toward the left as viewed in FIG. 1, while levers **85** extend toward the right from the fixed shaft **87**.

An hydraulic cylinder piston arrangement **91** is pivotally connected at **93** both to the lever **90**, near the free end thereof, and to a fixed vertical support structure **95**. The free end of the lever **90** is also fitted with a slotted finger member (not shown) that cooperates with a conventional hydraulic control valve **97** mounted to a fixed support structure **99**.

Hydraulic control valve **97** regulates the flow of fluid into and out of the expansion cylinder **91** and thus regulates the movement of the lever **90**. It is to be understood, however, that in some applications the control valve **97** may be an electrical switch device that controls the flow of fluid to the expansion cylinder **91**, if such type of apparatus be preferred.

Referring to FIG. 3A, the side-frame members **31, 33** are each provided with vertically arranged axial apertures **101, 103** in the top and bottom horizontal portions of the skeletal frame **40**, and in the aperture **101** at the top of the skeletal frame **40** there is a bushing **105** in which a push rod **107** reciprocates.

The push rods **107** extend both above and below the top horizontal skeletal member **40**; the upper portions engaging the rollers **27** while the bottom ends of the push rods **107** are each welded to a flange-like abutment **109**. A pilot portion **111** on each lower end extends below the abutment **109** and mates in a hole **113** in another abutment **115** of substantially the same size as the abutment **109**. The abutment **115** is welded to the upper threaded end portion of a spring rod **117** that supports upper and lower spring retainers **119, 121**, respectively.

A compression spring **123** encircles the spring rod **117** and cooperates with the upper and lower spring retainers **119, 121**. The location of the upper spring retainer **119**, relative to the spring rod **107**, is determined by the location of a pair of lock nuts **125** threaded on the spring rod **117**. The lower spring retainer **121**, however, is not adjustable since it engages the lower horizontal skeletal frame member **40**. The lower spring retainer **121** also is provided with a bushing **127** within which the lower end portion of the spring rod **117** reciprocates.

The lower end portion of the spring rod **117** has therethrough a transverse hole **129** that is alignable with holes **131** in the spring retainer **121** for use in assembling the apparatus **11**. When assembling the apparatus **11**, the spring **123** is compressed, in any suitable manner, until the hole **129** in the spring rod **117** is aligned with the holes **131**; then, a pin (not shown) may be inserted through both sets of holes **129, 131** to keep and maintain the spring assembly in a slightly compressed form which can be easily handled and inserted into place. When the pin is later withdrawn, the spring **123** expands and the spring retainers **119, 121** assume the position shown in FIG. 3A. Suitable lugs, or a ring **133** on the end of the lower spring retainer **121**, mates with a groove in the lower skeletal frame member **40** to keep and maintain the end of the lower spring retainer **121** in axial alignment with the hole **103** in the skeletal frame member **40**.

The mold support table **19** is preferably hollow and communicates with the annular cooling fluid space in the mold **13**, so that cooling fluid, entering the mold support table **19** through a conduit **135** (FIG. 2), circulates through the mold support table and the mold **13**. Thereafter, the fluid discharges from the mold table through drain conduits **137** that extend downwardly between the arcuate rail members **49, 51** (FIG. 3). To the lower end of each downwardly directed reciprocable drain conduit **137**, there is connected, as by a pin **139**, an arcuate drain conduit **141**. The drain conduit **141** is disposed within a spray shield **143** that surrounds the lower end of the mold **13** and is disposed between the mold and the side frame members **131, 133**. The lower end of the drain conduit **141** may be supported in any suitable manner (not shown).

The spray shield **143** comprises an open ended shroud that has a generally rectangular cross sectional shape and an arcuate profile, as viewed in FIG. 2. The spray shield **143** surrounds the lower end of the mold **13** and is supported at its bottom edge by bars **145** that are welded to the walls of the spray shield and engage the flange of an H-beam **147**, or other suitable firm supporting structure. While the spray shield **143** rests on the H-beam **147**, the top of the shield **143** is free to "float" between the top horizontal bars of the side-frame members **31, 33**.

Within the spray shield **143**, there is also a short length of apron structure **17** that is similar to the structure disclosed in my copending application Ser. No. 544,908, filed Apr. 25, 1966. The apron structure **17** comprises, generally, arcuate angle members **149** that support pairs of rollers **151, 153** mounted for rotation in mutual perpendicular planes (FIG. 4), and the structure is supported by vertical apertured side plates **155** that are fastened, as by bolts **157**, to a fixed supporting frame structure **159**.

As shown in FIG. 4, an opposed pair of rollers **161** are mounted to the bottom of the casting mold **13** to engage and guide a cast strand **163** as it emerges from the bottom of the mold **13**. In some applications two opposed pairs of such rollers **161** may be used in order to reduce wear on the mold.

In operation, molten metal **165** flows into the casting mold **13** from a tundish **167** located above the mold, and the mold is oscillated vertically along an arcuate path by the oscillating mechanism **15** to prevent the skin of the casting from sticking to the walls of the mold.

Fluid is introduced into the expansion cylinder **91**, and, as the piston portion moves upwardly, the lever **90** pivots clockwise about the shaft **87**. The levers **85**, being keyed to the shaft **87**, thus pivot clockwise and, acting through the links **77**, urge downwardly the mold oscillating assembly comprising: the top and bottom separators **21, 61** respectively; the arcuate side rails **49, 51**; the mold table **19**; and the mold **13**. As this assembly moves downward, the rollers **27** depress the push rods **107**, and the push rods **107**, acting on the spring rods **117**, compress the springs **123**.

As the lever **90** rotates clockwise during the downward portion of the stroke of the mold **13**, the free end of the lever **90** trips the valve **97**; the flow of fluid to the expansion cylinder **91** and the downward movement of the mold cease. During the downward portion of the mold movement, the springs **123** have become compressed by the action of the rollers **27** engaging the push rods **107** and spring rods **117**. After the downward movement of the mold ceases, the mold is free to move upward again. At this moment, the springs **123** urge the separator-rails-mold assembly upward, and the lever **90** pivots counterclockwise. As the lever **90** pivots counterclockwise, it actuates the valve **97** again and once more fluid flows into the expansion cylinder **91** pivoting the lever **90** clockwise, while the assembly of the separators **21, 61**, rails **49, 51**, and mold **13**, move downward again.

Thus, there is established cyclical oscillatory movement of the mold **13**; the stroke of which is established by a selected setting of the valve and valve operating mechanism **97**.

The continuous cast strand **163** first engages, and is guided by, rollers **161** fastened to the lower end of the

casting mold, but later the continuous cast strand engages the rollers **151, 153** of the short first apron structure **17** and is guided thence in the direction of the path of the principal apron structure **17***a* disposed below the spray shield **143**.

A feature of the present invention is that when the mold is urged downwardly under the influence of the expansion cylinder **91** and levers **90, 85** and links **77**, the path described by the mold is predetermined by an appropriate setting of the adjustable cam followers **65** that engage the side rails **49, 51**. Thus, the arcuate path described by the mold may become more nearly a true circular arc that is readily established by the adjustable cam followers fixedly mounted to the mold table supporting side-frame members.

A feature of the present invention is that significantly less power is required to reciprocate the mold since rolling friction and not sliding friction exists between the cam followers and the guide rails.

A feature of the invention is the well guided and smoothly oscillating movement of the mold provided by the rolling cam followers inasmuch as there is a minimum of restriction due to expansion and contraction under wide temperature fluctuations. The result is that significantly less power is required to oscillate the mold along an arcuate path and there is significantly less chance for misalignment of the apparatus.

A feature of the invention is the shield around the cast strand in the region where it leaves the casting mold. The shield serves not only to confine the cooling water spray to the casting and prevent the spray from contacting the rollers and side rails, but also to prevent radiant heat from the cast strand from reaching and distorting the side rails, cam followers, and side-frame members. Such a shield is both a spray shield and a heat shield.

Although the invention has been described herein with a certain degree of particularity, it is understood that the present disclosure has been made only as an example and that various modifications and changes may be made within the scope of the invention as defined by the appended claims.

What is claim is:

1. Apparatus for use in the continuous casting of metal comprising:

(a) an open-end, flow-through mold wherein a continuous cast strand is formable;

(b) a mold table carrying said mold and including:

(i) a top separator member fixed to said mold table, and

(ii) a bottom separator member spaced apart from said top separator member, and

(iii) spaced apart arcuate guide rails fixed to said top and bottom separator members disposed on opposite sides of said cast strand;

(c) a fixed support adjacent said mold;

(d) a frame surounding said mold table and fixed to said support;

(e) opposed adjustably fixable spaced apart rollers mounted to said frames and disposed along parallel arcuate paths, said rollers cooperating with said arcuate rails and defining a path along which said rails move;

(f) a shaft journalled to said fixed support;

(g) a lever journalled to said shaft and pivotally connected to the bottom separator;

(h) resilient bias means engaging said mold table and said support;

(i) means to pivot said lever and move said rails along the arcuate path defined by said rollers, said mold table and mold moving downwardly from an initial position and storing energy in said resilient biasing means; and

(j) means to release said stored energy whereby said mold moves upwardly to the initial position.

2. The invention of claim **1** wherein:

(a) said resiliently biased means are springs.

3. The invention of claim **2** including:

(a) a heat shield surrounding the lower portion of said mold and disposed between said cast strand and said rails; and

(b) an arcuate apron structure disposed within said heat shield and mounted adjacent the lower end of said mold for receiving and supporting said cast strand after it emerges from said mold.

4. The invention of claim **3** including:

(a) an expansion cylinder pivotally connected to said lever and to said support as the means for pivoting said lever; and

(b) valve means actuatable by said lever as it pivots to control the movement of said lever and the vertical downward movement of said mold.

5. In apparatus for the continuous casting of a metal strand, the improvement comprising:

(a) an open-end, flow-through mold wherein metal flows and a continuous cast strand is formed;

(b) a mold table for carrying said mold on an arcuate path comprising:

(i) arcuate guide rails connected to said mold table and disposed on opposite sides of said cast strand, and

(ii) means cooperating with said guide rails defining arcuate paths along which said rails move; and

(c) means engaging said rails for reciprocating the same and said mold along said arcuate path.

6. The invention set forth in claim **5** wherein:

(a) said reciprocating means includes a pivotally mounted lever linked to said rails and to an expansion cylinder adapted to move said lever whereby said rails and said mold move downward;

(b) springs are resiliently biased against said mold whereby, as said mold moves downward under the influence of said lever, energy is stored in said springs; and

(c) means to release said stored energy in said springs whereby said rails and said mold are returned upward to the initial top position.

7. The invention set forth in claim **6** including:

(a) an arcuate apron structure mounted adjacent the lower end of said mold for receiving and supporting said continuous cast strand after the same emerges from said mold; and

(b) shield means surrounding said cast strand and said apron structure and disposed between said apron structure and said guide rails whereby heat radiating from said cast strand is prevented from reaching said rails.

8. Vertical continuous casting mold-oscillating apparatus comprising:

(a) a reciprocable mold table carrying a vertical continuous casting mold;

(b) A frame fixedly supported adjacent said mold;

(c) adjustably fixable guide rollers mounted to said frame on opposite sides of said continuous cast strand;

(d) spaced apart guide rails fixed to said mold table and cooperating with said guide rollers;

(e) resilient bias means disposed between said frame and said mold table;

(f) a lever pivotally mounted to said frame and to said guide rails;

(g) means to pivot said lever for moving said mold downwardly from an initial top position along a path directed by the placement of said rollers which cooperate with and guide said rails, the downward movement of said mold table storing energy in said resilient bias means; and

(h) means to release said lever actuating means and release said stored energy for returning said mold

table and mold upwardly to said initial top position.

9. The invention of claim 8 wherein:

(a) said resilient bias means are springs; and

(b) said lever pivoting means is fluidly motivated.

10. The invention of claim 9 including:

(a) an apron structure disposed adjacent said casting mold for supporting said continuous casting as the same emerges from said mold; and

(b) a shield encompassing said apron structure and a portion of said mold, said shield being disposed between said rails and said casting.

References Cited

UNITED STATES PATENTS

2,815,551	12/1957	Hessenberg et al.	164—83
3,166,803	1/1965	Ruckstuhl	164—83 X
3,245,126	4/1966	Phillips et al.	164—83 X
3,343,592	9/1967	Vogel	164—260

J. SPENCER OVERHOLSER, *Primary Examiner.*

R. S. ANNEAR, *Assistant Examiner.*