

Feb. 17, 1970

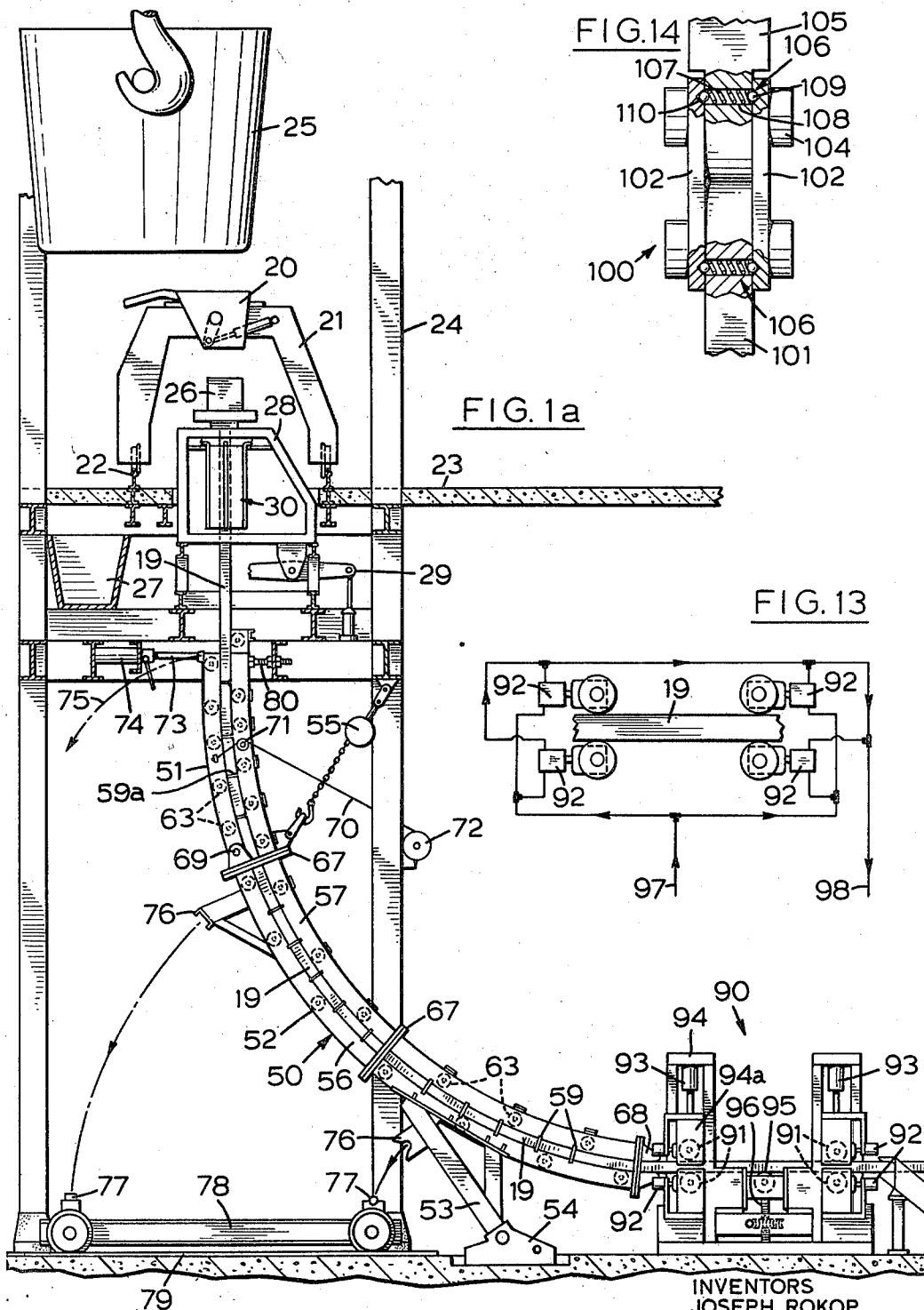
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3,495,651

STARTING DEVICE FOR CONTINUOUS CASTINGS

Filed March 8, 1967

5 Sheets-Sheet 1



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STARTING DEVICE FOR CONTINUOUS CASTINGS

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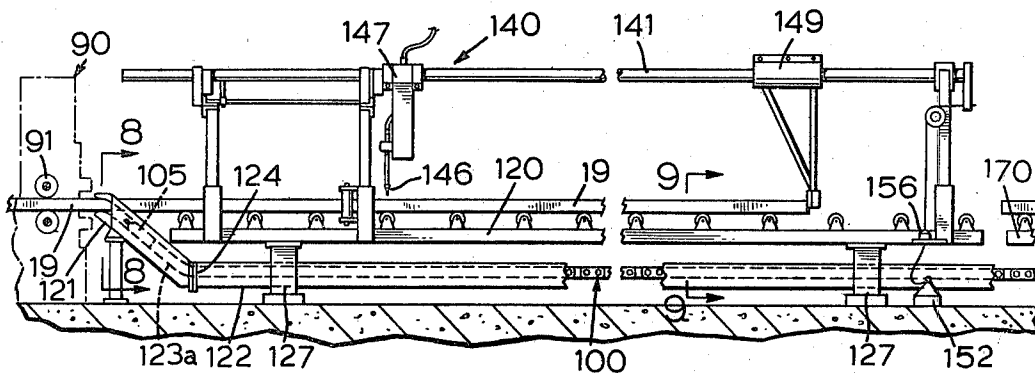


FIG. 1 b

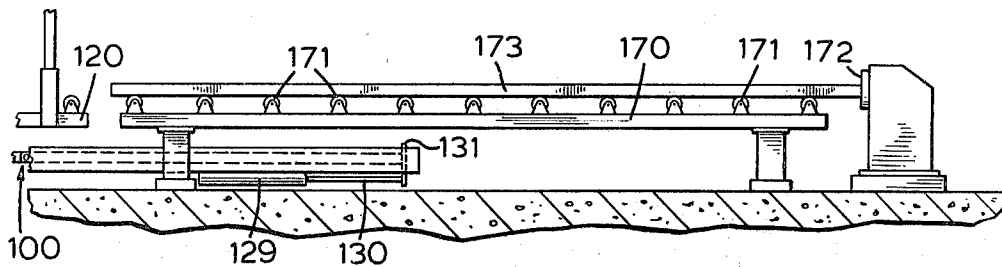


FIG. 1 c

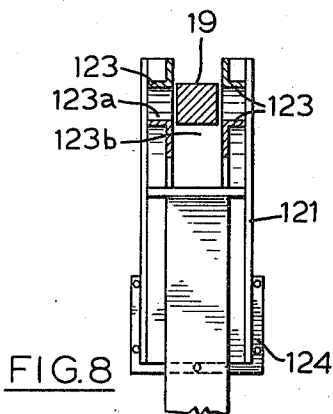


FIG. 8

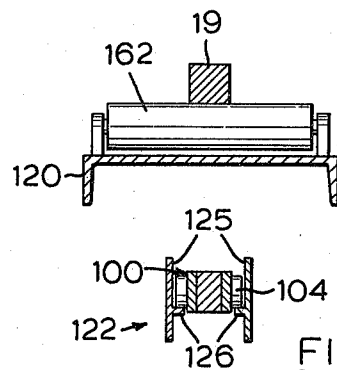


FIG. 9

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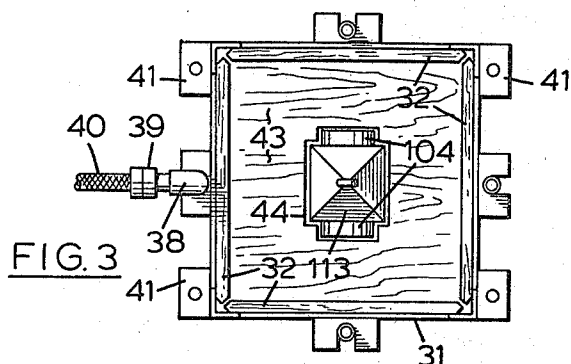
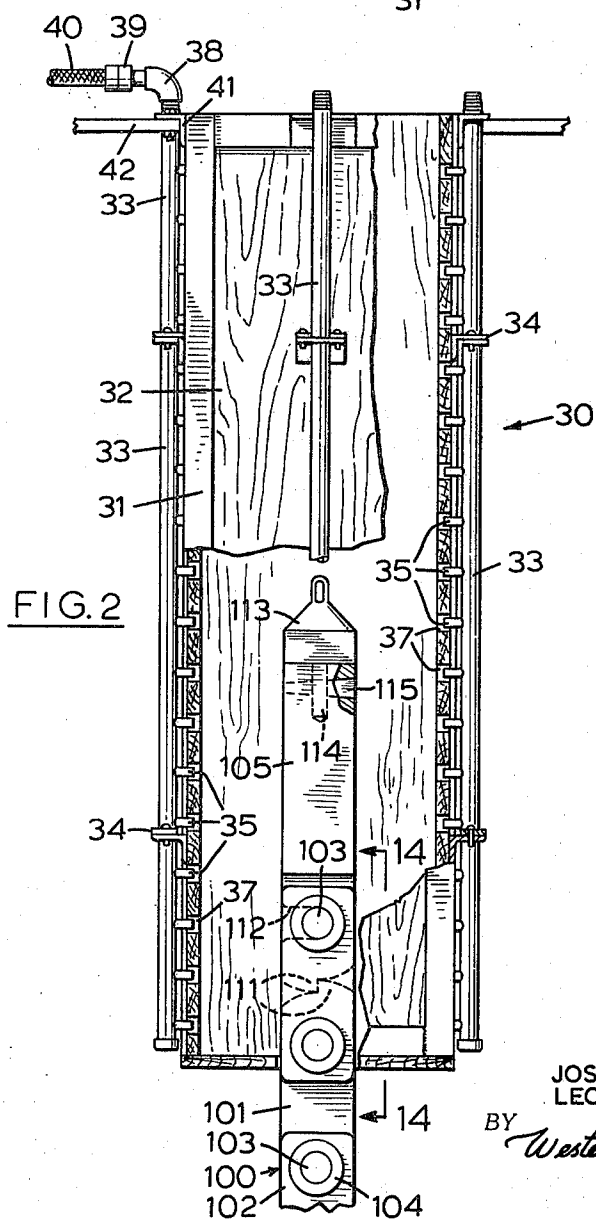
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STARTING DEVICE FOR CONTINUOUS CASTINGS

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5 Sheets-Sheet 3



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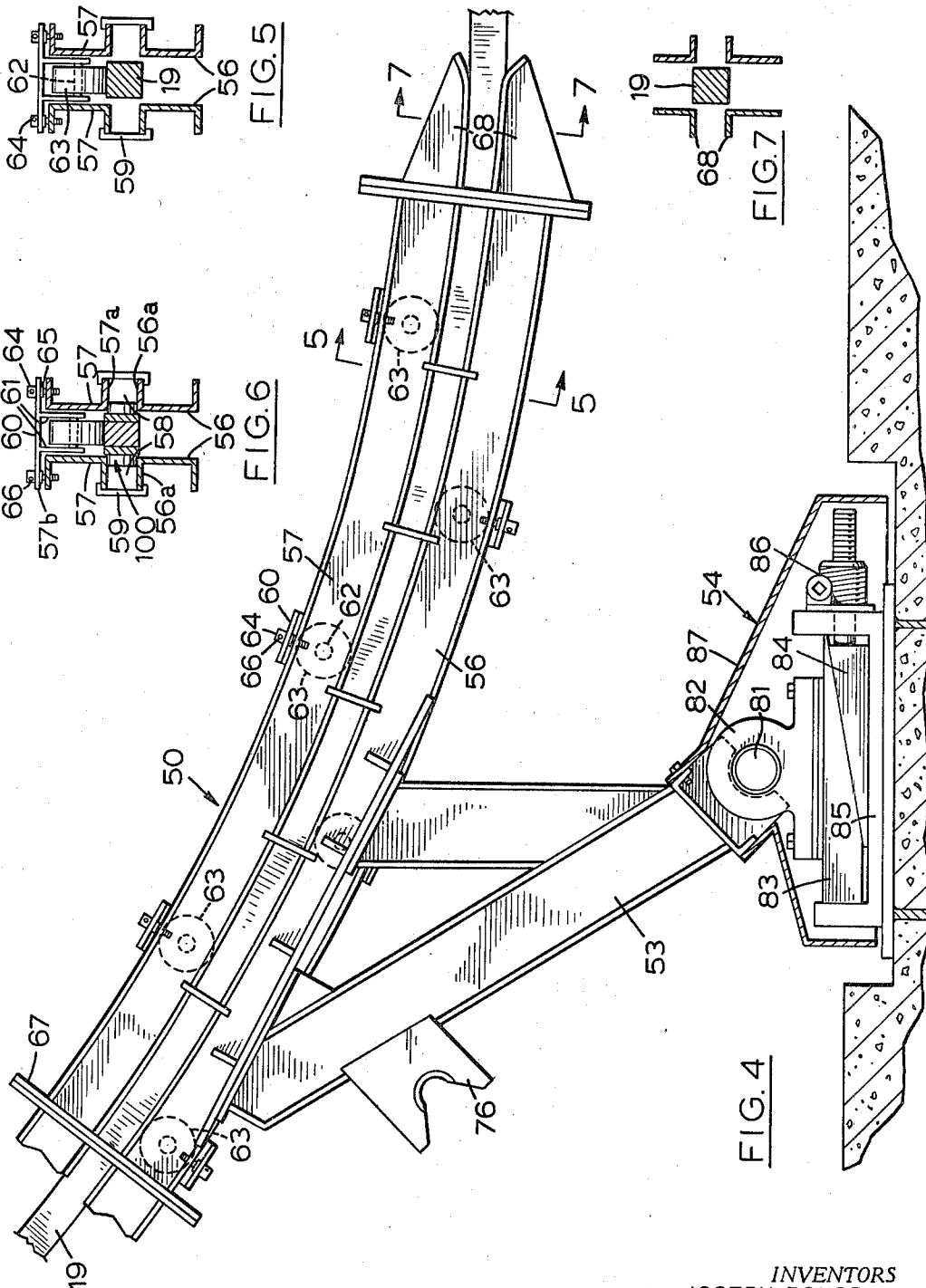
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STARTING DEVICE FOR CONTINUOUS CASTINGS

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5 Sheets-Sheet 4



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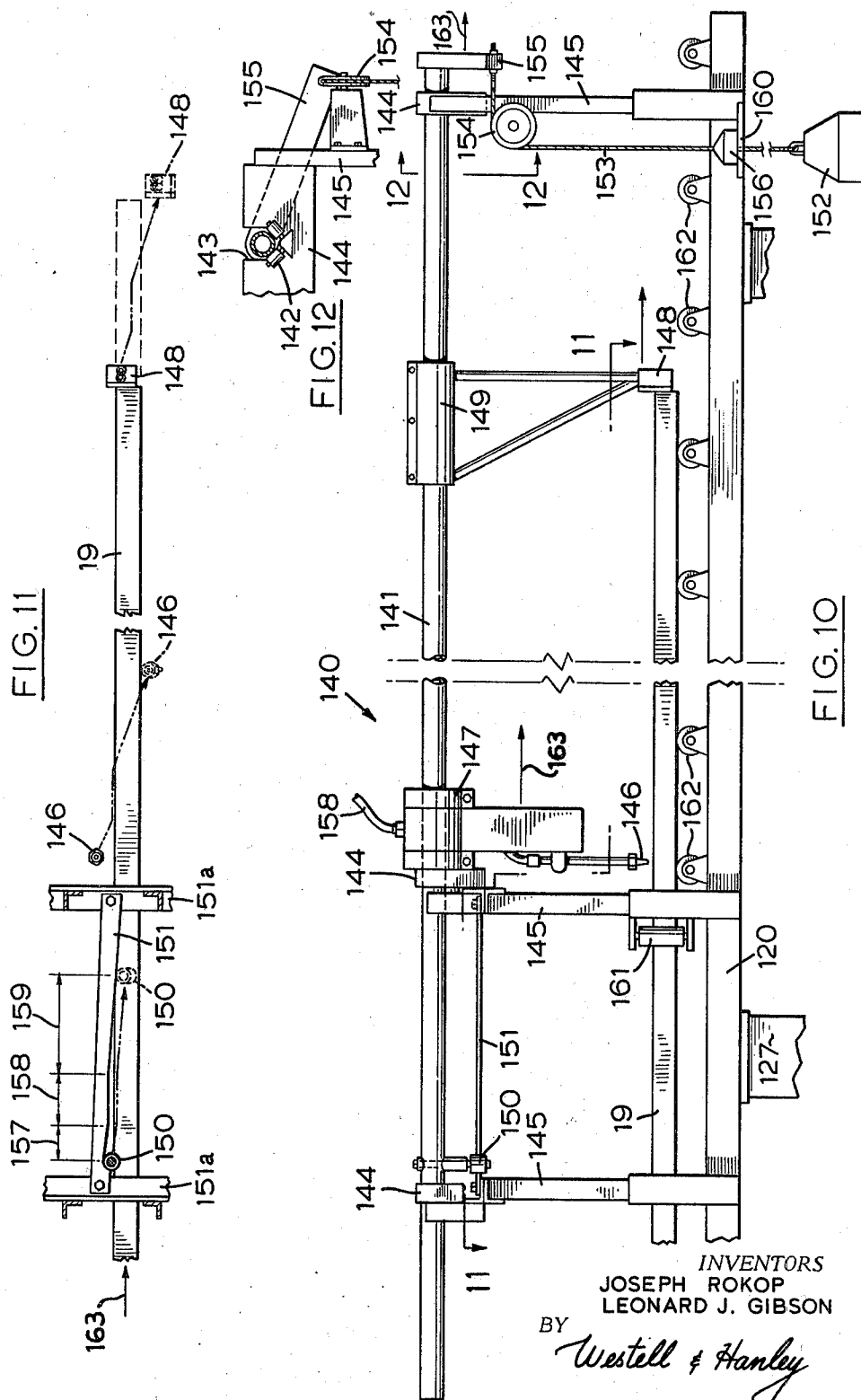
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STARTING DEVICE FOR CONTINUOUS CASTINGS

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3,495,651

STARTING DEVICE FOR CONTINUOUS CASTINGS

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7 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for the continuous casting of metal in which a strand is drawn from a flow-through mold, spray cooled, guided by an apron through a withdrawal mechanism, and cut into billets. The spray chamber is replaceable from the line and the spray apparatus is protected from splashing. A flexible starting device carrying side rollers allows use of a simplified apron having a trackway and using staggered guide rollers. The inlet portion of the apron is hinged for accessibility and the whole apron is removable. The inlet of the apron is spaced from the outlet of the spray chamber for reheating of the strand shell and allowing use of a straight flow-through mold together with bending rollers in the apron. Hydraulically activated drive rollers on the withdrawal mechanism are synchronized by the strand. Gravity storage of the flexible starting device is gravity stored for re-use. An automatic cyclical cutting mechanism is synchronized with, and motivated by, the moving strand.

The present invention relates to the casting of metal and more particularly to a method and apparatus for producing continuous metal strands.

Continuous strands of cast metal such as steel are produced by pouring the metal in a molten state through the top of a flow-through casting mold and drawing the metal continuously from an opening in the bottom of the mold as an elongated strand. In order to draw the metal in this manner the mold is placed in an elevated position and located above the mold is a ladle transporting the molten metal to the apparatus together with a tundish to receive the metal from the ladle and feed it continuously into the mold or a plurality of the molds.

To begin the continuous casting operation the bottom opening of the mold, from which the metal is to be continuously drawn, as initially plugged by a head attached to the end of a starting bar moving along a guideway. The molten metal in the mold solidifies about the head which is then drawn from the bottom opening of the mold followed by a continuous strand of the metal which progressively solidifies as it emerges and recedes from the mold. Vibratory apparatus prevents the molten metal from adhering to the sides of the mold during its sojourn within the mold.

On emergence from the mold the metal strand has a thin skin which thickens inwardly by cooling as its distance from the mold increases. To speed up solidification of the strand it is passed through a spray chamber immediately adjacent the mold outlet. This spray chamber carries a plurality of risers each having a line of nozzles impinging cold water onto the strand emerging from the mold. However, the skin of the strand sometimes ruptures before it has been sufficiently thickened and this "break-out" results in a molten metal adhering to the spray chamber and nozzles. When break-out occurs the spray chamber must be cleaned, resulting in a lengthy interruption in the operation of the machine.

It is an object of the present invention to provide, in

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a continuous metal casting apparatus, a spray chamber which is easily replaceable as a unit, allowing the chamber to be cleared of adhering metal after a break-out while another clean chamber enables the casting operation to proceed with a minimum of interruption.

When the continuous strand of metal emerges from the spray chamber it travels along a curved roller apron which feeds the strand to a withdrawal and straightening mechanism. The arcuate roller apron alters the direction of travel the metal strand from vertical to horizontal, thus enabling the overall height of the continuous casting apparatus to be reduced and allowing the metal strand to be cut into horizontally disposed billets. This apparatus is known as a "low head" machine as opposed to a "high head" machine in which the solidification is wholly completed along a vertical axis. Break-out also sometimes occurs in the roller apron, especially in that area adjacent the spray chamber. When this happens the roller apron, which consists of a series of bending or guide rollers arranged in a sequence of rectangles to form a guideway or passage, must be dismantled and cleaned. Like the cleaning of the spray chamber this is a laborious job and results in lengthy delays in production in the affected line. Moreover, the break-out produces a "flower" on the outside surface of the strand which solidifies and jams between the rollers of the apron or damages the rollers as the strand continues to be pulled forward by the withdrawal mechanism. After a break-out in this area, the strand has to be cut into sections for removal.

It is another object of the present invention to provide, in a continuous metal casting apparatus, an improved roller apron which may be easily disassembled sectionally or replaced, is simple in construction, and which will pass a flowered strand.

In a "low head" continuous casting apparatus the flow-through mold must have a curved longitudinal axis coextensive with the arcuate axis of the roller apron receiving the metal strand as it emerges from the mold and guiding it to the withdrawal and straightening mechanism. A curved mold is essential because mechanical bending forces cannot be applied to the strand while it is in its initial cooling stage and its outer shell or skin is thin. However, curved molds are expensive to produce.

It is a further object of the present invention to provide, in a continuous casting apparatus, a method and apparatus to allow use of a straight flow-through mold with an arcuate roller apron.

The mechanism which withdraws the strand from the mold through the roller apron, and which also straightens the strand, is located at the end of the apron remote from the mold where the strand is in an advanced stage of solidification. The withdrawal and straightening mechanism consists of drive or pinch rollers which pull the strand from the mold through the cooling chamber and guideway in synchronism with the rate that the liquid metal is poured into the mold whereby the level of liquid metal in the mold is maintained substantially constant. Usually two pairs of opposed drive rollers are employed in tandem with a single roller therebetween which bears against the strand to remove the axial curvature imparted to the strand by the arcuate roller apron. Since the drive rollers do not operate exactly in unison, i.e. with the same circumferential speed, even with additional controls, opposing forces will be set up between individual rollers and pairs of rollers acting on the strand. Because of this, the traction force required to withdraw the metal strand tends to be supplied by one roller and the resultant higher pressure may exceed that permissible against the incompletely solidified strand having a liquid core.

It is still another object of the present invention to

provide a method and means for synchronizing the operation of the drive rollers in the withdrawal and straightening mechanism of a continuous casting apparatus, or any device using drive rollers to move a strand longitudinally, by utilizing the moving strand as a synchronizer.

The starting device used to initiate the casting operation consists of a rigid bar of metal carrying at one end a head configured to plug the mold and of sufficient length to pass through the roller apron and reach the withdrawal and straightening mechanism. The rigidity of the starter bar makes it cumbersome to use and also to store when not in use. Proper coaction of the starting bar with the roller apron precludes any significant degree of articulation of the bar which would cause it to buckle in the apron.

It is another object of the invention to provide a starting device which is flexible in one lateral direction whereby it may be more easily handled and stored for re-use, and which carries roller means enabling simplification in construction of the roller apron.

After withdrawal of the strand of metal from the mold through the spray chamber, roller apron, and withdrawal and straightening mechanism, the starting bar is disconnected from the strand which continues to emerge from the mold as a ribbon. When disconnected the starting bar must be stored for re-use and this requires an additional structure either as an extension where the starting bar is straight or as an upwardly extending shunt where a curved roller apron and starting bar are used.

It is another object of the present invention to provide improved means for storing a starting device flexible in one lateral direction, whereby additional structural requirements are minimized.

After the solidified strand has passed through the withdrawal and straightening mechanism it is cut into billets of desired length. The continuous movement of the strand presents difficulties in carrying out the cutting operation and various cutting means have been developed which are, however, cumbersome.

It is yet another object of the present invention to provide an improved mechanism for cutting a continuously moving cast strand of metal into billets of desired length.

Example embodiments of the invention are shown in the accompanying drawing in which:

FIGURE 1 is a view in side elevation of a continuous metal casting apparatus with a strand passing there-through, FIGURE 1a showing a mold, spray chamber, roller apron, and a withdrawal and straightening mechanism, FIGURE 1b continuing to the right of FIGURE 1a and showing an automatic torch-cutting mechanism and chain bar storage means, and FIGURE 1c continuing to the right of FIGURE 1b and showing billet receiving means and a feed mechanism for the starter chain;

FIGURE 2 is a view in side elevation, partly in cross-section, of the spray chamber shown in FIGURE 1 and including a side view of the head portion of a starting chain;

FIGURE 3 is a top plan view of the spray chamber shown in FIGURE 2;

FIGURE 4 is a view in side elevation of the lower part of the roller apron shown in FIGURE 1a;

FIGURE 5 is a cross-sectional view of the roller apron taken along line 5—5 of FIGURE 4;

FIGURE 6 is a cross-sectional view of the roller apron taken along line 5—5 of FIGURE 4 but showing passage of a starting chain through the roller apron;

FIGURE 7 is a cross-sectional view of the roller apron taken along line 7—7 of FIGURE 4;

FIGURE 8 (on the same sheet as FIGURES 1b and 1c) is a cross-sectional view of the starting chain storage

FIGURE 9 (on the same sheet as FIGURES 1b and 1c) is a cross-sectional view of the cutting table and starting chain storage means taken along line 9—9 of FIGURE 1b;

FIGURE 10 is a view in side elevation of the automatic torch mechanism shown in FIGURE 1b;

FIGURE 11 is a cross-sectional view of the torch cutting mechanism taken along line 11—11 of FIGURE 10;

FIGURE 12 is an end view of the torch cutting mechanism taken along line 12—12 of FIGURE 10;

FIGURE 13 (on the same sheet as FIGURE 1a) is a schematic hydraulic flow diagram for the drive rollers of the withdrawal and straightening mechanism shown in FIGURE 1a; and

FIGURE 14 is a front view, partly cross-section, of the starting chain taken along line 14—14 of FIGURE 2 showing a releasable locking mechanism.

Referring first to FIGURE 1a of the drawings, the casting apparatus consists of a tundish 20 which is supported by a carriage frame 21 movable along rails 22 which are mounted on an elevated horizontal supporting floor 23 of a structural frame 24. A ladle 25 containing molten metal is movable by a service crane (not shown) into a position above tundish 20 which takes molten metal poured from the ladle and in turn pours the molten metal into one or more continuous type straight flow-through molds 26 vertically positioned beneath the tundish. A spill box 27 is also mounted on frame 24 and is located below tundish 20 adjacent mold 26 to receive overflow from the tundish. Mold 26 is fixed on a frame 28 which is connected to an oscillating mechanism 29.

A spray chamber or box 30 is fixed vertically on supporting floor 23 immediately beneath mold 26 and is axially aligned with the mold. As shown more particularly in FIGURES 2 and 3 of the drawings, spray chamber 30 consists of a rectangular metal open-ended box 31 having its inner walls lined by removable panels 32 of suitable material such as plywood. A spray riser or conduit 33 is fixed along the centre line of the outer side of each wall of frame 31 by brackets 34 and has a plurality of vertically arranged nozzles 35 projecting through apertures 37 in panels 32. The upper end of each riser 33 terminates in an elbow 38 which in turn carries a coupling 39 detachably connected to conduit 40. A plurality of flanges 41 are fixed to opposing panels 32 of frame 31 for attachment of spray chamber 30 to a suitable mounting 42 anchored on supporting floor 23 of frame 24. The bottom end of frame 31 is closed by a removable base panel 43 having a central aperture 44 to pass a starter chain 100 and a continuous strand 19 (see FIGURE 1a) drawn from mold 26 downwardly through the spray chamber. As continuous metal strand 19 passes through spray chamber 30 it is cooled by water or other suitable fluid impinging upon it from nozzles 35 fed under pressure through risers 33 from conduits 40. If a break-out occurs in the length of strand 19 within spray 30 the molten metal will splash against panels 32 and collect on base panel 43. When such a break-out occurs and after drawing operation is completed, spray chamber 30 may be removed by uncoupling conduits 40 from risers 33 and detaching flanges 41 from supports 42. A stand-by spray chamber 30 may then be mounted on supports 42, conduits 40 re-coupled with risers 33 and the apparatus is then available for a subsequent drawing operation. The contaminated spray chamber being cleaned when convenient. It will be appreciated that spray chamber 30 could be of any suitable cross-section and would be adaptable to cooling a strand moving in a direction other than vertically downward.

Referring again to FIGURE 1a of the drawings, a roller apron 50 is located beneath spray chamber 30 and has a curvilinear longitudinal axis co-extensive with the axis of the spray chamber and mold 26 to provide a change, from vertical to horizontal, in the direction of movement of metal strand 19 emerging from the mold and the spray chamber. Apron 50 is divided into an upper bender section 51 and a lower guideway section 52, both sections being supported by a brace 53 pivotally mounted on a vertically adjustable base 54. Apron 52 is held

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against pivotal movement about base 54 by an adjustable chain hoist 55 anchored to frame 24. As shown more particularly in FIGURES 4 to 7 of the drawings, apron 50 consists of a lower pair of channels 56 spaced apart in back-to-back relationship and an upper pair of channels 57 also spaced apart in back-to-back relationship. Inner flanges 57a of channels 57 are spaced from inner channels 56a of channels 56 to form a roller guideway 58, the pairs of channels being held in this position by a plurality of lateral braces 59 fixed to flanges 56a and 57a, in lower section 52 of apron 50 but spaced apart by lugs 59a in upper section 51 of the apron. Channels 56 are held in spaced-apart relationship by intermittently spaced plates 60 fixed to outer flanges 56b of channels 56 and channels 57 are likewise held in spaced-apart relationship by a plurality of plates 60 fixed to outer flanges 57b of channels 57. Each plate 60 carries a pair of flanges 61 extending inwardly between channels 56 or 57 and these flanges carry an axle 62 on which a roller 63 is journaled. Plate 60 is fixed to pairs of channels 56 or 57 by a pair of pins 64 threaded into outer flanges 56b or 57b of the channels and carrying a shoulder 65 fixed to the pin, each pin having an eye 66 for insertion of a tool for adjustment of roller 63 in a direction transverse to the longitudinal axis of apron 50 enabling strands 19 of different cross-sectional sizes to be drawn through the apron. It should be noted that the tension of strand 19 being drawn through apron 50 will prevent any appreciable lateral deviation of the strand into roller guideway 58. As with spray chamber 30, the construction of a horizontal apron 50 according to the present invention would be equally operable.

Rollers 63 are located in staggered relationship along apron 50 as shown in FIGURES 1a and 4 of the drawings, i.e. any roller journaled between upper channels 57 is not directly opposite a roller similarly journaled between lower channels 56 but is offset therefrom longitudinally with respect to the axis of the apron. Thus if a break-out occurs in metal strand 19 the resultant flowerling will not cause the strand to jam between rollers 63 in apron 50 since the strand, being still malleable, will snake between the rollers until the line can be shut down, thus avoiding damage to the rollers and a strain on the withdrawal mechanism as well as preventing further rupture of the strand. The staggered roller arrangement will also permit the continuation of the casting if the nature of the break-out is of the so-called "healing" type.

Roller apron 50 is built up of arcuate sections of channels 56 and 57 joined together by centrally apertured abutment flanges 67, the upper section of the apron comprising bender section 51 and the remaining sections constituting lower guideway 52 which carries a set of terminal guide flanges 68 at its free end. Channels 56 are connected at their lower ends to a pivot 69 mounted on adjacent abutment flange 67 and are held in operable position against lugs 59a on channels 57 by a cable 70 which passes over a pulley 71 mounted on one of channels 57 and is attached to a winch 72 anchored on frame 24. The upper ends of channels 56 in bender section 51 are laterally braced by a piston 73 extending from a hydraulic cylinder 74 fixed on frame 24. Since the skin of metal strand 19 thickens as it proceeds along roller apron 50, break-out is more likely to occur in upper bender section 51 than in lower guideway section 52 and the described structure of the bender section enables it to be cleaned, without removing the whole of the apron, by releasing piston 73 and unwinding winch 72 to lower channels 56 about pivot 69 in the direction shown by arrow 75.

It will be appreciated that although an arcuate roller apron 50 has been described certain features of the construction would be applicable to aprons of other configurations such as those providing a horizontal or a vertical guideway.

Roller apron 50 as a whole, mounted on braces 53, is pivotable about base 54 by the release of piston 73 and

chain hoist 55 accompanied by the unwinding of winch 72. Apron 50 carries a pair of legs 76 engageable, when the apron is lowered, with a pair of mounts 77 fixed on a carriage 78 moveable along rails 79. By this construction apron 50 may be removed for cleaning should a break-out occur in its lower portion 52. When in operable position apron 50 bears at its upper end against a horizontally adjustable abutment screw 80 which contacts channels 57 and the apron is vertically adjustable by wedge mount 54 shown in FIGURE 4 of the drawings. Brace 53 is pivoted at its lower end though a pin 81 journaled in bosses 82 which are mounted on an upper wedge plate 83 resting on a lower wedge 84 which in turn rests slidably on a base plate 85. A worm and screw adjustment 86 moves wedge 84 horizontally along base plate 85 which acts to move apron 50 vertically. A housing 87 for pivot assembly 54 is removable to allow pivoting of apron 50 into a lowered position to rest on carriage 78.

The inlet end of roller apron 50 is spaced a pre-determined distance below the outlet end of spray chamber 30, the spray chamber being of a length to allow strand 19 to cool sufficiently to form an outer shell or skin thick enough to withstand laterally impinging bending forces without rupturing. By allowing strand 19 to travel a given distance through an ambient (i.e. normal) temperature zone after it leaves spray chamber 30 (or any other suitable cooling chamber or zone) heat from the liquid core of the strand dissipates through the thickened skin to make it malleable for bending which is effected by rollers 63 in bender section 51 of apron 50. By this means a straight vertically oriented flow-through mold 26 is able to be employed with an arcuate roller apron 50 forming a "semi-low head" continuous casting apparatus.

A withdrawal and straightening mechanism 90 is located at the lower outlet end of roller apron 50 adjacent terminal guide flanges 68 of the apron, as shown in FIGURE 1a of the drawings. Withdrawal mechanism 90 consists of two pairs of pinch or drive rollers 91 each driven by a separate hydraulic motor 92. Each drive roller 91 is urged towards metal strand 19 by pressure from a hydraulic cylinder and piston assembly 93 mounted on a fixed frame 94 and acting against a floating frame 94a on which each drive roller is journaled. Located between the two pairs of rollers 91 is an upwardly directed roller 95, adjustable vertically by means of a worm and screw arrangement 96, which acts to straighten metal strand 19 emerging from apron 50 by bearing against its concave side. FIGURE 13 shows schematically the hydraulic flow path for motor drives 92 in which a common input conduit 97 delivers hydraulic fluid from a pressure delivery means (not shown) directly and under equal pressure in parallel to all four motors and a common output conduit 98 from the motors drive recirculates the hydraulic fluid back to the pressure delivery means. Connection of each drive motor 92 in parallel with input and output lines 97 and 98 enables strand 19 to synchronize the circumferential speed of drive rollers 91 as it is drawn by these rollers through mechanism 90, thus achieving an even distribution of traction force applied to metal strand 19 and preventing distortion or rupture of the metal strand which is still at an elevated temperature and incompletely solidified when passing through mechanism 90. In the conventional operation of a withdrawal mechanism, as mentioned previously, the drive rollers are driven, usually electrically, by individual power feed lines and because of this the rollers act individually. Synchronizing mechanisms are employed but these cannot adjust for slight variations in the diameters of the drive rollers or for minor differences in the loads applied to the rollers to obtain the required traction force. Consequently the rollers in fact work against each other and to achieve the required traction force through only one effective roller a substantially increased load is impressed transversely through that roller onto the billet, thus often exceeding the permissible load limit and deforming or rup-

turing the strand. This defeats the purpose of having a multiplicity of drive rollers to distribute the load and reduce that applied by individual rollers to the strand. By providing individual hydraulic motors 92 connected in parallel according to the present invention the pressure input of the hydraulic system varies with the least load on drive rollers 91 thus making it impossible to damage the strand or the mechanism as long as a normal load is impressed on each roller. If the load impressed on a particular drive roller 91 is too small and/or slippage occurs between a roller and strand 19 then the torque on the remaining drive rollers will decrease until the particular roller again picks up its share of the load, i.e., provides its share of the traction force output. This method and apparatus would be equally applicable whether the drive rollers are applied against one or both sides of a strand.

FIGURES 1b, 2, 3, 6, 9 and 14 of the drawings show a starting chain 100 comprising a series of blocks 101 connected or coupled by pairs of link plates 102. A lateral pin 103 pivotally connects each pair of link plates 102 to each block 101 and carries at each end a roller 104 located outside the adjacent link plate whereby the rollers are journaledly mounted on the chain. As shown in FIGURE 6 of the drawings, rollers 104 are spaced apart a distance sufficient to bridge the space between lower channels 56 of roller apron 50, inner flanges 56a of channels 56 being used as tracks or rails for the chain rollers and inner flanges 57a of channels 57 being used as upper guides. One end of starter chain 100 carries a head 105 (see FIGURES 2 and 3) dimensioned or configured to plug the outlet opening of mold 26. In the first portion of the length of chain 100 immediately adjacent head 100, say ten feet, blocks 101 carry a self-locking and self-releasing device 106 shown in FIGURE 14 of the drawings which consists of a compression spring 107 located in a bore 108 in block 101 parallel to and adjacent each pin 103. Spring 107 bears at each end against a ball 109 which is partially received or seated in a circular depression or recess 110, located in the inner face of each adjacent link plate 102, when the longitudinal axes of each block 101 and connecting link plates 102 are parallel, i.e. when that portion of chain 100 is straight. When a predetermined degree of force is applied laterally to chain 100 through a pair of rollers 104 then balls 109 at each end of spring 107 will disengage from depressions 110 in link plates 102 associated with those particular rollers allowing the chain to flex laterally between that block 101 associated with the particular rollers and the adjacent connecting link plates. This construction imparts lateral rigidity to starter chain 100 in the area between the bottom outlet opening of mold 26 and the top end of roller apron 50. It will be appreciated that the provision of such a flexible starting chain 100 would necessitate an increase in the number of guide rolls 63 in a conventional roller apron to prevent the chain from buckling but rollers 104 on chain 100 perform this function as they pass along guideway 58 between opposing flanges 56a and 57a of the two pairs of channels 56 and 57 of roller apron 50. It will also be appreciated that any suitable number of rollers 104 may be journaled along each side of chain 100, either in pairs or singly. Starter head 105 is detachable from starting chain 100 by means of inter-engaging latch members 111 formed on the end of head 105 and on the end of first block 101 of chain 100, head 105 being engaged with adjacent pin 103 of the chain through a slot 112 opening from the side of the head. A cap 113 is detachably attached to head 105 through an axial rod 114 fixed to the cap which extends into the body of the head and is engaged by a shim 115.

After emerging from withdrawal mechanism 90 metal strand 19 continues onto a cutting table 120 where it is cut into billets of suitable length. Before reaching cutting table 120, starting chain 100 is automatically disengaged from the strand at its connection with head 105 and is

withdrawn by gravity to a storage area, thus requiring no synchronous drive mechanism to shunt the starting device out of the path of the strand. FIGURE 1b and FIGURE 1c of the drawings show a drop track 121 feeds from the output side of withdrawal mechanism 90 to a horizontal storage track 122 located below the line of travel of metal strand 19 as the strand emerges from the withdrawal mechanism onto cutting table 120. As shown more particularly in FIGURES 8 and 9 of the drawings drop track 121 has an inlet mouth consisting of four guide flanges 123 spaced back-to-back to provide a downwardly directed guideway track 123a for starting chain rollers 104 and a gap 123b allowing metal strand 19 to pass onto cutting table 122. Drop track 121 is joined by abutment flanges 124 to storage track 122 which consists of two parallel elongated plates 125 spaced apart horizontally and having inwardly directed flanges 126 providing a horizontal guideway track for rollers 104 of chain starter 100. Plates 125 are mounted on suitable supports 127 which also carry cutting table 120 above the storage track. Mounted on storage track 122 adjacent its end remote from drop track 121 is a hydraulic cylinder 129 having a reciprocal piston 130 which carries on its free end a pusher plate 131. Starting chain 100 is fed into withdrawal mechanism 90 by the action of cylinder 129 and piston 130 on the end of the chain which when stored bears, at its end remote from head 105, against pusher plate 131. The stroke of piston 130 need only be sufficient for head 105 of starting chain 100 to engage that pair of drive rollers 91 of withdrawal mechanism 90 nearest drop track 121, after which rollers 91 may be driven in reverse to feed the starting chain up through roller apron 50 and spray chamber 30 to plug the outlet end of mold 26.

An automatic torch cut-off mechanism 140 is shown in FIGURE 1b and more particularly in FIGURES 10, 11 and 12 of the drawings. Cut-off mechanism 140 consists of a push rod 141 freely slidable axially on rollers 142 journaled in notches 143 of a series of cross-bars 144 which are supported by upstanding pairs of legs 145 mounted on cutting table 120. Push rod 141 is thus freely movable axially in a direction parallel to cutting table 120 and the direction of a strand 19 moving on the cutting table. Push rod 141 is also rotatable about its axis. A cutting torch 146 is adjustably mounted on push rod 141 by a clamp 147 and extends downwardly towards cutting table 120. A dog 148 is also adjustably mounted on push rod 141 by a clamp 149 and is located on the rod forwardly of torch 146 in the direction of movement of metal strand 19 (to the right as seen in the drawings), extending downwardly into the path of the strand. A cam follower 150 is fixed to push rod 141 rearwardly of torch 146 and extends downwardly to engage a cam profile 151 which is fixed, parallel to rod 141, to a pair of spaced braces 151a each spanning a pair of legs 145. A weight 152 is connected to the forward end of push rod 141 by a cable 153 passing over a pulley 154 which is mounted on one of legs 145, the other end of the cable being fastened to an arm 155 fixed to the push rod. A second smaller weight 156 is fixed on cable 153 above weight 152. The profile of cam 151 consists of three sections, a first rear section 157 angled with respect to the axis of rod 141, a second intermediate section 158 parallel to the axis of rod 141 and a third forward section 159 again angled with respect to the rod axis. When torch mechanism 140 is in a position of rest cam follower 150 bears against the rearward end of section 157 of cam 151 and torch 146 is directed laterally away from strand 19 with weight 152 resting on ground level as shown in FIGURE 1b and weight 156 resting on an upper apertured support 160 fixed to one of legs 145. A shut-off valve (not shown) is connected through a conduit 158 with an oxygen supply which feeds torch 146. The shut-off valve is triggered to supply oxygen to torch 146 at the beginning of the forward stroke of rod 141 and cut off the

supply at the end of that stroke. Pairs of vertical side rollers 161 are journaled on pairs of legs 145 at each side of strand 19 to restrain the strand laterally as it moves forwardly on horizontal rollers 162 which are journaled on cutting table 120.

In the automatic operation of torch cutting mechanism 140 the position of rest of push rod 141 and its appurtenances is shown in FIGURE 10 of the drawings with cutting torch 146, dog 148 and cam follower 150 assuming positions shown in solid lines in FIGURE 11 which also shows metal strand 19 emerging from withdrawal mechanism 90 onto table 120 and meeting dog 148 located in its path. The force of strand 19 moving along table 120 and bearing against dog 148 will move push rod 141 forwardly on rollers 142 in the direction of arrows 163. Initial movement of push-rod 141 will open the oxygen supply valve to torch 146 while the torch is directed away from the strand. As push-rod 141 moves forward the interaction of cam follower 50 bearing against section 157 of cam profile 151 will cause the push-rod, together with torch 146 and dog 148, initially to rotate about the axis of the rod and by this rotation the torch will be brought to point to the edge of strand 19. When cam follower 150 reaches section 158 of cam profile 151 which is parallel with the longitudinal axis of push rod 141 the push rod stops its rotational movement, thus allowing torch 146 to pre-heat the edge of strand 19 while the push rod and strand continue to move forward. When cam follower 150 reaches and moves along section 159 of cam 151, push rod 141 will again rotate about its axis as well as moving forward and strand 19 will be severed to form a billet 173 of a desired length (which has been determined by presetting the distance between torch 146 and dog 148). As cam follower 150 reaches the forward end of section 159 of cam profile 151 the oxygen supply valve is automatically cut off and also dog 148 moves out of the path of strand 19 which allows weight 152 to return push rod 141 to its original position of rest. Weight 152 is brought to rest before the completion of return travel of push rod 141 and the rod is moved the remaining distance by the action of smaller weight 156 which decreases the momentum of the mechanism as it approaches the final rearward stop. In the rearward position of rest of push rod 141 clamp 147 of torch 146 bears against a pair of supporting legs 145 and dog 148 is again located in the path of strand 19. The paths of travel and final forward positions of cam follower 150, torch 146 and dog 148 are shown by dotted arrows and lines in FIGURE 11 of the drawings.

Positioned forwardly of cutting table 120 is a discharge table 170 as shown in FIGURE 1c of the drawings, the two tables forming a continuous rolling surface. A plurality of rollers 171 journally mounted on table 170 are rotated at a circumferential speed faster than the travelling speed of metal strand 19 to clear each severed billet 173 from the strand and allow movement of dog 148 back into the path of the strand. A billet stop 172 is located adjacent the end of discharge table 170 remote from cutting table 120 to arrest further forward movement of the billet which is then removed laterally from the discharge table to a storage area.

I claim:

1. In a continuous metal casting apparatus the combination comprising:

- (a) an elongated starting member comprising:
 - (i) an articulated chain assembly including a plurality of elements coupled together in series one with another by transverse pins, with

- (ii) a plurality of pairs of rollers oppositely journaled to said pins, and with
- (iii) a head portion attached to one end of said chain assembly; and

- (b) a roller apron having a pair of laterally spaced-apart tracks engaged by said rollers for supporting said starting bar member and for the passage of said starting member therealong.

2. A starting device for use in a continuous metal casting apparatus having a flow-through mold, comprising: a plurality of elements coupled in series by lateral pins journaled therein to form an elongated articulated unit, a plurality of rollers carried by certain of said pins at spaced intervals along each side of said unit, and a head detachably coupled with the terminal element of said unit and adapted to plug the outlet of the flow-through mold.

3. A starting device as claimed in claim 2 in which the elongated articulated unit is a block chain comprising a series of blocks connected one with another through said pins by pairs of link plates.

4. A starting device as claimed in claim 3 including a releasable locking means engaging at least those elements in the portion of the unit within a selected distance of the head, said locking means comprising a bore in each block adjacent and parallel to each pin journaled therein, a compression spring located in the bore, a recess in the face of each link plate adjacent the bore and in axial alignment with the bore when the longitudinal axes of the link plates and the block are parallel, means adapted to seat in each recess and urged therein by said spring, said seating means being forced out of said recess on flexing of the pair of link plates out of axial alignment with the adjacent block.

5. In a continuous metal casting apparatus having a flexible starting device carrying rollers laterally therealong, storage means for said starting device comprising a pair of laterally spaced tracks having inlet means adapted to receive the starting device operatively moving in the casting apparatus but to pass a strand formed thereby, said tracks being positioned to receive the starting device by gravity feed, and means to feed the starting device back into operative position.

6. Apparatus as claimed in claim 5 in which the tracks are located below the line of travel of the strand and substantially parallel therewith.

7. Apparatus as claimed in claim 5 in which the inlet means is positioned adjacent a reversibly operable withdrawal mechanism moving said strand and the means to feed the starting device back into operative position comprises a movable pusher plate bearing against that end of the starting device stored in the storage means remote from the inlet means, said pusher plate being actuable to move the stored starting device into engagement with the withdrawal mechanism.

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Notice of Adverse Decisions in Interferences

In Interference No. 97,430 involving Patent 3,495,651, J. Rokop and L. J. Gibson, STARTING DEVICE FOR CONTINUOUS CASTINGS, final judgment adverse to the patentees was rendered June 25, 1973, as to claims 1, 2, 3, 5, 6 and 7.

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