Oct. 3, 1967 K. REINFELD ETAL 3,344,844

APPARATUS FOR HANDLING A CURVED CONTINUOUS CASTING STARTING BAR

Filed Aug. 10, 1964 2 Sheets-Sheet 1

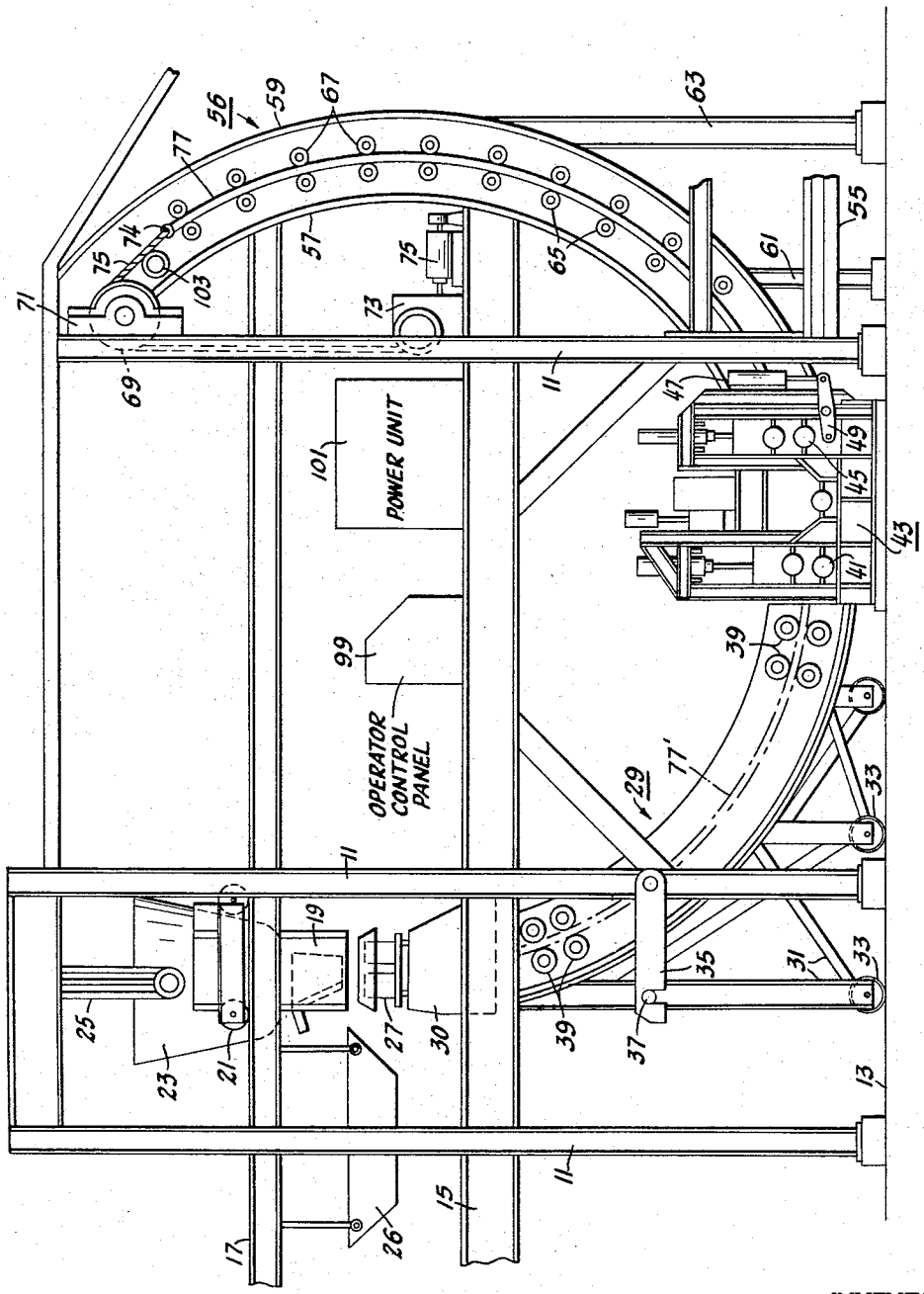


FIG. 1

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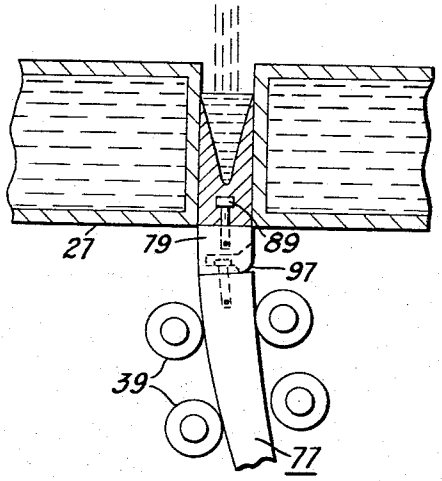


FIG. 2

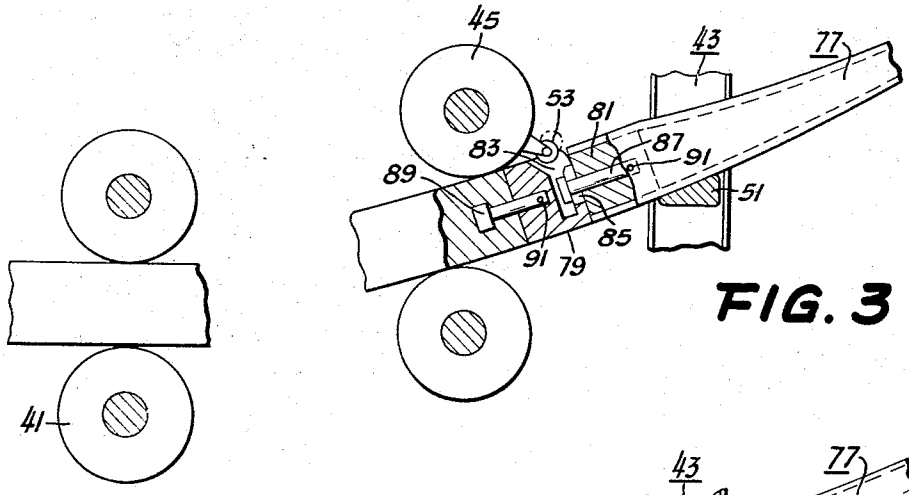


FIG. 3

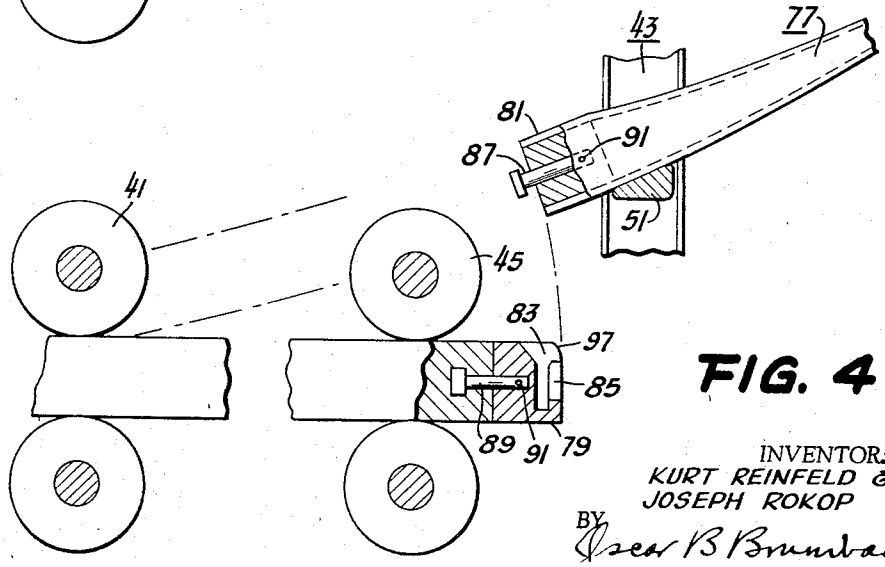


FIG. 4

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APPARATUS FOR HANDLING A CURVED CONTINUOUS CASTING STARTING BAR

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The present invention relates to the art of continuous metal casting and, more particularly, to improved apparatus and method for producing continuous metal castings.

The casting of a continuous strand of metal involves pouring molten metal into a flow-through type of casting mold, which confines the molten metal and partially shapes it to a desired cross section, and withdrawing the metal from the mold as an elongate continuous strand or billet. The casting mold is usually established at a convenient fixed level above a working area, and a ladle of molten metal is transported by a vehicle or crane to a position above the casting mold and machine.

Before teeming the ladle and starting the strand, it is first necessary to temporarily close the bottom of the mold to prevent the molten metal from simply running through the open bottom end of the mold. The open bottom end of the mold is usually closed by means of a dummy bar or starting bar, which is threaded through a customary set of pinch rolls located below the mold for the purpose of driving the dummy bar or starting bar up into the bottom of the mold and later withdrawing it. After the starting bar has been driven into the bottom of the mold, the clearance gap between the head end of the starting bar and the walls of the mold is then sealed with a suitable refractory material. The mold is now ready to receive molten metal from the ladle and a preheated tundish.

Once the mold is prepared to receive the molten metal, the ladle is teemed or discharged into a rectangular trough called a tundish located between the ladle and the mold and from which the metal flows directly into the casting mold. The molten metal first entering the mold is allowed to solidify and become fastened to the head end portion of the starting bar. After the molten metal has risen to some predetermined level in the mold, the mold may be oscillated or reciprocated to prevent sticking of the casting to the mold walls, and the pinch rolls may be actuated to start withdrawing the starting bar and casting from the mold.

The steel continues to solidify as the strand is withdrawn, and a thin skin, which forms on the surfaces of the strand adjacent the inner walls of the mold, thickens as the metal is pulled through the mold. To hasten cooling and to increase the thickness of the skin, the strand is usually passed through a cooling chamber located below the mold where it is sprayed with water from an array of nozzles. The solidifying strand, still at red heat, is pulled by the pinch rollers from the mold in synchronism with the rate of pouring metal into the mold so that the level of the liquid metal in the mold is maintained at a substantially constant level and the strand is formed in a steady continuous manner. At a convenient level below the mold the starting bar is disconnected from the strand and the strand is cut into convenient lengths for subsequent reduction in size.

Two general types of continuous casting machines are employed. One type of machine is known as a vertical cut-off casting machine wherein the casting is withdrawn in a vertical position and is cut to desired lengths at some point below the mold. In such machines, a straight rigid starting bar is used, and after the casting has descended and passed through the pinch rolls, the starting bar is disconnected from the strand and is stored in a convenient position until it is needed for the next casting. The other type of machine is called a horizontal cut-off casting machine wherein the casting is bent from the vertical and is guided by a chute toward a horizontal attitude.

Two main types of horizontal machines exist; one employs a vertical roller apron above a set of pinch rolls and the other employs a curved roller apron and no pinch rolls. A horizontal cut-off casting machine also employs a set of straightener rolls between which the casting passes and from which it emerges as a straightened horizontal casting.

Vertical cut-off casting machines require an installation which are generally too large to be practical or economical. Horizontal cut-off casting machines, on the other hand, obviously do not require as large an installation as the vertical cut-off machines and for that reason they are more practical and economical. On some horizontal machines, a straight rigid starting bar is used wherein the bar is bent and straightened on each cast. However, repeatedly bending, straightening, and bending the rigid starting bar deforms it to such an extent that it is no longer useful.

It has been proposed heretofore to use articulated starting bars which readily bend and conform to the geometry of the curved roller apron structure, without the attendant difficulties of the straight rigid bar which must be continually bent and straightened. One form of articulated starting bar, of the sort mentioned, is described in U.S. Patent No. 2,920,359. Such starting bars, however, after being disconnected from the strand, must still be removed and stored in some location near the casting machine until they are to be used again. In the overall operating time to make a casting, the time lost in picking up the stored starting bar, threading it back into the machine, and the time to disconnect it and place it back in storage, can become a serious economic factor.

The present invention relates to apparatus and method for handling curved rigid starting bars of a type useful in horizontal cut-off casting machine. In accordance with the present invention, there is provided a curved starting bar supporting structure, which adjacently is positioned opposite the discharge end of a horizontal cut-off continuous casting machine, and on which a curved rigid starting bar may be conveniently stored when not in use. In a further aspect of the present invention, straightener rolls engage the curved rigid starting bar and drive it upward into operative engagement with the mold and withdraw it and the casting from the mold; the straightener rolls incorporating a novel mechanism for disconnecting the head end of the starting bar from the casting.

For a further understanding of the present invention and for advantages and features thereof, reference may be made to the following description taken in conjunction with the accompanying drawings forming a part of this application in which:

FIG. 1 is a schematic elevational view of a horizontal cut-off continuous casting machine incorporating an embodiment of the present invention;

FIG. 2 is a schematic view, partly in section, showing the head end of the starting bar in mated relationship to a casting mold;

FIG. 3 is a schematic view, partly in section, showing the head end of the starting bar and the casting in relation to the disconnect apparatus; and

FIG. 4 is a schematic view, partly in section, showing the starting bar disconnected from the casting.

Referring to the drawings, FIG. 1 illustrates a portion of a continuous casting machine including a plurality of vertical columnar members 11, which are fixed to and

rise above a working floor or ground level **13**, and which support a plurality of horizontal girders **15** and **17** forming working support levels above the floor or ground level **13**. The upper horizontal girders **17** support a conventional movable tundish **19**, which is supported by or suspended from a suitable support carriage **21** that is rollable on the horizontal girders **17**.

A conventional ladle **23** is shown in an operative position directly above the tundish **19**. The ladle **23** is supported in a conventional manner by an arrangement of cables **25**. A conventional spill-over box **26** is also suspended from the upper horizontal girder **17** and below the tundish **19**.

Below the tundish **19** and ladle **23**, there is a continuous type of vertical flow-through casting mold **27**, which is established and fixed on the lower horizontal girders **15**. Beneath the mold **27**, there is positioned a conventional type of curved roller apron structure **29**, having a typical water cooling spray section enshrouded by an enclosure **30**.

It is generally desirable to support the roller apron structure **29** on a suitable framework **31**, which includes a plurality of wheels **33** that bear and roll upon suitable rails (not shown) fastened to the working floor or ground level **13**. The apron structure **29** and framework **31**, may be readily maintained in an operative position, about where shown in FIG. 1, by means of latch arms **35**, which are pivotally connected to the upright columnar members **11**, and which engage suitable latch pins **37** fixed to the framework **31**.

The arcuate roller apron structure **29** includes a plurality of spaced apart guide rollers **39**, upon which the casting is supported as it is withdrawn from the mold. The apron structure is positioned, preferably, so that the upper end is substantially vertical and adjacent the bottom of the fixed mold **27**. The lower end of the apron structure extends generally horizontally and at a convenient level above the working floor or ground level **13**. Moreover, the curvilinear axis of the apron structure is generally coplanar with the vertical axis of the mold, the tundish, and the ladle.

Preferably, the axis of the apron structure, at the lower horizontal end, is at substantially the same level as a first entrance set of straightener rolls **41**, in a straightener apparatus **43**, which is fixed to the working floor or ground level **13**. The straightener apparatus **43** also includes a second exit set of straightener rolls **45**, which are adjustable and movable vertically by means of a suitable ram cylinder **47** and link mechanism **49**, mounted conveniently on the straightener apparatus, about as shown in FIG. 1.

Adjacent to and just beyond the vertically movable straightener exit rolls **45**, there is a triangular shaped stop bar **51** (see FIG. 3), which is mounted rigidly to the frame of the straightener apparatus **43** in a manner such that the stop bar **51** is generally perpendicular to the plane of the casting machine. Also, there is mounted near the upper straightener exit rolls **45**, a conventional roller type limit switch **53**, which is for a purpose to be described hereinafter.

To the right of the straightener apparatus **43**, as viewed in FIG. 1, there is a conventional casting take-off apparatus **55**, on which the straightened casting is supported as it moves toward a conventional cut-off mechanism, not shown.

Just above the casting take-off apparatus **55**, there is provided an arcuate starting bar rack structure **56**, the axis of which is substantially coplanar with the axis of the roller apron structure **29** and the casting mold **27**. The starting bar rack structure **56** includes a pair of arcuate spaced apart parallel plates **57**, **59**, which may be maintained in such relation by being fixed to the horizontal girders **15**, **17**, and to a plurality of vertical support columnar members **61**, **63**, or in any other appropriate manner.

Between the spaced apart plates **57**, **59**, there may be mounted, in any suitable manner, a plurality of guide rollers **65** and support rollers **67**, which are conveniently disposed oppositely and in spaced apart relation, about as shown in FIG. 1. The rollers **65**, **67** are spaced apart a distance sufficient to accommodate a curved starting bar **77**, when the same is disposed therebetween in a manner to be described hereinafter.

Above the upper horizontal girder **17**, there is provided a conventional type sheave **69**, which may be mounted in a vertical position, about as shown in FIG. 1, in a suitable bearing support **71** which may be fixed to the columnar members **11**. Below the sheave **69**, there is provided a suitable hoisting mechanism **73**, which may be conveniently powered by an electric motor **75**; both of which are fixedly mounted on the lower horizontal girders **15**. The hoisting mechanism **73** is positioned, preferably, so that a hoisting cable **75**, that is wound on the hoisting drum, passes over the sheave **69**, and is connectable to a suitable joining eye **74**, fixed in one end of the curved starting bar **77**. The curved startting bar **77** is shown in its stowed position in FIG. 1, from which position it is readily removable at the commencement of a casting, as will be described hereinafter.

Referring to FIG. 3, the lower end, or what is actually the head end of the starting bar **77**, includes first and second body portions **79**, **81** that are detachably connected together. The first body portion **79** has a cross section that is generally rectangular or square and, a length which is substantially equal to the width of the casting. The first body portion **79**, moreover, has a plurality of slots **83**, which have a generally Y-shape configuration, similar to that shown in FIG. 3. There is provided in the right hand wall forming the vertical leg of the Y, another rectangular slot **85**. A bolt-like member **87** is fixed to and projects outwardly from the body portion **81** in such a manner that the shank of the bolt **87** is received in the slot **85**, and the head of the bolt is received in the slot **83**. A similar bolt-like member **89** is fixed to and projects from the first body portion **79**.

As may be seen in FIG. 2, when the head end portion of the starting bar is positioned in mated relationship with the casting mold, the bolt-like member **89** projects into the bottom portion of the mold and becomes fixed to the solidified initial portion of the casting, when it is poured. Each of the bolt-like members **87**, **89** may be readily maintained in its respective body portion **81**, **79**, by means of suitable keeper pins **91**, or in any other appropriate manner. To facilitate disconnecting the first body portion **79** from the second body portion **81**, the upper part of the surface of the body portion **79**, which abuts the body portion **81**, is curved, about as shown in FIGS. 3 and 4.

Referring to FIG. 1, it is convenient to assume that a continuous casting has just been completed and that another is to be commenced. The starting bar **77** at this time is in its stowed position in the starting bar rack structure **56**, and it is held in this stowed position by the hoisting cable **75** and hoisting mechanism **73**. The casting machine may be conveniently operated from a control console or panel **99** located on the lower horizontal girders **15**, at which location, an operator regulates and controls the power output from a power unit **101**, conveniently located nearby, to operate the casting machine.

The exit straightener rolls **45** are first raised to the position shown in FIG. 3, and then opened or separated a distance great enough to admit the starting bar **77**, which, at the same time, is being lowered from the rack structure until the head end of it passes between the exit straightener rolls **45** and between the entrance straightener rolls **41**. The entrance straightener rolls **41** may then be actuated to drive the starting bar **77** upward toward the mold **27**.

It will be noted that the hoisting cable **75**, as it pays out to lower the starting bar, may be guided by a suit-

able guide roller **103**, fixed to the starting bar rack structure, and by the other guide rollers **65**. The starting bar **77** is driven upward by the straightener rolls **41** until the head end abuts the mold in mating relationship, about as shown in FIG. 2. The joint between the mold and the head end may now be suitably sealed with a suitable refractory material to prepare the mold to receive molten metal. The ladle, with molten metal therein, may thereupon be teemed, and the metal flows into the tundish and into the mold to initiate the casting.

After the casting has become inseparably connected to the bolt-like member **89**, the straightener rolls **41** may be reversed to withdraw the starting bar and the casting from the mold. The starting bar will follow the curvature of the apron structure to which it is conformable, and the lower end of the starting bar again passes between the spaced apart vertically movable exit straightener rolls **45**. The starting bar will then enter between the rollers **65**, **67** in the starting bar rack structure **56**. The curved roller apron structure and the starting bar rack support structure have, peferably, the same curvature so that there will be no bending forces exerted on the starting bar. The entrance straightener rolls **41** continue to withdraw the starting bar and casting from the mold at substantially the same rate of speed as the casting is being formed in the mold. It will be appreciated by those skilled in the art, that in the present invention there is no need to employ the usual set of pinch rolls which ordinarily engage the starting bar and drive it into the mold, and later withdraw it and the casting from the mold. In the present invention, the starting bar, being a curved rigid member, may be readily moved forward and backward by the straightener rolls. One purpose of the straighteners rolls is to advance and retract the curved starting bar without deforming it. So, too, the straightener rolls later engage the casting when it has grown sufficiently in length and passes through the straightener rolls. By the time the straightener rolls engage the casting, it is solid throughout and there is little or no danger of inducing cracks, flaws and other defects.

After the head end of the starting bar and casting have passed through the exit straightener rolls **45**, and are in a position about as shown in FIG. 3, a limit switch, not shown, is actuated by the roller contact member **53** falling into one of the Y-shaped slots **81**. The downward movement of the roller contact member causes the ram cylinder **47** to move the pivotal link member **49** so that the straightener rolls **45** move rapidly downward. In doing so, they exert a downward force on the end of the casting and the starting bar to which it is connected. However the tapered end portion of the starting bar bears against the stop bar **51** and is restrained from downward movement. Consequently, the bolt-like member **87** becomes disengaged from the slots **83**, **85** and the first body portion **79** is separated downwardly from the second body portion **81**.

During the downward motion of the rolls **45** to disconnect the casting from the starting bar, the hoisting mechanism **73** is actuated to exert a pulling and restraining force on the starting bar which is sufficient to hold it, and to advance it upwardly further into the storage rack. After the casting has been disconnected, it will be straightened in the usual manner and directed horizontally, about as shown in FIG. 4. The casting moves toward the casting take-off apparatus, mentioned previously; the driving force being exerted by the entrance set of straightener rolls **41**.

After a casting has been completed, the same curved starting bar is readily available and may be quickly positioned, as described hereinbefore, to commence another casting.

We claim:

1. A starting system for a continuous metal casting machine having an arcuate roller apron structure with an entrance end adjacent the bottom of a fixed vertical flow-through casting mold and a discharge end oriented in a substantially horizontal direction, comprising:

(a) an arcuate rigid starting bar conformable to the curvature of said arcuate roller apron structure;

(b) staightener apparatus adjacent the discharge end of said apron structure and having a set of first roller members for advancing said arcuate starting bar into mating relation with said casting mold and for controllably withdrawing said bar and casting from said mold, said straightener apparatus having a set of second movable vertically opposed rollers capable of operating upon said bar and casting;

(c) a starting bar support adjacent said straightener apparatus and substantially coplanar with said roller apron structure for receiving and supporting said starting bar;

(d) a limit switch actuatable at a predetermined moment after the end portion of said casting has passed between said vertically opposed rollers to move said rollers downward rapidly and disconnect said starting bar from said casting; and

(e) a hoisting mechanism fixed to said starting bar support and having a cable connected to said arcuate starting bar whereby said starting bar engages said starting bar support and said bar is maintained in said support.

2. A starting arrangement for a continuous metal casting machine having an arcuate roller apron structure with an entrance end adjacent the bottom of a fixed vertical flow-through casting mold and a discharge end oriented in a substantially horizontal direction, comprising:

(a) an arcuate rigid starting bar conformable to the curvature of said apron structure; and

(b) straightener rolls positioned adjacent the discharge end of said apron structure and adapted to operate upon said arcuate starting bar for advancing the same into mating relation with said casting mold and controllably withdrawing said bar and casting from said mold.

3. A starting arrangement for a continuous metal casting machine having an arcuate roller apron structure positioned with its entrance end adjacent the bottom of a vertical flow-through casting mold, and its discharge end oriented in a substantially horizontal direction, comprising:

(a) an arcuate rigid starting bar conformable to the curvature of said arcuate roller apron structure;

(b) straightener apparatus positioned adjacent the discharge end of said apron structure and having a set of first roller members for advancing said starting bar toward said casting mold and controllably withdrawing said bar and casting from said mold, said straightener apparatus having a set of second vertically movable roller members capable of operating upon said bar and casting;

(c) a stop bar fixed in relation to said vertically movable roller members and downstream therefrom;

(d) an arcuate structure positioned adjacent said straightener apparatus and substantially coplanar therewith, said arcuate structure being conformable to the curvature of said arcuate rigid starting bar and adaptable to support the same;

(e) means actuatable at a predetermined moment after an end portion of said casting has passed between said vertically movable roller members and said starting bar bears against said stop bar whereby said vertically movable roller members descend rapidly and disconnect said starting bar from said casting; and

(f) means for supporting and maintaining said starting bar in said arcuate structure.

4. A starting arrangement for a continuous metal casting machine having an arcuate roller apron structure positioned with its entrance end adjacent the bottom of a vertical flow-through casting mold, and its discharge end oriented in a substantially horizontal direction, comprising:
(a) an arcuate rigid starting bar conformable to the curvature of said arcuate roller apron structure;
(b) means for advancing said starting bar toward said casting mold and controllably withdrawing said bar and casting from said mold;
(c) an arcuate structure adjacent said starting bar advancing means and substantially coplanar with said apron structure, said arcuate structure being conformable to the curvature of said arcuate rigid starting bar and adaptable to support the same;
(d) means actuatable at a predetermined moment after said bar has been received by said arcuate structure to disconnect said casting from said starting bar; and
(e) means for maintaining said starting bar in said arcuate structure.

5. A continuous metal casting machine comprising:
(a) a vertical flow-through casting mold;
(b) an arcuate roller apron structure positioned with its entrance end adjacent the bottom of said mold and its discharge end oriented in a substantially horizontal direction;
(c) an arcuate rigid starting bar conformable to the curvature of said arcuate roller apron structure;
(d) means for advancing said starting bar toward said casting mold and controllably withdrawing said bar and casting from said mold;
(e) an arcuate structure adjacent said starting bar actuating means and substantially coplanar with said apron structure, said arcuate structure being conformable to the curvature of said arcuate rigid starting bar and adaptable to support the same;
(f) means actuatable at a predetermined moment after said bar has been received by said arcuate structure to disconnect said casting from said starting bar; and
(g) hoisting means to elevate and maintain said starting bar in said arcuate support structure.

6. A starting arrangement for a continuous metal casting machine, comprising:
(a) a rigid arcuate starting bar;
(b) an arcuate structure adjacent to and lying substantially in the vertical plane of said machine for receiving and supporting said arcuate starting bar; and
(c) means for maintaining said starting bar in an elevated position adjacent said machine and for lowering said starting bar from said arcuate structure to operatively coact with said machine.

7. A horizontal cut-off continuous metal casting machine comprising:
(a) a vertical flow-through casting mold;
(b) an arcuate roller apron structure for supporting said casting;
(c) a rigid arcuate starting bar conformable to and cooperative with said apron structure;
(d) means actuatable at a selected time to disconnect said starting bar from said casting;
(e) an arcuate structure adjacent to and lying substantially in the vertical plane of said machine for supporting said arcuate starting bar in an elevated position after the same has been disconnected from said casting and maintaining said bar adjacent said machine in such a manner that said starting bar may be lowered from said support structure to operatively coact with said machine; and
(f) powered means to elevate and maintain said starting bar in said support structure.

8. A horizontal cut-off continuous metal casting machine comprising:

(a) a vertical flow-through casting mold;
(b) an arcuate roller apron structure capable of supporting said casting;
(c) a rigid arcuate starting bar conformable to and cooperative with said apron structure;
(d) powered roller means adjacent said apron structure engageable with said starting bar to drive said bar into operative relation with said mold and withdraw said bar and casting from said mold;
(e) means actuatable by said starting bar for disconnecting said starting bar from said casting;
(f) an arcuate structure adjacent to and lying substantially in the vertical plane of said machine for supporting said arcuate starting bar in an elevated position after the same has been disconnected from said casting and maintaining said bar adjacent said machine in such a manner that said starting bar may be lowered from said support structure to operatively coact with said machine; and
(g) means for elevating and maintaining said starting bar in said support structure.

9. A continuous metal casting machine of the horizontal cut-off type comprising:
(a) a vertical flow-through casting mold;
(b) an arcuate roller apron structure positioned with one end adjacent the bottom of said mold and with the other end oriented in a substantially horizontal direction, said apron structure and said mold being substantially coplanar;
(c) a rigid arcuate starting bar conformable to and cooperative with said apron structure and said mold;
(d) straightener apparatus positioned adjacent the discharge end of said apron structure and having a set of first powered roller members engageable with said starting bar for driving said bar toward said casting mold and controllably withdrawing said bar and casting from said mold;
(e) a set of vertically movable roller members adjacent said straightener apparatus and positioned downstream therefrom which are capable of operating upon said casting to exert a downward force thereon;
(f) an arcuate structure adjacent to and lying substantially in the vertical plane of said machine for supporting said arcuate starting bar in an elevated position after the same has been disconnected from said casting and maintaining said bar adjacent said machine in such a manner that said starting bar may be lowered from said support structure to operatively coact with said machine;
(g) means for restraining said starting bar from downward movement relative to said casting;
(h) means for moving said vertically movable roller members downward at a predetermined moment and disconnecting said casting from said starting bar; and
(i) hoisting means connected to said starting bar for elevating the same in said arcuate structure after said bar has been disconnected from said casting, and maintaining said bar in a selected position in said arcuate structure.

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