United States Patent [19]

Follrath et al.

[11] **3,908,746**

[45] **Sept. 30, 1975**

[54] **CONTINUOUS CASTING MACHINE**

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[73] Assignee: **Clark Automation, Inc.,** Belding, Mich.

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[21] Appl. No.: **346,305**

[52] **U.S. Cl.** **164/152;** 164/4; 164/70; 164/82; 164/263; 164/282

[51] **Int. Cl.** **B22d 11/12**

[58] **Field of Search** 164/4, 70, 82, 89, 152, 164/263, 269, 277, 282

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Primary Examiner—R. Spencer Annear
Attorney, Agent, or Firm—Wolfe, Hubbard, Leydig, Voit & Osann, Ltd.

[57] **ABSTRACT**

A horizontal continuous metal casting system adapted to efficiently and safely cast a metal ingot and cut the ingot into predetermined lengths. The machine includes a graphite mold which is supported within an adjustably positionable water jacket and is uniformly cooled by tangentially directed streams of water about its outer periphery. The drive means for moving the emerging cast ingot in a downstream direction away from the mold includes a plurality of drive rollers that are axially movable by air cylinder actuating means to vary the roller driving pressures and to compensate for variations in the diameter of the cast ingot. The machine has various safety features including a protective enclosure for shielding the operator from the heat and splattering of molten metal flowing into the mold and rotatable gates mounted at the mouth of the mold for sensing unintended bleed-out of molten metal.

18 Claims, 14 Drawing Figures

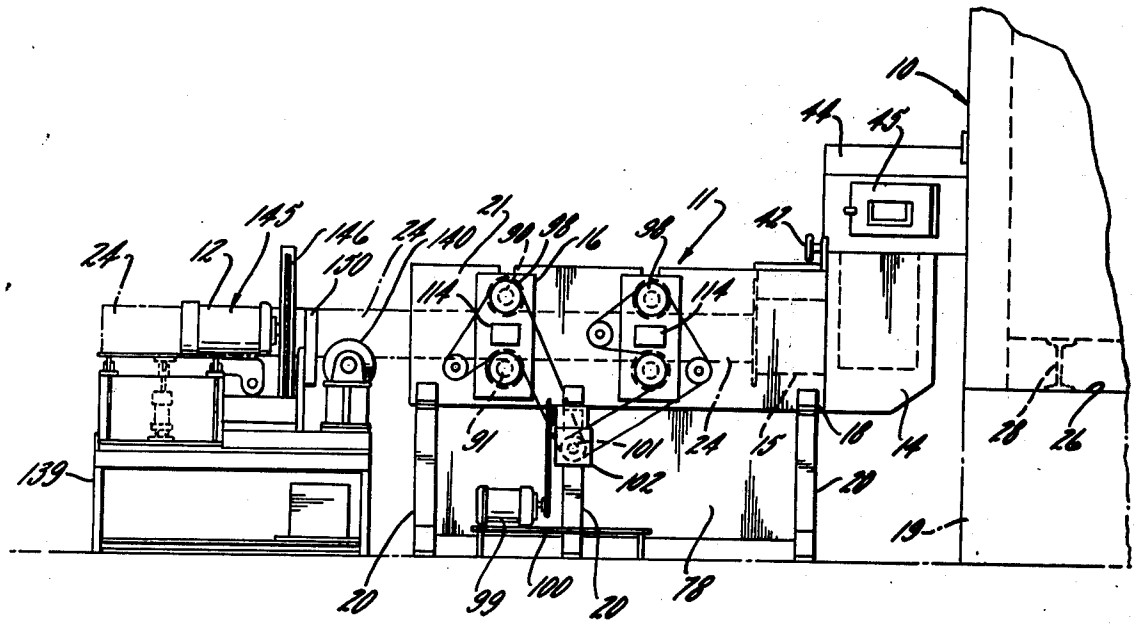


Fig. 1

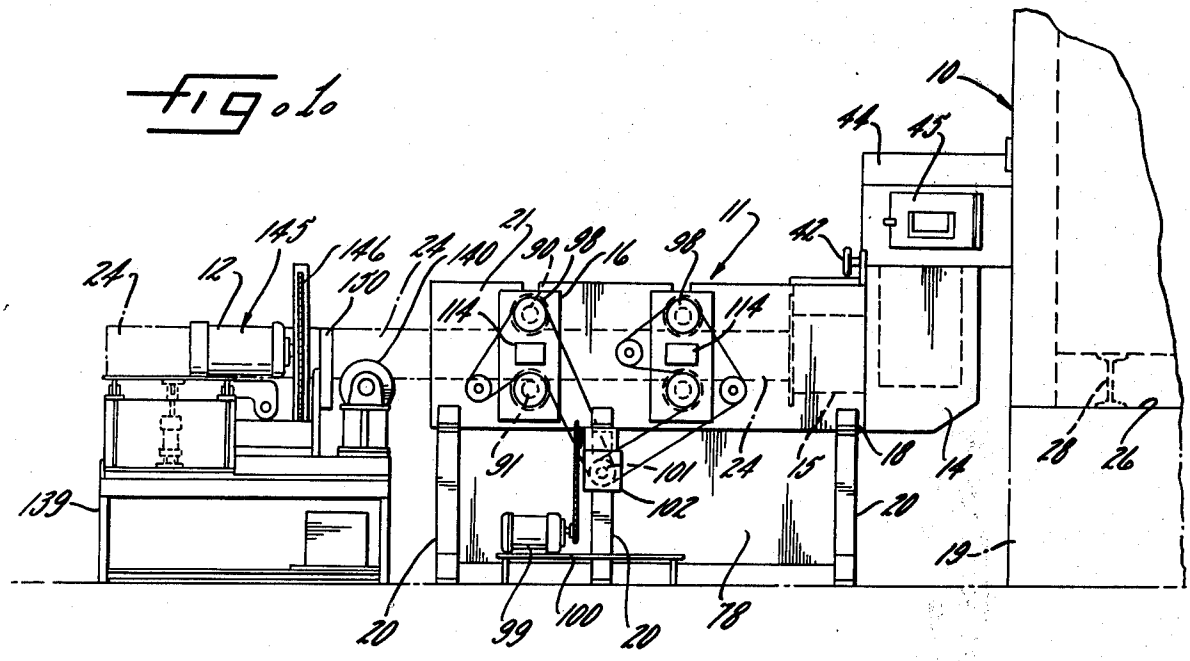

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Fig. 2

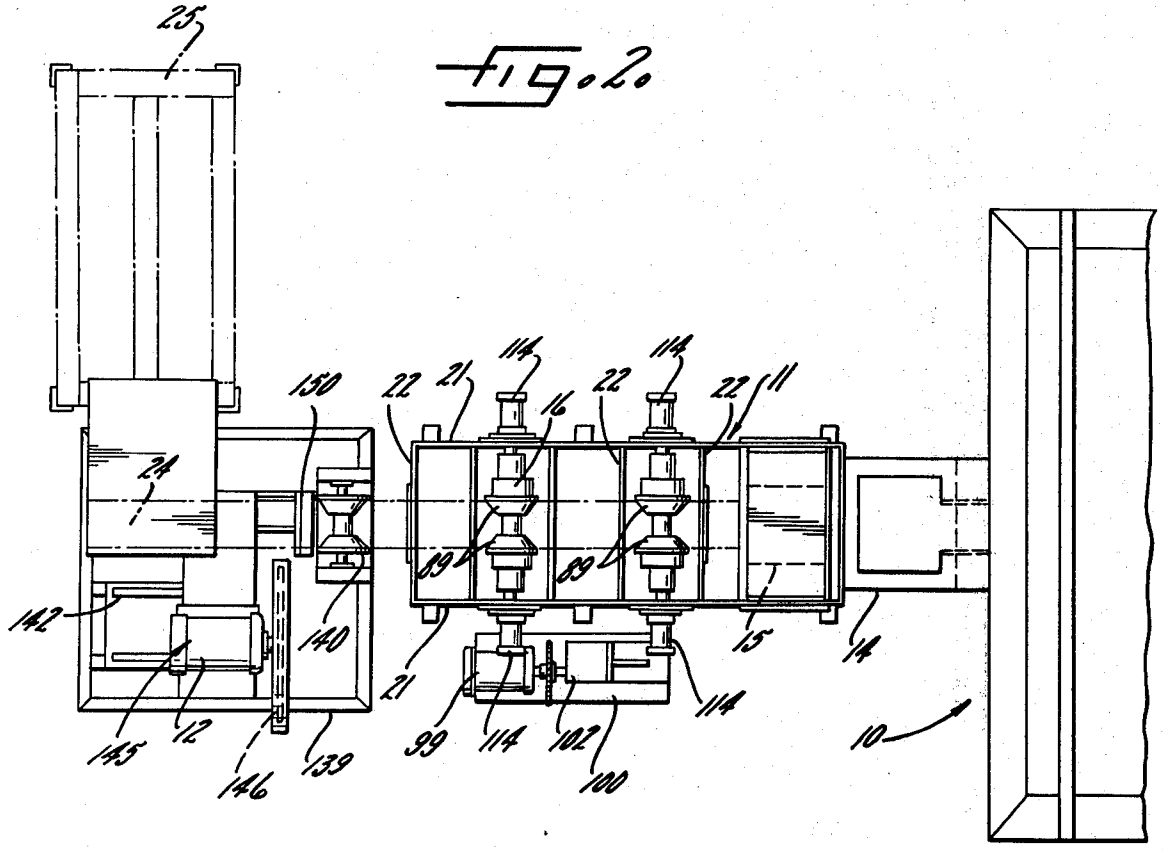

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Fig. 3

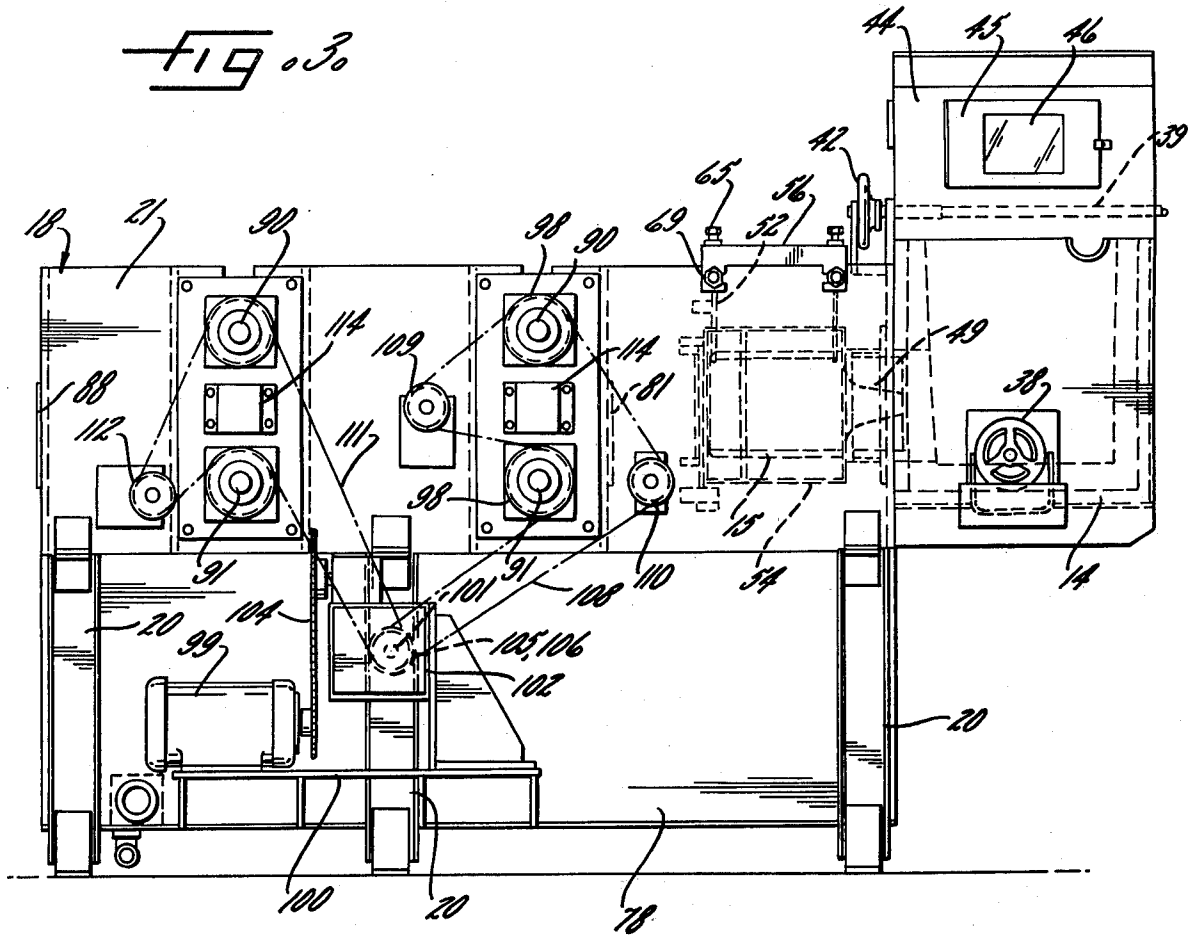


Fig. 4

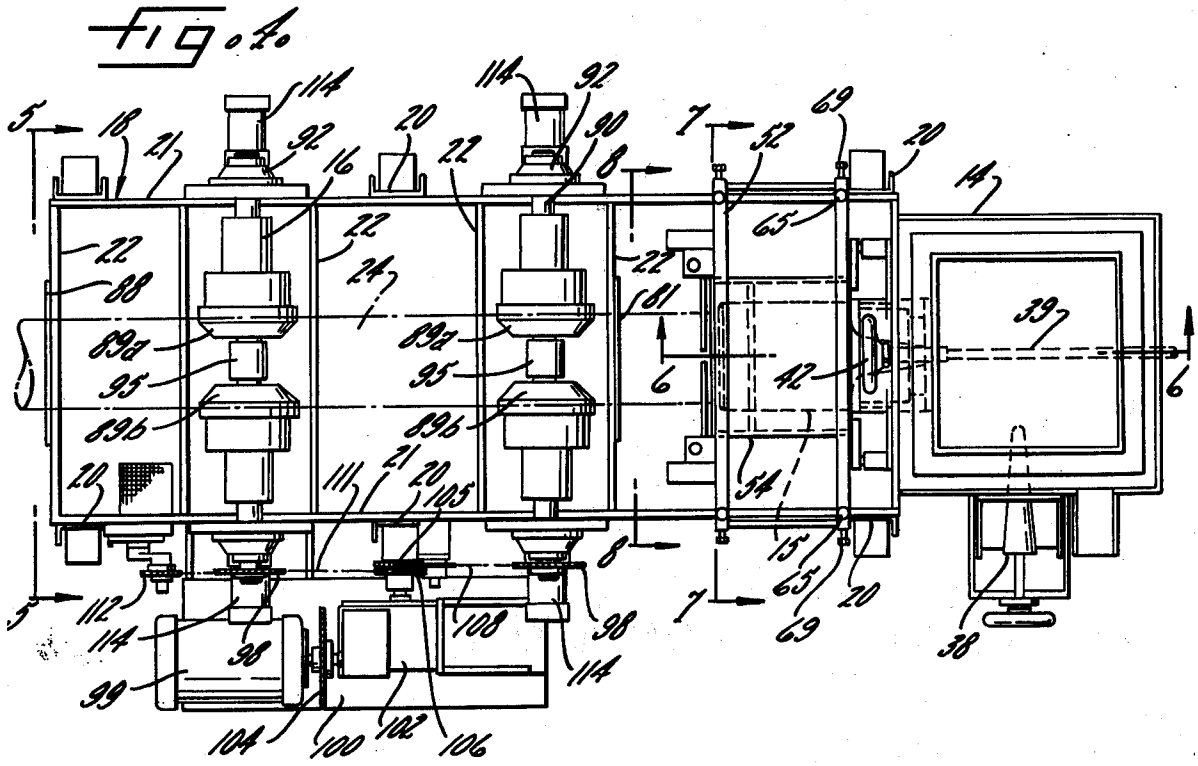


Fig. 5

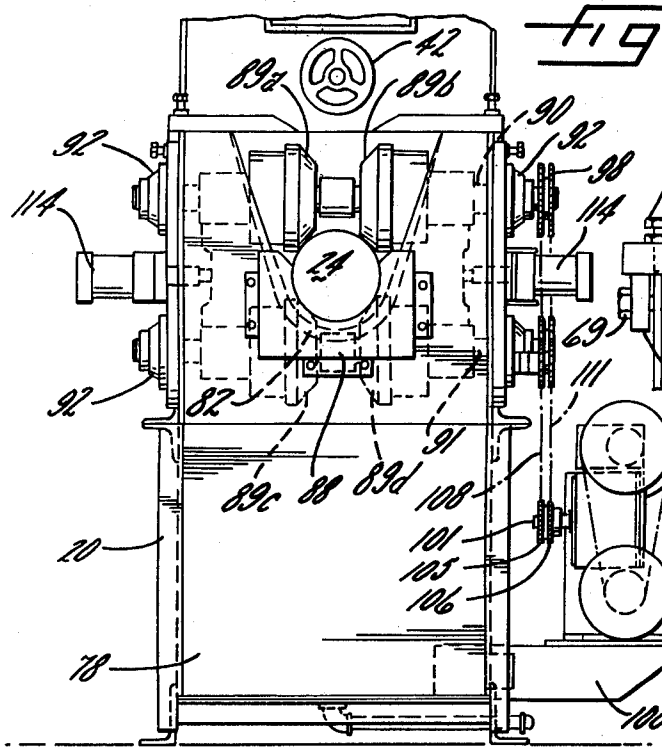


Fig. 7

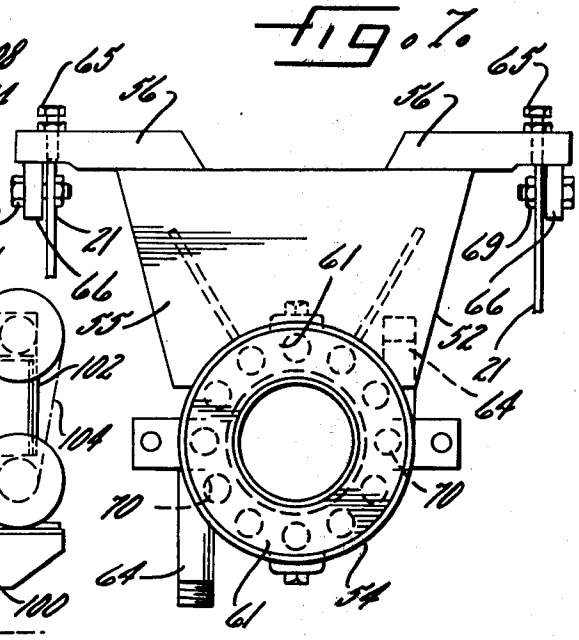


Fig. 8

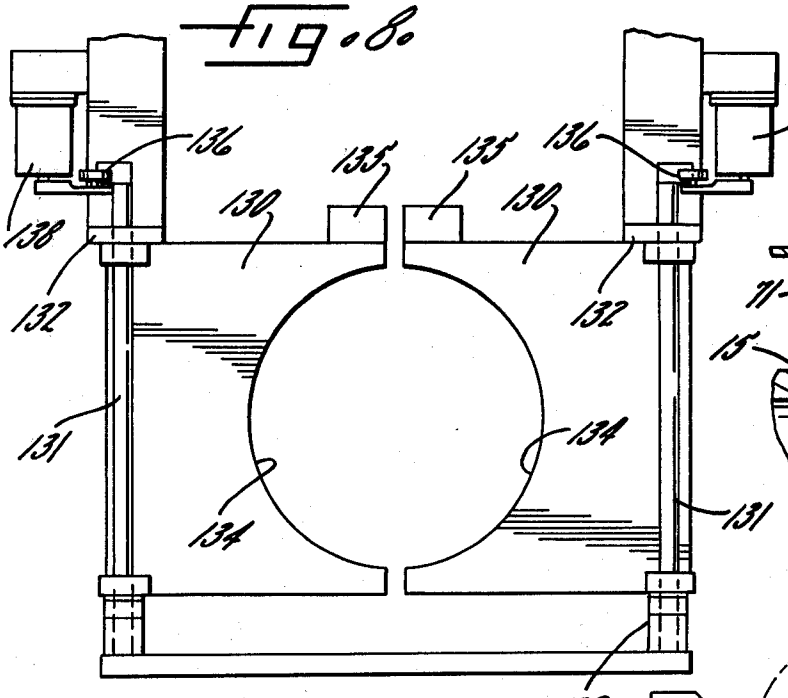


Fig. 6a

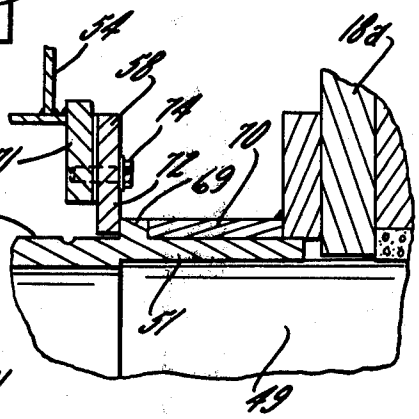
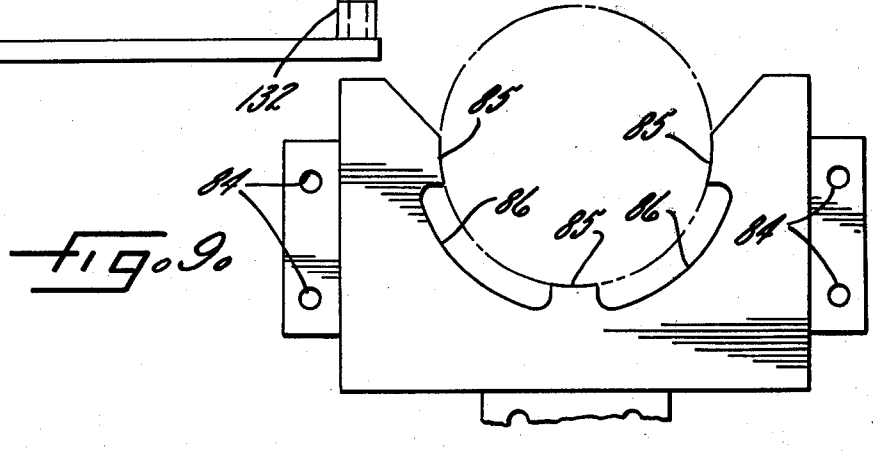


Fig. 9



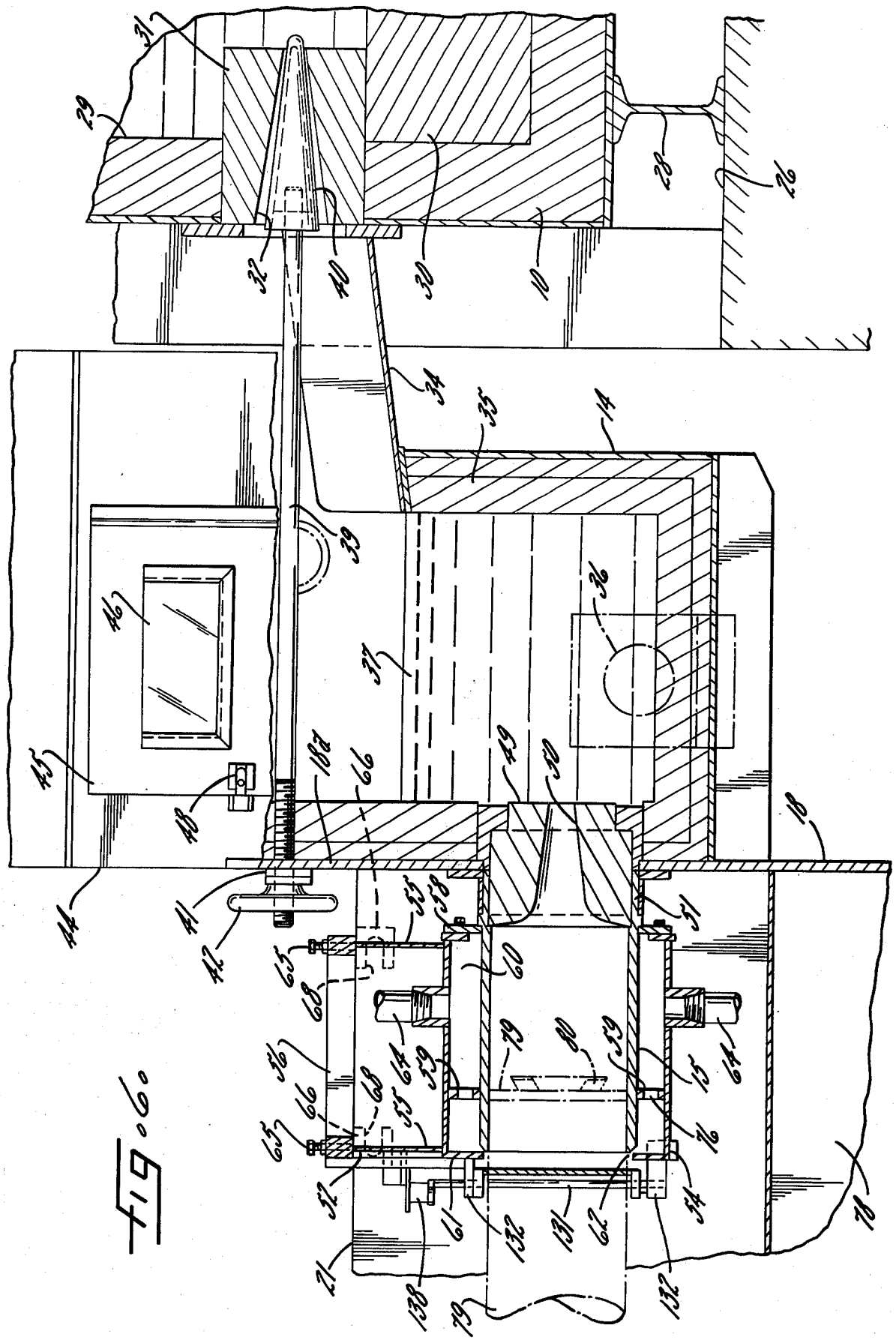


Fig. 6

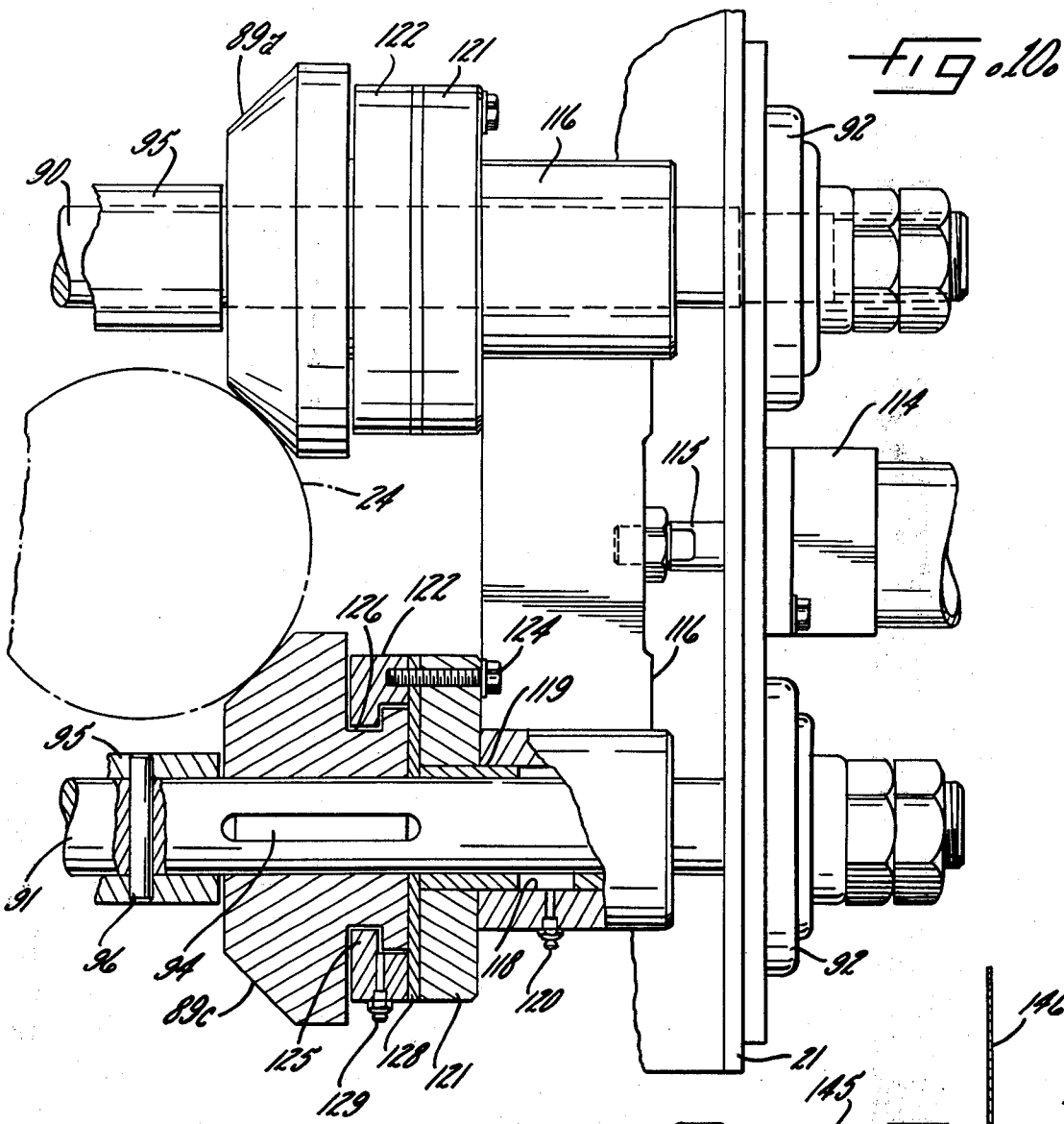

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FIG. 10

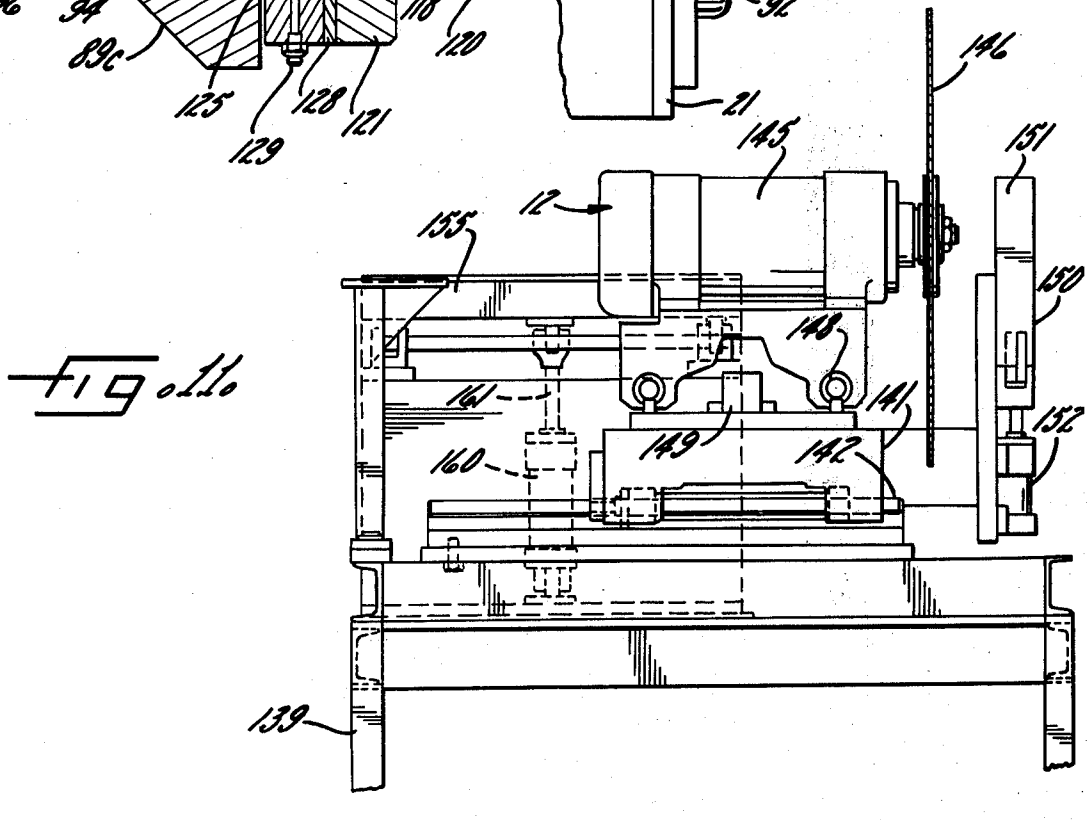

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FIG. 11

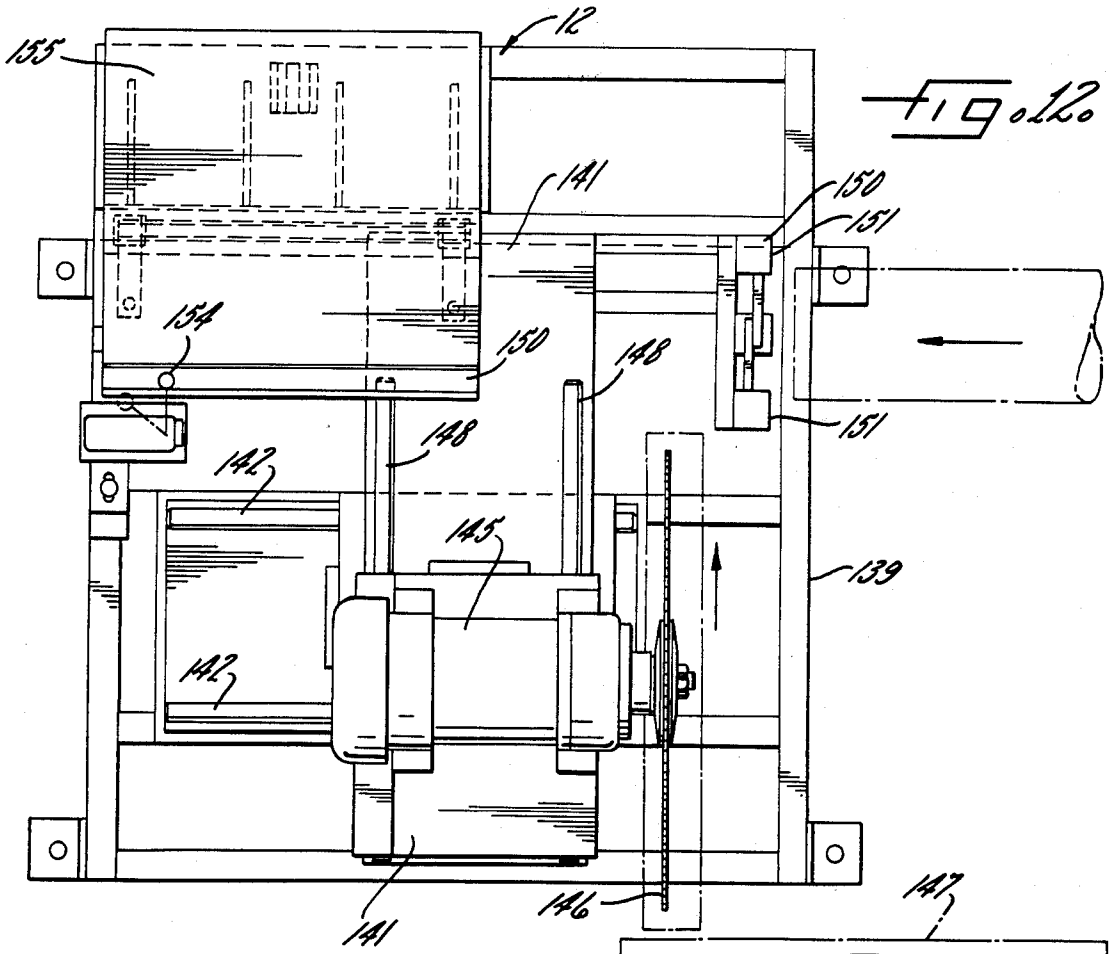

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Fig. 12.

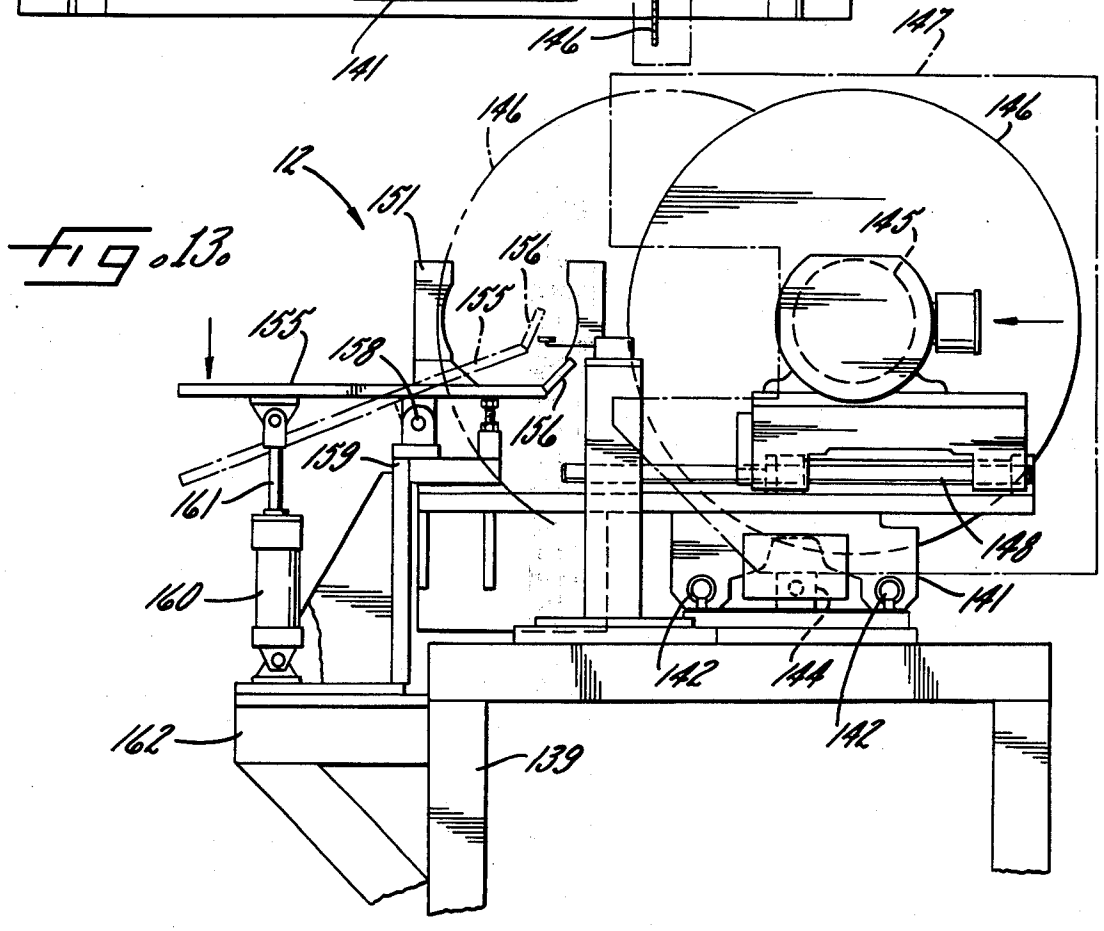

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Fig. 13.

CONTINUOUS CASTING MACHINE

DESCRIPTION OF THE INVENTION

The present invention relates in general to continuous casting of metal, and more particularly, to an integrated system for horizontally casting aluminum and its alloys and for cutting the emerging cast ingot into predetermined lengths.

Since horizontal continuous casting systems have considerably lower equipment and installation costs than do vertical casting systems, horizontal casting machines recently have been employed for use by even the small volume aluminum extruder so as to permit him to reclaim his scrap directly and recast it into reusable billets. However, a number of problems have been encountered in the use of present horizontal aluminum casting machines, particularly when used by the small extruder who may not be highly experienced in metal casting.

Such present horizontal casting systems have had both performance and safety inadequacies. For example, due to the horizontal position of the mold, difficulties have been encountered in evenly cooling the casting mold and the emerging ingot, resulting in metallurgical imperfections in the ingot. Moreover, when water-cooled graphite molds have been employed in such machines, the mold frequently must be replaced. Due to the build-up of foreign material about the mold during its use, in present machines mold removal and replacement generally is not readily accomplished. Further difficulties have been experienced in accurately positioning the replacement mold in the machine.

In addition, since the starting tube employed to commence the casting process generally is about 1/8th inch greater in diameter than the cast ingot, and inherent variations unavoidably occur in the diameter of the ingot as it is cast, the downstream drive rollers of current machines frequently will not maintain firm driving engagement with the starting tube and cast ingot so that the rate of movement of the emerging ingot may be affected. In the past, it has been necessary to make manual adjustments to the drive rolls in close contact with the hot moving ingot to reinstate the necessary driving pressures. The intense heat near the furnace and the emerging ingot, the chance of unexpected bleed-out of molten metal from the mold, and even possible eruptions of molten metal from the holding box have further presented dangers to the operator in the immediate vicinity of the machine.

Accordingly, it is an object of the present invention to provide an improved horizontal aluminum continuous casting system that is safer and more efficient in operation than such prior casting machines.

Another object is to provide a continuous metal casting system as characterized above which has a water-cooled graphite mold that is readily removable and replaceable, and is adapted for precise selective positioning. A related object is to provide such a continuous casting system which includes means for quickly and accurately positioning the starting tube in the mold during the commencement of the casting process.

A further object is to provide a horizontal continuous casting system of the above kind which has means for more uniformly cooling the graphite mold and the emerging cast ingot.

Another object is to provide a continuous casting system as set forth above with downstream ingot driving means which are easily adjustable to compensate for differences between the diameter of the starting tube and the ingot and for variations in the diameter of the cast ingot.

Still another object is to provide a continuous casting machine of the above type which includes means for shielding the machine operator from intensive heat of the molten metal or eruptions of the metal at the holding box and for automatically shutting off the machine in the event of a bleed-out of molten metal at the mouth of the mold.

Yet another object is to provide an integrated continuous metal casting system of the above kind which has means for cutting the cast ingot into predetermined lengths as it is being case and for automatically placing such ingots on a stacking table.

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1 is a partially diagrammatic side elevation view of a continuous casting machine embodying the present invention;

FIG. 2 is a partially diagrammatic top view of the machine shown in FIG. 1;

FIG. 3 is an enlarged side view of the molten metal holding box, the casting mold, and ingot drive assembly for the machine illustrated in FIG. 1;

FIG. 4 is a top view of the holding box, casting mold, and drive assembly shown in FIG. 3;

FIG. 5 is an end elevational view of the ingot drive assembly, taken in the plane of line 5—5 in FIG. 4;

FIG. 6 is an enlarged fragmentary section of the molten metal holding box and casting mold, taken in the place of line 6—6 in FIG. 4 and showing in phantom for illustrative purposes the end of a starting tube within the mold;

FIG. 6*a* is an enlarged fragmentary section showing the manner in which the casting mold is secured in position adjacent the molten metal holding box;

FIG. 7 is an enlarged fragmentary section taken in the plane of line 7—7 in FIG. 4 showing the mold support;

FIG. 8 is an enlarged fragmentary section taken in the plane of line 8—8 in FIG. 4 showing the safety gates located at the mouth of the casting mold;

FIG. 9 is an enlarged vertical view of a starting tube support cradle utilized in the run-out table of the illustrated machine;

FIG. 10 is an enlarged fragmentary section of two of the adjustable drive rolls included in ingot drive assembly;

FIG. 11 is an enlarged side elevational view of the saw assembly included in the illustrated machine;

FIG. 12 is a top view of the saw assembly shown in FIG. 11; and

FIG. 13 is an end elevational view of the saw assembly shown in FIG. 11.

While the invention is susceptible of various modifications and alternative forms, a specific embodiment thereof has been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that it is not intended to limit the invention to the particular form disclosed, but, on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

Referring more particularly to FIGS. 1 and 2 of the drawings, the invention is there embodied in an illustrative horizontal aluminum continuous casting machine. The machine comprises basically a reverberatory melting furnace **10**, a casting unit **11**, and a saw assembly **12**. The casting unit **11** in this case includes a molten metal holding box **14**, a casting mold **15**, and a drive assembly **16** all supported as a single unit by a frame **18** in a recessed pit **19** immediately downstream from the furnace **10**. The frame **18** has a plurality of legs **20** supporting a pair of longitudinally extending side panels **21** that are interconnected by cross panels **22**. Molten metal flows from the furnace **10** into the boiling box **14** which, in turn, is channeled into the mold **15**. A cast ingot **24** emerging from the mold **15**, as shown in phantom in FIGS. **1** and **2**, is continuously propelled by the drive assembly **16** and is guided into the saw assembly **12** which cuts the ingot into predetermined lengths and deposits them onto a storage table **25**.

The furnace **10** is supported above a concrete base **26** by an I-beam frame **28** and includes a conventional refractory lining **29** and a refractory base **30** for the containment of molten metal, as shown in FIG. **6**. Suitable heating means is provided for melting scrap aluminum and like metal alloys introduced into the furnace. The furnace has a tap-out block **31** formed with a tapered aperture **32** to permit the flow of molten metal from the furnace **10** to the holding box **14** which is supported by the casting unit frame **18** at an elevation slightly below that of the furnace bed **30** and is connected to the furnace by a transfer trough **34**. The holding box **14** similarly has a refractory lining **35** for containing molten metal **37**. To permit emptying of the holding box **14** after each usage of the machine, the holding box has a drain hole **36** in its lower side and a removable plug **38** (FIGS. **4** and **6**).

In carrying out one aspect of the invention, means are provided for permitting an operator to accurately and safely control the flow of metal from the furnace **10** in the holding box **14**. To this end, a selectively adjustable metering rod **39** formed with a cone-shaped head **40** is supported above the holding box **14** for cooperation with the tap-out block aperture **32**. The metering rod head **40** preferably has an outer liner of a known type that is replaceable after each casting operation. To facilitate longitudinal movement of the metering rod **39**, a forward end of the rod threadably engages a support **41** mounted at the top front side of the holding box **14**. By turning a round handle **42** secured at the forwardmost end of the metering rod **39**, the head may be selectively and precisely moved relative to the tap-out block **31** to accurately govern the flow of molten metal.

To protect the operator of the machine from the intense heat and possible eruption or other splattering of molten metal that might occur during its flow from the furnace into the holding block box **14**, a protective housing **44** is supported above the holding block box **14**. The illustrated housing **44** has a metal panel construction formed in a general rectangular shape enclosing the top of the holding box **14**. To permit access to the interior of said housing **44**, a door **45** having a viewing window **46** is hinge mounted to one of the side panels of the housing. A latch **48** releasably secures the door in a closed position. Since the metering rod handle **42** is on the outside of the housing **44**, an operator may easily control the flow of metal from the furnace and is effectively protected from the molten metal.

For the purpose of forming the cast ingot, the casting mold **15** is of a sleeve-shaped graphite construction and is adapted to be continuously cooled by water about its outer periphery during the casting operation. The mold is connected at its upstream end to a header **49** which is supported within the lower front wall of the holding box **14** and serves to direct the flow of molten metal **37** from the holding box **14** to the mold **15**. The header **49** extends a distance from the wall of the holding box and is formed with a central nozzle opening **50** that becomes gradually larger as it progresses from the interior of the holding box to the mold. The graphite mold **15** is formed with a lip portion **51** that overlaps the protruding end of the header **49**.

In carrying out another feature of the invention, the graphite mold is supported for ready removal and replacement and may be adjustably positioned relative to the holding box. As best shown in FIGS. **6** and **7**, the mold **15** is carried in an adjustable support **52** comprising a cylindrical water jacket **54** with a pair of vertical plates **55** extending upwardly from the water jacket. The upper ends of the vertical plates **54** are connected by cross members **56** that extend laterally outward from the plates **54** for positioning on the top of the two frame side panels **21**. The water jacket **54** surrounds the mold **15** and supports it coaxially therein by means of inwardly extending radial plates **58, 59** to form a cooling chamber **60** about the outer periphery of mold **15**. A forwardmost radial plate **61** has a central opening slightly larger than that of the outer periphery of the mold so as to define an annular exit port **62** for cooling water. Lines **64** connected to the water jacket on opposite sides thereof supply water from a suitable source to the cooling chamber **60** (FIG. **7**). For the purpose of illustrating the manner in which the lines **64** are connected to the water jacket **54**, in FIG. **6** the lines **64** have been revolved 90° to a vertical plane.

To vertically adjust the position of the mold **15** relative to the holding box **14** and the header **49**, adjusting bolts **65** are provided in threaded apertures in each of the cross members **56** for engagement with the upper edges of the frame side panels **21**. By threadably advancing or retracting the bolts **65** in their respective aperture, the height of the support **52** and the mold **15** is supported therein may be selectively varied. To adjustably position the mold **15** in a lateral direction, depending flanges **66** extend downwardly from the horizontal cross members **56** in close relation to the side frame panels **21**. Each flange **66** is formed with an inwardly directed U-shaped opening **68**, and adjusting bolts **69** passing through each opening **68** couple the flange **66** to the side frame panel **21** with the desired spaced relationship.

When the mold **15** is in position about the protruding cylindrical portion of the header **49**, an external shoulder **69** formed near the end of the mold is interposed between the rearward radial flange **58** of the water jacket **54** and a cylindrical flange **70** extending from a vertical panel **18***a* of the support frame **18** so that the mold is held in firm engagement with the header **49**. To remove the mold **15** from the header **49** for replacement by a new mold, as is periodically necessary with such graphite molds, the water lines **64** may be disconnected and, after removing the lateral adjusting screws **69**, the support **52** containing the mold **15** may be slid

a downstream direction off the end of the header **49.** The mold **15** may then be removed from the water jacket **54** for replacement.

Since deposits of foreign material from the cooling water generally accumulate on the outer surface of the mold within the cooling chamber **60,** in prior horizontal casting machines, it often has been difficult to slide the tight fitting water jacket **54** off of the mold. To alleviate this problem, the rearward radial plate **58** of the water jacket is made of a two-part disengageable construction. As best shown in FIG. **6***a*, the radial plate **58** includes a first flange **71** which is welded to the outer cylindrical wall of the water jacket **54** and formed with opening of significantly greater diameter than the outer dimensions of the mold. A removable plate **72** formed with an opening that fits in close water-tight relation with the mold **15** is secured to the first flange **71** by screws **74.** A suitable gasket may be interposed between the flange **71** and the removable plate **74** to provide a watertight seal. By removing the screws **74** so that the plate **72** is disengaged from the water jacket **54,** the larger opening of the flange **71** permits quick removal of the water jacket from the mold leaving the plate **72** in position on the mold for removal later.

The operation of the horizontal casting process relies on the necessity of keeping the molten metal above the solidification temperature until it contacts the smooth, continuously cool, casting surface of the graphite mold. The molten metal must then be rapidly transformed into a solid skin defining the outer surface of the cast ingot. This allows the ingot to be slowly withdrawn from the mold while solidification of the ingot is being completed. By virtue of the horizontal orientation of the mold, heretofore it has been difficult to evenly cool the mold so that the ingot can be cast with the optimum metallurgical qualities.

In keeping with the invention, cooling water is directed into the water chamber **60** in a tangential direction about the outer surface of the mold **15** from the lines **64** at the opposite sides of the mold. In the illustrated embodiment, water is directed from each of the lines **64** in a counterclockwise direction, as viewed in FIG. **7.** The support flange **59** has a plurality of circumferentially spaced apertures **76** which permit the water to flow the entire length of the mold and then onto the emerging ingot through the exit port **62.** It has been found that by directing the cooling water in such a tangential manner, the water tends to continue to circulate about the horizontal mold as it flows to the exit port **62,** thereby achieving more uniform cooling of the mold and the ingot being formed therein. After the water has run onto the emerging ingot, it eventually drops into a tank **78** located below the mold and drive assembly. The water may be pumped from the tank **78** to a suitable cooling tower and then recirculated through the mold in a conventional manner.

At the start of the casting operation, a starter tube **79,** shown in phantom in FIG. **6,** is inserted a short distance into the open end of the mold **15** to block the initially entering molten metal. The starting tube **79** preferably is of such length that it extends out of the mold to at least the end of the drive assembly **16** so that it can be positively driven by the drive assembly to start the downstream movement of the cast ingot. The end of the tube **79** inserted in the mold is formed with a dovetail extension **80** which becomes embedded in the molten metal and serves to assist in pulling the ingot away from the mold after the mold is completely filled and solidification of the ingot has commenced.

To accurately support the starting tube in the mold, a removable and adjustable cradle template **81** (FIGS. **4** and **9**) is secured to the first cross panel **22** downstream from the mold **15.** Each of the cross panels **22** is formed with a generally U-shaped top opening **82** (FIG. **5**) which permits the passage of the moving ingot **24** with ample clearance. The cradle template **81** is formed with circumferentially spaced pads **85** for supporting the starting tube **79** and relieved areas **86** between the pads **85** permit cooling water emerging from the end of the water jacket **54** to flow down the ingot past the cradle template **81** to further the cooling of the ingot. The cradle template **81** is secured to the first cross panel by fastening means, such as screws, passing through slightly oversized apertures **84** which permit sufficient adjustable positioning of the template on the cross panel **22** so that the starting tube may be precisely aligned with each new replacement mold that is installed. A similar cradle template **88** preferably is secured to the cross panel **22** at the end of the drive assembly **16,** but this template need not be formed with water passage relieved areas (FIG. **4**). After a casting operation has commenced, the cradles **81** preferably may be removed from their respective cross panels **22** leaving the emerging log to be supported by the drive assembly **16** as will be described below. If the cradles are not so removed, it is possible that slight blisters or warpage of the emerging log might engage the cradles, causing movement of the log to be hindered and the machines to be unnecessary shut down.

To move the starting tube and the emerging cast ingot away from the mold, the drive assembly **16** includes a plurality of power driven rollers **89** located above and below the starting tube **79** and the intended line of travel of the emerging ingot **24.** In the illustrated embodiment, the drive assembly includes two identical sets of drive rollers **89.** Each set includes two rollers **89***a*, 89*b* mounted on a shaft **90***a* above the level of the ingot, and two rollers **89***c*, 89*d* mounted on a shaft **91** below the ingot level. The rollers **89** each have inwardly tapered cone-shaped surfaces adapted to engage the sides of the starting tube and the cast ingot. The shafts **90, 91** are rotatably mounted between the side frame panels **21** by suitable flange bearings **92** (FIGS. **5** and **10**), and the rollers **89** each are secured to their supporting shafts by a key **94** for rotation with the shaft and axial movement relative to the shaft. Each pair of rollers **89***a*, 89*b* and **89***c*, 89*d* are separated by a collar **95** coaxially mounted at the center of the respective shaft and secured thereto by a pin **96.**

For rotatably driving the shafts **90, 91** and the drive rolls **89,** a protruding end of each shaft carries a drive sprocket **98.** A suitable electric motor **99** is mounted below on a frame **100** adjacent the water tank **78** and is adapted to drive an output shaft **101** of a reducer **102** through a chain and sprocket connection **104.** The reducer output shaft **101** carries two driven sprockets **105, 106** (FIGS. **3** and **5**). One endless chain **108** is trained about the reducer sprocket **105,** idler sprockets **109, 110** and the two drive sprockets **98** carried by the shafts **90, 91** for one set of the drive rollers **89.** Another chain **111** is trained about the other reducer sprocket **106,** an idler sprocket **112,** and the two drive sprockets **84** for the shafts **90, 91** of the other set of drive rollers. Operation of the motor **99** thereby drives all of the rol-

lers **89** in unison and by appropriate control means, the speed of the motor, and thus the drive rollers, may be varied for the particular casting operation.

In carrying out another aspect of the invention, means are provided for readily adjusting the axial position of the drive rollers **89** to vary the driving pressure on the cast ingot **24** and to compensate for any variations between the diameter of the starting tube and the cast ingot. In the illustrated embodiment, each set of drive rollers has an air cylinder **114** mounted on opposite side panels **21** intermediate the shafts **90, 91** for simultaneously actuating both the upper and lower drive rollers located on the respective side of the shafts. Thus, an air cylinder **114** is mounted on one side of the frame for actuating the drive rollers **89***a*, 89*c* and another air cylinder **114** is mounted on the opposite frame side panel **21** for actuating the rollers **89***b*, 89*d*. Since each of the air cylinders **114** is identical in construction and operation, only one need be described in detail.

The air cylinder **114** shown in FIG. **10** includes a piston rod **115** that is connected to the center of an axially adjustable hub **116** which is supported at opposite ends by the upper and lower shafts **90, 91** through cylindrical openings **118** in the hub **116.** Interposed between each cylindrical hub opening **118** and the respective shaft **90, 91** is a bearing sleeve **119** to permit free rotation of the shafts relative to the hub. A grease fitting **120** extending radially through operable ends of the hub **116** permits lubricant to be applied to the bearings **119.** The hub **116** in this case has a pair of flanges **121** which are welded to the body of the hub adjacent the rollers **89***a*, 89*c*. The rollers **89***a*, 89*c* each are secured to one of the hub flanges **121** by a retaining ring **122** for axial movement with the hub **116** and for relative rotational movement. Each retaining ring **122** is secured to one of hub flange **121** by a plurality of screws **124** and is formed with an inwardly directed radial flange **125** that engages a groove **126** formed in the respective roller **89***a*, 89*c*. To facilitate the rotational movement of each roller **89***a*, 89*c* relative to the retaining ring **122** and hub flange **121,** a radial bearing plate **128** is interposed between the hub flange **121** and the roller and a grease fitting **129** is provided in the retaining ring **122** to lubricate the surfaces between the retaining ring and the roller. Since the key connection between the rollers **89***a*, 89*c* and their respective shafts **90, 91** permits relative axial movement of the rollers, actuation of the air cylinder **114** will exert an axial force on the hub **116** that is transmitted to both rollers to simultaneously move them. The central collar **95** in this case serves to limit axial roller movement in the inward direction and similar stop means may be provided for limiting roller movement in the opposite direction. It will be appreciated that by appropriate monitoring means an operator located at a safe and comfortable distance from the hot emerging ingot may selectively regulate the pressure to the cylinders **114** and thus the position and driving pressures of the drive rollers **89.**

As a further safety feature of the machine, means are provided for automatically stopping the drive rollers in the event of a bleed-out of molten metal from the mouth of the mold **15** or the formation of a blister or other protruding deformity in the emerging cast ingot. As best shown in FIGS. **6** and **8,** a pair of rotatable gates **130** are mounted at opposite sides of the downstream end of the mold **15.** The gates **130** each are mounted on a shaft **131** that is pivotably secured at opposite ends by brackets **132** extending outwardly from the forwardmost plate **61** of the water jacket **54.** The gates **130** each are formed with a semicircular opening **134** the diameter of which is greater than the intended diameter of the cast ingot **24** by a predetermined amount, preferably about 5/8th of an inch. To keep the gates in a normally closed position, as shown in the drawings, magnetic flanges **135** are provided at the top of each gate.

In the event of an unintended bleed-out of molten metal from the mouth of the mold or the formation of a blister or the like on the emerging ingot, the metal will contact the safety gates **130,** overcome the magnetic closure force of the flanges **135,** and push the gates to an open position. To sense such opening of the gates, each shaft **131** has an eccentrically mounted cam **136** at the upper end thereof which is engageable with a limit switch **138.** Appropriate circuitry may be employed to automatically turn off the power to the drive motor **99** upon actuation of the limit switch **138.** As a further safety precaution in the event of bleed-out of molten metal, a predetermined water depth may be maintained in the tank **78** below the mold and drive rollers so that the run-out molten metal will be contained within the tank and quickly cooled.

As the ingot **24** leaves the casting unit drive assembly **16,** it is guided onto the saw assembly **12.** The saw assembly **12** is mounted on a frame **139** which has a pair of guide rollers **140** at its forwardmost end. The saw assembly includes a carriage **141** slidably mounted upon ways **142** for longitudinal movement on the frame **139** parallel to the ingot **24.** To move the carriage **141** in such a longitudinal direction, an appropriate hydraulic cylinder **144** is located intermediate the ways **142.** A saw **145** with a conventional rotary cutting blade **146** is mounted upon the carriage **141** on ways **148** for lateral movement relative to the ingot through actuation of a hydraulic cylinder **149.** A protective guard **147** may be provided about the saw blade **146.** Secured forwardly of the carriage **141** for movement with the carriage is a clamping mechanism **150** having a pair of clamping arms **151** immediately downstream of the saw assembly guide rollers **140.** The clamping arms **151** are movable by means of a hydraulic cylinder **152** between an open position which permits passage of an ingot **24** relative into the saw assembly and a closed position engaging the ingot.

The ingot is moved into the saw assembly under power of the drive rollers **89** until a predetermined length is sensed by a limit switch **154** located at the downstream end of the saw assembly **12** which activates the hydraulic cylinder **152** for the clamp **150** causing the clamping arms **151** to engage the ingot **24.** The engagement of the clamp about the ingot, the saw carriage **141** will be moved along its ways **142** with the moving ingot. At the same time, the saw **145** is energized and the hydraulic cylinder **149** actuated to move the saw in a lateral cutting direction to cut through the ingot as the saw and log progress in a downstream direction.

At the end of the sawing cycle, the saw **145** has moved to the position shown in phantom in FIG. **13** and has progressed a longitudinal distance along the carriage ways **142** so that the cut-off ingot length is centered over and rests upon a saw table **155.** The saw table **155** has an upwardly inclined flange **156** on one

side thereof that is positioned in close relation to the moving ingot when the table is in a horizontally disposed position to prevent the cut ingot length from rolling off that side of the table.

In order to automatically transfer the cut-off length of ingot **24** from the table **155** to the adjacent storage pallet **25**, the table **155** is pivotably mounted on a transverse rod **158** supported by a vertical extension **159** of the furnace **139**. To tilt the table **155**, a hydraulic cylinder **160** located below the outer end of the table has a piston rod **161** which is rotatably secured to the table for movement between an extended horizontal table position and a retracted tilted table position, shown in phantom in FIG. **13**. To facilitate such movement of the table, the lower end of the hydrauilc cylinder **160** is pivotably mounted to a horizontal extension **162** of the support frame **139**. Thus, by actuation of the hydraulic cylinder **160**, the table **155** may be tilted downwardly causing the ingot length supported thereon to roll or be dumped onto the storage pallet **25** (FIG. **2**).

Upon completion of the sawing and dumping operations, the saw **145** is returned to its laterally retracted position by actuation of the hydraulic cylinder **149**, the hydraulic clamp **150** releases the ingot and the carriage **141** is then returned to its upstream position by actuation of the hydraulic cylinder **144**. It will be understood that the sequencing of the operation of the ingot clamps **151**, the outward movement of the cutting saw **145**, the saw return movement, and the carriage return movement may all be controlled through a suitable hydraulic power unit.

As can be seen from the foregoing, the continuous horizontal casting system of the present invention is both safe and highly efficient in operation. Such a system makes it possible for even the small aluminum extruder to now readily and efficiently reclaim its own scrap directly and recast it into the reusable ingots. In fact, one operator can generally control the operation of the machine, except for perhaps charging of the furnace. It will be understood that while the illustrated machine is intended for casting one continuous ingot, multiple ingots could be cast by placing two more units side by side and feeding them from a common furnace.

We claim:

1. A continuous metal casting machine comprising a furnace for melting metal to a molten state, a holding box for receiving molten metal from said furnace, a graphite casting mold having cylindrical outer periphery and an internal horizontally directed casting surface extending through said mold and communicating with said holding box, a water jacket surrounding and supporting said graphite mold and defining a cooling chamber about the outer periphery thereof, means for supplying water to said chamber and into direct contact with the outer periphery of said graphite mold for uniformly cooling said mold and molten metal therein to continuously form and cast a metal ingot, said water supply means including at least two water supply lines connected to said water jacket on opposite sides of said mold for directing water in a tangential direction about said mold so as to impart a circumferential flow of water about the mold as it is in contact with the outer periphery thereof, and drive means for moving said continuously cast ingot in a downstream direction away from said mold.

2. The continuous metal casting machine of claim **1** including means for selectively adjusting vertically and laterally the position of said water jacket and the mold supported therein relative to said holding box without disassembly of said water jacket.

3. The continuous casting machine of claim **1** in which said drive means includes a plurality of pairs of cone shaped rollers for engaging opposite sides of a cast ingot as said ingot emerges from said mold, said rollers of each pair being mounted in axial spaced relation for rotational movement and relative axial movement, power means for rotatably driving said rollers, and means including selectively operable air cylinders for axially moving said rollers of each pair relative to each other and to the emerging cast ingot to compensate for variations in the diameter of said ingot and to adjust the driving pressures of said rollers.

4. A continuous metal casting machine comprising a furnace for melting metal to a molten state, a holding box for receiving molten metal from said furnace, a casting mold having an internal horizontally directed casting surface extending through said mold and communicating with said holding box, a selectively removable water jacket surrounding and supporting said mold and defining a cooling chamber about the outer periphery thereof, a frame having a pair of spaced apart longitudinally extending side panels at opposite ends of said mold and water jacket, said water jacket having upper horizontal cross members removably supporting said water jacket on said frame side panels with said mold adjacent said holding box, a plurality of screws supported within said cross members for engagement with said frame side panels whereby rotational adjustment of said screws alters the position of said cross member and water jacket relative to said frame side panels, means for supplying water to said water jacket chamber for cooling said mold and the molten metal therein to continuously form and cast a metal ingot, and drive means for moving said continuously cast ingot away from said mold in a downstream direction.

5. The continuous metal casting machine of claim **4** in which said water jacket includes at least two radial flanges for supporting said mold, one of said radial flanges including a first flange part rigidly secured to said water jacket and formed with a central opening substantially larger than the outer dimensions of said mold periphery, a second removable flange part releasably secured to said first flange part and being formed with a central opening for receiving in close relation the outer periphery of said mold, said second flange part being disengageable from said first flange part to permit quick removal of said water jacket from said mold.

6. The continuous metal casting machine of claim **5** in which said two-part disengageable radial flange is located at an upstream end of said water jacket, said second radial flange being located downstream from said two-part radial flange and being formed with a plurality of openings to permit the passage of cooling water along the length of said mold periphery, and said water jacket defining an exit port about the outer periphery of said mold at the downstream end thereof to permit the passage of cooling water from said chamber onto an emerging cast ingot.

7. A continuous metal casting machine comprising a furnace for melting metal to a molten state, a holding box for receiving molten metal from said furnace, a casting mold having cylindrical outer periphery and an internal horizontally directed casting surface extending

through said mold and communicating with said holding box, means for directing water uniformly about the outer periphery of said mold for cooling said mold and molten metal therein to continuously form and cast a metal ingot, drive means for moving said continuously cast ingot in a downstream direction away from said mold as it emerges from said mold, means for sensing an accidental bleed-out of metal from the downstream end of said mold, said sensing means including a rotatable gate mounted in a normally close relation to the downstream end of said mold and having an opening therein that is greater than outer dimensions of the merging cast ingot by a predetermined amount, and said gate being rotatable in an outward direction in the event that metal emerging from said mold engages said gate, and limit switch means being actuated in response to said outward rotary movement of said gate to automatically shut off the operation of said drive means.

8. A continuous metal casting machine comprising a furnace for melting metal to a molten state, a holding box for receiving molten metal from said furnace, a casting mold having an internal horizontally directed casting surface extending through said mold and communicating with said holding box for continuously forming a cast ingot, means for directing cooling water about the outer periphery of said mold and the emerging cast ingot, drive means for moving said continuously cast ingot away from said mold in a downstream direction, a frame for supporting said mold and drive means, said frame having a pair of side panels extending longitudinally a distance beyond the end of said mold with a plurality of cross panels secured therebetween, said cross panels each being formed with a generally U-shaped top opening to permit the passage of a moving ingot with substantial clearance, at least one of said cross panels having a removable and adjustable cradle template, and said cradle template being formed with circumferentially spaced support pads arranged to closely coincide with the outer periphery of a moving ingot.

9. The continuous casting machine of claim **8** in which said cradle template has relieved areas between said pads to permit cooling water to flow along the moving ingot passed said template.

10. The continuous metal casting machine of claim **8** including a metal panel enclosure mounted over the top of said holding box for substantially shielding the immediately surrounding area about said holding box from the heat and eruption of molten metal contained therein.

11. The continuous metal casting machine of claim **10** in which said furnace has a tap-out aperture for permitting the flow of metal from said furnace to said holding box, a metering rod extending through said enclosure and having a head at one end for cooperation with said tap-out aperture and a handle at the other end thereof on the outside of said enclosure, support means holding said metering rod in predetermined relation to said tap-out aperture, said metering rod being in threaded engagement with said support means so that upon rotation of said metering rod said head is selectively positionable relative to said tap-out aperture to govern the flow of molten metal from said furnace.

12. A continuous metal casting machine comprising a furnace for melting metal to a molten state, a holding box for receiving molten metal from said furnace, a casting mold having an internal horizontally directed casting surface extending through said mold and communicating with said holding box, means for directing water onto the outer periphery of said mold for cooling said mold and the molten metal contained therein to continuously form and cast a metal ingot, a plurality of pairs of spaced apart, inwardly tapered rollers for engaging said cast ingot as it emerges from said mold to move said ingot in a downstream direction, said rollers of each pair being mounted on opposite sides of the ingot path for rotational movement and relative axial movement, power means for rotatably driving said rollers, and means for adjusting the axial spacing of the rollers of each pair to compensate for variations in the diameter of said ingot and to regulate the driving pressures of said rollers against said ingot.

13. The continuous metal casting machine of claim **12** in which said roller axial spacing adjusting means includes at least one fluid actuated cylinder having a piston rod, means connecting said piston rod one of the rollers of at least one pair, and control means for selectively actuating said fluid cylinder to axially move said connected roller.

14. The continuous metal casting machine of claim **12** in which one pair of said rollers is carried on a rotatable shaft mounted above the line of travel of said ingot and one pair of said rollers is carried on a rotatable shaft mounted below the line of travel of said ingot, said rollers on said lower shaft being vertically aligned with corresponding rollers on said upper shaft, and means for simultaneously moving one of the rollers on said lower shaft and the vertically aligned corresponding roller on said upper shaft axially relative to the respective other roller of each pair.

15. The continuous casting machine of claim **14** including means for simultaneously moving the other roller carried by said lower shaft and the vertically aligned corresponding roller on said upper shaft axially relative to the respective opposite roller of each pair.

16. The continuous casting machine of claim **14** in which said roller moving means includes a hub supported at opposite ends by said upper and lower shafts for relative axial movement, means connecting said one roller on said lower shaft and said aligned roller on said upper shaft to said hub for axial movement with said hub and relative rotational movement, a fluid actuated cylinder having a reciprocal piston rod connected to said hub, and means for selectively actuating said cylinder to move said hub and the upper and lower rollers connected thereto relative to the respective shafts on which said rollers are mounted.

17. A continuous metal casting machine comprising a furnace for melting metal to a molten state, a holding box for receiving molten metal from said furnace, a casting mold having an internal horizontally directed casting surface extending through said mold and communicating with said holding box, means for directing water onto the outer periphery of said mold for cooling said mold and the molten metal contained therein to continuously form and cast a metal ingot, a plurality of rotatable and axially movable rollers for engaging opposite sides of a cast ingot as it emerges from said mold to move said ingot in a downstream direction, power means for rotatably driving said rollers, means for automatically adjusting the axial position of said rollers to compensate for variations in the diameter of said ingot and to adjust the driving pressures of said rollers against said ingot, a saw positioned downstream of said

rollers, means for sensing when a predetermined length of said ingot has moved past said saw, clamping means for engaging said ingot to move said saw in a downstream direction with said ingot upon triggering of said sensing means, means for laterally advancing said saw to cut said ingot to a predetermined length as said saw is moving in a downstream direction with said ingot, a table for receiving and supporting the cut-off length of said ingot upon completion of cutting by said saw, means for automatically tilting said table after an ingot length has been cut by said saw to remove said ingot length from said table, means for returning said saw to its original upstream and laterally retracted position upon completion of cutting of said ingot length, and means for returning said table to its original position for receiving another ingot length.

18. The continuous metal casting mchine of claim **17** in which said table is pivotably mounted, and said tilting means is a hydraulic cylinder having a reciprocal piston rod connected to one side of said table.

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