United States Patent [19]

Geiger et al.

[11] **3,926,247**

[45] **Dec. 16, 1975**

[54] **LEAD SHEET CASTING MACHINE**

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[73] Assignee: **Cominco Ltd.,** Vancouver, Canada

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[52] **U.S. Cl.** **164/263;** 164/276

[51] **Int. Cl.²** **B22D 11/126;** B22D 11/06

[58] **Field of Search** 164/276, 281, 73, 74, 77, 164/87, 270, 89, 278, 263; 65/198

[56] **References Cited**

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1,879,336	9/1932	Foley et al.	164/276
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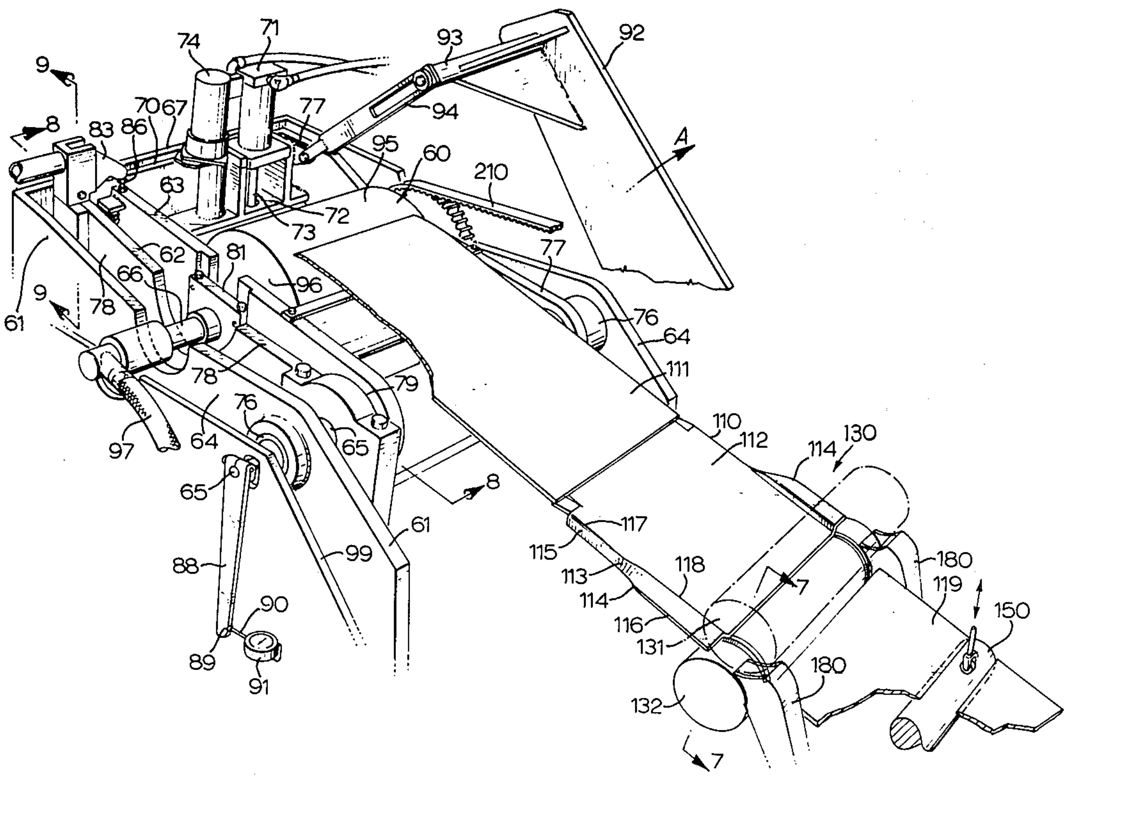
3,773,102	11/1973	Gerding	164/276
3,858,642	1/1975	Battiston et al.	164/276

Primary Examiner—Robert D. Baldwin
Assistant Examiner—John S. Brown
Attorney, Agent, or Firm—Arne I. Fors

[57] **ABSTRACT**

A machine for casting of uniform sheet from low melting point metals such as lead or reactive molten lead alloy comprises a combination of a furnace for retention of molten alloy, a casting trough that provides a constant-level, non-turbulent supply of molten metal to a water-cooled casting drum, a casting drum assembly with means for controlled immersion and levelling of the drum to produce sheet having predetermined uniform thickness or uniform lateral taper, means to flatten and trim the edges of cast sheet and recover shredded edge scrap, means for precision determination of the thickness of the cast sheet, pull roll sheet withdrawing means that is synchronized with the rotation of the casting drum, and an inclined table upon which cast sheet is guided from the casting drum through the edge trimming means and the sheet thickness determining means to the pull roll withdrawal means. All zones within which lead alloy is present in molten form, except for the area immediately around the casting drum, are enclosed to provide a protective atmosphere of inert gas.

29 Claims, 16 Drawing Figures



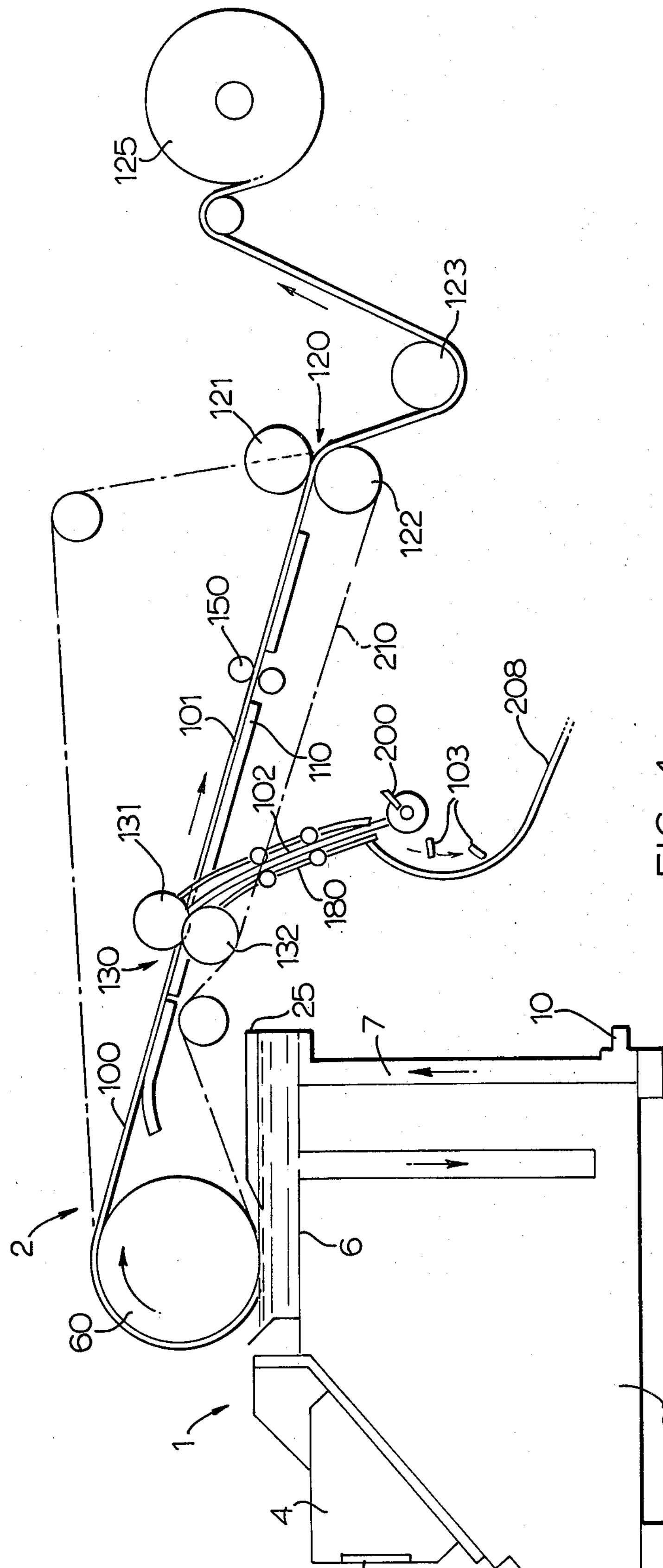

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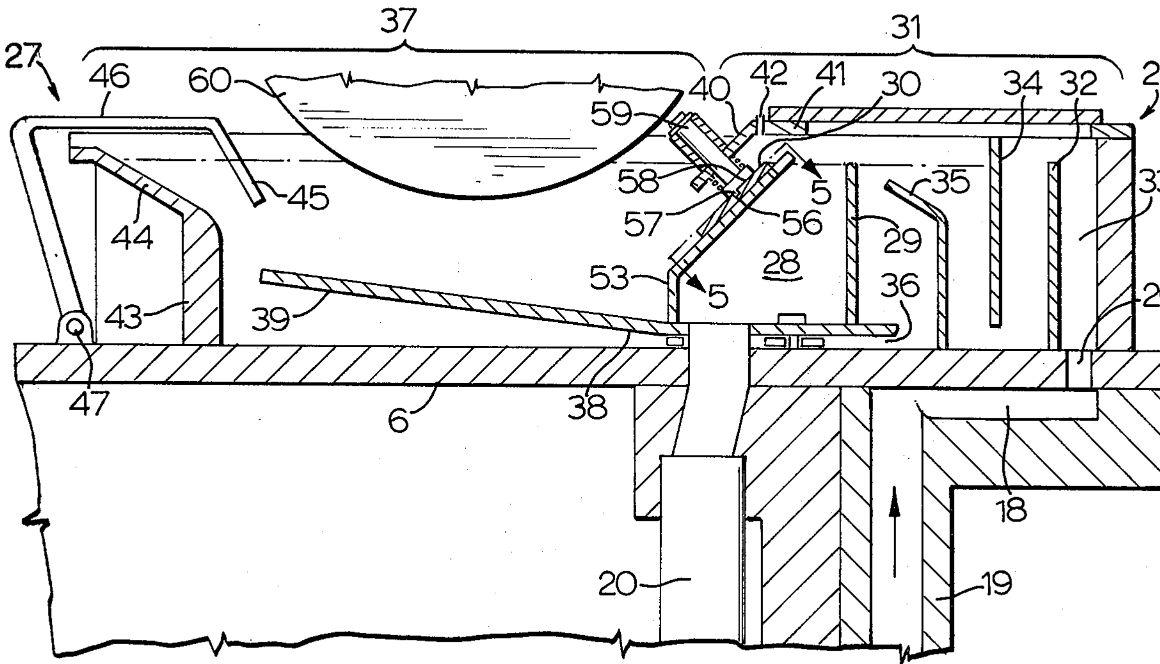
FIG. 1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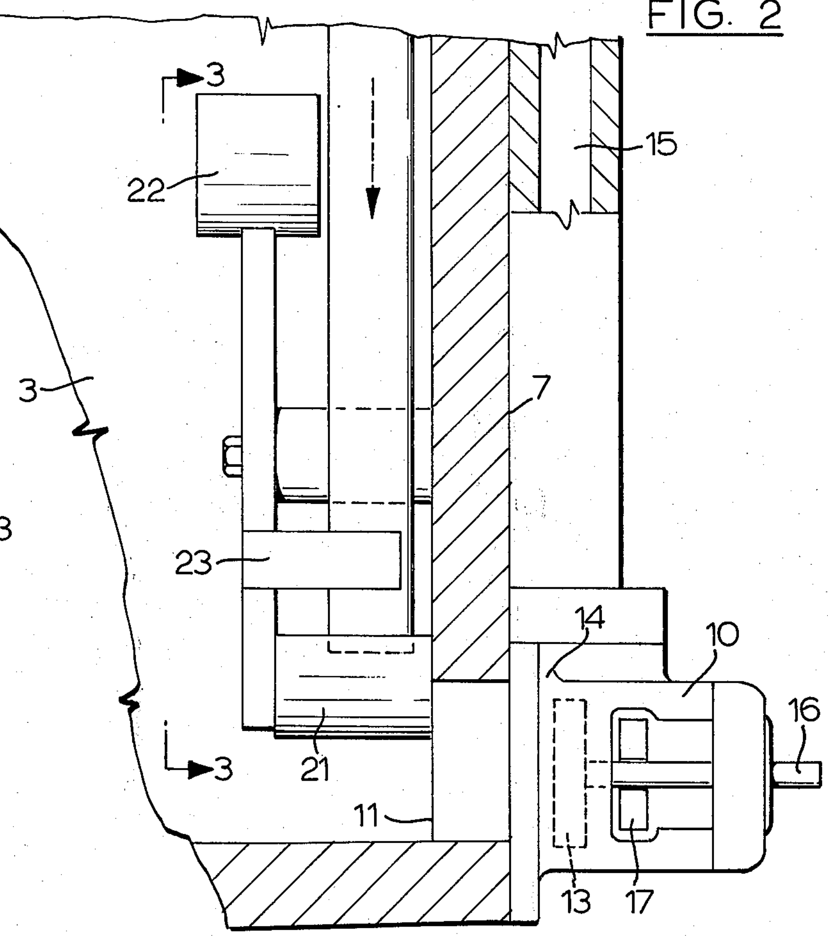
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FIG. 2

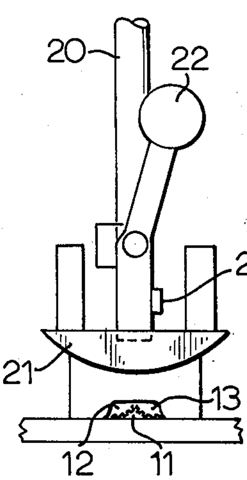
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FIG. 3

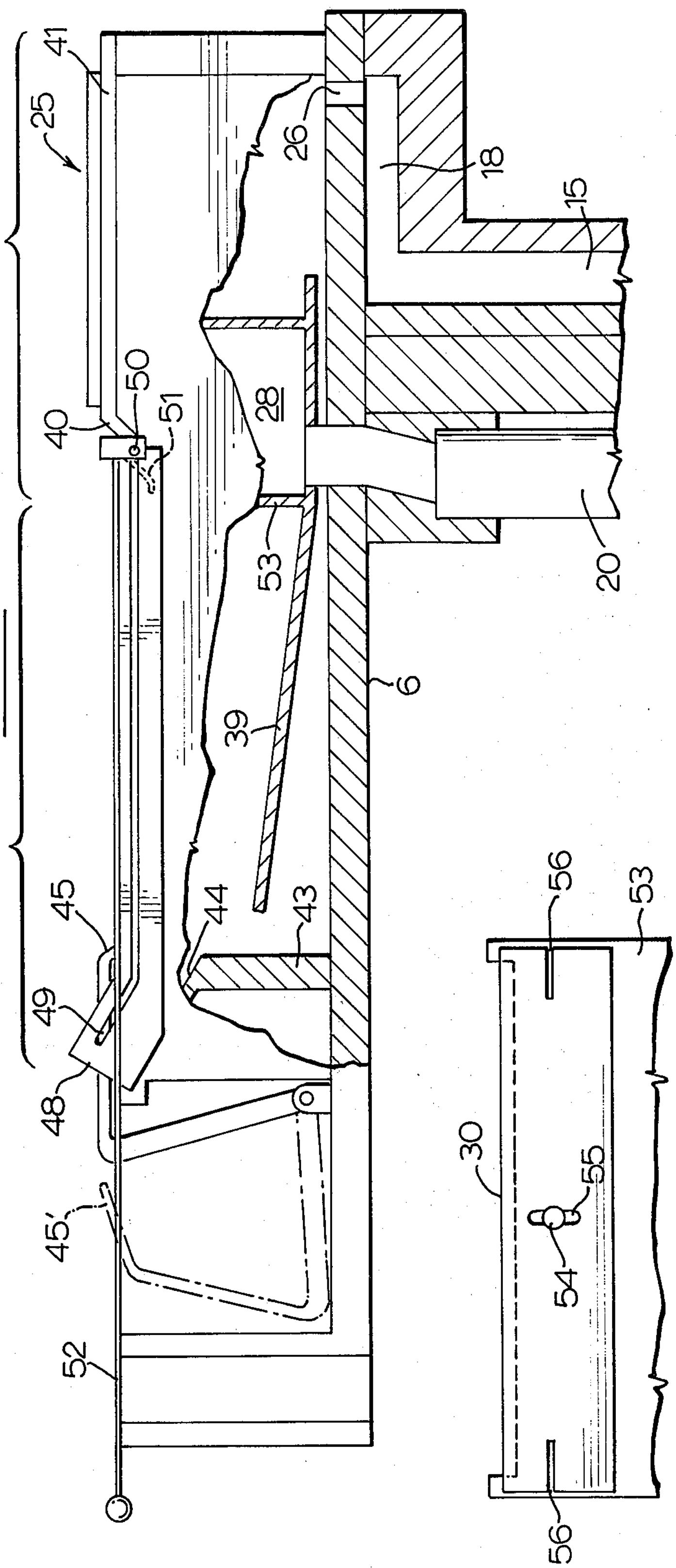
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FIG. 4

FIG. 5

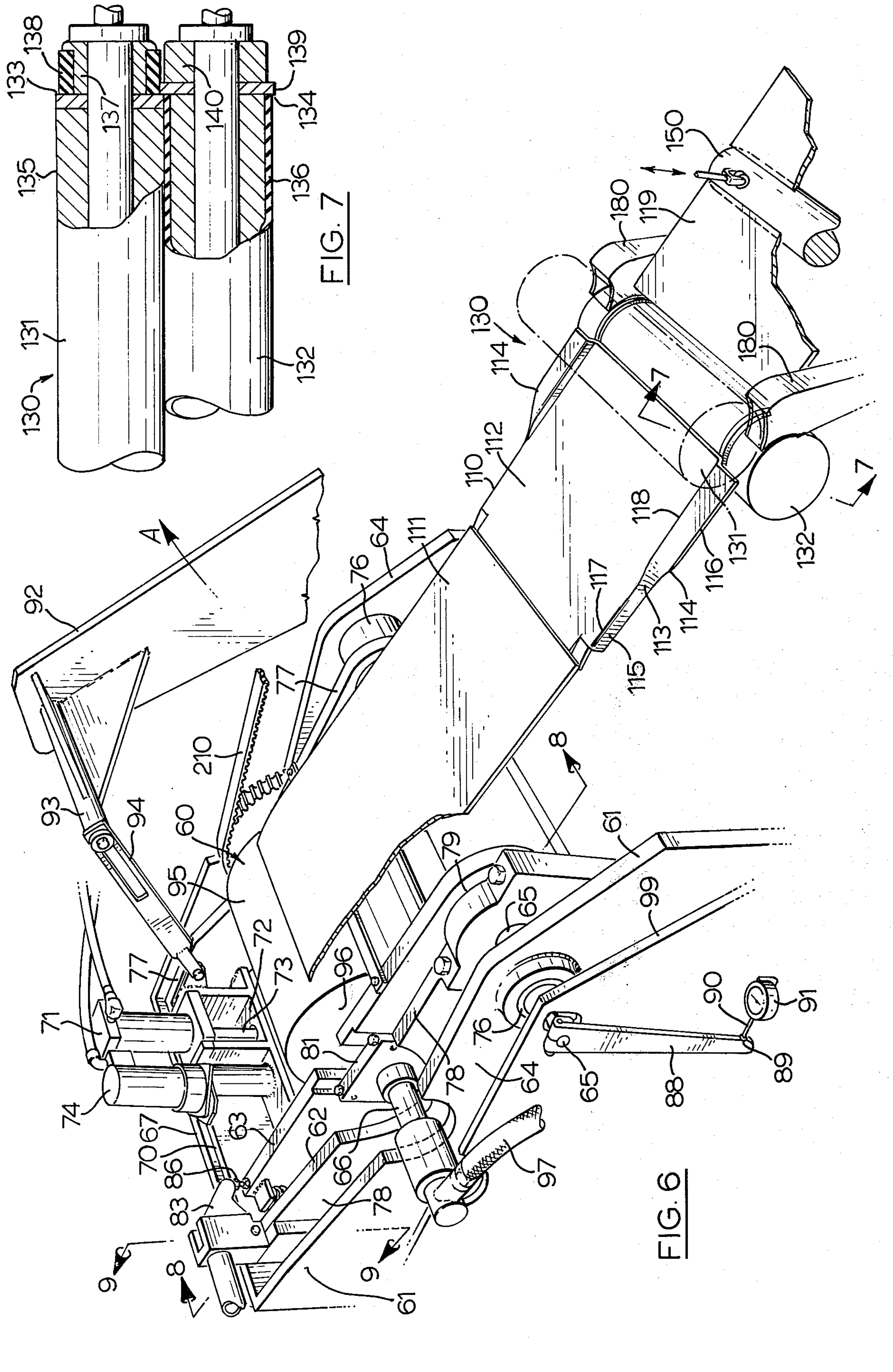

FIG. 7

FIG. 6

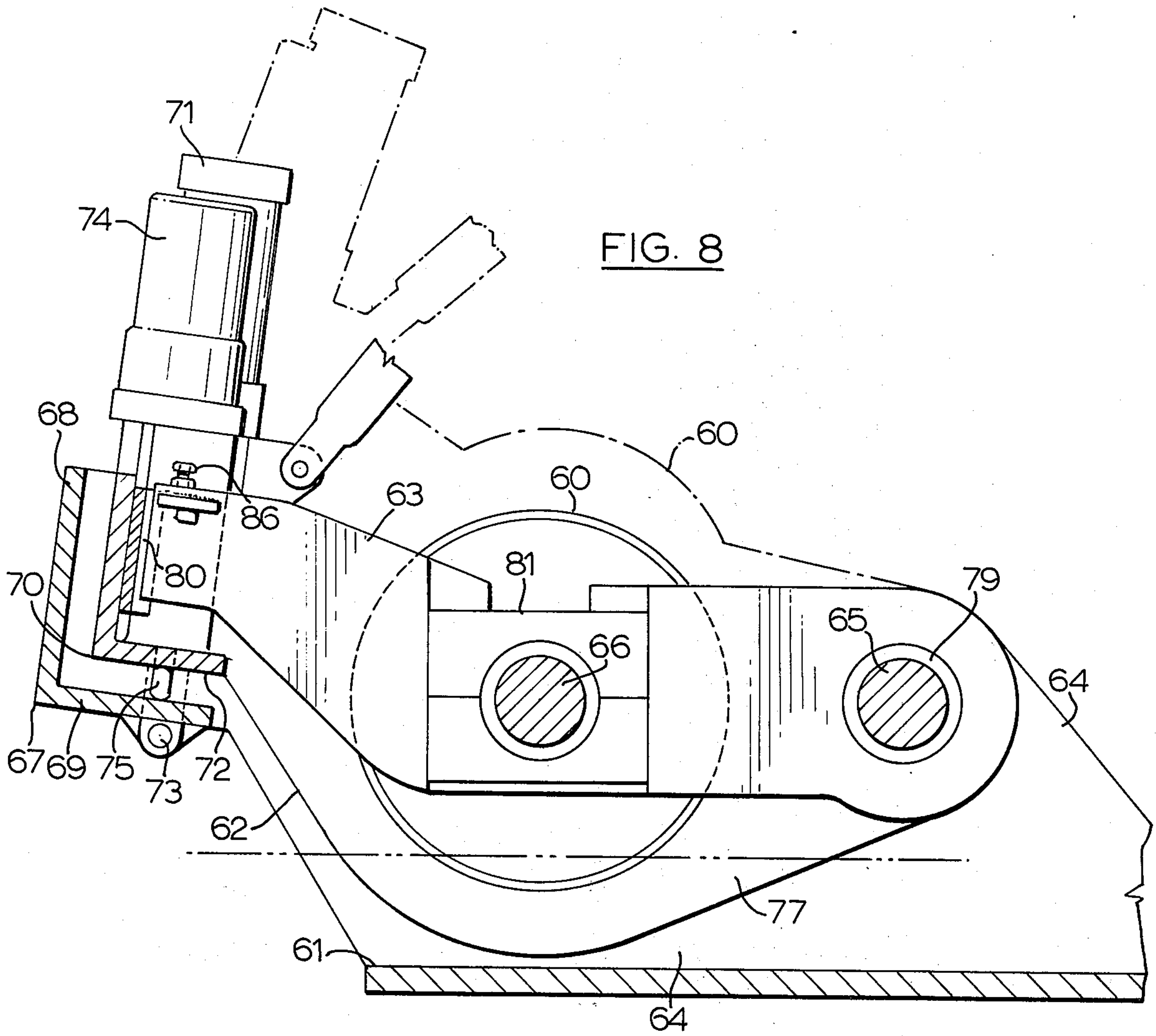

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FIG. 8

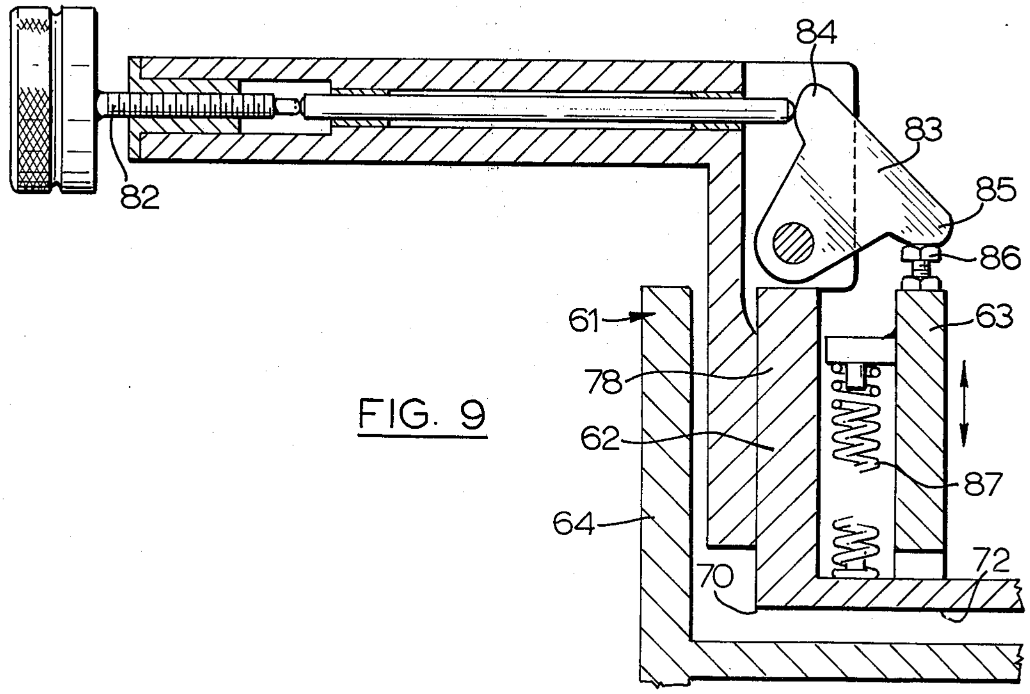

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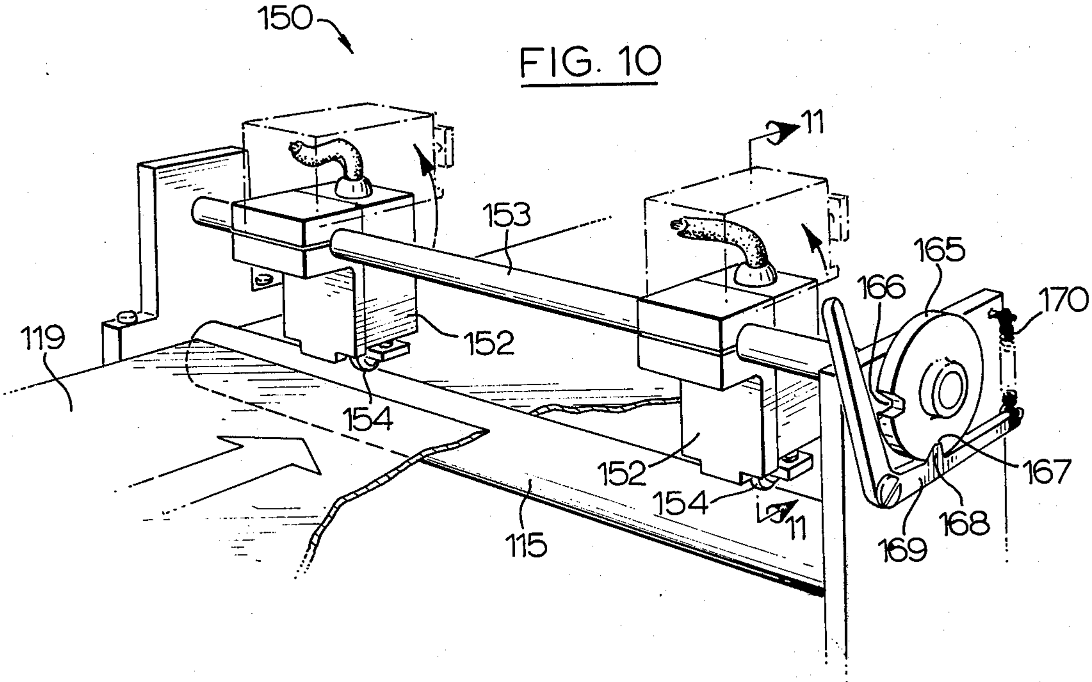
FIG. 9

FIG. 10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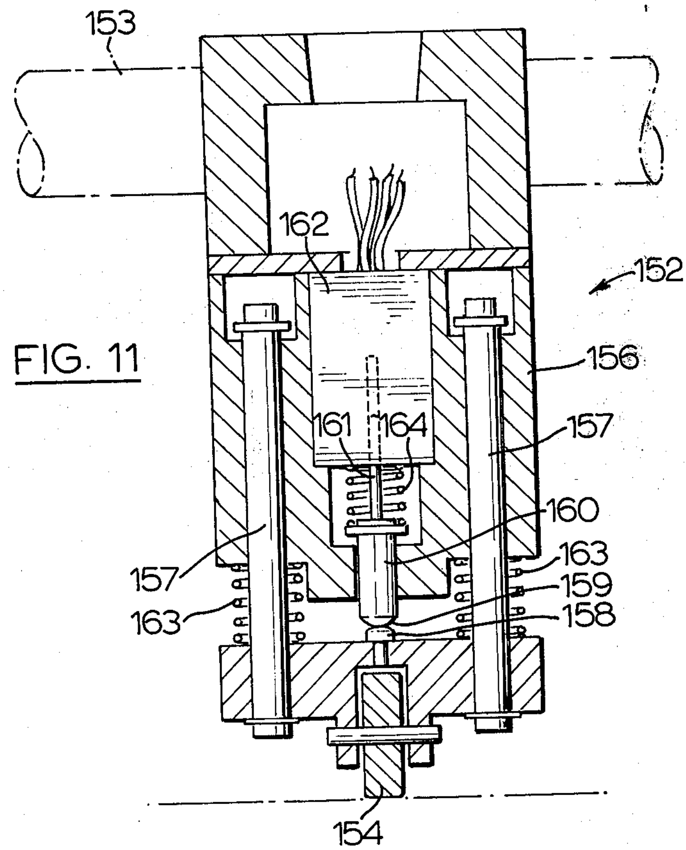
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FIG. 11

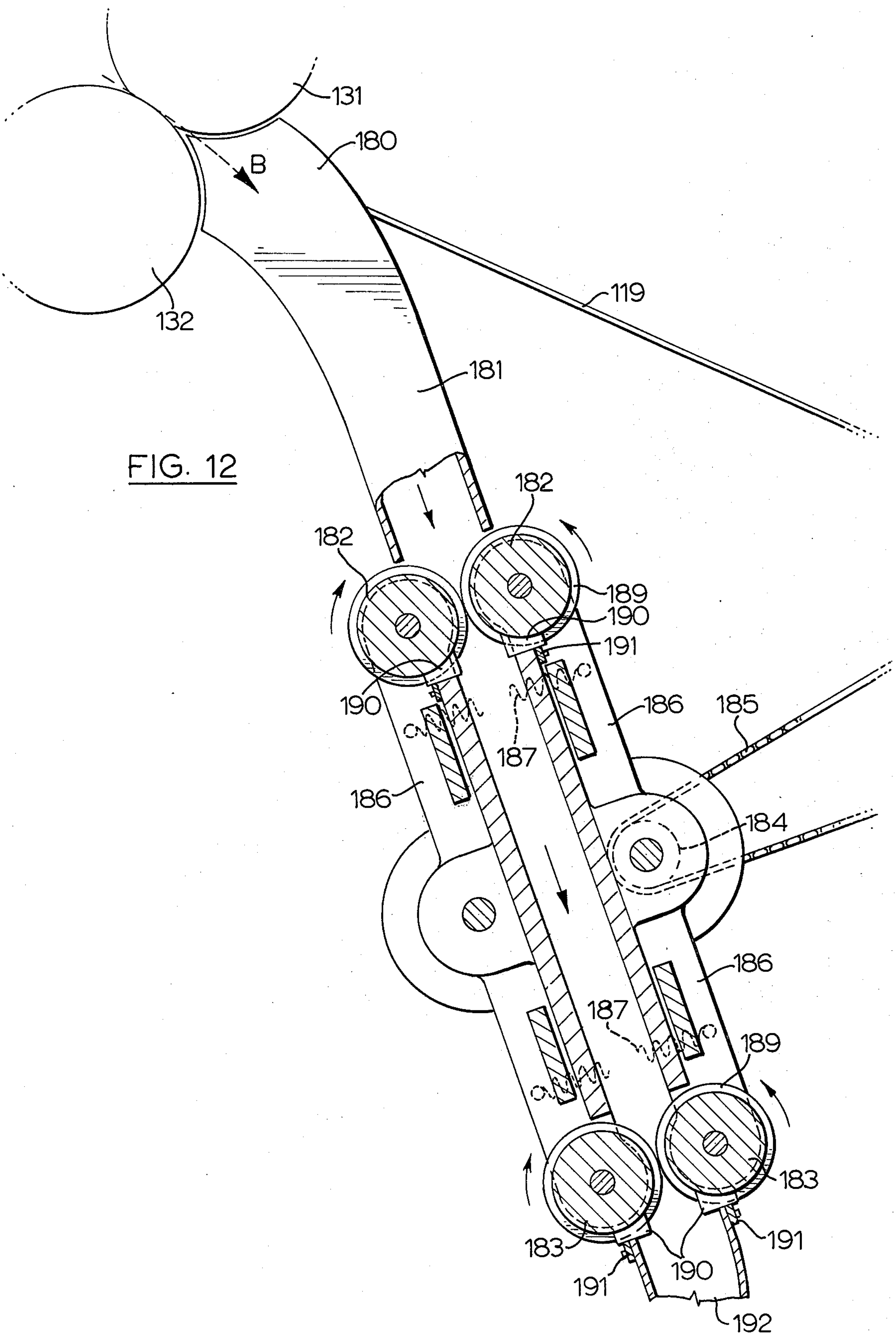
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FIG. 12

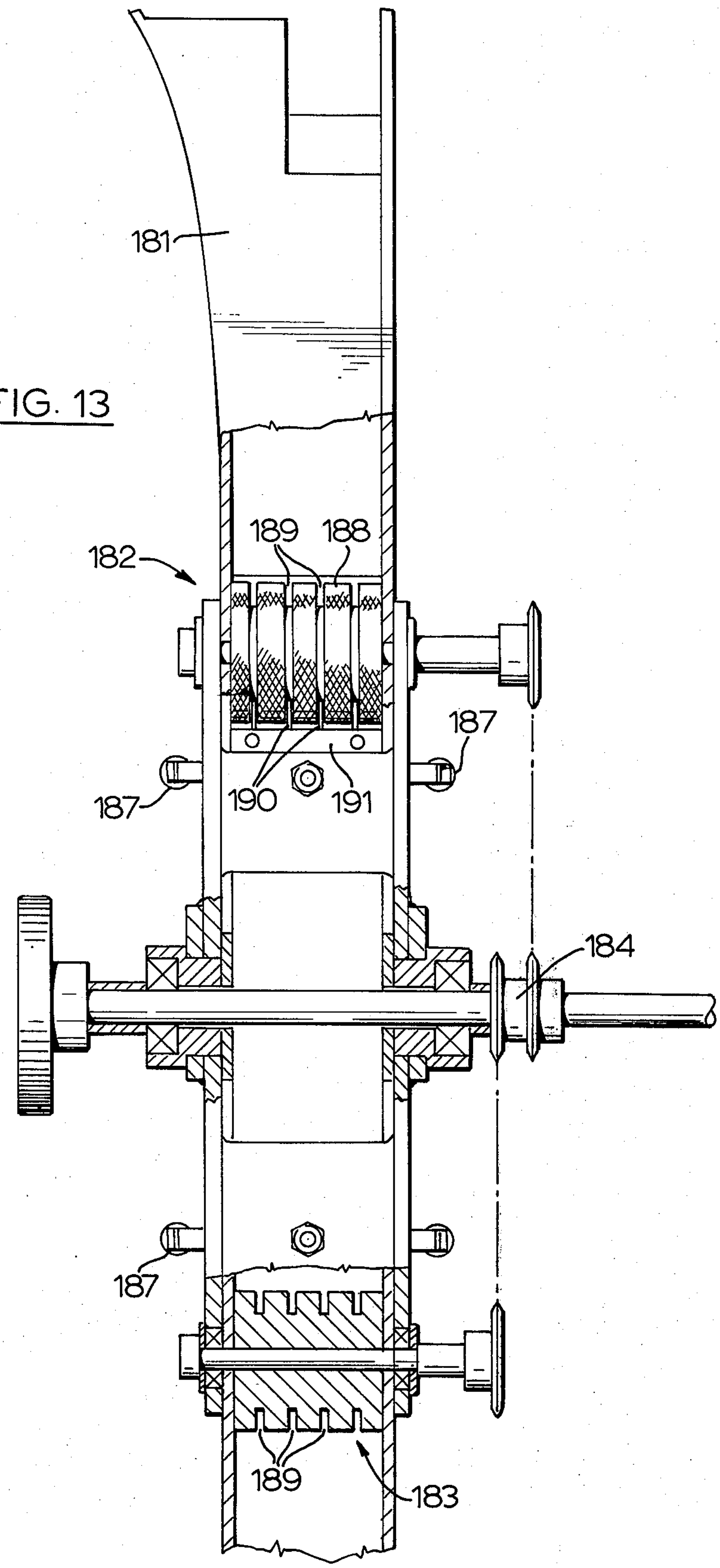

FIG. 13

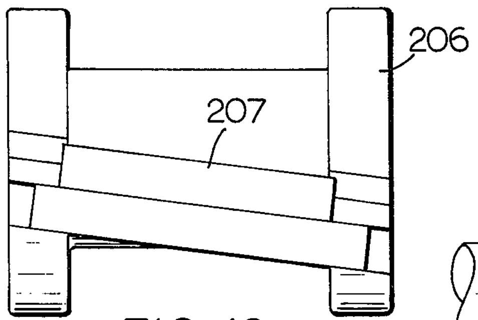

FIG. 16

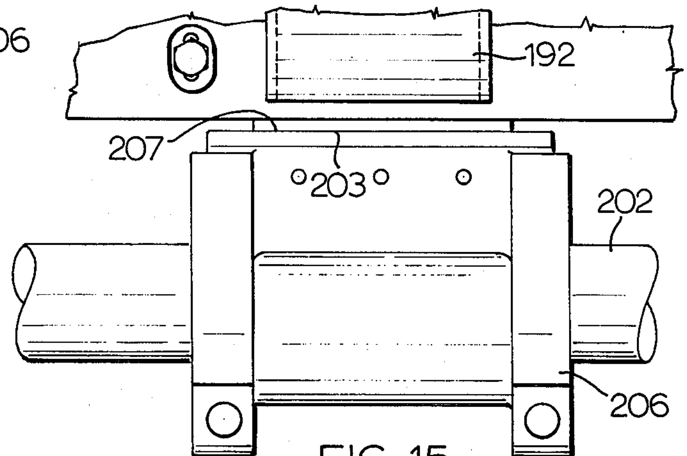

FIG. 15

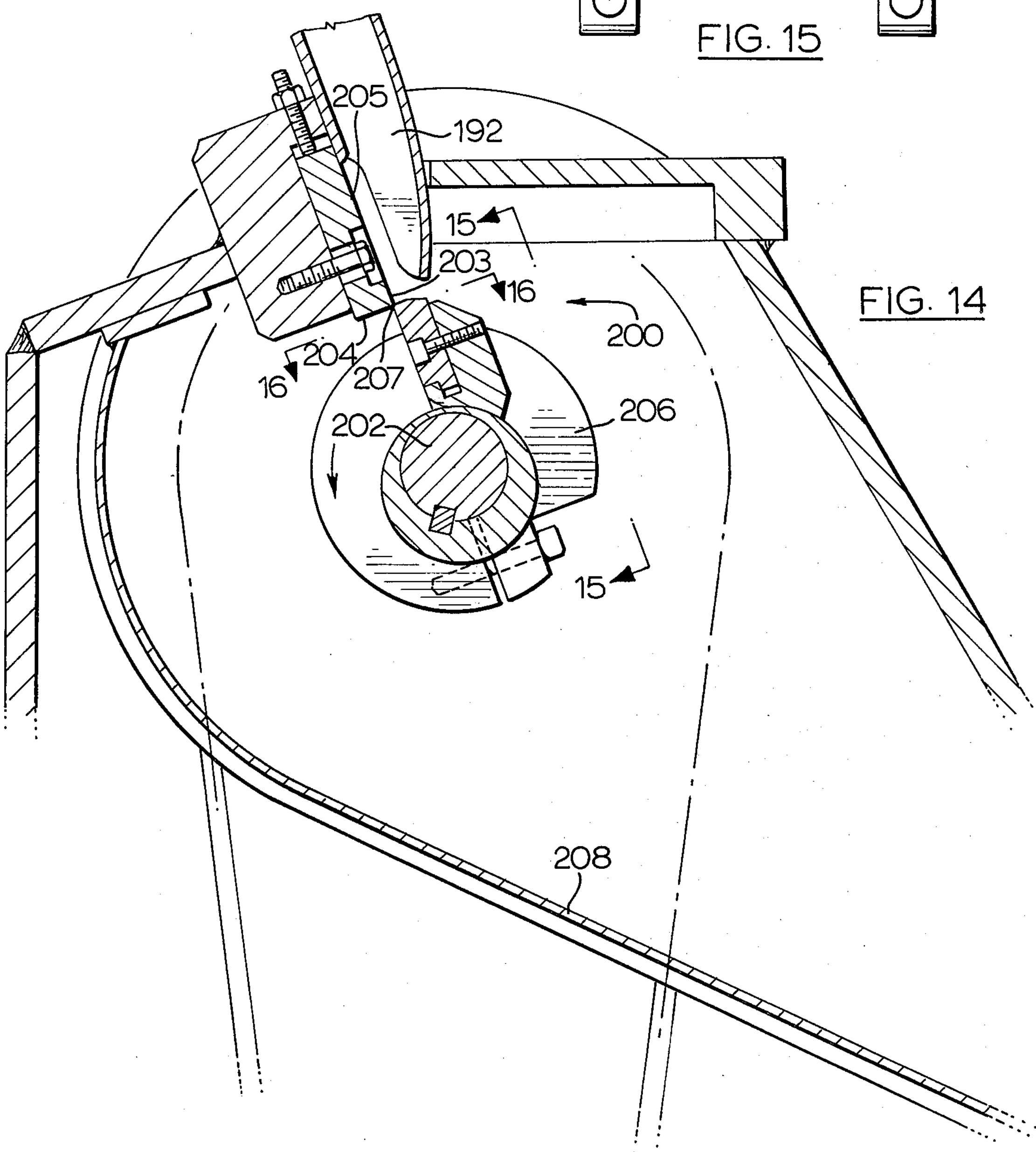

FIG. 14

LEAD SHEET CASTING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to a machine for casting metal sheet directly from molten metal and, more particularly, relates to a machine for continuously casting low melting point metals such as lead and lead alloys as sheet.

Apparatus for casting continuous metal strips or sheets from molten metal are known. Canadian Pat. No. 396,499 describes a machine for casting low melting point metals such as lead and it alloys into a continuous sheet for use as a cathode starter sheet for the electrolytic refining of lead. The cylindrical surface of an internally cooled, horizontally rotating drum dips into a bath of molten metal for the continuous casting of a layer of the metal onto the drum surface. The layer of cast metal is carried out of the bath by the rotating drum, from which it is removed as a continuous sheet. The casting drum shaft is supported by pivotably mounted arms which are controlled mechanically to provide the desired depth of immersion of the drum in the molten metal bath.

U.S. Pat. No. 1,879,336 discloses the casting of metal strip on a water cooled drum dipping into a molten metal bath. Cooling water flows through lengthwise extending passages with inlet and outlet chambers at the ends of the drum. Solidified metal leaves the drum between a doctor blade and a guide roll.

The casting drum of U.S. Pat. No. 2,074,812 rotates in molten metal in a gas filled chamber that has a baffle to exclude slag. Arrangement of a cooling coil within the drum may be varied to provide sheet that is uniformly thick across its width or that has thickness differences between the centre and the edges. Non-conducting side flanges do not remove metal from the bath and therefore define sheet width. Dependence of sheet thickness on the temperature and speed of rotation of the drum is disclosed.

Trimming of edge strip from continuously moving sheet material with subsequent cutting of the strip into short pieces is known. U.S. Pat. No. 2,497,155 illustrates use of a rotary shear to cut edge material which is fed parallel to the face of a stationary knife. U.S. Pat. No. 2,788,853 provides tiltable guiding means to control the path of severed edge strip leaving an overlapping pair of rotating circular trimming knives. In U.S. Pat. No. 3,069,949, a scrap chute between trim slitters and a trim chopper is adapted to open to release jammed strip. The scrap chopper of U.S. Pat. No. 3,799,020 has angularly disposed rotary blades to facilitate a progressive cut.

Canadian Pat. No. 810,586 discloses the use of a linear displacement transducer to convert thickness change to an electrical signal which may be used to control casting speed or cooling rate. Detectors of thickness change due to bulging of an insufficiently solidified continuous casting comprise wheels which are resiliently urged towards the casting. A transducer core is attached to each wheel mounting.

Lead alloy sheet for use in the manufacture of battery grids should be thin, of uniform thickness or taper, and substantially free of dross. Lead-calcium alloy, which is good grid material for maintenance-free batteries, is difficult to cast in a conventional grid casting machine, particularly as castings less than 0.05 inch in thickness, and since the alloy depends on aging to achieve

strength, it is very difficult to handle immediately after casting. Lead alloy sheet, cast onto a rotating drum which dips into a molten metal bath, has strength properties that give it advantages over conventional book mold type castings or sheet that has been rolled from conventional castings We believe that rapid, unidirectional solidification of molten metal cast on a drum suface provides a casting having greater resistance to intergranular corrosion by eliminating shrinkage cavity defects which occur in conventional book mold castings which solidify from the outisde towards the centre. The reactive calcium alloying additive makes the use of an inert atmosphere imperative.

SUMMARY OF THE INVENTION

We have found that the shortcomings of known processes can be substantially overcome and the advantages of continuously cast lead and reactive lead alloy sheet can be attained by the casting of sheet by the apparatus of the present invention.

It is the principal object of the present invention to provide cast sheet from lead alloyed with reactive metals such as calcium for the making of improved battery grids.

It is also an object of the present invention to limit undesirable reactions in the handling of molten reactive lead alloys by prudent isolation techniques and good metal flow control.

It is a further object of the invention to provide novel casting drum support and levelling means for rapid production of quality sheet of uniform thickness.

It is also an object of the invention to provide for the trimming of sheet edges and the separation of edge scrap from the sheet without distortion of product sheet and to prepare the scrap for return to the operation.

BRIEF DESCRIPTION OF THE DRAWINGS

The casting machine of the present invention will now be described in detail, reference being made to the following drawings in which:

FIG. 1 shows schematically a holding furnace for molten metal, circulatory flow of molten metal to a casting trough, rotation of a casting drum to withdraw sheet metal from the casting trough, means for handling cast sheet comprising an inclined table, pull rolls, edge trimming rolls to sever and separate edge strip, a sheet thickness measuring assembly and a winder, and means for removing and cutting trimmed edge strip;

FIG. 2 is a longitudinal section of the holding furnace and casting trough of the invention and shows in detail the pumping of molten metal from the holding furnace to the casting trough, casting trough structure and overflow means for circulation of excess flowing metal;

FIG. 3 is an end elevation taken along line 3—3 of FIG. 2 to show operation of a seal cup on the overflow return line;

FIG. 4 is a longitudinal section of the casting trough of the invention, partly cut away, and illustrates a skimmer structure not shown in FIG. 3;

FIG. 5 is a plan view, taken along line 5—5 in FIG. 2, showing the weir construction;

FIG. 6 is a perspective view of a portion of the casting machine showing the supporting structure and mounting adjustments for the casting drum and the upper end of the inclined table including the edge trimming assembly;

FIG. 7 is a transverse elevation along line 7—7 of FIG. 6, partly cut away, to show the edge trimmer roll's construction;

FIG. 8 is a side view of the casting drum mounting structure, partly in section, shown in perspective in FIG. 6;

FIG. 9 is a transverse section taken along line 9—9 of FIG. 6, to illustrate the drum levelling means;

FIG. 10 is a perspective view of the sheet thickness measuring assembly of the invention;

FIG. 11 is a transverse section taken along ine 11—11 of FIG. 10;

FIG. 12 is a side view, partly cut away, of the trim feeder of the invention;

FIG. 13 is a plan view, partly cut away, of the trim feeder shown in FIG. 12;

FIG. 14 is a side view, in section, of the scrap cutter of the invention;

FIG. 15 is an elevation taken along line 15—15 of FIG. 14; and

FIG. 16 is an elevation taken along line 16—16 of FIG. 14.

DESCRIPTION OF PREFERRED EMBODIMENTS

The apparatus of the invention as illustrated schematically in FIG. 1 generally comprises a sheet casting portion 1 and a cast sheet handling portion 2. The sheet casting portion 1 comprises holding furnace 3 which provides protection against drossing of reactive additive during the melting of lead alloy and subsequent handling of the molten metal, means by which pump designated by numeral 10 delivers a non-turbulent flow of molten metal to casting trough assembly 25, which casting trough 25 is adapted to provide lateral adjustment of a smooth flow of substantially dross-free molten metal to a zone through which the periphery of casting drum 60 moves, and cooled casting drum 60 which rotates on a substantially vertically adjustable axis to form cast sheet 100. In the sheet handling portion 2 of the apparatus, cast sheet 100 is pulled by pull roll assembly 120 comprising opposed rolls 121,122 down inclined table 110 on which edge strip is straightened, trimmed by edge trimmer 130 and monitored for thickness uniformity by thickness measuring assembly 150. Product sheet is guided to winder 125 or is cut into convenient lengths. Edge strip severed from sheet 100 is withdrawn by trim feeder assembly 180 and guided to trim cutter 200. Synchronized rotation of pull rolls 121,122, trimming rolls 131,132 and casting drum 60 can be provided by continuous belt 210 travelling on appropriate drive and idler sheaves as depicted by the broken line in FIG. 1. Rotation of casting drum 60 can be effected by the tension of sheet 100 drawn from the casting drum, as will be described hereinbelow.

Holding furnace 3 is an insulated chamber that is substantially rectangular in shape. Easy access to the interior of furnace 3 is provided at one end by an inclined opening that extends laterally across the wdith of the furnace and longitudinally from about the middle of the top of the furnace to about the middle of one end thereof. The access opening is shown sealed by cover 4. Cover 4, with side and top walls substantially aligned with the corresponding walls of furnace 3, is provided with end window 5 and with a gasketed seal, not shown. Damage to the gasket due to repeated removal and replacement of the cover is minimized by attachment of the cover to an external vertical shaft, not shown, which provides for controlled vertical movement and pivoting of the cover during opening and closing of the furnace. Window 5 in the vertical endface of cover 4 permits easy viewing of the level of the molten metal and of the operation of moving parts within the furnace. The gasketed seal, while it is not perfectly airtight, does allow an inert atmosphere under low pressure to be maintained in the furnace by slow admission of an inert gas such as nitrogen into the furnace through an inlet near the top. A flow rate of the order of 5 $ft.^3/hr.$ provides sufficient protection. The furnace may be heated electrically.

FIG. 2 shows in some detail the means by which pump 10 delivers molten metal to casting trough assembly 25, which is bolted onto horizontal top surface 6 of furnace 3. Pump 10 is preferably a positive displacement type (gear pump) that provides a smooth flow of molten metal to the trough. Pulsating action, such as with a centrifugal pump which tends to aerate the molten metal and to promote drossing of active metal alloying additive, is avoided. A gear pump is also less prone to blockage by dross than an impeller pump. Pump 10 is mounted externally on furnace end wall 7 and is easily accessible for maintenance. It is reversible, permitting immediate removal of molten metal from the casting trough and communicating piping at the end of a casting operation.

Molten metal from furnace 3 enters pump inlet 11 and is moved by rotation of gears 12 and 13 to pump outlet 14 and vertical insulated pipe 15. Outwardly extending shaft 16 of gear 13 is connected to a variable speed drive, not shown. Leakage of molten metal along shaft 16 is prevented by sealing means 17. Vertical insulated pipe 15 carries molten metal from pump 10 to horizontal passage 18 immediately below the bottom of a portion of casting trough 25 which extends beyond furnace end wall 7. Passage 18 fans out horizontally to the width of casting trough inlet 26 which extends laterally across the width of the trough. Insulation 19 encloses pipe 15 and passage 18. Electric heaters may be placed close to pipe 15 to ensure that the molten metal does not solidify in the pipe.

Excess molten metal which is not removed from casting trough 25 by casting drum 60 returns to furnace 3 through communicating means in the form of substantially vertical pipe 20. Splashing onto the surface of molten metal in furnace 3 tends to cause dross formation and such splashing is prevented by overflow cup 21 which holds sufficient molten metal to seal the lower end of pipe 20. Preferably, overflow cup 21 is cylindrically dished and is pivotally mounted to rotate clear of the pipe outlet. Counterweight 22 and detent 23 hold cup 21 in its molten metal-sealing position during operation of the casting machine. Rotation of cup 21 free of the lower end of pipe 20 permits easy cleaning of the pipe.

Casting trough assembly 25, which is the subject of co-pending U.S. Pat. Application Ser. No. 367,143 now U.S. Pat. No. 3,858,642 is attached to horizontal top surface 6 of furnace 3 with one end 27 near the top of furnace opening cover 4 and the other end extending beyond furnace end wall 7 to cover horizontal passage 18 from which laterally extending inlet 26 receives molten metal from pump 10. Centrally located overflow chamber 28 is placed to receive excess molten metal flowing over level-controlling weirs 29 and 30 for return to furnace 3 via pipe 20. Holding section 31 of casting trough 25 receives molten metal through inlet 26. As disclosed in the aforementioned patent application, molten metal flows over wall 32 of feed gallery 33, under partially submerged baffle 34 and over inclined baffle 35 and thence through channel 36 into casting section 37. Plate 38 defines the upper face of channel 36 and has a sloping portion 39 which extends into casting section 37 to conduct molten metal to one side of the casting drum. The level of molten metal in holding section 31 is controlled by the level of overflow weir 29, while the volume of metal supplied to casting section 37 is controlled by the level of weir 30.

The height of weir 30, which is essentially no greater than that of weir 29 to ensure flow of metal through the trough, is adjustable to provide regulation of that flow. Flowing metal in excess of that which is removed on the periphery of a casting drum that dips into molten metal in the casting section passes under partially immersed baffle 40 which is attached to cover 41 and over weir 30 to enter overflow compartment 28 between weirs 29 and 30 and returns to furnace 3 through pipe 20. Discharge of molten metal over weir 29 removes dross that may be separated during flow through the holding section and eliminates surges that may be caused by flow irregularities. Holding section 31 and a part of casting section 37 that is adjacent to overflow weir 30 are enclosed by cover 41 and the attached baffle 40.

A flow of inert gas through an inlet, eg. 42, in cover 41 inhibits dross formation in underlying areas. Immersed baffle 40 keeps this gas away from casting drum 60. End wall 43 of casting section 37 has an upper portion 44 that is inclined outwardly to assist the action of a skimmer that is hereinafter described. Gas bubbles that may form against the bottom face of sloping conduit portion 39 of plate 38 are directed away from the periphery of immersed casting drum 60 by inclined baffle 45 which overlaps the upper edge of conduit 39. Baffle 45, which is wider than the casting drum, is conveniently mounted on arm 46 which rotates on axis 47 which is attached to the casting trough assembly outside the trough itself, thereby permitting easy removal of baffle 45 to position 45′ (FIG. 4) during skimming of the molten metal bath as hereinafter described. When the casting drum is in its operating position its periphery dips into the molten metal between immersed baffles 45 and 40.

If pump 10 is a gear pump, the flow of molten metal to casting section 37 of trough 25 may be sufficiently smooth to permit simplification of holding section 31 by removal of one or more of the baffles 32, 34 or 35 without adversely affecting the quality of cast lead alloy sheet. FIG. 4 shows a holding Section 31 in which all three baffles have been deleted.

Casting section 37 of the casting trough may be provided with means to remove dross that forms when the machine is opened for servicing. In FIG. 4, there is shown attached to opposite side walls of casting trough assembly 25 and extending horizontally from baffle 40 past the top end of sloping portion 44 of end wall 43 a pair of plates 48 with slots 49 that guide a transverse shaft 50 to which skimmer plate 51 is attached. Skimmer plate 51, which is substantially as wide as the inside of the trough, is curved to dip under the surface of the molten metal so that, when it is pulled horizontally from its rest position on baffle 40, a thin surface layer is drawn across the bath and up inclined wall portion 44 to be discarded at the end of the trough. A rod 52, that runs the length of the casting section but that is not directly above the casting zone, may be used to move the skimmer. Since freedom from dross and other foreign

matter is very important in cast lead alloy sheet that is to be used for battery grids, occasional skimming of the surface of the molten metal in casting section 37 contributes to the production of better sheet. Good protection against drossing of the molten metal is provided in the holding section 31 of casting trough 25 even during start-up and in the casting section 37 when all parts of the apparatus that handle molten metal are covered during continuous operation. During the skimming operation, bubble diverting baffle 45 is pivoted to its position outside the trough as shown by the broken lines designated by numeral 45′. Casting drum 60 is elevated as hereinafter explained.

Adjustment of weir 30, both to change its height relative to that of weir 29 for controlled continuous discharge of excess molten metal from casting section 37 and to provide coarse adjustment, during machine operation, for transverse taper of cast sheet, is shown in FIGS. 2 and 5. Weir 30 is attached to weir holder 53 by a spring loaded bolt 54 extending through slot 55 on the centre line of the weir. The central portion of the upper edge of holder 53 is recessed to ensure a level below the normal level of molten metal at the top of the weir. Weir 30 extends in length beyond each end of the holder recess and has formed at each of its ends a rectangular slot 56 which receives a corresponding cylindrical projecting portion 57 of face 58 of one of a pair of spring tensioned adjustment screws 59 which may be rotated in a fixed position on baffle 40. As a screw 59 is rotated, action of projecting portion 57, which is in an off-centre position on face 58, in slot 56, causes that end of weir 30 to move up or down relative to the other end by as much as one-fourth inch. Equal raising of both ends of weir 30 decreases the flow of molten metal in casting section 37. Raising of one end of weir 30 decreases the flow of metal at that end, thereby permitting greater cooling to provide relative increase in the thickness of sheet cast at the corresponding end of the drum. Lowering of one end of weir 30 increases the flow of molten metal across that end. Spring tension on each screw 59 below baffle 40 is sufficient to prevent accidental rotation during machine operation.

With reference now to FIGS. 6, 8 and 9, the supporting structure of casting drum 60 comprises a main stationary outer frame 61 and an inner adjusting frame 62 with an adjusting arm 63. Outer frame 61, which is set on top surface 6 of furnace 3, encloses the assembly at the bottom, sides and ends. Its side plates 64 extend parallel to the sides of casting trough 25 to support, near one end, shaft 65 on which inner adjusting frame 62 and adjusting arm 63 are pivotally mounted. The central parts of side plates 64 are recessed to permit free vertical movement of casting drum shaft 66. Cross bar 67, which joins the left ends of side plates 64, as shown in FIGS. 6 and 8, has a substantially vertical plate portion 68 and a bottom plate portion 69 attached thereto at right angles. Cross bar 67 adjustably supports cross bar 70 of like configuration of adjusting frame 62 by pneumatic piston-cylinder assembly 71 mounted on bottom plate 72 of cross bar 70. Piston rod 73 of cylinder assembly 71 is pivotably attached to bottom plate 69 of cross bar 67 to provide coarse adjustment of the height of the drum in the casting trough. Application of air pressure to the cylinder causes inner adjusting frame 62 to pivot on shaft 65 to raise casting drum 60 to an upper position with its periphery removed from molten metal in casting trough 25. Release of air pressure permits the drum to descend into the trough to a depth of immersion of its periphery in molten metal which is determined by the setting of adjacent gear motor and extensible and retractable support rod assembly **74,** also mounted on plate **72.** Rod **75** extends through a hole in plate **72** to press onto horizontal plate **69** of the main frame **61** when the casting drum is in its lowered position. Rod **75** is advanced or retracted by action of the gear motor to provide fine adjustment of the depth of immersion of the casting drum.

In the start-up of a casting operation, drum **60** is lowered by release of air from cylinder assembly **71,** to a preset depth of immersion determined by the distance between plates **69** and **72** as the end of rod **75** contacts plate **69.** If a change in the thickness of cast sheet is desired, the gear motor is operated either to advance or to retract rod **75,** thereby providing fine adjustment of the depth of immersion of the drum.

Shaft **65** journalled in bearings **76** secured to side walls **64** supports side plates **77** and **78** of adjusting frame **62** at the end opposite cross bar **70** and provides pivotal mounting for frame **62.** Side plate **77,** which is at the driven end of casting drum shaft **66,** is keyed to shaft **65** to rotate therewith and is provided with a bearing (not shown) to support shaft **66.** Side plate **78,** which is at the free running end of casting drum shaft **66,** is recessed to permit free movement of shaft **66.** Adjusting arm **63** is pivotally mounted on bearing **79** at one end on shaft **65** and extends parallel to adjacent side plate **78.** The other end of adjusting arm **63,** supported by adjusting frame **62,** is capable of limited vertical movement in a slot in skid plate **80** mounted on cross bar **70** of frame **62.** Adjusting arm **63** provides bearing support **81** for the free running end of casting drum shaft **66.** Drum shaft **66** is thus journalled in bearings secured in side plate **77** and arm **63.** Vertical movement of adjusting arm **63** relative to the corner of adjusting frame **62** raises or lowers the free turning end of the casting drum shaft relative to the drive end. Raising and lowering of adjusting arm **63** is effected by action of biasing means interposed between the end of the arm opposite to the pivotal mount and adjacent side plate **78.** Micrometer screw **82** and double lobe cam **83,** mounted on side plate **78** of adjusting frame **62,** act through abutment of screw **82** on cam lobe **84,** causing cam lobe **85** to exert downward pressure on pin **86** against upward pressure of biasing means such as compression spring **87,** the lower end of which presses against the upper side of bottom plate **72** of cross bar **70** of the adjusting frame. With the casting drum supporting structure of the present invention, adjusting frame **62** can, by the action of gear motor **74,** be raised or lowered to cause the drum periphery to be immersed into the molten metal bath to a depth that produces cast sheet having desired thickness. Incorporation of adjusting arm **63** into the supporting structure eliminates a need for precise lateral levelling of the whole apparatus in order to keep the thickness of cast sheet across its width within close tolerances. Use of micrometer screw **82** as described permits levelling of drum **60** and fine adjustments of thickness differences across the width of cast sheet to be made during operation of the machine.

A simple external indication of depth of immersion of drum **60** into the molten metal in the casting trough may be effected by use of indicating arm **88** adjustably attached to a part of shaft **65** extending through a main frame side wall **64** and through a side wall portion **99** of a protective enclosure. Since side plate **77** of adjusting frame **62** is keyed to shaft **65,** rotation of shaft **65** equals angular rotation of drum **60** about shaft **65** as drum **60** is raised or lowered. A gauge piston contact pad **89** is located on arm **88** at a distance from the centre of shaft **65** equal to the distance from the centre of shaft **65** to the axis of rotation of the casting drum **66.** As drum **60** is lowered into the molten metal, after initial contact of its periphery with the surface, pad **89** moves in an arc having a length equal to the depth of drum penetration to press piston **90** of linear displacement measuring gauge **91.** If piston **90** is set against pad **89** to give a zero reading as the drum periphery just touches the molten metal bath surface, the gauge will give direct readings of depth of immersion.

Complete withdrawal of casting drum **60** from trough **25** by vertically pivoting adjusting frame **62** on shaft **65** is effected, after disconnecting the linkage of air cylinder assembly **71** to outer frame **61,** by rotation of lifting arm **92** as shown by arrow A (FIG. **6**). Horizontal cross bar **93,** attached to the upper end of lifting arm **92,** is adjustably linked to side plate **77** of adjusting frame **62** by linkage assembly **94.** Action of a manually operated screw on the lower end of lifting arm **92** causes adjusting frame **62** to rotate about shaft **65** until the casting drum comes to a rest position slightly beyond the vertical plane of shaft **65.** Reverse action of the screw lowers casting drum **60** into its operating position.

Casting drum **60** is a hollow structure having a cylindrical peripheral wall **95** and circular end walls **96.** It is mounted on shaft **66** which has hollowed ends to permit admission of a coolant, such as water, through connecting hose **97** and discharge of coolant by like means at the other end. Spaces between walls **96** and **95** and corresponding walls of a concentric inner drum provide a lateral passage adjacent one end wall **96** to conduct inlet coolant to the drum periphery, a passage adjacent peripheral wall **95,** and a lateral passage adjacent the other end wall **96** to conduct outlet coolant to a hollowed discharge portion of shaft **66.** Since more effective cooling is achieved by rapid flow of coolant through a narrow passage adjacent peripheral wall **95,** it is advantageous to avoid build-up of corrosion products in the passage. With water as the coolant, a corrosion inhibitor should be added, in which case a small volume of recycling treated water may be cooled in a heat exchanger.

Cast metal sheet is withdrawn from drum **60** by pull roll assembly **120** to move down inclined table **110.** Drum **60** is rotated at a speed not greater than the normal casting speed by linkage with the pull roll assembly or by a separate motor, not shown. At the start of a run, the lead end of the cast sheet is removed from the drum manually and is directed onto inclined table **110.** Before reaching pull roll assembly **120,** the cast sheet passes through edge trimmer **130,** and thickness measuring device **150.** The pull rolls are synchronized to provide a marginally-greater peripheral speed, about 5%, than that of the casting drum. Consequently, when the slower moving sheet, produced at a start-up speed provided by powered drum rotation, is threaded through the pull rolls, the pull rolls then overdrive the casting drum which incorporates a clutch allowing the drum to free-wheel. Separate drum driving means permits reduction of the required length of belt **210.**

During the formation of continuously cast metal sheet on the peripheral surface **95** of a casting drum, some metal envelops the ends of the drum to solidify on the rims of end walls **96** to form down-turned strips of edge metal disposed at an angle to the plane of product sheet. The amount of such edge metal varies with the depth of immersion of the drum into the bath of molten metal. After leaving drum **60**, the central, planar product portion of the cast sheet is conveyed on removable, upper component **111** of table **110**, while the outer edge portions extend, unsupported, beyond the edges of the table. Upper table component **111** is removably hinged to adjacent stationary table component **112** to permit easy access to drum **60** and casting trough **25** when the machine is not operating.

It is the purpose of edge trimming assembly **130** to separate irregularly formed edge material from central, planar material by leveling and longitudinally trimming the sheet edges to continuously yield product sheet having smooth, straight edges. Immediately before entering between the opposed rolls **131,132** of the edge trimmer, the down-turned portions of metal which are formed on the sides of the casting are turned upwardly and outwardly into a roughly horizontal position, even with or above the plane of the central sheet portion, thereby eliminating any tendency of the edge portion to fold under the central product portion to cause buckling of the latter on passing between rolls **131,132.** Turning of each edge portion of the sheet is effected by guiding its inner edge face against the outer face **118** of a deflector plate **114**, one of which is securely attached to or formed in each of the longitudinal side edges of component **112** of the table. Each deflector plate **114**, observed from left to right in FIG. **6** as if following passage of cast sheet towards the rolls **131,132,** has a top edge **117** initially even with the table top. Top edge **117** then rises to a height of about one-fourth inch above the plane of the table while the outer face **113** of the plate is twisted and shaped outwardly and upwardly in a smooth curve from a vertical plane **115** to a horizontal plane **116** parallel to, and preferably above, the plane of the table, but not above the maximum height of top edge **117.** A portion **118** of top edge **117** of this elevated portion of deflector plate **114** is generally parallel to the direction of movement of cast sheet and extends inwardly over table portion **112** relative to the lateral spacing of vertical plane portions **115**, which corresponds with the width of casting drum **60**, so that the spacing between opposed edges **117** of the pair of deflector plates **114** is slightly less than the planar portion of cast sheet, i.e., slightly less than the width of casting drum **60.**

By action of a guiding deflector plate **114** on each side of the table section **112** the edges of sheet moving downwardly along the table are leveled into an approximately horizontal, outwardly extending position by first being lifted slightly above the table plane to collapse into a nearly flattened state before entering the edge trimmer rolls. By use of this device, the rolls are provided with sheet material which can be handled conveniently. The main body of product cast sheet is not distorted by use of this edge flattening means. Without prior controlled leveling of down-turned edges, double thickness sheet may enter between the slitter rolls to cause undesirable distortion of planar product material and may even, on cutting of double thickness, result in edge material being carried forward with product sheet. This edge lifting and twisting action may be accomplished in about 5 inches of sheet travel. We have observed that cast sheet is handled more effectively if, on entering the trimming rolls **131,132,** the outer part of each edge portion is slightly elevated above the plane of the product portion.

One end of opposed upper roll **131** and lower roll **132** of edge trimmer **130** is shown in FIG. **7.** Rolls **131** and **132** are journalled across table section **112** for rotation one above the other is biased abutment with each other. Upper roll **131** is provided with circular machined cutting faces **133** in proximity to each end while lower roll **132** is provided with engaging circular machined faces **134** in like manner in proximity to each end. A steel cylinder portion **135** of upper roll **131** between faces **133** provides a rigid peripheral surface having a diameter equal to that of faces **133,** while the corresponding portion of lower roll **132** between faces **134** is covered with resilient material **136,** e.g., rubber, to provide a resilient peripheral surface which has a diameter sufficiently less than that of faces **134** to provide positive but yielding engagement with cast metal sheet. The portions **137** of the ends of upper roll **131** which are adjacent machined faces **133** are recessed to accommodate sleeves with resilient peripheral surfaces **138** which are sufficiently wide to engage the partially straightened edge portions of the cast metal sheet. The end portions **140** of lower roll **132** which are adjacent discs **139** have rigid peripheral surfaces and are spaced apart to provide positive but yielding engagement with the partially straightened edge portions of the cast metal sheet.

The resilient roll portions as hereinbefore described provide traction which aids advancement of the sheet into the trimming rolls without deforming the sheet, and also provide accommodation of a range of sheet thicknesses, e.g., between 0.02 and 0.06 inch, without change of roll spacing. With this arrangement, soft metal sheet such as lead or lead alloy leaving the trimming rolls is directed by the contour of the steel roll, product sheet following the rigid peripheral surface of upper roll portion **135** to turn upwardly and edge scrap following the rigid peripheral surface of lower roll portion **140** to turn downwardly, thereby providing effective initial separation of the scrap from the product.

On leaving edge trimmer **130,** trimmed product sheet is carried on inclined table section **119** to thickness measuring assembly **150,** FIG. **10,** which comprises a roll **151** journalled in the machine below table section **119** to extend transversely to the direction of travel of the sheet so that its periphery penetrates sufficiently to support the cast sheet, and at least one thickness measuring unit **152** depending from horizontal bar **153** disposed above the table in parallel spaced relationship with roll **151** and journalled for rotation in the machine. Each thickness measuring unit **152** comprises a roller **154** that rides on the upper surface of the cast sheet and is carried by unit head **155** which is adjustably attached to main body portion **156** by a pair of slide bars **157.** Pad **158,** centrally located above roller **154,** makes point contact with convexly curved end face **159** of plunger **160.** Upper end **161** of plunger **160** is the core of linear displacement transducer **162.** Head **155** and plunger **160** are maintained in operating positions by pressure on compression springs **163,** which encircle slide bars **157** with their ends pressing against head **155** and body portion **156,** and on compression spring **164,** which encircles plunger **160** with its ends pressing against the plunger and the body of transducer **162** to oppose the action of springs **163.** As the thickness of cast sheet moving under roller **154** changes, this change is transmitted to core **161** which moves within transducer 162 to change its electrical output. Calibrated indication or recording of the transducer output shows changes in the thickness of the cast sheet within close tolerances that are required.

In order to detect variations in thickness across the width of cast sheet, two or more thickness measuring units are used. If a thickness measuring unit monitoring one side of cast sheet indicates thickness greater or less than that on the other side, correction may be made by resetting adjusting arm 63 of the casting drum support structure. Electrical output of the linear displacement transducers may also be used to control casting variables, such as the rate of cooling and the rate of rotation of the casting drum, to change the thickness of the cast sheet.

In order to facilitate good resolution in the measurement of thickness change, the stroke of transducer plunger 160 has been limited to about 0.2 inch. This limitation permits the foregoing units to provide, simply, indications of 0.001 inch changes in thickness. Because of this provision for sensitivity, protection of the transducer against damage during start-up of operation and by impact of foreign objects that may be carried on the cast sheet surface has been provided by means for rotation of units 152 about horizontal bar 153 out of contact with sheet 100. Cam 165 that is mounted on the end of horizontal bar 153 has two peripheral slots 166 and 167 about 90° apart that engage detent 168 on the arm of lever 169. During operation of the thickness measuring units, detent 168 is biased in slot 167 by tension on spring 170. Counterclockwise thrust, as shown in FIG. 10, on a roller 154 causes units 152 to rotate about horizontal bar 153 until detent 168 engages slot 166 to hold the units in a horizontal position until released by manual depression of lever 169. Attached signalling means indicates any need to correct irregularities in operation and to reset the thickness measuring device.

Cast sheet continues to move on inclined table 110 to pull roll assembly 120 journalled in the machine where it passes between rubber covered upper roll 121 and steel surface lower roll 122. Rate of movement and tension on the cast sheet throughout the machine is controlled by pull roll assembly 120. Cast sheet then passes under idler 123 from which it may be fed to winding mechanism 125. The winder spool is conveniently rotated by a constant torque drive, adjusted to exert constant tension on the sheet which is always less than the pull roll tension at all casting speeds but which is sufficient to avoid sagging between idler 123 and the spool.

To each side of the casting machine there is attached a trim feeder 180, FIG. 12, disposed to receive downwardly turning edge strip 102, indicated by arrow B in FIG. 12, from edge trimmer 130 and to provide powered guidance, under sufficient tension to preclude misdirection or buckling of the soft metal, of this edge strip into trim cutter 200. Short upper passage 181, rectangular in cross section, leads to an upper pair 182 of two spaced-apart pairs of opposed rolls 182 and 183 which are rotated by means of centrally mounted drive pulley arrangement 184 which, in turn, is linked by chain 185 with pull roll assembly 120. Each roll rotates on a horizontal axis parallel to the plane of a cross section of moving strip and attached to an arm 186, which is pivotably mounted to permit variable spacing of the rolls of a pair. Each pair of rolls is biased together by tension on a spring 187. Faces 188, FIG. 13, of the rolls are knurled to provide, under spring tension, for bearing against each other, firm gripping of edge strip advancing between a pair of rolls. Each roll has spaced, circular grooves 189 across its length in which, on the exit side, stationary fingers 190 attached to a bar 191 are inserted. These fingers and bars guide moving strip in a linear path to prevent coiling of the strip about the rolls. Spring mounting of roll pairs 182 and 183 provides variable spacing to accommodate for variations in thickness of cast sheet and for thickness irregularities of edge strip. The springs may be sufficiently extensible to permit access into the feeder to remove any obstructions. These rolls rotate at a speed which constantly provides tension on edge strip moving through the feeder. Since this speed is controlled by the speed of the pull rolls, no adjustments are required to maintain tension on the edge strip as the rate of casting changes. Edge strip leaving lower pair of rolls 183 is driven through converging exit channel 192, FIG. 14, into trim cutter 200.

At each side of the casting machine, trim strip is cut into short pieces by action of a rotating blade against a stationary blade. Two rotating blades 201 are mounted on a common horizontal shaft 202, one at each end of the shaft, 180° apart to provide balanced rotation. The edge 203 of stationary blade 204 extends horizontally adjacent the lower end of exit channel 192. Approaching strip 102 follows face 205. Each blade 201 is mounted on an arbor 206 with one end of its edge 207 ahead of the other end to provide, on rotation, shearing engagement of its edge 207 with edge 203 of the corresponding stationary blade. As the two edge strips are driven into trim cutter 200, they are alternately sheared to form short pieces of scrap material 103 which are carried forward by the rotating knives to fall onto inclined tray 208 and thence into a convenient receptacle or recycling system.

Casting drum 60 and edge trimmer 130 can be connected to pull roll assembly 120 by belt 210 that engages sheaves mounted on the shafts of the drum. The trim feeder is attached to the pull rolls by a separate belt or chain. In this way the trim feeder and the lower rolls of the slitter and the pull rolls are synchronized. Connection through a one-way clutch of the casting drum to belt 210 or to separate drive means providing rotation at a rate not exceeding the rate of withdrawal of sheet by the pull rolls ensures that the drum is not powered to rotate at a speed which forms cast sheet more rapidly than it is withdrawn by the pull rolls. However, the drum can be freely rotated at any greater speed. This simplifies manual start-up, as the sheet can be pulled quickly to provide a thin section that can be cut easily to remove a rough portion that forms at the beginning of a run. This thinner than usual starting strip is more easily fed through the pull rolls than the rough portion. Quicker initiation of automatic casting is achieved. Pull roll assembly 120 is preferably synchronized with casting drum 60 to move cast sheet at a speed which is as much as 5% greater than the peripheral speed provided by powered rotation of the casting drum. Because of this small difference, tension is constantly maintained on sheet moving between the drum and the pull roll assembly.

The sheet casting and sheet handling sections of the casting machine are protected by a vented enclosure on which is mounted a panel of instruments which indicate or record operating variables. The enclosure, including side wall portion 99 shown in FIG. 6, is provided with a side window immediately above side wall portion 99 and a top panel which are easily removed to facilitate access for maintenance and during start-up.

What we claim as new and desire to protect by Letters Patent of the United States is:

1. In a machine for casting metal sheet from molten metal by rotating a drum in a pool of said molten metal contained in a trough for casting of the metal onto the drum and withdrawal of said cast metal as a continuous sheet, support means for raising and lowering said drum and for leveling said drum comprising: a stationary outer frame enclosing the casting trough on its sides and at least one end, an inner adjusting frame pivotally mounted at one end within said stationary outer frame and enclosing the casting trough on its sides and its end opposite the pivotal mounting having said drum journalled in bearings secured therein, means for raising and lowering the inner frame relative to said outer stationary frame for angular rotation about the pivotal mounting for coarse and fine adjustment of the height of the drum in the casting trough, said coarse adjustment for placement of the drum in a lower position in the trough to immerse the drum periphery to a preset depth below the surface of molten metal in the trough and placement of the drum in an upper position to remove the drum periphery from said molten metal in the trough and said fine adjustment for providing changes in said preset depth, means for raising or lowering one side of said inner frame relative to the other side for adjusting the level of the drum, and means connected to said inner frame for pivoting said inner frame out of contact with said stationary outer frame for removal of the drum from the casting trough.

2. In a machine as claimed in claim **1**, said means for raising and lowering the inner frame relative to the stationary outer frame about the pivotal mounting for coarse and fine adjustment of the height of the drum in the casting trough comprising a cross bar formed in the end of the stationary frame, a cross bar formed in the end of the inner frame, means secured to the inner frame cross bar adapted to abut the stationary frame cross bar for said coarse adjustment of the height of the drum, and means secured to the inner frame cross bar adapted to abut the stationary frame cross bar for said fine adjustment of the height of the drum.

3. In a machine as claimed in claim **1**, said means for raising and lowering the inner frame relative to the outer stationary frame about the pivotal mounting for coarse and fine adjustment of the height of the drum in the casting trough comprising a cross bar formed in the end of the stationary frame, a cross bar formed in the end of the inner frame, means secured to the inner frame cross bar adapted to abut the stationary frame cross bar for coarse adjustment of the height of the drum, including a piston-cylinder assembly interconnecting the stationary frame and inner frame, and means secured to the inner frame cross bar adapted to abut the stationary frame cross bar for fine adjustment of the height of the drum, including a gear motor with extensible and retractable support rod abutting the said stationary frame cross bar.

4. In a machine as claimed in claim **1**, said drum rotating on a shaft driven at one end thereof, said inner frame comprising a pair of spaced side plates interconnected by said cross bar and an arm, said side plates and arm pivotally mounted at one end within the stationary outer frame, one side plate of said pair, at the driven end of said casting drum shaft, being provided with a bearing to support the drum shaft, one side plate of said pair, at the free running end of the casting drum shaft, being recessed to permit free movement of the shaft, said arm extending parallel and adjacent to the recessed side plate to an end adjustably supported by said recessed side plate, and said arm being provided with a bearing to support the drum shaft at its free running end, said means for raising or lowering one side of the inner frame relative to the other side for adjusting the level of the drum comprising biasing means interposed between the end of the arm opposite to the pivotal mount and said adjacent side plate for urging said arm and the supported end of the drum in an upward direction and screw means for positively lowering said arm relative to the said adjacent side plate.

5. In a machine as claimed in claim **4**, said screw means comprising a micrometer screw mounted on said adjacent side plate of the inner frame and a double-lobed cam pivotally mounted on said side plate having one lobe engaging the screw and the other lobe engaging the arm whereby extension of the screw lowers the arm relative to the side wall.

6. In a machine as claimed in claim **1**, means for indicating depth of immersion of the drum in said pool of molten metal in the casting trough comprising an indicating arm attached to the inner frame pivotal mounting for angular rotation about the pivotal mounting with the inner frame and the drum supported thereby and a linear displacement measuring gauge adapted to be abutted by said indicating arm as the drum touches the pool of molten metal whereby the gauge provides direct readings of depth of immersion of the drum as the drum is raised and lowered in the said pool.

7. In a machine as claimed in claim **1**, pull roll means journalled in said machine and spaced from the casting trough for receiving cast metal sheet therefrom, drive means for rotating said drum at a start-up speed, a clutch interconnecting said drive means with said drum permitting free rotation of said drum in the direction of rotation of the drive means at speeds faster than the said start-up speed, and drive means for rotating the pull roll assembly at a desired casting speed faster than the start-up speed, whereby the casting drum can be rotated at the start-up speed by the drum drive means for initiating casting of metal sheet and rotated at the casting speed through the movement of cast sheet under tension drawn from the casting drum by the pull rolls.

8. In a machine as claimed in claim **7**, belt means for interconnecting the pull roll assembly drive and drum drive for rotating said pull rolls and drum in synchronization whereby said pull rolls rotate at a peripheral speed about 5% faster than the peripheral speed of the drum.

9. In a machine as claimed in claim **8**, a winder mechanism journalled in said machine spaced from the pull roll assembly for winding product sheet on a spool, said winder mechanism having a constant torque drive for exerting a constant sheet tension less than the pull roll tension on the sheet at all casting speeds.

10. In a casting machine as claimed in claim **1**, a table on which cast metal sheet moves and an edge trimming assembly for longitudinally trimming the sheet edges interposed between said casting drum and pull roll assembly.

11. In a casting machine as claimed in claim **10**, said edge trimming assembly including a deflector plate formed in each of the longitudinal side edges of the table and spaced from each other a distance substantially equal to the width of the casting drum for leveling down-turned edges of the cast sheet by raising said sheet edges to at least the height of the level of the sheet and cutting rolls for trimming said leveled edges for separation from the sheet.

12. In a casting machine as claimed in claim **10,** each of said deflector plates comprising a downwardly inclined portion curving from a vertical plane outwardly and upwardly to a horizontal plane at a height at least equal to the plane of the table.

13. In a casting machine as claimed in claim **12,** the horizontal portion of the deflector plate rising slightly above the plane of the table for elevating the edges of the sheet above the plane of the table.

14. In a casting machine as claimed in claim **13,** the distance between the downwardly inclined portions of the deflector plates across the table being substantially equal to the width of the drum and the distance between the inner edges of the horizontal portions of the deflector plate being slightly less than the width of the drum.

15. In a casting machine as claimed in claim **10,** said edge trimming assembly including a deflector plate formed in each of the longitudinal side edges of the table and spaced from each other a distance substantially equal to the width of the casting drum, each said deflector plate comprising a top edge initially even with the table top and rising to a height slightly above the table top generally parallel to the movement of cast sheet and an outer face initially in a vertical plane and shaped outwardly in a smooth curve from said vertical plane to a horizontal plane parallel to the plane of the table, for leveling down-turned edges of cast sheet by raising said sheet edges to a height slightly above the table top, and cutting rolls in proximity to said elevated top edges for trimming said edges for separation from the sheet.

16. In a casting machine as claimed in claim **15,** each said deflector plate top edge rising to a height slightly above the table top and extending inwardly over the table top whereby the distance between the opposed top edges becomes slightly less than the width of the casting drum.

17. In a casting machine as claimed in claim **16,** each said deflector plate outer face shaped outwardly in a smooth curve from the vertical plane to a horizontal plane parallel to the plane of the table above the plane of the table and not above the maximum height of the top edge.

18. In a casting machine as claimed in claim **11,** opposed cutting rolls of said edge trimming assembly journalled across the table for rotation one above the other in biased abutment with each other, each of said rolls having in proximity to each end cutting means for severing sheet passing therebetween, said cutting means in proximity to each end of the rolls being spaced apart a distance less than the length of the drum, said upper roll having a resilient peripheral surface on an end portion extending from the cutting means towards the corresponding roll end and said lower roll having a rigid peripheral surface on an end portion extending from the cutting means towards the corresponding roll end, the upper roll having a rigid peripheral surface between the cutting means and said lower roll having a resilient peripheral surface between the cutting means, whereby sheet metal trimmed by passing through said edge trimming assembly is turned upwardly as it passes between the cutting means of the opposed rolls and edge trim severed therefrom is turned downwardly for effective separation of sheet from edge trim.

19. In a machine as claimed in claim **18,** said cutting means on each roll comprising a circular machined cutting face formed on the upper roll in proximity to each end and a circular machined cutting face formed on the lower roll in proximity to each end, in engagement with each other, said rigid peripheral surface on the upper roll intermediate the upper cutting faces having a diameter equal to the diameter of the upper cutting faces, and the corresponding lower roll resilient surface having a diameter less than the diameter of the lower cutting faces to provide a positive but yielding engagement with cast metal sheet, the upper roll resilient peripheral surfaces adjacent the upper cutting faces and extending towards the corresponding roll ends having a diameter less than the diameter of the upper cutting faces, and the corresponding lower roll rigid peripheral surfaces having a diameter less than the diameter of the lower cutting faces, to provide a positive but yielding engagement with the partially straightened edge portion of the cast metal sheet.

20. In a casting machine as claimed in claim **18,** a trim feeder on each side of the machine for receiving edge trim from the cutting rolls and feeding said trim to a cutter, said trim feeder comprising two spaced-apart pairs of opposed knurled rolls biased together to permit variable spacing between said opposed rolls for gripping and advancing edge trim passing therebetween, each said roll having spaced circular grooves across its length and stationary fingers inserted therein to prevent coiling of edge trim around the rolls, and means for rotating said rolls at a speed to constantly provide tension on edge trim moving therethrough.

21. In a machine as claimed in claim **1,** a holding furnace for melting the metal to be cast, means for communicating the furnace with the trough, and means forming part of said holding furnace for continuously feeding molten metal to and for receiving molten metal from the trough, said feeding means including a gear pump for providing a smooth flow of molten metal to the trough and said receiving means including means for preventing splashing of molten metal received in the holding furnace from the trough.

22. In a machine as claimed in claim **21,** said splash prevention means comprising a substantially vertical return pipe forming part of means for communicating the furnace with the trough, an overflow cup pivotally mounted at the lower end of said pipe adapted to hold sufficient molten metal to close and seal said lower end of the pipe, and means for normally holding said cup in its operative sealing position while permitting pivotal movement of the cup free of the pipe lower end.

23. A casting machine as claimed in claim **1,** a weir formed in said casting trough for controlled continuous discharge of excess molten metal from said casting trough, means for selectively raising and lowering each end of said weir relative to the other whereby raising of the weir at one end decreases the flow of metal across that end and lowering of one end increases the flow of metal across that end.

24. In a machine as claimed in claim **1,** said casting trough having a casting section, weir means mounted in the said casting section in proximity to the drum comprising a weir holder mounted transversely in the trough, said weir holder having a central recess formed in the upper edge thereof extending substantially the width of the trough defining a level below the normal level of molten metal in the trough, a weir having a length greater than the recess attached to the weir holder across the recess, and means for selectively raising and lowering each or both ends of the weir on the holder for increasing and decreasing the rate of flow of molten metal through the casting trough.

25. In a machine as claimed in claim **24,** said means for selectively raising and lowering each or both ends of the weir comprising a slot formed at each end of the weir and a spring tensioned screw, having an off-centre projection adapted to fit said slot, rotatably mounted at each end of the weir.

26. In a casting machine as claimed in claim **1,** conduit means for supplying molten metal into the casting section of said casting trough to one side of the casting drum, an immersed baffle overlapping the edge of the conduit whereby any gas bubbles formed in the molten metal are directed away from the casting drum, and means for pivoting said immersed baffle out of the molten metal for easy access to the casting section of the trough.

27. In a casting machine as claimed in claim **26,** dross removal means comprising a pair of guides formed in each side of the casting trough, a skimmer plate extending across the casting section of the trough slidably mounted in said guide means, and means for actuating said skimmer plate for drawing a thin surface layer of molten metal over an inclined wall portion of the trough at an end of the trough for removal of dross from the said casting section.

28. In a casting machine as claimed in claim **1,** an assembly for measuring the thickness of sheet comprising a support roll journalled in the machine in the plane of the table transversely to the direction of travel of the sheet, at least one thickness measuring unit disposed above the support roll having a linear displacement transducer with a plunger effectively biased downwardly against a roller resiliently mounted on said thickness measuring unit to ride on the upper surface of the cast sheet as the sheet moves over the support roll thereby measuring the change of thickness of sheet passing therebetween, said thickness measuring unit mounted on a bar extending parallel to the support roll and journalled for rotation in the machine, a cam mounted on said bar having a pair of angularly spaced slots formed in its periphery, and a detent adapted to be biased into either of said slots for holding the thickness measuring unit in either an operative sheet thickness measuring position or, on rotation, in an inoperative position, said unit being rotated to its inoperative position during start-up of operation or by impact against the resiliently mounted roller of a foreign object on the surface of the sheet of cast metal.

29. In a casting machine as claimed in claim **28,** said assembly comprising two or more said thickness measuring units disposed in a spaced relation from each other above said support roller.

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