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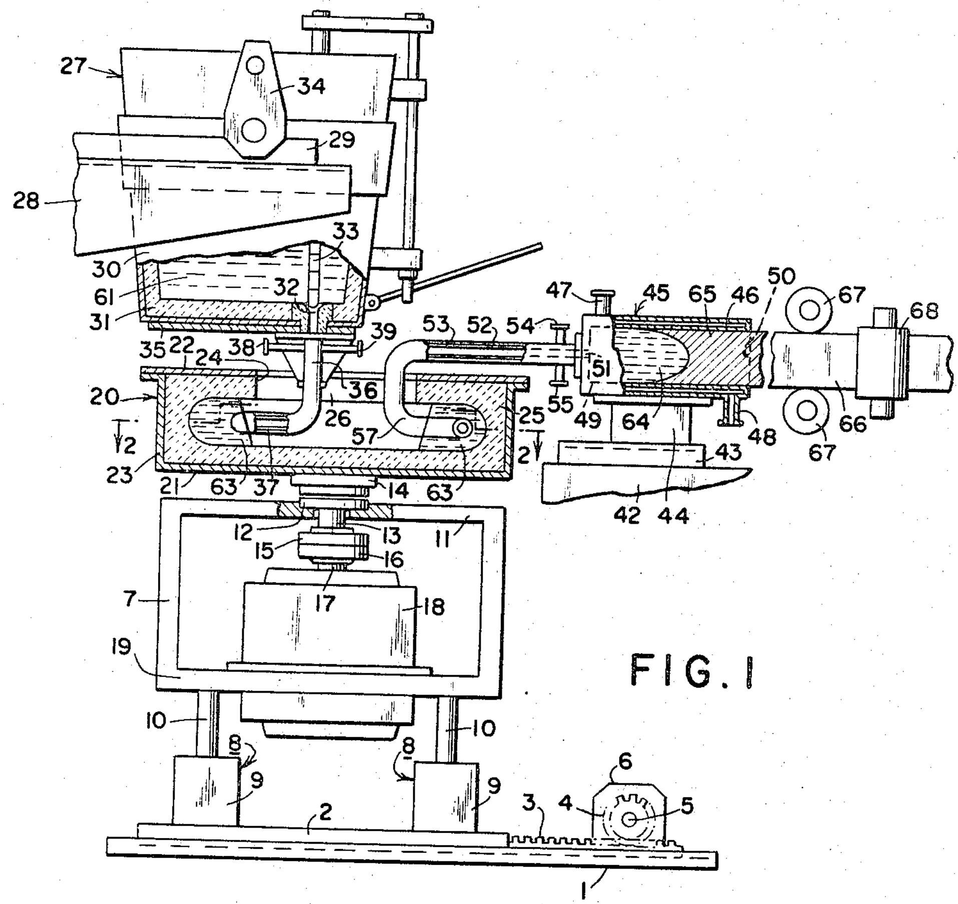

FIG. 1

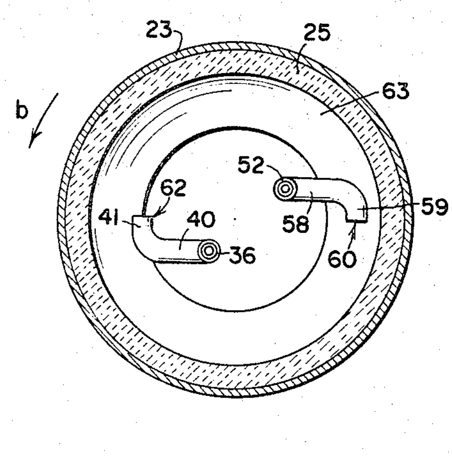

FIG. 2

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APPARATUS FOR CONTINUOUS CASTING OF ROD AND OTHER STRAND MATERIAL

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Our invention relates to the production of intermediate or semi-finished products of rod or other strand shape, such as round, square or otherwise profiled stock for wire, screw, shaft or rail production and the like, and in a more particular aspect to the production of such ingot or stock materials by continuous casting.

According to the continuous casting method, metal in molten condition is continuously supplied to a mold from one end thereof. The mold encloses a space of prismatic or cylindrical shape whose opposite end is open. The material continuously issues from the open end as a solidified product whose cross section corresponds to that of the casting mold. Our invention is based on the same casting principle.

It is an object of the invention to improve the continuous casting of rod and other strand material in various respects. One of the more specific objects is to produce a material of an improved, more densified structure. Another object is to produce a product which exhibits a minimized amount of impurities, such as occluded oxides, slag and other contaminations.

Still another object of the invention is to provide an apparatus from which the material being cast will continuously issue in a horizontal direction so that it can be passed to further fabrication without necessitating a reversal in direction or a subdivision by cutting. Another, more specific object akin to the one last mentioned is to provide a continuous casting apparatus that affords issuing a rod material of infinite length suitable to be directly passed into a rolling mill.

The foregoing and further objects and advantages of the invention as well as its essential features, these features being set forth with particularity in the claims annexed hereto, will be apparent from the following description of an embodiment of a continuous casting machine according to the invention illustrated by way of example on the accompanying drawing in which:

FIG. 1 is a partly sectional side view of the machine in schematic representation, and

FIG. 2 is a cross section taken along the line 2—2 in FIG. 1.

Mounted on a foundation **1** is a horizontally displaceable slider **2** which is joined with a rack **3** meshing with pinion **4** on the shaft **5** of a motor **6** operable in one or the other direction for shifting the slider **2** to one or the other side.

The slider **2** carries four legs **8** of a frame structure **7**, only two legs being visible on the drawing. Each leg is formed by a hydraulic cylinder **9** with a piston rod **10** which is vertically displaceable in the cylinder. By supplying or draining oil from each cylinder, the pistons can be moved upwardly or downwardly for changing the height of the frame structure **7**.

The top portion **11** of the frame structure **7** carries a bearing **12** for a vertical shaft **13** which is provided above the frame portion **11** with a flange **14** and below the frame portion **11** with another flange **15**. The flange **15** is coaxially joined with a flange **16** on the vertical shaft **17** of an electric motor **18** carried by the bottom portion **19** of the frame structure **7**. By means of the motor **18**, a relatively rapid rotation can be imparted to the shaft **13** and thus to the top flange **14**.

The flange **14** carries a coaxial drum generally denoted by **20**. The drum has a bottom wall **21**, a top wall **22** and a circularly cylindrical jacket **23**. The bottom wall **21** is firmly joined with the flange **14**. The top wall **22** has a central circular opening **24**. Top, bottom and peripheral jacket of drum **20** consist of sheet steel and are internally lined with refractory material **24** which covers the entire inner wall surface and has an opening **26** registering with the opening **24**.

Provided above the drum **20** are means for suspending a casting ladle generally denoted by **27**. The ladle-suspension means comprise a support **28** on which a slider **29** is horizontally displaceable. The ladle **27** has a shape as conventional in steel mills and consists of an outer steel shell and an inner refractory lining **31**. The bottom of the ladle has an opening **32** which can be closed by a conventional plug **33**. A bracket **34** on each side of the ladle is mounted on the slider **29** and carries in its upper end a pivot for the ladle. The ladle **27**, thus supported on the slider **29**, can be moved into and out of the illustrated position by correspondingly shifting the slider.

Attached to a bottom plate **35** of the ladle **27** and in alignment with the bottom opening **32** is an outlet pipe **36**. This pipe can be cooled with water and for this purpose has a double wall indicated at **37**. Two nipples or stub pipes **38** and **39** serve for passing the water through the jacket space of pipe **36**. Starting from opening **32**, the pipe **36** extends vertically downward. At some distance below the ladle, the pipe **36** is bent laterally so as to form a horizontal portion **40** (FIG. 2). The lower end of the pipe is curved about 90° away from portion **40** in the same horizontal plane and forms another, likewise horizontal portion **41** of very short length (FIG. 2).

Located beside the drum **20** is a foundation structure **42** with guide means **43** for a slider **44** which can be horizontally displaced on foundation **42** in two coordinate directions, namely in the plane of illustration and perpendicularly thereto. The slider **44** carries a chamber structure denoted as a whole by **45**. The design or shape of the chamber structure **45** generally resembles that of the casting molds or ingot molds heretofore employed in continuous stock-casting processes, except that the longitudinal axis of the chamber **45** extends horizontally. The cross-sectional shape of the chamber **45** corresponds to that of the elongated rod or other product to be cast. Consequently, the space formed by the chamber may be prismatic or cylindrical. When the cross section of the product is to be of circular shape, the chamber space has the shape of a circular cylinder. The wall of chamber **45** is cooled with water and forms a jacket space **46** which communicates with inlet and outlet ducts **47** and **48** for the supply and discharge of the coolant water.

The left side of the chamber **45** is closed by a rear wall **49**. The right or front end **50** is continuously open. The rear wall **49** has an opening **51** connected with a material supply pipe **52**. This pipe is also water cooled and for this purpose has a double wall indicaed at **53**, as well as nipples **54** and **55** for the supply and discharge of coolant water. The shape of pipe **52** is similar to that of pipe **36**, that is, the horizontal portion of pipe **52** adjacent to the chamber **45**, is followed by a vertical portion **57** extending downwardly through the openings **24** and **26** into the drum **20**. The vertical portion **57** is continued by a horizontal portion **58** (FIGS. 1, 2) whose end curves laterally away to form still another horizontal but short portion **59** in the same horizontal plane (FIG. 2). By virtue of this particular shape, the tube **52** is located in the interior of the drum **20** in the particular manner apparent from FIGS. 1 and 2. The opening **60** of tube **52** is located in eccentric relation to the axis of drum **20** and below the top wall **22**. The direction of the opening **60** is tangential to a circular cylinder whose axis coincides with the axis of the drum **20**. The radial distance of opening **60** from the axis of drum **20** can be changed by displacing the slider **44**.

The above-described device is operated as follows:

A ladle **27** according to FIG. 1 is filled with molten steel **61** and is placed upon the slider **29** with the aid of a crane. The tube **36** then passes through the opening **24** into the interior of the drum **20**. The ladle **27** is then slightly moved toward the left by correspondingly shifting the supporting slider **29**, so that the opening **62** of pipe **36** is situated beneath the top wall **22** of drum **20**. The opening **62** then extends tangentially to a circular cylinder whose axis coincides with the axis of the drum **20**, in this respect corresponding to the positioning of the opening **60** of tube **62**. The adjustment now is the one shown in FIG. 2.

Then the drum **20** is placed in rotation by means of the motor **18** in the direction of the arrow *b* shown in FIG. 2. This direction is opposed to that of the tube openings **60** and **62**. The pipes **36** and **52** as well as the casting chamber **45** are supplied with coolant water. Thereafter the plug **43** is pulled out of the ladle outlet opening so that the melt **61** drains through the opening **32** and the pipe **36** into the rotating drum **20**.

The melt issuing from opening **62** flows onto the bottom of drum **20** and is then flung outward by centrifugal force toward the drum periphery. Consequently there is formed a ring-shaped body **63** consisting of liquid steel and having a radial thickness which increases with the further supply of molten steel from the ladle **27**. As a result, the opening **60** of tube **52** passes into the ring-shaped body **63**. Since this opening is opposed to the direction of rotation *b*, some of the molten steel enters into the pipe **52** and is pressed through this pipe into the chamber **45**. As the thickness of the ring-shaped body **63** increases, the opening **62** of the tube **36** also becomes immersed in the rotating melt. Since the opening **62** is likewise directed in opposition to the rotational direction *b*, there occurs a back pressure which tends to prevent the further drainage of molten steel **61** from the ladle. This results in an equilibrium condition. Consequently, even if no molten material is withdrawn through the pipe **52**, the maximal thickness of the rotating ring **63** is limited by the back pressure at opening **62** reaching an equilibrium with the gravity of the molten material. For that reason the drum can never overflow, and the quantity of steel being replenished from the ladle **27** is accurately controlled in accordance with the quantity which is being withdrawn from the rotating ring body **63** through the tube **52**.

Due to the centrifugal force produced in the rotating drum, the molten material is forced into the chamber **45** under a considerable amount of pressure. The temperature of the melt becomes reduced at the intensively cooled wall of this chamber so that the molten material solidifies. As in the known continuous casting of strand material, there occurs between a still liquid region **64** and an already solidified region **65** a boundary whose shape approximates that of a paraboloid. An already solidified rod or strand body **66** thus issues from the front opening **50** of the chamber **45** and can be supported by roller pairs **67** and **68** in the conventional manner.

The acceleration due to centrifugal force in the rotating drum **20** is considerably larger than the acceleration due to gravity. This has the effect that any impurities contained in the melt **61** and having a lower specific gravity than the molten metal, are floated to the surface with a particularly good effectiveness. Hence such impurities are rapidly transported to those localities of the ring-shaped body **63** that have the smallest distance from the drum axis. The molten material entering into the opening **60** thus exhibits a considerably higher degree of purity than the melt entering into the casting mold of the conventional continuous casting devices.

With the known continuous casting of rod stock, the melt enters into the vertically upright casting mold only by gravity. According to the invention, however, the melt entering into the chamber **45** is subjected to the high pressure produced by centrifugal force. This pressure can be made as high as desired, simply by correspondingly selecting the rotating speed of the motor **18**. Under the effect of the high pressure, the resulting product **66** possesses a structure which is considerably denser and therefore better than the structure obtainable with the continuous stockcasting method heretofore known.

As mentioned, the known casting processes rely on gravity for filling the molds so that these must be arranged vertically. Consequently, the resulting elongated product issues in a vertical direction which requires cutting it into relatively short pieces or guiding it by relatively complicated direction-changing means so that it will travel on a generally horizontal path. The latter expedient, however, is applicable only with relatively thin stock material. In contrast thereto, the invention affords the possibility of operating with a horizontal casting chamber **45** from which the strand product **46** issues already in a horizontal direction. The product, therefore, need not necessarily be cut into shorter pieces but, in principle, can be given any desired or infinite length. This offers the possibility, for example, to guide the resulting strand product without interruption directly into a rolling mill.

While the invention has been described with reference to the processing of steel, it is obvious that it is readily applicable to other metals.

To those skilled in the art it will be obvious from a study of this disclosure that the invention affords of various modifications and can be given embodiments other than particularly illustrated and described herein, without departing from the essential features of the invention and within the scope of the claims annexed hereto.

We claim:

1. Apparatus for producing intermediate products in elongated rod or strand shape comprising:

(a) a rotatable drum having a vertical axis and having a top wall with an opening;

(b) a first pipe protruding downwardly through said opening into the interior of said drum and having in said drum an outlet opening portion radially spaced from the drum axis and extending substantially in a direction tangential to an imaginary cylinder having an axis coincident with said drum axis;

(c) means for feeding molten metal into said first pipe;

(d) a second pipe protruding from above through said top-wall opening of said drum to below said top wall and having in said drum an inlet opening portion extenting substantially in a direction tangential to an imaginary cylinder having an axis coincident with the axis of said drum which is directed in the same sense, relative to said drum axis, as said outlet opening portion of said first pipe;

(e) means for driving said drum in a sense directed toward the inlet opening end of said second pipe;

(f) a casting chamber having an open front end for issuing a solidified casting, said second tube being connected to the opposite end of said chamber for supplying it with molten metal from said drum under pressure due to centrifugal force produced by rotation of said drum; and

(g) means for cooling said casting chamber and means for guiding the solidified casting issuing from the open end of said casting chamber.

2. In a continuous casting apparatus according to claim **1**, said casting chamber having a horizontal axis so that the casting issues in a horizontal direction.

3. Continuous casting apparatus according to claim **1**, comprising means for changing the radial distance between the outlet opening of said first pipe from the axis of said drum.

4. Continuous casting apparatus according to claim **1**, comprising means for varying the radial distance between the outlet opening of said second pipe from the axis of said drum.

5. Continuous casting apparatus according to claim **1**, comprising means for displacing said drum in a direction radial to its axis.

6. Continuous casting apparatus according to claim **1**, comprising means for displacing said casting chamber in a direction radial to the axis of said drum.

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