Sept. 30, 1958 J. H. BEYER 2,853,755

CENTRIFUGAL CASTING METHOD

Filed Jan. 13, 1955 2 Sheets-Sheet 1

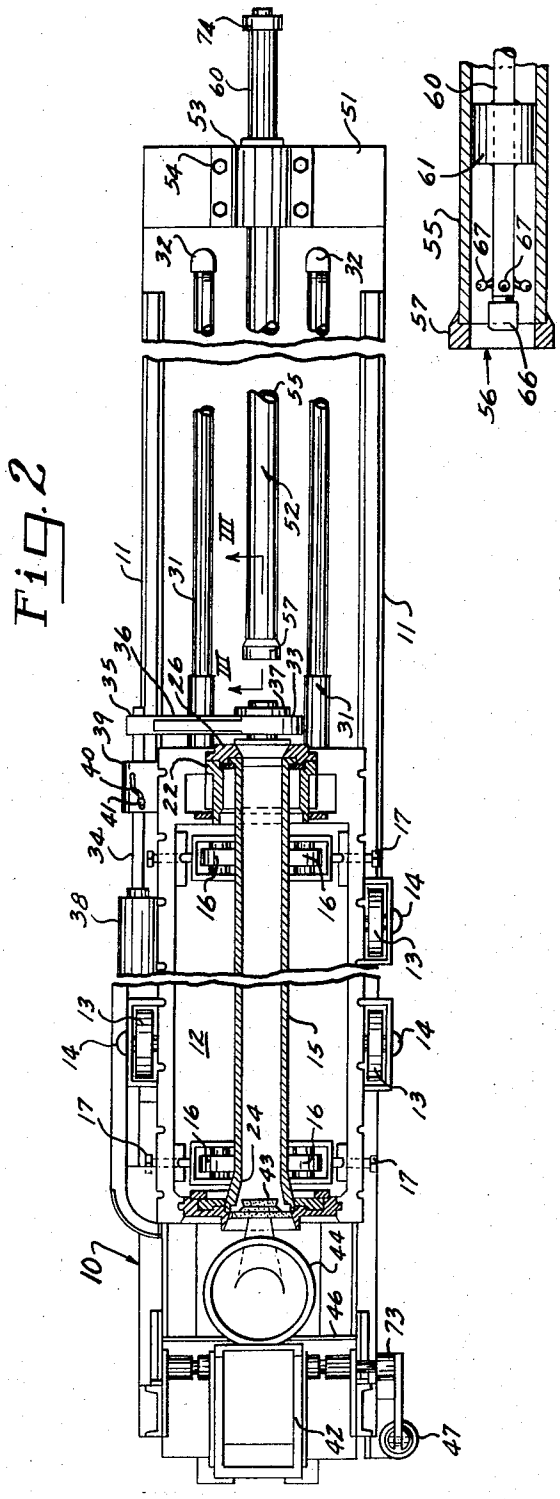


Fig. 2

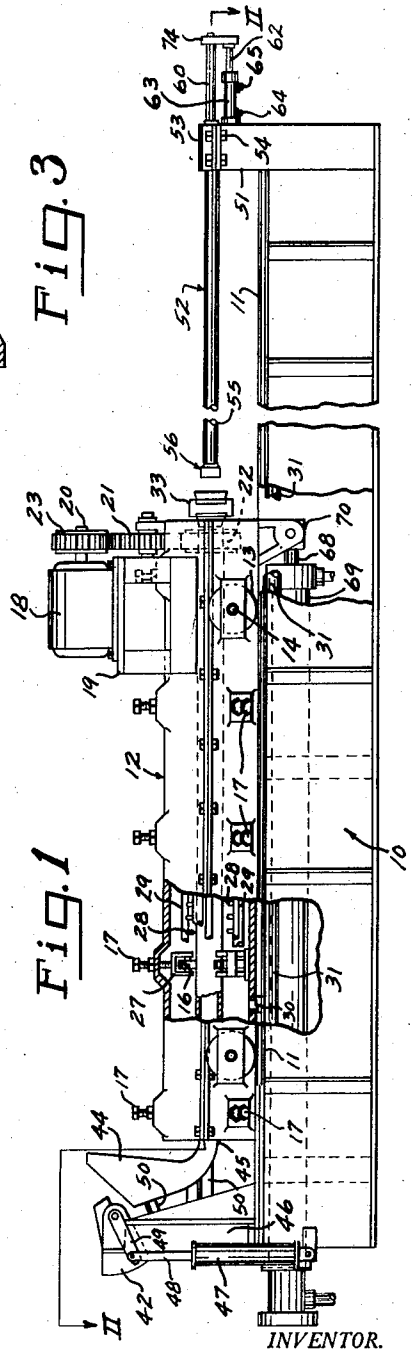


Fig. 3

Fig. 1

INVENTOR.
JOHN H. BEYER
BY
ATTORNEY

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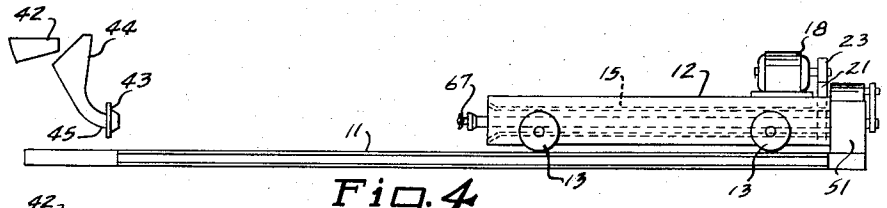


Fig. 4

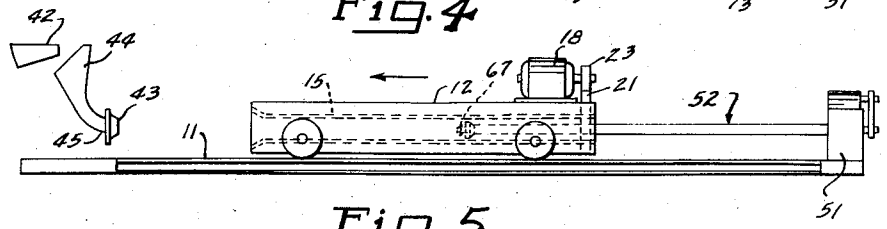


Fig. 5

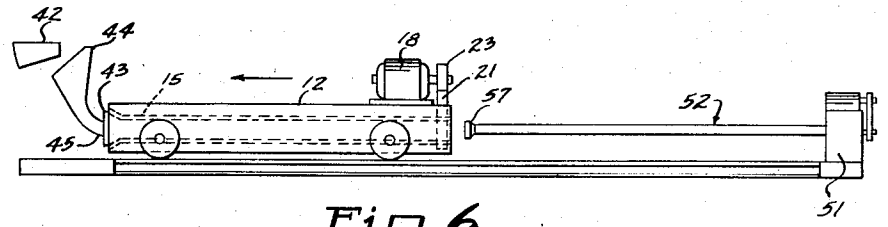


Fig. 6

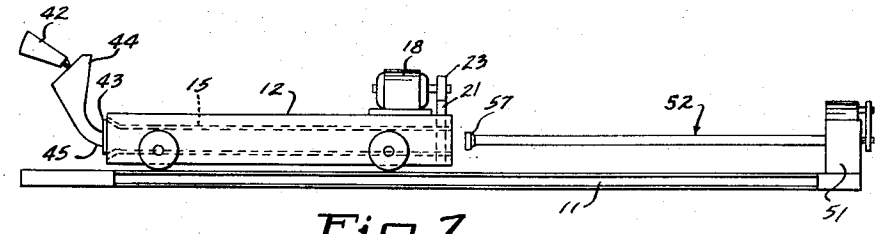


Fig. 7

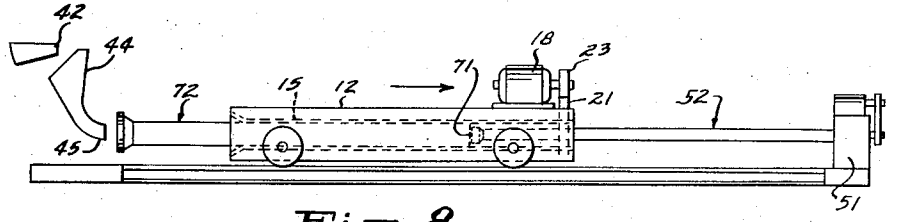


Fig. 8

INVENTOR.
JOHN H. BEYER
BY
ATTORNEY

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2,853,755

CENTRIFUGAL CASTING METHOD

John Henry Beyer, Beverly, N. J.

Application January 13, 1955, Serial No. 481,670

5 Claims. (Cl. 22—200.5)

The present invention relates to the manufacture of tubular metal castings, and more particularly is concerned with the manufacture of cast iron pipe having bell and spigot ends, in permanent metal molds rotated horizontally.

It is well known to cast pipe in permanent metal molds, such methods having been practiced extensively in this country for about 30 years. Present methods comprise the use of cylindrical metal molds mounted on rollers in a water jacket and adapted to be rotated at suitable speeds. The water jacket is mounted on wheels so that the entire assembly can be moved by means of a hydraulic cylinder in the direction of the longitudinal axis of the mold on a fixed bed inclined slightly from the horizontal. The molten iron is fed into the mold through a trough similarly inclined. In casting, a ladle containing molten iron is tilted at a uniform rate to maintain a constant pouring rate. When the mold is at the extreme upper end of the fixed bed, it is ready for casting at which time the trough extends down the barrel of the mold for nearly its full length. After the casting ladle has been filled by the transfer ladle, the machine operator brings the mold up to speed and actuates the mechanism controlling the tilting of the ladle. In a few seconds the iron has filled the bell space at which time the operator starts moving the mold carriage longitudinally down the bed. The stream of iron discharged from the trough flows onto the surface of the mold, where it is held in place by centrifugal force and forms the pipe.

Early in the development of such machines, it was discovered that far better results are obtained if, instead of pouring the iron onto the bare mold, a dry unbonded powdery material, such as ferro-silicon, is applied on the inner mold surface just ahead of the iron stream. While constituting a definite improvement, the use of such linings nevertheless did not result in completely acceptable pipe, there always being so-called "pinholes" or "laps" or "cold shuts."

Perhaps the greatest stride in overcoming these disadvantages of casting pipe in permanent metal molds was the invention described and claimed in Schuh et al. Patent No. 2,399,606. Briefly stated, that invention comprises spraying the inner surface of the metal mold with a liquid suspension of a powdered refractory material and a binder to form incrementally an insulating coating adherent to the mold and having a multiplicity of spaced protuberances on its inner face.

One of the distinct advantages of using permanent metal molds is the speed with which a great number of pipes can be cast, as compared to other methods such as pit casting and centrifugal casting in sand lined molds. Maximum casting speeds have not been attained, however, due to the necessity of moving the mold through two two-way strokes for each pipe cast. One two-way stroke is required for pouring the metal throughout the length of the mold, while moving the mold relative to the pouring trough, and extracting the cast pipe by return of the mold to casting position. The additional two-way stroke is required in some methods to apply the mold coating,

and in others to position the mold in a convenient position for setting the bell core. The extra two-way stroke has been dispensed with only where additional means have been provided for extracting the pipe without longitudinal movement of the mold. The latter method requires fifty percent additional longitudinal space as well as added equipment and so has not been generally adopted.

It is, accordingly, the principal object of the present invention to provide a casting procedure or method for producing pipe in a reciprocating permanent metal mold wherein only one two-way stroke of the mold is required for the production of each pipe.

Another object of the invention is the provision of a casting method whereby pipe can be made in a horizontally rotating permanent metal mold without the necessity of a separate two-way traverse of the mold for insertion of a bell core or for applying a mold coating.

Still a further object is to provide a method for casting metal pipe in a horizontally rotating permanent mold in which the mold is moved in one direction along its horizontal axis to extract the pipe and is moved in the opposite direction to receive a refractory mold coating and/or to be positioned for reception of molten metal.

Still another object is the provision of a method for casting metal pipe in a horizontally rotating permanent metal mold in a shorter time than heretofore considered possible.

This invention has other objects that will be apparent from a consideration of the method described herein and of the specific embodiment shown in the drawings accompanying and forming part of the present specification. Such form will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is defined by the claims appended hereto. In the drawings:

Figure 1 is a side elevation of a pipe casting machine suitable for practicing the process of this invention, and with parts thereof broken away.

Figure 2 is an enlarged sectional view taken substantially on the line II—II of Figure 1, with parts being broken away.

Figure 3 is an enlarged sectional view taken along line III—III of Figure 2, showing in greater detail the push-out bar and spray nozzles for applying a refractory coating to the mold interior.

Figures 4 through 8 are diagrammatic sketches, omitting details, illustrating the various steps in the novel casting cycle comprising the present invention.

The machine generally comprises a supporting platform **10** of conventional design, provided with a pair of horizontal, parallel rails **11**. Carriage **12** is adapted for reciprocal movement over rails **11** by means of wheels **13** attached to the carriage through axle **14**. Carriage **12** carries cylindrical mold **15** which defines the exterior surface of the pipe produced therein. Mold **15** is supported by a plurality of rollers **16** rotatably mounted on brackets **27** which are adjustable away from or toward the mold by adjustment screws **17** threadedly engaged to carriage cover **12**. Thus the rollers serve the purpose of centering the mold by adjustment of the screws **17**, as well as supporting the mold and holding it against bowing during rotation about its horizontal axis. Power for rotation of the mold is supplied by electric motor **18**, mounted on carriage cover **12** by supporting structure **19**. Rotary motion from electric motor **18** is transmitted from shaft **20** to gear **23** through idler **21** to mold drive gear **22** drivingly attached to mold **15** through ring **26**.

Cooling of the mold **15** is effected by spraying a cooling fluid, preferably water, upon its exterior by means of

a plurality of spray jets **28** spaced adjacent the length of the mold and supported by fluid conduits **29** which supply the cooling fluid to the jets. In the apparatus illustrated in Figure 1 there are three conduits provided, one directly beneath the center of the mold and one each spaced 120° therefrom on both sides of the mold. The conduits are connected with fluid supply means (not shown) which include controls for turning the supply of cooling fluid on or off as required during casting operations. Cooling fluid is removed from the machine, after contact with the mold exterior, by gravity through outlet conduits **30**, spaced along the bottom of carriage **12** and leading into telescoping pipes or outlet troughs **31** and thence through drains **32**. Alternatively, the mold can be cooled by immersion in a water jacket in accordance with well known means.

A spigot end closing device **33** is provided for prevention of metal runout at the spigot end of the mold during casting. In accordance with the structure shown in Figure 2, there is provided a longitudinal shaft **34** supported by bearings (not shown). To one end of the shaft **35** there is secured a lever **36** supporting a cage **37** in which is mounted, through the medium of a bearing (not shown), a ring the external diameter of which will fit snugly in the interior of the mold. The internal diameter is equal to or less than the internal diameter of the pipe to be made in the mold. The spigot end closing ring is moved into and out of position at the spigot end of the mold by means of air cylinder **38**. Shaft **35** passes through a bracket **39** mounted on carriage **12**, and provided with a helical slot **40** adapted to receive a pin **41** protruding therethrough and rigidly attached to shaft **34**. Thus when the piston in air cylinder **38** is forced toward the bell end of the mold, shaft **34** and pin **41** are also forced in that direction. In order to move, however, pin **41** must follow the helical path of slot **40**, causing rotation of shaft **34** and consequent movement of lever **36** and the attached closing device to the position shown in Figure 2. Conversely, when pressure on the piston in cylinder **38** is reversed, shaft **34** is forced to move away from the mold and to rotate in the opposite direction, thus moving the end closing ring out of alignment with the mold.

In accordance with the present invention metal is poured through the bell end core **43** into the rotating mold **15** from a pouring ladle **42** and is guided by a pouring spout **44**, the small end **45** of which extends into the mold about equal distance with the innermost part of the core **43**. Pouring ladle **42** is preferably of metal construction with a refractory lining, and should be of such size as to hold sufficient molten metal to produce one pipe of the size determined by the mold and of predetermined wall thickness. The ladle is pivoted on the front by a fixed support **46**. Metal is poured from the ladle by raising the rear thereof by means of hydraulic lift comprising a cylinder **47** and piston **48**. An arm **49** is pivotally connected to the upper extension of piston **48** and the other end of arm **49** is rigidly attached to shaft **73**. This shaft is rotatable in bearings seated in support **46** and the other end of the shaft is rigidly attached to one side of ladle **42**. A similar shaft arrangement supports the opposite side of the ladle. In operation shaft **73** rotates to tilt the ladle when piston **48** is forced upward. Spout **44** is attached to and supported by fixed support **46** through supports **50**. Alternatively, and particularly when the cast pipe is to be removed by means holding it in fixed position rather than by push out means as shown, the ladle and pouring spout may be movable by hydraulic cylinders out of alignment with the mold and away from the mold. Suitable apparatus for this alternative is shown, for example, in Patent No. 1,942,919.

At the end of supporting platform **10**, opposite the pouring end, there is provided a fixed support **51** for one end of a combination push-out lance and spray coating equipment, shown generally at **52**. This portion of the machine illustrated comprises essentially a lance tube portion **55** rigidly attached to the support **51** by bracket **53** secured by bolts **54**. The outer tube **55**, which acts as a support for the spray equipment, is of such length that when carriage **12** is retracted to contact with support **51**, the end **56** extends to a position adjacent to or past the outer portion of bell cavity **24** of the mold. The free end of tube **55** is provided with pushout ring or head **57**, rigidly secured as by brazing or welding, which is adapted to contact the spigot end of the pipe formed in mold **15**. Pushout ring **57**, has an outside diameter smaller than the inside diameter of mold **15** but at least slightly greater than the inside diameter of the pipe to be cast.

A smaller tube **60** is mounted within outer tube **55** and is maintained coaxially therewith by means of a cylinder **61** slidably mounted within tube **55** and rigidly attached to tube **60**. One end of tube **60** is attached to an arm **74** said arm being also connected to extension **62** of a piston, parallel to tube **60**. The piston is operated reciprocally within a cylinder **63** by fluid pressure introduced through fittings **64** or **65**, depending on the direction it is desired to move the piston and connections thereto. At the other end of tube **60** is a threaded closure cap **66**, and adjacent thereto are spray nozzles **67** for spraying refractory mold coating compositions. In operation, spray nozzles **67** are retracted into tube **55** as shown in Figure 3 while the lance is being used to push a cast pipe from the mold. When end **56** of the lance is protruding past the bell cavity, after having pushed the pipe out, fluid pressure is applied through fitting **65** to force the piston in cylinder **63** toward the casting machine, thus causing inner tube **60** to move in that direction until spray nozzles **67** are moved to an exposed position past end **56**. The mold coating material is then introduced into pipe **60** and is forced by pressure out of nozzles **67**.

In the specific embodiment shown, lance **52** is in fixed position so that the free end may transpierce the mold **15** as the mold carriage **12** is moved back and forth on rails **11**. A piston **68** operating in a cylinder **69** secured to the base **10** has its outer end connected to the under side of carriage **12** by a coupling member **70** for moving the carriage to and fro on the rails **11** during operation.

The series of steps comprising the casting process of the present invention will now be described with particular reference to Figures 4–8, inclusive, which show diagrammatically the operations performed and the positions of parts of the apparatus during each step. In the first step, Figure 4, rotation of the mold about its horizontal axis is commenced by activation of motor **18**. The spray nozzles **67** are advanced so as to protrude past the end of tube **55** to an exposed position. In the meantime, pouring ladle **42** has been charged with the proper amount of molten metal for making one pipe of predetermined wall thickness and of an outside diameter determined by the inside diameter of mold **15**. A bell core **43** is placed in position around the spout end **45** of pouring spout **44**.

Spray of coating material is then begun as the mold carriage is moved in the direction of the arrow (Figure 5), and is continued until the carriage reaches the position shown in Figure 6. The spray nozzles will have then passed through the complete length of the mold while spraying the mold coating. The spray is then stopped and spray nozzles **67** retracted to the position within the tube **55**.

Rotation of the mold is then stopped in order that the bell core **43** may be seated and secured in the bell cavity of the mold. The piston **34** in cylinder **38** is forced toward the spigot end of the mold, thus causing the spigot end closing device **33** to close the spigot end of the mold.

In the step illustrated in Figure 7, the mold is again

rotated, cooling water is sprayed onto the outside surface of the mold through nozzles **28**, and the pouring ladle **42** is tilted, molten metal being poured therefrom through pouring spout **44**, the small end **45** of which extends into the mold through the bell core **43**, terminating at the inner extremity of said core. The molten metal is carried throughout the length of the mold by centrifugal force.

Rotation of the mold is continued until the metal has solidified to a point where it is self-supporting, at which time rotation is stopped, water spray onto the mold is stopped, and spigot end closure ring **33** is moved out of position in line with the mold. Mold carriage **12** is then moved in the direction of the arrow in Figure 8. Push-out ring **57** enters the spigot end of the mold and engages the spigot end **71** of the pipe **72** which has been formed in the mold. Continuation of movement of the carriage to the position shown in Figure 4 causes the pipe to be pushed completely out of the mold where it is received and removed by any suitable means (not shown).

While in the preferred embodiment, illustrated and described, the mold coating lance is adapted to operate also as a pipe pushout device, the feature is not essential to the process comprising the present invention. The process does, however, require that the pipe be removed by means holding it in fixed position, as shown in Figure 8, while the mold is traversed until free of the pipe. This result can be accomplished by alternative means which clamp and hold the bell end of the pipe while the mold is traversed. Suitable grasping means are well known in the art.

After extraction of the pipe the mold is again in position to be rotated, moved toward the pouring equipment, and supplied with a new mold coating. The heat remaining from the previous casting is sufficient for drying or curing the mold coating material, when required. The mold must be heated by other suitable means prior to spray coating at the beginning of casting operations.

The foregoing process makes it possible, for the first time, to produce a casting with a single two-way stroke of the mold, where as conventional casting cycles require two two-way strokes of the mold for each casting or one two-way stroke of the mold with additional means for extraction of the pipe requiring additional space. The elimination of a complete stroke without adding a separate extraction unit is made possible only by the combination of features described in this specification for the first time. In addition, the process makes it possible to apply a mold coating of a type requiring drying or curing without the necessity for an added stroke of the mold. Essentially, the coating must be supplied by a lance entering the mold from the spigot end, which lance can serve the additional purpose of ejecting the cast pipe by applying force thereto toward the bell end when the mold is moved to cause the lance to enter the mold. It is likewise essential, in this operation, that non-retractive pouring of metal be utilized; specifically, the metal must be poured through the bell end of the mold, while the mold is rotating horizontally about its axis, but while the mold is maintained stationary longitudinally.

In order to realize the full benefits of the casting method of this invention, it is necessary that the entire charge of molten metal be distributed throughout the length of the mold as rapidly as possible, and particularly before any portions thereof are solidified. To accomplish this result requires a proper balance between pouring temperature, time of pouring and rate of mold rotation during pouring. While exact limits for all possible combinations cannot be defined exactly, the limits for any combination, taken with other variables such as metal composition, mold coating composition and thickness, mold wall thickness and length and diameter of the pipe to be cast, can easily be determined by experimentation as is necessary in conventional casting methods. In fact, the determinations are simplified by the method of this invention due largely to elimination of the human error factor inherent in prior methods which require judgment in the rate of pouring metal along the length of the mold.

I claim:

1. In the method of making tubular metal castings in a horizontal, cylindrical, externally cooled metal mold having bell and spigot ends, the method steps which comprise retracting the said mold from a fixed lance extending from the spigot end through the mold along the longitudinal axis thereof, said lance applying a mold coating throughout the inner surface of the mold during such retraction, stopping longitudinal movement of the mold when fully retracted from said lance, placing a bell core and a spigot end closure in the respective mold ends, rotating the mold and pouring molten metal therein through said bell core, whereby said molten metal is uniformly distributed throughout the inner surface of the mold by centrifugal force, stopping mold rotation when the said molten metal has solidified to form a pipe, and ejecting said pipe from said mold by moving the mold longitudinally against said lance, whereby the end of the lance engages the end of the pipe and holds the pipe stationary relative to mold movement until fully ejected from the bell end of said mold.

2. In a method of casting pipe from molten metal in externally cooled centrifugal metal molds having bell and spigot ends, the method steps which comprise setting the mold in rotation and pouring molten metal therein through the bell end, continuing rotation of the mold until the poured metal is uniformly distributed throughout the mold by centrifugal force and is solidified to form a pipe, then stopping mold rotation and moving the mold along its longitudinal axis in the direction of its spigot end whereby the spigot end of said cast pipe engages a fixed pushout lance to hold said pipe stationary against longitudinal movement with the mold, continuing and longitudinal movement of the mold until the bell end of the mold has passed the spigot end of the pipe whereby the pipe is extracted, then setting the mold in rotation and retracting the mold to its original position while simultaneously applying a coating to said mold from an applicator mounted on said lance.

3. The method of casting metal pipe in a horizontal permanent metal cylindrical mold having bell and spigot forming ends, rotatable about its horizontal axis and reciprocatable along its longitudinal axis which comprises, rotating the said mold, pouring molten metal into the rotating mold through the bell end thereof while maintaining the mold longitudinally stationary and while spraying water onto the exterior surface of the mold, stopping mold rotation and water spray when the poured metal has solidified to form a pipe, moving said mold along its longitudinal axis in the direction of its spigot end whereby the spigot end of said cast pipe engages a fixed pushout lance which holds said pipe stationary against movement of said mold, rotating said mold after the bell end thereof has cleared the spigot end of the stationary cast pipe, retracting said rotating mold to its original position while applying an interior refractory coating thereto.

4. The method of casting metal pipe in a horizontally rotatable, reciprocatable, permanent metal cylindrical mold having a bell and a spigot end which comprises, securing a bell core in the bell end and closure means in the spigot end of the mold, thereafter rotating the mold and applying cooling means to the exterior surface thereof, pouring molten metal into the rotating mold through the bell end thereof whereby it is distributed uniformly throughout the mold by centrifugal force, stopping rotation of the mold when said poured metal has solidified to form a pipe, removing said spigot end closing means, moving the mold along its longitudinal axis in the direction of its spigot end whereby the spigot end of said cast pipe engages a fixed pushout lance to hold said pipe stationary against longitudinal movement with the mold,

continuing said longitudinal movement of the mold until said pipe is completely extracted and removed, rotating said mold and retracting it to its original position while applying a mold coating thereto by means carried by said pushout lance.

5. In the method of making tubular metal castings in a horizontal, cylindrical, externally cooled metal mold having bell and spigot ends, the method steps which comprise retracting the said mold from a fixed lance extending from the spigot end through the mold along the longitudinal axis thereof, said lance applying a mold coating throughout the inner surface of the mold during such retraction, stopping longitudinal movement of the mold when fully retracted from said lance, placing a bell core and a spigot end closure in the respective mold ends, rotating the mold and pouring molten metal therein through said bell core, whereby said molten metal is uniformly distributed throughout the inner surface of

the mold by centrifugal force, stopping mold rotation when the molten metal has solidified to form a pipe, and ejecting said pipe from said mold by moving the mold longitudinally in the direction of the spigot end while maintaining the pipe stationary until fully ejected from the bell end of said mold.

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