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Stone

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[54] **CENTRIFUGAL CASTING OF BI-METAL ROLLS**

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[51] **Int. Cl.** **B22d 13/02**, B22d 25/06

[58] **Field of Search** 164/286, 94–96, 164/114–116

[56] **References Cited**

UNITED STATES PATENTS

2,008,196 7/1935 Weber ..... 164/95 X

FOREIGN PATENTS OR APPLICATIONS

676,886 6/1939 Germany 164/286

880,206 9/1971 Canada 164/95

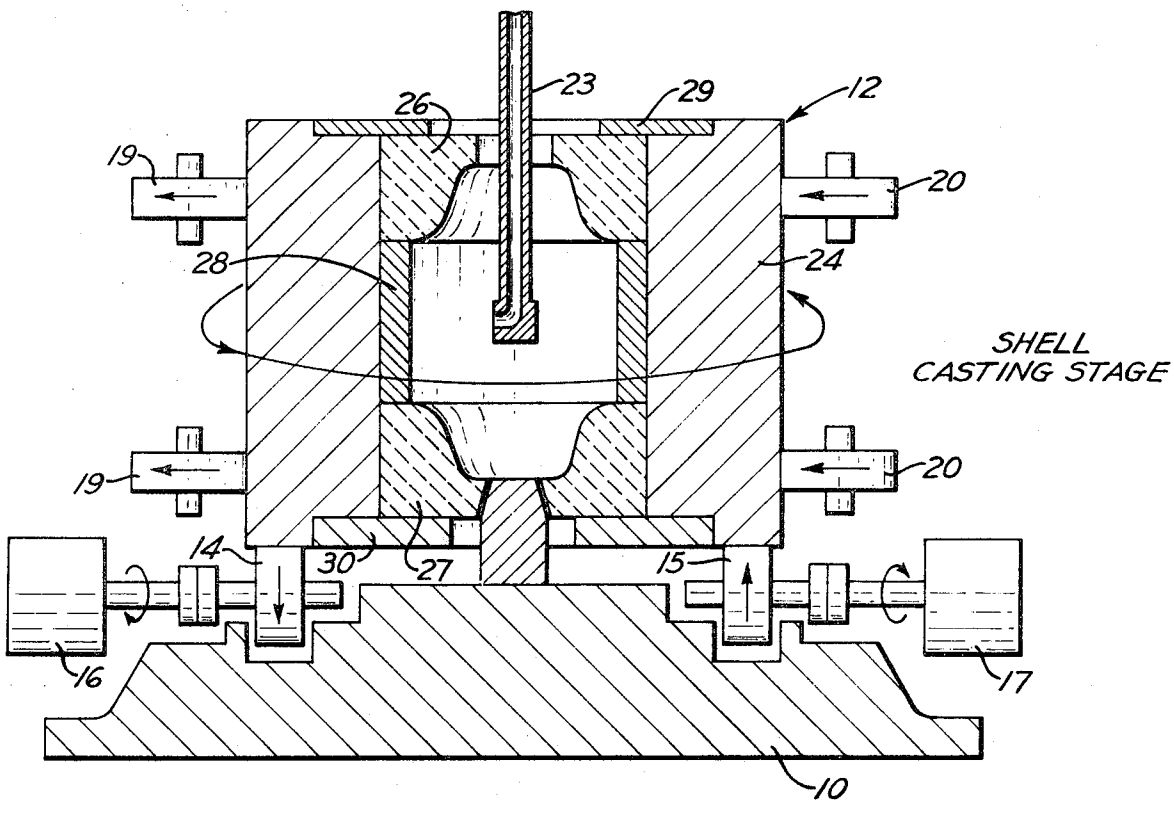
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[57] **ABSTRACT**

A method for centrifugally casting bi-metal or composite iron and steel rolling mill rolls. The shell of the roll is centrifugally cast by rotating a mold with its major axis arranged vertically, in which, immediately before the shell metal is completely solidified, the rotation of the mold is greatly reduced or stopped and unsolidified shell metal is drained. Immediately after this, the mold is filled with a second metal that makes up the core portion of the roll as well as the neck portions, during which period the mold is static or rotated at a low r.p.m. around its vertical axis as the second metal is fed to the mold from the top thereof.

3 Claims, 2 Drawing Figures



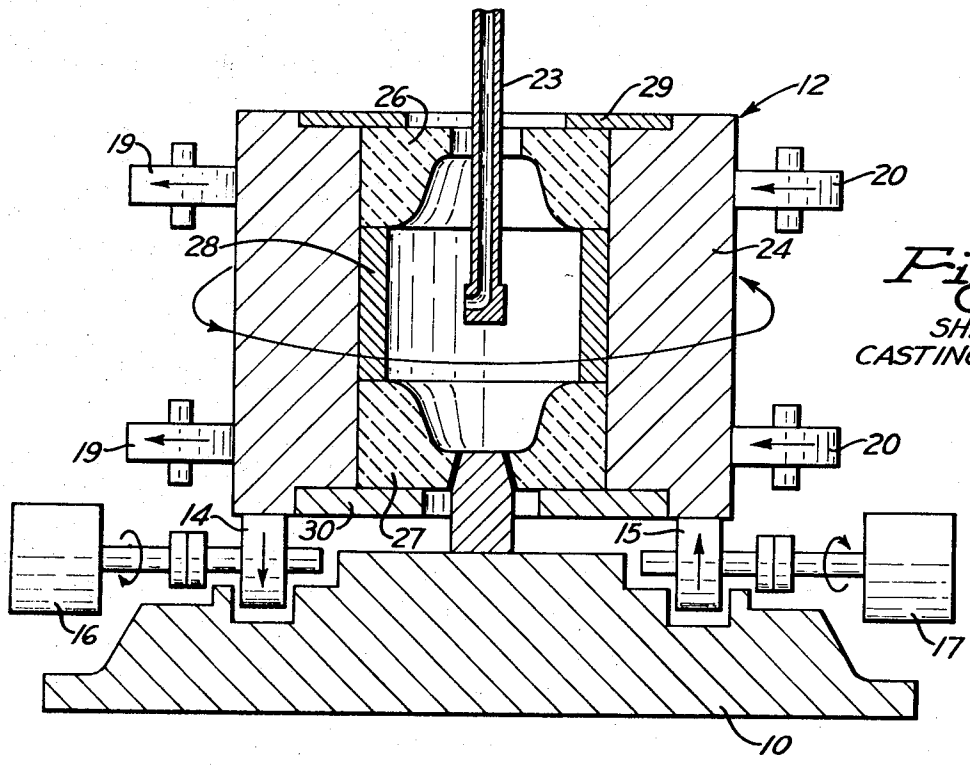


Fig. 1
SHELL CASTING STAGE

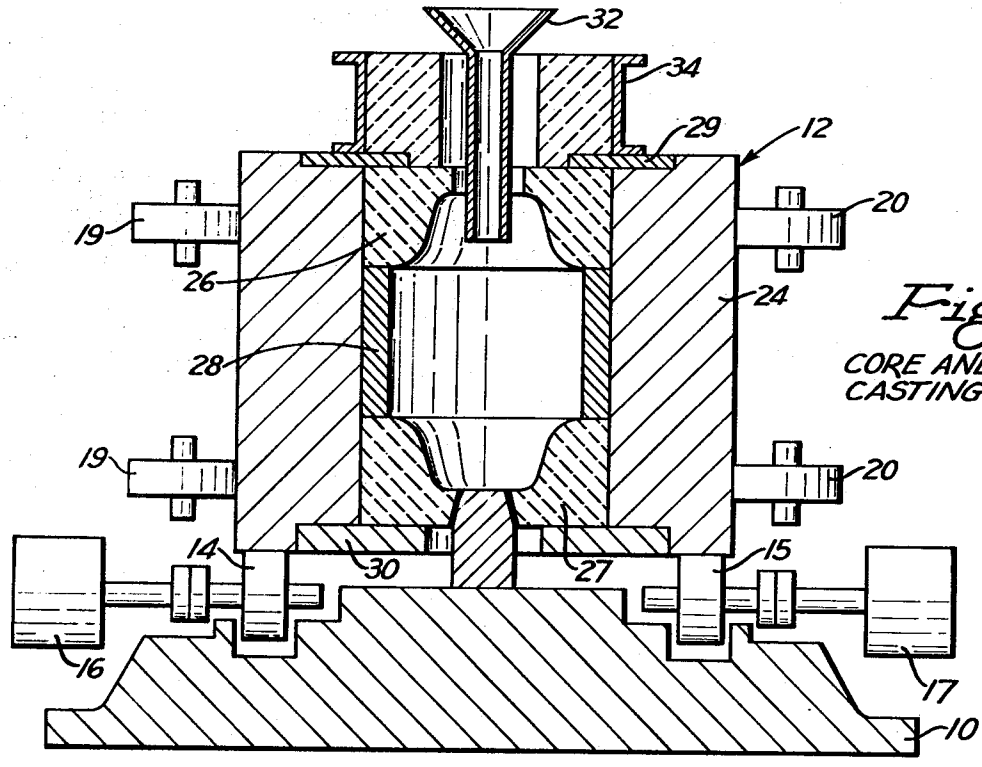


Fig. 2
CORE AND NECKS CASTING STAGE

CENTRIFUGAL CASTING OF BI-METAL ROLLS

Many attempts have been made in the past to produce commercially acceptable centrifugally cast tubular metal articles, such as pipe and rolls, and while for certain tubular articles great success has been enjoyed; in others, and particularly rolls, the results have been much less successful. With reference, for example, to rolls for metal rolling mills and rolls for rubber and paper calenders, both of which in use are subject to tremendous internal and external stresses, much difficulty has been experienced and, prior to this invention, centrifugally cast rolls have not found general use in such machinery.

The inability during the casting process to achieve a satisfactory bond between the shell metal and the fill metal when casting a composite or bi-metal roll was one of the major difficulties in prior practices. Two of the principal reasons for this condition was the inability to obtain an amenable surface condition between the two mating surfaces and not being able to pour the fill metal at the ideal time to improve the opportunity in obtaining an acceptable bond.

The creation of bands in the solidified shell when the centrifugal casting was performed while rotating horizontally was another important problem that has not been solved by prior practices. This banding may be described as the development in the shell during the horizontal casting of a series of essentially circumferential bands of varying hardnesses formed axially of the roll at one or more levels which become evident as the roll is used and, particularly, as it wears.

Lastly, high neck failure has been experienced in the past when both the body and the neck portions were centrifugally cast. This was due to the inherent differential shrinkage that takes place between the body and the neck portions of the roll, and the physical shifting or displacement of the rapidly rotating casting during the latter stages of the casting process, after the fill metal metal has been poured which placed high stresses on the still weak neck portions of the roll.

With reference to the aforesaid inability and difficulty of prior means and methods to centrifugally cast bi-metal rolling mill rolls, and to the extent that such difficulties are applicable to centrifugal casting of other metallic bi-metal tubular articles, a method is provided in which a first or shell metal is fed to a mold while the mold is rotating with its major axis arranged vertically and at a speed and for a time period sufficient to centrifugally cast the shell metal into an outer shell portion of the article to be cast, interrupting the centrifugal casting of the shell by stopping the rotation of the mold at a point immediately prior to the complete solidification of the shell metal and thereafter and while the mold is still in said vertical position, filling the mold with a second metal to make up the roll core and neck portions thereof.

It is an object of the present invention to provide that during the formation of the shell the centrifugal casting be interrupted by stopping the rotation of the mold at a point immediately prior to the complete solidification of the shell metal to allow the unsolidified inside surface metal of the shell to drain away.

It is a further object of the present invention to provide during the pouring of the fill or second metal that the mold be rotated at a speed substantially below that required to effect a centrifugal casting of the fill metal.

It is a still further object of the present invention to feed the second metal to the mold from the top of the mold and to rotate the mold while the second metal is being fed at a very low r.p.m.

These objects as well as other novel features and advantages of the present invention will be better understood when the following description of one embodiment thereof is read along with the accompanying drawings of which:

FIG. 1 is an elevational view, partly in section, of a means for carrying out the disclosed method for centrifugally casting the shell of a composite rolling mill roll, and

FIG. 2 is a view similar to FIG. 1 but showing the condition of the apparatus for casting the core and neck portions of a composite rolling mill roll.

With reference to FIG. 1 there is shown a base **10** for rotatably supporting a mold assembly **12** in a manner that its major axis is vertically arranged. The rotation of the mold assembly **12** about its major axis is achieved by a plurality of pairs of diametrically spaced-apart, horizontally arranged rollers, one pair of which is shown at **14** and **15.** These rollers are driven and controlled by driving assemblies **16** and **17,** respectively. It will be appreciated that the driving assemblies will include the necessary controls for effecting a rotation of the mold at a speed to effect a centrifugal casting of the shell, quickly braking the rotation of the mold, and providing for a slow rotation of the mold, the purposes for which will be explained in detail later.

The mold assembly **12** is retained in the horizontal direction by a plurality of cooperative pairs of non-driven, vertically arranged rollers, two pairs of which are shown in FIG. **1** as **19** and **20.** It will be appreciated that much of the construction of the mold assembly follows well-known practice in the art of casting iron and steel rolling mill rolls, including the stationary vertically arranged feed pipe **23** located at the open top of the mold assembly into which opening the two metals are introduced into the center of the mold. As shown in FIG. **1,** the shell portion of the roll is formed by the cylindrical chill **24** that makes up the outer portion of the mold assembly **12;** whereas, the neck portions of the roll are formed by vertically opposed refractory formed mold elements **26** and **27,** which are retained in the horizontal direction by the chill **24** and in the vertical direction by customary keeper plates **29** and **30,** respectively.

As the legend associated with FIG. **1** denotes, this figure is intended to portray the condition of the mold assembly during the shell casting stage of the casting procedure, the arrows associated with the moving parts of the mold denoting that the mold is rotating in a counterclockwise direction by virtue of the drive assemblies **16** and **17.**

Turning now to FIG. **2,** it will be noted that its legend indicates that this figure portrays the condition of the mold preparatory to the casting of the core and neck portions of the roll. Since, aside from the feed pipe **23,** the elements are the same as illustrated in FIG. **1,** the same reference characters have been applied to FIG. **2.** In FIG. **2** the feed pipe **23** has been replaced by a funnel **32** and above the keeper plate **29** there is arranged a hot top **34** which functions in a manner well known in the art of casting rolling mill rolls.

It is important in comparing FIGS. **1** and **2** to note that the casting apparatus in FIG. **2** is either in a static

condition or what is described as an essentially static condition when it is receiving the filled or second metal. Another observation that is worthy of note in comparing the two figures is the fact that both of these figures show a completely cast outer shell which is indicated by the reference character **28** so that in FIG. **1** it is assumed that the mold has received the last of the first or shell metal; whereas, in FIG. **2** the pouring of the second or filled metal is about to commence.

A brief description of one method of employing the apparatus illustrated in the aforesaid figures will now be given. Let it be assumed that it is desired to cast a composite or bi-metal rolling mill roll of the general type described in U. S. Pat. No. 2,097,709 which issued to H. E. Walters on Nov. 2, 1937 in which the outer shell is to be formed of hard high alloy metal comprising 2.84 percent carbon; 0.28 percent silicon; 0.07 percent sulfur; 0.14 percent manganese; 0.41 percent chromium; 0.30 percent molybdenum; 0.38 percent phosphorous; 4.05 percent nickel and the remainder iron. The roll core and the necks of the roll are to be cast out of a relatively softer and ductile metal, for example, in accordance with the aforesaid patent of an ordinary gray cast iron. Such a roll will have the important properties of the shell being very hard and highly resistant to wear, but low in ductility; whereas, the body portion, and particularly the neck portion, will have the properties of being soft and ductile. A roll of this type would have immediate application as a work roll in the finishing train of a continuous hot strip mill.

Once a vessel containing the shell metal at the proper pouring temperature is brought to the mold assembly **12**, the drive assemblies **16** and **17** are operated to bring the rotation of the mold assembly to the desired centrifugal casting speed and the shell metal is fed to the interior of the chill **24** by the feed pipe **23.** The mold will continue to be operated at the centrifugal casting speed until the proper thickness of the shell **28** has been formed. While the inner surface of the shell will take the form of a paraboloid revolution, a generally uniform shell thickness can be obtained, as indicated by the drawings, and, particularly so, if the r.p.m. is maintained high enough. In one application of the invention it was determined for an inside shell radius of 7.5 inches drawn at the bottom of the shell, as one views FIG. **1**, and where the thickness at the top of the shell measured 3 inches, that at an r.p.m. of 750 the shell was thicker at the bottom by 0.50 inches; whereas, for 1,250 r.p.m., the radius increased to 7.83 inches making the difference, in thickness, only 0.17 inches.

Once the shell metal has been completely fed to the mold assembly, the mold's rotation is maintained until solidification thereof has taken place which, in a given case, may approximate **20** minutes. The rotation of the mold assembly **12** is then interrupted by discontinuing the operation of the drive assemblies **16** and **17.** Before this, and while the mold is still rotating, if desired, the pipe **23** can be removed from the mold assembly **12** and in its place a hot top **34** and funnel **32** can be positioned as shown in FIG. **2.** A vessel, not shown, containing the second or fill metal is brought to the mold assembly **12** and at the ideal time and temperature to assure the obtaining of an amenable bond between the shell and the body portion of the roll, the fill metal is poured into the funnel **32** to fill the remaining cavity of the roll. As noted before, during this casting phase, the mold may be held stationary. According to well-known practice, as the interior of the roll is filled gradually from the bottom to the top, the funnel **32** is removed from the hot top **34** and the hot top is filled with molten metal to complete the metal feeding cycle.

The present invention contemplates the obtaining of additional benefits by providing a method wherein immediately before total solidification of the shell, the rotation of the mold assembly is interrupted to allow the unsolidified metal on the inside surface of the shell **28** to drain from the surface. In the above case requiring twenty minutes of total casting time, the mold assembly should be stopped approximately after **18** minutes of casting time has expired. In this way the segregation and/or oxidized elements that would otherwise solidify to form the inner surface of the shell are allowed to drain down into the bottom of the drag roll neck area of the mold assembly **12,** thereby assuring that a clean and strong bond will be obtained between the shell metal and the fill metal.

Alternately or in combination to the above benefits, additional advantages are contemplated by the present invention. Instead of the mold assembly **12** being held in a static or stationary condition during the filling stage, the mold assembly **12** can be rotated at below the speed at which centrifugal casting is effected. This rotation of the mold during the filling stage is described as essentially static in comparison with the speed required to centrifugally cast the shell. The force, in terms of gravity, employed to centrifugally cast the shell must be sufficient not only to overcome the weight of the metal which may only require from 4 – 5 g's, but must be sufficient within the time allowed to generate enough force to cause the lighter particles of the metal to find their way to the inside of the shell; thereby obtaining a better shell surface condition in terms of density, hardness and finish. For a roll approximating 20 inches in diameter, the centrifugal force required would be of the order from 50 – 150 times the force of gravity. In terms of the r.p.m. required to centrifugally cast the shell at 100 g's, the r.p.m. would amount to 590 r.p.m. as derived from the formula $w^2r = 100$ g where

w is the rotational speed in radians per second,
g is the acceleration of gravity, and
r represents the radius of the roll or shell.

The speed at which the mold assembly would be rotated during the fill state is at an essentially static speed in comparison with the speed required to centrifugally cast the shell. The important consideration is that the speed be maintained very low to avoid any rotational forces exerting stresses on the neck portions of the core of the roll and, particularly, where the core and neck portions join each other. A speed corresponding to 1 g or below for a roll of the above diameter would be satisfactory, which in terms of r.p.m. would be of the order of 60 r.p.m. or less.

One of the important features of imparting a rotation to the fill metal is to create a positive swirling action in the metal as it enters the mold which tends to displace the lighter particles of the metal to the inside of the casting and, hence, away from the bonding surface thereof so that the bond is made up of the smaller and stronger particles of the fill metal. This benefit is realized without exposing the neck portions to any objectionable stresses during the period of solidification, since the speed of rotation of the mold assembly is very low and substantially below what is required to create a centrifugal casting action.

In accordance with the provisions of the patent statutes, I have explained the principle and operation of my invention and have illustrated and described what I consider to represent the best embodiment thereof.

I claim:

1. A method of producing a bi-metal rolling mill roll or like article, comprising the steps of:

arranging a mold with its major axis vertical and rotating the mold about the axis,

pouring an outer shell metal into the rotating mold to centrifugally cast an outer shell of that metal,

continuing the rotation of said mold until all but the last portion of the poured shell metal is solidified,

stopping the rotation of said mold just prior to solidifying of the inside surface of said shell,

allowing the unsolidified shell metal to drain from said inside surface of said shell, and

immediately thereafter pouring a fill metal into the mold while the mold is in said vertical position to cast the remaining portion of said article.

2. In a method according to claim 1, the additional step of rotating the mold about its major axis during the period the fill metal is being poured and until solidification thereof takes place at a speed below that in which centrifugal casting would be effected and pouring said fill metal from the top of said mold.

3. In a method according to claim 2 wherein said additional step of rotating said mold is further characterized in that the speed of rotation is maintained below that required to overcome the force of gravity.

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