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METHOD OF MAKING ROLLS

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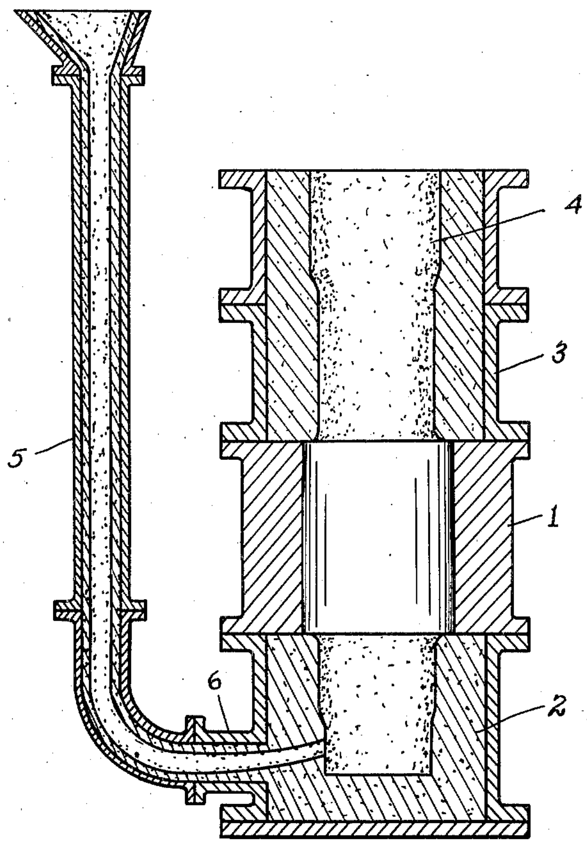

INVENTOR

Fred. C. T. Daniels

by Christy and Wharton

attorneys

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METHOD OF MAKING ROLLS

Fred C. T. Daniels, Bridgeville, Pa., assignor to Mackintosh-Hemphill Company, a corporation of Delaware

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This invention relates to the casting of metal-working rolls.

The object of the invention is to provide a simple and effective method of making cast-iron rolls by which the roll body has a hardened surface and is, to an appreciable depth, of relatively hard metal, while the metal forming the interior of the roll body and the roll necks is inoculated with a strength-increasing different metal (usually a metal softer and less brittle than that of the hardened surfact) so that the roll body is of improved strength, and the rolls are so strong that the probability of breaking them in service is greatly reduced. A closely related object is, by such a method, so to conduct the casting operation that the necks of the roll are of metal rendered by inoculation relatively so soft that the necks are both of them relatively susceptible to machining.

It is quite usual in casting rolls that a metal which hardens well in contact with a chill does not in slow cooling in the interior of the roll body and necks, give such graphite distribution as to produce a strong body and necks, or have such alloy content that a roll having a strong body and necks is produced. In simple cast iron the graphite form and distribution, under the rate of cooling fixed by the general conditions under which the roll is cast, determine the strength and ready machinability of the cast iron. A cast iron which is readily machinable is considered to be a "soft" cast iron, and usually the graphite distribution which makes a cast iron "soft," is a factor which also contributes to the strength of the cast iron.

In various roll casting methods the core of a roll body and one or both of the roll necks are made of metal softer than the metal of a chilled, or otherwise hardened, shell which surrounds the interior of the roll body, by sweeping out with softer metal a large proportion of the hard metal with which a mold for casting the roll is initially filled. This has been done by sweeping from the mold either by upward displacement, or by downward displacement, the hard metal which initially occupies the space within the chilled shell of the roll body and/or the spaces provided for the metal of the roll necks. The method which I hereinafter describe presents in the making of metal-working rolls purposed for a relatively wide range of use, substantial advantage over methods which involve the bodily sweeping of hard metal from a roll mold. This is because my method, hereinafter to be described, avoids the waste attendant upon collecting and re-melting metal which has been displaced from the mold, because it produces greater homogeneity in the composition of the interior roll body and of the necks, and because it leads to a more uniform production of sound rolls in which the structure of the roll metal is undeteriorated by shrinkage stresses, cleavage planes, or lack of perfect bonding between the chilled shell of the roll body and the interior body structure of the roll. My method is also economically advantageous, in that it involves the replacement, in each roll, of a substantial proportion of the relatively expensive conventional roll metal with a cast iron of lower cost. My method consists primarily in the quiet inoculation of the unchilled portion of an initial mold content of metal with a metal of softer, or at least of strength-increasing sort.

The accompanying drawing, which is to be taken as a conventional representation of a mold assembly for roll casting, shows in vertical section a conventional structure in which my method may advantageously be practiced. In the drawing there is shown a sectional, vertically positioned, roll casting mold. As illustrated, the mold comprises a body chill 1, a sand drag 2 providing the mold for one roll neck, a sand cope 3 providing the mold for the other roll neck, and a sink head 4 providing an upward extension of the mold assembly. A vertical runner 5 communicates with the lower region of the drag neck by way of a gate 6 in the drag mold 2.

In conducting my method, the mold cavity is, by pouring through the vertical runner, initially filled with metal to a level above the upper extent of the roll body cavity, and below the upper level of the cavity within the mold cope provided for the casting of one roll neck. I then wait until centrifugal motion in the metal teemed into the mold has ceased, and the metal has become quiet. I then clear the runner of hard metal by teeming a different metal into the runner and forcing the metal initially contained in it upwardly into the mold cavity. I then form a shell of solidified metal for the roll body against the chill in the body cavity of the mold, by waiting for an appropriate time before further continuing the casting operation. This time may be varied in accordance with the depth of chill which is desired and the composition of the inoculant metal. It should not be a time so long that the inoculant metal tends substantially to thicken in the runner. I have found that from 1 to 2 minutes is usually an appropriate time interval between active steps of the method in which to form the surface chill on the roll body.

At this stage in my method the entire charge of hard metal having been introduced into the mold, and a shell of hard metal having been formed in the body region of the roll, I proceed quietly to inoculate the uncongealed metal in the mold with a strength-increasing, and usually softer metal. This quiet inoculation I effect by slowly pouring the soft inoculant metal through the runner into the lower region of the mold; in the mold to percolate upward through the unsolidified portion of the initial body of metal to mix homogeneously therewith. The rate at which the inoculant metal is added I make so slow that there is no bodily displacement of any portion of the metal initially contained in the mold, but on the contrary as the level of the total metal in the mold slowly rises, the softer inoculant metal with great rapidity spreads through the body of initial metal, the concentration of the softer metal, rather than its distribution, becoming greater as the inoculation slowly proceeds. It is thus the inoculated metal, and not the initial hard metal, which rises to fill the mold cavity for the upper roll neck.

As inoculation proceeds, and the total volume of metal in the mold increases, the level of the metal rises upwardly beyond the upper mold space for one of the roll necks, and into the adjacent hot top of the mold. By appropriate proportioning of the total mold cavity and the level (about the body cavity of the mold) to which the mold initially is filled, I may add inoculant metal in a proportion of from 15% to 25% the total weight of the roll without displacing any metal from the mold.

The slow addition of the inoculant metal is a feature of my method which should be emphasized since such slow addition results in homogeneity in the composition of the metal in all regions of the roll, save the chilled surface of the body. This is resultant from the fact that the quiet inoculation renders it possible to avoid any such thrust of the inoculant metal as bodily to displace any of the still liquid metal already contained in the mold. This is in accordance with my discovery, above noted, that inoculation seems to proceed so rapidly throughout the body of initial metal in the mold that is still in the liquid state (i. e., that metal that has not been congealed by the body chill mold). I have found that, depending upon the conditions of the roll-casting operation, I may vary the time of pouring the inoculant from 4 to 20 minutes; but in any case it is added slowly, and either continuously or in very small closely timed increments.

It will be readily understood that my method of quiet inoculation avoids all the disadvantageous effects incident to relatively violent displacement of metal from the mold. By heat transfer through the body of metal in the mold, it tends to preserve uniformity of temperature in the entire metal of the casting, and tends wholly to eliminate gases from the metal during the relatively extended period in which the inoculant metal is added. Tests have shown the rapidity with which thet metal in the upper region of the mold becomes uniform in composition with that in the lower mold regions, and that the progress of inoculation after the first introduction of the inoculant metal consists chiefly in progressive concentration of the inoculant. This is shown by the approximately complete homogeneity in character of the metal in the necks and body interior of each inoculated roll.

The method of my invention provides a practical process for making rolls in which it is desired to combine strength with a desirably high surface hardness and hardness penetration. I have found that the advantages of my method of roll casting are realized in the casting of metal-working rolls up to an 85 scleroscope hardness and with a chilled depth in the approximate proportion of from 1 to 2 inches for a 12 to 18 inch diameter roll, and of from 2 to 4 inches for a 20 to 40 inch diameter roll. They are, however, also realized in rolls which are surface hardened, but which do not have a sharply defined, or "clear" chill structure.

The following are given as exemplary of many compositions of iron, which are advantageously used in my method as the hard metal constituent of the roll:

	1	2	3	4	5
C	2.95	3.15	3.28	3.20	3.46
Si	.62	.55	.51	.95	.96
Mn	.25	.26	.24	.46	.43
Ni	------	2.15	4.21	1.04	4.49
Cr	------	.32	.68	.96	1.95
Mo	------	.26	.45	------	------

In each formula the percentages of alloying ingredients are given, as is usual, by weight, and in each the remainder of the composition is iron, except for small quantities of the usual impurities.

In practicing my method it is advantageous that the "hard", initially cast, metal should be one of those ferrous compositions, or alloys, which do not tend rapidly to thicken when poured into the mold. The propriety of utilizing an initial metal which tends to retain fluidity will be clear in view of the manner in which I perform the inoculation step; adding the inoculant metal slowly, and avoiding bodily displacement of any substantial portion of the initial metal. If the initial metal be of a sort which tends rapidly to thicken, inoculant may in substantial quantity be nonetheless added. The proportion of inoculant which may homogeneously be distributed through the body of metal initially in the mold is, however, limited by the decreased time available for the inoculation due to obstruction to its spreading presented by the thickening of the metal initially in the mold.

Usually it is desirable that the softer inoculant metal be of such composition that it develops to a great extent a graphitizing tendency, so that it may serve adequately to soften and strengthen the initially hard metal which it inoculates. A generally advantageous formula for the inoculant metal may be given as follows:

Formula No. 1

	Per cent
Carbon	3.25 to 3.75
Silicon	1.00 to 2.00
Manganese	.50 to 1.00

The remainder iron and small quantities of the usual impurities.

A formula for producing a graphitizing effect of the inoculant more extreme than produced by the inoculation formula first noted above, may be given as follows:

Formula No. 2

	Per cent
Carbon	4.00
Silicon	2.10
Manganese	1.00

The remainder iron and small quantities of the usual impurities.

In connection with the duration of the period of quiet inoculation, given above as from about 4 to about 20 minutes, I prefer to employ as much time in inoculation as the teeming temperature and composition of the metals will permit. Thus, if the initially cast metal be teemed at high temperature, and be of a composition capable of retaining a condition of high fluidity for a relatively long time (the inoculant metal similarly meeting those requirements) I prefer to teem so slowly that as much as ten minutes is usually taken for conducting the quiet inoculation step, in making rolls of average size. If on the contrary the conditions are such that a lesser order of fluidity of the initial metal is to be expected, the time during which the inoculant is added should be shortened.

In relating the time during which the inoculant metal is added to the size of the roll which is cast by my quiet inoculation method, and the relative proportions of the metals desirably poured in the several stages of casting, I give the following illustrative information. A roll requiring 10,000 lbs. of total metal, I have cast with 7500 lbs. of metal in the initial pouring, and have then inoculated it with 2500 lbs. of the inoculant metal, taking about 5 minutes for the inoculation step. I have cast a 30,000 lb. roll, using 21,000 lbs. of metal in the initial pouring, and adding 9000 lbs. of the inoculant metal during an inoculation period of 10 minutes. I have cast a 71,000 lb. roll, using 48,000 lbs. of metal during an inoculation period of about 18 minutes. The roll last noted represents approximately the maximum weight of rolls commonly cast. It is to be understood, however, that if even heavier rolls are being cast, the inoculation period may well be extended beyond 20 minutes. In each noted instance the initial metal was poured at a temperature in the neighborhood of 2500° F. and the inoculant was poured at a temperature in the neighborhood of 2400° F.

In general I may say that I prefer to inoculate as slowly as the several conditions of the casting process will permit; and in this connection may note that (other conditions being equal) it is possible, and desirable, to inoculate a large roll casting proportionally more slowly than a small roll casting, because of the greater total heat content of the larger body of metal. One skilled in the art of roll casting will, with these general guides, be enabled, without experiment, and using merely reasonable care, properly to time the length of the inoculation period.

By the simple method above described, I have made rolls having in the roll body a scleroscope hardness of from 60 to 85; and in which test pieces taken from the necks, and the interior of the roll body show (uniformly for each individual roll) a tensile strength of from 32,000 lbs. per sq. in. to 48,000 lbs. per sq. in.

It has been indicated above that my quiet inoculation method is not limited to procedure which provides a definite, or "clear," chill structure. Illustration of that fact is given in the formulae for the initially poured metal of the roll. Of these formulae, 1, 2, and 3 give a substantial depth of definite, or "clear" chill structure, while formulae 4 and 5 give a roll having a hardened surface, but without a sharply defined, or "clear" chill structure. These latter rolls are, therefore, to be considered to be of the "grain" type, rather than of the chilled type.

It may be that an initial metal which, because of its chill, will have a sufficiently hard surface, may, because of its composition and the slow rate of cooling in the sand portions of the mold, give necks which, although they contain a relatively high proportion of graphite, have their graphite in large platey structure, and are for that reason weak. In such case an inoculant metal though it be inherently "harder" than the unchilled portion of the initial metal, may so improve the form and distribution of the graphite structures in the necks, so to increase the strength of the necks. Whereas throughout the specification the initial metal has been spoken of as "hard" metal, and the inoculant metal as "soft" metal (as is usually the case) it is thus apparent that the procedure of my method is consistent with the use of an inoculant inherently no softer than the initial metal. It must, however, be of strength-increasing character. Thus the inoculant metal will have strength-increasing qualities, though not necessarily softer but even harder than the initial metal, if it be within the ranges of the commonly known "high-test" cast irons. A proportioning of alloys in the initial metal and the inoculant also may cause the inoculant to impart the desired strengthening effect without being inherently softer than the initial metal.

I claim as my invention:

1. In making cast-iron rolls having a hardened body surface and relatively soft and strong body and necks those steps which consist in initially filling a mold contoured for the casting of rolls to a level slightly above the body cavity of the mold, surface chilling the body portion of the roll to form a cylindrical shell of solidified metal, and inoculating all the initial metal of the roll other than that contained in the chilled surface of the roll body by slowly introducing at the bottom of the mold a strength-increasing different metal while permitting the level of the total metal to rise in the mold.

2. In making cast-iron rolls having a hardened body surface and relatively soft and strong body and necks those steps which consist in initially filling a mold contoured for the casting of rolls to a level slightly above the central body cavity of the mold with a metal of relatively high fluidity, surface chilling the body portion of the roll to form a cylindrical shell of solidified metal, and during the continuance of the fluidity of the said metal initially in the mold inoculating all the said initial metal of the roll other than that in the chilled surface of the roll body by slowly and quietly introducing at the bottom of the mold an inoculant strength-increasing metal different from the initial metal, while permitting the level of the total metal to rise in the mold.

3. In making cast-iron rolls having a hardened body surface and relatively soft and strong body and necks those steps which consist in initially filling a mold contoured for the casting of rolls to a level slightly above the central cavity of the mold, surface chilling the body portion of the roll to form a cylindrical shell of solidified metal, and quietly inoculating substantially the entire body of the metal initially in the mold other than that contained in the chilled surface of the roll body by adding as slowly as the persistence of fluidity in the said initial metal will permit strength-increasing different inoculant metal introduced at the bottom of the mold, while permitting the level of the total metal in the mold to rise.

4. In making cast-iron rolls having a hardened body surface and relatively soft and strong body and necks those steps which consist in initially filling a mold contoured for the casting of rolls to a level slightly above the central body cavity of the mold, surface chilling the body portion of the roll to form a cylindrical shell of solidified metal, and effecting quiet inoculation of all the initial roll metal other than that comprised in the chilled surface of the roll body by slowly intro-

ducing at the bottom of the mold an inoculant metal softer than that first introduced into the mold, while permitting the level of the total metal to rise in the mold.

5. In making composite cast-iron rolls having a hardened body surface of one composition and a body interior and necks of a different composition the steps of pouring into a mold contoured for the casting of rolls metal to be included in the hardened body surface of the roll to a level above the body cavity in the mold, forming a solidified shell on the body region of the initially poured metal in the body cavity of the mold, and then while retaining in the mold substantially the total initially poured metal mixing a molten different metal with all the still-liquid portion of the total initially poured metal standing in the mold.

6. In making composite cast-iron rolls having a hardened body surface and a body interior and necks of a softer and stronger composition than that included in the hardened body surface of the roll, the steps of pouring into a mold contoured for the casting of rolls metal to be included in the hardened body surface of the roll to a level above the body cavity in the mold, forming a solidified shell on the body portion of the initially poured metal in the body cavity of the mold, then while retaining in the mold substantially the total initially poured metal mixing a molten strength-increasing and softening metal with the still-liquid portion of the total initially poured metal standing in the mold.

FRED C. T. DANIELS.