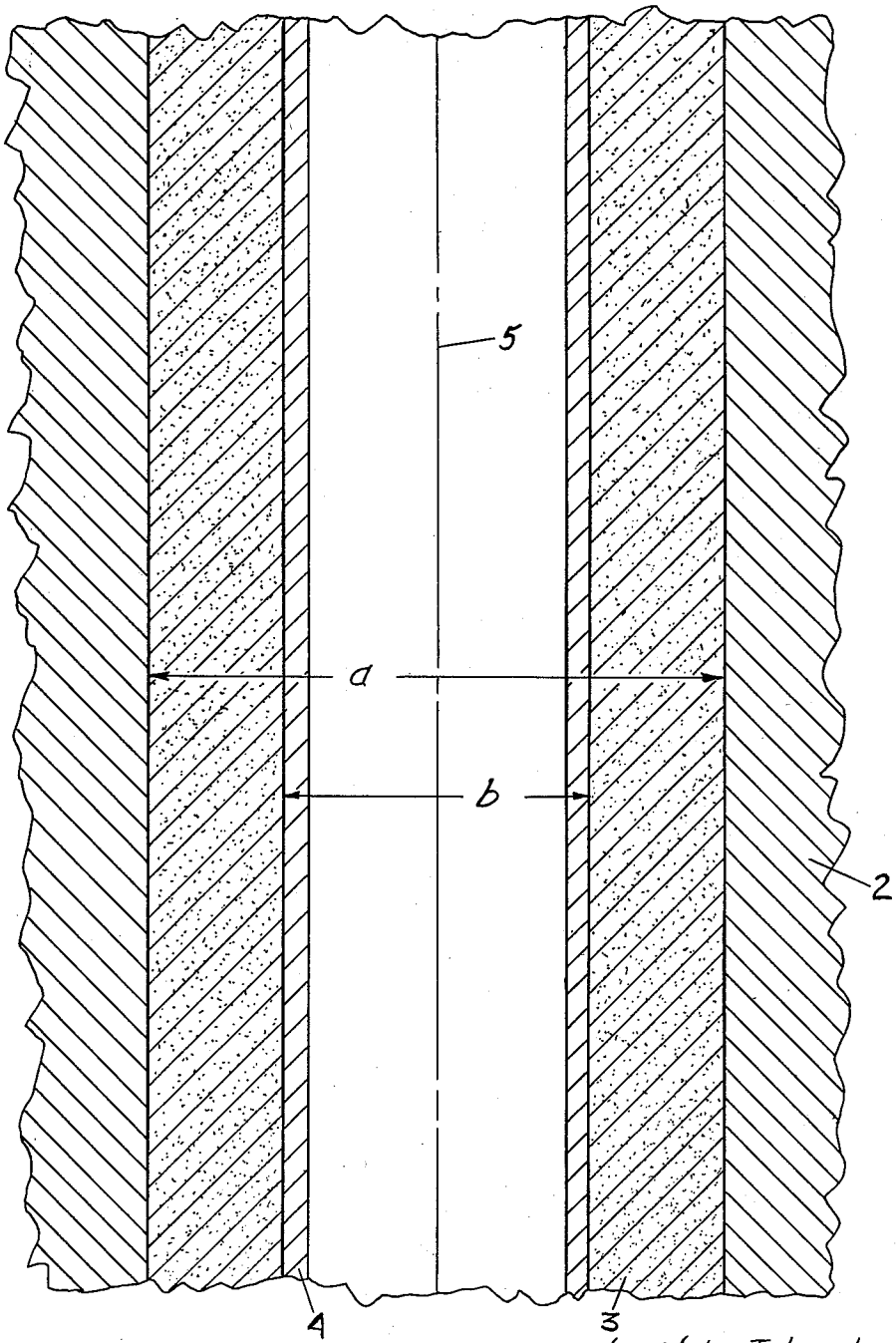
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METHOD OF MAKING A HOLLOW MOLD OF COMPACTED MOLD FORMING MATERIAL

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## METHOD OF MAKING A HOLLOW MOLD OF COMPACTED MOLD FORMING MATERIAL

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2 Claims. (Cl. 22—197)

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This invention relates to apparatus for casting hollow articles and preparation thereof. It relates particularly to the preparation of molds for the casting of elongated articles by the compacting within a flask of mold forming material such as is used in foundries, e. g., sand, graphite and the like.

While my invention is of general utility in the preparation of hollow molds of compacted mold forming material it has especial application in the preparation of molds for the centrifugal casting of elongated articles such as lengths of pipe. Purely for purposes of explanation and illustration the invention will be described in connection with the preparation of compacted sand molds in elongated generally cylindrical flasks for use in the centrifugal casting of cast iron soil pipe. Apparatus such as will be referred to herein may, for example, be embodied in molding machines of the type disclosed in my copending application Serial No. 648,318, now Patent 2,449,900, issued September 21, 1948.

One method of preparing a mold for the centrifugal casting of cast iron soil pipe is to introduce loose or uncompacted mold forming material such as sand into an elongated generally cylindrical flask and compact the sand against the inner wall of the flask to form a hollow generally internally cylindrical compacted sand mold. The thus formed mold is rotated at high speed and molten iron is introduced into it to centrifugally cast lengths of pipe. Soil pipe is made in a range of standard nominal diameters, i. e., 2", 3", 4", 6" and 8". For each nominal diameter there is a specified external diameter of the pipe and, of course, the internal diameter of the mold must be such as to form the pipe to the proper external diameter. The wall thickness and internal diameter of the pipe are controlled by the quantity of molten metal introduced into the mold.

In a foundry for the centrifugal casting of cast iron soil pipe there are provided flasks of different sizes or large flasks adapted to receive inserts to form in effect flasks having different internal diameters. The sand may be compacted within the flasks by mandrels. One method of procedure is to introduce loose sand into a flask and rotate the flask fast enough to cause the sand to cling to the inner wall of the flask and

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somewhat densify itself, thus forming a hole in the sand through the flask through which a mandrel may be introduced. A mandrel is then introduced and moved transversely of the axis of the flask to compact the sand against the inner wall of the rotating flask. The flask may be oriented with its axis generally vertical when the sand is introduced and it may be oriented with its axis generally horizontal when the mandrel is introduced.

It is important that the sand molds formed within the flasks be of proper density and properly shaped and surfaced from end to end of the flask; otherwise the pipe cast in the mold may be defective. If the loose sand which is initially introduced into the flask does not substantially completely fill the flask that sand may not be, and often is not, properly distributed along the flask, and thus the mold is likely to be imperfect adjacent one end of the flask. Hence the flask should be filled substantially full of loose sand at the beginning of the mold forming operation. However, this may entail the subsequent removal from the flask of sand initially introduced thereinto in excess of the quantity of sand required to form the mold. For example, in my said copending application there is disclosed a screw conveyor adapted to be introduced into the flask before the mandrel is introduced to remove excess sand. This is an undesirable operation because it entails the expenditure of considerable time, the employment of labor and a substantial additional initial outlay for equipment. Moreover it is wasteful of sand which in the grades required for foundry work is costly. Also, the sand withdrawn from the flask has to be removed, which entails additional time, labor and equipment.

Efforts to obviate the introduction of excess sand into the flask have been unsuccessful. While the quantity of sand needed for formation of a mold is known in advance, if that sand is measured before being introduced into the flask additional measuring equipment, time and labor are required. Moreover, if the required amount of said is insufficient to substantially fill the flask before the sand is compacted a defective mold may be formed, as above explained. The problem has been a vexing one and has not been solved prior to the present invention.

I have discovered that all of the disadvantages above referred to which have existed in foundry practice for many years may be obviated by proper proportioning of flask diameter in relation to the diameter of the mold to be formed in the flask. This involves consideration of the initial volume of the uncompacted molding material, its volume when compacted and hence the difference in density between the uncompacted and compacted molding material. Consideration must be given to the relative internal diameters of the flask and the mold to be formed in the flask.

I utilize for the formation of an elongated hollow mold of compacted molding material a flask whose volume is substantially equal to the volume of the uncompacted molding material required for formation of the desired mold in the flask. In other words, the flask itself may be employed to measure the loose or uncompacted molding material, thus obviating any other measuring apparatus. When my flask is filled substantially full of uncompacted molding material it contains the proper quantity of molding material for formation of the mold. Since the flask is filled substantially full of uncompacted molding material the molding material is disposed against the inside of the flask from end to end of the flask and the formation of a proper mold is thus assured. No mechanism such as the screw conveyor of my said application is needed to remove from the flask sand in excess of the amount required for formation of the mold since only the amount required is initially introduced. There is no wastage of sand and no means need be provided for removing excess sand.

Proper proportioning of the flask requires consideration of the relationship between the internal diameter of the flask and the internal diameter of the mold as well as the ratio between the specific gravity of the mold forming material when in loose or uncompacted condition and the specific gravity of the mold forming material when compacted to form the mold. I find that within the normal range of sizes of cast iron soil pipe and especially the smaller sizes which are in greatest demand my improved results are obtained when the internal diameter of the flask bears approximately the following relation to the internal diameter of the mold to be formed therein (which is approximately the same as the external diameter of the pipe to be cast therein):

$$a^2=\frac{s'}{s}(a^2-b^2)$$

in which $a$ is the internal diameter of the flask, $b$ is the internal diameter of the mold and

$$\frac{s'}{s}$$

is the ratio of the specific gravity of the compacted mold forming material to the specific gravity of the uncompacted mold forming material as delivered into the flask before formation of the mold.

It is a rule of thumb which has become standard in foundries that a cubic foot of rammed or compacted sand weighs 100 pounds. This, of course, is not always strictly true as the weight of a cubic foot of compacted mold forming material depends on the precise grade of material employed, the force with which it is compacted, the amount of moisture it contains, etc. However, it is found that for practical purposes the weight of a cubic foot of compacted mold forming material may be considered as being 100 pounds. Rarely will the weight of a cubic foot of compacted mold forming material be less than 90 pounds or more than 115 pounds.



The extent to which mold forming material is compacted in the formation of foundry molds varies somewhat, but, generally speaking, it is compacted to approximately the extent that the specific gravity of the compacted mold forming material is about 1.4 times the specific gravity of the uncompacted mold forming material. The specific gravity of the uncompacted mold forming material averages around 72 pounds per cubic foot and is rarely less than 65 pounds per cubic foot or more than 80 pounds per cubic foot. For practical purposes the weight of uncompacted molding material may be considered as being between 70 and 80 pounds per cubic foot.

The equation given above may be simplified for practical purposes if 1.4 be substituted for the ratio

$$\frac{s'}{s}$$

This leads to the equation

$$a=\sqrt{3.5b^2}$$

which in all cases which I have encountered has proved applicable; that is to say, if the internal diameter of the flask is made to bear the relationship expressed by the equation just given to the internal diameter of the compacted mold formed in the flask, the flask may be used to measure the amount of uncompacted mold forming material introduced into it and that material when compacted in accordance with accepted foundry practice will substantially exactly form a mold of the desired internal diameter. As a matter of fact, the variable is not the internal diameter of the mold but rather its density since the internal diameter of the mold is determined by the extent of movement transversely of its axis of the mandrel used for compacting the mold forming material. When the amount of mold forming material employed for making a mold is determined as I have explained above and the mold is compacted and shaped by the mandrel to the desired internal diameter its density will be found to be satisfactory and will be in the neighborhood of 1.4 times the density of the loose or uncompacted mold forming material as introduced into the flask before formation of the mold.

Since the internal diameter of the mold for each size of soil pipe is fixed, I can, by application of the above formulae, determine the internal diameter of the flask which should be used for each size. If the practice in any foundry is unusual so that the mold forming material is not compacted to the extent that the specific gravity of the compacted mold forming material is in the neighborhood of 1.4 times the specific gravity of the uncompacted mold forming material, the particular practice followed in that foundry is taken into consideration and the proper value of

$$\frac{s'}{s}$$

is inserted into the equation first given above, whereupon since the value of $b$ is given the value of $a$ may be determined. In foundries following normal practice in selection and compacting of mold forming material the second formula given above may be employed and the internal diameter of the flask for making a compacted mold of

predetermined internal diameter may be computed.

To illustrate the practical operation of my invention I give below a partial tabulation of flask and mold diameters which may be employed in connection with the centrifugal casting of soil pipe:

| Nominal Diameter | Internal Diameter of Mold | Internal Diameter of Flask |
|---|---|---|
| *Inches* | *Inches* | *Inches* |
| 2 | 2⅜ | 4½ |
| 3 | 3½ | 6¾ |
| 4 | 4½ | 8⅛ |

Ii will be seen by computation that the figures given in the above table do not exactly follow my formulae but they are so close that the differences between the figures obtained by my formulae and those given in the table are immaterial. So long as my formulae are followed within a plus or minus variation of 20% the improved results of my invention are obtained.

I shall give a specific example of application of my invention. Assume that it is desired to prepare a compacted sand mold for the centrifugal casting of soil pipe of 2'' nominal diameter. I select a flask whose internal diameter is 4½''. This may be the internal diameter of the flask itself or it may be in the internal diameter of an insert disposed within the flask. In either event the effective internal diameter of the flask so far as formation of the mold is concerned is 4½''. I dispose the flask with its axis generally vertical. With the flask thus disposed I fill it level full of molding sand of normal type and consistency for the purpose. The sand is simply poured into the upended flask and fills it up substantially to the top while the sand is in loose or uncompacted state. I then orient the flask with its axis generally horizontal and rotate it at high enough speed so that the sand, which lies against the flask throughout the entire length of the flask, is somewhat densified and an opening formed through it axially of the flask. I then introduce through the opening a sand compacting mandrel such as is shown in my said copending application. That mandrel may be journaled for rotation at both ends just outside the flask. While the flask continues to rotate the mandrel is moved transversely of its axis to compact the sand against the inner wall of the flask. The internal diameter of the compacted sand mold is determined by the amplitude of lateral movement of the mandrel which is controlled so that the internal diameter of the mold is 2⅜''. It will be found that the quantity of sand determined by measuring it level full in the flask when the sand is in loose or uncompacted state is the proper amount for formation of the mold of desired density. While the density of the mold may vary within narrow limits it will be found to be eminently satisfactory for the purpose intended.

The accompanying drawing is a fragmentary axial cross-sectional view of a flask containing a hollow mold of compacted sand adapted to be rotated at high speed for the centrifugal casting of elongated hollow articles. The flask is shown at **2** and the hollow mold therein of compacted sand is shown at **3**. An elongated hollow article centrifugally cast in the mold **3** is shown at **4**. The flask, mold and centrifugally cast elongated hollow article are all of annular cross section.



The common axis of all thereof is designated by the chain line **5**. The internal diameter of the flask **2** is designated by the letter $a$ and the internal diameter of the mold **3** is designated by the letter $b$. The internal diameter of the flask bears approximately the following relation to the internal diameter of the mold:

$$a=\sqrt{3.5b^2}$$

While I have described a present preferred embodiment of the invention and have explained a present preferred method of practicing the same it is to be understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. A method of making a hollow mold of compacted mold forming material adapted to be rotated at high speed for the centrifugal casting of elongated hollow articles comprising selecting a hollow flask whose internal diameter bears approximately the following relation to the internal diameter of the mold to be formed:

$$a=\sqrt{3.5b^2}$$

in which $a$ is the internal diameter of the flask and $b$ is the internal diameter of the mold, disposing the flask generally on end, filling the flask substantially full of uncompacted finely divided solid mold forming material, orienting the flask with its axis generally horizontal and rotating it while compacting the molding material until its density is approximately 1.4 times the density of the uncompacted mold forming material, so that the flask itself can be used to measure the quantity of uncompacted mold forming material needed for the mold and the uncompacted mold forming material is distributed along substantially the entire length of the flask during compacting thereof.

2. A method of preparing apparatus for forming hollow articles by centrifugal casting comprising providing a hollow flask adapted to have disposed therein a hollow mold of compacted finely divided solid mold forming material such that the internal diameter of the flask bears approximately the following relation to the internal diameter of the mold:

$$a^2=\frac{s'}{s}(a^2-b^2)$$

in which $a$ is the internal diameter of the flask, $b$ is the internal diameter of the mold and

$$\frac{s'}{s}$$

is the ratio of the specific gravity of the compacted mold forming material to the specific gravity of the uncompacted mold forming material as delivered into the flask before formation of the mold, disposing the flask generally on end, filling the flask substantially full of uncompacted mold forming material, orienting the flask with its axis generally horizontal, rotating the flask and compacting the mold forming material in the flask to form the mold until the specific gravity of the compacted mold forming material bears to the specific gravity of the uncompacted mold forming material as delivered into the flask before formation of the mold the ratio

$$\frac{s'}{s}$$

whereby the quantity of uncompacted mold

forming material employed for the formation of the mold is such as to substantially fill the flask, so that the flask itself can be used to measure the mold forming material, and the uncompacted mold forming material is distributed along substantially the entire length of the flask.

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