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METHOD AND APPARATUS FOR PRODUCING METAL CASTINGS  
USING MOLTEN METAL COOLED BEFORE TEEMING  
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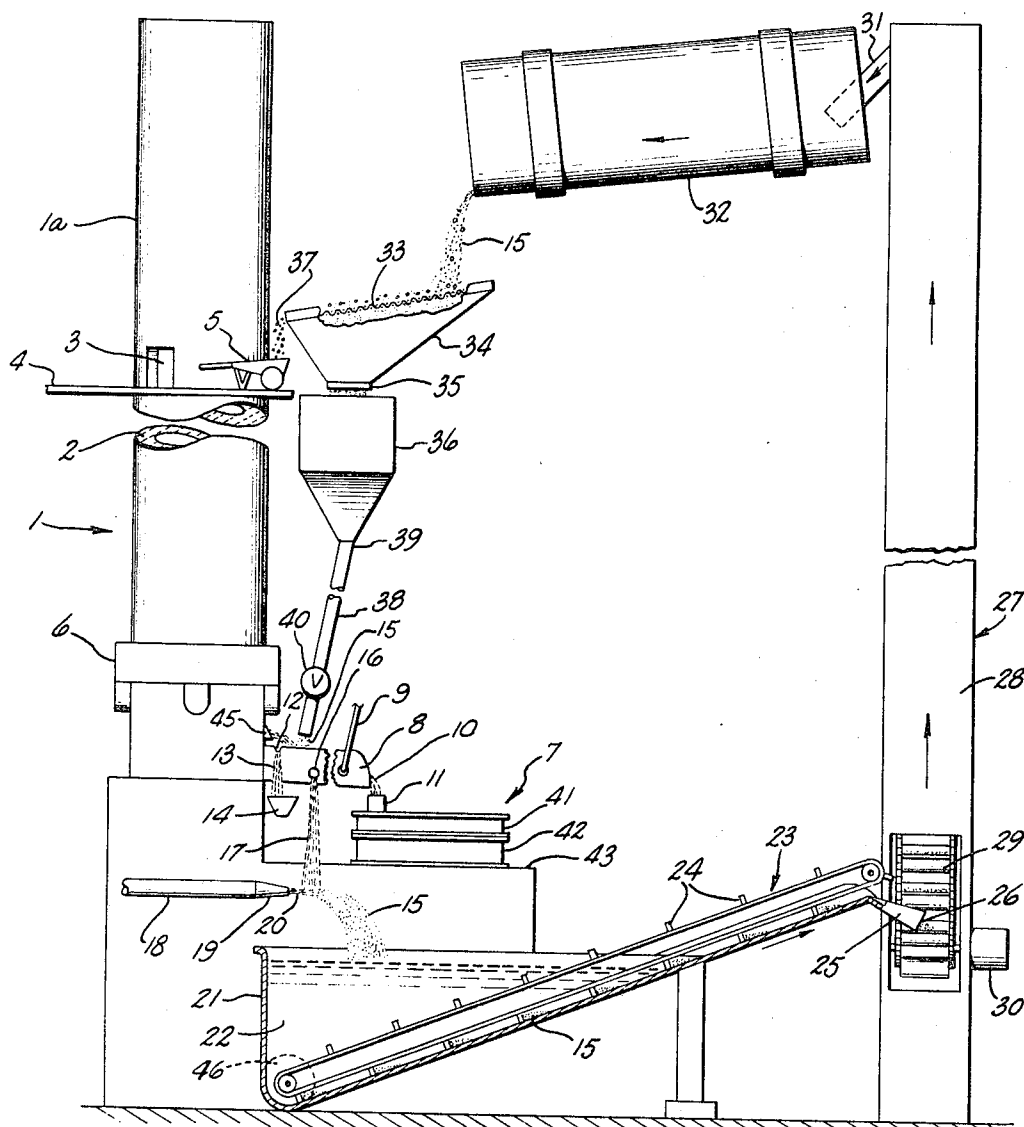


FIG. 1

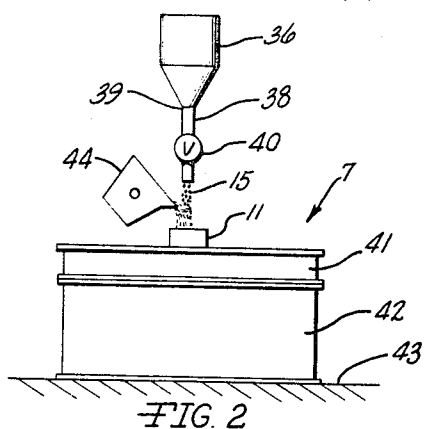


FIG. 2

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## METHOD AND APPARATUS FOR PRODUCING METAL CASTINGS USING MOLTEN METAL COOLED BEFORE TEEMING

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### ABSTRACT OF THE DISCLOSURE

The present disclosure relates broadly to improved foundry practices, and in its more specific phases to the formation of metal shot and the use of same in the casting of metal.

#### Background of the invention

Conventional foundry practice for a great many years has involved the melting of metal in a cupola, withdrawing same into a suitable pouring ladle, and pouring it into conventionally prepared molds utilizing firmly packed molding sand in which a cavity has been formed through the use of a pattern which has been removed from the mold prior to the pouring of the molten metal into same. This molten metal is poured into the mold at a temperature considerably above the metal melting point, and where the finished casting is large or has heavy section portions, shrinkage flaws or holes commonly form as the casting outer surface solidifies first while the inner body of molten metal gradually cools and solidifies during which time it also shrinks.

To offset this shrinkage problem a common practice has grown up of placing metal chills in the mold, particularly at the heavy section points to quickly cool the whole molten metal body to the solidifying point and thus minimize the formation of shrinkage flaws in the finished casting. Some forms of these chills are provided with a pronged end which can be pushed into the molding sand to hold them up into the body of the mold cavity for internal chilling of the metal body rather than merely surface cooling of the metal which is used to provide special properties of the casting in the chilled surface area.

The use of inwardly projecting chills as noted presents the disadvantage of leaving end portions of the chills projecting out of the rough casting so as to require later removal of same. Moreover, the composition of the chills, at best, is only approximately like the metal poured into the mold so that there is non-uniformity of the metal in the final casting, with the inherent disadvantages well known to the art. It was a recognition of these and other problems in the foundry field and the lack of a wholly satisfactory commercial solution to same which led to the conception and development of the present invention.

#### Summary of the invention

Accordingly, among the objects of the present invention is the provision of an improved metal casting pro-

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cedure wherein, among other things, the chilling of the metal near to the solidifying point before being poured into the mold may be partially accomplished before pouring starts or substantially completed during the actual pouring and with the avoidance of chilling of the molten metal with fixed chills in the mold made from a different batch of metal having a composition normally considerably different from the molten metal being poured.

Another object is to provide both the equipment and a suitable method for the formation of metal shot and the use of same to cool the metal from substantially the same melt to a temperature better adapted for pouring into a mold with a minimum of casting shrinkage flaws.

Another object is to provide a method and apparatus wherein molten metal withdrawn from a suitable source, such as a cupola, is temporarily held in a receiver and cooled to a suitable temperature close to but just above the metal solidifying point and then poured into the mold so as to minimize shrinkage difficulties where the outer surface portion of the casting starts solidifying while the center portion is still at a temperature high above the solidifying point and wherein this molten metal shrinks with the production of shrinkage flaws in the casting as the temperature of the cast metal drops to the solidifying point.

A further object is to use shot made from substantially the same melt as an additive to the molten metal as it passes into the mold so as to control the temperature of the metal and avoid the use of inward projecting chills placed in the mold before pouring is started.

A still further object is to use shot made from substantially the same metal melt as an additive to the molten metal body being held in preparation for pouring, to lower its temperature, with or without the further addition of said shot to the molten metal as it is being poured into a mold, to bring the temperature of the whole metal body down very close to solidifying temperature and thus minimize the development of shrinkage flaws.

Still further objects and advantages of the invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, consists of the methods and means of forming metal castings hereinafter fully described and particularly pointed out in the claims, the annexed drawing and the following description setting forth in detail certain means and modes of carrying out the invention, such disclosed means and modes illustrating, however, but several of the various ways in which the principle of the invention may be used.

#### Brief description of drawings

In the annexed drawing:

FIGURE 1 diagrammatically illustrates in schematic side elevation, and partly in section, the overall assembly showing the various working parts in their proper relative relation.

FIGURE 2 diagrammatically illustrates the addition of chilling metal shot to the molten metal being poured into a mold to form a casting.

*Description of specific embodiment*

Referring more particularly to FIGURE 1 it will be noted that there is shown a conventional cupola 1 lined with fire brick 2 and having a charging hole 3 at the base of the upper or chimney portion 1a of the cupola 1 and which charging hole is elevated well above the bottom of the cupola, as illustrated. Said charging hole 3 is preferably positioned above a loading deck or floor 4 over which the material to be charged into the cupola 1 is transported, for instance, by means of a wheelbarrow 5 where hand operation is carried out in a small foundry set-up, or by means of conveyors (not shown) where the foundry is automated. Such cupola 1 would be charged conventionally with coke, limestone and iron with the coke being ignited at the bottom of the cupola. Air for burning the coke to melt the iron would be supplied by a fan or the like (not shown) in accordance with standard practice through a wind box 6 from which conventionally extend air delivering tuyeres (not shown) directly into the cupola at a suitable elevation above its bottom.

In older foundry practice the cupola 1 would be operated until a sufficient body of molten metal had accumulated in its bottom for pouring into a ladle ready for transporting to and filling the mold in which a casting is to be made. The cupola would then be tapped, a suitable amount of the molten metal withdrawn through pluggable outlet 45 into the ladle (not shown), the outlet 45 of the cupola again plugged, and the metal poured from the ladle into the mold for forming the casting. While the present invention can be used in this manner, it is contemplated that in an efficiently operating foundry continuous operation of the cupola would be carried on as will be hereinafter set forth in detail.

Instead of drawing the molten metal from the cupola into a ladle, and then plugging the cupola outlet, an automated procedure would involve operating the cupola 1 with the molten metal flowing continuously from same, as much as possible, through an outlet 45. Here the molten metal would flow continuously from the cupola (except when it was desired to temporarily stop such flow by conventionally plugging the cupola outlet) into an open top, trough-like, fire brick lined receiver 8. This receiver might be stationary, but preferably would be pivotally supported at its cupola end and have its outer end supported by conventional means 9 for limited pivotal movement in a horizontal plane to better facilitate lining up its pluggable pouring outlet 10 with the inlet gate 11 of mold 7. Since the substantially continuous flow of molten iron out of cupola 1 into open top receiver 8 would normally include some molten slag, the receiver 8 would be provided with an overflow notch 12 to permit the excess of such slag 13 to overflow into a suitable receiver such as a slag bucket 14.

One phase of the present invention is the production of metal shot 15 for use in the manner to be hereinafter set forth in detail. A convenient way to produce such shot 15, as diagrammatically shown in FIGURE 1, is to provide the open top receiver 8 with a pluggable molten metal outlet opening 16 through which a small stream 17 of molten metal will flow. A water pipe 18 with nozzle 19 mounted in position to direct a stream of water 20, under suitable pressure against said molten metal stream 17, would, under operating conditions, result in said water shreading said molten metal stream into metal droplets or shot 15 which would fall into a tank 21 of water 22 to protect and cool same. This tank 21 is provided with a conveyor 23 of movable type which may be conventionally driven as by means of a geared down electric motor 46. Such conveyor is preferably a dewatering one with cross flights 24 which scrape the shot 15, as shown, to a discharge chute 25, the outlet end 26 of which delivers same to an elevator assembly 27 having a housing 28 in which is mounted a continuous bucket conveyor 29 driven, for instance, by a suitable geared down electric motor 30, or the like. This

bucket conveyor conventionally delivers the shot 15, after elevating same, through a discharge chute 31 into the upper end of a diagrammatically shown rotary dryer 32. As the shot 15 pass through the rotary dryer 32 they become dry and flow out of the lower end of same.

The dry shot 15 passing out of the lower end of the rotary dryer 32 preferably fall onto an inclined screen 33, which may be of the continuously shaking type, and through which the small shot 15 drop into a funnel shaped hopper 34, while the rough pieces 37 which were formed along with the small shot work their way down screen 33 and drop into a suitable receiver such as a wheelbarrow 5, ready for delivery to cupola 1 through charging hole 3 for remelting. Shot 15 delivered through screen 33 into hopper 34 pass down through the outlet 35 of same into shot storage hopper 36 which preferably has a shot delivery tube 38 mounted by means of a pivot 39 on the lower or outlet end of same. This shot delivery tube 38 in turn is provided with a control valve 40 to control the amount and rate of delivery of shot 15 from the shot storage hopper 36 for a purpose to be hereinafter explained in detail.

The mold 7 with its cope 41 and drag 42 filled with molding sand (not shown) rammed firmly with an inlet gate or gates and suitable vents to a casting recess in same, is then ready for carrying out the casting procedure. This mold 7 may be placed on the foundry floor or platform 43 as shown in FIGURES 1 and 2, or in the place of such floor or platform the mold may be mounted on railway cars, or other suitable mold transporting means, for moving the mold to and from the metal casting position, and it is intended that the drawing be considered as diagrammatically showing same. With the transportable mold system the molds, after having the molten metal poured into same, may be moved to a suitable storage area and allowed to stand until the casting has cooled sufficiently for removal from the mold. In accordance with standard practice the molding sand, after removal of the casting, is then reconditioned ready for reuse.

The molten metal flowing from the cupola 1, or any other source of same, into open top receiver 8 may well be at a temperature one hundred degrees or more above the solidifying point of the metal, and if delivered at this temperature into a mold 7 having a relatively large section casting recess, the metal will first chill and solidify on the surface of the casting while the center will remain molten and contract as it cools. This causes shrinkage flaws or holes in the final casting. On the other hand, the castings must be rather rapidly made for economy of operation if competitive costs are to be met. Accordingly, one phase of the present invention involves adding a suitable amount of metal shot to the body of molten metal in the open top receiver where they melt and reduce its temperature to a suitable point for pouring into mold 7 to substantially reduce or minimize shrinkage flaws or holes in the finished casting.

The above can be readily accomplished by checking the temperature of the molten metal in open top receiver 8 with a pyrometer to determine how much the temperature of the molten metal should be lowered before the molten metal is poured into mold 7. With this information as a guide, control valve 40 then is opened to deliver an appropriate amount of shot 15 into the molten metal in open top receiver 8 to drop the temperature of the molten metal to the desired pouring temperature as again determined through the use of a pyrometer. The metal thus cooled is then poured through gate 11 into the conventionally prepared mold 7 to form the casting.

Where the temperature of the metal to be poured into mold 7 is higher than desired for the particular casting involved, another procedure, as shown in FIGURE 2, involves adding shot 15 to the molten metal as it is poured from ladle 44 into gate 11 of mold 7. The molten metal melts the shot, delivered in appropriate amount, so that the poured metal in the mold at the end of the pouring operation is relatively close to the metal solidify-

ing temperature so as to overcome or substantially minimize the formation of shrinkage flaws or holes in the finished casting.

A combined casting operation can be availed of if desired wherein some shot are delivered into the molten metal in the open top receiver 8 to be melted therein and partially reduce the temperature of the molten metal to a point which is still higher than the desired casting temperature, and then when this molten metal is poured through gate 11 into mold 7, some additional shot, in predetermined amount, may be added to the flowing metal in accordance with the diagrammatic showing in FIGURE 2. This makes possible holding the molten metal longer in the open top receiver 8, without solidification danger, if the molds are not promptly in position for the pouring operation, and which might readily happen in an automated foundry where the molds would be moved on railway cars, or the like, to filling position under pouring outlet 10 of open top receiver 8.

While various forms and ways of carrying out the present invention have been shown and described, other forms will now be apparent to those skilled in the art. Therefore, the embodiments of the invention shown in the drawing and described herein have been set forth primarily for illustrative purposes as well as for better understanding the principles of the present invention, and are not intended to limit the spirit and cope of the invention as above described and illustrated in the drawing.

Other modes of applying the principles of my invention may be employed instead of those explained, change being made as regards the means and the methods herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:

1. The method of making castings from molten metal poured into a mold which comprises the steps of:

- (a) providing a supply of molten metal,
- (b) delivering said molten metal to a container,
- (c) removing a portion of said molten metal from the container and forming solid metal particles from said portion,
- (d) delivering said particles to a storage area,
- (e) introducing a predetermined amount of said metal particles to the molten metal in said container to lower the temperature of the metal, and
- (f) delivering a stream of cooled molten metal from the container to the mold.

2. The method of making castings as set forth in claim 1 wherein the molten metal is iron.

3. The method of making castings as set forth in claim 2, including the further step of adding iron particles to the precooled molten iron stream as it is being poured into the mold.

4. The method of making castings as set forth in claim 1, wherein said portion of the body of molten metal to be poured into a mold is withdrawn in the form of a molten metal stream, shredding same with a water jet into metal droplets largely in the form of shot which is received in a tank of water to cushion and cool same, separating said shot from said water, drying said shot, screening said dried shot to predetermined maximum size, and storing said shot ready for addition to said molten metal used in making the casting.

5. The method of making castings as set forth in claim 4, wherein the metal involved is molten iron.

6. The method of making castings as set forth in claim 2, wherein same includes the further steps of melting said iron in a cupola, withdrawing same substantially continuously from said cupola into said suitable temporary storage container, withdrawing a portion of said molten metal from said container, and forming said iron particles from said withdrawn molten metal portion.

7. The method of making castings as set forth in claim 6, wherein some of said particles are added to the molten

metal in said container and melted therein, and the so treated molten metal is then poured into said mold while adding a further portion of said particles to said molten metal at a point between said container and said mold.

8. A metal casting apparatus combination for producing metal castings in molds comprising:

- (a) means supplying molten metal at a temperature well above its melting point,
- (b) a container means to receive said molten metal from said supply means,
- (c) means for delivering said molten metal from said supply means to said container means,
- (d) means forming metal particles from a portion of said molten metal in said container means,
- (e) a storage means for said metal particles,
- (f) means delivering a predetermined amount of said metal particles from said storage means to said molten metal in said container means to lower the temperature of the molten metal in the container means, and
- (g) means delivering a stream of cooled molten metal from said container means to said molds.

9. A metal casting system as set forth in claim 8, wherein said container means for the molten metal has means for removing molten slag floating on said molten metal.

10. A metal casting apparatus combination as set forth in claim 8, wherein:

- said particle forming means includes means for shredding said molten metal to provide shredded particles and
- said apparatus combination further including a tank means containing a suitable liquid coolant,
- means delivering particles from said metal particle forming means to said tank means to cool said particles,
- means for drying said shredded metal particles,
- means removing said shredded metal particles from said coolant to said drying means, and
- means separating said dried shredded metal particles into a first portion for delivery to said storage means and a second portion to be scrapped.

11. A metal casting apparatus combination as set forth in claim 8 wherein said particle delivery means for said molten metal supply means includes a readily movable outlet and a particle flow cut-off means.

12. A metal casting apparatus combination as set forth in claim 8 wherein:

- said metal is iron,
- said molten metal supply means is a cupola, and
- said means for delivering a predetermined amount of metal particles to said molten metal includes a tubular member.

13. A metal casting apparatus combination as set forth in claim 12, wherein said tubular member includes a valve for controlling the flow of said metal particles therethrough, and a pivot connection for operably joining said tubular member to said storage means for said metal particles.

14. A metal casting apparatus combination as set forth in claim 13, wherein:

- said particle forming means includes means for shredding said molten metal to provide shredded particles,
- said apparatus combination further including a tank means containing a suitable liquid coolant,
- means delivering particles from said metal particle forming means to said tank means to cool said particles,
- means for drying said shredded metal particles,
- means removing said shredded metal particles from said coolant to said drying means, and
- means separating said dried shredded metal particles into a first portion for delivery to said storage means and a second portion to be scrapped.

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