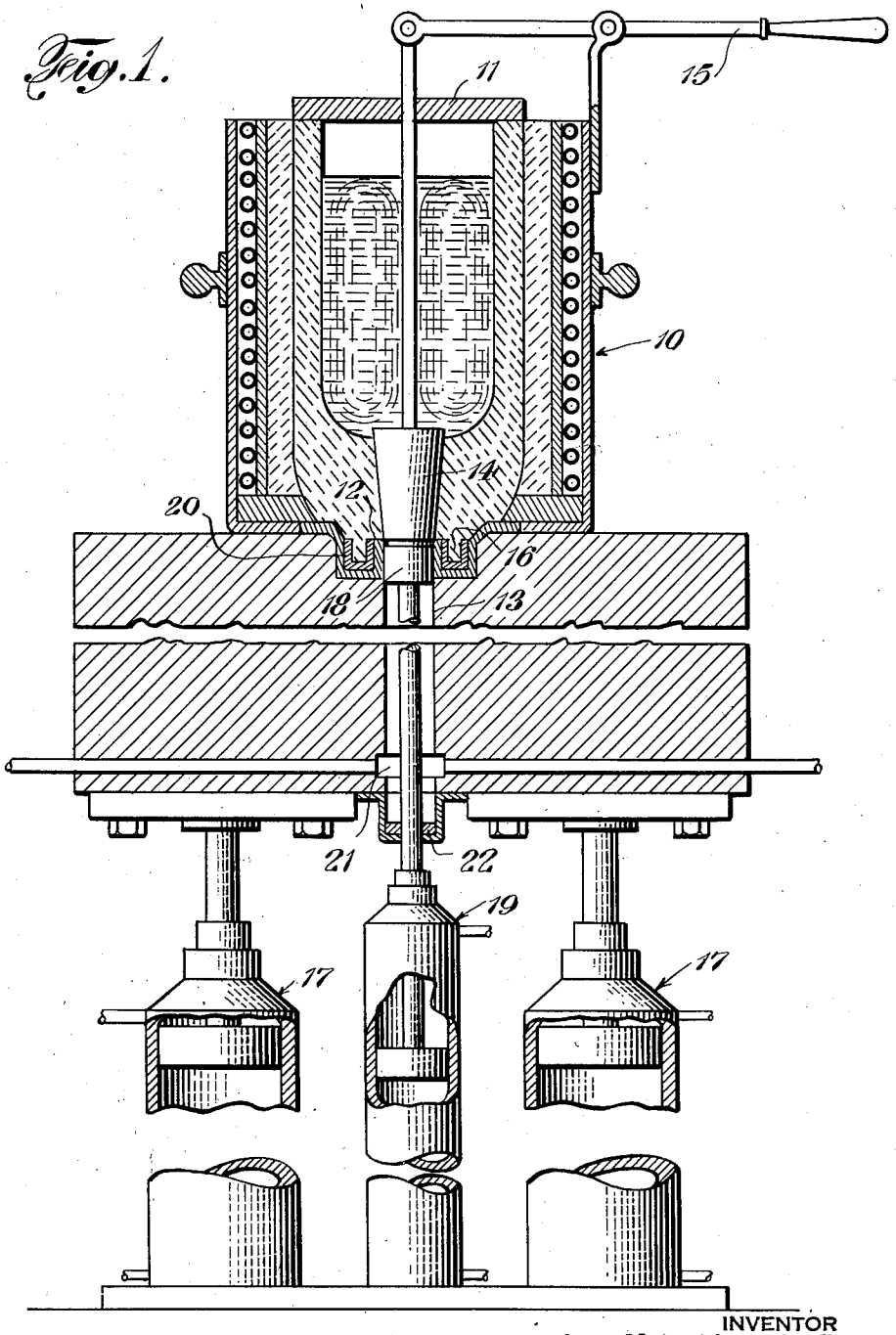
Sept. 30, 1941. J. H. L. DE BATS 2,257,713

METAL TREATING

Filed Oct. 19, 1940 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

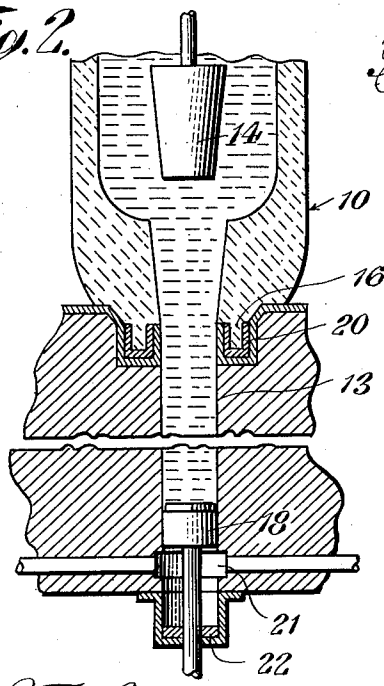


Fig. 3.

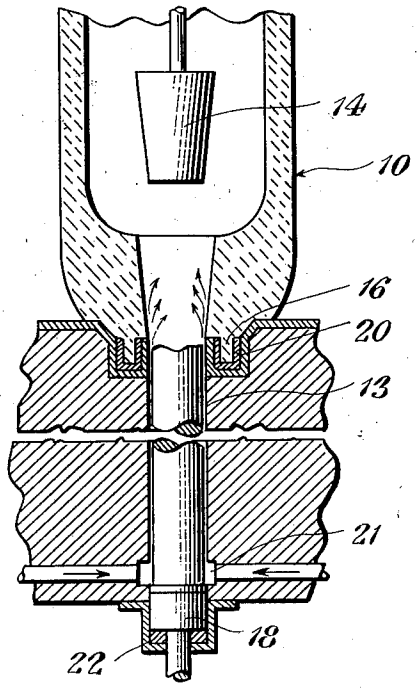
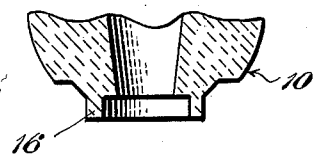


Fig. 4.



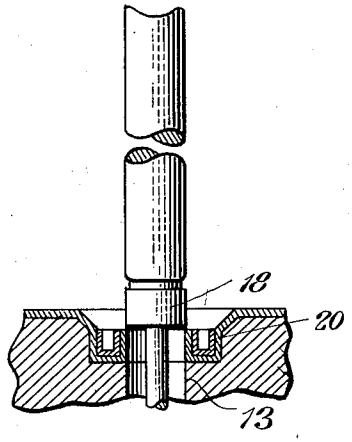
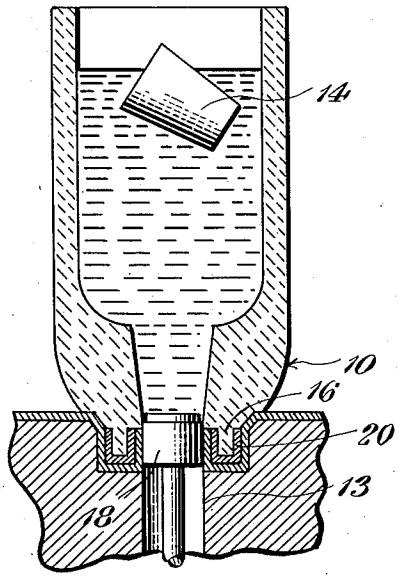


Fig. 5.



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METAL TREATING

Jean Hubert Louis De Bats, East Orange, N. J.

Application October 19, 1940, Serial No. 361,851

10 Claims. (Cl. 22—212)

This invention relates to method and apparatus for treating metals to produce superior castings from molten metal and has for an object the provision of improvements in this art.

There is an increasing demand for metal of high purity either alone—a pure metal, as such—or in definite predetermined ratios with other ingredients. It is recognized that the desired metals (or alloys) can be produced in the molten state, as, for example, in furnaces, particularly electric furnaces. The difficulty comes in getting the metals (or alloys) into castings (herein meaning any solid-from-molten condition) because the air reacts upon the molten metals with such extreme rapidity.

There are various vacuum casting methods but they are very expensive, slow and uncertain. There are protective gas methods but these require rather elaborate equipment and considerable care in use. There are processes involving protective solid substances and diluents but these obviously change the character of the metal, hence are mainly useful when the protective substance is also utilized as a desired alloying ingredient. One way of proceeding would be to permit the metal to solidify in the furnace in which it was brought to purity but obviously these vessels, such as electric furnaces, are neither suitable nor economical for handling solid metal castings. Other methods might be mentioned.

The manner in which the metal solidifies also greatly affects its quality because the crystal growth may be so variable in any one casting as to cause serious difficulties in subsequent working operations, even after annealing, and in many cases uniformity can never be re-established. In the case of alloys (or mixtures) there may be such segregation in the casting that the metal is worthless—or, at best, less perfect than desired.

For example, in the usual chill casting method the metal is frozen in a thin layer on the outside, after which the casting shrinks and the mold expands to permit separation, and thereafter the cooling is slower because of loss of metal-to-metal contact and the hot air gap between, and consequently the crystal growth interiorly becomes slower and more uncertain, the crystals getting larger and larger toward the center of the casting. This action is aggravated by the incremental pouring procedure which continues to add molten metal to the upper parts of the mold while metal therebelow solidifies, the mold continuing to expand from the continued heating. Because of this the casting may actually be larger at the upper end of a mold of initially uniform size. Hence the casting may be difficult to remove.

The present invention utilizes a carefully chosen combination of steps which together provide accurate control, eliminate the former difficulties, and produce a metal (or alloy) of unusual purity or accurate predetermined character.

According to this method the metal (or alloy) is brought to the desired state of purity in a melting furnace or ladle, preferably an electric furnace which produces vertical currents of metal circulation extending to the surface of the metal to eliminate gas inclusions or "kill" the metal. A high frequency induction furnace is one suitable form. The metal may either be melted and purified in the furnace or alternatively, for greater speed, may be poured molten into the furnace, treated until purified, and circulated while protected fully from the air until "killed."

After purification the metal is transferred without space separation into a mold which increases in size as fast as the metal can enter it and in which the metal enters through an opening the full size of the mold. Consequently the metal fills the mold almost instantly. This results in the surface solidification of the casting all at once and the shrinkage from the walls of the mold simultaneously throughout the entire facing area of the casting. Moreover, the entire action of pouring and surface solidification is so rapid that the temperature of the mold is not appreciably raised. The mold is made to have a high heat dissipating value so as to aid in avoiding temperature rise during the very short pouring period. It may be formed of copper or other highly heat conductive metal and have very thick walls or be rapidly cooled by fluid.

As soon as the metal cools to form a shell on the outside of the casting a cooling gas is forced through the space between the casting and mold to continue the rapid cooling and prevent enlarged crystal growth interiorly of the casting.

The total result of the process is to produce castings of high purity, substantially free from porosity, and having relatively uniform composition and structure throughout.

In order to make the principles and advantages of the invention more readily apparent an exemplary embodiment thereof will be described herein, reference being made to the accompanying drawings, wherein:

Fig. 1 is a vertical section through the apparatus before pouring;

Fig. 2 is a similar partial view after pouring;

Fig. 3 is a similar view during the later cooling stage;

Fig. 4 is a similar view showing the billet removal stage; and

Fig. 5 is a vertical section of a modified pouring arrangement.

Referring to the drawings, the apparatus suitable far practicing this invention comprises a furnace or teeming ladle 10 in which the metal may be purified and kept molten. Preferably it is an electric furnace which produces a vertical circulation of the metal to bring all parts rapidly to the furnace to free it completely of air or gases. A high frequency induction furnace may serve this purpose. The effect of air or gas removal is to "kill" or quiet the metal so that porosity in the castings is avoided. For certain metals the gas inclusions or gas-forming inclusions may be removed in whole or in part by other methods. A removable cover 11 fits fairly closely to completely prevent air entry and to permit escape of released gases.

The furnace or ladle may hold a large quantity of metal or just enough to fill one mold. In it the metal may be melted or may be received in molten condition.

The bottom of the furnace or ladle is provided with a pouring opening 12 substantially as large as the cross section of the opening of the mold 13 to be filled and this pouring opening is closed by a plug 14 which may be opened by a handle 15, as shown in Fig. 1, or by a push from below to float up, as shown in Fig. 5.

The furnace bottom is shaped, as by an annular tapered projection or nozzle 16, to fit tightly against the top of the mold. For further exclusion of air a liquid seal 20 of low melting point metal may be provided, the mold being hot enough (say 360° F.) to keep it molten. Either the furnace, or mold, or both, may have vertical movement to make the connection before pouring commences and to break the connection after pouring. Or under certain conditions the connection may be permanent. As shown, the mold may be raised and lowered by a fluid ram 17. The furnace may be raised and lowered by a crane or hoist (not shown) or by hand if small.

The mold is filled substantially instantaneously and without free fall. This avoids splashing and insures that the casting will solidify simultaneously throughout its full length, also that the mold will not expand to any extent during pouring but will expand, if at all, uniformly from top to bottom after pouring and during the cooling period.

The means for effecting this mode of filling the mold comprises a close fitting piston or plunger 18 which also fits the bottom opening of the furnace and which is operated by a fluid ram 19. The ram may be operated in one or both directions by compressed air and be evacuated by suction on the other side whereby the plunger may be lowered approximately with the speed at which the metal would fall by gravity. In a sense the metal will be sucked into the mold by the piston of the plunger, the metal seal above and the close fit of the plunger below serving to prevent the intake of air during this action.

At the beginning of the mold filling operation the piston of the plunger is moved up against the plug and may push the same up until the full opening of the nozzle is available for metal flow. This brings metal immediately against the top of the piston. Preferably the top of the piston is covered by insulation to prevent adhesion of metal thereto. The metal may be superheated by a hundred degrees or more to "kill" it and then cooled to the desired temperature for pouring.

After the plug has been fully opened the plunger descends at high speed to allow the mold to fill in an instant. Initially the piston stops at the position shown in Fig. 2 but as soon as a shell of metal forms in sufficient thickness to support the interior molten metal of the casting—which experience will soon indicate—the piston is lowered further, as shown in Fig. 3, to bring the lower end of the casting opposite an annular air (or gas) manifold 21 in order that the air may be forced up through the space now formed between casting and mold to hasten the cooling of the casting. An inert gas which burns at the outlet, like carbon monoxide, may be used for some metals. For other metals other known protective gases which are suited thereto may be used and after the castings are sufficiently cool to avoid deleterious action the selection of gases increases as does also the availability of air. At the same time the mold and furnace are separated or an outlet is opened at the top of the mold to allow the air to escape. If there is metal left in the furnace the plug may be replaced after the mold is full. Preferably the mold is made to take all the metal in the furnace. The bottom of the piston may be closed against a seal 22 to prevent cooling fluid from escaping.

After complete solidification the casting is removed from the mold, either by further lowering of the plunger if of sufficient length, or by pushing the casting out the top of the mold, the furnace being raised or the mold being lowered to accomplish this. The casting may be readily taken off the end of the piston because it does not adhere to the refractory surface of the upper end of the piston. This may be formed of graphite which fits tightly in the mold and acts as a lubricant to promote easy movement. If the carbon would affect the metal (such as steel) a refractory cover of a different material may be placed above it. Preferably the mold is lined with seamless copper. The whole mold may be of thick copper to provide inertia against quick heating or the mold may be cored for rapid water circulation, in which case the outer parts may be of aluminum, steel or graphite. If it is desired to cast tubes a core is placed in the mold and an annular piston is used. This may be cooled on both sides of the wall by the mold and then by the cooling gas.

It is thus seen that the purified and "killed" metal is cast without possibility of contamination and is solidified under conditions which minimize segregation and improper crystalization. As applied to steels the method will produce super-high carbon metal never approached heretofore. It is easy to produce this steel with a higher carbon content than heretofore and in greater quantities and at a low cost. Previously steel of a very high carbon content was difficult to produce because the air rapidly burned out the excess carbon. Hereby steels up to 2% carbon, or all the iron can hold in solution, may be readily made. Such steels are very advantageous for razor blades, knives, surgical instruments and the like. They are much easier to roll and are much harder after tempering than other steels. They can be rolled thinner and do not burr on the edge.

Also stainless steel, high silicon steel, alumi-

num, tin, silver or the like will be greatly improved through increase in ductility; and through freedom from porosity can be rolled much thinner than formerly without developing pin holes. This is of great advantage for sheet for tin cans because the sheets can be much thinner but still rigid and free from porosity.

While one embodiment of the invention has been described, it is to be understood that the invention may have various embodiments within the limits of the prior art and the scope of the subjoined claims.

I claim:

1. The method of treating metals to produce sound castings of uniform predetermined purity which comprises, providing in an enclosed vessel a body of molten metal of predetermined purity free from gas inclusions, pouring the metal from the bottom into a mold in a solid column the full size of the mold with substantially the speed at which the metal falls by gravity but without space separation of the metal, partially solidifying the metal to form a retaining shell the full length of the casting, and thereafter forcing a cooling gas through the shrinkage space from one end to the other between the mold and casting to accelerate the normal rate of solidification.

2. The method of treating metals to produce sound castings of uniform predetermined purity which comprises, causing the molten metal to circulate to the surface by heating free from contamination until the metal is free from gas inclusions, pouring the metal from the bottom into a mold in a solid column the full size of the mold without space separation to fill the mold substantially instantaneously, partially solidifying the metal to form a retaining shell the full length of the casting, and forcing air through the space from one end to the other between the casting and mold after partial solidification to accelerate the normal rate of solidification and thereby inhibit excess crystal growth.

3. The method of treating metals to produce sound castings of uniform predetermined purity which comprises, causing a body of molten metal in a vessel closed against inflow of air to circulate to the surface by heating free from contamination until the metal is free from gas inclusions, and pouring the metal from the bottom through an opening the full size of the mold to fill the mold substantially instantaneously but without space separation of the metal.

4. The method of treating metals to produce sound castings of uniform predetermined purity which comprises, heating a body of the molten metal in a high frequency induction furnace closed against the inflow of air until all of the gases are eliminated, pouring the killed metal without space separation upon a piston in a vertical mold while withdrawing the piston substantially with the speed of gravity to fill the mold almost instantaneously, and accelerating the cooling of the casting by forcing a cooling gas through the shrinkage space between mold and casing after a shell forms on the casting.

5. The method of treating metals to produce sound castings of uniform predetermined purity which comprises, heating a body of the molten metal in an induction electric furnace closed against the inflow of air which circulates the metal to the surface until substantially all the gases are eliminated, pouring the killed metal without space separation upon a refractory surfaced piston in a vertical mold while withdrawing the piston with such rapidity that substantially none of the metal solidifies until after the mold is completely filled, allowing the metal to solidify until a shell is formed on the surface, dropping the casing until the shell uncovers an air space to force air up through the shrinkage space between mold and casting, and thereafter removing the casting from the mold.

6. The method of treating metals to produce sound castings of uniform predetermined purity which comprises, filling a vertical mold substantially instantaneously with molten killed metal the full size of the mold without space separation from the body of supply metal, and solidifying the metal at a substantially uniform rate over the entire mold-facing surface, first by rapid cooling through the mold walls until a shell is formed throughout the length of the casting, and then by a stream of harmless cooling fluid directed through the shrinkage space from one end of the casting to the other.

7. Apparatus for treating metals to produce sound castings, comprising in combination, a closed electric induction furnace for producing a forced circulation of metal to the surface to eliminate all gas inclusions, a vertical mold provided with a cooling gas opening near its bottom, a pouring opening in the bottom of said furnace the size of said mold, a piston in said mold, means for lowering said piston suddenly to a point just above said gas opening and for thereafter lowering the casting to said gas opening to permit gas to be forced through the shrinkage space between the mold and casting.

8. Appparatus for treating metals to produce sound castings, comprising in combination, a closed vessel for maintaining a body of killed molten metal, said vessel being provided with a bottom nozzle and removable plug therefor, a mold below said nozzle, a liquid metal seal between said vessel and mold, a piston in said mold for feeding down the whole body of metal, a cooling gas inlet opposite the initial stopping point of said piston, and a seal for the bottom end of the piston to prevent escape of gas when the piston moves down further to uncover said gas inlet to the sides of the casting.

9. Apparatus for treating metals to produce sound castings, comprising in combination, a vertical mold, means to fill said mold very rapidly in a column the full size of the mold, said means including a close-fitting piston in the mold, and a cooling gas inlet in the side of the mold which admits cooling fluid around the sides of the casting when the piston passes the inlet.

10. Apparatus as set forth in claim 9 which further includes means to force cooling fluid under pressure to said inlet to flow up along the casting and out at the top of the mold.

JEAN HUBERT LOUIS DE BATS.

CERTIFICATE OF CORRECTION.

Patent No. 2,257,713. September 30, 1941.

JEAN HUBERT LOUIS DE BATS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 8, for the word "far" read --for--; line 13, for "furnace" read --surface--; page 3, second column, line 12, claim 5, for "casing" read --casting--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of November, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.