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F. F. POLAND

2,131,070

APPARATUS FOR CASTING METAL

Original Filed April 12, 1935

Fig. 1

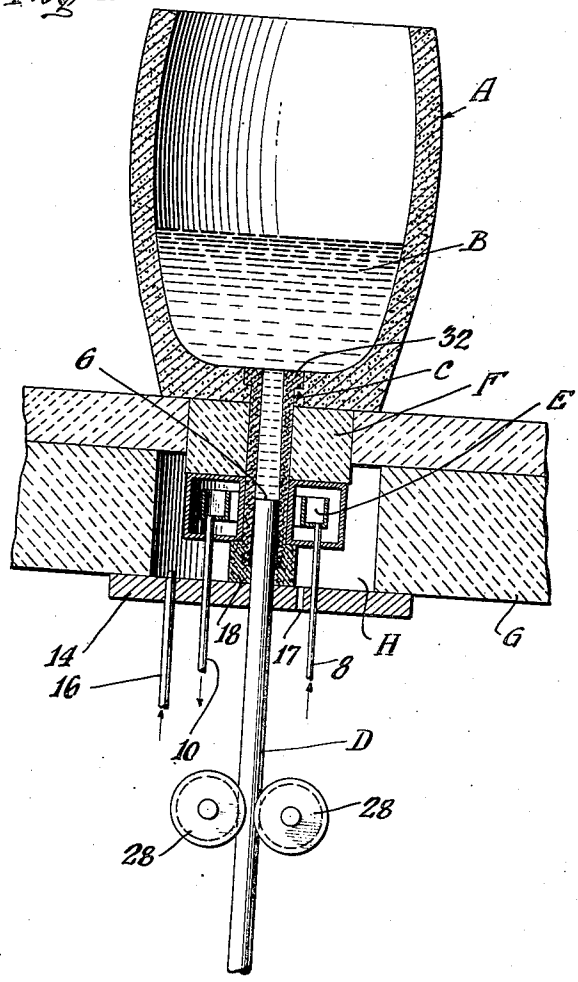



Fig. 2

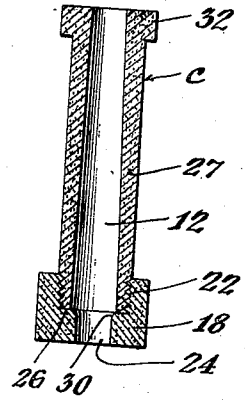



Fig. 4

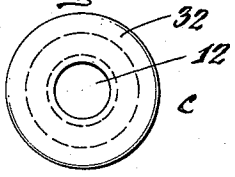



Fig. 3

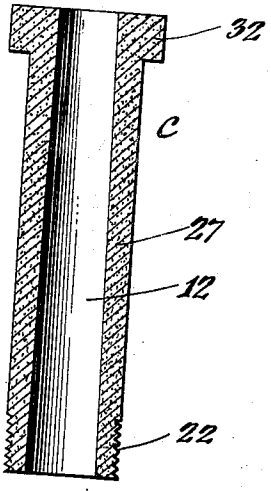
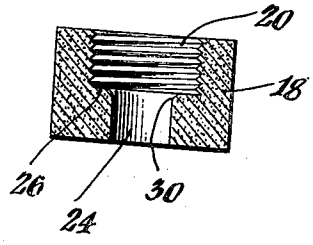



Fig. 5




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# UNITED STATES PATENT OFFICE

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## APPARATUS FOR CASTING METAL

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Application April 12, 1935, Serial No. 15,968
Renewed December 13, 1937

4 Claims. (Cl. 22—57.2)

In accordance with the present invention, there is provided an improved apparatus for producing in a continuous manner, cast shapes of metals, such as copper, in which shapes the copper is characterized by its high density, freedom from porosity, included oxides and gases.

In the production of such shapes, it is known to operate in such a manner that the molten copper is led from a suitable container or reservoir for the molten metal into a congealing chamber in which it is solidified, the solidified metal being superposed by the molten metal and being withdrawn continuously from the congealing chamber as the metal solidifies, a suitable plug having been inserted in the die or mold defining the congealing chamber when the metal is first poured into the reservoir, the metal solidifying in the die forming a union with the plug, thereby enabling the withdrawal of the solidified metal from the die to be started. Furthermore, the practice has been to maintain the molten metal and the die defining the congealing chamber at the same temperature, so that there will be no heat interchange between the metal and the die; and also the conditions of operation are maintained so that there is no temperature gradient between the die and the solidified portions of the metal, the solidification of the metal being obtained by withdrawing substantially all of the heat from the metal through the solidified portions of the metal.

It has been demonstrated in practice that the above outlined procedure is difficult to carry out. One of the factors contributing to the difficulties lies in the danger of the freezing location of the metal being brought unduly low in the die defining the congelation chamber so that during operation the metal will not solidify in the die, but will run out therefrom in molten condition. Furthermore if sufficient superheat is not present in the reservoir of molten metal to maintain the metal in the reservoir and in the congelation chamber above the position of freezing in a thoroughly liquid condition, solidification of the metal above the die will take place, plugging the die from above with solid metal, thereby preventing the operation.

The matter of friction between the solidified metal and the die is also one of importance. In this connection, it may be noted that the practice commonly has been to use straight-walled dies; and since the metal, such as copper, has but a low tensile strength at the temperatures encountered during operation, the friction between the metal and the straight walls of the die tends to cause fracturing of the newly solidified metal.

One of the factors influencing this friction is the condition of the inner surfaces of the die, repeated tests confirming that the die must possess as nearly a perfectly smooth, non-porous surface as is mechanically possible to obtain, the surface having a mirror-like polish.

In view of the difficulties indicated above, particularly with regards to the friction between the cast metal and the die, the present invention provides an improved process and apparatus in which the friction between the die and the solidified metal is reduced to the minimum. One of the steps utilized, in accordance with the present invention, to reduce this friction is to operate with a tapered die, in which the metal becomes separated from the walls of the die substantially as solidification occurs.

Another factor involved in the successful operation of continuous casting is the matter of cooling the metal, it being found in practice that most efficient results are obtained by the rapid extraction of heat from the solid phase of the liquid-solid interface of the metal in the die.

Still another factor involved in the successful operation of continuous casting lies in what appears to be a lubricating effect between the metal and the die, the influence of which effect in reducing friction in the die becomes of importance when the fragility of the cast metal, because of its low tensile strength at the high temperatures encountered during operation, is considered.

These factors are important considerations in the selection of a suitable die material. Such material must be comparatively easy to machine for the production of the required taper for the bore, and the imparting of a mirror-like surface thereto; it must have high heat conductivity; it should have a lubricating action on the metal.

While various materials may be used for dies, it has been found that graphite fulfills the above requirements better than any other die material known up to the present time; particularly if the graphite has been treated by any one, or combination, of the known proceses utilized to reduce the porosity of the graphite, by means of which all porosity of the surface exposed to the metal may be eliminated.

Graphite, however, has certain inherent disadvantages. It is soft; it tends to burn away rather rapidly at the temperatures unavoidably employed in the casting operation. This softness soon destroys the smoothness of the die surface engaged by the metal, particularly if the metal is not removed from the die in perfect axial alignment with the bore of the die. Also, the burning

away of the die not only weakens the entire structure of the die and virtually prohibitively shortens its life in this manner, but by virtue of the fact that there is a space between the solidified metal and the die surface, entry of air will very quickly produce irregular erosions of the die surface, thereby destroying the smoothness and mirror-like qualities which appear to be a requirement for successful operation of this process.

The present invention has for its principal object the overcoming of the above mentioned difficulties in the use of a graphite die, thereby rendering such a die practicable to use and retaining the desirable properties of graphite.

The attainment of this object is realized generally in two ways, according to this invention: First, by providing a guide on the die in axial alignment with the bore of the die, through which guide the solidified metal is withdrawn; and second, by surrounding the die with a non-oxidizing atmosphere.

The accompanying drawing shows convenient means of accomplishing the objects of the invention, it being understood that various modifications of the specifically illustrated construction may be made without departing from the concept or scope of the invention.

In the drawing,

Fig. 1 represents a sectional elevation of an apparatus embracing the principles of the present invention.

Fig. 2 represents a sectional elevation of an assembled die constructed in accordance with this invention.

Fig. 3 is a sectional elevation of the die shown in Fig. 2.

Fig. 4 is a plan view of the die of Fig. 3.

Fig. 5 is a sectional elevation of the guide for the metal being withdrawn this guide being adapted to be fitted over the outlet end of the die.

Referring more particularly to the drawing, A represents a reservoir containing molten metal B which is being cast, the reservoir A being maintained at temperatures substantially above the melting point of the metal B, which metal may be copper, for example.

Operatively associated with the reservoir A and adapted to receive molten metal therefrom is a die C, which is sealed into the reservoir A and which contains congealed or solidified metal D, which may be a starting rod used to close the outlet of the die C, and upon which congeals the adjacent molten metal at the interface 6, the location of which interface may vary with respect to the die, as will be hereinafter explained in more detail.

It will be observed that the die extends from the reservoir A for a rather substantial distance, there being a water-jacket E positioned around the die and enclosing a substantial portion of the length thereof, water being circulated continuously through this jacket by way of inlet 8 and outlet 10. This water jacket abstracts heat from the metal, effecting congelation thereof, the heat being extracted predominantly from the metal through the die itself, and rapidly abstracting both latent and sensible heat from the metal interface 6. The location of this interface which represents the congelation point of the metal is maintained preferably below the level of the water-jacket E, and in order to assure this a highly heat insulating sleeve F of a substantial thickness is snugly fitted around the die C between the water jacket E and the metal reservoir A.

The reservoir A is positioned in a suitable heating chamber maintained at suitable temperatures for maintaining the metal B thoroughly molten, the bottom of this heating chamber being shown fragmentarily at G, this bottom having a space H therein, in which space the die and water jacket are enclosed.

As will be noted from Figs. 2 and 3, the die C has a uniformly tapered bore 12 extending therethrough, in which bore the metal B congeals. The taper of the bore 12 is such that there is an open space between the congealed metal and the die, which space extends from the congealing zone of the metal to the outlet of the die. Experience has shown that air in contact with the graphite die rapidly burns away the die both from the outside and inside thereof, owing to the fact that the molten metal maintains the die at relatively high temperatures, notwithstanding the water jacket E, and that the die is rapidly consumed and destroyed.

In order to prevent this burning away of the die, the space H is sealed by a plate 14, which may be of metal, such as steel, which plate is suitably cemented in position. The plate 14 is provided with at least one inlet 16 and an outlet 17, the inlet 16 being adapted to be connected to a supply of non-oxidizing gas (not shown) such as an illuminating gas line, or a supply of nitrogen gas, or carbon monoxide, or the like, whereby the space H and the space between the die and solidified metal may be maintained flooded with such gas, so that the die will be maintained continuously in an atmosphere or envelope of inert gas, thereby preventing burning of the die and prolonging indefinitely the life thereof, so far as concerns destruction of the die by burning.

It has been mentioned above also that it is desirable to withdraw the cast metal shapes or rod accurately axially from the die, as any deviation from a true axial withdrawal results in increased wear on the die with consequent deformation thereof and increased friction on the metal increasing thereby the chances of fracturing the casting during its withdrawal from the die.

In order to reduce such tendencies, the die is provided with a guide positioned in true axial alignment with the bore of the die, through which guide the rod moves as it issues from the die.

Such a guide is indicated on the drawing as 18, and it is specifically illustrated as being a collar provided with internal threads 20, this collar being adapted to fit over the outlet end of the die C, which outlet end is externally threaded as indicated at 22 to receive the threads 20 of the guide collar 18. The collar 18 is bored through as shown at 24, this bore being accurately made to be in axial alignment with the bore 12 of the die. When assembled as shown in Fig. 2, the die C and collar 18 are screwed together until tight, the outside wall 27 of the die fitting snugly in the guide 18, and with the end of the die abutting the annular shoulder 26 in the collar 18.

The bore 24 in the collar 18 is straight-walled instead of being tapered as is the bore 12 in the die, and the bore 24 is somewhat smaller in diameter than is the outlet of the bore 12. Therefore, as the rod is withdrawn from the die through the rolls 28 which are concentrically positioned relative to the axis of the die and collar, which rolls also guide the rod, the collar 18 serves as a support for the rod and prevents any tendency of side pulling of the rod within the die, the rod being supported and guided so that it is withdrawn straight from the die.

The surface of the bore 24 is highly polished

and the edge of the shoulder 26 is rounded as at 30, to reduce friction against the metal being withdrawn. The collar 18 may be of graphite or it may be metal or other suitable material.

A flange 32 on the die provides a means for securing the die in position in the reservoir A.

What is claimed is:

1. Apparatus for continuously casting metals comprising the combination with a reservoir for molten metal and a die operatively associated with the said reservoir in which die metal is adapted to be solidified and continuously removed therefrom, of means defining a closed chamber externally of the reservoir and enclosing the die, cooling means for the die within the chamber and arranged to abstract principally all of both latent and superheat from the metal through the die at the zone of solidification of the metal, and means for maintaining the chamber enclosing the die filled with a gaseous atmosphere inert to the die for preventing destructive burning of the die.

2. Apparatus for casting metals comprising the combination with a reservoir for molten metal, of a die connected to the reservoir for receiving molten metal from the reservoir, a relatively short water jacket around the die adjacent to the reservoir for effecting solidification of the metal in the die, there being a substantial amount of exposed die surface exteriorly of the water jacket, means for enabling a non-oxidizing atmosphere to be maintained about the exposed die surfaces to prevent oxidation of the die during casting operations, and means for withdrawing solidified metal from the die.

3. Apparatus for casting metals comprising the combination with a reservoir for molten metal, of a die connected to the reservoir for receiving molten metal from the reservoir, cooling means for chilling the molten metal in the die, means defining a gas chamber enclosing the said cooling means and exposed portions of the die for enabling the maintenance of a non-oxidizing atmosphere about the die to prevent oxidation of the die during casting operations, and means for filling the chamber with a medium which is non-oxidizing with respect to the die.

4. Apparatus for continuously casting metal comprising the combination with a reservoir for molten metal communicating with a graphite die positioned below said reservoir, of cooling means surrounding a portion of said die for congealing metal therein and means for maintaining a non-oxidizing atmosphere in contact with the exposed die surfaces.

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