

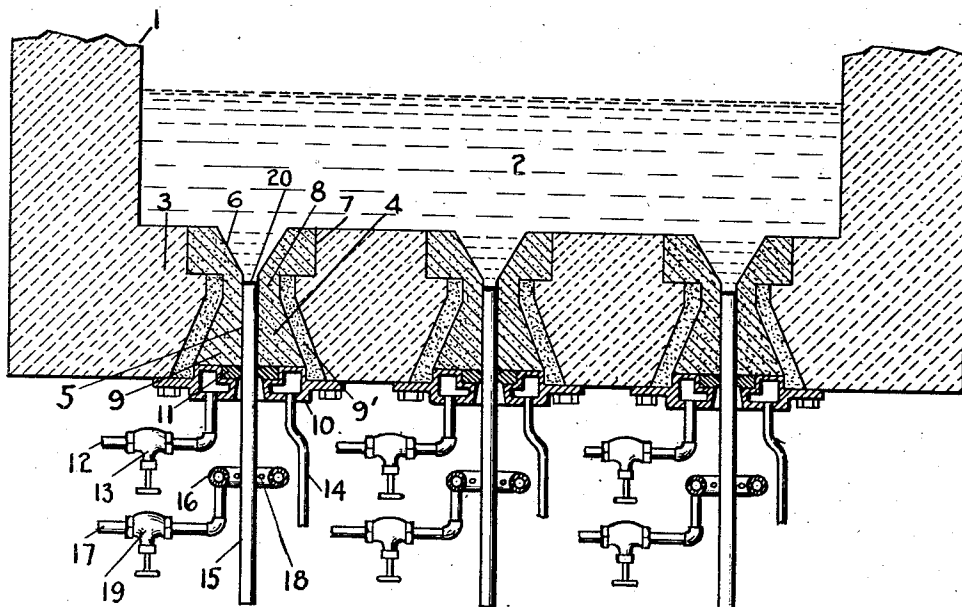
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METHOD OF CASTING MOLTEN METALS

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METHOD OF CASTING MOLTEN METALS

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This invention relates to methods of an apparatus for producing formed shapes of copper, aluminum and other metals and alloys and is a continuation in part of my prior copending application filed September 28, 1929.

Molten copper, as well as some other metals, contains considerable quantities of dissolved gases. These metals on cooling pass from the liquid to the solid state so quickly that the dissolved gas when freed may remain entrapped within the solidified metal, ingot or casting to cause flaws, such as unfilled cavities, and render these metals useless for further working to commercial forms. Pure copper presents this detrimental property to a degree which has seriously militated against its use in the arts and its use in pure form has heretofore demanded an excessive amount of working to obtain the desired shapes. For example, when copper is fabricated into wire, sheets and tubes it has heretofore been necessary to start the operation from a cast ingot of limited size and proportion, and of comparatively small mass to obviate such flaws or unfilled cavities or, for example, to start the operation from an ingot produced by the method, as disclosed in my Patent 1,217,581, February 27, 1917.

Ingot in such form require subsequent heating and breaking down into rods or plates by mechanical working. Copper, like other pure metals, gains no added valuable physical properties through continued working, and therefore any suitable casting method which will provide copper in such form as to eliminate, as a whole or in part, any part of the mechanical working tends to cheapen the cost of production of the finished product.

In my patent above referred to, I disclosed a method for producing homogeneous copper castings by means of molten copper in a suitable mold and solidifying the copper in said mold progressively from the bottom upward by basal chilling. My present method effects an improvement over the invention of my patent in that it provides for a continuous process and eliminates in a large measure the operation of subsequent heating and working into commercial shapes. In the former method the entire mold was cooled to a temperature below the melting point of the molten metal before the ingot could be removed. Whereas in the present method the solidified metal is removed substantially as soon as solidification takes place, and it may be removed if desired substantially in the required form desired.

Various efforts have been made to free molten copper of gases by the addition of boron and other chemical elements or compounds, but they have not been generally satisfactory from a commercial standpoint.

In prior methods the crystals in the congealed metal of the billet had their primary axes arranged in various directions. When these billets were subsequently heated and fabricated into shapes the crystals had no definite predetermined alignment. The primary axes of certain of the crystals might extend across the shapes while others might extend longitudinally therein or in a multiplicity of directions. This more or less heterogeneous arrangement of crystals is detrimental to subsequent working.

When billets of prior methods are utilized for subsequent fabrication such billets must be reheated, which is expensive. Also expensive rolling mills must be used to roll the copper or other metal billet to smaller forms.

By my invention a superior product can be obtained while obviating these expensive operations as the smaller shapes may be, if desired, obtained directly from the furnace by a continuous casting method with congealation proceeding from the bottom upwardly, thus eliminating gas defects. In carrying out the method I so control the congealation by proper cooling that I may continuously form a rod, plate or other shape from molten metal with the primary axes of the crystals extending substantially in the same direction, preferably longitudinally of such shapes. This improvement enables one to produce shapes which on subsequent working provide articles of superior quality. I also have found that copper shapes produced by my

method have increased density. At 20° centigrade the density of the copper casting is substantially nine.

The various objects of the invention will now be generally set forth.

One of the objects of the invention is to produce copper castings free from blow holes and other defects.

It is an object of this invention to produce rods, plates and other shapes with crystals having their primary axes extending in the same general direction.

Another object of the invention is to mold metal shapes in a forming chamber, the walls of which are maintained at approximately the same temperature as the metal therein.

Another object is to cast metal shapes in a mold or forming chamber with constant supplying of heat to the walls and extracting heat therefrom from sources other than the metal therein.

Another object of the invention is to cast metal continuously into an elongated shape in a mold by withdrawing the heat of congelation substantially solely through the previously congealed metal.

Another object is to start the growing of crystals in a mold or other forming chamber by abstracting heat from the molten metal therein and causing said crystals to grow in length by congealing thereon the superposed metal by withdrawing the heat of congelation substantially solely through the previously formed crystals.

Another object is to cause molten copper and other metals and alloys of high melting point to pass into a congealing zone free from oxidizing atmosphere and removing the congealed metal from said zone on congelation therein to permit the continuous casting of the metal free from oxidation such as oxidation at the crystal boundaries.

Another object of the invention is to produce metal shapes of higher than usual density.

Another object is to produce metal shapes with the foregoing properties by a continuous forming method.

Other objects will appear in the following description, reference being had to the drawings in which:

The single figure is an illustration of a furnace for carrying out the invention.

The furnace for carrying out the method may be of any convenient type, such as is well known in the art, the figure of the drawing being a conventional showing of such a furnace, the walls of which are designated by reference character 1.

In the bottom 3 of the furnace are arranged any number of forming chambers and by way of example, I have shown three of such chambers. These chambers may, of course, be of different shape, but in the drawing I have shown them of the same shape and

construction. The forming chamber or tube 4 may be made of dense graphite, corborundum or other material resistant to heat and corrosion by copper or other metal being fabricated.

In the drawing I have shown a furnace designed to enable one to continuously cast copper rods, hence the chambers 4 have circular channels 5 of the desired size. These channels preferably flare outwardly at 6 in funnel shape, as shown, to permit molten metal to more readily flow into the forming chamber and facilitate the passage of expelled gas. The upper part of the chamber 4 is preferably flanged to form a head 7 to facilitate passage of heat from the molten copper 2 to the walls of the forming chambers. The middle portion of the chamber 4 is reduced in cross section at 8 and the lower portion extends outwardly in general conical form at 9. Between the chamber 4 and the furnace base I place some material 9' of high heat insulating value as it is preferable to prevent or limit the passage of heat between the furnace and the chamber below the flange 7.

Supported beneath the furnace base, or attached thereto, is a cooling chamber 10 preferably supporting a die 11. Water is admitted to the cooling chamber through pipe 12 with some suitable means to regulate the cooling such as a valve 13, for example. The water may escape from the cooling chamber through pipe 14.

The copper rod 15 congealed in the channel 5 is cooled by any suitable means, such as a water spray from coil 16. Water may be admitted to this coil by pipe 17 and discharged through holes 18 and the rate of cooling may be controlled by regulating the water supply as by a valve 19 or by raising or lowering the coil 16 in respect to the base of the chamber 4, or in any other appropriate manner. To cool the molten mass one may also use any other fluid such as air, for example.

Any well known means may be used to draw the metal from the forming chamber. Such devices are old in the art and are therefore not shown. To start the operation a copper rod of appropriate size and shape is passed through the die and into the channel 5 of the chamber 4. The protruding rod is then gripped by the drawing devices above referred to. Molten copper is poured into the furnace or melted therein by appropriate gas or oil burners or by electrical or other heating means. This molten copper preferably should be maintained slightly above the congealing point by suitable heating means, preferably automatically controlled by means well known in the art. The copper enters the channel 5 and fuses to the rod previously inserted therein.

The drawing device is then started into operation and the copper rod is pulled out of the channel and through the die 11. Heat

from the molten copper 2 enters the head 7 of the forming chamber and passes down through the middle portion 8 and the base portion 9 and out into the cooling chamber 10.

The water spray from coil 16 is so adjusted as to withdraw the heat from the molten copper in the upper part of the channel 5 and congeal it therein. The rate of withdrawal of the rod 15 and the cooling of the same is so controlled as to maintain the congealing line in the neighborhood of the line 20 with a sufficiently shallow congealing zone to prevent the trapping of gas freed by the congealed metal. As the copper rod is withdrawn the crystals forming at the line 20 are moved from the congealing zone and such crystals grow in length of primary axes as additional copper is congealed thereon and large crystals may be thus formed and orientated. The shape of the chamber 4 and the amount of cooling thereof by cooling means 10, or both, is preferably such that the heat of the superposed copper 2 keeps the walls of the chamber around the congealing zone 20 at about the same temperature as the metal in such zone.

In forming rods by my method it is also preferable to regulate the rate of cooling in the cooling chamber 10 so that the temperature gradient in the forming chamber wall below the congealing zone is the same as that of the copper rod. In such case there will be substantially no passage of heat between the forming chamber and the congealed copper rod in either direction.

Since copper is a better conductor of heat than graphite or carborundum it is desirable to provide for this by the design of the apparatus. In the drawing this is illustrated by a flare in the lower part of the forming chamber wall outwardly to facilitate the passage of heat therethrough from the cooling chamber 10. To regulate the cooling of the forming chamber it is desirable to insulate it by the insulating material 9' so as to control the heat flow thereto and therefrom.

It is preferable in carrying out my method to so control the rate of cooling as to maintain the congealing zone 20 within the neck 8 of the forming chamber.

It is not necessary to use the die 11 as the congealed metal may be drawn out of the chamber without it, but I have used it as a convenient means of maintaining the rod in position.

The rod 15 drawn from the die may be cut into desired lengths or it may be wound upon any collecting means such as a drum. If the rod is to be drawn down to smaller sizes, as it usually would be, additional drawing dies and pulling devices may be used to directly draw it down as soon as it is pulled from the forming chamber so as to obviate otherwise necessary rehandling.

In my improved method of continuous casting of copper rods and other shapes the molten metal is caused to flow from a furnace directly into the forming chamber or other mold out of contact with oxidizing atmosphere and thus there can be substantially no oxides formed at the crystal boundary or at any other points.

The castings made by my improved method are therefore remarkably free from oxides at the crystal boundaries.

While I have definitely proven that copper castings made by my process are substantially free from oxides it is my belief that the process will produce castings of other metals likewise free from oxides and the invention is not limited to any particular metal.

My method may also be advantageously employed for weld casting of dissimilar metal shapes wherein the one metal is cast upon another metal of higher melting point, for example, copper upon iron.

In describing the operation of the furnace I have referred to copper as the metal to be cast into shapes, but aluminum or any other suitable metal or alloy may be cast into shapes in the same way and the orientation of the crystals may be controlled in a similar manner. Also, by changing the size or shape of the forming chambers, other shapes may be continuously formed.

My continuous casting of copper has decided advantages regardless of the elimination of gas defects. Therefore my process may be advantageously used for casting copper from gas free copper such as boronated copper. As a further modification I may use a vacuum type of furnace to facilitate gas removal from the molten copper, as such furnaces are well known in the art.

Various other modifications may be used without departing from the spirit of the invention.

The product of my method is not claimed in this case but is claimed in my divisional application Serial No. 589,548, filed January 29, 1932.

Having described my invention, what I claim is:

1. The method of casting metal shapes which consists in continuously supplying molten metal from a reservoir of molten metal to a forming chamber having congealed metal in the lower portion, congealing additional metal thereabove by withdrawing heat therefrom substantially solely through the congealed metal, removing the congealed metal and cooling the walls of the forming chamber to maintain the said walls substantially at the same temperature as the adjacent metal in the chamber.

2. The method of casting metal shapes in a forming chamber having congealed metal at the base of the chamber, which consists in withdrawing heat from the molten metal

- through the congealed metal to congeal thereon the adjacent superposed metal, removing the congealed metal from the congealing zone and cooling the walls of the forming chamber to maintain substantially the same temperature gradient in the walls of said chamber and the adjacent metal. 70
3. The method of casting metal shapes which consists in leading molten metal into a mold having congealed metal at the base thereof, congealing the superposed molten metal by withdrawing heat through the congealed metal and separately cooling the mold. 75
4. The method of casting metal shapes which consists in continuously supplying molten metal from a reservoir of molten metal to a forming chamber having congealed metal in the lower portion, congealing additional metal thereabove by withdrawing heat therefrom substantially solely through the congealed metal, removing the congealed metal and maintaining a substantially constant temperature gradient in the metal thus solidified therein by controlling the removal of congealed metal. 80
5. The method of casting metal shapes which consists in continuously supplying molten metal to an open ended forming chamber, having congealed metal in the lower portion, congealing additional metal thereabove by withdrawing heat therefrom substantially solely through the congealed metal, removing the congealed metal and cooling the forming chamber to maintain a substantially constant temperature gradient therein. 85
6. The step in the method of casting metal shapes which consists in supplying molten metal to a mold, and heating the top of the mold thereby and withdrawing heat from the bottom of the mold at a predetermined rate to maintain a substantially constant temperature gradient in the walls of said mold below the congealing zone. 90
7. The method of casting metal shapes in a mold which consists in cooling the mold and the metal therein to maintain transverse sections of the mold and metal at successively lower temperatures, and withdrawing the metal in the mold at such rate as to maintain each of the said sections respectively at a substantially constant temperature thereacross. 95
8. The method of casting metal in a mold having a channel therethrough, which consists in arranging the mold with the channel extending upwardly, cooling the metal at the bottom of the mold to withdraw heat from the metal in the congealing zone downwards through the congealed metal, removing the congealed metal from the mold, and regulating the withdrawal of heat and the removal of metal to maintain the congealing zone in horizontal position within the mold. 100
9. In the art of making a continuous metal casting in a unitary mold having a vertically positioned congealing chamber for escape of gas, the method which consists in closing the lower end of the mold with congealed metal, adding molten metal thereabove, withdrawing heat substantially entirely downwards through the congealed metal to congeal the molten metal progressively upwards, drawing congealed metal through the mold and adding additional molten metal above the congealed metal to replace the metal thus removed. 105
- In testimony whereof, I have signed my name to this specification this 2nd day of June, 1930. 110
- BYRON E. ELDRED. 115
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