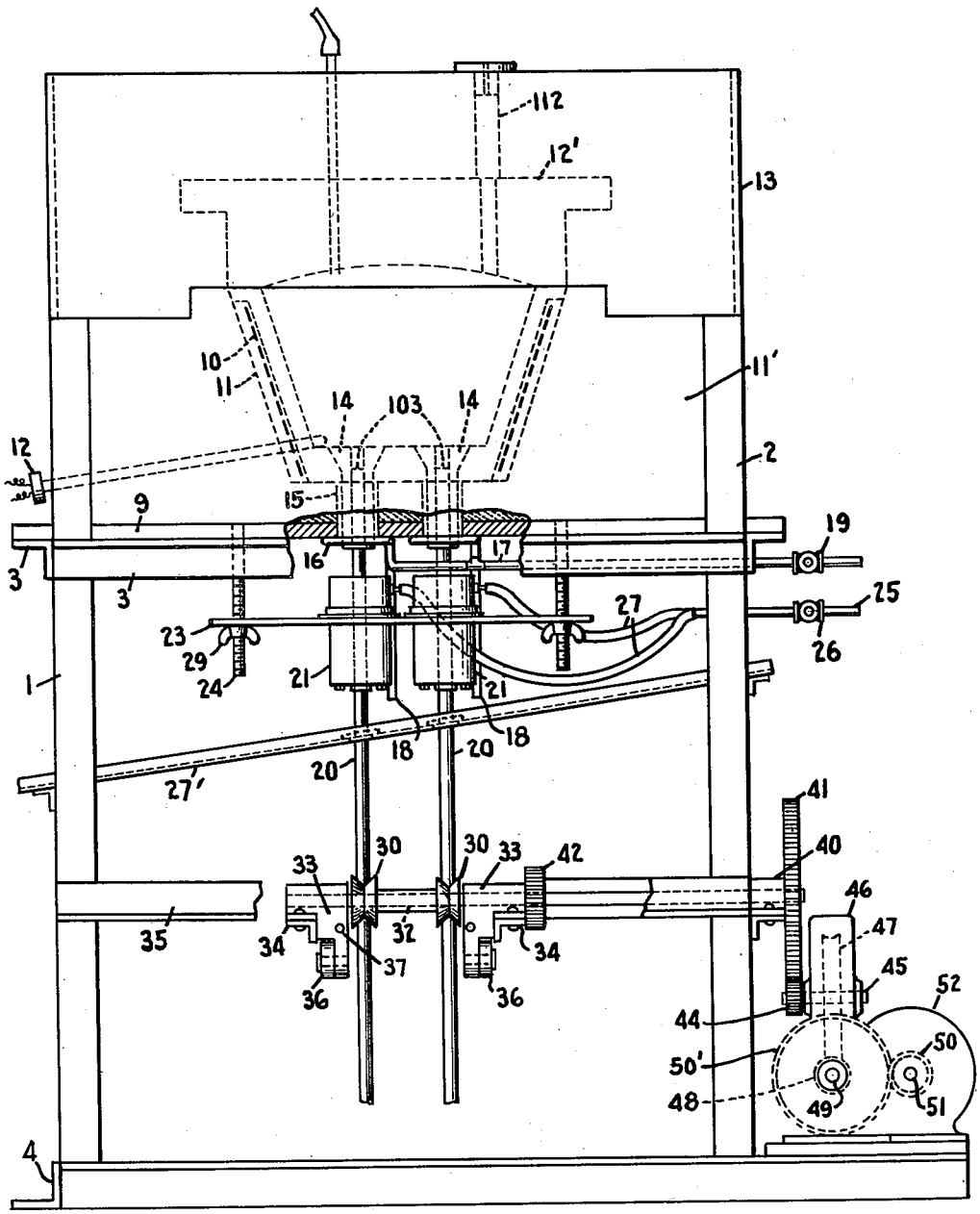
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METHOD OF DRAW CASTING METAL TUBES

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FIG. 1



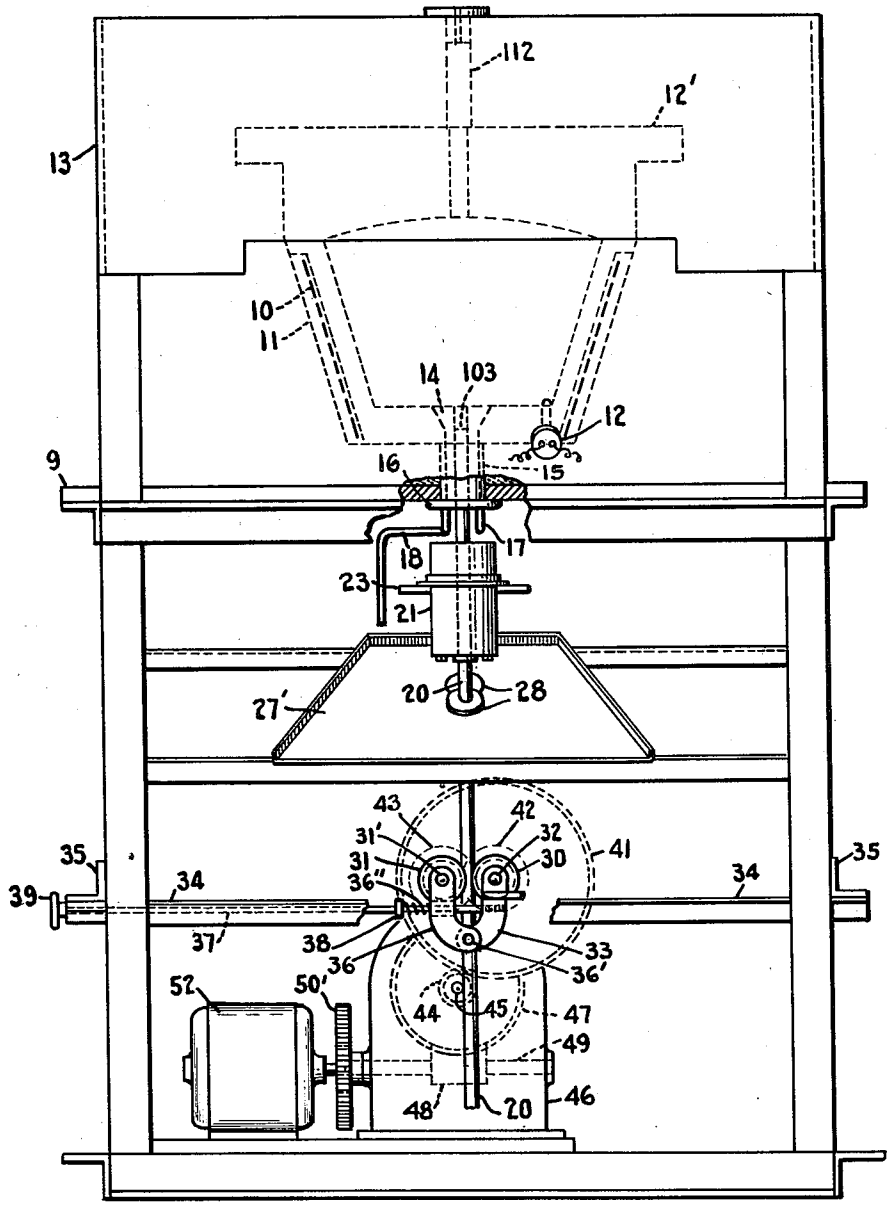
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METHOD OF DRAW CASTING METAL TUBES

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FIG. 2



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FIG. 3

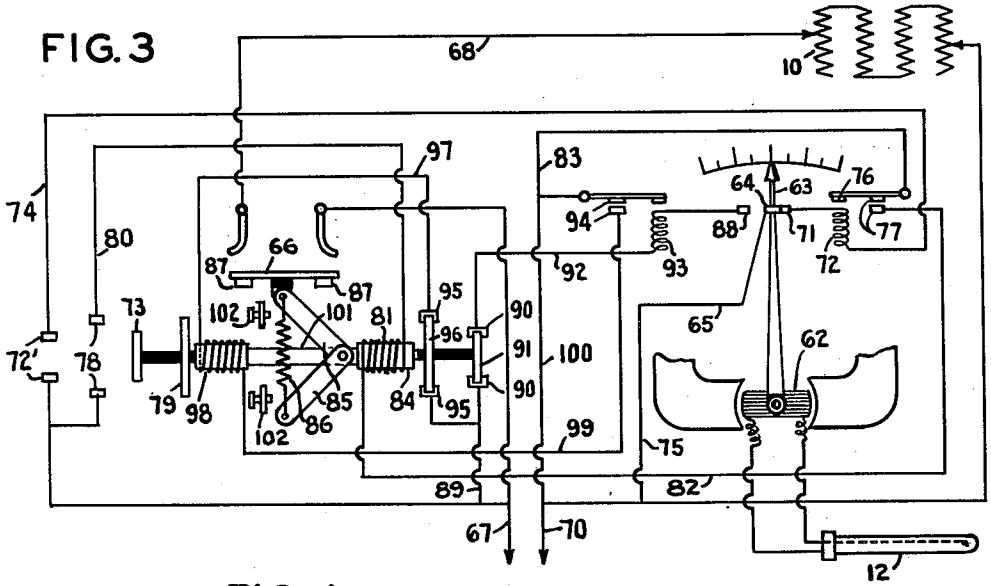


FIG. 4

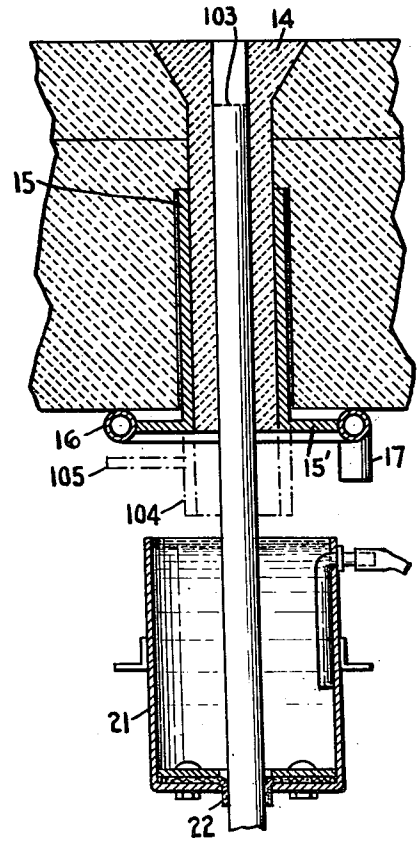


FIG. 5

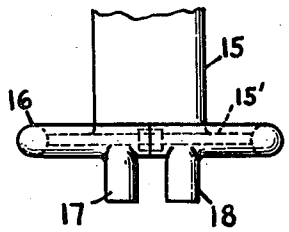


FIG. 8

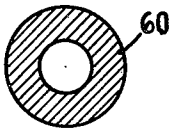
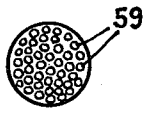


FIG. 7



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FIG. 6

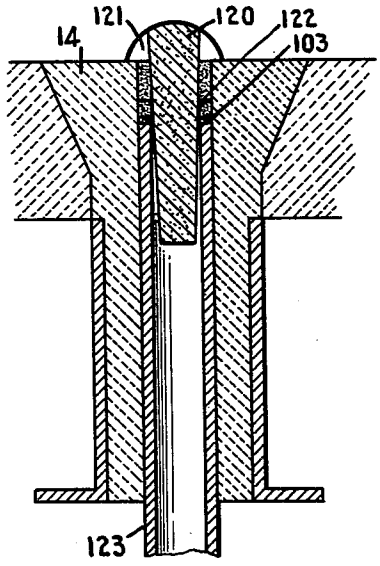


FIG. 12

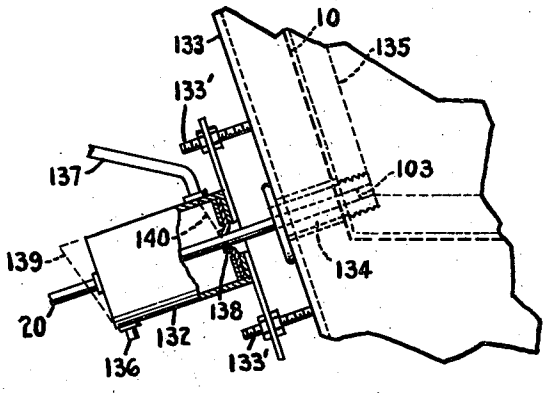


FIG. 6a

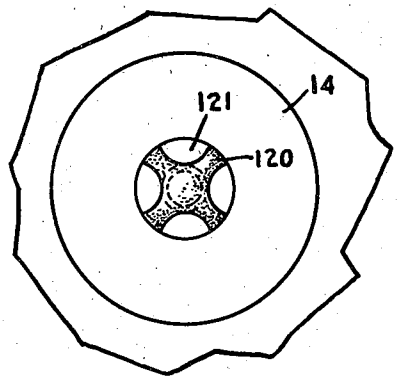


FIG. 9

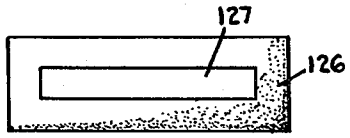


FIG 10

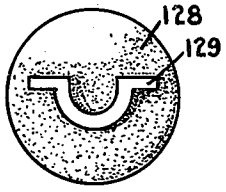
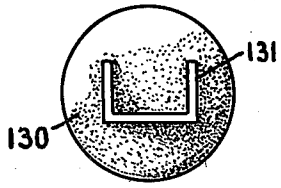


FIG. 11



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UNITED STATES PATENT OFFICE

2,048,734

METHOD OF DRAW-CASTING METAL TUBES

Byron E. Eldred, New York, N. Y.

Application March 16, 1933, Serial No. 661,013

3 Claims. (Cl. 207—11)

Metals have long been cast in sand or other molds by pouring the molten metal into the mold where it solidifies throughout without relative movement between the metal and mold. Products made in this way have been called "cast products" or "castings". This process was later improved upon, particularly for small castings, by utilizing metal die molds with applied pressure to force the molten metal into all parts of the mold. These products have acquired the name of "die castings".

In my Patent 1,868,099, July 19, 1932 I have devised a process of forming metal shapes from molten metal by drawing the cast shape from an open ended mold, die or forming chamber as the metal solidifies, chilling the adjacent molten metal through the congealed metal and maintaining a cross section plane of congelation with formation of crystals at right angles thereto. This process is distinctly different from the other processes and produces a markedly superior product. I call the process "draw-casting" and the products "draw-castings". These products are readily distinguishable from the other forms of castings as the crystals are regular, elongated and all extend generally in the direction of the longitudinal axes, that is, in the direction in which the article is withdrawn from the die. The products can be made to have increased density, greater ductility and increased electrical conductivity which appear to be due to the long longitudinal crystals, the absence of gas defects and oxygen, or other contamination. The draw-cast products are uniform in structure throughout.

In this application I have developed apparatus and methods for casting of tubular shapes and it is the object of the invention to produce these with all the desirable characteristics of non-tubular shapes.

Referring to the drawings:

Fig. 1 is a side view of the apparatus for producing draw-cast products.

Fig. 2 is an end elevation viewed from the left in Fig. 1.

Fig. 3 is a diagram of the electrical circuit of the furnace.

Fig. 4 is a section of the die and chilling chambers used in Figs. 1 and 2.

Fig. 5 is a view of a portion of the die chilling chamber as viewed from the right of Fig. 4.

Fig. 6 is a sectional elevation of the die and mandrel for draw-casting tubes.

Fig. 6a is a plan of the die with the mandrel.

Fig. 7 is a plan of a draw-cast rod having filamentary channels therein.

Fig. 8 is a section of a draw-cast tube.

Figs. 9, 10 and 11 show dies for making different forms of shapes.

Fig. 12 is a modification, a part only, of the apparatus being shown.

In the drawings, (Figs. 1 and 2) the supporting frame may consist of a plurality of columns such as a pair of spaced angle bars 1 on one side, and another spaced pair of angle bars 2 on the opposite side. Two cross angle bars 3 and 4 are riveted, bolted, or welded to the uprights at the top and bottom respectively.

A plate 9 may be riveted or bolted to the top of the frame to support the furnace which consists of a crucible of graphite or other suitable material surrounded by electrical heating coils 10 of resistance material capable of operating at the desired temperature. Nichrome No. 4 is suitable for temperature of 1083° C., the melting point of copper. Carbon resistors, "glow bars" or fuel or other heating means may also be used to heat the metal in the furnace.

The coils of resistance ribbon 10 are kept in proper relation to each other and to the crucible by a mass of cement, such as alundum cement 11. The outer wall and bottom 11' of the furnace may consist of appropriate refractory insulator. I have found a "silocel" brick and alundum cement suitable for the purpose. A thermocouple 12 is used to control the temperature, as later described.

The cover may consist of a graphite or other refractory cap 12' held in place by a further refractory insulation such as silocel bricks and cement. The bricks on the cover may be held in compact rigid position by metal casing 13.

The crucible and bottom portion of the furnace has a plurality of holes, two being shown by way of example, which contain a die or mold 14 of some refractory. I have found that graphite is an excellent material for this purpose.

The die 14 as shown has an enlarged tapered head portion fitting in the crucible bottom to prevent metal leakage and its withdrawal downwards.

The refractory die or forming chamber may have a central channel of any desired form, depending upon the product to be draw-cast. In Figs. 1 and 2 I have shown a cylindrical channel for drawing rods.

I preferably surround the dies 14 with metal sheaths 15, having web 15' (Fig. 4) welded, soldered, or otherwise attached to a water coil 16 having inlet and outlet pipes 17 and 18 (Fig. 5).

Valves 19 permit the proper control of the cooling water flowing into the pipe 16.

To chill the draw-cast rods 20 I surround them with water cups 21 having holes in the bottom for passage of the rods therethrough. Gaskets 22 of rubber or other material prevent the leakage of water around the rods and through the holes (Fig. 4). It is highly important to control the relative position of the cooling water and I support the cups 21 in a strap 23, adjustably held on bolts 24 fastened to the plate 9. The cups 21 are kept full by inlet pipes 25 having control valves 26, one only being visible in Fig. 1. Flexible connections 27, such as rubber hose, may conveniently join the pipes 25 to the cups 21. The water in the cups 21 flows over the top and passes down into trough 27' which may discharge the water into any suitable drainage connection not shown. The trough 27' may have gaskets 28 around the holes that permit the rods to pass therethrough. The elevation of the cups may be adjusted by nuts 29.

To draw the rods or other shapes 20 out of the dies 14 I use a pair of pull-down rolls 30, 31 for each rod, having knurled grooves for gripping the rods, but leather or other facing may be used to furnish the gripping action. The contour of the face of these rolls would depend upon the metal shape being drawn. Each of the rolls 30 is secured to shaft 32 journaled in bearing blocks 33 secured to angle bars 34 fastened to frame bars 35. The rolls 31 are keyed on shaft 31' and journaled in bearings 36 pivoted at 36' to the bearing 33. Springs 36'' fit over pins 37 threaded in the bearings 33. One end of the spring bears against the collars 38. Hand wheel 39 permits one to vary the spring pressure exerted on the rolls 31 and thus control the gripping force on the draw-cast rods 20.

Shaft 32 extends through bearing block 40 and is keyed to gear wheel 41. Pinions 42, 43 have long intermeshing teeth that will permit of gear action through adjustments made by hand wheel 39 and are respectively keyed to shafts 32 and 31'.

Gear 41 meshes with pinion 44 secured to shaft 45, journaled in housing 46 and keyed to worm gear 47, meshing with worm 48 keyed to shaft 49 with gear 50' and is driven by pinion 50 on armature shaft 51, electric motor 52. The gear worms and pinions give the desired reduction in speed of the pull down rolls.

To produce dense homogeneous rods or shapes of copper it is advisable to keep the amount of super heat down to the minimum necessary to insure fluidity and freedom from the effects of slight temperature changes. It is accordingly best to so control the heat that the molten copper is only a few degrees above the congealing point of copper. This also would seem to be the rule for brasses, bronzes and other metals and alloys, which when poured by other methods are invariably superheated to provide against too sudden chilling. Therefore, I use an automatically controlled furnace, the electrical circuits of which are shown in Fig. 3.

In Fig. 3 the thermocouple 12 is in circuit with meter coil 62 secured to meter needle 63 having contact 64 connected to conductor 65.

Let it be assumed that switch 66 is closed, current then would flow from line 67, through switch 66, line 68 to heating coil 10 to the other line 70. The charge of molten metal, say copper, is heated by this coil to maintain it slightly above the congealing point 1083° C. If the molten copper should increase in temperature thermocouple 12 would cause contact 64 to engage contact 71. This would energize magnet 72 by current passing from line 67 to contact 72' and bar 73 then in engagement with each other, line 74, magnet 72, contacts 71, 64, lead 65, conductor 75 to line 70. This exerts a pull on armature 76 and brings contacts 77 into engagement with each other. Current then passes from line 67 through contacts 78 and bar 79 (then in engagement with each other), conductor 80, switch coil 81, conductor 82, contacts 77, conductor 83 to line 70. This energizes coil 81 and pulls the core 84 to the right in Fig. 3. This pulls the toggle bars 85 past the dead center and spring 86 snaps the core 84 quickly to the right. This opens switches 66, 72' and 78. This action interrupts the flow of current through the heating coil and at the time interrupts the current through coils 81 and 72. The switches referred to are held open by the action of spring 86 which holds the bar 66 against the abutments 87 even though the switch coil 81 is deenergized.

When the furnace cools slightly the thermocouple will cause contact 64 to engage contact 88. Current will then flow from line 67 through wire 89, contacts 90 and bar 91, wire 92, relay coil 93, contacts 88, 64, flexible lead 65, wire 75 to line 70. This will energize relay coil 93 and bring together the contacts 94. Currrent will thus flow from line 67, wire 89, contacts 95, bar 96, wire 97, switch coil 98, wire 99, contacts 94, wire 100 to the other line 70. This will pull core 101 to the left in Fig. 3 and through the action of spring 86 will snap the toggle bars 85 past the dead center until they engage adjustable stops 102. In this position switch bar 66 engages the main contacts and again closes the circuit to the heating coil. These main contacts may be made of laminated spring strips to give a yielding wiping action. This same action pulls the bars 91, 96, off of their contacts, interrupts the circuits of coils 98 and 93 and moves bars 73 and 79 on the contacts 72' and 78 in position to energize coils 72 and 81 when the thermocouple 12 causes the meter needle 63 to bring the contacts 64 and 71 into engagement again.

By this arrangement the temperature of the molten metal is accurately controlled to maintain a condition of thermal balance and superior quality rods or other shapes are drawn out of the dies without interruption by the motor 52 and the attached gearing and pull-down rolls previously described.

Assuming for purposes of explanation, that copper rods are being cast, to start the furnace in operation the cover is removed. Preformed copper is inserted between the rolls 30, 31, through the cooling cups 21 into the crucible. Molten copper is then supplied to the crucible and the cover replaced. The inner end of the preformed rod is melted by the heat of the molten copper. The automatic temperature control already described maintains this molten copper slightly above the congealing point. Molten copper may also be introduced through opening 112 by removing perforated plug.

The water is circulated through the cooling coils 16 and the cups 21 and when ready for drawing congealed metal out of the mold the motor 52 is started. The amount of water, the rate of flow and the position of cups 21 are so controlled that heat drawn down through the dies 14 and rods 20 is such that substantially no heat passes from the solidified metal to the walls

of the die, as described in my above mentioned patent. In other words, the withdrawal of the rods 20 and the control of the cooling fluid is such that temperatures are substantially the same in an imaginary section plane of the die walls and solid metal in the channel, at least the temperature difference at any cross-section level is not so great as to cause a detrimental amount of heat to flow in either direction between die wall and the solidified metal therein.

As the rods 20 are drawn downwards by the rolls 30, 31, superposed molten copper is solidified at the congealing plane 103 thereto by the action of the chilling water in cups 21.

By adjusting the nuts 29 the cups 21 may be raised or lowered until the temperature gradient outwards through the congealed metal in the mold is substantially the same as the temperature gradient in the die walls. This produces a level congealing zone or plane and forms longitudinal crystals in the congealed rod 20 which produces the superior product referred to in my above mentioned patent.

The supporting frame of the furnace may rest upon an elevated platform so that the draw-cast rods 20 may extend a considerable distance below the rolls 30, 31. When sufficient length of rods have been obtained they may be cut off by means of bolt cutters or other appropriate tools without interrupting the operation of the furnace. Alternatively, the rods may be coiled on drums, not shown. If desired, the spring 36'' may be omitted and the adjusting screw 37 made to positively adjust the rolls 31 toward and from the rolls 30.

To prevent coloration of the draw-cast shapes by oxidation the walls 15 may extend downwards, as shown at 104 in dotted lines and contain a reducing gas, for example, hydrogen introduced through a pipe 105 (Fig. 4).

To cast pipe with a predetermined wall thickness I use a mandrel 120 (see Fig. 6). For casting copper this mandrel should be tapered downwards as shown in this figure since copper shrinks on chilling, otherwise it would be difficult to pull the congealed copper pipe out of the die 14. I have found it preferable to make the mandrel of some refractory material, graphite being an admirable substance for the purpose. The taper of the mandrel need not be more than 1° for three-fourth inch tubes, outside diameter, but as will be readily understood this taper will necessarily vary with diameter and wall thickness of the tubes and with materials used. The taper has been exaggerated in Fig. 6 for purposes of illustration.

Means must be provided for the flow of molten metal in the die around the mandrel and I have provided a plurality of inlets 121 shown in Figs. 6 and 6a.

Since graphite as well as most materials from which the mandrel would be made is lighter than the molten copper the shank 122 frictionally engages the walls of the die to prevent the mandrel from rising in the molten metal. It is preferable to taper this shank so as to make a snug fit with the die. In Fig. 6 I have shown the molten metal as dotted to distinguish it from the congealed metal and it will be seen that the molten metal extends below the shank 122 of the mandrel.

To start the furnace for draw-cast tubes a preformed tube 123 would be inserted in the die to a point above the contemplated congealing zone, say to the bottom of the shank 122. Molten metal enters the die from the furnace and melts the end of the preformed tube. By making the mandrel in tapered form there is practically no friction through withdrawal of the congealed tube as there is proper clearance as soon as the tube is pulled away from the congealing plane 103.

Some metals expand on congealing, such as bismuth, and some alloys also expand during solidification by congealing. Ordinary type metal is such an alloy. I have also found that an alloy of copper and beryllium expands quite materially on congelation and this is the case even when less than 2% beryllium is used. To cast these expanding metals and alloys with more or less fragile dies it is essential that the die be tapered so as to flare outwardly. In making tubes of such expanding metals it would be feasible to use mandrels in which there is no taper. Since the metal expands on congealing it will properly clear the mandrel.

It is entirely feasible and in some cases desirable to use tapered dies for draw-casting metals and alloys that shrink on congelation to give greater clearance and increase the facility of withdrawal of the congealed metal from the die.

Various shapes may be draw-cast in accordance with my invention. It will be unnecessary to show all the various forms, but by way of example, I have shown in Fig. 9 a die at 126 for draw-casting a bar rectangular in cross section, the channel 127 having this shape.

In Fig. 10 I have illustrated a die 128 having a channel 129 capable of draw-casting a continuous shape of bronze, brass, or other bearing metal. These bars of bearing metal may be cut up in appropriate lengths for bearings.

In Fig. 11 I have illustrated a die 130 having a channel 131 for draw-casting a channel bar.

In making copper shapes I discovered that if the molten copper is too hot and the cast shape is withdrawn at too high speed, the draw-cast rods will have a smooth exterior but long holes or "pipes" 59 will result in the interior, producing a honeycomb structure, as shown in Fig. 7. By manipulation of temperature and speed and cooling, this structure may be made so fine that it is microscopic or so coarse that one or more large voids persist through the length of the structure. In fact, by raising the temperature of the copper, increasing the speed of withdrawal, and regulating the chill on the rod in cup 21 to provide a cold surface on the rod as it enters the cup, but chilling insufficiently, to provide an equal chilling of the central position of the rod, the effect is reflected in the zone of congelation where peripheral freezing takes place and a central void is produced in the rod. I have drawn out rods that have one hole 60 substantially regular and quite centrally located, as shown in Fig. 8. The holes 59 are discontinuous as in sponge rubber, but the hole 60 may be made continuous. The holes 59 and 60 are not due to gas expulsion primarily because the gas would apparently pass upward more freely through super-molten copper than through molten copper only slightly above the congealing point. This remarkable effect is due to physical action between the solidifying crystals and the molten copper.

Ordinarily pipes and filamentary cavities in cast material are considered defects but when they can be controlled, as they can be in my apparatus, such draw-castings have a particular use. For instance, copper rods such as shown in Fig. 7 may be used in curtain rods on account of their lightness.

In general, water will be used for cooling the congealed metal and the end of the die but other cooling media may be used, for example, molten lead or Wood's metal, but water is, of course, the preferred liquid. In some cases it may be desirable to use brine to obtain a cooling fluid having a temperature below 0° C.

The dies in the furnace need not be positioned vertically though this is desirable where a considerable quantity of gas is set free on congelation. It will be apparent that I may have the die enter the furnace at various angles. In Fig. 12 I have shown such an arrangement. In this figure the cylindrical water chamber **132** is secured to the casing **133** by adjusting bolts **133'** around the furnace so that it is coaxial with the angularly placed die **134** which as a variation is shown threaded into the crucible **135**. Inlet **136** admits water to the chamber and outlet **137** discharges it. The chilling chamber **132** is arranged so that the congealed metal **20** enters at right angles to the surface of the water and all points in a surface circle enter the water at the same time. This produces a right-angle plane of chilling as in Fig. 1 and a right-angle plane of congelation **103**. The gasket **138** may be made of any suitable heat resisting material, for example, a copper-cased asbestos.

When one constructs a furnace with the die substantially horizontal, one may tilt the chilling chamber walls slightly outward as at **139** and **140** so as to tilt the congealing plane outward parallel thereto. In this figure the pulling mechanism temperature control and other parts of the installation may be similar to that shown in Figs. 1 to 4. It will be apparent that mandrels may be used in this modification to draw-cast tubes and also that various dies may be used for various shapes.

I have also found that my method of draw-casting produces alloys of remarkably uniform arrangement of crystals throughout. I have no difficulty from segregation or liquation in making alloys of substantial proportionality heretofore not possible by previous methods of casting. As an example, I have readily draw-cast copper-tin alloy with a content of tin equal to 18%, whereas in other methods of casting this has heretofore been considered impossible without detrimental liquation and segregation.

Various other modifications may be made in the apparatus for carrying out my invention and the invention is not to be limited to any specific disclosure.

Having described my invention, what I claim is:

1. The method of draw-casting metal tubing in a mold containing a mandrel and having molten metal in one portion and protruding tubular congealed metal in another portion, which consists in applying a congealing fluid to the protruding congealed metal to chill the adjacent molten metal and withdrawing the tubular congealed metal from around the mandrel and out of the mold, said chilling withdrawing heat from the molten metal into the congealed metal in the direction of motion thereof, at such rate as to maintain a substantially planar congealing zone intermediate the ends of the mandrel and supplying molten tubular metal to the congealing zone as the metal is withdrawn from the mold.

2. The method of draw-casting metal tubing from metals that expand on congealing, which consists in congealing the metal in a mold having an outwardly tapered channel and a mandrel therein, by chilling the metal beyond the mandrel, withdrawing the congealed metal from around the mandrel and out of the mold, said chilling withdrawing heat from the molten metal into the congealed metal in the direction of motion thereof at such rate as to maintain a substantially planar congealing zone intermediate the ends of the mandrel, and supplying molten metal to the congealing zone as congealed metal is withdrawn from the mold.

3. The method of draw-casting tubular metal shapes in a mold containing a tapered mandrel and having molten metal in one portion and tubular congealed metal in another portion which consists in withdrawing the tubular congealed metal from the mold, simultaneously withdrawing heat from the molten metal into the congealed metal, and in the direction of motion thereof, to maintain a substantially planar congealing zone intermediate the ends of the mandrel, and supplying molten metal to the congealing zone as the congealed metal is withdrawn from the mold.

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