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ICHIJI OBINATA ET AL

2,856,659

METHOD OF MAKING INGOT OF NON-FERROUS METALS AND ALLOYS THEREOF

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FIG. 1.

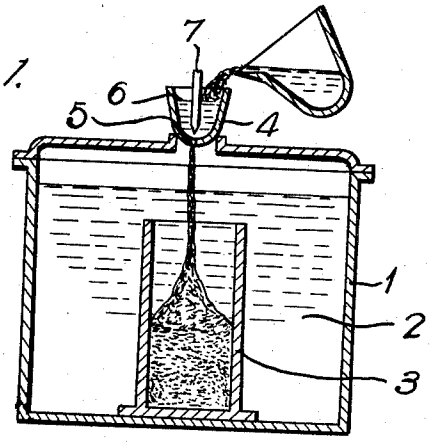


FIG. 3.

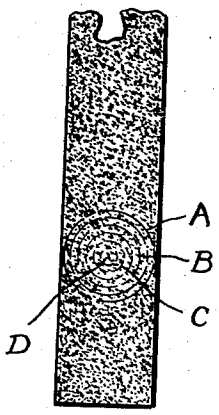


FIG. 2

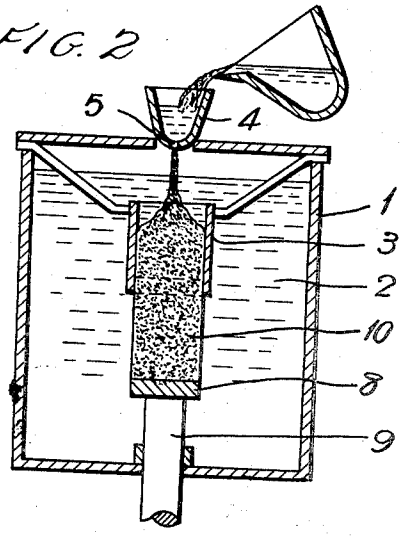
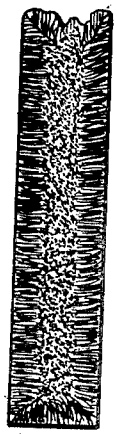


FIG. 4.



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METHOD OF MAKING INGOT OF NON-FERROUS METALS AND ALLOYS THEREOF

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3 Claims. (Cl. 22—210)

This invention relates to a method of making ingots of non-ferrous metals such as aluminum, zinc, copper and alloys thereof.

The principal object of this invention is to obtain a sound ingot of non-ferrous metal and its alloy consisting of fine equiaxed structure by using simple and inexpensive casting device.

In heretofore known casting process using a metal mold, a considerably high cost is required for the material of mold itself and also for its manufacture, nevertheless the ingot obtained shows unhomogeneous crystal structure and accompanies many inner defects such as blow holes and has disadvantages of making the after-working and heat-treatment difficult and also reducing the yield.

In a known continuous casting process using a water cooled mold, though it is an improved method suitable for mass production, the unhomogeneity of crystal structure is unavoidable similar to the method of metal mold casting process. Moreover this method has defects of causing longitudinal cracks and hair cracks in the casting as well as surface irregularity due to the discrepancy of solidifying speed of molten metal and the descending speed of solidified part.

The method of this invention is to obviate the above disadvantages and is characterized in that the molten metal of aluminum, zinc, or copper, or alloys thereof is directly poured into a liquid contained in or surrounded by a fixed or movable bottom metal mold which is made possibly thin but non-deformable during operation and completely immersed in the liquid, preferably hot water or hot oil at a temperature below its boiling point and is caused to successively deposit or accumulate on the previously poured and solidifying mass in the mold to form a cast mass making turbulent and violent interphase agitation between molecules in the mass due to the sudden contact of molten metal at a very high temperature and the liquid of lower temperature, thereby resulting in homogenous and uniform dispersion and mixing of particles and ingredients and completes the solidification in the hot liquid.

The temperature of hot liquid should be taken below the boiling point of water and above 30° C. for aluminum, zinc and alloys thereof, since in a hot liquid below about 30° C. the surface solidification occurs so rapidly that the occluded gases can not escape so quickly and it results irregular laminar ingot having many internal cavities, and the cooling effect of hot liquid above about 30° C. becomes slow so that the molten state may be maintained for comparatively long duration and the occluded gases can be ejected very easily, thereby resulting a sound ingot. In this case, the total volume of hot liquid in the bath is sufficient with about 300 times the inner volume of the mold.

In a modified embodiment of this invention, instead of statical casting process using a completely fixed metal

mold, the bottom of mold fixed in a hot liquid bath such as hot water bath is mounted on a movable support to be moved downwardly for a given distance when the molten metal poured in the mold has solidified to a desired degree by replacing the hot liquid in the mold and the molten metal is poured again in the mold on the formerly cast ingot, thus repeating the process continuously or step-by-step it is possible to provide an ingot of unlimited length having homogeneous and fine crystal structure. Using a water bath, the total quantity of hot water in the bath is sufficient with about 300 times the inside volume of mold having closed bottom, but water or other liquid of comparatively low temperature may be added or circulated, then there occurs no danger of explosive boiling or ebullition of liquid.

In casting of zinc or its alloys, if the molten metal is poured into water at a room temperature the metal is split into a number of droplets and solidifies into small pieces of needle form and never forms a sound ingot. On the other hand, if the temperature of water is raised above about 30° C. the cooling effect of water becomes more slow and maintains the molten state for a longer time so that the absorbed gases can easily be ejected and a sound ingot having homogeneous and fine structure can be obtained.

In case of making an ingot of copper and its alloy, the temperature of hot liquid such as hot water or hot oil may be selected as desired below the boiling temperature of water and to room temperature, but the lower temperature affects somewhat the surface of solidified mass according to the kind of copper alloys. But different from the metal of lower melting point such as aluminum, zinc and their alloys the temperature of liquid for copper and copper alloys has no important effect on the internal soundness of the ingot.

For a better understanding of this invention reference is made to the following description of representative embodiments thereof, taken in conjunction with the accompanying drawings, wherein,

Fig. 1 is a sectional elevation of a casting device for carrying out this invention;

Fig. 2 is a sectional elevation of a device for carrying out continuous casting in accordance with this invention;

Fig. 3 is a sectional view of a 99.5% aluminum ingot according to this invention showing the macro-structure etched in aqua regia;

Fig. 4 is a similar sectional view to Fig. 3 of a 99.5% aluminum ingot made by conventional casting method using an ordinary iron mold.

Now referring to Fig. 1, **1** represents a water tank filled with hot water **2** at 90° C. amounting to about 120 liters. **3** is a mold made of thin iron plate 1 mm. thick having inner diameter 45 mm. and 200 mm. long located in the tank underneath the water level. **4** is a graphite crucible having a small hole **5** (6 mm. diameter) at its bottom.

In carrying out the method of this invention, a molten metal **6** such as aluminum or aluminum alloy previously melted in a furnace is poured into the crucible **4** and when the temperature of molten metal arrives at about 690° C. the sealing rod **7** is taken off, then the molten metal flows down through the bottom hole of crucible **4** and passes through the hot water into the mold **3** and solidifies therein by replacing the hot water to form an ingot.

In Fig. 2, the same or similar parts are represented by the same reference numerals as in Fig. 1. In this case, the bottom **8** of mold **3** is made separately and supported on a movable support **9** and the molten metal such as

99.7% aluminum previously fused in a melting furnace and fed into the crucible **4** is flown down through its bottom hole **5** at a temperature of about 680° C. into the mold **3** similarly to the manner as explained with respect to Fig. 1. As the molten metal in the mold has solidified to a desired extent the movable support is slowly lowered carrying the solidified aluminum ingot **10** on it, and again cast the molten aluminum, thus repeating this process an ingot having a diameter of 60 mm. and 700 mm. long was obtained. The temperature of water used was 90° C.

In the example of making an ingot of copper and its alloy according to this invention, the temperature of water was taken for example at about 84° C. and a mold made of copper plate 2 mm. thick having inner diameter of 50 mm. and 230 mm. high was immersed into hot water in the tank, and the molten Phosphor bronze at a temperature of 1130° C. was cast through the hot water into the mold and solidified in the hot water.

In using the device as shown in Fig. 2, the movable bottom support **9** was lowered gradually as the molten Phosphor bronze is poured into the mold **3** and a Phosphor bronze ingot **10** of 540 mm. long was obtained.

The aluminum ingot made by the method of this invention showed uniform and fine granular structure as shown in Fig. 3 and the test piece of this ingot showed the attenuation of 0.33 db/cm. at the frequency of 3 mc./sec. as the result of test by an ultrasonic reflectoscope. On the contrary, the ingot made by an ordinary metal mold casting process showed the structure as shown in Fig. 4 and the attenuation of 0.56 db/cm. at the same condition, the latter being about twice as high as the former. Moreover the ingot according to the method of this invention has improved mechanical properties superior to those of ordinary method. For instance, comparative tests of aluminum ingots of 99.9% and 99.5% purity made by the method of this invention (A) and ordinary metal mold casting process (B) are shown in the following table:

Mold		Purity of Aluminum	Casting temp., ° C.	Temp. of water, ° C.	Average specific gravity	Tensile strength kg./mm.²	Elongation percent mark distance, 25 mm.
Method (B)	35 mm. thick	(1) 99.9	680	----------	2.728	4.56 to 5.35	44–56
	45 mm. inner dia	(2) 99.5	680	----------	2.745	6.39 to 7.88	28–41
	300 mm. long						
Method (A)	1 mm. thick	(1) 99.9	680	70–90	2.729	6.13 to 6.86	52–60
	45 mm. inner dia	(2) 99.5	680	70–90	2.742	7.73 to 8.66	32–48
	200 mm. long						

In case of copper and copper alloys, the ingot made by the method of this invention showed more homogeneous, fine macro-structure than that obtainable by heretofore ordinary method and the test results of inverse segregation of tin in case of Phosphor bronze are shown as follows:

Position (refer to Fig. 3):	Segregation of tin, percent
(A) Superficial layer	8.77
(B) Outer layer	8.65
(C) Inner part	8.68
(D) Central part	9.00

Thus very good ingot of Phosphor bronze can be made by the method of continuous casting according to this invention without substantially inverse segregation which gave troubles to working and heat treatment in the ingot made by an ordinary process.

What we claim is:

1. A method of making ingots of non-ferrous metals such as aluminum, zinc, copper and alloys thereof, which comprises pouring a molten metal directly into a liquid contained in an open bottom mold which is completely immersed in said liquid and causing the molten metal to deposit successively on the previously poured and solidifying mass after making turbulent and violent interphase agitation between molecules in the mass, thereby resulting in a uniform and homogeneous dispersion and mixing of particles and ingredients, and completing the solidification of the metal mass in said liquid.

2. A method of making a comparatively long ingot of non-ferrous metal such as aluminum, zinc, copper and alloys thereof according to claim 1, the mold having a movable bottom, comprising gradually lowering the movable bottom of the mold when the cast molten metal has solidified in the mold to a desired extent thereby producing an ingot of a desired length in continuous manner.

3. A method of making ingots of non-ferrous metals according to claim 1 which comprises using a liquid bath of water at a temperature of 30° to 90° C.

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