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Bray

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[54] METHOD AND APPARATUS FOR PRE-HEATING AND ADDING MASTER ALLOY TO A COPPER MELT

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[51] **Int. Cl.** **C22c 1/00**
[58] **Field of Search** .... 75/135, 93 R, 76, 153; 266/34 T

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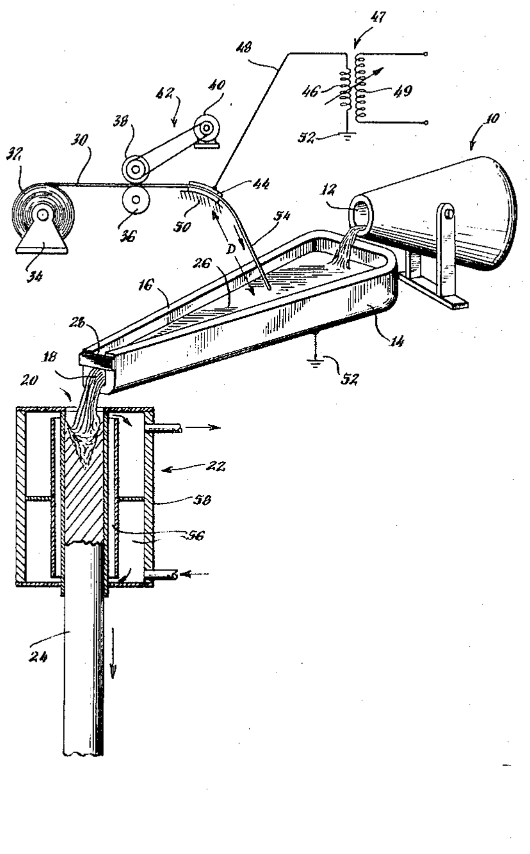
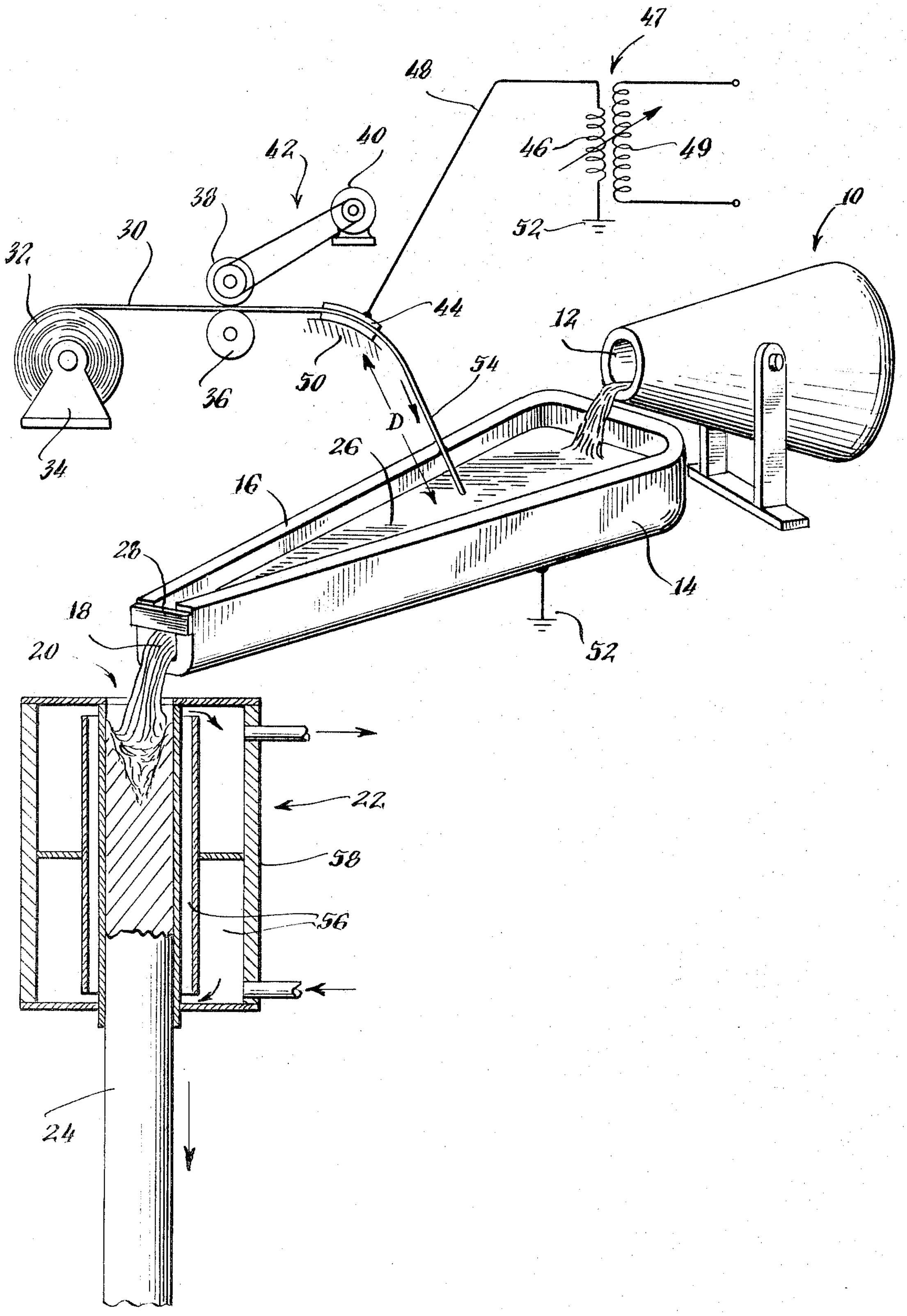
[57] ABSTRACT

Method and apparatus for pre-heating and continuously adding a dilute master alloy, for example, such as a master alloy of 2 percent boron-balance copper, to a copper melt flowing through a launder from a source of the molten metal, such as a furnace, into the top of a casting mold. The master alloy is formed as a wire, and the launder is made electrically conductive or an inert electrode is inserted into the molten metal flowing through the launder, while the wire is continuously fed into the flowing metal. In order to avoid quenching of the molten metal and to hasten the introducton of the alloy element into the melt so that thorough alloying can occur during the brief residence time of the flowing metal in the launder, the wire is pre-heated to a temperature level close to its melting point, e.g. within 100°C of the melting point, by feeding an electrical current longitudinally through a predetermined legnth of the wire as it is being fed continously into the flowing metal. The electrically conductive launder or immersed electrode and molten copper serve as one portion of the circuit, and an electrically conductive member positioned to engage the moving wire at a predetermined distance from the liquid level serves as another portion of the circuit, so that the predetermined length of wire immediately above the liquid level is heated.

7 Claims, 1 Drawing Figure

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METHOD AND APPARATUS FOR PRE-HEATING AND ADDING MASTER ALLOY TO A COPPER MELT

BACKGROUND OF THE INVENTION

Prior to the present invention, the way in which a dilute master alloy, such as a master alloy of 2 percent boron-balance copper, has been added to a copper melt has been to prepare the dilute master alloy in ingot form. The copper melt was heated in a furnace and then transferred into a crucible. A predetermined number of ingots were thrown into the molten copper in the crucible depending upon the volume of molten metal therein in order to produce the desired alloy. Thereafter, after suitable mixing of the alloy had occurred, the crucible was moved over to the mold, and the alloyed copper was poured into the mold to produce a usable product.

This prior procedure required a sequence of time-consuming handling steps. In addition, it required that the molten copper be heated to a temperature level above the level desired for pouring the alloyed copper melt into the mold, because there was a loss of temperature occurring in the handling steps. Also, an additional increment of temperature was necessary to be present initially in the copper melt to serve as a heat source for melting the master alloy ingots themselves which ingots were added at room temperature. In other words, this added increment of temperature was necessary to offset the quenching effect of the room-temperature ingots entering the molten metal, for these ingots had to be heated up and melted (change of state) which caused a significant quenching effect. Also, since the master alloy is relatively dilute (only 2 percent boron in the illustrative embodiment) a significant quantity of ingots were added, namely, approximately 1 percent of the mass of the molten metal, which means that a significant quenching effect occurred.

This elevated temperature above the desired level to offset quenching and other heat losses tended to be deleterious to the copper. A further problem with the prior art procedure was that a thorough mixing of the copper melt and the master alloy could be obtained only by arranging to hold the molten metal mixture in the crucible for a substantial period of time after the ingots were thrown in. The additional increment of temperature in the copper melt was also required to be sufficient to offset this heat loss occurring during the holding period in the crucible while thorough mixing occurred. This excess temperature and prolonged holding period in a crucible is harmful to the ultimate product because the solubility of atmospheric gases, such as oxygen, in the copper rapidly increases with elevation of temperature and the degree of gas pick-up or alloy loss increases with exposure caused by prolonged dwell time.

SUMMARY OF THE INVENTION

This invention relates to a method and apparatus for pre-heating and continuously adding a dilute master alloy, for example, such as a master alloy of 2 percent boron-balance copper, as a pre-heated wire being fed into a copper melt while the pure molten copper is running through a launder from a furnace into a mold. The launder is narrow and elongated and is constructed of an electrically conductive material, such as graphite, or an inert electrode is inserted into the flowing metal. In order to avoid quenching of the metal in the launder and to hasten the introduction of the alloy element into the melt so that thorough alloying can occur in a brief residence time of the flowing metal in the launder, the launder or immersed electrode and molten copper serve as one portion of the circuit for feeding electric current longitudinally through the wire. An electrically conductive member positioned to engage the moving wire at a predetermined distance from the liquid level serves as another portion of the wire heating circuit.

Among the many advantages of the method and apparatus embodying the present invention are those resulting from the fact that the copper melt can be heated to the desired temperature in the range from 1,100° C to 1,275° C, and often can be heated to the optimum temperature of 1,150° C to 1,175° C, without requiring overheating to compensate for any quenching effect when the dilute master alloy is added. Moreover, the copper is continuously flowing through the narrow launder as the heated wire is being added, thus a thorough mixing of the dilute master alloy and copper melt is obtained as a result of the agitation produced by the flowing motion of the molten metal in the launder.

Another advantage resulting from employing the present invention is that there is only a brief time period occurring while the molten copper is flowing through the launder. The dilute boron master alloy in the illustrative embodiment is added for the purpose of deoxiding the melt. By virtue of the thorough mixing obtained in the agitated flowing metal, a most effective deoxidizing action is obtained. Then, there is very little opportunity remaining for atmospheric gases to again become dissolved in the molten metal because of the brief transit time to exit from the launder and pass into the mold. In this embodiment, the flowing metal is covered with a layer of carbon or soot or other chemically reducing substance to provide a reducing environment at the liquid surface.

A further advantage of the present invention is that overheating of the master alloy wire is limited. Should the electrical energy being fed into the master alloy wire momentarily exceed the desired predetermined heating level, the wire melts and momentarily breaks the circuit, thus interrupting the heating effect. The wire is supplied from a reel at ambient temperature, when the wire passes through the electrically conducting zone between the conductive member and the molten metal, it is quickly heated up to a temperature close to its melting point, e.g. within 100° C. of its melting point. In the illustrative example, the melting point of the dilute master alloy wire is between 1,062° C and 1,083° C. The wire is pre-heated to a temperature above 962° C before it enters the copper melt. Thus, any significant quenching is avoided and the alloy wire quickly melts and thoroughly mixes with the pure molten copper in the launder before it passes into the mold. A boron deoxidized cast copper product of high electrical conductivity and uniform properties is produced.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The various objects, novel aspects and advantages of the present invention will become more fully understood from a consideration of the following detailed description of a preferred mode of putting the invention into practice when read in conjunction with the accompanying drawing.

In this drawing is shown a casting method and apparatus in which the copper melt is flowing from a furnace through an electrically conductive launder into the top of a continuous casting mold and the master alloy in the form of a wire is being continuously led into the flowing molten metal in the launder while being heated by passage of electrical current longitudinally through a predetermined length of the wire immediately above the surface of the molten metal.

This embodiment of the invention which is presently preferred by the inventor is described, but it is to be understood that the scope of the invention as claimed is broader in certain of its aspects than this particular embodiment.

The melt of metal to be alloyed, for example, such as essentially pure copper, is heated to the desired temperature in a furnace **10.** The molten metal is released at a controlled rate through an outlet **12** into a launder **14.** The melt flows through a relatively narrow channel **16** in the launder to its discharge end **18** from which the alloyed metal is discharged continuously into the entrance **20** at the top of a direct chill casting mold **22** of the continuous casting type. The cast product **24** moves intermittently downward from the bottom of the mold **22.**

The residence time of the molten metal **26** in the channel **16** is brief, e.g. less than 1 minute, so that there is only a small heat loss which occurs as the metal flows toward the discharge **18.** A layer of particulate carbon, such as graphite powder or soot, is floated upon the molten metal **26,** so as to maintain a reducing environment adjacent to the liquid surface. A barrier **28** at the discharge end of the launder retains the protective layer of particulate carbon.

By virtue of the minimum number of handling steps and the brief residence time before entering the mold at **20,** the temperature of the base metal, e.g. essentially pure copper, in the furnace **10** can be held within the desired range of 1,100° C to 1,275° C and often can be held at the optimum temperature level from 1,150° C to 1,175° C.

The alloy constituent, for example, such as the element boron, is previously mixed with the base metal to provide a dilute master alloy, consisting essentially of 2 percent boron-balance copper. This master alloy is formed into a wire **30** and wound into a large coil **32** to serve as a source of the master alloy.

This wire coil **32** is mounted on a stand **34** near the launder **14,** and the wire **30** is continuously fed into the molten metal **26** by passing it between an idler roller **36** and a companion roller **38** driven by an adjustable speed motor **40.** The components **36, 38** and **40** comprise adjustable speed wire feed means generally indicated at **42.** The rate of feed of the wire **30** is adjusted in accordance with the flow rate in the channel **16** for producing the desired alloying action in the flowing metal **26.** In this illustrative embodiment, the cast product **24** being produced is boron deoxidized high conductivty copper having the Copper Development Association, Inc. designation No. 109 alloy.

In order to avoid quenching of the molten metal **26** and to hasten the introduction of the alloying constituent into the melt so that thorough alloying can occur during the brief residence time while the metal is in the channel **16,** the master alloy wire **30** is pre-heated. This pre-heating is advantageously accomplished by flowing electric current longitudinally through a predetermined length of the master alloy wire **30.**

An electrically conductive member **44** engages the wire **30** to make electrical contact therewith at a predetermined distance "D" from the surface of the molten metal **26.** A source of electrical energy, for example, shown as the secondary winding **46** of a variable transformer **47,** has one side connected by a lead **48** to the conductive member **44.** The primary **49** of the transformer is connected to an alternating current circuit, for example, such as a conventional 220 volt-60 Hertz circuit.

Thus, the conductive member **44** serves as a portion of a circuit for feeding current through the wire **30.** If desired, the rollers **36** and **38** of the adjustable feed mechanism **42** can be made conductive and be connected to the lead **48** and be positioned to serve in lieu of the contact member **44.** However, the advantage of utilizing a separate contact member **44** is that it can be adjustably mounted on an insulating support **50** for appropriately adjusting the distance D, whereas it is more convenient to have the adjustable feed mechanism **42** fixed in position.

The launder **14** is formed of electrically conductive material such as graphite, and it is connected to a common return circuit **52,** i.e., it is "grounded." The other side of the secondary **46** is also connected to the common return circuit and thus the conductive launder **14** and the molten metal **26** serve as another portion of the circuit for feeding current through the predetermined length of wire **54** between the conductive member **44** and the surface of the molten metal.

The current flow through the wire is adjusted to heat the wire length **54** up to a temperature close to its melting point before wire enters the metal **26,** that is, the wire is pre-heated to within 100° C of its melting temperature. During the start-up period, in the event the current flow is inadvertently set slightly too large, the wire length **54** melts, thus temporarily interrupting the circuit. The operator can then reduce the energy output from the power source **47** to the appropriate value.

In lieu of an electrically conductive launder **14,** an inert electrode (not shown) of graphite can be immersed in the molten metal **26** and be connected to a common ground circuit.

By virtue of the fact that the metal is flowing in the narrow channel **16,** and is continuously passing by the point at which the master alloy is being introduced, there is a uniform distribution and inter-mixing of the alloy constituent into the flowing base metal **26.** Also, the fact that the master alloy is dilute aids in producing a uniform distribution of the alloy constituent throughout the melt because the relatively large or dominant proportion of pre-heated base metal in the heated wire **54** (which is close to its melting point) acts as a vehicle for carrying the alloy constituent throughout the base metal of the melt **26.**

In the continuous casting mold **22** a liquid coolant such as water is fed through passages **56** in a cooling jacket **58** for extracting heat to solidify the cast product **24.**

I claim:

1. The method for adding a master alloy to a base metal in a melt comprising the steps of:

producing a dilute master alloy of the alloy constituent and the base metal in which the base metal is the dominant proportion,

forming this dilute master alloy into a length of wire,

heating the base metal to be alloyed in a furnace to produce a melt thereof at a temperature near the desired casting temperature,

controllably releasing the molten metal at a predetermined flow rate from the furnace to pass through a narrow channel leading into a casting mold,

continuously feeding the master alloy wire into the molten metal passing through the narrow channel, and

pre-heating the master alloy wire to a temperature close to its melting temperature, said wire being heated continuously as it is being fed into the molten metal by feeding electric current longitudinally through a predetermined length of the wire immediately above the flowing metal by using the molten metal in the channel as a portion of the electric circuit for feeding the current longitudinally through the wire and through the molten metal.

2. The method of adding a master alloy to a base metal in a melt, as claimed in claim **1**, in which:

said narrow channel is formed by an electrically conductive launder which serves as a portion of the electric circuit for heating the length of wire.

3. The method of adding a master alloy to a base metal in a melt, as claimed in claim **1**, wherein:

said base metal flowing through said narrow channel is essentially pure copper covered by a layer of material producing a reducing environment at the surface of the molten metal,

the residence time of the molten copper in said narrow channel is less than 1 minute, and

said dilute master alloy is an alloy of boron and copper for producing boron deoxidized high conductivity copper passing from the narrow channel into the mold.

4. Apparatus for introducing a master alloy into a metal melt, comprising:

a furnace for heating the base metal to a desired temperature for casting and having an outlet for releasing the molten metal at a controlled rate of flow,

a launder defining a narrow channel for flowing the molten metal from the furnace outlet into a casting mold,

a wire formed by the master alloy with the alloy constituent being a dilute proportion of the wire,

adjustable feeding means for feeding the wire at a predetermined rate into the molten metal flowing through the channel toward the mold,

an electrically conductive member engaging the moving wire at a predetermined distance from the launder, and

a source of electrical current having one side connected to said member and having the other side connected to the molten metal in said narrow channel for feeding electric current longitudinally through the length of wire entering the molten metal for pre-heating said length of wire to a temperature close to its melting point, said length of wire being heated continuously as it is being fed into the molten metal,

thereby to avoid quenching of the melt and to hasten the alloying action.

5. Apparatus for introducing a master alloy into a metal melt, as claimed in claim **4**, in which:

said launder is formed of electrically conductive material and the other side of said source of electrical current is connected to the launder.

6. The method of adding a dilute master copper alloy to a copper melt in order to hasten the introduction of the alloying material into the melt and avoid holding time delay comprising the steps of:

producing a dilute master copper alloy wire of the alloy constituent and copper in which the copper is the dominant proportion,

heating the copper to be alloyed in a furnace a produce a melt thereof at a temperature near the desired casting temperature, said temperature being in the range from 1,100° C to 1,275° C,

controllably releasing the molten copper at a predetermined flow rate from the furnace to pass through a narrow channel leading into a casting mold,

flowing the copper melt along said narrow channel with a brief residence time in said channel of less than 1 minute,

pre-heating the master copper alloy wire to a temperature close to its melting temperature,

feeding the pre-heated master copper alloy wire into the flowing copper melt moving along said channel, said wire being heated continuously as it is being fed into the flowing copper melt,

whereby the alloy becomes thoroughly mixed with the copper melt flowing in said narrow channel, thereby avoiding any holding time delay for the alloying to take place, and

whereby any significant quenching effect is avoided, by virtue of which the copper melt can initially be heated to the desired temperature in the range from 1,100° C to 1,275° C without requiring overheating to compensate for any significant quenching effect when the dilute master alloy is added.

7. The method of adding a dilute master copper alloy to a copper melt as claimed in claim **6**, in which said master copper alloy is pre-heated to a temperature within 100° C of its melting temperature.

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