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APPARATUS AND METHOD FOR AUTOMATICALLY CONTROLLING THE MOLTEN METAL BATH LEVEL IN A METALLURGICAL PROCESS

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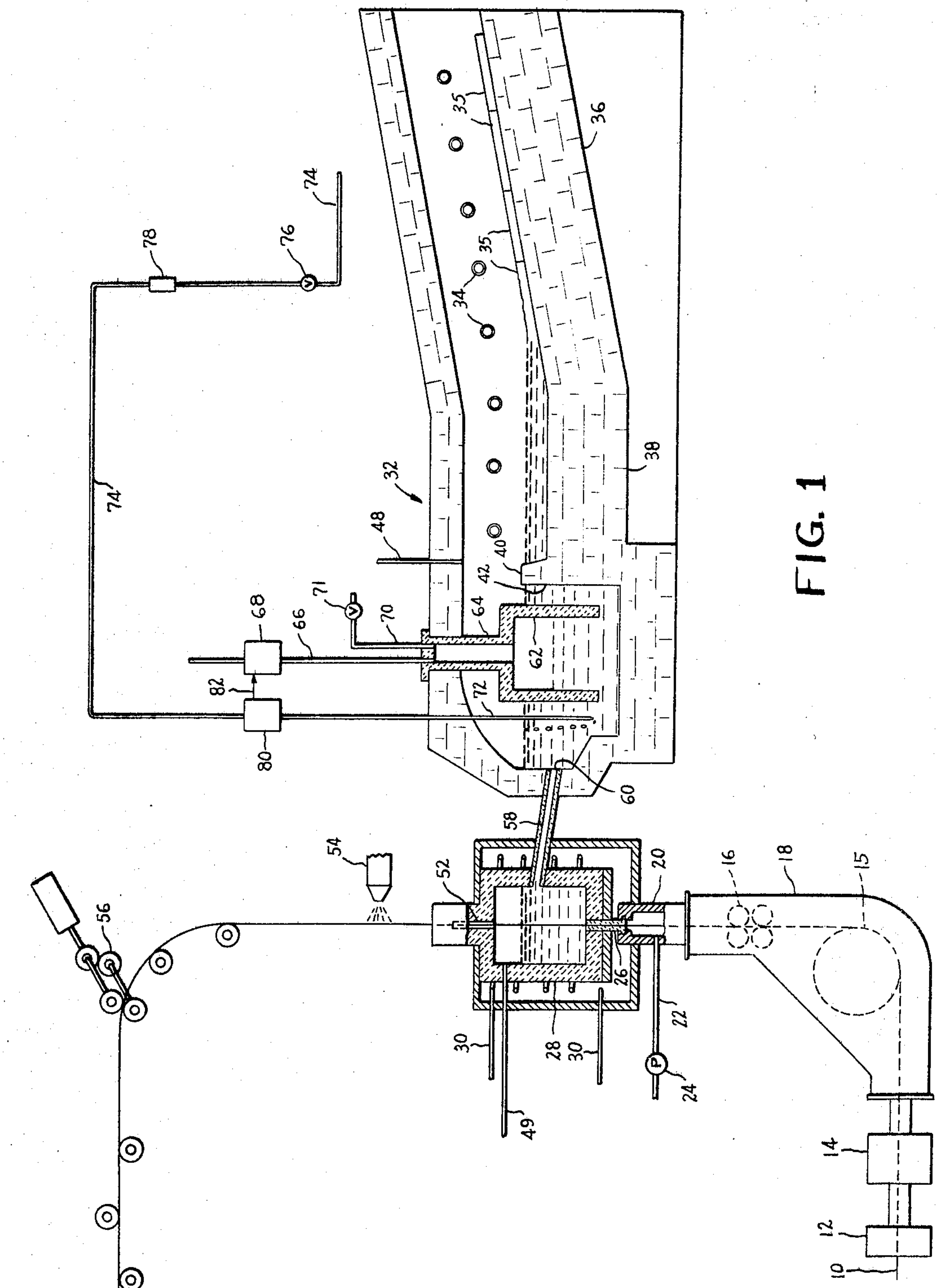

FIG. 1

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APPARATUS AND METHOD FOR AUTOMATICALLY CONTROLLING THE MOLTEN METAL BATH LEVEL IN A METALLURGICAL PROCESS

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ABSTRACT OF THE DISCLOSURE

In the dip-forming process for accreting metal onto a core member passed through a crucible containing a molten bath of metal, a melt of molten metal is continuously supplied to the crucible from a holding chamber. An inverted pressure bell is disposed in the holding chamber, and gas is introduced into the enclosed portion of the bell for exerting pressure on the surface of the molten metal within the bell. A liquid level sensing means is immersed in the molten metal, and gas is continuously introduced through the liquid level sensing means whereby a back pressure is established in the sensing means which is correlated with the level of molten metal in the holding chamber.

The dip-forming process, such as used in casting metal, is now well known in the art. According to this process, an elongated body such as a metal rod is typically pretreated by passing it through a straightener, and a surface cleaning apparatus, and then through a vacuum entrance chamber arranged in the wall of a crucible which contains a bath of molten material. The elongated core or body is passed through the molten bath, which bath may have been the same chemical composition as that of the core or a different composition. The molten material in the crucible accretes or deposits upon the outer surface of the core thereby increasing its cross-sectional area appreciably. After emerging from the crucible, the resulting cast member is cooled as by a water spray from one or more jet nozzles at least sufficiently so that the cast member can be rolled or worked. From there, the cast member may be passed through a suitable roll mechanism where it is reduced in cross-sectional area and then passed to a suitable receiving means such as a take-up reel.

It is essential for the successful operation of the dip-forming process that the depth of molten metal in the crucible be controlled accurately. If the bath of molten metal is too shallow relative to the core size and speed, full accretion will not occur and output therefore will be lost. On the other hand, if the bath is excessively deep, re-melting of the cast body will occur which results also in reduced output.

This invention has therefore as among its objects to provide a means and method for accurately controlling the bath depth of molten metal which eliminates wide fluctuations in bath depth.

Other objects and advantages of the invention will best be understood by referring to the following detailed specification, and to the accompanying FIG. 1 illustrating in elevation a preferred embodiment of the invention, with the control mechanism being illustrated schematically.

In general, the apparatus of this invention employed in a dip-forming process, in which molten metal is accreted to a core passed through a crucible containing the molten metal, includes a holding chamber disposed adjacent the crucible and in communication therewith. The holding chamber, which contains a supply of molten metal, is provided with suitable means for adjusting or regulating the level of molten metal, such as an inverted displace-

ment bell, or a graphite block as disclosed in United States Pat. No. 3,060,053 to Carreker et al. and assigned to the assignee of this application. Gas is continuously introduced through a liquid level sensing device immersed in the molten metal, whereby the back pressure established in the device is correlated with the level of molten metal in the holding chamber. The level regulating means is adjusted in response to the back pressure thereby regulating the bath level within the holding chamber and, in turn, within the crucible.

Although the invention is described hereinbelow with reference to dip-forming a copper rod, it is understood that the invention is applicable to other metals.

Referring to the drawing, core rod **10**, such as a copper rod, is supplied to a drawing apparatus **12** located adjacent a suitable shaving apparatus **14** which shaves a thin layer of metal from the periphery of the rod to remove the oxide coating and other surface contaminants therefrom. If desired, other cleaning means such as chemical cleaning means may be utilized for removing the oxide coating and cleaning the surface of the rod. The rod is passed through a suitable drive means, including capstan **15** and drive rolls **16** contained in housing **18**, and from there into tube **20**. Members **12**, **14**, **18**, and **20** are sealed and interconnected by a suitable passageway, and tube **20** has connected thereto exhaust tube **22** and evacuating pump **24** to maintain a vacuum in the passageway. Entry port member or nozzle **26** is mounted in the upper end of tube **20** and extends into crucible **28** which is maintained at the desired elevated temperature by suitable heating means such as electric induction heater **30**. Core rod **10** is fed through nozzle **26** and into crucible **28** where the rod comes into contact with the molten copper which accretes to the rod.

Molten copper is supplied to crucible **28** from a suitable melting furnace indicated generally by the numeral **32**, which is heated by a plurality of silicon carbide electric radiant heaters **34**. Cathode copper plates **35**, or other suitable feed material of low oxygen content, is supplied to the furnace **32** by any suitable means such as a mechanical drive means (not shown). Desirably the furnace is provided with a sloping or inclined section **36** and an integral horizontal section **38**. The cathode copper plates are charged to section **36** of the furnace through a flapper-type door (not shown), and melted gradually on the incline as they pass to the horizontal section **38** where a pool of molten metal collects. The molten metal flows by displacement over a weir **40** into a holding chamber **42** of the furnace described hereinbelow in greater detail. It is desirable that an inert or reducing atmosphere be maintained above the melt in the furnace as well as in the dip-forming crucible, which may be supplied through line **48** and line **49**, respectively, from any suitable source (not shown). As the core rod passes through the molten bath of metal in the crucible, copper accretes progressively thereon thereby forming a rod of increased diameter with molten metal substantially bonded to the core rod.

An elongated tube **52** extends upwardly from crucible **28**, and the resulting cast rod having copper accreted thereto is passed out of the crucible to the extension tube. The cast rod emerging from the crucible and extension tube is at a relatively high temperature and is cooled somewhat by cooling means **54**, such as a water spray nozzle, before the rod is passed through direction changing rolls **56**. From there the cast rod is directed to a suitable rolling mill and coiling apparatus (not shown) and to a storage area as desired.

Passageway or conduit **58** establishes communication between the holding chamber **42** and the crucible **28**, and molten metal will flow from the holding chamber to crucible when the level of molten metal in the holding chamber adjacent the inlet **60** of the communicating passageway **58** is above the level of the passageway. An inverted pressure bell or displacement bell **62** is disposed within the holding chamber in order to selectively adjust the level of molten metal in the holding chamber, described hereinbelow in greater detail. The side walls of the bell are at least partially immersed below the level of molten metal contained in the holding chamber, and desirably the bottom edge of the bell is spaced from the bottom surface of the holding chamber so as to enable molten metal to flow into the enclosed portion of the bell. The top portion of the pressure bell has a cylindrical extension **64** which projects upwardly through the upper wall of the holding chamber **42**. The cylindrical extension **64** is sealed at the top, and a first pipe **66** is mounted therein for conducting gas from a source (not shown) through a pressure control valve **68** and into the enclosed portion of the bell for applying pressure on the surface of the molten metal contained therein. A second pipe **70**, having valve **71** is mounted in the top of the extension **64** for exhausting the gas from within the bell for relieving the pressure on the surface of the molten metal contained therein.

During the dip-forming operation, the molten metal contained in the crucible and holding chamber decreases. In accordance with the present invention, the level of molten metal is continuously measured by a liquid level sensing device. For this purpose, a sensing device **72**, composed of a material substantially inert to the molten metal, is immersed in the bath, preferably in the holding chamber as shown in the drawings, but alternatively may be disposed in the dip-forming crucible. The sensing device is a substantially cylindrical member composed of molybdenum or other suitable material and provided with a longitudinal bore opening at the bottom thereof such that upon immersion in the coating bath, communication is established between the longitudinal bore and the interior of the crucible below the level of molten metal. In this manner, a gas, which is desirably inert to the molten metal, is introduced to the molten bath from a source not shown through line **74** to sensing device **72**, and bubbles to the surface of the bath. The rate of flow of gas introduced to the molten bath is automatically controlled at a constant value by pressure regulator or valve **76** and flow control meter **78**, both of which are incorporated in line **74**. Suitable gases, which may be used in either the sensing device or the displacement bell, include the inert or reducing gases, for example, nitrogen, argon, carbon dioxide, natural gas, etc.

When gas is introduced to the molten bath, the back pressure, or level indicating pressure, in the sensing device is measured. This pressure is a measure of the fluid level above the outlet of sensing device. This back pressure actuates differential pressure transducer **80**. The power output from the transducer is supplied to control valve **68** via line **82** which automatically regulates the gas pressure inside the inverted displacement bell above the molten metal. It will be observed that the pressure within the enclosed portion of the bell regulates the level of molten metal in the holding chamber and, in turn, the level in the crucible. This control substantially eliminates wide fluctuations in bath depth thereby rendering the process more efficient and providing a more uniform product.

The present invention is particularly useful in the dip forming process for casting copper on a copper core rod. It should be understood however, that the process is also applicable for use in casting dissimilar metals, such as copper or steel.

I claim:

1. In an apparatus for the continuous casting of metal which includes the steps of continuously passing an elongated core member through a bath of molten metal contained in a crucible thereby accreting metal to said core member, the improvement comprising:

(a) a furnace for melting feedstock having an integrally arranged holding chamber disposed adjacent said crucible for containing a supply of molten metal;

(b) communication means opening to said holding chamber and said crucible for establishing communication therebetween;

(c) an inverted pressure bell disposed in said holding chamber spaced from the bottom surface thereof and having its side walls at least partially immersed below the level of molten metal contained in said holding chamber, and including means for introducing gas into the enclosed portion of said bell for applying pressure on the surface of molten metal contained therein;

(d) a liquid level sensing means immersed in the molten metal;

(e) means for continuously introducing gas substantially inert to the molten metal through said liquid level sensing means whereby a back pressure is established in said sensing means which is correlated with the level of molten metal contained in said holding chamber; and

(f) means responsive to said back pressure for actuating the pressure within the enclosed portion of said bell thereby controlling the level of molten metal in said holding chamber.

2. In a method for the continuous casting of metal which includes the steps of continuously passing an elongated core member through a bath of molten metal contained in a cruible thereby accreting metal to said core member, the improvement comprising:

(a) continuously supplying molten metal to said crucible from a holding chamber arranged adjacent said crucible and in communication therewith;

(b) continuously introducing a gas into the enclosed portion of an inverted pressure bell disposed in said holding chamber and having its side walls at least partially immersed below the level of molten metal contained in said holding chamber thereby applying pressure on the surface of molten metal contained therein;

(c) continuously introducing gas substantially inert to the molten metal through a liquid level sensing means immersed in the molten metal whereby a back pressure is established in said sensing means which is correlated with the level of molten metal contained in said holding chamber; and

(d) continuously adjusting the pressure within the enclosed portion of said bell in response to said back pressure thereby controlling the level of molten metal in said holding chamber.

References Cited

UNITED STATES PATENTS

310,994	1/1885	Farmer	164—275
867,659	10/1907	Hoopes et al.	164—275 X
2,593,197	5/1952	Rough	65—346 X
2,664,852	1/1954	Chadsey	118—49
2,988,099	6/1961	Langhans	137—403 X
3,060,053	10/1962	Carreker et al.	164—86 X
3,104,678	9/1963	Cole	137—403
3,200,971	8/1965	Trethewey	137—403 X
3,384,150	5/1968	Newsome	164—337 X

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