April 21, 1964 J. W. VEIL, JR 3,129,473

THROUGH-PLUG MOLD STOOL

Filed Nov. 9, 1960

2 Sheets-Sheet 1

FIG.1.

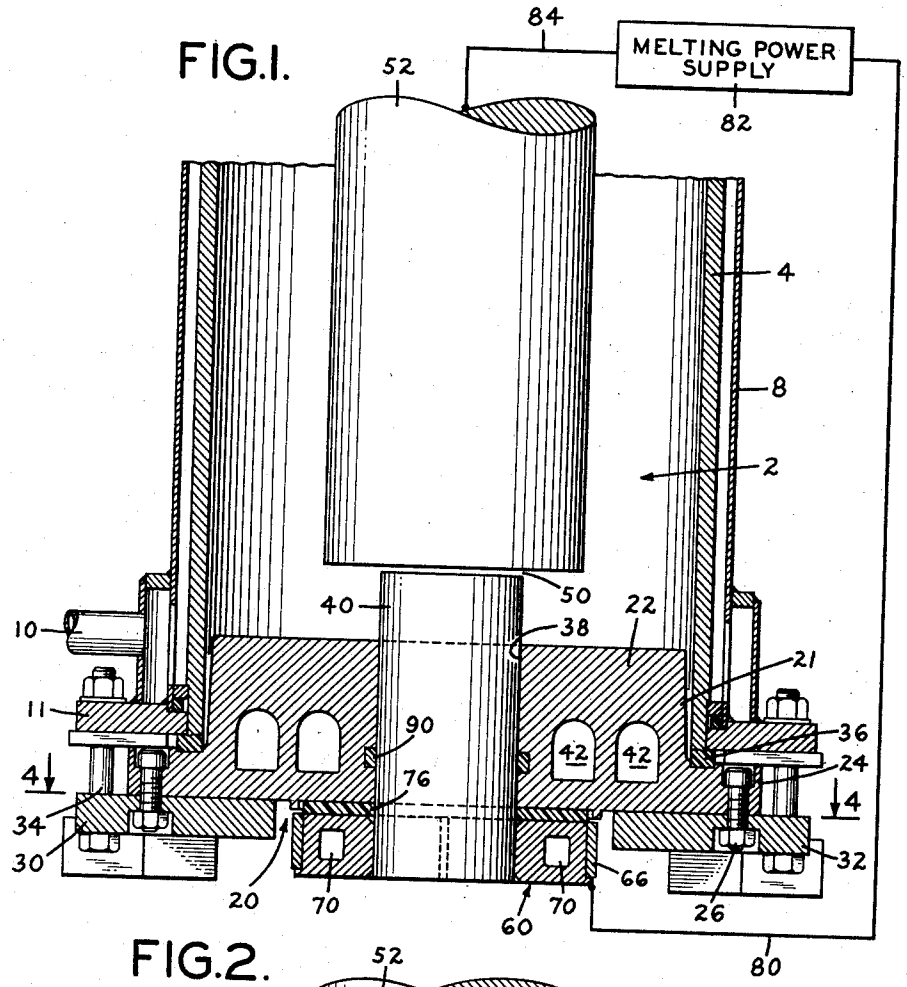
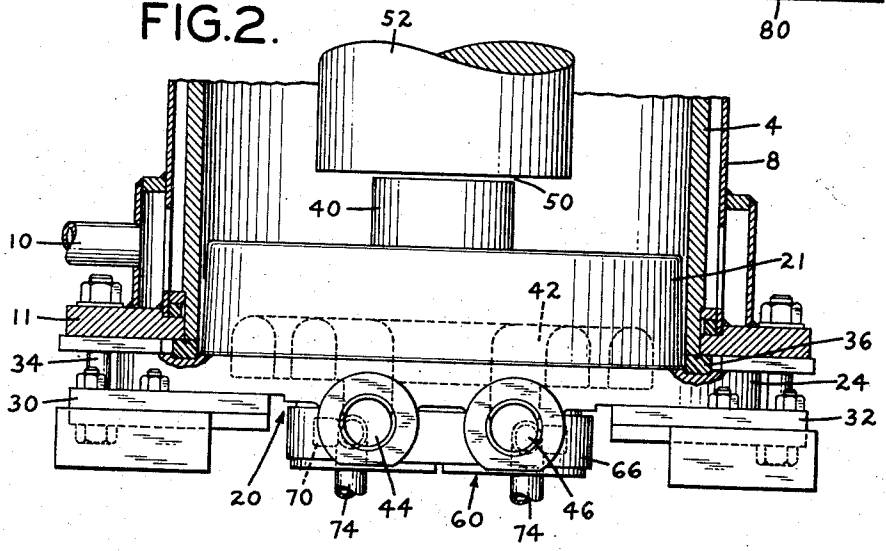


FIG.2.



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FIG. 3.

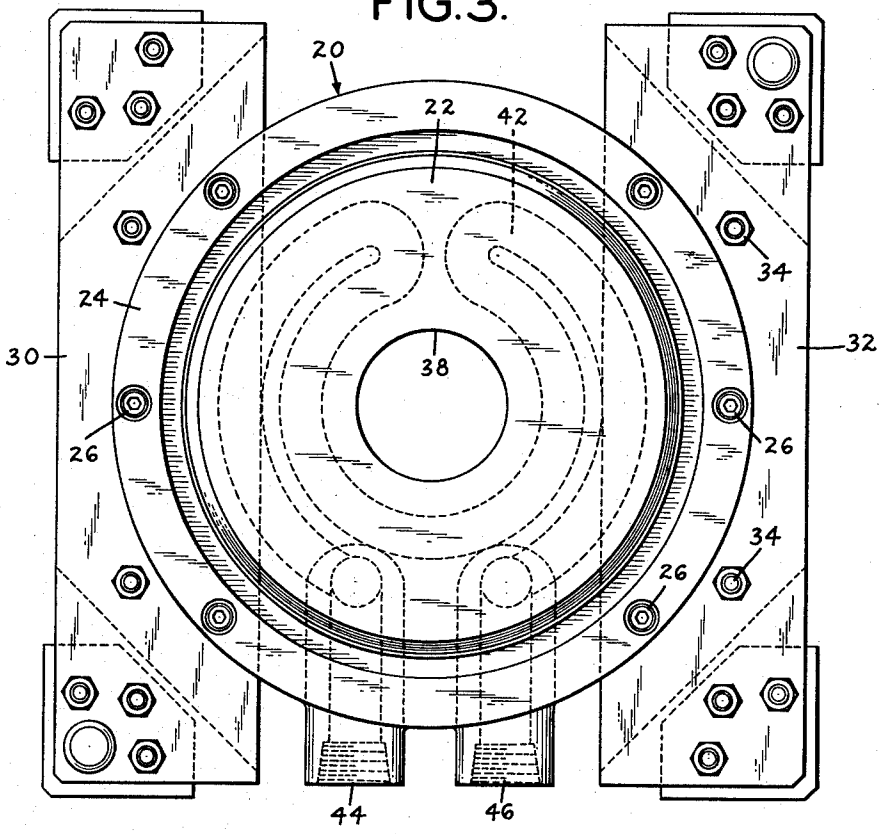
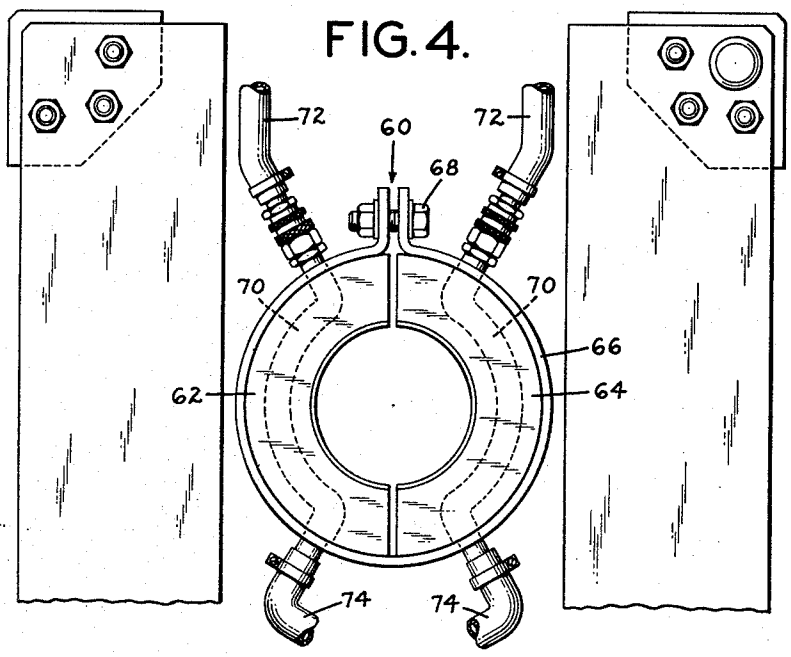


FIG. 4.



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THROUGH-PLUG MOLD STOOL

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This invention relates to apparatus for melting and casting ingots and, more particularly, to electrical arc melting furnaces or molds in which the metal to be melted and cast is subjected to the heat generated by an electrical discharge.

In cold mold arc melting for casting of forging ingots, to which this invention particularly relates, an electrical current is utilized to form an arc in a mold in the presence of the metal to be formed into an ingot. The heat generated at the arc melts the metal, causing the melted or molten metal to flow to form the ingot. As the molten metal is deposited in the ingot it is cooled and solidified. Thus, as the process continues, metal is melted and flows downward progressively forming the ingot.

In apparatus conventionally employed in such process, an electrode is positioned in the mold cavity and serves as one of the electrical terminals for the arc. The electrode may be of the consumable type wherein, as the process progresses, the lower or arc end of the electrode is melted and is the source of metal for the ingot being formed or the electrode may be non-consumable or fixed, the metal for melting being supplied from a separate source.

During the initial stages of the process, the electrical arc is struck between the electrode and the stool or bottom of the mold which serves as the other electrical terminal. As the process progresses and the ingot forms, the stool is covered by the melted metal and the ingot, as it forms, progressively fills the mold cavity. Whether of the consumable type or of the non-consumable or fixed type, the height of the lower or working end of the electrode is adjusted during the process to maintain a relatively constant arc gap between the electrode and the top of the rising ingot. Once the stool is covered by the forming ingot the electrical circuit is completed through the mold to the ingot, across the arc to the electrode, and through the electrode to the other terminal. Current flow from the mold to the ingot depends upon physical contact between the inner mold wall and the ingot surface.

Since the ingot shrinks within the mold cavity upon solidification and cooling, a positive, fixed area of contact for current flow between these two surfaces does not always exist throughout the melting process. The generally accepted view is that the most intimate contact, for purposes of current flow, exists at the level of the top of the ingot where the metal is still liquid before solidification and appreciable cooling occurs. At this level the metal is fluid and free to contact the wall of the mold intimately. Thus, as the level of the ingot moves upward as molten metal is deposited from the electrode onto the ingot, the intimate contact surface between the ingot and the mold moves upward. Because vapors, arising from the molten metal pool as the pool forms at the top of the ingot, tend to condense on the mold wall ahead of the forming ingot, a rough shell or crust is formed on the wall immediately above the rising ingot. As the molten pool rises, this shell or crust tends to adhere to the lateral surfaces of the ingot causing the outer walls of the ingot to be rough. This rough outer ingot surface promotes random current paths between the ingot and the mold wall and often results in non-uniform current flow. Since the properties of the

ingot are, to a large extent, dependent on a substantially uniform flow of current, the variations in the current flow occasioned by the shell or crust on the ingot wall can have an adverse effect on the uniformity of the properties in the final ingot.

In addition to effecting the uniformity of the properties of the material in the formed ingot, the apparatus conventionally employed in this process are deficient in yet other respects. The shell or crust formed on the inner wall of the mold by the condensing vapor not only promotes random current paths between the ingot and the mold walls but also causes fluctuations in current flow. These fluctuations in flow result in variations in the molding temperature as the ingot is formed. This is, of course, highly undesirable since the properties of the ingot are, to a great extent, controlled by the temperature at which the ingot is formed. In some instances the resistance created by the shell or crust to electrical flow may become so great that an effective electrical insulator is formed at the inner wall of the mold preventing electrical flow between the forming ingot and the mold. When this condition exists, arcing between the electrode and the mold wall may occur. This arcing not only disrupts the ingot forming process but often causes damage to the mold walls.

It is an object of the instant invention to provide an improved apparatus for cold mold electrical arc molding.

A further object of the invention is to provide such an apparatus in which there is a definite and fixed electrical path between the ingot and the electrode.

A still further object of the invention is to provide such an apparatus in which the path of electrical flow is independent of the mold.

Still a further object is to provide an apparatus in which an initial arc is established and maintained throughout the molding operation.

A further object is to provide such an apparatus in which the electrical arc and, hence, the molding temperature can be controlled, as desired, throughout the process.

These and other objects will be apparent from the following description and drawings illustrating a preferred embodiment of the invention in which:

FIG. 1 is a vertical elevational view in section of the apparatus of the invention;

FIG. 2 is a view similar to FIG. 1, showing the stool in front elevation;

FIG. 3 is a top plan view of the mold stool; and

FIG. 4 is a sectional view along the line 4—4 of FIG. 1, showing the clamping means for the starting plug.

In the instant invention a removable stool is provided at the bottom or foot of the mold which carries a starting plug. One of the electrical supply leads is connected to the starting plug and the other lead is connected to the electrode. When the furnace is started the lower end of the electrode is positioned a short distance above the upper end of the starting plug, forming an air gap or arc zone therebetween. The current flows in a path directly from the starting plug, through the arc gap and into the electrode. As the metal to be formed into the ingot melts, the molten metal flows downward onto the starting plug, filling the mold cavity and forming a pool of liquid or molten metal around and then on top of the plug. As the process continues additional metal is melted and flows downward into the mold cavity, progressively filling the mold cavity and forming the ingot. As the ingot forms, the air gap or arc zone between the forming ingot and the electrode is maintained relatively constant, the current continuing to flow directly from the starting plug and ingot, and from the electrode through the arc zone. Thus

throughout the process, the flow of current is maintained in a definite and fixed path.

The starting plug may be matched to the material of the ingot or may be of other material so long as the material is electrically conductive. The melt is started by striking an arc between the electrode and the starting material and, as the melt progresses, the arc is maintained between the electrode and the surface of the melted metal adjacent the electrode. The arc is, therefore, centered in the mold and melting progresses in a uniform concentric pattern. Since the mold itself is eliminated from the electrical current path, if desired, the mold may be constructed of electrically non-conductive materials.

Because the melt is started by striking an arc through the air gap between the electrode and the starting plug, which can be easily regulated by adjusting the relative positions of the electrode and starting plug, the use of turnings, powders, grits and the like, to initiate the melt is eliminated. These materials, in the past, have been found to represent a potential source of ingot contamination.

As the melt progresses and the ingot is formed, the ingot, as it cools and solidifies, fuses to the starting plug. Because the starting plug is locked in the stool by the power clamp, the starting plug, after it is fused to the ingot, prevents the ingot from lifting free of the stool. Thus, the ingot is locked to the stool. This reduces mechanical damage to the stool surface particularly during the ingot stripping operation.

Referring to the attached drawings, in FIG. 1 illustrating an embodiment of the invention employing a consumable electrode there is shown a mold cavity, generally designated **2**, having an inner vertical wall **4** surrounded by a cooling jacket formed intermediate spaced walls **4**, **8**. A port **10** is connected to cooling jacket wall **8** for admitting coolant into the spaced intermediate walls **4** and **8**. An outwardly extending flange **11** is fixed at the lower end of mold cavity **2** and is fastened to walls **4**, **8** by welding, brazing or in any other suitable manner. The lower end of mold **2** is closed by a stool, generally designated **20**, which forms the base or bottom wall of the mold.

The stool includes a base **21** having an enlarged central portion **22** and an outwardly extending flange **24**. Base **21** is fastened to the lower end of furnace **2** by bolts **26** which pass through flange **24**, fastening the flange to spaced plates **30**, **32** which, in turn, are fastened by bolts **34** to flange **11** on mold **2**. A gasket **36** is positioned between the upper surface of flange **24** and the lower surface of flange **11**, forming a seal between the flange surfaces for reasons which will be more apparent hereinafter.

At the center of enlarged portion **22** a hole **38** passes through base **21**. Starting plug **40** of electrically conductive material is positioned in hole **38** completely filling the hole. At its opposite ends, plug **40** projects beyond the opposite faces of enlarged portion **22**.

As best shown in FIG. 3, a coolant passage **42** is formed in the enlarged portion **22** of base **21** and extends arcuately around hole **38**. At its opposite ends, coolant passage **42** is connected to ports **44**, **46**, respectively, for delivering and exhausting a coolant to the passage. As shown in FIG. 3, coolant passage **42** consists in two U-shaped portions arranged arcuately around hole **38**. At one of their legs, the U-shaped portions are joined to each other and, at their opposite legs are connected to ports **44**, **46**. Thus, as coolant is delivered to passage **42** the coolant flows from the port down the leg of one of the U-shaped portions, around the U-shaped end and up the other leg into the leg of the other U-shaped portion, around the U-shaped bend in that portion and up the other leg and out through the port.

Referring now to FIGS. 1, 2 and 4, as aforestated plug **40** extends outwardly from the opposite sides of enlarged portion **22** of base **21**. At its upper end plug **40** extends into mold cavity **2** where, for reasons which will be pointed out hereinafter, it is spaced by a discharge gap **50** from furnace electrode **52**.

A power clamp, generally designated **60**, consisting in semicircular identical halves **62**, **64** of electrically conductive material are held in clamping engagement with the lower end of plug **40** by band **66** and bolt **68**. Semicircular halves **62**, **64** are each provided with a coolant passage **70** connected at their opposite ends in conventional manner to coolant conduits **72**, **74**. If desired, a gasket **76** may be positioned between the adjacent faces of plug **40** and clamp **60**.

As shown diagrammatically in FIG. 1, clamp **60**, which is of electrically conductive material, is connected by lead **80** to one side of a melting power supply **82**, the other side of which is connected by a lead **84** to electrode **52**.

In operation, starting plug **40** is positioned in base **21** with the opposite ends of the plug projecting from the opposite sides of the base. Power clamp **60** is fastened to the lower end of plug **40**. Base **21**, with plug **40** in position, is fastened to the bottom of mold cavity **2**. The melting power supply is connected to electrode **52** and to starting plug **40** through clamp **60** and electrode **52** is adjusted with respect to the upper end of plug **40** to form the required air or arc gap. The various coolant supplies are connected and the melting power supply turned on.

With the power supply turned on, the current flow is from power source **82** through leads **80**, **84**, electrode **52**, clamp **60** and plug **40** and across gap **50**. The heat generated by the arc at gap **50** heats the lower end of electrode **52**, causing the lower end of the electrode, adjacent plug **40**, to melt, the melted or molten metal flowing downward onto base **21** filling the mold cavity. As electrode **52** is melted, the electrode is fed downwardly in a conventional manner toward plug **40** maintaining the arc gap between the lower end of the electrode and the plug. As the electrode melts, the height of the molten metal in the furnace cavity increases until the height of the molten metal reaches the top of plug **40**. After the height of the molten metal increases above the upper end of plug **40**, the arc gap between the lower end of electrode **52** is then maintained with the top of the molten metal pool. Thus the melting process progresess, melting metal from the electrode and depositing it at the top of the rising molten pool until the required casting height is reached.

As the molten pool rises, the metal at the lower end of the furnace adjacent base **21** cools and solidifies, fusing with the extending end of starting plug **40**. Thus, the processed metal in the furnace is locked to base **21** by plug **40**, clamp **60** preventing starting plug **40** and the fused metal from rising in the furnace off of the base as the metal solidifies and shrinks. At the end of the process the stool, with the casting fused to the starting plug, is withdrawn from the furnace by disconnecting and withdrawing stool **20** with the starting plug attached. Base **21** is then removed leaving the starting plug attached to the casting. The starting plug may then be removed by turning the end of the casting.

The stool and starting plug of the instant invention may be used in processes carried out under atmospheric conditions or under pressures or vacuums. When carried out under pressure or vacuum, starting plug **40** is fitted into hole **38** of base **21** with gasket **90** to form an airtight fit therein. Base **21** may be formed from any material which will withstand the temperature of the molten metal and will support the necessary load. Clamp halves **62**, **64** may be formed from any material which is electrically conductive. Copper has been found to be a suitable material for both the base and clamp halves and, for some purposes, may be preferred.

While the instant description has been directed primarily to an embodiment where a consumable electrode is employed in the process, it is to be understood the invention is also applicable to processes where a non-consumable or fixed electrode is employed. In the latter, the metal to

be melted and formed into the ingot is fed to the melting zone adjacent the arc from the top of mold cavity **2**. As the molten metal pool rises above the top of starting plug **40**, the electrode is slowly withdrawn to maintain the arc gap between the lower end of the electrode and the top of the forming ingot substantially constant.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A mold for electric arc casting of an ingot comprising, a vertically extending wall forming an opened end mold cavity, a base for receiving said wall and forming a closure at the bottom of said mold cavity, a hole in said base forming an opening through said base communicating with said cavity, a plug in said hole extending, at one of its ends, into said cavity and means at the opposite end of said plug for attaching an electrical lead to said plug.

2. A mold for electric arc casting of an ingot comprising, a vertically extending wall forming an opened end mold cavity, a base for receiving said wall and forming a closure at the bottom of said mold cavity, a hole in said base forming an opening through said base communicating with said cavity, a plug in said hole extending through said base and projecting at one of its ends into said cavity and at its opposite end from said base and means for attaching an electrical lead to said opposite end of said plug.

3. A mold for electric arc casting of an ingot comprising, a vertically extending wall forming an opened end mold cavity, a base for receiving said wall and forming a closure at the bottom of said mold cavity, means for fastening said base to said wall, a hole in said base extending through said base, a plug in said hole projecting at one of its ends from the cavity side of said base into said cavity and, at its opposite end, from the opposite side of said base, a clamp on said plug in gripping engagement with said opposite end of said plug and means for attaching an electrical lead to said clamp.

4. A mold for electric arc casting of an ingot comprising, a vertically extending wall forming an opened end mold cavity, an electrode in said cavity extending axially therein, a base for receiving said wall and forming a closure at the bottom of said mold cavity, a hole in said base forming an opening through said base communicating with said cavity and in substantial axial alignment with said electrode, a plug in said hole extending through said base and projecting at one of its ends into said cavity in substantial axial alignment with said electrode and means for attaching an electrical lead to the opposite end of said plug.

5. A mold for electric arc casting of an ingot comprising, a vertically extending wall forming an opened end mold cavity, a coolant jacket around said wall, an electrode of electrically conductive material in said cavity extending axially therein; a base for receiving said wall and said coolant jacket, said base forming a closure at the bottom of said mold cavity, means for connecting said wall and said coolant jacket to said base, a hole in said base forming an opening through said base communicating with said mold cavity and in substantial axial alignment with said electrode, a plug of electrically conductive material in said hole extending through said base in substantial axial alignment with said electrode, said plug projecting at one of its ends into said mold cavity and at its opposite end from said base, a clamp in gripping engagement with said opposite end of said plug and means for attaching an electrical lead to said clamp.

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