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2 Sheets-Sheet 1

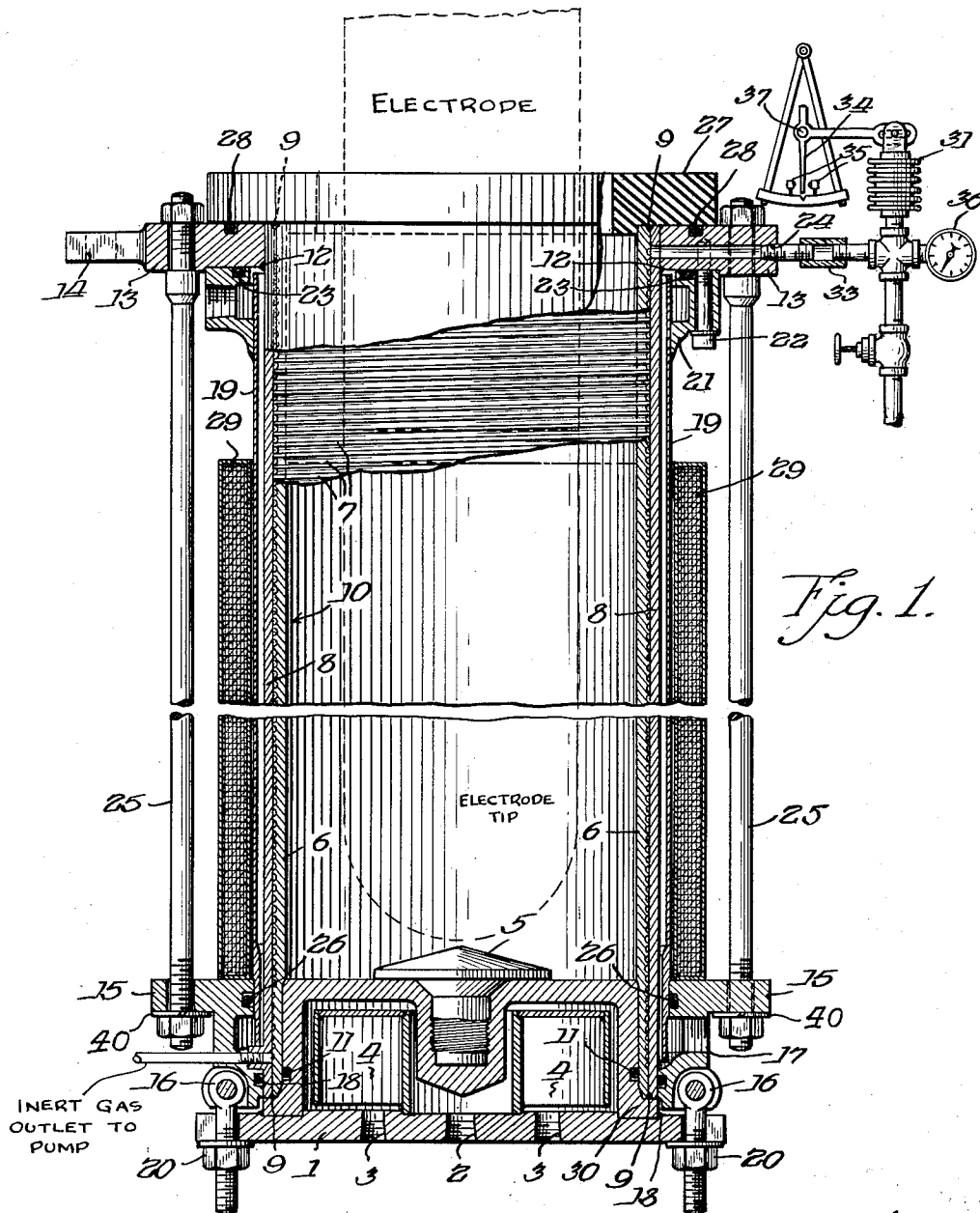


Fig. 1.

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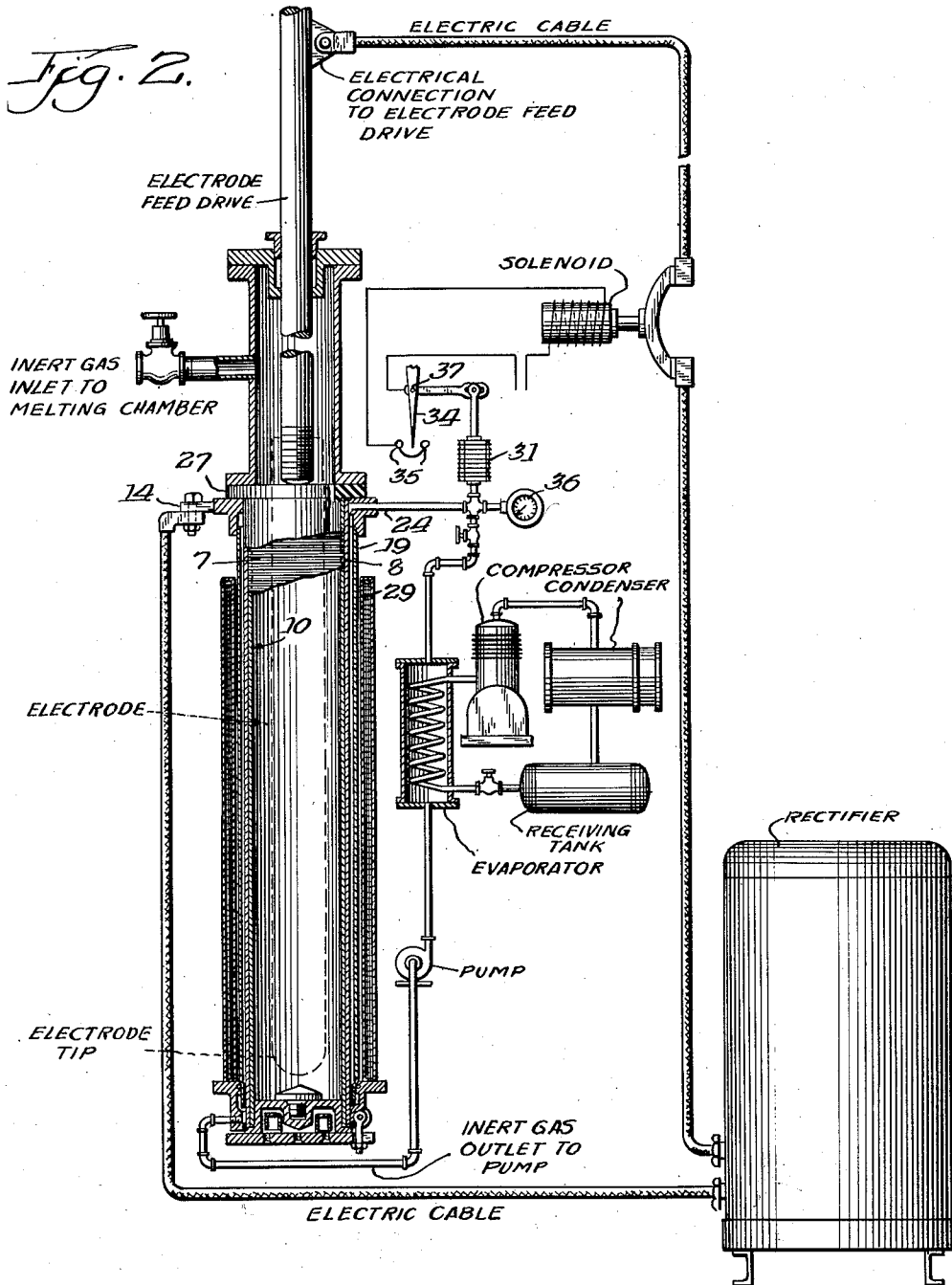
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SAFETY MOLD CHAMBER FOR ARC MELTING FURNACES

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10 Claims. (Cl. 13—9)

The present invention relates to a safety mold chamber for arc melting furnaces and is therefore particularly adaptable to the melting of refractory metals such as titanium and zirconium.

In order to better appreciate the contribution made to the art by our invention, the following background at the outset should be borne in mind. The high melting temperatures required in forming ingots of the refractory metals makes the utilization of electric-arc techniques desirable. However, in attaining the necessary higher melting temperatures, regard must be given to a danger present by virtue of the usual furnace construction employed.

In the usual ingot mold construction, an inner shell of copper or other material of similar high thermal conductivity comprises the mold wall. Another outer shell wall concentric with the copper shell forms a cooling jacket enabling a cooling fluid, usually water, to pass between the two shell surfaces in the normal course of furnace operation.

The existing danger lies in the possibility of an arc burn through of the inner copper shell. This may result from excessive spattering which in the case of titanium is in turn caused by a high magnesium chloride content in the sponge which chloride is deliquescent in nature. Upon the sudden release of the water of hydration occurring as a result of the arcing heat, spattering of molten metal takes place with a possibility for a burn through of the inner copper shell.

A second instance of a burn through may take place if the cooling water circulating in the cooling jacket surrounding the inner copper shell is not flowing at a sufficient rate to remove the heat developed in the arcing chamber. As a result, steam jackets may develop with the generation of a temperature sufficiently high to melt the surrounding copper shell.

It is obvious that a rupture of the copper shell would enable the cooling water to contact the molten refractory metal resulting in an instantaneous generation of steam which is confined in the mold. If sufficient pressure generated by the expanding steam develops, a disastrous explosion of steam, molten metal and furnace fragments may result.

It is one of the main objects of our invention therefore to obviate this danger in the electric arc furnace by providing a mold having a novel mold shell having an intermediate layer of arc cooling or gas maintained under pressure.

It is therefore a secondary object of our invention to provide a novel furnace construction in which an arc-extinguishing relay is provided to assure an added factor of safety as will hereinafter be explained in greater detail.

A further object of our invention is to present a novel mold design in which a safety layer of inert gas may simultaneously effect a mold cooling function by being joined to a recirculating refrigerating system.

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The above and other objects of our invention will become more manifest upon proceeding with the following detailed description, in which

Fig. 1 is a sectional assembly view of an electrical arc melting furnace mold utilizing our invention.

Fig. 2 is a diagrammatic layout of a control arrangement for effecting combined electrical switching and fluid flow.

Referring now to the drawing, an ingot mold or crucible construction is depicted utilizing our invention. The mold comprises the usual crucible bottom 1 having the inlet 2 and preferably the twin outlets 3. The cooling chamber 4 enables a large surface area of the crucible bottom 1 to receive the beneficial effects of the circulating water. The titanium or other refractory metal button 5 threadedly engaged to the crucible bottom initiates the arcing with the usual electrode tip (shown in dotted lines). The ingot mold 10 comprises the inner shell 6 which is spirally relieved at 7 so as to define the annular passage illustrated running the entire length of the outer surface of the inner shell. The solid outer shell 8 is fixedly attached to the inner shell 6 by shrinking the solid shell 8 onto the outer surface of the inner shell 6. The two shells are suitably welded as at 9 so as to make either annular end limit of fluid tight construction. The crucible wall 10 forms a fluid seal with the crucible bottom 1 by means of the O-ring 11. The crucible wall 10 is also welded at 12 to the flange member 13. The latter flange member has the copper lugs 14 for engaging an electrical energizing terminal from a conventional generating source in cooperation with a rectifier as shown in Fig. 2. The water inlet ring 15 is firmly affixed to the crucible bottom by means of the eye-bolts 16 cooperating with the nut members 20. The latter ring is tapped at 17 for engaging a fluid inlet. The water inlet ring 15 provides a fluid-sealing relationship with the outer surface of the crucible 10 by means of the O-ring 18.

A cooling jacket 19 is welded to the water outlet ring 21, which ring is in turn bolted to the flange member 13 by the cap screws 22. A fluid seal is maintained between the latter two flange members by means of the O-ring 23. The aperture 24 entering the flange member 13 enables an inert gas to circulate between the inner shell 6 and the outer shell 8 by means of the spiral passage 7. The crucible wall 10 is clamped to the crucible bottom flange 30 by means of the illustrated tie-rod and nut assemblies 25.

It should be appreciated that the spring washer members 40 inserted between the lower superposed flange 15 and the rod and nut assemblies 25 enable expansion to take place between the furnace shells 8 and 10 and the assemblies 25. Expansion between the aforementioned members occurs as a result of the heat generated in the course of the arcing operation. The O-ring member 26 maintains a fluid seal between the water inlet ring 15 and the water jacket 19.

The insulated ring 27 enables the ingot mold to be electrically insulated from the electrode member shown in dotted lines in the normal course of furnace operation. The latter ring member effects a fluid seal with the flange member 13 by means of the O-ring 28.

Particular attention is now directed to the coil 29 which is essentially a direct current solenoid wrapped about the outer periphery of the water jacket 19 for purposes of stabilizing the arc in the course of normal furnace operation. The stabilizing action is a result of the inner action of the arcing current with the magnetic field generated by the solenoid. Notice is also given to the pressure responsive bellows member 31 which is interposed between the inert gas supply source (not shown) and the

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inert gas inlet 24 positioned on flange member 13. The connection 33 maintains a state of electrical insulation between the ingot mold and the gas supply. The gauge 36 measures the inert gas pressure entering the spiral passageways 7 of the ingot mold. It should also be noted that the pressure responsive bellows 31 reciprocally move, actuating the pointer 34, pivoted at 37, in so doing. The pointer 34 is centered between the two contact points 35. Upon the occurrence of a contact between the pointer member 34 and a contact point 35, the electrode member will become de-energized immediately stopping the arcing operation taking place in the mold chamber.

It is thus apparent that upon occurrence of a fluctuation of the inert gas pressure in the spiral chamber 7 of a predetermined magnitude the pressure responsive bellows 31 will be forced to expand in the case of an over pressure of the inert gas, or be forced to contract in the instance of an under pressure in the spiral passageway 7. An over pressure, for example, may occur upon the failure of the cooling fluid entering at 17 (see Fig. 1), as a result, the inert gas will expand actuating the bellows member and thereby deactivate the electrode member and stopping the arcing operation. Should the arc shown between the electrode member and the melt surface jump or extend to the crucible wall 10 and burn a hole there-through, the inert gas circulating in the spiral passage 7 will enter the area of the arcing. It should be noted that the inert gas passing through the aperture in the shell 6 cools the arc and moves the arcing action from the vicinity of the aperture periphery. Further enlargement of the aperture is thereby prevented, and the burn through of the outer shell 8 which is a confining wall of the cooling water is concomitantly obviated. The inert gas serves to cool the arcing action and also move the arcing from the area of danger.

Simultaneously, the pointer member 34 will contact the point 35 de-energizing the electrode, actuated preferably on low voltages by means of the solenoid shown in Fig. 2 in collaboration with a source of power as the rectifier illustrated. Consequently, the possibility of an arc existing so long as to burn through both the inner shell 6 and the solid outer shell 8 is obviated by our invention. The complete burn through of the ingot mold wall being made practically impossible by our invention, the aforementioned dangers resulting from the contact of the molten metal and the circulating cooling fluid is eliminated.

As shown more clearly in Fig. 2; it should at this time also be noted that inert gas outlet piping may be inserted in the lower portion of the double wall mold penetrating the wall of the outer shell 8 and communicating with the outer surface of the inner shell 6 thereby enabling the inert gas to continuously circulate through the spiral chamber 7. A refrigerating means such as the illustrated compressor, condenser, evaporator and receiving tank may be interposed as a unit between the inert gas inlet 24 and the inert gas outlet illustrated so as to enable the circulating gas to effect a secondary function, namely, that of cooling the ingot mold wall in view of the said gas circulation through the spiral grooving 7. The inert gas may therefore simultaneously perform the arc extinguishing function and an ingot mold cooling function.

It is thus apparent that in the normal course of furnace operation, a safety feature is present, such as that illustrated, which obviates the possibility of an electric arc burn through of the entire thickness of the crucible wall. This is made possible by our novel circulating layer of inert gas which may form a secondary cooling function if desired. A static layer of inert gas maintained under pressure is obviously of equivalent safety.

The illustrated structure may of course be subjected to many modifications by those skilled in the art and still remain within the spirit of our invention, and therefore

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we wish to be limited only by the scope of the appended claims.

We claim:

1. In an electric arc melting furnace, the combination comprising at least one electrode member, means energizing said electrode member, an ingot form member cooperating with said electrode member, said ingot form member having a hollow wall portion defining a fluid-tight passageway, a cooling jacket concentric with said ingot form member, exteriorly accessible inlets and outlets for said ingot form fluid tight passageway and for said cooling jacket, an inert gas supply maintained under pressure connected to said ingot form fluid-tight passageway, pressure responsive means interposed between said inert gas supply and said ingot form passageway inlet, said pressure responsive means actuating said means energizing said electrode member.

2. In a mold of the character described, an inner shell of non-ferrous material, said inner shell being peripherally relieved on the outer surface along the entire length thereof forming a continuous passageway thereon, an outer shell, the inner annular surface of said outer shell being in fluid sealing engagement with said inner shell outer surface, an inlet affixed to one end limit of said inner shell continuous passageway, an inert gas maintained under pressure joined to said inner shell continuous passageway inlet.

3. In an electric arc melting furnace, the combination comprising at least one electrode member, means energizing said electrode member, a mold member in cooperation with said electrode member, said mold member wall having an internal chamber, said internal chamber having an exteriorly accessible inlet and outlet, means providing for an inert gas being maintained under pressure and connected to said internal chamber inlet, means for deenergizing said electrode member when said inert gas pressure is varied a predetermined amount.

4. In an arc melting furnace, the combination comprising at least one electrode member, means energizing said electrode member, a mold therefor having an internal passageway, said passageway having an exteriorly accessible inlet and outlet, and being interposed between substantially the entire inner and outer surfaces of said mold, the said passageway providing for an inert gas maintained under pressure circulating through said passageway in the normal course of operation, refrigerating means interposed between said passageway outlet and inlet, and a cooling chamber surrounding the said mold.

5. In an electric arc melting furnace, a mold comprising an inner shell relieved on its outer surface whereby a spiral passageway is formed thereon, said mold also comprising an outer shell engaging the outer raised surface of said inner shell and positioned in tight abutting relation therewith, exteriorly accessible inlet and outlet means connected to said passageway end limits, a jacket member surrounding said mold, said jacket member defining an annular chamber in cooperation with said mold, the said annular chamber providing for the exteriorly accessible inlet and outlet.

6. In an electric arc melting furnace, the combination comprising at least one electrode member, means energizing said electrode, an ingot mold member, said mold member having an inner fluid-tight chamber interposed between substantially all the inner and outer surfaces of the ingot mold member, an outer cooling jacket means surrounding said ingot mold, said ingot mold fluid tight chamber having an exteriorly accessible inlet and outlet, a source of inert gas maintained under pressure attached to said fluid tight chamber inlet, a pressure responsive bellows member interposed between said source of inert gas and said fluid tight chamber inert gas inlet, and a circuit breaking means interposed between said pressure responsive bellows member and said means energizing the said electrode.

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7. In a mold member for use in an electric arc melting furnace or the like, the combination comprising a non-ferrous shell member disposed about the electric arc of the furnace, a second non-ferrous shell member disposed about said first non-porous shell member and in tight abutting relationship therewith, a fluid-tight passageway disposed about an interface of said shell member, a cooling chamber disposed about said second shell member outer surface, means providing for an inert gas pressure source in communication with said fluid tight passageway, energizing means supplying current for the electric arc, circuit breaking means in communication with said energizing means, and pressure responsive means in interposed relation to said circuit breaking means and said fluid-tight passageway.

8. In an arc melting furnace substantially as described, the combination comprising an electrode member, means energizing said electrode, an arcing chamber, said arcing chamber having a mold member, the said mold member having at least one fluid-tight passageway interposed between the inner and outer surfaces of said mold member, means for a source of inert gas being maintained under pressure in communication with said fluid-tight passageway, cooling fluid means disposed about said mold chamber outer surface, and pressure responsive means in communication with said fluid tight passageway, the said pressure responsive means also being in communication with said means energizing said electrode.

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9. In an electric arc melting furnace, the combination comprising an electrode member, means energizing said electrode member, a non-ferrous mold wall, said mold wall having at least one fluid tight passageway disposed therein, an inert fluid means source in communication with said fluid-tight passageway, and pressure actuated means interposed between said fluid means source and said fluid tight passageway.

10. In a mold of the character described, an inner shell of non-ferrous material, an outer shell in tight gripping engagement therewith, said shell interface being suitably relieved to form a continuous passageway extending substantially the length of the shell interface, an inlet cooperating with one end limit of said continuous passageway, means for an inert gas supply being maintained under pressure and joined to said inlet.

References Cited in the file of this patent

UNITED STATES PATENTS

1,427,319	Peacock	Aug. 29, 1922
1,683,856	Baily	Sept. 11, 1928
1,880,806	Cioffi	Oct. 4, 1932
2,266,735	Berghaus et al.	Dec. 23, 1941
2,541,764	Herres et al.	Feb. 13, 1951
2,640,860	Herres	June 2, 1953
2,662,104	Southern	Dec. 8, 1953
2,697,126	Herres	Dec. 14, 1954