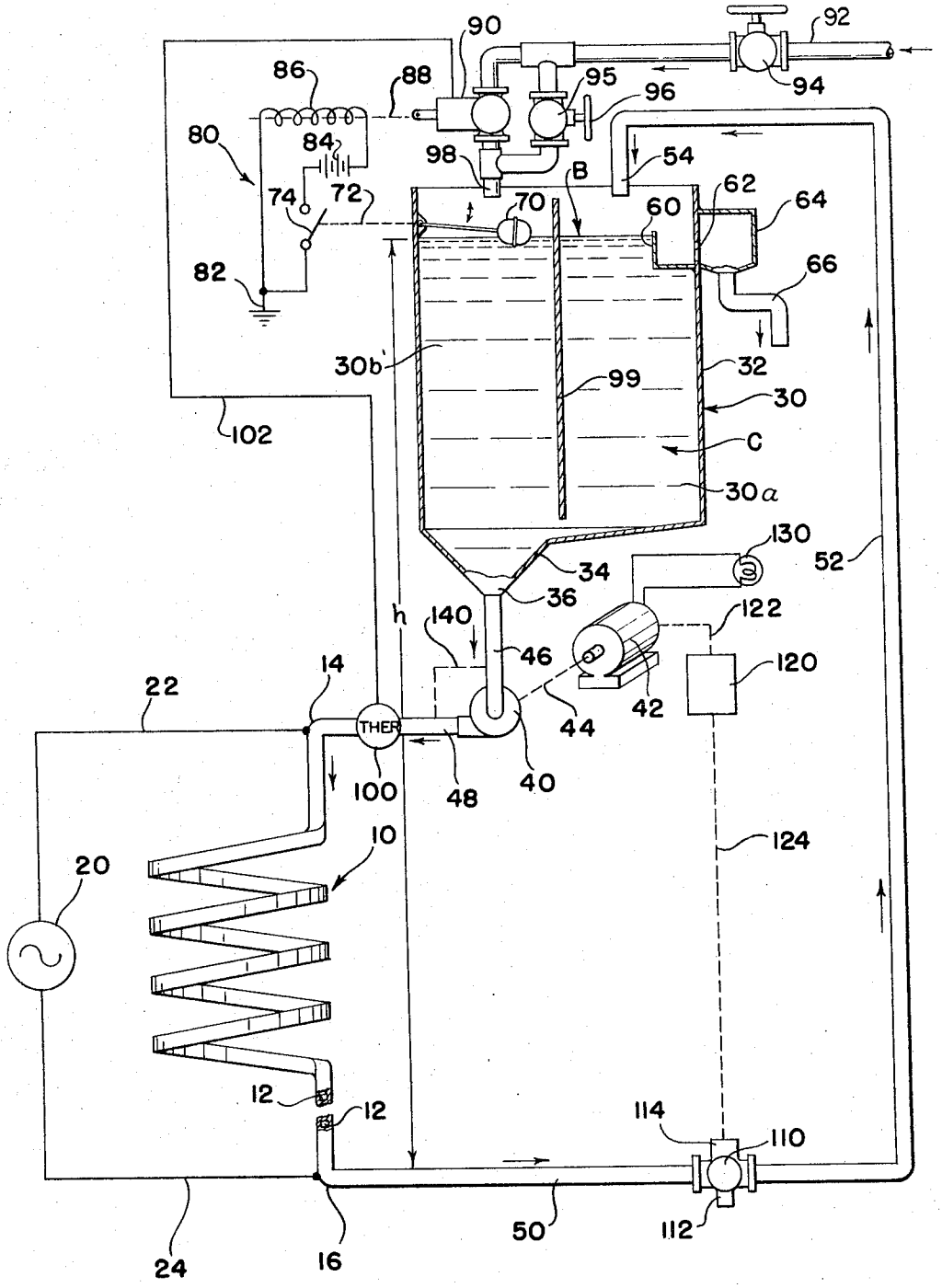
Jan. 24, 1967 R. J. KASPER 3,300,563

APPARATUS AND METHOD FOR PROTECTING THE COIL OF AN INDUCTION MELTING FURNACE

Filed March 9, 1964



INVENTOR.
ROBERT J. KASPER

BY
Tilberry & Body
ATTORNEYS

United States Patent Office 3,300,563 Patented Jan. 24, 1967

3,300,563

APPARATUS AND METHOD FOR PROTECTING THE COIL OF AN INDUCTION MELTING FURNACE

Robert J. Kasper, Seven Hills, Ohio, assignor to The Ohio Crankshaft Company, Cleveland, Ohio, a corporation of Ohio

Filed Mar. 9, 1964, Ser. No. 350,440
8 Claims. (Cl. 13—26)

The present invention pertains to the art of induction heating and more particularly to an apparatus and method for protecting the coil or coils of an induction melting furnace, especially for protecting these coils in the case of failure of the pump in the coil coolant system.

The invention is particularly applicable to the protection of a single coil of an induction melting furnace used in melting metals having high melting temperatures, such as iron and steel, and the invention will be described with particular reference thereto; however, it will be appreciated that the invention has broader applications and may be used for the protection of a plurality of coils for induction melting furnaces of a type used to melt various metals.

An induction furnace for melting metals usually includes a crucible for supporting the metal, a hollow coil surrounding or inside of the crucible, a source of current of a low frequency or high frequency for energizing the coil and a coolant system for continuously circulating coolant, such as water, through the hollow coil for maintaining the temperature of the coil within safe limits. In accordance with the normal practice, the coil coolant system generally includes a tank for holding a supply of coolant and a pump for circulating the coolant from the tank, through the coil, and back into the tank. By utilizing this recirculating arrangement for the coolant, less coolant is required and the expense of maintaining the temperature of the coil at the desired level is correspondingly decreased.

The hollow coil is usually formed from copper, or a similar highly conductive metal, which metal has a melting temperature substantially lower than the melting temperature of the metal being melted within the crucible. For this reason, it is essential that a large quantity of coolant be continuously circulated through the coil to prevent melting of the coil by the heat of the metal within the crucible or the I^2R heat generated in the coil itself. Consequently, if the coolant circulating pump fails for any reason, and the flow of coolant through the coil is stopped, the heat of the metal within the crucible and the I^2R heating of the coil tend to melt the coil which, obviously, destroys its usefulness. When this happens, the melting furnace must be completely shut down and repaired, which, not only involves considerable material and labor expense, but also incapacitates the melting furnace for a prolonged time. This results in a loss of melting capacity which can be quite serious if there is no other furnace to assume this loss in capacity.

In addition, when the coil melts, the residual coolant is sometimes released directly into the molten metal within the crucible. This coolant either forms steam or ionizes with such a release of energy that an explosion can occur to splatter molten metal from the crucible. This splattering molten metal can cause serious injury to persons around the melting furnace.

The present invention is directed toward an apparatus and method for protecting the coil of an induction melting furnace so that the coil is not damaged upon failure of the coolant circulating pump.

In accordance with the present invention, there is provided an improvement in an induction furnace of a

type including a coil with a central coolant receiving passageway with a first and second access opening, a power source for imposing a low or high frequency current across the coil, a coolant circulating pump having an inlet and an outlet, a tank for supplying coolant to the pump inlet, first conduit means for communicating the pump outlet with the first access opening, second conduit means for communicating the second access opening with the tank and means for maintaining a given level of coolant within the tank. The improvement in the above-described melting furnace, as contemplated by the present invention, includes means for by-passing water through or around the pump when the pump is stopped, a drain communicated with the second access opening, the given level being substantially above the coil, the drain being substantially below the given level to establish a coolant pressure head on the drain, and valve means for selectively opening the drain as the pump stops.

By constructing the melting furnace in accordance with the invention, as defined above, coolant will be circulated by the coolant pressure head through the coil as soon as the drain is opened, even though the pump is inoperative. This circulation of coolant prevents the metal within the crucible from raising the temperature of the coil above the melting temperature of the metal forming the coil.

In accordance with another aspect of the present invention, there is provided a method of preventing destruction of the melting furnace coil upon failure of the pump in the coolant circulating system for the coil, the method comprising: providing a coolant drain in the coolant circulating system, storing a supply of coolant above the coil to develop a coolant pressure head greater than five feet of water on the drain and, on failure of the pump, opening the drain whereby the pressure head forces the coolant through the coil and out of the drain.

The primary object of the present invention is the provision of an apparatus and method for preventing destruction or damage of a melting furnace coil upon failure of the pump in the coolant circulating system for the coil, which apparatus and method are inexpensive and easy to incorporate in existing equipment.

Another object of the present invention is the provision of an apparatus and method for preventing destruction or damage of a melting furnace coil upon failure of the pump in the coolant circulating system for the coil, which apparatus and method maintain coolant flow through the coil even if the pump should fail.

Still another object of the present invention is the provision of an apparatus and method for preventing destruction or damage of a melting furnace coil upon failure of the pump in the coolant circulating system for the coil, which apparatus and method involve the provision of a coolant supply tank above the coil and a drain below the level of coolant in the tank so that upon failure of the pump the drain can be opened to allow gravity flow of coolant through the coil out of the drain.

Yet another object of the present invention is the provision of an apparatus and method for preventing destruction or damage of the melting furnace coil upon failure of the pump in the coolant circulating system for the coil, which apparatus and method involve the provision of the coolant supply tank above the coil and a drain below the level of the coolant in the tank whereby a pressure head is established on the drain so that upon failure of the pump the drain can be opened to allow gravity flow of the coolant through the coil and out of the drain.

These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment of the present invention

as read in connection with the accompanying drawing, in which the figure is a side elevational, somewhat schematic, partial view illustrating the preferred emobdiment of the present invention.

Referring now to the drawing wherein the showing is for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, the drawing shows a coil 10, taking the form of a multiple turn solenoid type of coil with an internal coolant passageway 12 having an entrant opening at elbow 14 and an exit opening at elbow 16 so that a coolant can be circulated through the coil. The coil 10, in accordance with the preferred embodiment of the present invention, is utilized for heating a batch of metal within a crucible, not shown, so that the coil raises the temperature of the metal to its melting point. The coil 10 may be positioned within the refractory wall of the crucible or it may be located within the metal receiving cavity of the crucible without departing from the intended spirit and scope of the present invention. The location of the coil with respect to the crucible is not an important aspect of the present invention and further discussion thereof is not necessary to appreciate and understand the present invention.

A power source 20 is adapted to generate a high or low frequency current, which current is supplied across the coil by power leads 22, 24 connected onto elbows 14, 16, respectively. It is appreciated that various power sources may be utilized in accordance with the invention; however, in practice it is common to use line frequency or a motor-generator power source with a generator frequency of 1,000 cycles per second or more.

To provide coolant for the coil 10, the preferred embodiment of the present invention includes a coolant tank 30 having a vertical casing 32 and a lower sump wall 34 with an outlet 36. The tank is filled with an appropriate coolant C, which in practice is usually water. Below tank 30 there is provided a coolant circulating pump 40 driven by a motor 42 through a shaft, schematically represented as dashed line 44. An inlet line 46 of the pump is connected onto the outlet 36 of tank 30 and the outlet line 48 of the pump is connected onto elbow 14 so that coolant can be forced into the entrant opening of coil 10 for circulation of coolant through the coil.

Below the coil there is provided a return line 50 having a generally vertical portion 52 and a discharge end 54, which is communicated with tank 30 so that coolant being pumped through coil 10 can be discharged through end 54 into the tank. By the structure so far described, coolant within the tank can be recirculated by pump 40 in a manner commonly known in the induction heating field.

The coolant within tank 30 is maintained at a level B, which ranges from a maximum determined by weir 60 to a minimum determined by float 70, in a manner to be hereinafter described in detail. The weir 60 extends laterally across the tank 30 and coacts with an aperture 62, a drain casing 64 and a drain line 66 to prevent the level B from exceeding a predetermined maximum level. This construction is common in coolant tanks for the coil of an induction melting furnace.

Referring now to the float 70, this float is mechanically connected, by a means represented schematically as dashed line 72, onto a switch 74 so that the switch will be closed when the level B is lowered beyond a preset level. The switch 74 controls a valve closing circuit 80 which is schematically represented as including a ground connection 82, a battery or other voltage source 84 and a solenoid coil 86. The solenoid coil, when actuated, operates a schematically represented element or arm 88. Actuation of arm 88 opens control valve 90 to allow water from city line 92 to pass into the tank 30. Thus, when the switch 74 is closed, the valve 90 is opened to replenish the coolant C within the tank 30.

City line 92 is provided with a conventional inlet valve 94 and a manual control valve 95 which may be actuated by a handle 96 to supply water to tank 30 even when the circuit 80 is not energized. Below valves 90 and 95 there is provided a coolant outlet 98 for directing the coolant from the valves into the tank 30.

As described, the coolant C will be circulated through the coil 10 by pump 40; however, during some stages of the heating cycle it is usually found that the coolant C absorbs a substantial amount of heat energy from the coil 10 so that the coolant enters the coil at a relatively high temperature. This substantially decreases the cooling efficiency of the coolant. To overcome this difficulty, it is common practice to provide a partition 99 within the tank 30, which partition divides the tank into inlet portion 30*a* communicated with the discharge end 54 of line 50, and an outlet portion 30*b* which is communicated with the outlet 36 of the tank. The function of this partition is to allow heat stabilization of the coolant C within the tank 30 so that the temperature of the coolant entering the coil 10 is at the lowest possible temperature.

Quite often, the provision of partition 99 is not sufficient to reduce the temperature of coolant C in line 48 to a temperature necessary for efficient cooling of the coil. Thus, a thermal actuator 100 is provided in the outlet line 48, which actuator is connected by a schematically represented control line 102 onto the automatically controlled valve 90. In operation, when the temperature of the coolant within line 48 exceeds a predetermined value, actuator 100 is energized to open valve 90. The particular arrangement for accomplishing this is not important; however, in practice there is usually provided a solenoid coil, such as coil 86 of circuit 80, for opening the valve 90 upon receipt of a signal from actuator 100. When the valve 90 is opened, water from line 92 flows into tank 30, irrespective of the position of float 70. Thus, the hot coolant received by inlet portion 30*a* is flooded over weir 60 and expelled through drain 66. The cooler water coming from outlet 98 takes the place of this expelled hot water. It is obvious how this reduces the overall temperature of the coolant within tank 30. After the temperature of the coolant is lowered to a preset value, the actuator 100 is de-energized and the control valve 90 is again closed. Thereafter, the coolant is circulated by pump 40 in the previously explained manner.

The apparatus and method for circulating coolant C through the coil 10, as so far described, are substantially in accordance with the prior art and the remaining discussion pertains to an improvement of the prior art to which the present invention is directed. Return line 50 is provided with a drain valve 110 having an outlet 112 and a solenoid controlled actuator 114. When energized, actuator 114 maintains valve 110 closed and when this actuator is deactuated, valve 110 is opened. The location of the drain valve with respect to the coolant level B and the location of the coolant level B with respect to the coil 10 form a primary aspect of the present invention. In accordance with the invention, the drain outlet 112 is spaced below the level B a distance *h*, which distance represents a coolant head between the level B and the drain outlet 112. In addition, the level B is substantially above the coil 10 for a reason to be hereinafter described in detail. It has been found that the coolant head represented by distance *h* must be greater than approximately five feet of water to cause the proper flow of coolant through the coil in a manner to be described.

A control device 120 is connected with motor 42 by schematically represented line 122 and wtih actuator 114 by schematically represented control line 124. When the motor 42 fails during normal operation of pump 40, device 120 is deactivated. This de-energizes actuator 114

to open valve **110** by an appropriate mechanism, such as a spring within valve **110**. Accordingly, when the motor fails, drain valve **110** is automatically opened by device **120** and actuator **114**. Failure of motor **42** during normal use is indicated by a signal device **130**, which, in accordance with the illustrated embodiment of the present invention, is an incandescent lamp. The pump **40** is provided with a means **140** for allowing flow of coolant C through the pump even when the pump is not being rotated by the motor **42**. This means **140** is schematically represented as a dashed line; however, in accordance with the preferred embodiment of the present invention, the means **140** includes passageways within the pump itself for allowing flow of coolant through the pump when the pump is de-energized.

In operation of the invention, the head *h* between level B and drain outlet **112** has no effect during the normal operation of the coolant system. The pump **40** will circulate the coolant C through the coil **10** and the valve **90** will replenish the coolant when switch **74** is closed, or will reduce the temperature of the coolant when actuator **100** is actuated. Upon failure of motor **42**, the drain valve **110** is opened automatically by device **120**. This immediately brings into operation the coolant head *h* so that coolant C in tank **30** will be forced by this head through the means **140**, which in accordance with the preferred embodiment of the present invention is within the pump **40**, and out of drain outlet **112**. In this manner, failure of the motor **42** does not allow the molten metal being heated by coil **10** or the resistance heating of the coil to damage the coil in a manner explained in connection with the prior water circulating devices.

Upon opening of valve **110**, valve **90** is automatically opened or valve **95** is manually opened, by means not shown, so that the coolant C may be replenished as it flows under the influence of head *h* through the coil **10** and out of outlet **112**.

By constructing the water circulating system for an induction melting furnace in a manner explained above, coolant is continuously circulated through the coil even though motor **42** may fail. Accordingly, there is no tendency for the heated metal within a crucible associated with coil **10** to damage the coil. This is a substantial advance in the art of induction melting furnaces and improves not only the safety, but also the operation of an induction melting furnace.

The present invention has been described in connection with one structural embodiment; however, it is to be appreciated that various structural embodiments may be utilized without departing from the intended spirit and scope of the present invention as defined by the appended claims.

Having thus described my invention, I claim:

1. In an induction melting furnace comprising a coil with a central coolant receiving passageway and a first and second access opening, a power source for imposing an alternating current across said coil, a coolant circulating pump having an inlet and an outlet, a tank for supplying coolant to said pump inlet, first conduit means for communicating said pump outlet with said first access opening, second conduit means for communicating said second access opening with said tank and means for maintaining a given level of coolant in said tank, the improvement comprising: means for by-passing water around said pump when it is stopped, a drain communicated with said second access opening, said given level being substantially above said coil, said drain being substantially below said level to establish a coolant pressure head on said drain, and valve means for selectively opening said drain as said pump is stopped whereby said coolant will flow by gravity from said tank, through said coil, and out said drain.

2. The improvement as defined in claim **1** wherein said by-passing means is a passage in said pump for allowing gravity flow of coolant through said pump when said pump is stopped.

3. The improvement as defined in claim **1** wherein said drain is located below said coil.

4. The improvement as defined in claim **1** wherein said pressure head on said coolant is greater than approximately five feet of water.

5. The improvement as defined in claim **1** wherein said means for maintaining said given coolant level in said tank includes a level sensing means, a cool coolant inlet pipe communicated with said tank and means responsive to the sensing means for opening said inlet pipe when said level decreases below a given amount.

6. The improvement as defined in claim **5** including means for opening said inlet pipe when said motor is stopped.

7. The improvement as defined in claim **1** including means for automatically opening said valve means when said motor is stopped.

8. A method of preventing destruction or damage of a melting furnace coil upon failure of the pump in the coolant circulating system for said inductor, said method comprising: providing a coolant drain in the coolant circulating system, storing a supply of coolant above said coil to develop a coolant pressure head greater than approximately five feet of water on said drain, and, on failure of said pump, opening said drain whereby said pressure head forces said coolant through said coil and out of said drain.

References Cited by the Examiner

UNITED STATES PATENTS

1,805,938	5/1931	Clouse	219—10.49
2,490,105	12/1949	Strickland	219—10.51

RICHARD M. WOOD, *Primary Examiner.*

ANTHONY BARTIS, *Examiner.*

L. H. BENDER, *Assistant Examiner.*