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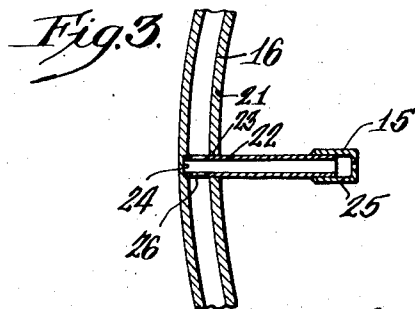
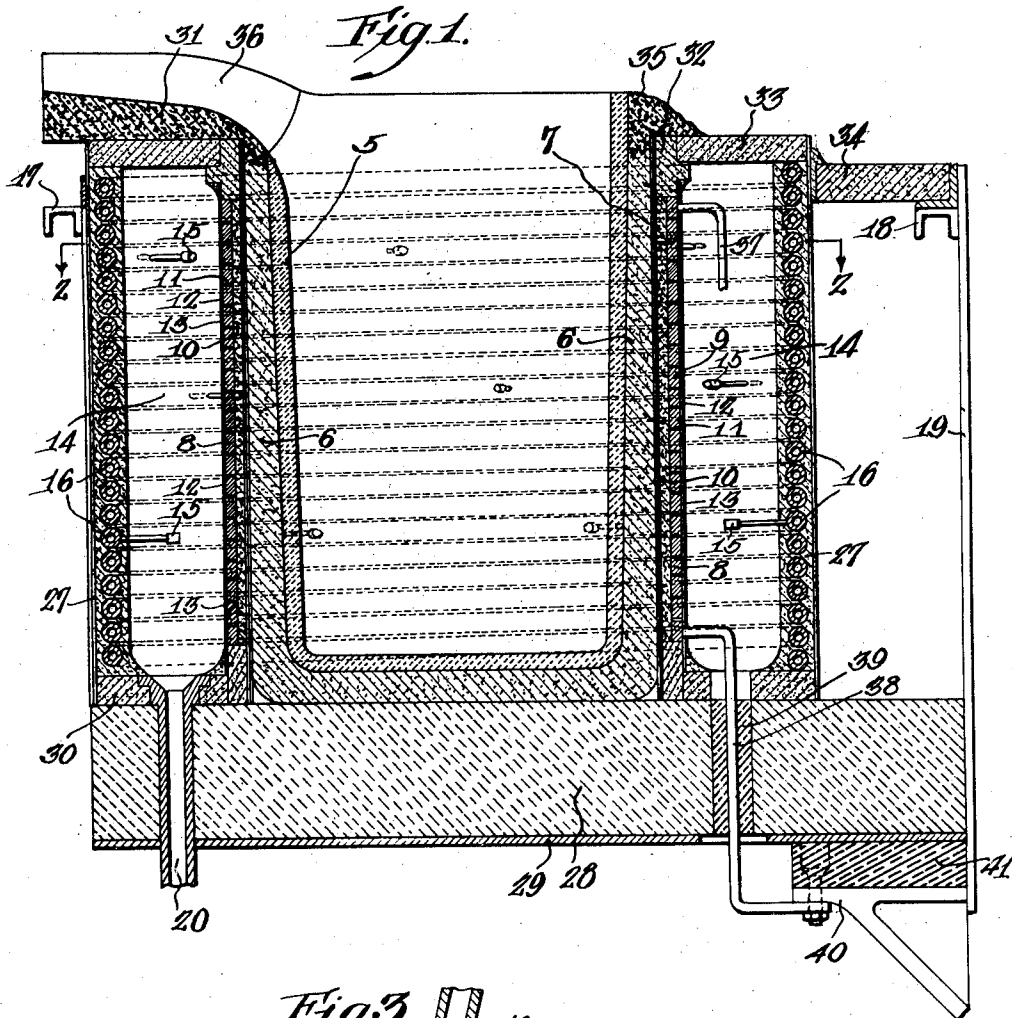
E. F. NORTHRUP

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INDUCTION ELECTRIC FURNACE

Filed July 13, 1929

2 Sheets-Sheet 1



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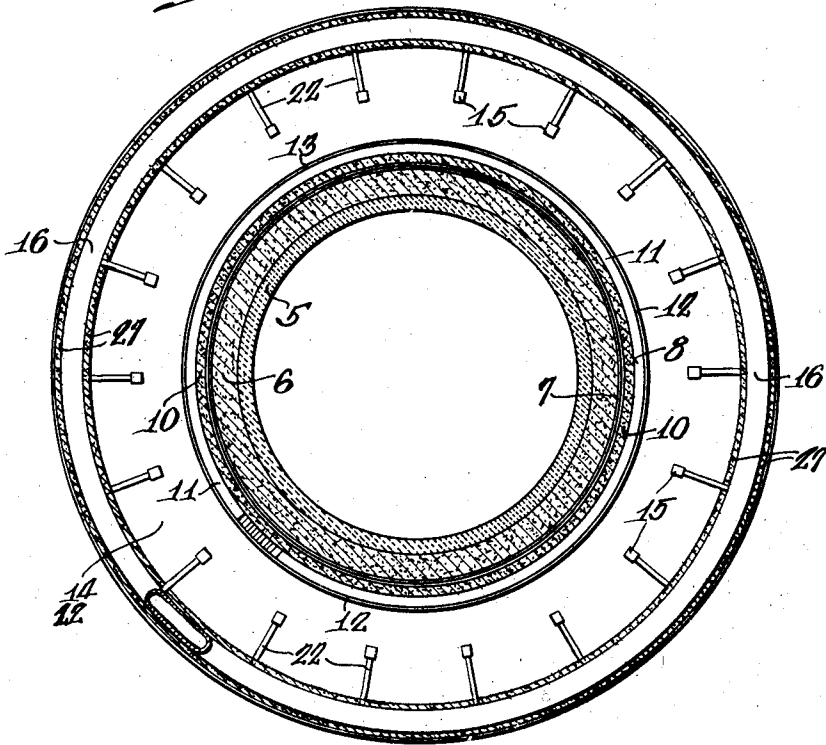
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Fig. 2.



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UNITED STATES PATENT OFFICE

EDWIN FITCH NORTHROP, OF PRINCETON, NEW JERSEY, ASSIGNOR TO AJAX ELECTROTHERMIC CORPORATION, OF AJAX PARK, NEW JERSEY, A CORPORATION OF NEW JERSEY

INDUCTION ELECTRIC FURNACE

Application filed July 13, 1929. Serial No. 378,036.

My invention relates to induction electric furnaces and particularly to cooling the inductor coils of such furnaces.

The main purpose of my invention is to cool the inductor of an induction electric furnace by vaporization of a liquid through the heat of the furnace inductor, applying the latent heat of vaporization of the liquid to the cooling of the furnace inductor.

A further purpose is to electrically insulate an inductor furnace inductor against short circuiting by liquid application and to spray the liquid upon the insulated surface taking up the heat of the furnace in vaporization of the liquid.

A further purpose is to greatly reduce the amount of liquid required for cooling a furnace inductor.

A further purpose is to use a liquid spraying coil outside of a furnace inductor for the double purpose of carrying liquid to spray upon the inductor and of eliminating the external field about the inductor.

A further purpose is to use a liquid spraying coil outside of a furnace inductor for the double purpose of carrying liquid to spray upon the inductor and of mechanically protecting from leakage of molten metal.

Further purposes will appear in the specification and in the claims.

My invention relates to the methods involved and also to apparatus by which the methods may be carried out.

I have preferred to illustrate one form only among the various forms in which my invention may be practiced, selecting a form which is practical, efficient and reliable and which at the same time well illustrates the principles of my invention.

Figure 1 is a vertical central section through the pouring spout of a coreless induction electric furnace in connection with which my invention is shown.

Figure 2 is a section of Figure 1 taken upon line 2—2.

Figure 3 is a fragmentary enlarged section showing a portion of a spraying coil at the point at which a spraying outlet is attached.

In the drawings similar numerals indicate like parts.

I apply my invention to a form of induction electric furnace to which it is well suited but which for my broader disclosure must be regarded as largely diagrammatic since the detail of the furnace may be greatly varied without interfering with application of the broad invention to the inductors of furnaces. Viewed from this standpoint the presence of the crucible in the furnace, as distinguished from a sintered lining, for example, the detail of the cross-section and arrangement of the inductor of the furnace, the character and distribution of the insulation, the shape of pool provided and the finish, character of frame and support of the furnace are not material to the broader disclosure which requires only that there be a furnace inductor upon which my cooling spray may be directed.

Water cooling of furnace inductors is not new; but in the past it has been customary to pass water through a hollow coil conductor in sufficient quantity to keep the conductor temperature down. This has involved the supply of a large quantity of water since the water cannot take up much heat from the coil before it must be discharged from the coil.

In the present case approximately a twentieth as much water is required as compared with the prior art and it can be supplied as a small stream within thick pipe walls, thoroughly safeguarding the water used.

Describing in explanation and not in limitation:—

In the furnace shown I have illustrated a crucible 5 surrounded by a finely divided refractory 6, which is tamped in, and a retaining shell such as micanite 7, for example. Outside of the micanite and in engagement with the turns 8 of inductor 9 I provide an air-dried shell or lining 10 of molded refractory for which I find quite acceptable a mixture of 70% sand, 20% thermolite (chrome ore with a binder) and 10% sodium silicate. The finely divided refractory, micanite and air-dried lining represent one desirable form of heat insulation, which at the same time protects well against engagement of the coil by molten metal leaking from the melt and is suitable whether a crucible be used or not.

When a crucible is not used the finely divided refractory is increased in depth and sintered to form a holding wall.

Good results have been secured from a refractory 6 formed of 85% chrome ore and 15% thermolith.

The inductor coil, as shown, is formed of copper strips spirally wound with a spacing between which may be filled with a separate insulator 11.

For a purpose hereinafter pointed out the inductor coil is coated with a water-proofing material which is also desirably an electrical insulator and which will stand a temperature of several hundred degrees Fahrenheit. I have used a so-called white porcelain which is sprayed on and of which there are several on the market, one under the name of "Insalute". This insulation protects against leakage of liquid through the coil and also fully protects against current short-circuiting. The insulated coil is wound with a tape 13 which acts as a wick when liquid is sprayed upon it. As the most desirable liquid is water I will treat this liquid as water in the specification with the understanding that it is intended to cover any other liquid vaporizable to advantage for the purpose intended. For this tape 13 I find asbestos to be advantageous. The wick-like covering distributes water sprayed upon it so as to make practically the whole surface available as a vaporizing surface.

It will thus be seen my preferred inductor is composite comprising not only the coil proper but the insulation and wicking by which higher voltages are permitted or closer spacings of the turns can be used without short-circuiting and the moisture sprayed can be distributed to the best advantage.

Outside of the inductor I provide a vapor space 14 between the coil and spraying nozzles 15. These nozzles are supplied with water for spraying purposes from a pipe 16 which most desirably forms a spiral surrounding the inner coil. It is short-circuited to permit flow of current by induction within the outer (spraying) coil to act as an eliminator of stray field beyond this coil. This eliminator action takes place because this induced current being opposite to that in the inductor it sets up magnetic lines outside of the (spraying) coil opposing the field at this point from the furnace inductor. These opposing lines can be made to equalize the field from the inductor.

The coil 16, considered as a stray field eliminator may be short-circuited directly as by connection of both ends with a metal furnace casing or frame of which a part only is shown at 17, 18, 19 or can be short-circuited through condensers.

In practice it is quite common to use a voltage between inductor turns of the order of 30 volts. At this voltage the electrical

short-circuiting from spraying pure water upon the surface would be negligible but the result from leakage of water through between the turns of the coil might be much more serious. The Insalute or other "porcelain" water-proof enamel fully protects against both of these and permits free application of the water directly, if preferred, but much more desirably through a wick-like covering. The functions can be performed separately or together as desired. The inductor of course must be much hotter than the vaporizing temperature of the water and thus has a tendency to maintain dry the portion of insulation immediately adjoining it. I prefer not to rest upon any such action, however, and form a complete water-proof insulation between the wick-like material and the coil. However, this need not be formed as one material as the insulation if desired can be effected by an insulating tape and the water-proofing function can be performed directly or outside of the tape by a coating which need not be an insulator.

If asbestos tape be used for the insulating function the requirements of the coating upon it become less stringent and require water-proofing only to prevent short-circuiting by water which is carried by the outer wick-like covering.

I distribute the nozzles 15 close enough together circumferentially and vertically to secure good distribution of the water over the surface. The nozzles spray directly upon the inductor surface, which in my best form, therefore, means directly upon the covering of the inductor coil and are intended to spray just sufficient water so that the spray will be fully vaporized. However, the variation in the furnace performance by which the furnace current may be cut down at times may result in the spray slightly exceeding that which is required; and for this reason the lower part of the space 14 is formed to guide any water present into an outlet or drain 20 by which it is drawn away from the furnace.

The spraying nozzles 15 are anchored firmly in the coil by any suitable means which I recognize may be greatly varied. For purpose of illustration only I show in Figure 3 one excellent way for effecting this anchorage.

Because of the small amount of total water flow required I am able to use quite heavy, preferably copper, tubing for the water-carrying coil. This provides thick tube walls without unduly restricting the quantity of water flowing through the tubing. The nozzle stems 22 pass through openings 23 in one wall and are seated in sockets 24 formed in the opposite wall. They may be soldered in position and their outlet heads 25 are also soldered on the nozzle stems. This

makes it possible to mount them quickly and to remove them quickly in case of stoppage.

The nozzle stems are laterally apertured at 26 to receive water from the outer coil and these openings permit water not only to enter to supply the spray for the individual stems, but to pass through the stems to provide for the spray demand for other stems.

The outer coil is insulated, is closed against passage of leakage metal through between its turns and is mechanically protected and further supported by an insulating medium 27 which fills the spaces between the coils and covers the inside and outside of the coils. I find that the so-called white porcelain insulate is quite effective for this purpose.

As stated the frame support for the operating parts of the furnace may be widely varied. No attempt has been made to indicate any exact form other than to suggest that it may be made up of structural shapes and metal plate in one convenient form. The elimination of stray fields outside of the water-supplying coil permits the frame to be built without regard to possible magnetic leakage.

The furnace shown rests upon a brick base 28 which may conveniently be of silocel or other form and which is supported by a metal plate bottom 29. The spraying coil and inductor rest upon heat insulation and at the top are protected by heat insulation both of which may also be electrically insulating and which is shown as comprising asbestos lumber 30, 31, 32 and 33 and a filling of asbestos lumber is shown at 34. The upper part of the crucible is protected by an air-dried insulating covering 35 and the spout 36 may conveniently be molded from the same material using a 70-20-10 mixture such as has been described above.

The inductor is supplied with current by conductors 37 and 38 of which 37 is broken away to clear the illustration. Both are insulated by sleeves 39.

These conductors receive their current from corresponding supply conductors of which one only, 40, is shown. It is insulated from the bottom of the furnace by a strip 41.

To prevent the formation of moisture upon the conductors 37 and 38 and to avoid the consequent loss in insulation these conductors may be insulated in any suitable way such as by incasing them in a porcelain or enamel coating.

Much of the description above has been included for the sake of completeness only and is not necessary for my invention except that the various functions performed must be performed by some corresponding structure or be omitted. My invention resides primarily in the provision of a vapor spray using a liquid which vaporizes effectively

against the furnace inductor whether it be insulation covered or carry a moisture distributor or have both provisions and utilizes the latent heat of vaporization for the cooling of the furnace. The insulation of the coil and the wick covering are auxiliary to the main purpose. I take advantage also of the need of liquid supply for this vaporization to apply it in the form of a short-circuited mechanically and magnetically protective coil.

Obviously the invention is not restricted to melting furnaces as distinguished from heating or heat-treating furnaces in which the charge is not melted. Nor is the invention restricted in its usefulness even with furnaces having a molten charge to such as have a conducting charge but applies also to furnaces in which the heating is effected in a supplemental electrically conducting secondary which may be a crucible or auxiliary resistor.

All of these furnaces have inductors and the inductors if they transmit much energy may desirably be or must be artificially cooled.

In operation the furnace may be heated by the inductor and the operations in it may be handled in the same manner as in other furnaces. The coil, however, whether coated and/or covered or not is permitted to attain a much higher temperature than with inter-iorly water-cooled coils.

The water is sprayed against what for cooling purposes is effectively the exterior of the coil; and that it is not actually the exterior of the coil is due to the need of protection against leakage, requiring a thin insulation, and to the desirability of distributing the vaporizing function over a larger area of the inductor than would be true if the wick-feeding of the water were omitted. The moist wick takes up the water quickly and reduces the tendency of the sprayed water to splash. In order to conveniently cover the invention whether the spraying take place directly upon the coil or not, I have used the word "inductor" to cover the "unit" of bare coil or insulated coil or insulated and wick-coated coil.

The amount of water sprayed may be controlled not only by the size of the spray outlets but by the resistance met by the water in other parts of the water circuit and by determination or adjustment of the pressure of the water. This last control makes regulation of the water flow easy.

It is desirable to spray the water at a rate as near to the water vaporizing rate of the inductor as may be, securing a maximum cooling effect from the heating of the water and from the latent heat of vaporization. Excess spraying may be detected quickly and surely by the discharge of water through the drain, keeping in mind that some water va-

porized by the inductor will recondense in the space surrounding the inductor and discharge as water—as distinguished from steam—through the drain unless the temperature of the inductor be kept high enough to maintain a vaporizing temperature throughout the walls of this space.

The outer surface of the wick-like covering material about the inductor coil will be maintained in moist condition by the spray; as the water feeds inwardly toward the coil it will be vaporized resulting in a progressive inward movement of the water toward the coil and outward movement of steam away from it.

The drain provides ample outlet for the steam and for any water condensed or present by reason of feeding water in excess of the inductor capacity for vaporization.

Since the water is vaporized normally as rapidly as it is fed to the space surrounding the inductor the rate of vaporization cannot rise much higher than normal even if molten metal leak from the pool into this space; and the inductor with its insulation forms a mechanical guard against such a contingency.

I appreciate that the method and apparatus are effective to cool heated inductors without regard to the character of the charge to which they are applied.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown, and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The method of cooling a heating inductor, which consists in spraying a vaporizable liquid about the inductor.

2. The method of cooling a heating inductor, which consists in distributing a liquid over the surface of the inductor and in utilizing the latent heat of vaporization of the liquid to reduce the temperature of the inductor.

3. The method of cooling a heating inductor, which consists in spraying a liquid upon the inductor in such limited quantity that substantially all of it is vaporized by the heat of the inductor and in thus protecting against the presence of free water for engagement by leakage furnace charge.

4. The method of cooling a heating inductor, which consists in spraying the inductor with a vaporizable liquid and distributing the liquid by capillary action over the surface of the inductor for purposes of vaporization.

5. The method of cooling a heating inductor, which consists in protecting the inductor against water leakage between the turns, in distributing a liquid over the surface of the inductor by capillary action and vaporizing the liquid so distributed by the heat of the inductor utilizing the latent heat of vaporization to cool the inductor.

6. The method of cooling a furnace inductor and at the same time protecting from stray field about the inductor, which consists in spraying a vaporizable liquid upon the surface of the inductor and utilizing the path of supply of the sprayed liquid to set up a magnetic field outside of it in opposition to the field there set up by the current in the furnace inductor.

7. The method of cooling an electric furnace inductor, which consists in spraying a vaporizable liquid about the inductor while limiting the quantity of said liquid applied to substantially the quantity vaporizable by the inductor.

8. The method of cooling an electric furnace inductor, which consists in spraying a vaporizable liquid about the inductor while limiting the quantity of said liquid applied to substantially the quantity vaporizable by the inductor and draining any excess liquid applied from the inductor.

9. The method of cooling an electric furnace inductor, which consists in applying water to the surface of the inductor and draining excess of water applied by gravity from the inductor.

10. A furnace inductor and means for spraying the vapor of a liquid upon the surface of the inductor to cool the inductor.

11. A furnace inductor insulated to protect from short-circuiting, a source of liquid supply thereabout and connections from the source adapted to spray the liquid upon the furnace inductor to cool the inductor by vaporizations of the liquid.

12. In a cooling mechanism for furnaces an inductor coil, a wick-like covering upon the coil and means for spraying liquid upon the covering to distribute it over the inductor by capillary action.

13. In an inductor type electric furnace, a coreless furnace inductor, a source of alternating current therefor, a mechanically protective water-carrying coil surrounding the inductor coil and spray connections from the water coil adapted to spray the surface of the inductor to cool the inductor by reason of the latent heat of vaporization of the liquid.

14. In an inductor type electric furnace, a coreless furnace inductor, a source of alternating current therefor, a short-circuited water-carrying coil about the inductor adapted to reduce the stray magnetic field outside the coil and connections from the coil upon the inside adapted to spray the water from the coil upon the inductor.

15. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, a water-carrying coil outside of the inductor, connections for spraying the water from the coil into vaporizing heat-transfer relation with the inductor coil, an insulating coating upon the inductor coil, a finely divided refractory between the inductor coil and the charge and walls inside the refractory adapted to hold the charge. 70

16. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, a heat-conducting insulator upon the inductor coil, a short-circuited water-carrying coil about the inductor coil adapted to reduce the stray magnetic field outside the coil and connections from the coil upon the inside adapted to spray the water from the coil toward the inductor coil. 80

17. In an inductor type electric furnace, a coreless furnace inductor, a source of alternating current therefor, a water-carrying coil spaced from the inductor and having a drain between it and the inductor and spraying connections from the water-carrying coil directed toward the inductor. 85

18. In an inductor type electric furnace, a coreless furnace inductor, a source of alternating current therefor, a short-circuited water-carrying coil concentric with and spaced from the inductor adapted to reduce the stray magnetic field outside the coil, a filling between the turns of the coil closing the spaces between the turns of the coil, and connections from the coil upon the inside adapted to spray the water from the coil upon the inductor. 90

19. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, a water-proofing insulating coating on the inductor coil, a source of water supply outside the inductor coil and spraying devices connected with the source for spraying the insulated surface of the inductor coil. 95

20. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, a short-circuited water-carrying coil about the inductor coil adapted to reduce the stray magnetic field outside the water-carrying coil, an insulating water-proofing coating upon the inductor coil, a capillary covering upon the coating and connections from the water-carrying coil upon the inside adapted to spray the water from the water-carrying coil upon the covering of the inductor coil. 100

21. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, a short-circuited water-carrying coil about the inductor coil adapted to reduce the stray magnetic field outside the water-carrying coil, an insulat- 105

ing water-proofing coating upon the inductor coil, a capillary covering upon the coating and connections from the water-carrying coil upon the inside adapted to spray the water from the water-carrying coil upon the covering of the inductor coil. 110

22. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, an insulating water-proofing covering on the inductor coil, a capillary water spreader about the covering and means for spraying water upon the spreader. 115

23. In an inductor type electric furnace, a coreless furnace inductor coil, a source of alternating current therefor, a crucible within the inductor coil, a sinterable finely divided refractory about the crucible, an air dried sinterable refractory lining the inductor and about the finely divided refractory, a water-carrying coil outside of the inductor coil, an insulating water-proofing coating on the inductor coil, means for spraying water toward the inductor coil from the outside to vaporize the water and a drain freeing the space about the inductor coil from excess water. 120

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