

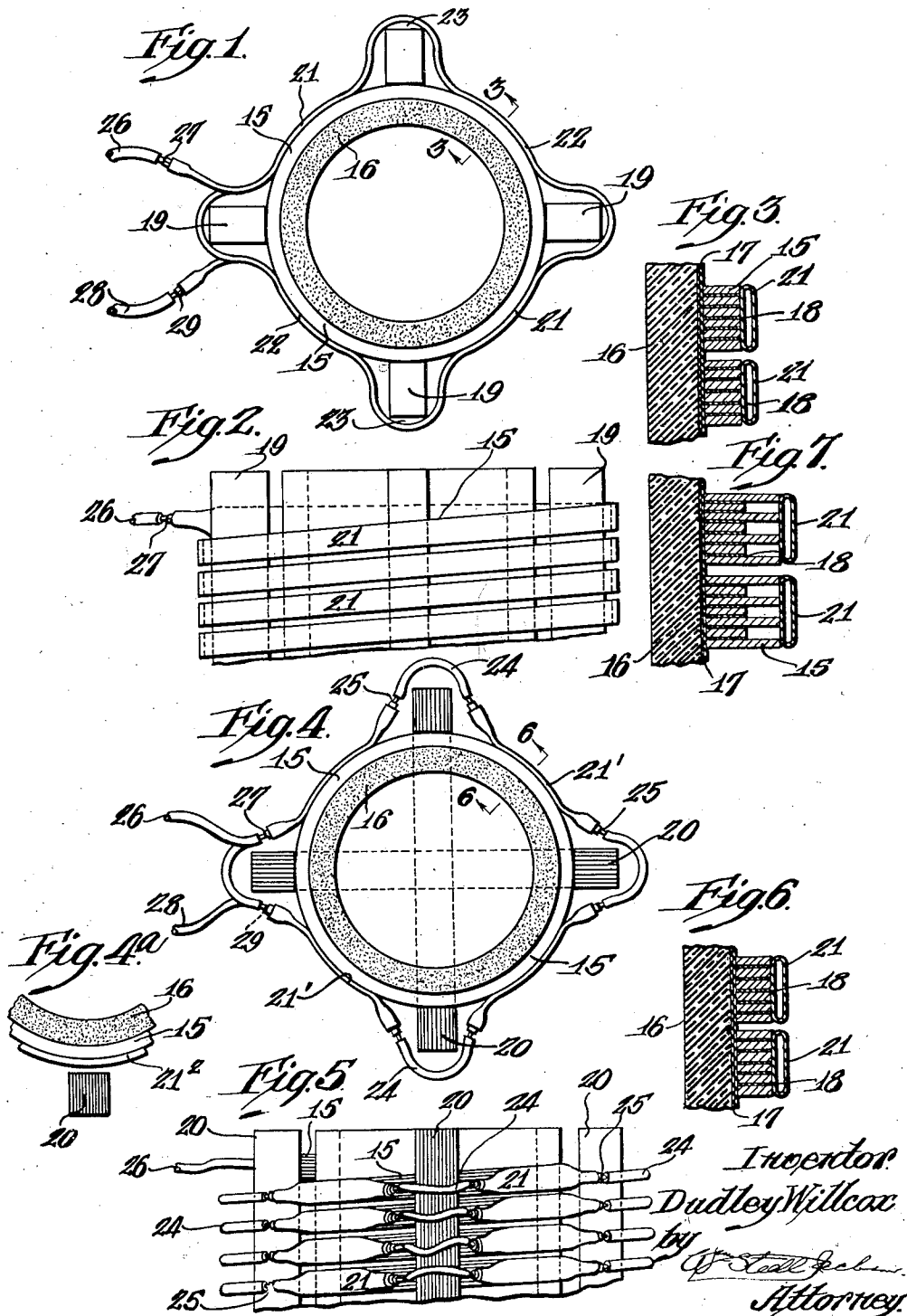
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ELECTRIC INDUCTION FURNACE

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UNITED STATES PATENT OFFICE

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ELECTRIC INDUCTION FURNACE

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My invention relates to the cooling of windings for electric induction furnaces.

One purpose of my invention is to utilize the conductivity of copper to carry the heat away from a section so that water-cooling can be effected by water located in a protected position.

A further purpose is to form the current-carrying part of an inductor of solid material close to the furnace and to locate the water-cooling section upon the outside where the water will be protected against contact with molten metal leaking from the furnace by the body of the coil.

A further purpose is to attach cooling elements to a furnace coil at intervals only about the circumference, relying upon these elements to cool by heat conductivity those portions of the coil lying between.

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

I have preferred to illustrate my invention by a few forms only among the many in which it may appear, selecting forms which are practical, efficient and reliable and which at the same time well illustrate the principles of my invention.

Figure 1 is a top plan view of one embodiment of my invention shown in a furnace in which coil supports interfere with the placing of the cooling elements.

Figure 2 is a side elevation of the structure seen in Figure 1.

Figure 3 is a section upon line 3—3 of Figure 1.

Figure 4 is a top plan view of a further form.

Figure 4a is a fragmentary top plan view showing a slight modification of Figure 4.

Figure 5 is a side elevation of the form seen in Figure 4.

Figure 6 is a section of Figure 4 taken upon line 6—6.

Figure 7 is a fragmentary section similar to Figure 6, but showing a modification.

In the drawings similar numerals indicate like parts.

This application is a division of an application filed by me August 13, 1928, Serial Number 299,156.

My invention is intended to safeguard application of water cooling to the coils of electric furnaces and, though applicable most conveniently and to the greatest benefit to inductor coils for furnaces of the so-called coreless type (lacking interthreading of the coils by transformer or crucible iron) is suited also for use with windings of so-called core type furnaces.

By illustrating the coreless type only it is not intended to suggest that the invention is useful in this type alone.

Existing windings of furnace inductor coils are made of tubing or of solid strips or straps of copper. The tubing is cooled by water passing through the tubing. One sample of water cooled coils is to be seen in Northrup Patent No. 1,328,336.

When the inductor is made of solid metal it is necessary to cool the coil by a blast of air or other means to take the place of the water cooling in the hollow tubular form.

My invention contemplates cooling an otherwise solid coil by water cooled means located outside of the coil where the water-carrying members are protected against flow of molten metal leaking from the furnace. These water cooling members may be attached to the coils, but ordinarily should be attached at intervals only along the length of the coils.

The points of attachment may be located at different points along the lengths of the coils or at different points about the circumference or both. In the case of larger coils it is desirable to have several points of attachment on each turn.

Though the invention is valuable for small furnaces its paramount value as a safeguard against injury from water contact with molten metal makes it still more useful with large furnaces.

With its greater power of cooling as compared with air cooling, and with spacing of the water cooling outside of the furnace coils, my invention makes it possible to wind the turns of the primary coils axially closer together than is possible with the air cooled coils, using very thin electrical insulators between in the form of cut rings or strips of mica, for example, which will completely fill

the space between the turns instead of the small insulating pieces at intervals about the coils now required with air cooled coils in order to give greater room for penetration of cooling air between the turns.

This makes it possible to carry more turns per axial inch of coil length than previously and to obtain a greater number of ampere turns about a given mass or charge of material to be heated than could otherwise be secured.

The additional safety of the present invention as compared with the usual form of water cooled coil made of conducting tubing through which a stream of water is passed will be clear from the fact that molten metal leaking through the insulation of a furnace using a tubular current-carrying inductor coil may melt the inside of one or more of the conducting turns of the coil. This would not only allow the molten metal to engage the water, but this would take place at a point on the inside of the coil where the resulting steam or vapor cannot escape, thus possibly causing an explosion which would blow molten metal out of the furnace.

An interior line of discharge of the water from the coil also throws the water toward the charge increasing the danger. The present invention keeps the cooling liquid well away from the molten metal, discharges the cooling liquid outwardly, and utilizes the coil as a shield and guard against flow of molten metal and water toward each other.

In Figures 1 and 2 each turn of the inductor consists of a plurality of strips 15 connected electrically in parallel. Each of the strips is wound from a copper member of rectangular cross section. The inductor as shown in Figures 4 and 5 is generally similar in character.

In all of Figures 1 to 7, except 2 and 5, heat insulation within the coil is shown at 16. Electrical insulation between the coil 15 and heat insulation 16 is shown at 17 in Figures 3, 6 and 7 and insulation between the inductor members of each turn in order to reduce eddy currents and between the respective members, appears at 18 in Figures 3, 6 and 7. In Figures 1 and 2 non-metallic coil supports are shown at 19.

Figures 4, 5 and 6 are generally similar to Figures 1, 2 and 3, except that laminated magnetic return circuits are provided for the magnetic flux from the coil as indicated at 20 in Figures 4 and 5, instead of the coil supports 19 as seen in Figures 1 and 2.

In Figures 1, 2 and 3 water cooling is obtained by use of a flattened copper tubing 21, flat wound about the turns of the inductor 15, and brazed or soldered thereto at points between the supports 19, or at any other suitable interval, as shown at 22, Figure 1. The copper tubing is bent outward to pass about the non-metallic supports between the points

of contact with the inductor, as indicated at 23, Figure 1.

In Figures 4, 5 and 6 the method of water cooling is essentially the same as that employed in the form of Figures 1, 2 and 3, except that the flattened copper tubing is not continuous about the circumference of the inductor. The hollow copper tubing is interrupted by the insertion of connecting tubes 24 to provide for conduction of the cooling liquid about the laminated magnetic return circuit. The short sections of copper tubing 21' are connected to the inductor as in the form of Figures 1, 2 and 3, and provided with nipples 25 at either end for more ready fitting into the connecting tubes 24.

In both of the forms shown, inlet tube 26, Figures 1, 2, 4 and 5, connected to inlet nipple 27, supplies water to the apparatus, and outlet tube 28 connected with outlet nipple 29 conducts the water away. The nipples are preferably fitted into the copper cooling tubing at points where the tube is not flat.

In Figure 4a the laminated return circuits are spaced from the coil a sufficient distance to permit the employment of water cooling tubing 21² which is continuous about the outside of the inductor 15. In this form the flattened copper tubing is continuously in contact with the adjacent turn of the inductor.

In both of the forms shown in Figures 1 to 7 the same hollow water-cooling conduit is connected to cool a number of inductor members in parallel which make up a complete turn of the inductor, and the conduit engages the contour of these inductor turns at intervals or follows the contour with such continuity about the circumference as may be required to cool the inductor effectively.

In both of the forms the liquid conduit is on the outside where it is protected from flow of molten metal not only by the turns of the inductor itself but by any electrical insulation or other filling which may be desired, permitting complete sealing of the melt from the water-carrying tube by a wall formed by the current-carrying part of the inductor and the insulation within it and between its conductors.

The selection of the form of cooling and the number of places about the circumference of the coil at which the cooling is applied depends, of course, upon the needs of the individual installations. My illustrations for this reason have been suggested merely as ways in which my invention may be carried out so as to place the cooling tubing on the outside where leakage of water from it will least effect the charge and furnace and where the tubing is best protected from flow of metal from the charge. The cooling system is not confined so as possibly to run the risk of a serious explosion if it be overheated.

For large furnaces of the high frequency

induction type holding, for example, five tons of steel, it would be desirable to have the furnace coil made of a plurality of layers of edgewise wound copper strips or straps approximately as shown in Figures 3 and 6. Very thin insulating material, such as mica, should be used between the individual turns to prevent setting up of eddy currents and it is desirable to have the copper or other conductor as close as possible to the furnace charge. Not all of the conductors of a turn need be in thermal contact with the cooling element. In Figure 7 alternate layers of the strap conductors extend further away from the furnace charge than the layers of conductors between them, so that the cooling water is still further removed from the hot metal for the sake of safety. In such a construction good heat-conducting contact is desirable between the intervening strips and those engaging the tube.

The use of a water cooled tube continuously engaging the outer edge of the coil, as shown in Figure 4a would be more effective and less likely to give trouble than the other forms, except that water might be trapped behind members 19 or 20, Figures 1 and 4.

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 part or all 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. In an electric furnace, an inductor having each turn composed of a plurality of edgewound solid conductors electrically in parallel and a flat wound flattened water cooled tube thermally connected with all of the conductors.

2. In an electric furnace, a primary winding, an outer flattened flat wound tube connected to cool the winding and means for supplying water to the tube.

3. In an electric furnace, an inductor, sections of flat metallic tubing flat wound about the outside of the inductor at intervals in heat-conducting contact with the inductor, and insulating tubing connections between the sections.

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