

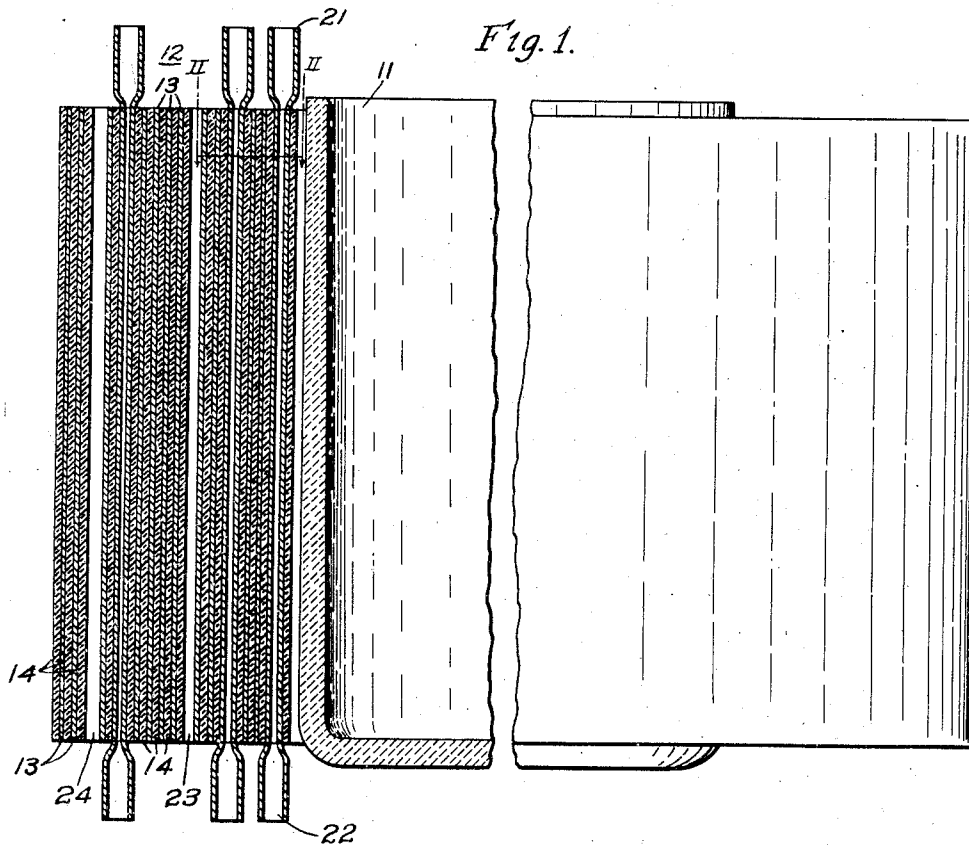
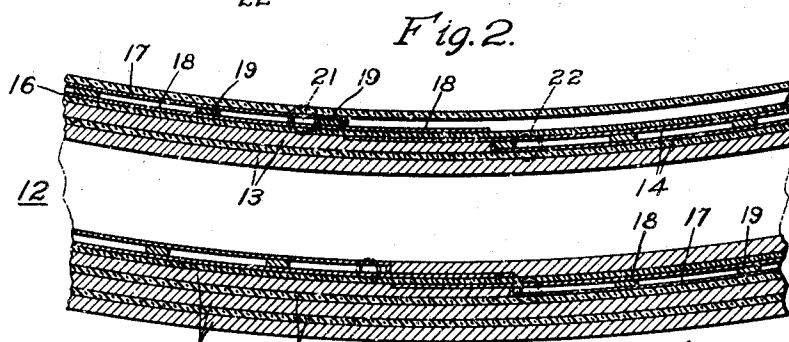
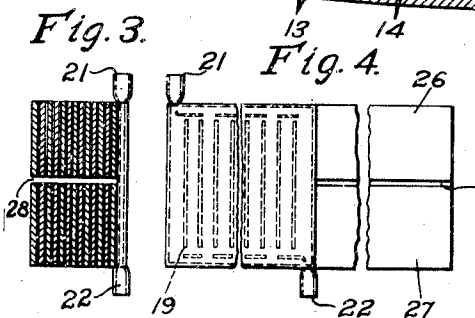
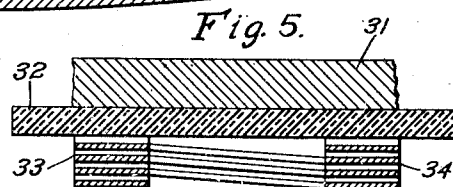
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INDUCTOR COIL

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INDUCTOR COIL

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My invention relates to inductive heating and particularly to energizing coils for inductive heating devices.

5 An object of my invention is to provide a novel, simple and highly efficient energizing coil for an inductive heating device.

Another object of my invention is to provide an energizing coil for an inductive heating device that includes only one turn adjacent to the material being heated, thereby greatly reducing the possibility of a destructive short circuit in case the material being heated is molten metal, and part of it escapes from the containing crucible.

15 Another object of my invention is to provide an energizing coil that shall be effective to reduce the stirring action caused by the electromagnetic field, by reducing the radial component of the field.

20 In practicing my invention, I provide an energizing coil in which the conductor is constituted by a relatively thin solid sheet or sheets of current-conducting material, the total width being substantially the same as the axial length of the coil, wound in spiral form to constitute a plurality of layers or turns. A plurality of spaced turns are constituted by fluid-traversed portions, also traversed by the current, and a plurality of air spaces may be interspersed with the fluid-cooled layers.

In the single sheet of drawing:

Figure 1 is a view, partially in side elevation and partially in vertical section, through an induction furnace including the coil embodying my invention.

Fig. 2 is an enlarged fragmentary view, in vertical section through the coil, taken on the line II—II of Fig. 1,

40 Fig. 3 is a schematic view in radial section through one-half of a coil embodying a modified form of my invention,

Fig. 4 is an extended view of the conductor shown in section in Fig. 3 of the drawing, and

Fig. 5 is a schematic view, in vertical section, of a modified form of coil embodying my invention.

Referring more particularly to Fig. 1 of the drawing, I have there illustrated a crucible 11 adapted to contain metal to be melted which is intended to be illustrative of any material which may be heated or heat treated by inductive action.

A coil 12, constituting more particularly my invention, includes a plurality of spiral layers 13 of a suitable conductor which is preferably made in the shape of a solid sheet of highly electric-conducting material, such as copper. The width of the conductor 13 is substantially equal to the axial length of the material to be inductively heated or, in other words, the strip or sheet of copper constituting the conductor is as wide as the energizing coil is long, axially of the structure.

55 A strip 14, of a suitable electric-insulating material, is located between the adjacent layers of the electric-conducting material 13 and extends to within the innermost layer of the coil.

The innermost layer of the coil is constituted by a double-wall structure 16 which may be built up of two cooperating thinner sheets 17 and 18 (see Fig. 2) which are soldered or brazed together at their edges in order to provide a double-wall fluid-conducting structure, the parts 17 and 18 being separated by a plurality of thin metal strips 19, which are shown in broken lines in Fig. 4 of the drawing.

An inlet 21 and an outlet 22, each of tubular construction, are secured to the opposed corners of the double-wall structure in order to permit such structure to be traversed by a cooling fluid.

I have illustrated two additional fluid-and-electric-conducting layers in Fig. 1 of the drawing, only one of these being shown in Fig 2 of the drawing, in order that a substantially uniform and relatively low temperature may be maintained within the energizing coil structure.

As an additional means for effecting a reduction in the temperature of the energizing coil, I may provide two air spaces 23 and 24, each of these extending through substantially 360° peripherally of the coil structure.

I have elected not to show the details of a clamping or of a supporting structure for

the coil, as these details constitute no particular part of my present invention.

Reference may be had to the sectional view of Fig. 2, wherein I have shown the overlapping connection of the current-and-fluid-traversed part of the conductor and of the substantially solid conductor which, as shown, are overlapped for a short peripheral distance and suitably brazed or soldered together, in order that the fluid-traversed double-wall structure may be connected in series electric circuit with the other portion of the coil and conductor. Instead of using a single sheet of conducting material, the width of which is substantially equal to the axial length of the coil, I may use a plurality of narrower pieces of thin conductor in side-by-side location.

If it is desired to provide a radial air space within the coil, I may provide two strips 26 and 27 of a solid electric conducting material, (see Fig. 4) each strip being slightly less than one-half the width of the double-wall structure hereinbefore described and, upon winding the coil, as on a suitable mandrel or former, an air gap 28, as shown in Fig. 3 of the drawing, will be provided to extend radially of the coil. This, of course, is in addition to the desired number of fluid-conducting layers and in addition to the axially extending air gaps 23 and 24, as shown in Fig. 1 of the drawing.

It is obvious that the innermost fluid-cooled layer will be highly effective in reducing the amount of heat which can flow from the material being heated in the crucible 11 to the rest of the coil structure, and, in order to make this innermost layer as effective as possible, I prefer to have any cooling fluid traverse the innermost layer first and thereafter the other cooling-fluid-traversed structures, so that the coolest cooling fluid will be available at that part of the coil structure subjected to the highest temperature.

The other layers of double-wall structure, traversed not only by an electric current but also by a cooling fluid, will be effective to ensure a low and substantially uniform temperature in a relatively compact coil structure.

Referring to Fig. 5, I there illustrate a modified form of coil embodying my invention. 31 indicates a mass of material to be heated, shown schematically only and supported by a base 32 of some suitable refractory material. A coil 33 located beneath the base or support 32 embodies a plurality of turns of a thin-metal-sheet conductor 34, wound in helical form, the adjacent turns being insulated from each other by suitable means (not shown) in the usual manner. Water-cooled turns may be employed in this form of coil, as were hereinbefore described in connection with Figs. 1 and 2.

A coil embodying my invention may have various ratios of the axial length of coil to the inner diameter thereof and I have found that my improved design of coil is very useful in energizing coils for the inductive transfer of energy in which the axial length of the coil is equal to at least one third of the internal diameter of the coil.

An important element entering into the design of induction coils the conductor of which is to be traversed by a relatively heavy current is the effect of leakage flux thereon. One leakage flux is that which traverses the space between the material being heated and the inner periphery of the coil, and a second leakage flux is that which is not interlinked with all of the turns or layers of the energizing coil. This leakage flux is, of course, that flux which is located in, or transverses the space occupied by the coil itself and flows in a substantially axial direction.

In order to reduce the eddy-current losses in the conductor, it is desirable that the thickness of the conductor be made relatively small and that the plane surface of the metal-sheet conductor extend substantially in the direction of the leakage flux. The method of determining the optimum thickness of such conductor is well known in the art and is substantially the same method as is used to determine the optimum thickness of the conductors in large rotating machines. Having in mind this consideration and also the different sizes of coils, both as to axial length and internal diameter, I prefer to make the ratio of the thickness of the conductor to its width less than one to twenty, or, stated in another way, the width of the sheet conductor is many times its thickness. I find that this results in relatively low losses in the conductor, an important consideration when the material being heated reaches relatively high temperature values, as, for instance, when melting high-temperature alloys or heating metal ingots to rolling temperature.

A coil of this kind will have a smaller radial component of electromagnetic field, in comparison with the axial component of this field, thus making it possible to utilize an electric screen of the general kind disclosed and claimed in a copending application, Serial Number 433,291, filed March 5, 1930 by myself and J. V. Breishy and assigned to Westinghouse Electric & Manufacturing Company, except that the shield need not be subdivided to reduce the eddy-current loss therein.

One filed of application in which my improved coil may advantageously be utilized is in the welding of pipe blanks. In this kind of work, an energizing coil is located either outside of a pipe blank to be welded or on the inside thereof and is traversed by

an alternating current of a suitable frequency to induce alternating current in the pipe blank of such intensity as to raise the abutting or overlapping edges of the seam to a welding heat, pressure or pinch rolls being provided to effect the weld, such devices being old in the pipe-welding art and hence not illustrated here in detail.

As the coil is stationary and the pipe blank is moved relatively thereto, some difficulty has been experienced heretofore in inductive pipe welding machines embodying energizing coils of the type including a plurality of turns per layer located in side-by-side relation. When the leading end of a pipe blank is located intermediate the ends of the coil, axially thereof, that part of the coil not covered by the pipe blank acts as a reactor, thereby reducing the value of the current traversing the coil and making it substantially impossible to effect a perfect weld until all of the coil length is covered. The result of this is that a part of the pipe at each end must be cut off, thereby reducing the output of perfect pipe, or, in other words, reducing the length of perfect pipe which can be obtained from a given length of pipe blank.

If a coil of the kind hereinbefore described is used as the energizing coil in a pipe-welding machine, the effect is quite different, in fact, the coil operates as one having an infinitely large number of turns connected in parallel-circuit with each other.

Assuming that the leading end of a pipe blank is at about one-fourth of the axial length of the coil, that is, about one-fourth of the axial length of the coil is covered by the pipe blank, the part of the coil thus covered will be provided with a closed-circuit secondary of relatively low ohmic resistance while the uncovered part of the coil will ordinarily tend to act as a reactor. In the present type of coil, however, the two paths, i. e., the low-reactance part and the high-reactance part of the coil are in parallel and, hence, the effect of the part of the coil momentarily unprovided with a secondary circuit, is almost negligible. A multi-layer single-turn-per-layer coil of this kind may, therefore, be utilized to advantage in work such as pipe welding, the comments made above applying both to the type of device wherein the pipe blank surrounds or covers the coil and that in which the coil surrounds the pipe blank.

Various modifications may be made in the device embodying my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or are set forth in the appended claims.

I claim as my invention:

1. In an electric induction heater, a plu-

ral-layer energizing coil having a single turn per layer of a relatively thin metal sheet and a cooling-fluid-conducting metal member constituting the innermost layer of said coil.

2. In an electric induction heater, a plural-layer energizing coil having a single turn per layer of a relatively thin metal sheet and including a plurality of radially-spaced individual turns of a double-wall electric-conducting structure, and means for conducting a cooling fluid to and from said individual turns.

3. In an electric induction heater, a plural-layer energizing coil having a single turn per layer of a relatively thin solid-sheet conductor and including a plurality of individual layers of a relatively thin double-wall fluid-and-electric-conducting structure, one of said last-named layers constituting the innermost layer of said coil.

4. In an electric heater for inductively heating material, a plural-layer coil in inductive-energy-transferring relation to material to be heated, said coil having a single turn per layer of a relatively thin solid-sheet conductor, one layer of a fluid-and-electric-conducting structure located at that surface of the coil adjacent to the material being heated, said coil including also a plurality of individual layers of a fluid-and-electric-conducting structure spaced throughout the thickness of the coil, all of said layers being electrically connected in series circuit relation to each other.

5. In an electric induction heater operatively associated with material to be heated by inductive transfer of energy, an energizing coil having a plurality of layers of a relatively thin solid-sheet conductor and one layer of a fluid-and-electric-conducting element located at that surface of the coil adjacent to the material to be heated.

6. In an electric induction heater, a plural-layer energizing coil in inductive energy-transferring relation to material to be heated, said coil including a plurality of layers of a relatively thin current-conducting material, and at least one layer of a current-and-fluid-conducting structure within the coil for cooling the same.

7. In an inductive heating device, a single turn per layer plural-layer energizing coil embodying a conductor whose width throughout the length of the conductor is substantially equal to the axial length of the coil.

8. A device as set forth in claim 6 in which the width of the relatively thin current-conducting material throughout the length thereof is substantially equal to the axial length of the coil.

9. A device as set forth in claim 1 in which the width of the relatively thin metal sheet and of the cooling-fluid-conducting

metal member is substantially equal to the axial length of the energizing coil.

10. A device as set forth in claim 6 in which the layer of current-and-fluid-con-
5 ducting structure is in series circuit relation to the other layers.

11. In an electric induction heater, a plural-layer energizing coil in inductive energy-transferring relation to material to be
10 heated, said coil including a plurality of layers of a current-conducting sheet whose width throughout the length of the sheet is substantially equal to the axial length of the coil to effect a predetermined current dis-
15 tribution axially of the current-conducting sheet in accordance with the axial location of the material relatively thereto.

12. In an electric induction heater, a plural-layer energizing coil in inductive energy-
20 transferring relation to material to be heated, said coil including a plurality of layers of a current-conducting sheet whose width throughout the length of the sheet is substantially equal to the axial length of the
25 coil to automatically effect a greater current density therein in that part thereof in axial juxtaposition with the material being heated.

In testimony whereof, I have hereunto
30 subscribed my name this 21st day of November, 1930.

THOMAS H. LONG.

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