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INDUCTION HEATER COIL

Filed April 21, 1953

Fig. 1.

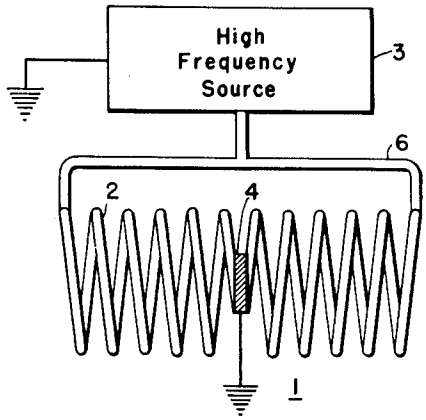
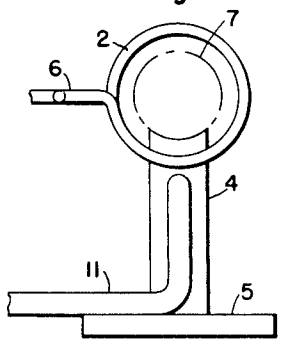


Fig. 2.



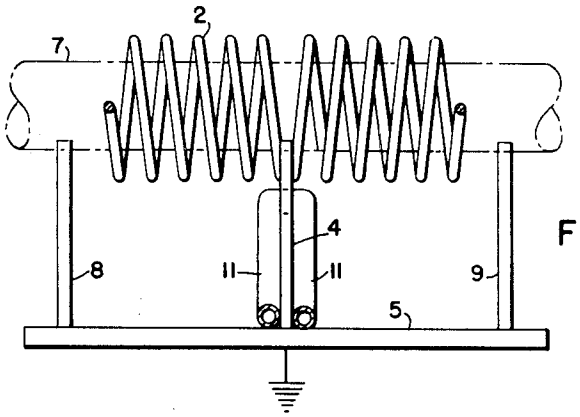
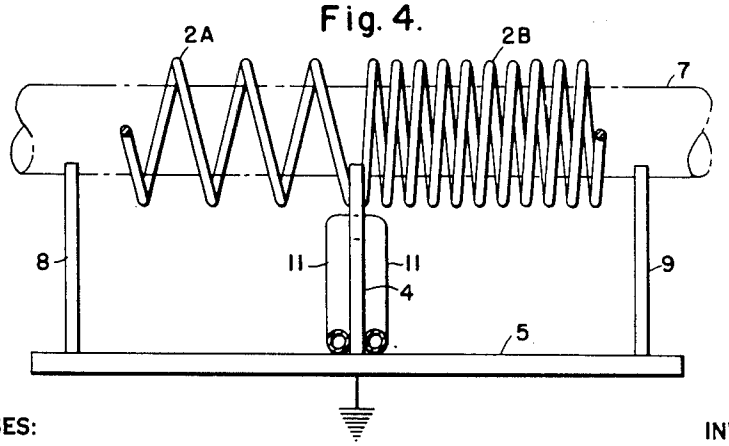


Fig. 3.

Fig. 4.



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INDUCTION HEATER COIL

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9 Claims. (Cl. 219—10.79)

My invention relates to high frequency induction heating apparatus and in particular relates to the structure of a coil for such apparatus having an open core through which the work to be heated is passed, and which carries the high frequency heating current.

Certain types of high frequency heating are carried out by positioning the object to be heated in the center of a helical coil, having a length several times its diameter, in which are flowing alternating currents. Other alternating currents are thus induced in a body positioned within the center of the helix and these heat the body to a high temperature. In the case of longer coils, there is need for some supports in the mid-portions of the coil for the work being heated, and in the prior art these have taken the form of a pair of rails running the length of the furnace. However, it is naturally desirable in most cases, for electrical reasons to minimize the cross-section of the furnace relative to that of the work, and the space required for the rails interferes with this, particularly where the furnace is of small diameter.

One object of my invention is accordingly to provide a new and improved structure for coil-type electric furnaces.

Another object is to provide a novel structure for helix-type electric furnaces in which a central support is provided for work positioned within the helix.

Another object is to provide a structure for helix-type high-frequency furnaces which shall be electrically symmetrical and which provides a support which is grounded at the mid-point of the helix.

Still another object is to provide a helix-type furnace in which the support is permanently positioned within the furnace and need not be withdrawn before power is applied in heating.

Still another object is to provide a helix type of electric furnace in which the spacing between the coils is reduced to a minimum as no spaces between turns are required for supports of my novel type, thus insuring uniform heating of the work.

Yet another object is to provide a helix-type furnace particularly adapted to heat magnetic material beyond the Curie point. In such a furnace, the material would be moved through the helix which would be more widely spaced on the half of its length where the work entered it, and would be more closely spaced in its other half which the material would traverse after heating beyond the Curie temperature at which it loses its high permeability.

Other objects of my invention will become evident to those skilled in the art upon reading the following description taken in connection with the drawings, in which:

Figure 1 is a schematic view in plan showing the heating helix of my invention together with its electrical connections;

Fig. 2 is an end view of the helix in Fig. 1;

Fig. 3 is an elevation of the helix in Fig. 1; and

Fig. 4 is an elevation view of a modification of my invention particularly adapted to heating magnetic loads to temperatures well above the Curie temperature.

Referring in detail to Figs. 1, 2 and 3, an electric furnace 1 adapted to heat metallic or other conductive rod or strip materials has a helical winding 2 comprising a rod or tubular conductor, which may, for instance, be of copper. Current is supplied at a high frequency from a source 3 of conventional type. The helix 2 comprises symmetrical halves of opposite pitch having their adjacent ends brazed or welded to a vertical non-magnetic metal plate 4, which may be of stainless steel, standing upon the base-plate 5 of the furnace. The plate 4 is grounded and so connected to one terminal of the source 3 which is also grounded. The opposite ends of the helical winding 2 are connected together by a bus-bar 6 which is connected, preferably at its mid-point, to the other terminal of source 3. The plate 4 projects somewhat beyond the inner face of the winding 2 and acts as a support for the work-piece 7. Vertical pillars 8 and 9 just outside the opposite ends of winding 2 act as supplemental support members for work-piece 7 from base-plate 5. Since plate 4 is grounded, it may be cooled by means of pipes 11 brazed to its opposite faces and traversed by cooling water or other suitable fluid from a source (not shown). The pipes 11 are connected near their upper ends by a passage through plate 4 so that cooling fluid may flow through them serially.

An arrangement in which the conductors of winding 2 and bus-bar 6 are tubular and have passages entering one pipe 11 and a return duct to the cooling-fluid source at the end adjacent high-frequency source 3 is within the purview of my invention, the cooling-fluid having a high resistivity in such case.

In some cases where the winding 2 is not of great length, the central pillar 4 need not extend to base-plate 5 but may be replaced by a mere work-support member to which the inner ends of the halves of the helix 2 are brazed, and which projects inside the helix to support the work. In such case, the bus bar 6 supports the helix 2 from source 3. The central junction would still be connected to one side of the high frequency source, however.

Referring to the Fig. 4 modification of my invention, iron and other substances have the property of showing a high magnetic permeability at room temperature; but, when they are being heated to a sufficient degree, arrive at a critical point known as the Curie temperature at which their permeability suddenly falls approximately to unity, and so continues at all higher temperatures.

While the furnaces I have been describing may be used by simply placing rods or strips of metal inside the helix to heat, they may also be used for passing long strips of material continuously through the furnace, sliding over the supports 4, 8 and 9. When this is done with magnetic materials, the permeability of the core increases the magnetic field intensity for a given heating current, so that fewer ampere turns per inch of length of the workpiece are required to produce a field-strength capable of generating high temperature than is the case where the work-piece is of non-magnetic material. When the material being processed is iron, its ferromagnetic property makes a relatively few ampere-turns per inch of its length suffice to produce intense heating where the iron is below the Curie temperature, but when in its progress through the furnace it reaches the latter temperature, its magnetic permeability drops abruptly to a low value which requires, for intense heating, a higher value of ampere turns per inch of furnace length.

The helix arrangement of Fig. 4 is especially adapted for such heating of continuously moving magnetic material. The two halves of the helical winding are made of different pitch. The section 2A, the entering end of the furnace for the work, has the turns of the helix widely

spaced to correspond with the lower requirement for ampere turns per inch of helical axis. The section 2B of the helix, on the other hand, is provided with turns more closely spaced to provide sufficient magnetic field intensity in the work-material when its permeability drops to unity on heating above the Curie temperature.

While, ideally prehaps, the material 7 should reach the Curie temperature as it passes the mid-support 4, this requirement is by no means critical. The temperature at which the work leaves the section 2B is, of course, determined in some degree by its length as well as the spacing of its turns and current flowing through the coil. A design in which the distance between the mid-support 4 and the outer end of section 2B is different than between mid-support 4 and the outer end of helix section 2A is within the contemplation of my invention. The provision of current varying means between the bus-bar 6 and the two helix-sections 2A and 2B is also within the scope of my idea.

While I have described my invention in a preferred practical application, it is obvious that its teachings are subject to more general application and that the equipment is subject to wide modifications which embody the principles and teachings disclosed herein.

I claim as my invention:

1. In an induction heating apparatus for heating a workpiece, which apparatus is operable with a grounded alternating-current supply source, the combination of a helical heater having an axis, a central work support, and a base member, with said helical heater having an inner face and two coaxial sections of opposite pitch, each of said sections having a first end portion and a second end portion, said coaxial sections extending perpendicularly and in opposite directions relative to said central work-support, with said first end portion of each section being electrically connected to the work-support, said work-support being attached to said base member and extending in a direction perpendicular to said axis and inside said helical heater beyond said inner face of the helical heater, circuit means for grounding said central work-support, said second end portion of each section being adaptable for connection to said supply source, a plurality of work support members, said work-support members respectively being positioned adjacent to the respective second end portions of the coaxial sections and attached to said base member and extending in a direction perpendicular to said axis of the helical heater, and means to cool said central work-support.

2. In an induction heating apparatus operable with a grounded alternating-current supply source, the combination of a helical heater having an axis, a central work support and a base member, with said helical heater having an inner face and two coaxial sections of opposite pitch, each of said two coaxial sections having first and second end portions, said second end portions of each section being adaptable for connection to said supply source, said coaxial sections extending perpendicularly and in opposite directions relative to said central work-support, said first end portions of each section being electrically connected to the work support, with said work-support being attached to said member and extending in a direction perpendicular to said axis and inside said helical heater beyond said inner face of the helical heater, a plurality of work-support members, with one of said work-support members being positioned adjacent to each of the respective second end portions of the coaxial sections and being attached to said base member and extending in a direction perpendicular to said axis of the helical heater, and means to cool said central work-support.

3. In an induction heating apparatus operable with a grounded alternating-current supply source, the combination of a helical inductor having an axis, a central work-support, a base member and a plurality of work-support members, with said helical inductor having an inner face and two coaxial sections of opposite pitch, each of said sections having first and second end portions, said coaxial sections extending perpendicular to and in opposite directions relative to said central work-support, said first end portion of each section being electrically connected to the work-support, with said work-support being attached to said base member and extending in a direction perpendicular to said axis and inside said inductor beyond said inner face of the helical inductor, circuit means for grounding said central work-support, said second end portion of each section provided with means for connection to said alternating-current source, said work-support members being positioned adjacent to said second end portions.

4. In an induction heating apparatus for heating a workpiece, which apparatus is operable with a grounded alternating-current supply source, the combination of a helical inductor having an axis, a central work-support, and a base member, with said helical inductor having an inner face and two coaxial sections of opposite pitch, each of said two coaxial sections having a first end portion and a second end portion, with each of the second end portions provided with means for connection to said alternating-current source, said coaxial sections extending perpendicular to and in opposite directions relative to said central work-support and electrically connected to the work-support, with said work-support being attached to said base member and extending in a direction perpendicular to said axis and inside said helical heater beyond said inner face of the helical heater, circuit means for grounding said work-support, and means for cooling said work-support.

5. In an induction heating apparatus, the combination of a helical heater having an inner face and an axis, a central work support, a base member and a plurality of work-support members, with said helical heater having two coaxial sections of opposite pitch, said coaxial section extending perpendicularly and in opposite directions relative to said central work-support, with said work-support being attached to said base member and extending in a direction perpendicular to said axis and inside said helical heater beyond said inner face of the helical heater, said work-support members being positioned adjacent to the coaxial sections and attached to said base and extending in a direction perpendicular to said axis of the helical heater, and means to cool said central work-support.

6. In an induction heating apparatus for heating a workpiece, the combination of a helical inductor having an axis and an inner face, a central work-support, a base member and a plurality of work-support members, with said helical inductor having two coaxial sections of opposite pitch, said coaxial sections extending perpendicular to and in opposite directions relative to said central work-support, with said work-support attached to said base member and extending in a direction perpendicular to said axis and inside said inductor beyond said inner face of the helical inductor, said work-support members being positioned adjacent to said inductor.

7. In an induction heating apparatus, the combination of a helical inductor having an axis and an inner face, a central work-support and a base member, with said helical inductor having two coaxial sections of opposite pitch, said coaxial sections extending perpendicular to and in opposite directions relative to said central work-support, with said work-support attached to said base member and extending in a direction perpendicular to said axis and inside said inductor beyond said inner face of the helical inductor.

8. In an inductor heating apparatus, the combination of a helical inductor and a central work-support, with said inductor having an axis, an inner face and two coaxial sections of opposite pitch, said coaxial sections extending perpendicular to and in opposite directions relative to said central work-support, with said work-support

extending in a direction perpendicular to said axis inside said inductor beyond said inner face of the helical inductor.

9. In an induction apparatus for heating a workpiece through a temperature range in which its electromagnetic properties change, a helical heater having an axis and comprising a plurality of coaxial sections, a first section being operative to effect the heating of said workpiece up to the Curie temperature and a second section being operative to effect the heating of the workpiece above the Curie temperature, with each of said sections having a plurality of turns of like pitch and with the turns of each section having a pitch which differs from the pitch of the turns of the adjacent sections.

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