June 13, 1944. H. E. SOMES 2,351,300

INDUCTION HEATING APPARATUS

Filed May 25, 1942 2 Sheets-Sheet 1

FIG. 2

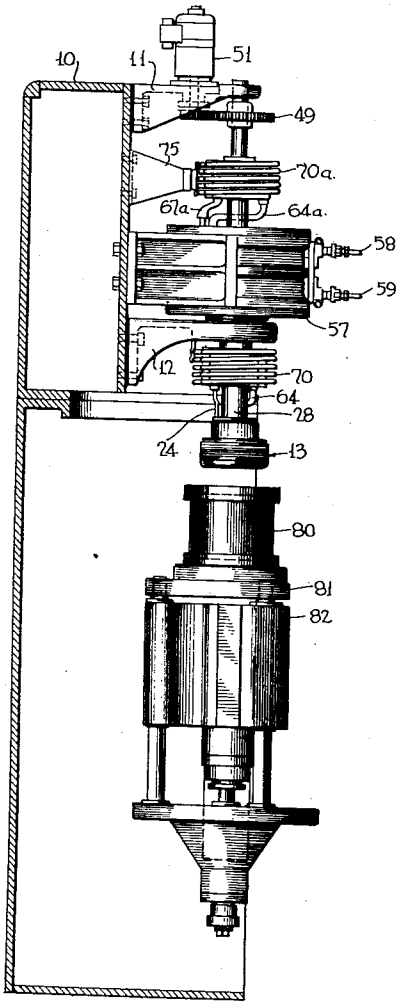
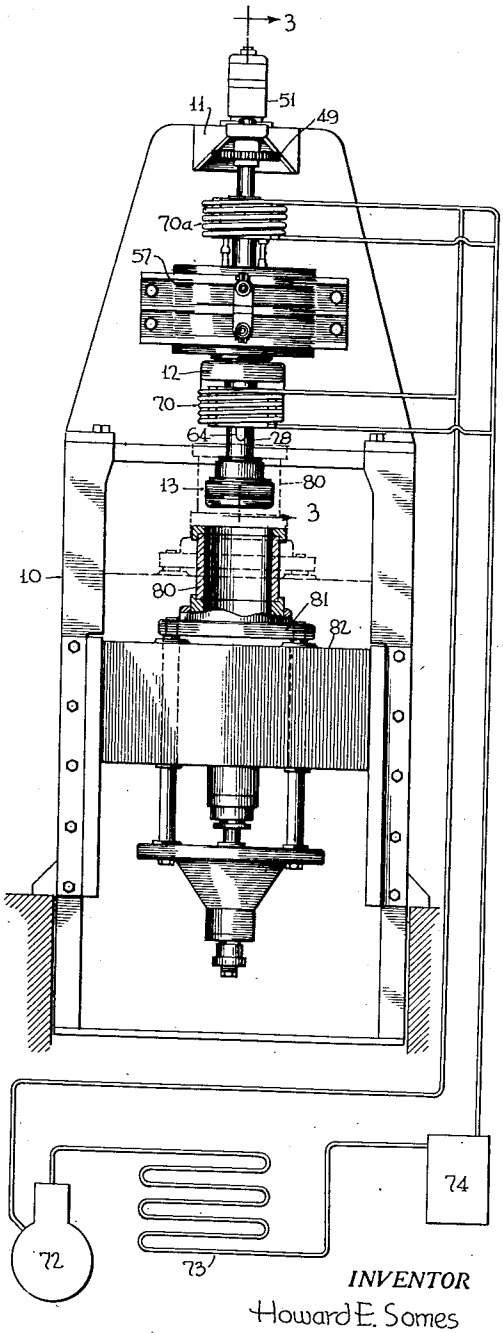


FIG. 1



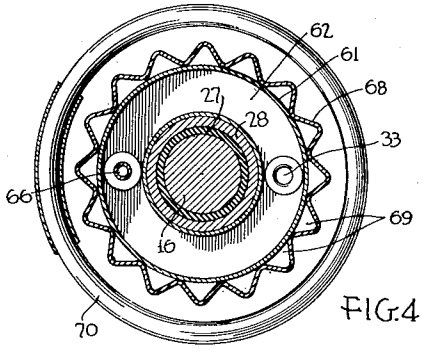


FIG. 4

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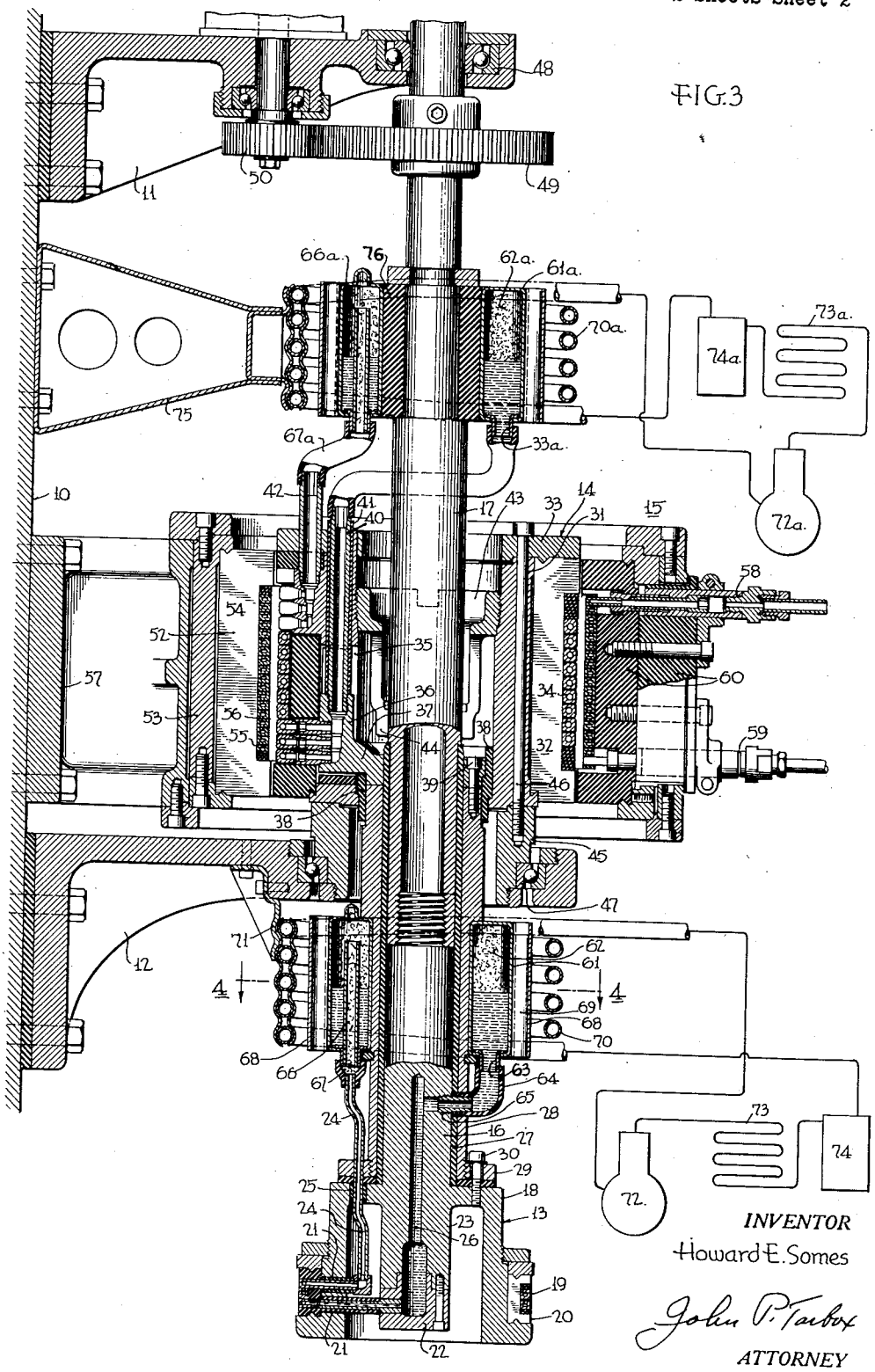
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FIG. 3



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INDUCTION HEATING APPARATUS

Howard E. Somes, Detroit, Mich., assignor to Budd Induction Heating, Inc., Philadelphia, Pa., a corporation of Michigan

Application May 25, 1942, Serial No. 444,344

13 Claims. (Cl. 219—13)

This invention relates to induction heating apparatus, particularly to new and improved means for effecting cooling of the induction element thereof.

In the use of induction heating apparatus for heating surface layers of cylindrical objects by electromagnetic induction it is desirable, especially in the case of heat treating the inner surfaces of tubes or cylinders, to effect relative rotation between the workpiece and the induction heating coil in order to effect uniform heating throughout the circumference thereof. In many instances, it is impractical to rotate the workpiece and hence in these cases it is desirable to rotate the heating coil. Heretofore, it has been the practice in the cooling of the heating coil of a rotary heat treating head to conduct the coolant to the head by rotary connections leading to a source of coolant supply. In my Patent No. 2,281,331 dated April 28, 1942, I have shown and described an induction heating apparatus having coolant connections of this character. Such connections are objectionable particularly where coolant under high pressure is employed because of wear and resultant leakage.

One of the objects of the present invention is to provide a rotatable heating coil of an induction heating apparatus with new and improved means for cooling the heating coil by means of which it is possible to eliminate objectionable rotary connections between the heating coil and a source of cooling medium with the result that not only is the danger of leakage eliminated, but also, the time and expense incident to repair and replacement of such connections is reduced to a minimum.

Another object is to provide a heating coil of this character with a coolant source which may be rotated and hence directly connected with the coil.

A further object, is to provide a rotary heating element of an induction heating apparatus with a coil cooling means in the form of a vaporizable refrigerant which is contained within a closed circulating system including the heating coil and a condensor which is so arranged and supported as to be directly connected and rotated with the coil.

A still further object is to provide an induction heat treating apparatus having a rotary heating coil with a transformer for energizing the coil in which the transformer secondary is rotatable with the coil and is provided with a cooling means therefor which is rotatable therewith whereby to eliminate rotary cooling connections.

With the above and other objects in view, which will be apparent from the following detailed description to those skilled in the art to which the invention appertains, the present invention consists in certain features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawings, and then claimed.

In the accompanying drawings, which illustrate a suitable embodiment of the invention,

Figure 1 is a front elevation of an induction heating apparatus having the cooling means of the present invention incorporated therein;

Figure 2 is a side elevation of the apparatus shown in Figure 1;

Figure 3 is an enlarged section taken on line 3—3 of Figure 1; and

Figure 4 is a transverse section taken approximately on line 4—4 of Figure 3.

Referring to the accompanying drawings in which like numerals refer to like parts throughout the views, I have shown only those parts of an induction heating apparatus which are essential to a clear understanding of the invention.

The apparatus of the present invention is supported from a suitable frame 10 having upper and lower brackets 11 and 12 respectively which rotatably support the rotary element. The rotary element includes the heating head 13 and the secondary 14 of the transformer 15 which supplies high frequency power to the heating head 13 comprises a conducting mandrel 16 threadably secured to a conducting shaft 17 and having an enlarged hollow head end 18. The heating coil 19 is hollow and surrounds a suitable core 20 of magnetic material which is carried by the head end 18. The terminal ends of the coil 19 extend through the wall of the head end 18 and are insulated therefrom as at 21. One coil end is electrically connected with a recessed cap 22 which is secured to an inner extension 23 of the mandrel 16, and the other coil end is electrically connected to a conduit 24 which extends longitudinally through the enlarged end and is insulated therefrom by a sleeve 25 of insulating material. It is to be noted that the mandrel 16 is provided with a passage 26 in communication with the coil end which is secured to the cap 22.

Surrounding the mandrel 16 and insulated therefrom by an insulating sleeve 27 is an outer conducting sleeve 28 having a nut 29 at its lower end which is secured by an insulated cap screw

30 to the enlarged head end 18 of mandrel 16 to hold the sleeve 28 against axial movement relative to the mandrel 16.

The transformer secondary 14 comprises an annular sleeve 31 which supports a surrounding core 32 of magnetic material that is securely mounted thereon by means of an end plate 33 and which carries the tubular secondary winding 34. One side of the sleeve 31 is recessed at 35 to receive the projecting portion 36 of an annular collar 37 which is insulated from the sleeve 31 by suitable insulation 38 and is secured to the upper end of the conducting sleeve 28 by one or more cap screws 39. The lower end of the triple wound winding 34 is electrically connected to the projecting portion 36 to which a coolant conducting conduit 40 is connected, the conduit 40 being surrounded by an insulating sleeve 41 and extending longitudinally through the end plate 33. The upper end of the winding 34 is electrically connected to the sleeve 31 and is in communication with a coolant conducting conduit 42 also extending longitudinally through the end plate 33.

The sleeve 31 to which the upper end of the coil 34 is connected is provided with an annular collar 43 having fingers 44 thereon in electrical contact with the shaft 17.

A shouldered sleeve 45 is secured to the lower end of the secondary supporting sleeve 31 by bolts 46 which also secure the end plate 33 to sleeve 31 and the sleeve 45 is rotatably supported on an anti-friction bearing 47 carried by the lower bracket 12. The upper end of the shaft 17 is also rotatably journalled in an anti-friction bearing 48 carried by the upper bracket 11 and is provided with a gear 49 fixed thereto which is meshed with a drive pinion 50. The drive pinion 50 is driven by the shaft of a suitable drive motor 51 mounted on the bracket 11.

It thus is seen that the motor 51 through gears 49 and 50 will cause the shaft 17 to rotate the transformer secondary 14 and the induction heating head 13.

The transformer primary 52 comprises an annular shell 53 which supports an annular magnetic circuit element 54 having a recess 55 at the inner surface thereof within which the primary winding 56 is mounted. This shell is supported within a suitable bracket 57 secured to the frame 10.

The primary winding 56 which surrounds the secondary 14 in circumferentially spaced relation has its terminals 58 and 59 extending radially outward through suitable insulating blocks 60.

Surrounding the outer conducting sleeve 28 is an annular metallic member 61 having an annular chamber 62 therein, the member 61 having good electrical contact with the sleeve 28. Extending from the bottom of the chamber 62 is a conduit 63 which is connected by a conduit 64 of non-conductive material with a nipple 65 threaded in the mandrel 16 to thus establish communication between the chamber 62 and the passage 26 in the mandrel 16. Also, extending upwardly through the bottom of the annular member 61 to a position near the top of the chamber 62 is a conduit 66 which through a connection 67 communicates with the conduit 24 which is electrically connected with the upper end of the inducing coil 19.

There is thus provided a continuous passage from the chamber 62 through conduit 64, nipple 65, passageway 26, through the tubular inducing coil 19 and back through the conduit 24 and riser conduit 66 to the chamber 62 adjacent the top thereof.

According to the present invention this continuous passage and the parts defining the same constitute a closed system containing a suitable vaporizable refrigerant having a level below the upper end of the riser conduit 66.

Due to the flow of high frequency high power electrical current through the coil 19 and the heat radiated from the surface of the workpiece undergoing heating by the coil 19, the workpiece surrounding the inducing head 13 as indicated in broken outline in Figure 1, the coil 19 is subjected to an extremely high temperature, the heat of which causes the liquid refrigerant in the coil to vaporize, due to the transfer of heat to the liquid refrigerant and, as a result, the vaporization of the liquid refrigerant refrigerates the coil and maintains it at a desired low temperature for efficient current flow. The vaporization of the liquid refrigerant is continuous, the refrigerant vapors rising through the longitudinally extending coil end and the riser 66 and discharging into the space above the liquid level where, due to the heat transfer through the chamber walls with the surrounding atmosphere, it is condensed back into liquid form. The refrigerant vaporized in the coil 19 is, of course, replaced by liquid refrigerant which flows by gravity downwardly through passageway 26 to the lower end of the coil.

In order to assist in this continuous operation, the chamber 62 may be exhausted to establish a vacuum therein whereby the vaporized refrigerant, the pressure within the chamber 62 being below atmospheric, will freely rise into the chamber.

Also, to materially assist in condensing the vaporized refrigerant, the outer peripheral wall of the annular member 61 is provided with an increased radiating surface in the form of a corrugated sleeve 68 spot welded or otherwise secured thereto in good thermal contact. This corrugated sleeve provides a plurality of longitudinal air passages 69 adjacent the chamber wall for air circulation.

During rotation of the unitary assembly which includes the annular member 61 and corrugated sleeve, the sleeve corrugations tend to act as a fan to effect increased air circulation, and obviously such circulation of air materially assists in the transfer of heat between the member 61 and the atmosphere to condense the refrigerant vapors in the chamber 62.

In order to assist in this condensation, where such assistance is necessary, the atmosphere surrounding the annular member 61 may be refrigerated, such as, for example, by surrounding the same with a tubular coil 70, supported from the lower bracket 12 by a bracket 71, and circulating a cooling medium, such as brine, therethrough or by connecting the coil with a suitable mechanical refrigerating system comprising a compressor 72, a condensor 73 and a receiver 74. In this latter case, a vaporizable refrigerant is employed, the boiling or vaporization of the liquid refrigerant supplied to the coil 70, due to the transfer of heat between the coil and surrounding atmosphere, creating a refrigerated atmosphere surrounding the annular member 61, the member 61 constituting a condensor for the closed secondary system which includes member 61 and the inducing coil 19.

Efficient cooling of the secondary 14 of the transformer 15 may be effected in a similar manner by mounting a similar annular member 61a

upon the shaft 17 through an annular insulator 76, the insulator being vulcanized or otherwise secured to the member 61a to hold it in place. In the drawings, those parts of the cooling system for the transformer secondary which correspond to that of the inducing coil 19 bear the same numerals with the suffix "a". The outlet from from the bottom of chamber 62a is connected through conduit 64a with the conduit 40 which leads to the lower terminals of the secondary winding 34 whereas the upper terminals of the secondary winding 34 through the conduit 42 and conduit 67a are connected to the riser conduit 66a. The coil 70a of the primary refrigerating system is supported from a bracket 75 secured to the frame 10.

The two primary cooling coils 70 and 70a may be connected to separate condensing units as shown in Figure 3 or if desired they may be connected to a single condensing unit as illustrated in Figure 1.

In Figures 1 and 2, I have shown a tubular workpiece 80 supported on a work support 81 reciprocably mounted on a portion 82 to move the workpiece in surrounding heating relation with the inducing head 13, as indicated in broken outline in Figure 1.

In my patent, No. 2,281,331, dated April 28, 1942, there is shown a complete induction heating apparatus to which the present invention is particularly applicable. It is to be understood also that the invention is applicable to any type of induction heating apparatus in which provision is made for rotation of the heating coil, and it will be obvious to those skilled in the art that in any such construction the advantages of the present invention are manifold.

Simplification of the apparatus is effected and also the danger of leakage is minimized through the elimination of rotary fluid couplings and packings and external conduits and the like. Another advantage is that a low boiling point refrigerant can be used in such a system which materially assists in cooling the heating coil and the transformer secondary.

It is to be understood that various changes may be made in the various parts described and their arrangements without departing from the spirit and substance of the present invention, the scope of which is defined by the appended claims.

What is claimed is:

1. In an induction heating apparatus, a rotatable support and a heating element secured to said support for rotation therewith and having a passage therethrough provided with an inlet and an outlet, means for cooling said heating element comprising a condensing element fixed to said support for rotation therewith, said condensing element having a chamber therein adapted to contain a vaporizable liquid refrigerant, a connection from said chamber to said inlet for conducting liquid refrigerant thereto, a connection from said outlet to said chamber for conducting refrigerant vapors thereto from said heating element, and means for rotating said support.

2. In an induction heating apparatus, a rotatable support and a heating element secured to said support for rotation therewith and having a passage therethrough provided with an inlet and an outlet, means for cooling said heating element comprising a condensing element fixed to said support for rotation therewith, said condensing element having a chamber therein adapted to contain a vaporizable liquid refrigerant, a connection from said chamber to said inlet for conducting liquid refrigerant thereto, a connection from said outlet to said chamber for conducting refrigerant vapors thereto from said heating element, and means for rotating said support, said condensing element being annular and concentric with said support.

3. In an induction heating apparatus, a rotatable support and a heating element secured to said support for rotation therewith and having a passage therethrough provided with an inlet and an outlet, means for cooling said heating element comprising a condensing element fixed to said support for rotation therewith, said condensing element having a chamber therein adapted to contain a vaporizable liquid refrigerant, a connection from said chamber to said inlet for conducting liquid refrigerant thereto, a connection from said outlet to said chamber for conducting refrigerant vapors thereto from said heating element, and means for rotating said support, said condensing element being of annular contour, carried by said support in surrounding relation and axially spaced from said heating element.

4. In an induction heating apparatus, a rotatable support and a heating element secured to said support for rotation therewith and having a passage therethrough provided with an inlet and an outlet, means for cooling said heating element comprising a condensing element fixed to said support for rotation therewith, said condensing element having a chamber therein adapted to contain a vaporizable liquid refrigerant, said support having a passageway therein communicating at one end with said chamber and at its opposite end with said inlet for conducting liquid refrigerant from said chamber to said heating element, and a connection between said outlet and the chamber above the level of the liquid refrigerant contained therein for conducting refrigerant vapor from said heating element to said chamber.

5. In an induction heating apparatus, a rotatable support and a heating element secured to said support for rotation therewith and having a passage therethrough provided with an inlet and an outlet, means for cooling said heating element comprising a condensing element fixed to said support for rotation therewith, said condensing element having a chamber therein adapted to contain a vaporizable liquid refrigerant, a connection from said chamber to said inlet for conducting liquid refrigerant thereto, a connection from said outlet to said chamber for conducting refrigerant vapors thereto from said heating element, and means for rotating said support, said condensing element being annular and concentric with said support and including a finlike heat radiating element in intimate thermal contact with the peripheral wall thereof.

6. In an induction heating apparatus, a rotatable support and a heating element secured to said support for rotation therewith and having a passage therethrough provided with an inlet and an outlet, means for cooling said heating element comprising a condensing element fixed to said support for rotation therewith, said condensing element having a chamber therein adapted to contain a vaporizable liquid refrigerant, a connection from said chamber to said inlet for conducting liquid refrigerant thereto, a connection from said outlet to said chamber for conducting refrigerant vapors thereto from said

heating element, and means for rotating said support, said condensing element being annular and concentric with said support and including a corrugated heat radiating element surrounding the peripheral wall thereof in intimate thermal contact therewith.

7. In an induction heating apparatus, a rotatable arbor comprising inner and outer concentric conductors insulated from each other, the inner of said conductors having a portion extending axially beyond the outer, a heating coil supported by said extending portion and having a passageway therethrough, an annular member of electrically conductor material surrounding and in electrical contact with said outer conductor, said annular member having a chamber therein for containing a vaporizable liquid refrigerant, said inner conductor having a fluid passage therein and said coil having one end in electrical contact with said inner conductor and in communication with one end of said passage, a fluid connection of non-conductive material between the other end of said passage and said chamber for conducting liquid refrigerant from said chamber through said passage to said coil, a fluid connector of electrically conductive material extending between the other end of said coil and said annular member into communication with the chamber thereof for conducting refrigerant vapor from said coil to said chamber, and means for rotating said arbor.

8. In an inductive heating apparatus, a frame member, an arbor, bearing means for rotatably supporting said arbor in said frame member, an induction heating coil carried by said arbor for rotation therewith and having a fluid passage therethrough, a source of electrical energy for said coil including an electrical current transformer having its secondary winding fixed to said arbor for rotation therewith and in circuit with said coil, an annular member fixed to said arbor in surrounding relation therewith and having a chamber therein for containing a vaporizable liquid refrigerant, fluid connections between said chamber and said coil, one for conducting liquid refrigerant from said chamber to coil and refrigerant vapor from said coil to said chamber, and means for rotating said arbor.

9. In an inductive heating apparatus, a frame member, an arbor, bearing means for rotatably supporting said arbor in said frame member, an induction heating coil carried by said arbor for rotation therewith and having a fluid passage therethrough, said arbor including inner and outer concentric electrical conductors insulated from each other, a source of electrical energy for said coil including an electrical current transformer having its secondary winding secured to said arbor for rotation therewith and having one terminal connected to one conductor and its other terminal connected to the other conductor, a member of electrically conductive material secured to said arbor for rotation therewith and having a condensing chamber therein, connections between said chamber and said coil for conducting liquid refrigerant from said chamber to said coil and refrigerant vapor from said coil to said chamber, said connections also establishing electrical current connections between said coil and conductors, one of said connections being through said chambered member, and means for rotating said arbor.

10. In an apparatus having a rotatable shaft and a tubular coil having a passage therethrough and provided with an inlet and an outlet and being carried by said shaft for rotation therewith, means for cooling said coil comprising a condensing element having a condensing chamber therein and adapted to contain vaporizable liquid refrigerant, said condensing element being mounted on said shaft for rotation therewith, conduit means for conducting liquid refrigerant from said chamber to said inlet and conduit means for conducting refrigerant vapors to said chamber above the level of liquid refrigerant therein, and means for rotating said shaft, said cooling means including a fixed tubular coil surrounding said condensing element in adjacent spaced relation and means for circulating a refrigerating medium through said last named coil.

11. In an apparatus having a rotatable shaft and a tubular coil provided with a cooling inlet and a cooling outlet and being carried by said shaft for rotation therewith, means for cooling said coil comprising a condensing element having a condensing chamber therein and adapted to contain vaporizable liquid refrigerant, said condensing element being mounted on said shaft for rotation therewith, conduit means for conducting liquid refrigerant from said chamber to said inlet and conduit means for conducting refrigerant vapors to said chamber above the level of liquid refrigerant therein, and means for rotating said shaft, said cooling means including a fixed tubular coil surrounding said condensing element in adjacent spaced relation and condensing apparatus connected with said last named coil for supplying liquid refrigerant thereto and withdrawing gaseous refrigerant therefrom.

12. In an apparatus having a rotatable shaft and a current conducting coil carried by said shaft for rotation therewith, said coil having a passage therethrough provided with an inlet and an outlet, means for rotating said shaft, means for cooling said coil comprising a closed secondary refrigerating system containing a vaporizable liquid refrigerant, said secondary system including said coil and having a condensing element carried by said shaft for rotation therewith and passaged connections between said condensing element and said inlet and outlet for conducting liquid refrigerant from said condensing element to said coil and vaporized refrigerant from said coil to said condensing element.

13. In an apparatus having a rotatable shaft and a current conducting coil carried by said shaft for rotation therewith, said coil having a passage therethrough provided with an inlet and an outlet, means for rotating said shaft, means for cooling said coil comprising a closed secondary refrigerating system containing a vaporizable liquid refrigerant, said secondary system including said coil and having a condensing element carried by said shaft for rotation therewith and passaged connections between said condensing element and said inlet and outlet for conducting liquid refrigerant from said condensing element to said coil and vaporized refrigerant from said coil to said condensing element, and a primary refrigerating system including a tubular coil surrounding said condensing and means for circulating a refrigerating medium through said last mentioned coil whereby to create a refrigerated zone surrounding and in heat exchange relation with said condensing element.

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