

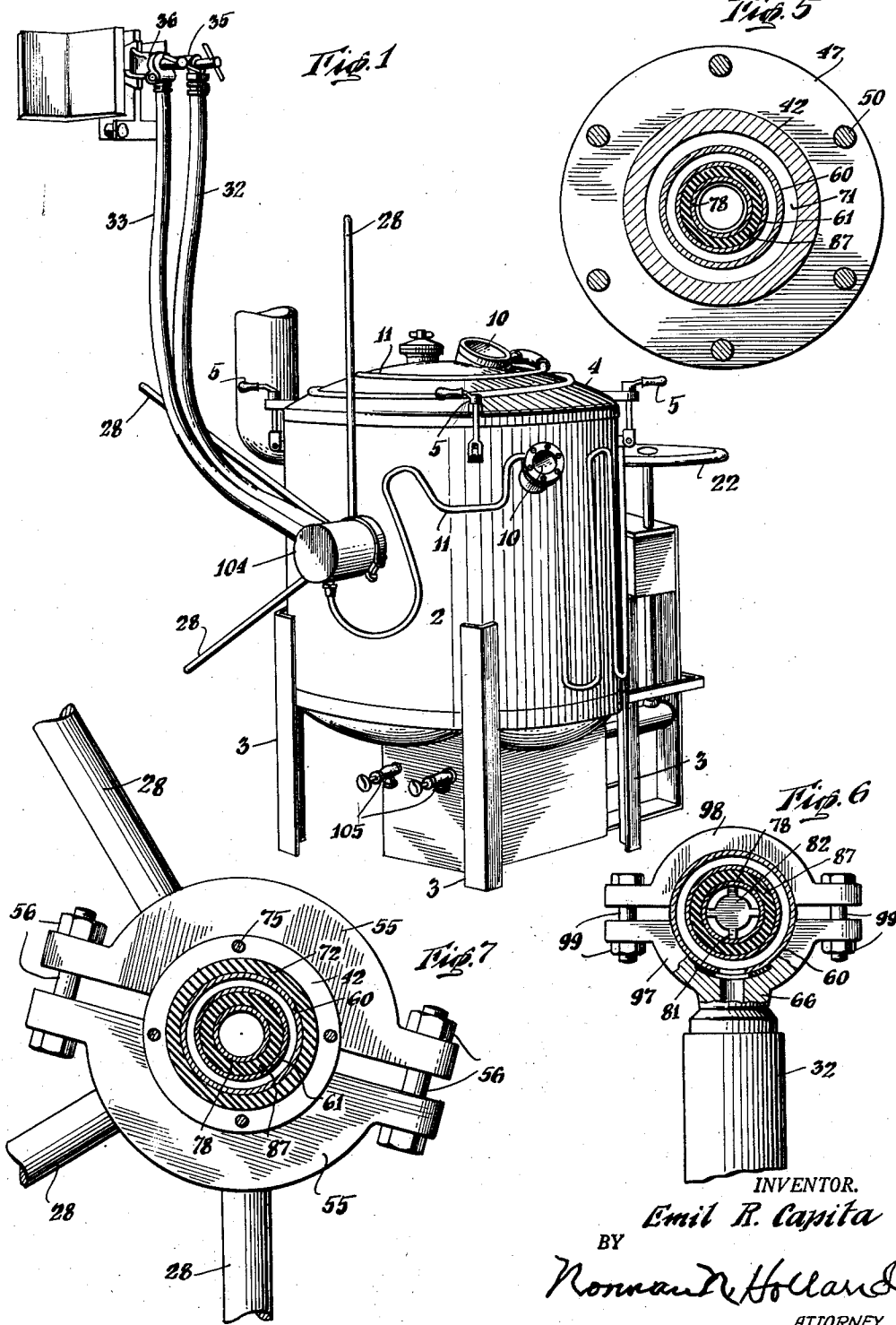
April 13, 1954

E. R. CAPITA
INDUCTION FURNACE

2,675,414

Filed Dec. 20, 1951

2 Sheets-Sheet 1



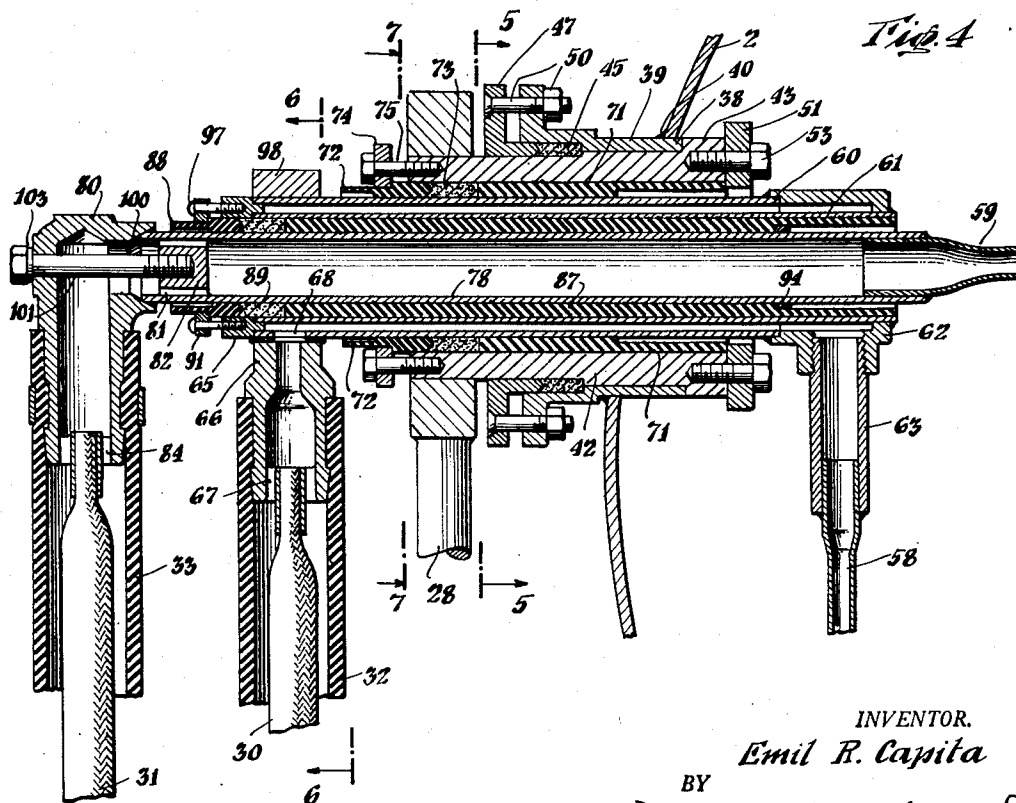
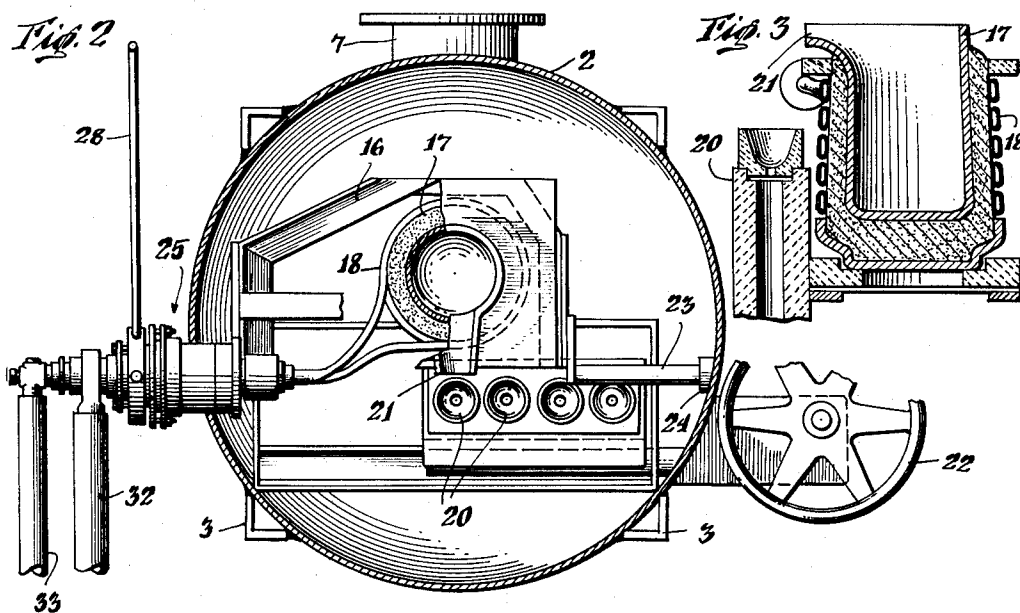
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INDUCTION FURNACE

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21 Claims. (Cl. 13—27)

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The present invention relates generally to vacuum heating furnaces of the electric induction type and more particularly to an improved vacuum furnace which embodies a stationary casing or shell containing a tiltable induction heating coil and crucible.

Induction heating furnaces for melting and pouring metals in vacuum, or in some particular gas atmosphere, are generally known but previous types have been objectionable for various reasons. Some of them have required opening the vacuum casing after the metal is molten in order to pour the molten metal from a crucible into a mold; this is highly objectionable and largely negates advantages gained by melting the metal in a vacuum or some desirable gas atmosphere for the reason that during pouring the molten metal is exposed and picks up oxygen and other gases in the atmosphere. In order to avoid this objection entire furnace casings together with their contained heating coils and crucibles have been mounted on trunnions, so that the whole structure could be tilted to pour molten metal from a crucible into a mold contained in a portion of the casing and tiltable therewith.

Tilting the whole furnace structure is objectionable in many instances as it is cumbersome, generally requires the use of a drive motor and gearing for tilting the entire furnace structure, and requires the use of excessively long electric conducting cable and water hoses to allow for movement of the furnace between melting and pouring positions.

The present invention aims to overcome or minimize the above and other difficulties by providing a new and improved vacuum heating furnace which utilizes a stationary vacuum casing containing a tiltable crucible and an induction heating coil, tilting of the coil and crucible being readily achieved from the exterior of the casing through means which conducts electricity and cooling fluid to and from the coil but which prevents passage of gases from the atmosphere into the casing.

An object of the present invention is to provide a new and improved vacuum type induction heating furnace.

Another object of the invention is to provide an improved vacuum heating furnace which embodies a stationary casing containing a tiltable heating coil.

Another object of the invention is to provide improved means for conducting electricity and cooling fluid to and from a heating coil but which is adapted to prevent passage of gases into a vacuum furnace.

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Still another object of the invention is to provide an improved vacuum type induction heating furnace of relatively simple and inexpensive construction.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings, forming a part of the specification, wherein:

Fig. 1 is a perspective view showing a preferred embodiment of the present invention;

Fig. 2 is a horizontal sectional view looking down into the furnace illustrated in Fig. 1;

Fig. 3 is a fragmentary sectional view illustrating the general relationship of the induction heating coil, crucible and pouring mold of the present invention;

Fig. 4 is a longitudinal sectional view showing the means for conducting electricity and cooling fluid to and from the heating coil with means for tilting the combined assembly;

Fig. 5 is a sectional view taken along line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken along line 6—6 of Fig. 4; and

Fig. 7 is a sectional view taken along line 7—7 of Fig. 4.

As shown in Figs. 1-3, the present vacuum heating furnace comprises a casing or shell 2, stationarily mounted on supporting legs 3. The casing may be built up by welding together suitable sections of non-magnetic steel. When charged and ready for use a cover member 4 may be placed over an open upper end of the casing 2 and clamped down against an intermediate gasket (not shown) by retaining dogs or latches 5 located at spaced intervals around the circumference of the casing. An opening at one side of the casing 2 may communicate with a conduit 7 for exhausting air from the casing, the air being withdrawn by a suitable vacuum pump (not shown). Windows 10 of heat resistant glass may be provided at suitable locations on the casing 2 or cover 4 for viewing the interior of the furnace. Any suitable pyrometer or other temperature indicating means may be provided for giving the temperature of metal or any portion at the interior of the furnace. Water cooling pipes 11 may be attached to and extend along appro-

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prate portions of the casing 2 and cover 4 for the purpose of keeping the cover or casing from becoming overheated.

Within the casing 2 and supported on a suitable rotatable or tiltable framework 16 are the crucible 17 and its encircling induction heating coil 18. The heating coil 18 is preferably of copper tubing wound in the form of a coil so that a crucible placed within the confines of the coil may be subjected to a high frequency electromagnetic field created by current flowing through the heater oil. Cooling water flows through the coil tubing to prevent overheating thereof. As shown in Fig. 3 any one of a plurality of molds 20 may be moved into alignment with a spout 21 of the crucible by rotating exterior hand wheel 22 so as to operate suitable shafting and gearing connected with the means which supports the molds 20.

The means 16 which supports the crucible 17 and coil 18 is rotatable about an axis which extends through a supporting shaft 23 and bearing 24 (right side of Fig. 2) and supporting and rotating means 25 (left side of Fig. 2). The latter means prevents passage of gases into the casing 2 and yet provides flow of electricity and cooling fluid to and from the induction coil 18 through the casing wall.

Handles 28 connect with the supporting and rotating means 25 at the exterior of the casing 2 to provide for tilting the induction coil 18 and crucible 17, as will be described in detail hereinafter. Current conducting cables 30, 31 and hoses 32, 33 are provided for conducting electricity and cooling fluid, usually water, from a supply connection 35 to the coil 18 and from the coil 18 to a discharge connection 36. Electric current may be furnished to the cables 30, 31 by any suitable generator (not shown).

The supporting and rotating means 25 which conducts current and water to and from the coil and serves to tilt the coil while retaining a vacuum-type seal with the casing wall, is shown in detail in Figs. 4-7 and will now be described. In the longitudinal sectional view of Fig. 4 the casing wall 2 is shown provided with an opening 38 through which extends a hollow member 39 of stainless steel. This member is tubular and is preferably attached by welding 40 to the casing wall 2 to form a fixed support through which extends a rotatable bronze tube or member 42, this member in turn carrying tubular copper members for conducting current and cooling fluid.

The rotatable tubular member 42 has an annular enlargement 43 adjacent its inner end which abuts against the end of the fixedly positioned hollow member 39, so that endwise movement of the tubular member in one direction is prevented. While the rotatable member 42 is preferably of bronze, it will be understood that any other suitable material may be utilized. Leakage of air between the fixed supporting member 39 and the rotatable tubular member 42 is prevented by a gasket 45 of neoprene or other suitable material. This gasket may be compressed, so as to form a tight seal between the fixed member 39 and rotatable member 42, by a gland member 47 which is pulled toward the fixed member 39 by bolts and nuts 50.

The inner end of the rotatable tubular member 42 preferably has attached thereto, by bolts 53, a portion 51 of the framework 16 which supports the coil and crucible. When rotatable member 42 is turned in the fixed supporting member 39 the crucible and coil turn with the

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framework 16. To facilitate such rotation an outer portion of the rotatable member 42 has attached thereto the tilting handles 28 which project from collar portions 55, the collars being firmly clamped against the rotatable member 42 by bolts and nuts 56.

Electric current and water are delivered to the inlet end 58 of the coil 18 by concentric or coaxial copper tubes 60, 61, current flowing through the copper tubes to a copper end cap 62, thence along a copper pipe 63 to the inlet end 58 of the induction coil 18. Cooling water reaches the inlet end 58 of the induction coil by passing through the space between the two concentric copper tubes 60 and 61. These two copper tubes are shown spaced from each other at their inner ends by securing them in spaced relationship to the copper end cap 62; at their outer ends the two copper tubes are held spaced from each other by an annular ring 65 of copper or other conducting material. Electric current may be delivered to the copper tubes by an inlet connection 66 which connects with the inlet cable 30 through apertured means 67. The rubber inlet hose 32 surrounds the inlet cable 30 and cooling water may pass through the hose 32, apertured means 67, terminal 66, opening 68 into the space between the two copper tubular members 60, 61.

The conducting tubes 60, 61 are separated from the rotatable tubular member 42 by generally tubular insulating members 71, 72 of Bakelite, teflon or other suitable material. A gas-tight seal is provided between the outermost conducting member 60 and the rotatable member 42 by a neoprene or other gasket 73, the annular insulating member 72 being movable inwardly by a retaining ring 74 and bolts 75 so as to compress the neoprene gasket 73 against one end of the tubular insulator 71. The innermost end of insulating member 71 is held against longitudinal movement as it abuts against an outwardly facing surface of the portion 51 which provides an attachment for the crucible supporting framework 16.

Each of the insulating members 71 and 72 preferably has a relatively long recess or cut-away portion at its inner annular surface. This provides a greatly increased "slide spark distance" and thereby minimizes passage of current from the copper tube 60 to adjacent portions of the rotatable member 42.

Current and cooling water which pass through the induction heating coil 18 are conducted away from an outlet end 59 thereof through a copper pipe 78 shown disposed centrally of and extending through the two outer copper tubes 60 and 61. Current flows along this central copper pipe 78, through copper end terminal 80 to outlet cable 31. Cooling water passes through the interior of central pipe 78, through apertures 81 of retaining means 82, through the interior end terminal 80, through apertures 84 in the end terminal, and thence out through the rubber hose 33.

The central copper pipe 78 is insulated from the inner copper tube 61 by generally tubular members 87, 88 of Bakelite, teflon or other non-conducting material. Here again a gas-proof joint is preferably provided by a neoprene gasket 89 which fills the annular space between the exterior of the copper pipe 78 and the interior of the copper tube 61. The gasket 89 may be compressed by a clamping ring 91 and bolts 92 which thread into suitable apertures in the annular copper ring 65 secured to the inner and outer tubular members 60 and 61. Insulating member 87 is prevented from moving longitudi-

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nally, under the influence of pressure applied against the neoprene gasket 89, by a retaining ring 94 soldered or otherwise secured to the exterior of the copper pipe 78. The insulator members 87 and 88 which encircle the central copper pipe 78 are preferably provided with relatively deep recesses or cut-away portions at their exteriors to provide increased slide spark distances such as those previously referred to in connection with the insulators 71, 72.

The inlet terminal 66 which delivers current and cooling fluid to the two outer tubular members may include semi-circular portions 97, 98, clamped against the exterior of the copper tube 60 by nuts and bolts 99. The hollow outlet terminal 80 has a conical surface 100 which may be pulled tightly against an end of the central copper pipe 78 by a bolt 101 which extends there-through and threads into an opening in the retaining means 82. A spark plug type gasket 103 may be used to form a tight seal between the terminal 80 and the head of the bolt 101, to thereby prevent leakage of fluid along the bolt.

While the current and cooling fluid have been described as entering through the terminal 66 and emerging through the terminals 80, it will be understood that the direction could be reversed so as to have current and fluid enter through the terminal 80 and emerge through the terminal 66.

When current has been flowing through the induction heating coil 18 for a sufficient time, metal contained in the crucible 16 will be molten. At this time the handles 28 may be moved so as to turn the rotatable member 42, supporting framework 16, coil 18 and crucible 17. Molten metal flows out the spout 21 into a mold 22 aligned therewith. The copper tubes 60 and 61, central copper pipe 78 and various insulators may turn with the rotatable member 42. Even though the interior of the casing 2 may be subjected to high vacuum no air or other gas enters the casing along any of the joints between the various tubes, insulators or pipes of the present coaxial conductor as the various gaskets tightly seal the joints against this. The coaxial conductor may be readily tilted by the handle 23. Only a slight amount of slack need be provided in the electric cables and hoses as the crucible may be emptied by turning it through a relatively short distance. Preferably exposed portions of the coaxial conductor, namely the terminals 66, 80 and other adjacent portions are covered by a protective cap 104. Valves 105 may be provided for admitting air to the casing 2 after metal has solidified in the molds 20.

It will be seen that the present invention provides a new and improved induction heating type of vacuum furnace which does not require rotating the entire furnace in order to pour molten metal into a mold. The furnace casing or shell may be stationarily mounted and only the crucible and heating coil need rotate at the interior of the casing. No auxiliary power motor is required to tilt the crucible as this may be readily achieved by applying leverage to suitable laterally projecting handles at the exterior of the casing, the handles connecting with a rotatable portion of the present new coaxial conductor. Current and cooling fluid readily pass through the coaxial conductor but passage of air along any joints between relatively movable parts is prevented.

As various changes may be made in the form, construction and arrangement of the parts here-

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in without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in a limiting sense.

What I claim is:

1. A device of the class described comprising the combination of a normally stationary casing, an induction heating coil in said casing, means for tilting said coil with respect to the casing including a rotatable member extending through a wall of the casing, hollow electric conducting means connected with said coil and extending through said casing wall for conducting current and cooling fluid to and from the heating coil, and leakproof means for tiltably mounting said conducting means with respect to the casing wall.

2. A device as claimed in claim 1, in which said rotatable member is hollow, said conducting means extends therethrough, and sealing means are located adjacent the ends of said rotatable member and said conducting means for providing a fluid passage through said rotatable hollow member between it and said conducting means.

3. A device as claimed in claim 2, in which a crucible supporting platform is connected to said rotatable member for rotation therewith.

4. In a device of the class described, the combination of a casing wall, a hollow member extending through said wall, a plurality of electric conducting members extending through said hollow member, sealing means intermediate said hollow member and one of said conducting members for minimizing passage of fluid therebetween, at least one of said conducting members being rotatable with respect to said hollow member, and an induction heating coil having terminals in communication with said conducting members within said casing wall.

5. A device as claimed in claim 4, in which said hollow member has an elongated tubular bearing surface at its interior for supporting said conducting members and a crucible supporting platform for a crucible adapted to seat in said coil.

6. In a device of the class described, the combination of a casing wall, a hollow supporting member extending through and rotatable with respect to said wall, a first hollow electric conducting member extending through said supporting member, a second electric conducting member extending through said first hollow conducting member, means intermediate said supporting member and said first hollow conducting member for minimizing passage of fluid therebetween, said conducting members being rotatable with respect to said supporting member, said first hollow conducting member being in communication with a terminal of an induction heating coil and said second electric conducting member being in communication with another terminal of said induction heating coil.

7. A device as claimed in claim 6, in which each of said conducting members is hollow and each is separated from the other by insulating means.

8. A device as claimed in claim 7, in which said insulating means is recessed adjacent end portions thereof to provide increased slide spark distance.

9. A device of the class described comprising the combination of a hollow member adapted to be secured to a casing wall and extend through an opening therein, electric conducting means comprising a pair of radially spaced hollow concentric conduits extending through said hollow member, additional electric conducting means

comprising a hollow electric conducting conduit extending through the first conducting means, insulating means intermediate said hollow member and first conducting means and intermediate the first conducting means and said additional conducting means, and means rotatably mounting said hollow member in said casing wall, whereby said conduits are adapted to communicate with an induction coil.

10. A device as claimed in claim 9, in which there is provided a heating coil of pipe having spaced portions electrically connected to and in fluid communication with the first conducting means and the additional conducting means whereby cooling fluid may flow into the pipe through one of said conducting means and out of the pipe through the other conducting means.

11. A device as claimed in claim 10, in which means is connected with said first conducting means adapted to conduct current thereto and cooling fluid to the space between said concentric conduits, and in which means is connected with said additional conducting means adapted to conduct current therefrom and cooling fluid from the hollow conduit thereof.

12. A device as claimed in claim 10, in which means comprising an electric cable surrounded by a hose is connected with said first conducting means adapted to conduct current thereto and cooling fluid to the space between said concentric conduits, and in which means comprising an electric cable surrounded by a hose is connected with said additional conducting means adapted to conduct current therefrom and cooling fluid from the hollow conduit thereof.

13. A device as claimed in claim 9, in which there is provided a rotatable member between said hollow member and the first conducting means, and an operating handle extends laterally from said rotatable member for rotating it.

14. A device of the class described comprising the combination of a normally stationary casing, a hollow member secured to a wall of said casing at an opening therein, electric conducting means comprising a pair of spaced hollow concentric conduits extending through said hollow member, additional electric conducting means comprising a hollow electric conducting conduit extending through the first conducting means, insulating means intermediate and separating said hollow member and first conducting means and intermediate and separating said first conducting means and said additional conducting means, an induction heating coil of pipe in said casing having spaced portions connected to and in fluid communication with the first conducting means and the additional conducting means, and means for tilting said coil from the exterior of said casing with respect to said casing, including means rotatably mounting said hollow member in said casing wall and means provided on said rotatable member in co-operative relation to said coil, said casing being adapted to be placed under a vacuum.

15. A device of the class described having a casing with an opening therein, a hollow member extending through said opening, an induction heating coil, a hollow electric conducting conduit extending through said hollow member into communication with said coil, an additional hollow electric conducting conduit extending through the first conduit also into communication with said coil, insulating means intermediate said hollow member and said first conduit and intermediate the first conduit and said additional conduit,

sealing means at the extremities of and intermediate said hollow member and said first conduit providing a passage for fluid, a first port for said passage communicating with an electric and fluid current source, and a second port for said passage communicating with a terminal of said coil and located on a side of said casing wall opposite that of said first port, said additional hollow electric conducting conduit communicating with another terminal of said coil and having a port communicating with an electric and fluid source.

16. A device as claimed in claim 15 in which means are provided rotatably mounting said hollow member with respect to said casing wall.

17. A device as claimed in claim 16 in which means are provided rotatably mounting said hollow member with respect to at least one of said conducting members.

18. A device as claimed in claim 15 in which means are provided rotatably mounting said hollow member with respect to said casing wall, and a crucible supporting platform is provided on said hollow member adapted to tilt said coil upon rotation of said hollow member.

19. A device as claimed in claim 18 in which means are provided rotatably mounting said hollow member with respect to at least one of said conducting members.

20. A device as claimed in claim 18 in which means are provided rotatably mounting said hollow member with respect to said first conduit, and means are provided rotatably mounting said first conduit with respect to said additional hollow electric conducting conduit.

21. In a device of the class described, the combination of a casing having a wall with an opening therein, a hollow member mounted in said wall at said opening, first electric conducting means extending through said hollow member, additional electric conducting means extending through said first conducting means, insulating means intermediate and separating said hollow member and first conducting means and intermediate and separating said first conducting and said additional conducting means, an induction heating coil in said casing having portions connected to and in fluid communication with said first conducting means and said additional conducting means, means for tilting said coil from the exterior of said casing with respect to said casing including means rotatably mounting said hollow member in said casing wall, and means provided on said rotatable member in co-operative relation to said coil, said casing being adapted to be subjected to a partial vacuum whereby said coil may be tilted within said casing in said partial vacuum and cooling fluid may be delivered thereto through the intermediation of said conducting means.

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