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ELECTRIC FURNACE

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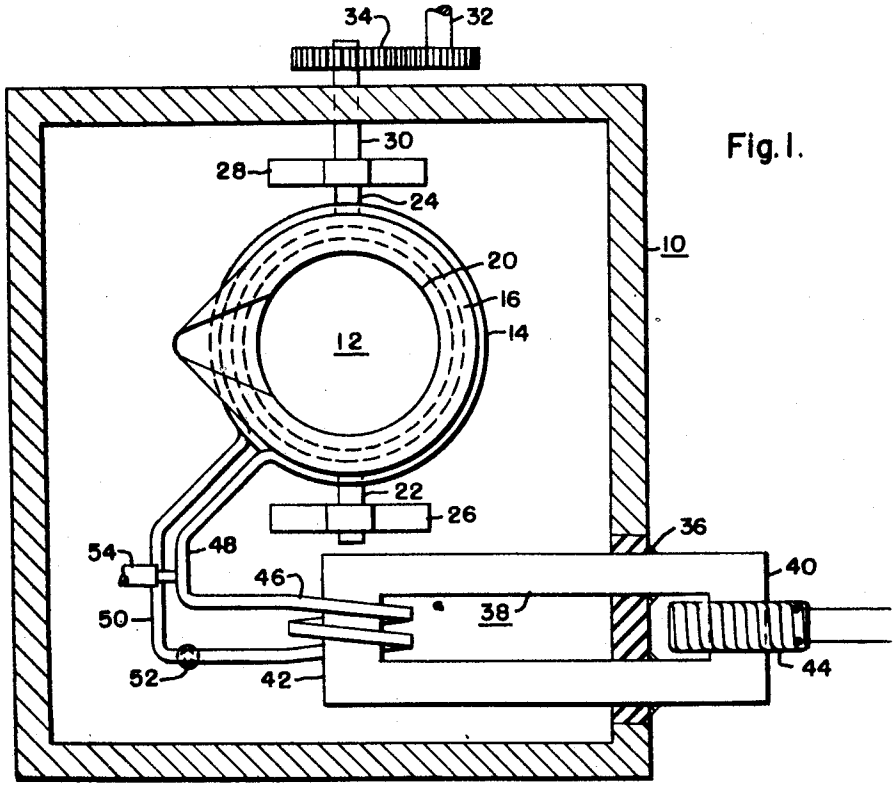


Fig. 1.

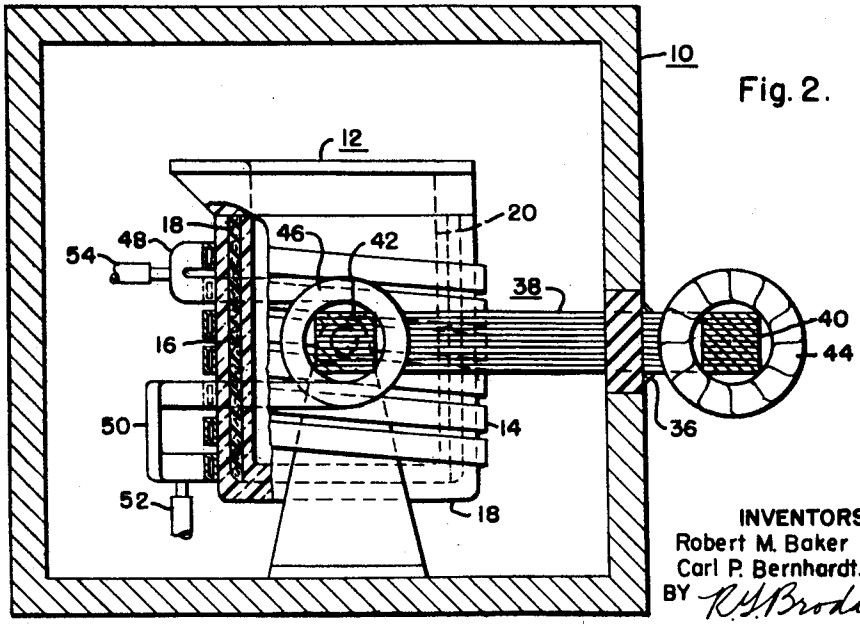


Fig. 2.

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ELECTRIC FURNACE

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This invention relates to an improved electric furnace and more particularly to means for introducing electrical power into an evacuated enclosure containing an induction furnace. The invention also relates to electric furnaces operated under a controlled atmosphere.

The principal object of the invention is to provide improved apparatus for the purpose stated in which corona effects resulting from the low pressure inside an evacuated enclosure are minimized. As is well known, corona results because of the lower ionization potential gradients of air at reduced pressures. Ionization of the atmosphere surrounding an induction coil, for example, causes flash-overs which might damage the coil or other associated parts.

Another object of the invention is to provide an arrangement whereby electrical energy may be transferred from a stationary magnetic core member to a rotatable member without the use of flexible conductors. In vacuum furnaces, for example, the conductors must in some cases carry currents in excess of 50,000 amperes. Such conductors must have large cross-sectional areas, and consequently require a special construction for flexibility. In addition, it is difficult to provide for effective cooling of such conductors, so it is altogether desirable to provide means employing rigid, rather than flexible, conductors for transferring electrical energy from a stationary magnetic core to a rotatable member.

A still broader object of the invention is to provide means for introducing electrical power into an evacuated enclosure.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification and in which:

Figure 1 is a cut-away top view of an evacuated enclosure containing an electric induction furnace constructed according to the principles of the present invention; and

Fig. 2 is a cut-away side view of the evacuated enclosure containing the aforementioned vacuum furnace.

Referring to Figs. 1 and 2, there is shown an enclosure **10** which is at least partially evacuated for a purpose which will hereinafter be explained. Positioned within the enclosure **10** is an induction furnace **12** which comprisess an induction coil **14** which is supported rigidly from an insulating network **16**. A bottom slab **18** is cast of furnace cement and is flush with the bottom of the coil. A crucible **20** is inserted into and supported by the coil **14**. The crucible may be made in any of several ways. It may be a prefired ceramic liner if the furnace is not large, with dry or semi-wet ramming compound rammed under the liner and between the liner and the coil. As an alternate, the liner may be formed by ramming compound between the coil and a thin-walled iron cylinder which is subsequently melted out. A third possibility is to form a liner by laying up a cylindrical wall of cemented dove-tailed bricks and ramming compound between the brick wall and the coil. Two pivot pins **22** and **24** extend outwardly from the sides of the coil and crucible supporting framework and rest on the upper extremities of two abutment members **26** and **28** respectively. Pivot pin **24** is integrally connected to a shaft **30** which extends through the wall of enclosure **10**. With this arrangement, the crucible **20** is rotated about the axis defined by pivot pins **22** and **24** by turning shaft **32** which, in turn, transmits rotary motion to shaft **30** through gears **34**.

As will be understood, evacuation of the enclosure **10** containing the induction furnace **12** is necessary in heating certain metals which oxidize upon coming into contact with air or otherwise chemically react with the elements in the air. Obviously, some means must be provided to evacuate the enclosure **10** or introduce an inert atmosphere; however, since this means forms no part of the present invention, it is not shown herein.

One portion of the outer wall of enclosure **10** is provided with an insulating insert **36**. A laminated iron core **38** extends through the insert **36** and into the interior of the enclosure **10**, the arrangement being such that one leg **40** of the core is outside the enclosure while the other leg **42** is within the enclosure. Referring to Fig. 2, it will be noted that the leg **42** is coaxial with respect to the axis of rotation of crucible **20**. Surrounding the leg **40** of core **38** is a primary winding **44** adapted for connection to a source of high voltage electrical energy, not shown. Surrounding leg **42** within the enclosure **10** is a rigid helical winding **46** having its opposite ends connected through rigid conductors **48** and **50** to the opposite ends of the induction coil **14** surrounding crucible **20**. The secondary winding **46** has relatively few turns and, therefore, supplies a suitably low voltage to the induction heating coil and leads so that corona does not form as a result of low pressure inside the enclosure.

The portion of core **38** external to the enclosure **10** is either impregnated to make it vacuum tight or is coated with an impervious covering of rubber or plastic material to accomplish the same purpose. Cooling fluid may be introduced through tap **52** into the closed circuit comprising coil **14**, leads **48** and **50**, and coil **46**. The fluid, after flowing through the coils, leaves through an outlet tap **54**.

In operation, a charge is inserted into the crucible **20**, and a source of alternating current is applied to the primary winding **44** on core **38**. The resulting magnetic field produced by the induction coil **14** creates a magnetic field which induces eddy currents in the charge. These eddy currents, in turn, create heat which melts the charge. Thereafter, the crucible **20** is rotated by turning shaft **32**; and the charge is poured into molds, not shown. As the crucible turns, the induction coil **14**, leads **48** and **50**, and secondary winding **46** all rotate as a unit about the axis defined by pivot pins **22** and **24**. In this manner the need for flexible conductors between secondary winding **46** and induction winding **14** is eliminated.

It can thus be seen that the present invention provides a simple means for bringing electrical power through the walls of a vacuum vessel without introducing undesirable corona effects, especially when power and current are high. Furthermore, the invention allows for the application of electrical power during pouring with the crucible in any position.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement in parts may be made to suit re-

quirements without departing from the spirit and scope of the invention.

We claim as our invention:

1. In combination, an enclosure, an electrically heated crucible positioned within said enclosure, said crucible being rotatable about a horizontal axis from an upright position to an inclined position, an induction coil surrounding said crucible, a closed magnetic path having a portion extending outside said enclosure and another portion extending into said enclosure, at least one section of the portion of said path inside said enclosure being coaxial with respect to said horizontal axis, a rigid helical coil of conductive material surrounding said section of the magnetic path, the inner diameter of said rigid coil being of a size to permit unstrained rotation of the rigid coil about said section, and rigid electrical conductors connecting opposite ends of said rigid coil to opposite ends of the induction coil surrounding said crucible whereby the crucible, rigid conductors and rigid coil are all rotatable about said horizontal axis as a composite unit.

2. In combination, an enclosure, an electrically heated crucible positioned within said enclosure, said crucible being rotatable about an axis from an upright position to an inclined position, an induction coil surrounding said crucible, a closed magnetic path having a portion extending outside said enclosure and another portion extending into said enclosure, a helical coil of conductive material surrounding the portion of the magnetic path inside said enclosure, said helical coil being rotatable about said path, and rigid electrical conductors connecting opposite ends of said helical coil to opposite ends of the induction coil surrounding said crucible whereby the crucible, rigid conductors, and helical coil may all rotate about said axis.

3. In combination, an enclosure, an electrically heated crucible positioned within said enclosure, said crucible being rotatable from an upright position to an inclined position, a heating element for said crucible, a closed magnetic path having a portion extending outside said enclosure and another portion extending into said enclosure, a helical coil of conductive material surrounding the portion of the magnetic path inside said enclosure, said helical coil being rotatable about said magnetic path, and electrical conductors connecting the opposite ends of said helical coil to the heating unit in said crucible.

4. In combination, an enclosure, an electrically heated crucible positioned within the said enclosure, said crucible being rotatable from an upright position to an inclined position, a heating element for said crucible, a step-down transformer having its primary winding outside said enclosure and its secondary winding within the enclosure, said secondary winding being capable of substantially unrestrained rotation about its central axis, and rigid electrical conductors connecting opposite ends of said secondary winding to the heating element in said crucible whereby the crucible, rigid conductors and secondary winding may all rotate as a composite unit.

5. In combination, an electrically heated crucible rotatable about an axis from an upright position to an inclined position, a heating element for said crucible, a closed magnetic path having at least one section coaxial with respect to said axis, a rigid electrical coil of conductive material surrounding said section of the magnetic path, the inner diameter of said rigid coil being of a size to permit unrestrained rotation of the rigid coil about said section, and rigid electrical conductors connecting opposite ends of said rigid coil to the heating element in said crucible whereby the crucible, rigid conductors, and rigid coil may all rotate about said axis as a composite unit.

6. In combination, an electrically heated crucible rotatable from an upright position to an inclined position, a heating element for said crucible, a magnetic core member having an helical coil of conductive material surrounding one portion thereof, said helical coil being rotatable about said portion, and rigid electrical conductors connecting opposite ends of said helical coil to the heating unit in said crucible whereby the crucible, rigid conductors and helical coil may all rotate as a composite unit.

7. In combination with a pressure tight enclosure and a rotary member within said enclosure to which it is desired to supply alternating current electrical energy from without said enclosure, a core member extending through an exterior wall of said enclosure in fluid-tight connection therewith, means for inducing flow of alternating current in said core from the exterior of said enclosure, and coil means encircling said core within said housing in inductive coupling therewith to generate flow of current therein responsively to flow of current in said core, said coil means being electrically connected to said rotary member for supply of current thereto and being mechanically connected thereto for rotary movement around said core while remaining in inductive coupling therewith.

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