Nov. 13, 1928. 1,691,349

G. F. HARRINGTON ET AL

HIGH FREQUENCY INDUCTION FURNACE

Filed June 1, 1927 2 Sheets-Sheet 1

Fig. 1.

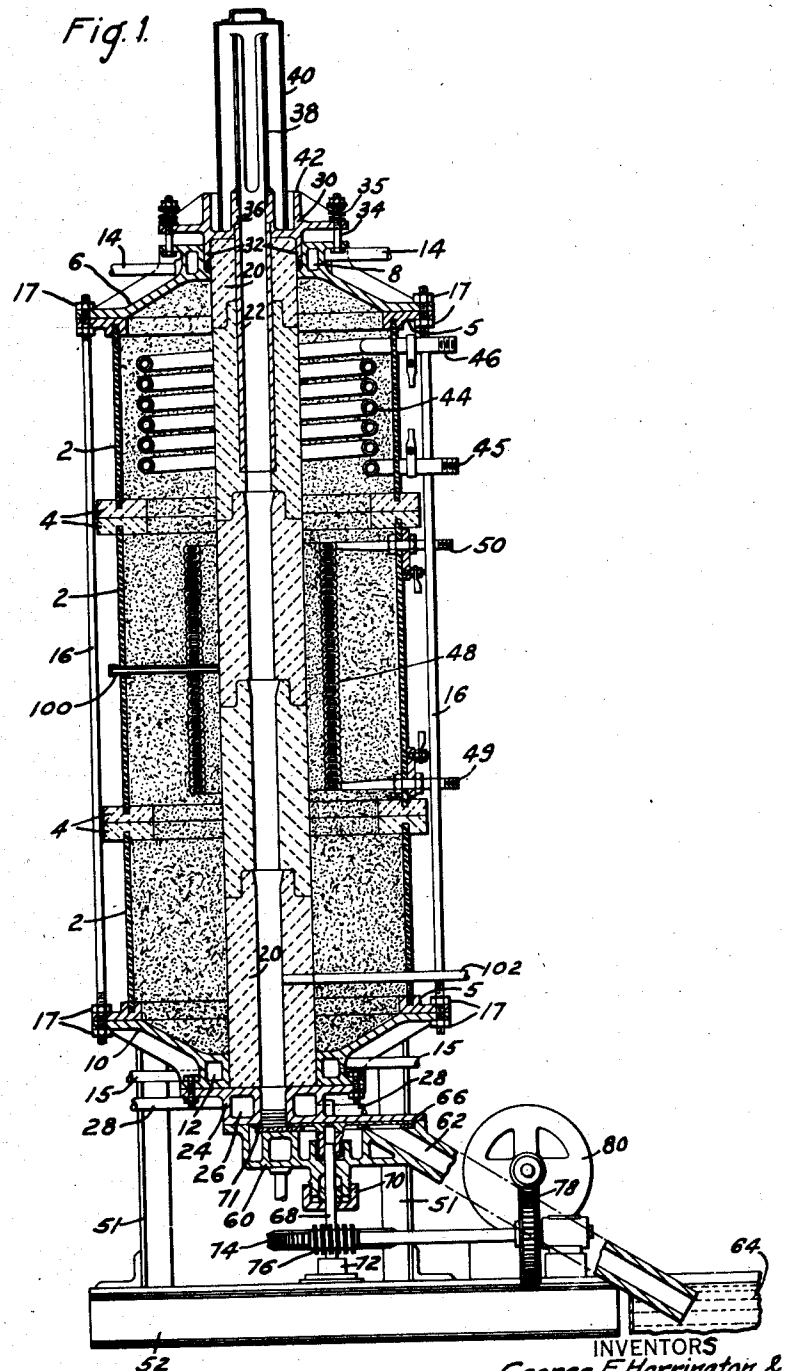

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Fig. 2.

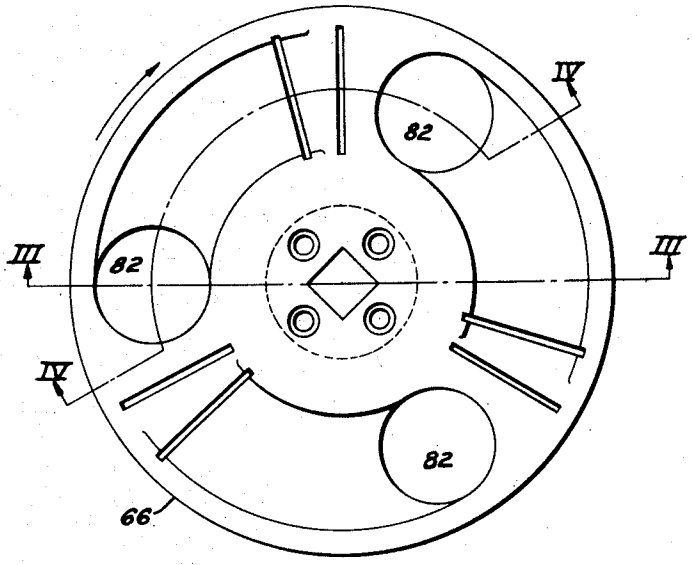
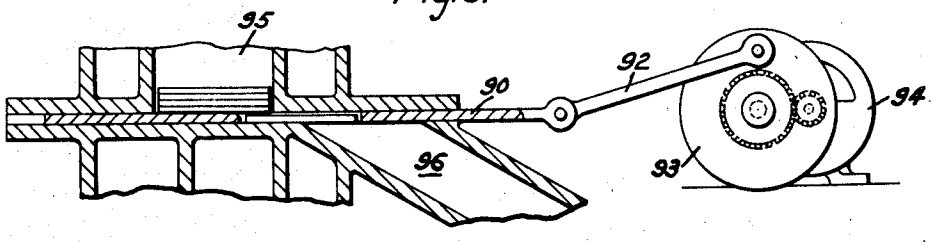


Fig. 3.

Fig. 4.

Fig. 5.



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Patented Nov. 13, 1928. 1,691,349

UNITED STATES PATENT OFFICE.

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HIGH-FREQUENCY INDUCTION FURNACE.

Application filed June 1, 1927. Serial No. 195,629.

Our invention relates to heat treating furnaces and more particularly to heat treating furnaces of the induction type.

An object of our invention is to provide an induction furnace for heat treating a plurality of articles of uniform size which are passed therethrough in a continuous stream at a predetermined rate of speed.

Another object of our invention is to provide a mechanism for discharging heat treated articles from a furnace at a predetermined rate, which means serves also to prevent the influx of air into the furnace chamber during the discharging operation.

Another object of our invention is to provide means for preventing condensation of moisture driven out of the heated articles at the cold or charging end of the furnace.

In practicing our invention we provide an elongated vertically disposed graphite tube or muffle with an inductor coil surrounding the central portion thereof to effect inductive heating of the muffle and of material passed therethrough. A plurality of articles, which in the present instance are of disc shape, are stacked within the muffle, and a motor-actuated means effects the removal thereof, one at a time, from the bottom of the stack. Upon the removal of each article, the stack remaining in the muffle is lowered by gravity to permit the removal of the next article. A second inductor coil of relatively few turns is provided at the upper end of the muffle to preheat said articles and maintain sufficient temperature thereat to prevent condensation of the moisture driven out of the articles during the heating operation.

In the drawings,

Figure 1 is a view, in vertical section, of a furnace embodying our invention,

Fig. 2 is a plan view of a detail of the discharge mechanism,

Fig. 3 is a view in section on the line III—III of Fig. 2,

Fig. 4 is a development in section on line IV—IV of Fig. 2, and

Fig. 5 is a fragmentary view in vertical section of a modified form of discharge mechanism.

The furnace embodying our invention comprises a casing formed of three superposed sections, each section comprising an annular shell 2 of suitable refractory heat-insulating material set in grooves in annular refractory plates 4. A grooved metallic annular ring 5 is seated upon the upper peripheral edge of the top section 2, and a similar ring 5 is seated upon the lower peripheral edge of the lower section 2. The top of the upper section is closed by a cast metallic cap 6 resting upon the ring 5 which is provided with an annular passage 8 to permit the circulation of a cooling fluid therethrough. A similar cap 10 closes the bottom of the lower section, in face-to-face relation with the lower ring 5, and is provided with an annular passage 12 for the circulation of a cooling fluid. Pipes 14—14 and 15—15 conduct the cooling fluid into and out of the passages in the upper and lower caps respectively.

The caps 6, rings 5, sections 2, and plates 4 are secured in assembled relation by a plurality of rods 16, the ends of which are screw-threaded and project through apertures formed in rings 5 and caps 6 and 10 to be engaged by nuts 17.

The caps 6 and 10 are apertured centrally thereof to permit the passage therethrough of a graphite tube or muffle 20, comprising a plurality of interfitting sections, which extends the entire length of the casing. The bore of tube 20 is slightly enlarged at the upper end thereof to accommodate a tube 22, of nichrome, or other suitable material, for a purpose hereinafter described. A plate 24 with an aperture in the center thereof adapted to register with the bore of tube 20, is bolted to the lower face of the casting 10 and supports the tube in position within the casing. The plate 24 is provided with a chamber 26 and pipes 28—28 to permit the circulation of a cooling fluid therethrough.

A plate 30, having an annular depending flange 32, caps the upper end of tube 20 and projects a short distance into the aperture in plate 6, and is resiliently clamped to the cap 6 by means of bolts and compression springs 34, 35, so that the sections of tube 20 are always forced together irrespective of the relative expansion and contraction of the tube and casing, and the tube is securely held in the casing.

The plate 30 is axially apertured and flanged at 36 to register with the bore of tube 20 and the flange is threaded to receive the threaded end of an extension 38 into which the articles to be heated are inserted. A

readily movable cover 40 encloses the extension 38 and rests in a groove in plate 30 defined by flange 36 and an annular flange 42.

Regulation of the flow of cooling fluid through the caps 6 and 10, or the omission of cooling means altogether, will effect desired changes in the temperature gradient through which the articles pass during the heat treating operation.

Within the upper section of the furnace casing and surrounding tube 20 is a hollow inductor coil 44 of a relatively small number of turns. Terminals 45, 46 thereof extend through shell 2 for connection with a suitable source of electric power and a cooling fluid supply.

In the center section of the casing is an inductor coil 48 comprising a helix of flattened tubing with terminals 49, 50 extending through the shell 2 to provide for connection with a source of electric power and a cooling fluid supply.

Thermal insulation consisting of a finely divided refractory, such as zirconium silicate, fills the entire casing and the space between the inductor coils and the graphite tube 20.

Supporting legs 51 are secured, at the upper ends thereof to the casting 10, and at their lower ends to a suitable base 52.

The discharge mechanism comprises a water cooled casting 60 secured to the lower face of plate 24 and provided with a circular recess in the face thereof adjacent to plate 24. A discharge passage 62 extends from said circular recess through the casting 60 into communication with a suitable receptacle 64. A circular disc 66 substantially fills said circular recess and is mounted for rotation upon an axis mid-way between the axes of the bore of tube 20 and of the opening of the discharge passage 62. Rotation of the disc 66 is effected by means of a shaft 68 keyed thereto which extends downwardly through a stuffing box 70 with the lower end thereof received in a suitable bearing 72. A worm gear 74 is keyed to shaft 68 and motion is imparted thereto through suitable reduction gearing 76, 78, driven by an electric motor 80.

The plate 66 shown more particularly in Fig. 2, is provided with a plurality of peripherally spaced apertures 82 of substantially the same diameter as the bore of tube 20 and so arranged that upon rotation of plate 66, the apertures will be moved to register with the bore of tube 20 and the opening of discharge chute 62 successively. With particular reference to the developed section of plate 66 as shown in Fig. 4, it will be noted that the surface of the plate is gradually inclined downwardly at 67 toward the apertures 82 and the portion of the plate at the opposite side of the aperture is slightly chamfered as at 69.

In the present embodiment, the furnace is designed for the heat treatment of disc shaped objects which are inserted in the upper end of tube 20 to form a stack therein. Rotation of plate 66 in a clockwise direction will bring one of the apertures 82 into registration with the bore of tube 20, thereby permitting one of the discs to be received therein and causing a consequent lowering of the stack. In effecting this result the disc at the bottom of the stack is gradually lowered by movement of the inclined surface 67 of plate 66 so that abrupt dropping of the stack is avoided. Further rotation of plate 66 brings the portion 69 thereof into engagement with the bottom disc thereby removing it from the stack, and continued rotation brings the disc into registration with the opening of discharge passage 62 and permits it to drop therein.

The slightly chamfered edge 69 of plate 66 permits operation of the device with discs varying considerably in thickness, the only requirement being that the disc be at least as thick as the vertical surface of the portion 69, and not greater in thickness than the thickness of plate 66. It is clearly within the scope of the present invention, however, to so proportion the thickness of plate 66 with a respect to the thickness of the discs, that the discharge of two or more of the discs at a time is possible.

The rotation of plate 66 is continuous at any desired speed depending upon the time necessary for the proper heat treatment of the discs within the tube 20.

A plate 71 of suitable heat resistance material is fixedly mounted in the circular recess in the casting 60 beneath plate 66 to effect a snug fit between the plate and castings 24 and 60 so that the entrance of air into tube 20 is substantially prevented. To insure a more complete exclusion of air, an air-tight cover (not shown) may be provided for the receptacle 64.

A tube 100 extends through the intermediate section of the furnace casing 2 into communication with the heated section of the tube or muffle 20, to accommodate a thermocouple or other appropriate means for determining the temperature of the heated zone of the muffle.

In Fig. 5 we have shown a modified form of discharge mechanism comprising an apertured plate 90 reciprocated by means of a connecting rod 92 and a crank disc 93 actuated by an electric motor 94. The reciprocation of the plate 90 successively brings it into registration with the bore 95, containing a stack of heated discs and the opening of a discharge chute 96, whereby the discs are removed one at a time from the bottom of the stack and dropped into the discharge chute.

In operation, the tube 20 is filled with a

stack of discs to be heated and inductor coils 44 and 48 are electrically connected to a suitable source of alternating current. The graphite tube 20 is thereby heated inductively and the heat is transmitted to the discs within the tube.

The purpose of coil 44 is to maintain the temperature of the upper end of tube 20 at a value sufficient to prevent condensation thereon of moisture driven out of the heated discs, and to preheat the discs as they are inserted into the tube. A small percentage of the moisture, however, tends to corrode the inner wall of tube 20 and to avoid this difficulty we have provided tube 22 of a suitable heat and moisture resistant material, such as nichrome, which lines the upper portion of the bore.

Energization of motor 80 rotates plate 66 and as the apertures 82 therein register with the bore of tube 20 the bottom disc of the stack is received therein and is carried, upon continued rotation, into registration with the discharge chute 62. Upon the removal of each disc, the discs remaining in the stack are lowered by gravity so that the movement of the discs through the tube is substantially continuous and the speed thereof may be readily controlled through motor 80. Additional discs may be added to the top of the stack in the tube 20, either by manual or by automatic means, as may be desired, so that the heat treating process is continuous.

It is obviously within the scope of our invention to modify the structure shown to heat treat articles of various shapes, the only requirement being that the articles be substantially uniform in size. The muffle 20 may be provided with a plurality of bores for increased production, and may be formed of various materials to effect desired chemical or thermal results. Also, the circulation of gases through the muffle to effect desired chemical action or to remove moisture driven out of the discs, may be resorted to and accomplished by extending a conduit, such as 102, permitting the passage of such gas through the furnace casing into communication with the bore of muffle 20.

By our invention, therefore, we have provided a furnace for heat treating a plurality of articles of uniform size passed in a continuous stream through an inductively heated muffle, or tube, with a discharge mechanism operable at a predetermined speed to remove the articles from the heating chamber, thereby effecting the constant movement of the articles through the chamber and the substantial exclusion of air therefrom.

Various modifications may be made in our invention without departing from the spirit and scope thereof, and we desire therefore that only such limitations shall be placed thereon as are imposed by the prior art and the appended claims.

We claim as our invention:

1. An induction furnace for heat treating a continuous train of articles of uniform size, comprising a vertically disposed elongated graphite tube adapted to contain a stack of said articles, an inductor coil surrounding the central portion of said tube to effect the heating thereof, and a second inductor coil of relatively few turns surrounding the upper end of said tube to effect a desired temperature gradient longitudinally of said tube.

2. In a heat treating furnace, the combination with a tubular muffle and an inductor coil for heating an intermediate portion only of said muffle, of an auxiliary inductor coil for heating the receiving end of said muffle to prevent the condensation therein of moisture driven out of the articles being heat treated, and a moisture resistant lining for said muffle at the receiving end.

3. In a heat treating furnace, the combination with a tubular muffle, an inductor coil for effecting heating of an intermediate portion only of the muffle, and a casing surrounding the muffle and coil, of closure members at the respective ends of the casing for holding the tubular muffle in proper operative position in said casing, and fluid cooling means in said closure members for ensuring a predetermined sequence of temperature values in said muffle longitudinally thereof.

4. In a heat treating furnace, the combination with a muffle comprising a plurality of coaxial interfitting tubular portions, and electric means for heating an intermediate portion only of the muffle to a relatively high temperature, of an auxiliary electric means for heating the inlet end of the muffle to a lower temperature than that of the intermediate portion, a casing surrounding the muffle and the several heating means, fluid cooled end members associated with the casing for closing the ends thereof and for holding the muffle therein, and resilient means associated with one of said end members for effecting close engagement of the interfitting portions of the muffle under all conditions of operation of the furnace.

In testimony whereof, we have hereunto subscribed our names this 9th day of May, 1927, and this 26th day of May, 1927, respectively.

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PORTER H. BRACE.