

April 17, 1945.

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2,373,719

INDUCTION FURNACE CONSTRUCTION

Filed March 18, 1943

2 Sheets-Sheet 1

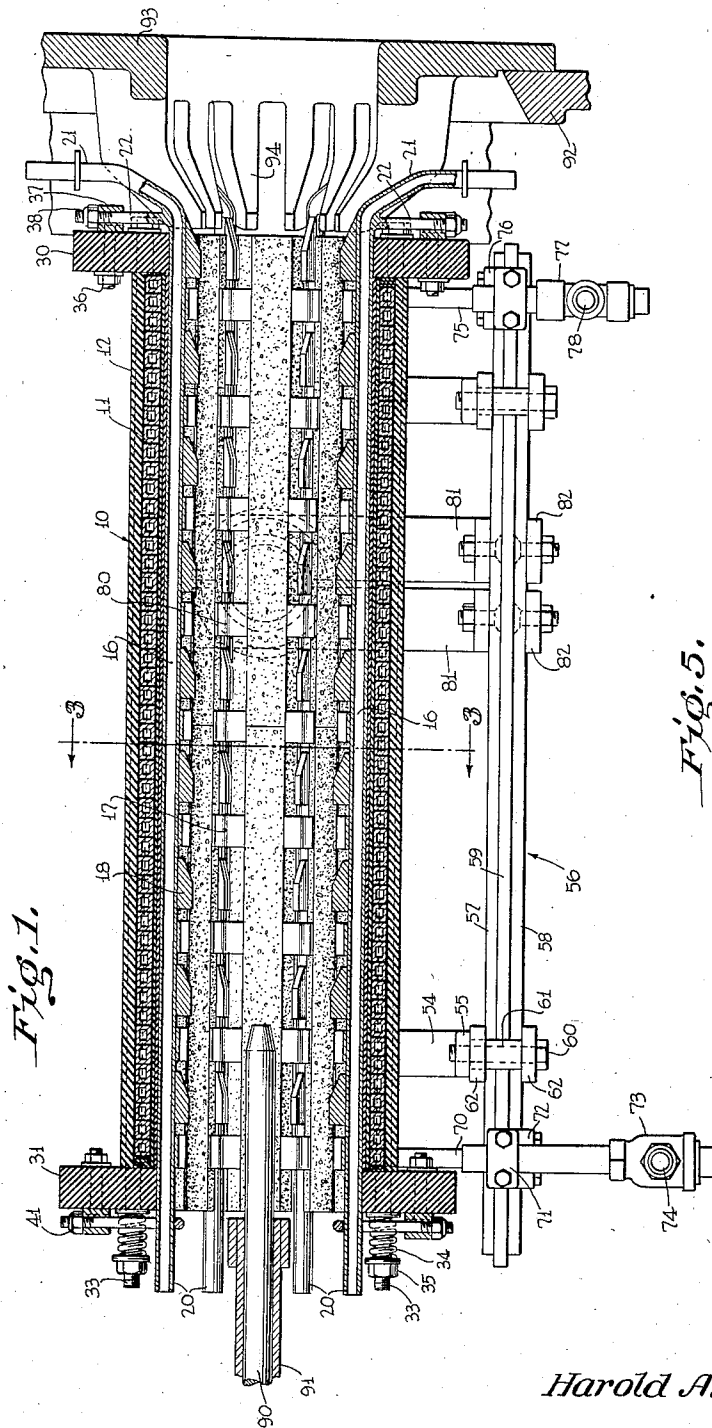
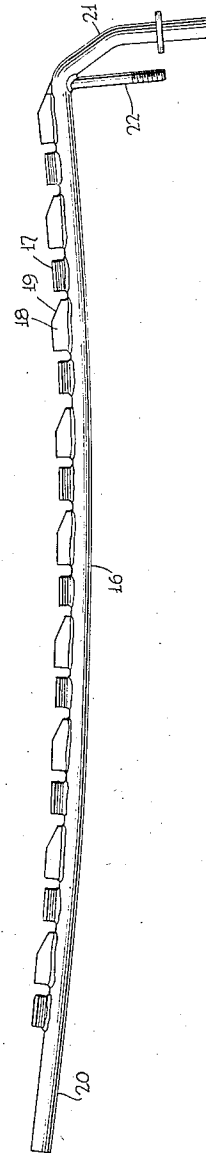


Fig. 5.



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Fig. 2.

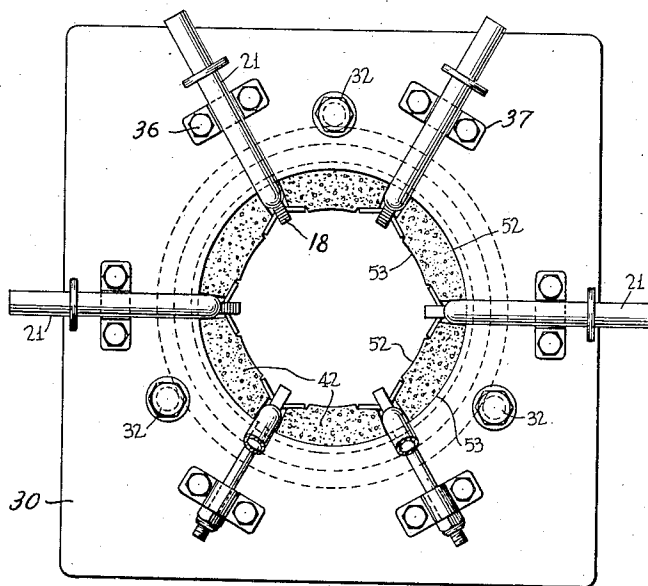


Fig. 3.

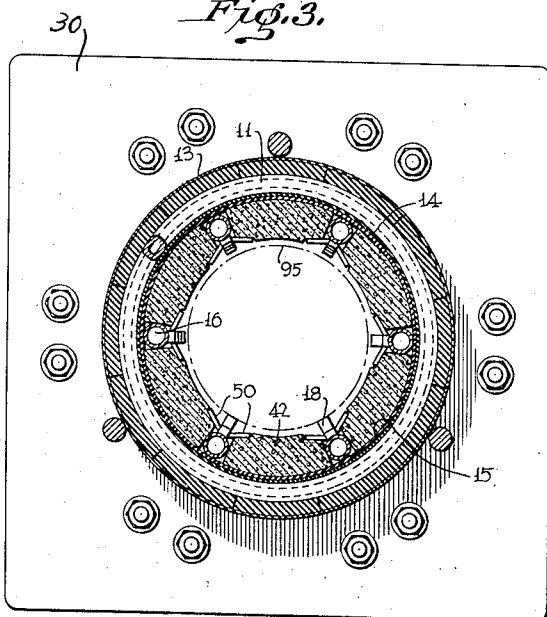
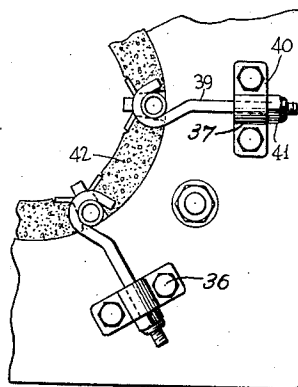


Fig. 4.



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2,373,719

INDUCTION FURNACE CONSTRUCTION

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Application March 18, 1943, Serial No. 479,556

14 Claims. (Cl. 219—13)

This invention relates to electric induction furnaces and particularly to furnaces of this type adapted for heating billets, bars and similar stock to forging temperatures.

In furnaces utilizing inductive heating means the inducing coil is usually arranged and supported so as to receive the billet or other charge or workpiece within the chamber formed by the convolutions of the coil. It is accordingly necessary that this coil be self-sustaining, that it be properly cooled to prevent overheating, that adequate head insulation be provided for protecting the supporting structure, and that the whole arrangement of coil, insulation, cooling devices and support be strong, rigid and free of cumbersome or bulky elements.

Accordingly, the objects of the invention may be enumerated as follows: to provide a self-sustaining induction furnace structure which permits elimination of internal supporting elements; to provide a structure which is stressed radially in order to effect rigidity in the component structural elements; to provide improved furnace end supports permitting elimination of bulky external elements; to provide end support means which serve to protect coil turns and external supporting elements from flame corrosion; to permit insertion and removal of fire brick from a furnace end with limited disturbance of the support means; and in general to provide a rigid, compact, self-sustaining furnace chamber construction with a reduced number of essential parts.

The above objects are realized in an arrangement, which may be preferred, hereinafter described and illustrated in the accompanying drawings in which:

Figure 1 is a horizontal section through the heating coil and associated supporting structure;

Figure 2 is an end view of the heating coil showing the front cooling rail terminals;

Figure 3 is a section on lines 3—3 of Figure 1 illustrating the coil supporting rails and insulating structure;

Figure 4 is a detail of the rear rail attachment means; and

Figure 5 is a view of a rail prior to assembly in the heating coil unit.

In my copending application Serial No. 384,503, and Patent No. 2,365,021, issued December 12, 1944, a division of said application, there is disclosed an arrangement of furnace parts which in many respects is satisfactory and which forms the basis of the improved arrangement as disclosed herein. As shown in said copending ap-

plication and patent and in the drawings accompanying this application, the heating unit 10 is substantially tubular in form having a front open end and a closed rear end, the workpiece being adapted for insertion through the open end into the interior of the heating chamber. In the form of the invention as shown in Figure 1 the heating unit includes a continuous coil of tubing 11 the same being of square section although obviously a circular or other form of section may be employed. A square section is desirable as it permits a close positioning of the coil turns and presents a uniform inner and outer plane surface upon which appropriate insulation can be placed. The various turns of the coil are spaced from each other and covered on all sides by appropriate insulation such as mica it being understood that the insulation may be in the form of a wrapping as well as in sheet form. External to the coil 11 is an outer casing 12 formed of segments of suitable insulation material, as "micarta" or other mica containing or phenolic layered substance the outer layer being held in position by means of tape 13 as more clearly shown in Figure 3.

Interiorly of the coil 11 is a layer 14 of mica or mica containing composition which is resistant to heat as well as electrically insulating. Within the layer 14 is an additional layer of mica or mica containing composition 15 which is preferably even more resistant to heat than layer 14. Alternatively both layers 14 and 15 may be made of glass fibre or a similar product.

The coil supporting structure is contained within the insulation layer 15 and consists of a plurality of axially extending rails 16 which as shown are of tubular construction with a circular cross section. Referring to Figure 5 it will be seen that these rails have a slight curvature from end to end the center of the curvature being on the inner side of the rail as positioned in Figure 1. On this inner side also are attached a series of supporting elements 17 and 18, the support 17 being intended for the retention of a fire brick as will be explained more fully hereinafter and the element 18 serving as a support and guide for the workpiece. It is noted that the forward or front end of the support 18 has an inclination 19 which serves to facilitate entry of the workpiece into the heating chamber. The support 18 as more clearly shown in Figures 2 and 3 is in the shape of a flat plate the edge of which opposite the inclined edge 19 being welded or otherwise attached to the inner surface of the rail 16. The rear end 20 of the rail is straight in

extension of the main body of the rail structure whereas the front end 21 of the rail is outwardly turned to afford a radial connection to tubing containing cooling fluid. Also at the angle of out turn of the front rail end at 21 there is positioned a finger 22 threaded at its outer end which is adapted for connection to the end supports as will now be described.

The assembled structure of coil insulation layers and rails is supported by end plates 30 and 31, 30 the end plate 30 covering the front end of the coil and the plate 31 the rear end. These plates are similar in construction being substantially square in outer outline as shown in Figures 2 and 3 with relatively large central openings coinciding with the heating chamber of the coil interior. These end plates are made of electrically non-conducting material which is also heat resistant and which moreover is structurally adequate for the support of the assembled coil structure. These plates are retained in position on the ends of the heating coil by means of external rods three of which are indicated in Figure 2 bearing the numeral 32, this figure showing the heads of the rods and Figure 1 showing the screw threaded rear ends 33 of the rods. Coil springs 34 are interposed between the rear end plate 31 and the retaining nuts 35 on the ends of the rods so that accommodation may be made in the structure for expansion due to heat.

Radial support for the coil construction is provided as hereinabove mentioned in the rails 16 which extend axially within the inner insulation layers and in contact therewith with their ends protruding forwardly and rearwardly through the central openings in the end plates 30 and 31. The front end of the rail is fastened to the front end plate 30 by means of bolts 36 which are positioned adjacent the outer edge of the end plate and which bolt clamps 37 through which the finger 22 of the rail extends and to which the finger is fastened by the nut 38. The rear end of the rail projecting from the end plate 31 is secured to the end plate by means of a hook 39 which underlies the rail end and projects under the clamps 40 to which it is secured by the nut 41. It is pointed out that the showing of Figure 1 of the rail in assembled position is different from the showing of the rail in Figure 5, this being due to the fact that in assembly the tension of the hook 39 and finger 22 when the nuts are drawn taut causes a straightening of the curvature of the rail with the result that the center section of the rail is strongly compressed on its outer surface against the load of insulation and coil thus insuring a tight, compact and solid assembly of the coil unit.

As described up to this point the internal surface of the heating chamber is formed of the rails and the enclosing mica insulation casing. To complete the interior surfacing of the heating chamber fire brick 42 is inserted preferably at the ends of the furnace chamber so as to lie between the adjacent rails and to fill the space between the mica casing 18 and the concentric surface defined by points concentric but inwardly displaced from the circle including the inner edges of the rail guides 16 as shown in dotted outline in Figure 3. To this end the clips 17 hereinabove mentioned are shaped in flat inwardly extending strips forming wings 50 (see Fig. 3) which are rigid with the rails 16 and form therewith inner supports for the fire brick edges. The fire brick 42 is formed particularly for in-

sertion in the furnace the same having axially curved inner and outer surfaces 52 and 53 the inner surface 52 having its edges inwardly recessed and outwardly inclined to form seats for the wings 50 of the retaining clips 17. It will be seen that this type of brick construction permits insertion of the brick by sliding the same from the ends of the furnace coil so that in the final formation of the inner surface there is a construction having alternate segments of continuous fire brick and metal rails cooled by the passage of a cooling fluid. This construction while including different materials such as metal and ceramic substance nevertheless combine to form a heat resistant surface of considerable effectiveness.

The heating coil as a whole may be supported by various means. Figure 1 suggests one method of support by use of supporting arms 54 which underlie the heating coil unit. Attached to the supports 54 are risers 55 to which are secured the bus bar assembly 56. As shown in Figure 1 this assembly includes bus bars 57 and 58 spaced by insulation 59 the assembly being attached to the risers 55 by bolts 60 passing through the insulation tube 61 and spaced from the bus bars by insulation washers 62. Connection to the bus bars 57 and 58 from the ends of the heating coil 11 is made at the terminals thereof. As shown in Figure 1 the rear end 70 of the coil is clamped directly by clamp 71 to a fitting 72 bolted to the bus bar 58, the coil extending into the coupling 73 at which connection is made to the cooling fluid conduit at 74. Likewise the front end 75 of the coil is clamped to the fitting 76 and leads into the coupling 77 and the inlet cooling fluid conduit 78. The power intake is from the tubular concentric risers 60 shown in dotted outline in Figure 1 the same extending in dual plates 81 and 82, plates 81 being bolted to bus bar 57 and plates 82 to bus bar 58.

There is shown additionally in the construction at the rear end of the furnace chamber an ejector rod 90 slidably movable in a combination stock gauge and support 91 the purpose of the ejector being to force out the workpiece from the heating chamber upon completion of the desired heating cycle. At the front end of the furnace there is also shown a portion of the front plate 92 and the mouth piece plate 93 with the rearwardly and inwardly projecting guide fingers 94 connected to center the workpiece in its movement into the chamber interior. It is noted that the mouthpiece plate at the point of contact with the front wall 92 has an inwardly offset circumferential recess permitting some degree of radial adjustment of the mouthpiece for centering purposes.

It is noted also that the locus of rail support inner edges 18 forms a cylinder the axis of which is offset upwardly from the heating coil axis in order to insure axially symmetric positioning of the workpiece as indicated in dotted outline 95 in Figure 3.

Attention is directed to the continuity of the fire brick and rail supporting structure both axially and circumferentially. Actual usage has demonstrated the importance of maintaining on the inner surface of a furnace adjoining the workpiece a substantially complete continuity of surfacing for the reason that where, as in prior structure, a break was made for insertion of additional support means, the projecting edges of the fire bricks at the break tended to fuse and

disintegrate, thus causing more or less frequent shutting down of the furnace to make necessary lining repairs. This factor is of additional importance because of the length of the furnace, auxiliary supports, causing a break in the continuity of the break structure, being placed at the approximate center of the axial length of the lining. Avoidance is made of construction necessitating a central break in the lining by usage of the rails having a normal outward convexity so that in the process of assembly the whole central area of the brick lining structure and associated casings and coil are placed under radial pressure thus overcoming any necessity for additional central supports. This results also in greater compactness of the unit in the final assembly. It is pointed out further that in case the fire brick is relatively loose in the guideways the rails would tend to assume their normal outward curvature giving a slightly bowed or arched effect axially of the furnace which would also tend to maintain the central sections of the coil structure.

The described arrangement has been found to be useful, operative and effective but it is apparent that modifications as to detail may be made and therefore limitation is not intended in the disclosed embodiment except insofar as imposed by the claims hereunto appended.

What is claimed is:

1. An induction furnace comprising a tubular heating coil, heat resistant rails axially positioned interiorly of said coil and forming a grill therein, heat insulating material between and supported by said rails, and end plates attached to said rails for supporting said rails and material.

2. An induction furnace comprising a tubular heating coil, metal rails axially positioned interiorly of said coil and forming a grill therein, heat insulating material between and supported by said rails, and end plates attached to said rails for supporting said rails and material, said rails extending outwardly at the ends through apertures formed in the end plates, the rail ends, insulating material and end plates at the mouth end of the furnace chamber forming a shield for the prevention of corrosion at the adjacent furnace end.

3. An induction furnace comprising a tubular heating coil, heat resistant rails each having an unstressed radially outwardly convex bend from end to end, positioned axially within said coil and insulated therefrom, heat insulating material interposed on the coil wall between said rails, said material being supported by said rails, apertured plates at each end of said heating coil, said rails extending through said plate apertures, and means for attaching the rail ends to said plates under radial tension.

4. An induction furnace comprising, an electrical tubular heating coil, heat resistant rails axially positioned interiorly of said coil and forming a grill therein, heat insulating material between and supported by said rails, end plates attached to said rails for supporting said rails and material, and means for holding said end plates in yielding co-relationship whereby adjustment may be made for axial rail and coil heat expansion.

5. In an induction heating furnace a tubular heating coil, metal rails laterally spaced in axial relationship within and adjacent said coil, electrical insulation between rails and coil, low heat conductive and heat resistant material between said rails, means secured to the rails for holding

said material between the rails, said rails having an unstressed radially outward convexity, means for supporting said rails under strain to reduce said rail convexity, and workpiece supports secured to said rails in spaced relationship along said rails whereby said rails are free to flex radially of the coil.

6. In an induction furnace, an electrical tubular heating coil, supporting metal rails forming a grill positioned axially within and adjacent to, but electrically insulated from said coil whereby electrical contact between coil and rail is prevented, heat resisting and insulating material supported by said rails and forming continuous axial layers therebetween, whereby a complete furnace chamber lining of said rails and material is formed, and means at the ends only of said heating coil for holding said lining in position adjacent said coil.

7. In an induction heating furnace, a supporting heat resistant rail for fire brick and the like comprising an extended member having a small degree of curvature from end to end, an end curved sharply in the direction of maximum rail curve convexity, and a support element fixed to the rail adjacent the point of end curvature and coplanar with said curved end and rail.

8. In an induction heating furnace, an electrical tubular heating coil, axially extending and laterally displaced metal rails positioned within and adjacent to but insulated from said coil and forming a grill framework therein, heat resisting and insulating material between, and supported by said rails whereby the coil is insulated from said rails, an integral finger attached to one end of the rail, heat and electricity insulating coil end plates having apertures for receiving the rail ends, said rail ends extending through said plate apertures, and radially adjustable support means at either end plate for attachment to the finger at one end and to the rail at the other end for supporting the adjacent rail end and imparting radial movement thereto.

9. In induction furnaces, an electrical tubular heating coil, a continuous heat resisting and heat insulating layer within and adjacent said coil and electrically insulated therefrom, and means at the ends only of said coil for holding said layer in position adjacent said coil.

10. In induction furnaces, an electrical tubular heating coil, a continuous heat resisting and heat insulating layer within and adjacent said coil and electrically insulated therefrom, and means at the ends only of said coil for holding said layer in position adjacent said coil, said layer including electrically conductive and non-conductive elements.

11. In induction furnaces, a tubular heating coil, axially extending and laterally displaced heat resistant rails positioned within and adjacent to but electrically insulated from said coil, fire brick supported by said rails therebetween and between the rails and coil, whereby adjacent rails are spaced by an axial segment of single bricks, and means including insulation end plates for supporting said rails at the coil ends only, whereby said bricks may be placed in position inside the coil from the coil end.

12. In an induction furnace, a tubular heating coil, a plurality of axially extending rails forming a grill adjacent the interior surface of said coil, insulation material supported between the coil and grill by said grill and means at the coil ends only for holding said grill in place.

13. In an induction furnace, a tubular heating

coil, a plurality of axially extending rails forming a grill adjacent the interior surface of said coil, insulation material supported between the coil and grill by said grill and support means at the coil ends for holding the insulation material in close proximity to said coil, said rails being normally curved outward convexly with reference to the coil axis whereby the rail ends are under pronounced radial inward tension when supported in position by said rail support means.

14. An induction furnace comprising a tubu-

lar heating coil, heat resisting rails axially positioned interiorly of said coil and forming a grill therein, heat insulating material between and supported by said rails and extending to the coil ends, and end plates attached to said rails for the support thereof, said coil end plates overlapping the coil ends and extending to the insulating material whereby a tubular protective shield is formed at the coil ends.

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