Dec. 12, 1944. H. A. STRICKLAND, JR 2,365,021

ELECTRIC FURNACE MACHINE

Original Filed March 21, 1941 2 Sheets-Sheet 1

FIG. 1.

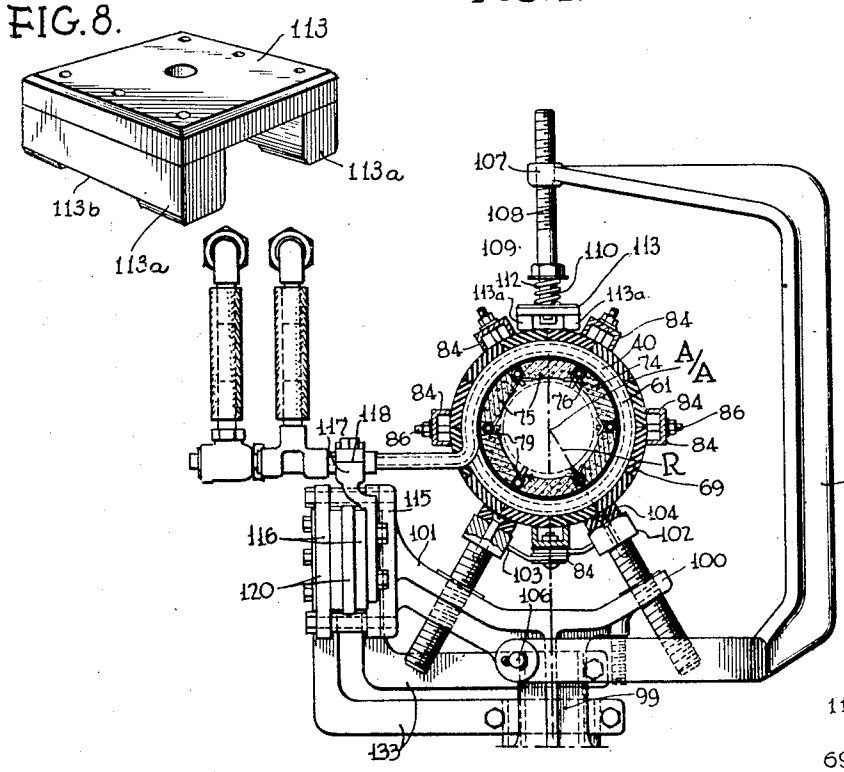


FIG. 8.

FIG. 9.

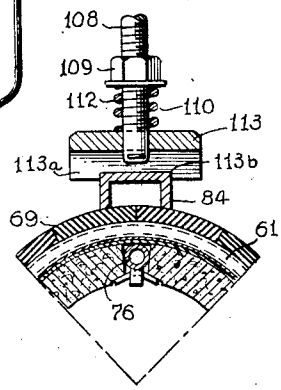


FIG. 7.

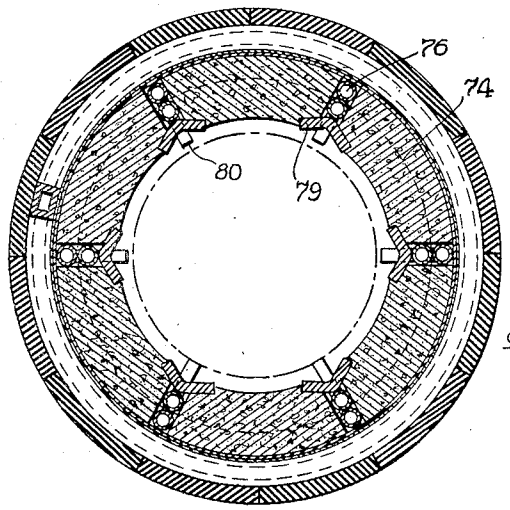
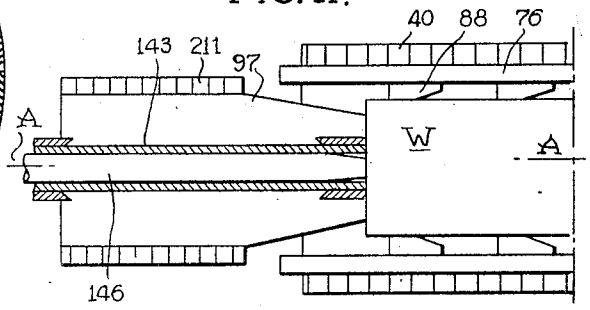


FIG. 11.



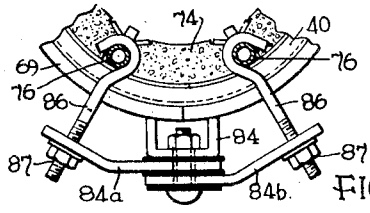


FIG. 10.

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ELECTRIC FURNACE MACHINE

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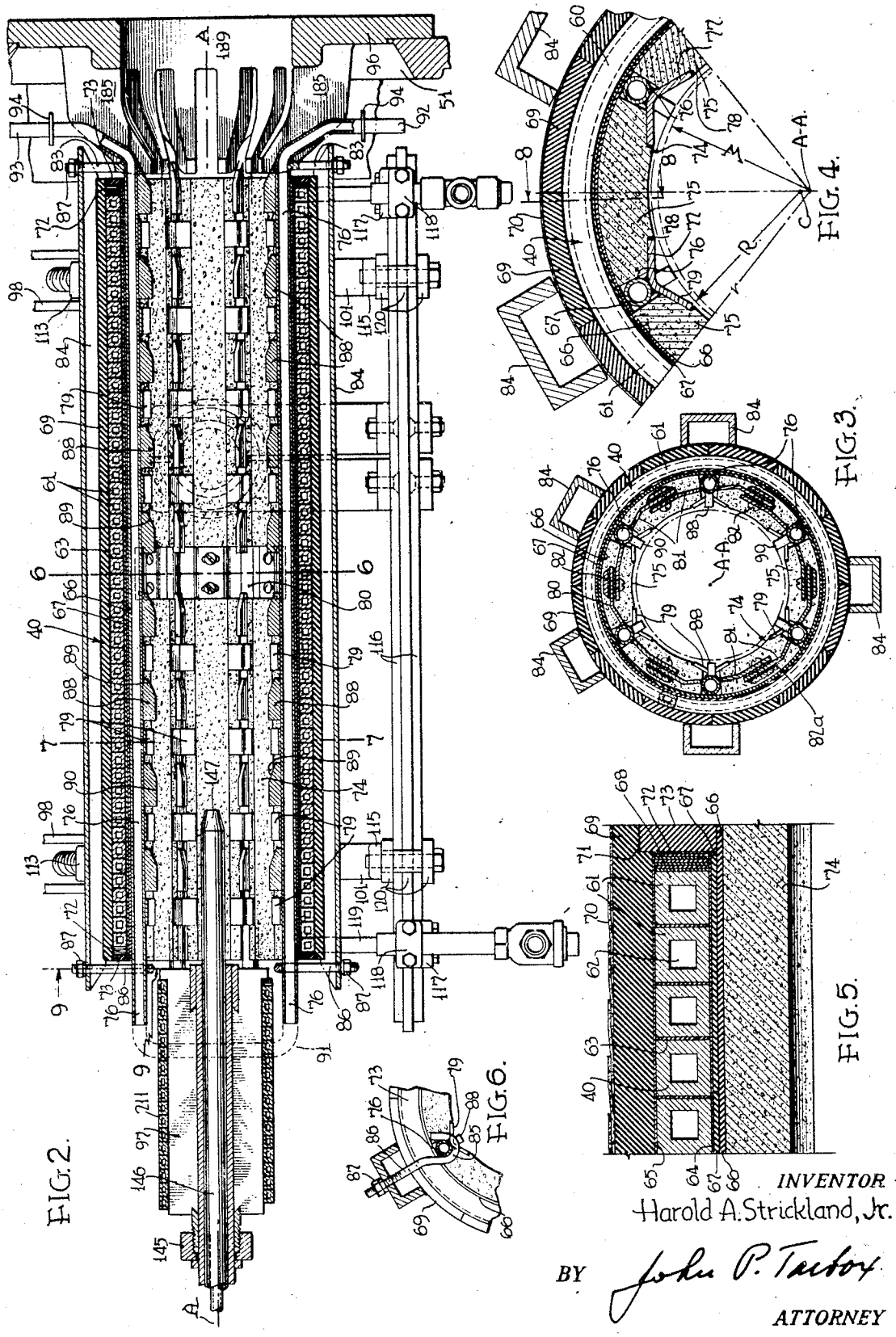


FIG. 2.

FIG. 4.

FIG. 3.

FIG. 5.

FIG. 6.

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UNITED STATES PATENT OFFICE

2,365,021

ELECTRIC FURNACE MACHINE

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Original application March 21, 1941, Serial No. 384,503. Divided and this application September 18, 1941, Serial No. 411,297

24 Claims. (Cl. 219—13)

This application is a division of my copending application Serial No. 384,503, filed March 21, 1941.

My invention relates to coils for furnaces for heating by electromagnetic induction, and particularly to those which can be used or are intended for use in the heating of bar or billet stock for forging purposes. In such furnaces, bar or billet stock of either solid or tubular form, and either circular or angular in cross-section, is inserted within a coil adapted to be supplied with power from an alternating current source, usually a high-frequency alternating current source of considerable voltage, and the power being turned on to the coil, heating currents are set up within the mass of the bar or billet to be heated due to the electromagnetic induction from the coil itself. These currents heat the bar or billet to a forging temperature. Such a bar or billet is commonly called a workpiece. The objects of my invention follow.

Outstandingly I aim to make such a furnace a machine. This I achieve through the construction, organization, and automatization of its various component parts, e. g., the heating coil into which the workpiece is thrust for its heating, and all appurtenant devices. I have aimed to achieve in this machine a quantity production apparatus outstandingly adapted for installation in connection with high-speed production systems and lines common in today's industry.

Reliability, consistency, and continuousness of operation have been important ends which I have had in view. Construction and arrangement of parts, and automatization have also played an important part in the attainment of these ends. Automatization and coordination of automatization in interlocking of control elements have enabled me to attain these ends to an extent practically eliminating the personal equation of the operator, and likewise eliminating disturbances of these several factors, reliability, consistency, and continuousness, occasioned by disorders of any kind emanating from whatever source reaching the machine.

One object of this invention is to produce an inducing coil adapted for operation at relatively high voltage so that the time for heating the work with a given current frequency is shortened. One factor contributing to this result is the hermetic encasement of the coil so that gases and fumes as well as moisture, scale, and dirt of various kinds cannot get in between the coil convolutions. Such sealing is more than mere insulation or mechanical protection.

Another object is to provide an improved work supporting track within the heating coil. The track is water-cooled to aid in conducting excess heat from the surface of the work. A further object is to construct this track so as to reduce the heat developed in it. Yet another object is to provide an improved construction of heating coil and its appurtenant parts.

There is delineated in the drawings that embodiment of my invention now best known to me, but it will be quite apparent that it is subject to yet other embodiments.

Of the drawings:

Figure 1 is a transverse section, transaxial to the heating coil;

Figure 2 is an enlarged horizontal cross-section of the heating coil in a view including the axis of the coil;

Figure 3 is a transaxial section of the heating coil on line 6—6 of Figure 2;

Figure 4 is an enlargement of a portion of such a transaxial cross-section of the coil taken on a line such as 7—7 of Figures 2 and 5;

Figure 5 is a correspondingly enlarged portion of a longitudinal section, being a view taken on line 8—8 of Figure 4 looking in the direction of the applied arrows;

Figure 6 is a rear end elevation of a detail of the heating coil showing the detail of the mounting of the work-supporting rails which lie within the coil taken on line 9—9 of Figure 2;

Figure 7 is a transaxial cross-section similar to that of Figure 3 applying to a modified form of coil and accompanying workpiece supports within the coil.

Figure 8 is a perspective view of a bridge-piece connected with a heating coil support clamp;

Figure 9 on the same sheet is a transaxial segmental section showing the bridge-piece of Figure 8 in use in connection with a special heating coil;

Figure 10 appearing on the sheet containing Figure 1 is a fragmentary rear end view of a heating coil showing means for securing workpiece guide rails in connection with the special coil of Figure 9;

Figure 11 is a diagrammatic illustration of a modified form of the magnetic core.

The heating coil 40 and the supports for the workpiece within it are of a very special construction which appears outstandingly in Figures 1 to 6. The coil per se 40 is comprised of hollow conductors 61 generally of square shape. Cooling water in sufficient volume to cool the coil 40 is passed through the hollow 62 of this conductor. Individual turns of the coil (see particularly Figures 2 and 5) are insulated from each other by a spiral of mica 63 or the like, or else the conductor throughout its length may be wrapped with an insulating tape of an appropriate character, preferably heat-resisting, suitably impregnated with a suitable varnish after the winding of the tape is complete. If the conductor is so wound, then when the coil is wound on a suitable mandrel, there results

inside and outside insulation 64, 65, as well as insulation 63 between the turns. The coil is wound on a suitable mandrel (not shown) preferably a collapsible mandrel. However, initially there is placed on a mandrel an innermost cylinder of high-grade mica sheets 66 capable of high-heat resistance and impervious to moisture and bonded with a resilient insulating varnish. Also superimposed on the innermost cylinder of mica 66 is a secondary cylinder of mica 67 which may be composed of "micanite" or other composite or compounded mica also bonded with varnish. Figure 5 is a section of one end of the coil, the right-hand end, as it appears in Figure 3. From this it will be seen that micanite cylinder 67 is shorter by a fraction of an inch than the mica cylinder 66, and that the endmost turn 68 of the coil 40 lies axially inwardly of the end of cylinder 67 a fraction of an inch, thus affording a stepped construction of the insulating cylinder ends. Coil 40 as insulated at 64, 65 is wound directly upon cylinder 67. Before the segmented strips are laid on, the coil is wrapped in a single layer of bonded mica set in varnish. This provides a very important seal against moisture if such should collect in the voids between the outside segments 69. Laid axially upon the exterior of coil 40 are segmental strips 69 of Micarta, Bakelite, or the like, which together completely encase the outer periphery of the coil 40. These longitudinally extending insulating strips 69 are bound in place by overlapped turns 70 of insulating tape given a water and moisture-proof treatment and baked. The opposite ends of the insulating strip 69 are provided with jogs 71 radially juxtaposed to the stepped ends of the insulating cylinders 66, 67. A series of mica rings 72 are laid over the end of cylinder 67 and against the end turn 68 of coil 40, and a unit insulating ring of Micarta or Bakelite 73 is laid over the end of mica cylinder 66, these rings completely filling the spaces between the endmost turn 68 and the ends of cylinders 66, 67 on the one hand, and of the strips 69 on the other. They are sealed in position by coating and baking with a resilient insulating compound. In such fashion the coil 40 is made and hermetically sealed inside, outside, and at each of its ends whereby heat may not crack the insulation, and moisture may not penetrate it.

Heat is prevented from being directly radiated from the red or white hot surfaces of a workpiece being heated to the mica insulating cylinders 66, 67 by an annular lining of insulating fire brick 74, also shown in Figures 1 and 2. This lining of firebrick like the insulating outer covering 69 is comprised of longitudinally-laid segments. However, instead of conjoining the end edges and hermetically sealing together by intervened baked insulating compound, as in the instance of the bars 69, the individual segments 75 of this lining are spaced from each other by water-cooled work-supporting rails 76 intervened between them, and so constructed as to hold them radially outwardly against the surface of mica cylinder 66. To this end the opposite side edges of the segments 75 of the insulating lining (preferably comprised of a high-grade insulating firebrick compound) are chamfered at 77, the chamfer terminating in a slight jog 78, and the rails 76 are provided with welded-on sheet metal holding clips 79 of the form having a branch extending on each side of the rail 76 at the angle of the chamber 77 whereby to lie flatly against the chamfer and within the depth of the jog 78.

The rails 76 are held radially outwardly by three sets of supports, one at the middle and one at each end. That in the middle is shown especially in Figures 2 and 3 to comprise an expanding ring 80 of sheet metal. The ring 80 is formed of the overlapping wings 81 of sheet or strip stock welded respectively to opposite sides of the rail 76, and joined in their overlapping portions by a clamping screw connection 82 having an appropriate lost-motion connection (not shown) between the overlapped ends permitting the expansion of the ring 80 to a diameter which moves the rails 76 toward or against the inner surface of the mica 66, and retains them in that position when the devices 82 are tightened up. Each of these joints is insulated by a set of amber mica washers 82a. These washers will stand a temperature of 1000° C. If these were not insulated, the ring would act as a short-circuited turn of a transformer.

The devices at the opposite ends of coil 40 are different. At the upper or right-hand end of the coil 40 as illustrated, there is secured to each rail 76 an outwardly and radially extended supporting stud 83. These studs are passed respectively through slots or holes, as may be preferred, in the outer ends of metal or insulating material (such as Bakelite or Micarta), rails 84 laid longitudinally over the length of the exterior of coil 40 to project slightly beyond each end. As shown, the rails are of channel cross-section to afford less generation of eddy currents as well as lightness with strength. At the opposite end (the left-hand, as shown) the projecting ends of work-supporting rails 76 are engaged within the loops 85 of screw-hooks 86, the threaded outer ends of which are carried radially through apertures or slots in the opposite ends of the rails 84, there being preferably though not necessarily one securing rail 84 for each work-supporting rail 76. When the nuts 87 respectively on the ends of studs 83 and screw-hooks 86 are tightened up, they hold the outer ends of the rails 76 toward or against the inner surface of the mica cylinder 66 as does the expanding ring 80. Thus the rails 76 are held in position throughout their length and firmly hold the firebrick lining 75 in place. There may be provided as many expanding rings 80 as are needful to meet the requirements of coil length.

The securing clips 79 are not of an adjacent continuous series. They are separated by wide intervened spaces. In these spaces there are edge-welded in the radial planes of the coil axis A—A to the tubular rails 76, an intervened series of workpiece supports 88 in the form of sheet or strip metal fins whose lengths are axially extending. Their leading edges are chamfered as at 89, to prevent obstruction to the movement of a workpiece being inserted within the coil. They are spaced slightly at each end from the intervened firebrick securing clips 79. Their radially inner edges 90 are parallel to the axis of the coil 40 though not radially equidistant, and their locus is a cylinder of radius R whose center C is eccentrically above axis A—A of coil whereby the axis of workpiece of radius W coincides with axis of coil. (See Figures 3 and 4.) The diameter of the locus cylinder of center C is slightly greater than the diameter of the heated workpiece to provide tolerance sufficiently great to prevent binding due to expansion. Rails 76, clips 79, expand-

ing rings 80, and work-supporting fins 88 are all of high heat-resisting metal, especially fins 88. Water is continuously circulated through the tubular rails 76 in pairs in series, or in series as a group, the connection being generally illustrated by a dotted line connection 91 between the two outermost tubes 76 of Figure 2 shown as provided respectively with inlet and outlet openings 92, 93 at the opposite ends of rails 76. Inlets and outlets are each provided with moisture-discharging lips or flanges 94 which prevent accumulated moisture from running down the rails into the coil.

The entire system of equidistantly spaced polygonal workpiece-supporting rails 76 and firebrick lining may be bodily removed from the interior of the heating coil 40, by simply removing nuts 87 and the screw-hooks 86, radially removing bars 84, and drawing the ensemble axially outwardly (that is to say, to the right in the instant case). This enables the replacement of worn or broken firebrick segments 75, and repair to any of the rails which may for any reason need repair. To facilitate this the expanding ring 80 need not quite expand the rails 76 and the firebrick segments 75 into contacts with the inner mica cylinder 66, but provides such tolerance as will enable the ensemble to be slid longitudinally outwardly without intermediately releasing the clamping screws 82. Ring 80 and the connected rails are readily adjusted to tolerance diameters by fitting to a suitable mandrel and checking by a sizing ring before placing in the coil. However, if need be, a suitable tool will enable the clamping screws 82 to be reached, and one or more of them released. The individual segments 75 axially separated in the middle by the expanding ring 80 may be individually placed in position or axially withdrawn from the inner or the outer end of the coil, as the case may be, merely by loosening the respective screw-hooks 86 and studs 83 once the expanding ring 80 provides the proper tolerance at their axially inner ends. Thus removals and replacements may be made without removing the ensemble. All of this, of course, is readily achievable when the heating coil and the workpiece-supporting rail ensemble are disassociated from the housing. However, all of these operations may also be achieved while the coil and rail ensemble are in place on the machine, merely by removing hood 47 and front plate 50 and its supported parts as a unit. They together constitute a unit subassembly and may be slid off forwardly.

Heating coil 40 with its workpiece supporting appurtenances is mounted with its axis coinciding with a general horizontal axis A—A of the furnace machine, by supporting it from coil centering C-clamps 98 carried from and forming a part of pedestals erected upon and secured to the cast foundation plate of the table-portion of the housing. Referring particularly to Figure 1 for the moment, it will be seen that the stock-gauge per se comprises a tubular arm 143 lying on the axis A—A of the coil 40, and supported from a plate of the coil casing for relative axial adjustment by a clamping bracket bolted to the support plate. The tubular arm 143 projects rearwardly through the support plate a considerable distance allowing it to be axially adjusted back and forth, to adjust its forward end with respect to the axially inner end of the coil 40, thereby to engage an inserted workpiece in different axial positions within the coil 40. Once adjusted for the proper gauging of the stock, for the proper heating thereof through the proper length, the gauge arm 143 may be firmly clamped in its supported position.

Mounted on this adjustable arm 143, as shown fixedly although it may be adjustable, is magnetic core 97 comprised of an annular series of radially-extending, radially-tapering laminations, the details of which are no part of the present invention and are, therefore, not shown. Sufficient to say, they are bound in place upon the support 143 or equivalent support by any suitable means such, for example, as the commonly known interlocking tongue and groove device 145. This magnetic core is of considerable diameter and axial extent. Therefore, a considerable magnetic mass is shown as of approximately the diameter of the workpiece accommodatable by coil 40. As projected in juxtaposition to the end of a workpiece, it receives the flux flowing external to the coil 40, collects and concentrates it, and conducts it more or less directly axially inwardly of the inner end of the workpiece. Its utilization and relative adjustment with respect to the end of the workpiece very considerably improves the reluctance of the magnetic circuit and affords a very flexible control of the distribution of heat in the heating of the axially inner ends of the workpiece. Thus with the proper gauge of the stock in position within the coil 40, plus adjustment of the flux through its axially inner end, irregular or imperfect heating or excessive heating in any portion in the inner end of the bar may be avoided. Thus it combines with such portion of the stock as may project from the outer end of the furnace to achieve a general reduction in the reluctance of the circuit.

The push-out mechanism comprises a preferably though not necessarily water-cooled push-out rod 146 working axially back and forth within the tubular workpiece stock gauge and support 143.

Devices associated with the feeding-in of the workpieces on the other hand, are mounted in connection with the front plate 50 of the housing of coil 40. Such are the coil mouthpiece 96 and the door and appurtenant instrumentalities. The mouthpiece 96, as has been said, serves to enter the workpieces of bar or rod stock properly upon the axis A—A of the coil 40 and the supporting rails 76. By virtue of its susceptibility to removal and replacement from the opening 51, it may be suited in size to the various sizes of coils and stock. It is suitably bolted in place (bolts not shown) and mounted with a clearance 96a for radial adjustment to precise position on axis A—A. On its inner side it is provided with an annular series of axially and inwardly projecting spaced teeth at 185, the inner side walls of which project radially and axially inwardly toward the coil, and the extremities of which have an extent substantially of the same diameter as those circles on which lie the inner edges of the work-supporting fins 88, while their inner sides meet their inner ends at a relatively sharp angle. All this clearly appears in Figure 2. Thereby these teeth guide the stock accurately into engagement with the fins 88 of the supporting rail 76, preventing impingement upon intermediate transversely-extending walls (this through their inclined inner walls and their extremities), and when the workpiece is pushed out, remove from its foreign matter such as light scale which may have formed (this through the sharp innermost edges). Such foreign matter as is removed falls between the teeth or past their inner extremities and upon the hopper plate

186 which discharges through opening 187 to a chute 188 projected from the opening 187 exteriorly of the machine. Thus no scale or other foreign matter drops to the foundation plate 39.

Effective provision is made for water-cooling of all parts whatsoever, such as may be heated in what otherwise would be an undue measure. This includes not only the coil 40 and its work supporting rails 76 and the water-cooled push rod 146 (mention of the hollow conductors for water-cooling of which has already been made), but also the iron core 97. It is pointed out in connection with the rails that through the use thereof a positive coolant is applied throughout the coil and rail length thus tending substantially to reduce the excess heat toward the coil center and to aid in prevention of rail warping. A coil of water-cooling tubing 211 is provided about the magnetic core 97 for the purpose of cooling this mass of laminated transformer iron.

My invention is susceptible of many modifications of its various component parts and their coacting inter-relationships and organizations. For example, the heating coil itself may be variously modified. I show in Figure 7 one such modification in which the rails 76 comprise each two tubular devices welded together in the radial plane whereby to give them greater radial depth and stiffness. The retaining clasps 79 and the fins 80 are in turn welded to the radially inner tubular sections. Cooling water is passed through both of the tubular sections. It may be passed down one such tubular section and returned by the other, or it may be passed through them in parallel as may be desired (such connections not being shown). This organization of the work-supporting rails permits a greater depth of heat insulating segments 74 and, of course, connotes a larger diameter of coil relative to the diameter of the workpiece, (the latter shown in Figure 7 generally in dot-and-dash-lines).

In connection with the laminated iron utilized in the magnetic circuit in extension of the axis of the workpiece, one form of this core has been described. The best distribution of heat in the end of the workpiece (and it is an aim of this laminated iron to secure better distribution of heat in the end of the workpiece) I conceive to be had when the diameter of the engaging end of the core is less than the diameter of the workpiece, by substantially about twice the skin depth of current penetration in the workpiece. A diameter of the engaging end of core about two-thirds of the diameter of the workpiece is believed by me to be a good proportion. Thus two important advantages of the inclusion of the core are conjoined, the collecting of the coil flux and in improving the impedance, and uniform heat-distribution in the juxtaposed end of the workpiece.

In Figure 11 I show diagrammatically only another form of the core 97 of transformer iron. It is the same in its general arrangement as that set forth in the principal figures of the drawings, but differs therefrom in having its forward end 97*a* reduced in diameter to such an extent that at its extremity it is less in diameter than the diameter of the workpiece W. This reduction, as illustrated, is attained by tapering the laminations radially inwardly, but it may be reduced in other ways. The proportions I have set forth above. While the main body 97 and coil 211 may be projected within the open end of the heating coil to meet the workpiece W, an end 97*a* of reduced cross-section can all the more readily be so projected as shown.

Throughout the specification I have used the term heating coil to apply to the electromagnetic inducing element to which the workpiece is juxtaposed to receive the electromagnetic induction. This term I wish broadly construed to comprehend electromagnetic inductor devices of all sorts irrespective of the shape and dimensions of the coil and indeed irrespective of whether or not a device has the form of a coil and is but an electrical conductor of some form or other, save as the claims specify otherwise.

Thus it is that I would call attention to the fact that it is my desire that the annexed claims be afforded breadth of interpretation commensurate with the spirit of my invention wherever that spirit is manifest and novel, irrespective of the circumstantial terminology which my present description of the instant embodiment of the invention, may have influenced me to use.

What I claim is:

1. An apparatus for heating a workpiece by electromagnetic induction comprising an inducing coil, and work supporting means within said coil comprising longitudinal passages for coolant circulation angularly spaced from each other, and projections of high heat resistant material from each such coolant passage, extending inward for cooperation with a workpiece, and longitudinally spaced apart along each coolant passage to reduce the tendency for longitudinal expansion of the heated inner portion of said projections to cause flexure and distortion.

2. An induction heating apparatus comprising a heating coil, and work supporting rails within the coil having heat resistant plates secured edgewise thereto and extending toward the coil center.

3. An induction heating coil having longitudinal work supporting rails within the coil, and segments of thermal insulating material held in place by and between said rails and adjacent the coil.

4. An induction heating coil having associated therewith a plurality of longitudinally and angularly spaced metal supports for cooperation with a workpiece.

5. An induction heating coil having on the inside a plurality of longitudinally and transversely spaced metal supports for cooperation with a workpiece and fluid cooled whereby said supports may conduct heat from the heated surface of a workpiece.

6. An induction heating coil having a plurality of angularly spaced fluid tubes extending longitudinally thereof, and a plurality of longitudinally spaced substantially radial work supports secured along each tube and extending toward the surface of the work to be heated.

7. An induction heating coil having a plurality of angularly spaced fluid pipes extending longitudinally thereof, and a plurality of longitudinally spaced substantially radial fins secured along each pipe and extending toward the surface of the work to be heated, heat insulating material angularly between the pipes and fins, and securing strips for the insulating material, carried by the pipes and extending transversely of the pipes longitudinally between said fins and into engagement with a face of the insulating material that is away from said coil.

8. An apparatus for heating bar stock workpieces by electromagnetic induction comprising a hollow heating coil adapted to receive the work within itself, and a body of magnetic core mate-

rial for said coil external thereto occupying a position as a substantially axial end extension of the workpiece when in heating position whereby it receives most of the coil flux, said body of magnetic material being substantially adjacent to an end of the workpiece and of a comformation similar to the adjacent coil end but of reduced dimensions.

9. An apparatus for heating a workpiece by electromagnetic induction comprising an inducing coil, a foundation therefor, a work support within the coil, a tapered mouth for directing a workpiece into said coil and work support, a support for said mouth connected to said foundation, said mouth being mounted on its support in a manner to possess limited adjustment in a plane transaxial of the coil whereby said mouth may be substantially axially alined with said coil.

10. An apparatus for heating a workpiece by electromagnetic induction comprising an inducing coil, means for substantially centering the work within said coil, an abutment adjacent at least one end of said coil and against which an end of the work may impinge as a stop, said abutment having laminations for juxtaposition to an end of the work whereby said laminations may function as a flux receptive end extension of the work for directing flux axially within said coil and longitudinally beyond said coil and work, said abutment also having a non-laminar projection extending toward the work and longitudinally beyond said laminations for receiving the impact of a workpiece against said projection as a stop.

11. An apparatus for heating a workpiece by electromagnetic induction comprising an inducing coil, a track within said coil and along which the work may be slid, high temperature ceramic segments within said coil extending lengthwise thereof and between portions of said track and means for interconnecting said track and segments.

12. An induction heating coil having therein a work supporting track, and a mouth having peripherally spaced tapered prongs whereby a workpiece may be directed into the coil, said prongs being connected at a location longitudinally spaced from the adjacent end of said coil whereby the tendency to heating of the prongs by circulation of peripheral currents therein is substantially reduced.

13. An induction heating coil having therein longitudinal metal strips constituting a track on which a workpiece may be slid into and out of the coil, said strips being transversely spaced and supported at longitudinally spaced locations at least one of which is beyond an end of the coil and another of which is intermediate the ends of the coil, said last-mentioned support comprising metallic strips connecting adjacent track portions and being provided with an electrical insulating material in said last-mentioned strips to suppress the peripheral circulation of induced currents therein.

14. An induction heating coil having work supporting rails within the coil, a tapered pronged mouthpiece whereby work may be guided within said coil, said mouthpiece and rails both being eccentric to the coil by an amount substantially such as to bring a cylindrical workpiece generally coaxial with said coil.

15. In apparatus for heating a workpiece by electro-magnetic induction, a tubular heating coil and a workpiece supporting tube within said coil, the axes of said coil and tube being displaced from each other, whereby the axis of a cylindrical workpiece placed in said tube, against the side thereof closest to the coil axis, lies in substantial coincidence with the coil axis.

16. The combination with a coil having a hollow workpiece receiving chamber, of an end extension from said coil generally coaxially aligned therewith of material of low magnetic reluctance, said end extension having a diameter less than that of the coil interior.

17. In a machine for heating workpieces by electromagnetic induction, a tubular heating coil, supports in said coil having engaging elements for supporting a workpiece therein, the transverse loci of said engaging elements forming a circle whose center is eccentric to the coil axis, whereby the axis of a workpiece positioned on the support elements nearest the coil axis is substantially coincident with the coil axis.

18. The combination with a coil for heating a workpiece by electromagnetic induction, of a casing for enclosing said coil, a track positioned within and adjacent the inner surface of the coil and along which a workpiece is slidable, said track extending beyond each end of said coil and casing, and track supporting means secured to said track ends and anchored on said casing for holding the tracks in position relative to said coil.

19. In electromagnetic induction apparatus, a heating coil, a releasable external support for the coil, a track within the coil along which a workpiece is shiftable, and a support for the track external to said coil, said coil and track forming together an assembly removable as a unit on release of said coil support.

20. The combination of a coil for heating a workpiece by electromagnetic induction, of a track having at least two rails positioned within and adjacent the inner surface of the coil and along which a workpiece is slidable, segments of thermal insulating material between the rails of said track, and track supporting means adapted to force said track and material radially outwardly against said coil.

21. An induction heating apparatus comprising a heating coil, and work supporting rails having plates secured edgewise thereto and extending inwardly toward the coil axis.

22. In electromagnetic induction apparatus, a heating coil having a heating chamber therein, a support for said coil, plural rails forming a grid framework extending axially within said coil, fire resistant material interposed between and secured to said grid rails and forming with said rails a composite tube within said coil, and a releasable support for said rails external to said coil whereby said tube is removable as a unit from said coil.

23. An induction heating apparatus comprising a heating coil and work supporting rails having longitudinally discontinuous support members secured thereto and extending toward the surface of the work to be treated.

24. An induction heating apparatus comprising a heating coil, tubular metallic rails inside and adjacent the coil, extending substantially parallel to and along the entire length of the tube axis and angularly displaced substantially completely about the coil periphery to form a tubular work supporting grille, said rails being adapted to receive a coolant throughout substantially the entire length thereof and to receive the work in direct thermal contact therewith.

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