

Jan. 13, 1970

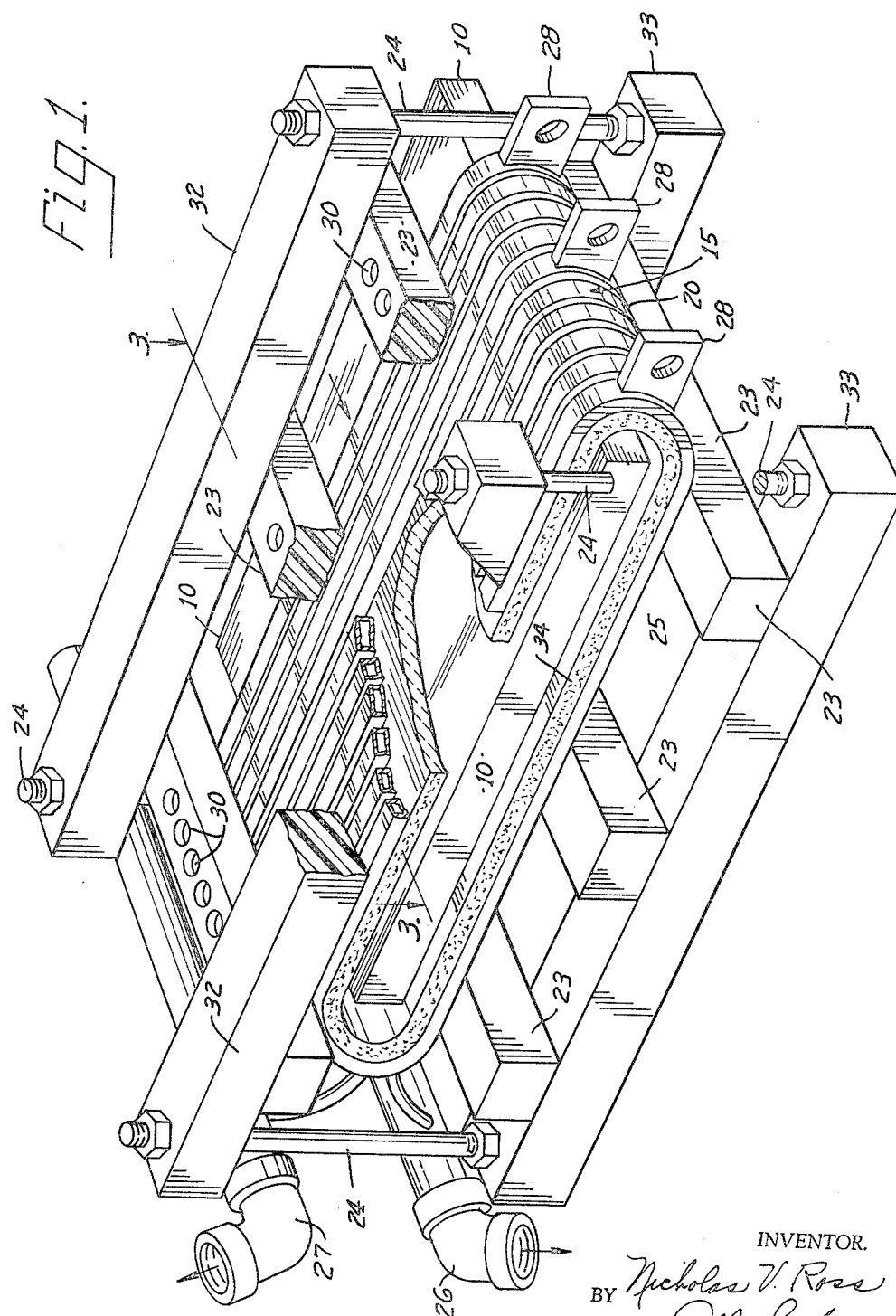
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3,489,875

APPARATUS FOR INDUCTION HEATING OF SLABS

Original Filed Oct. 27, 1966

5 Sheets-Sheet 1



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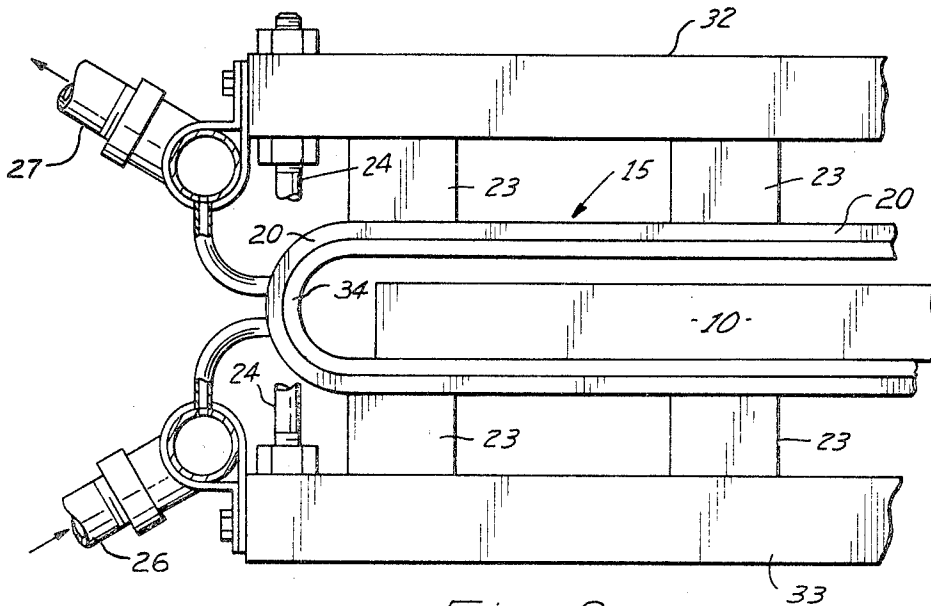
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APPARATUS FOR INDUCTION HEATING OF SLABS

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APPARATUS FOR INDUCTION HEATING OF SLABS

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5 Sheets-Sheet 3

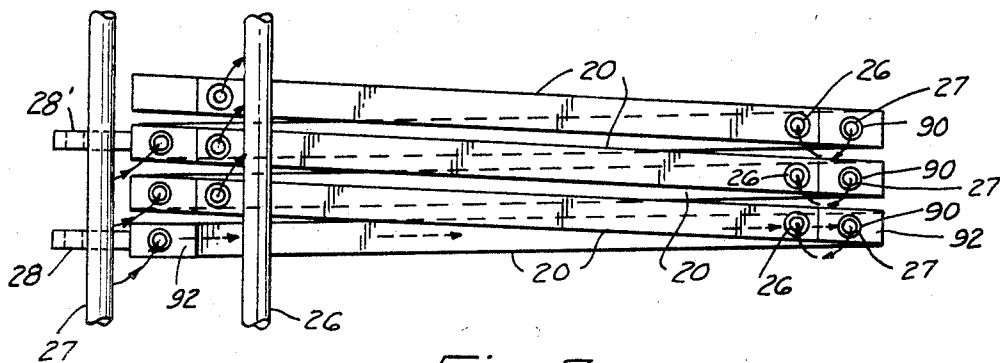


Fig. 3.

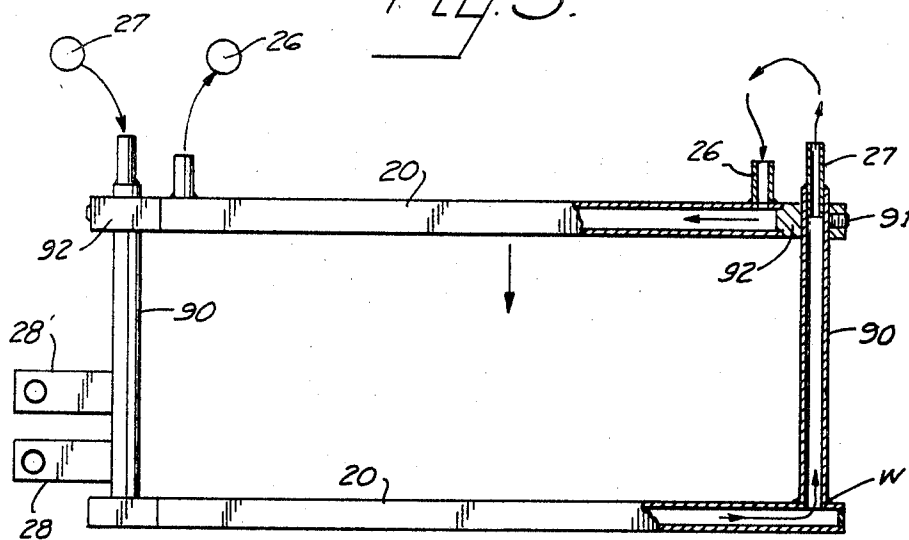


Fig. 4.

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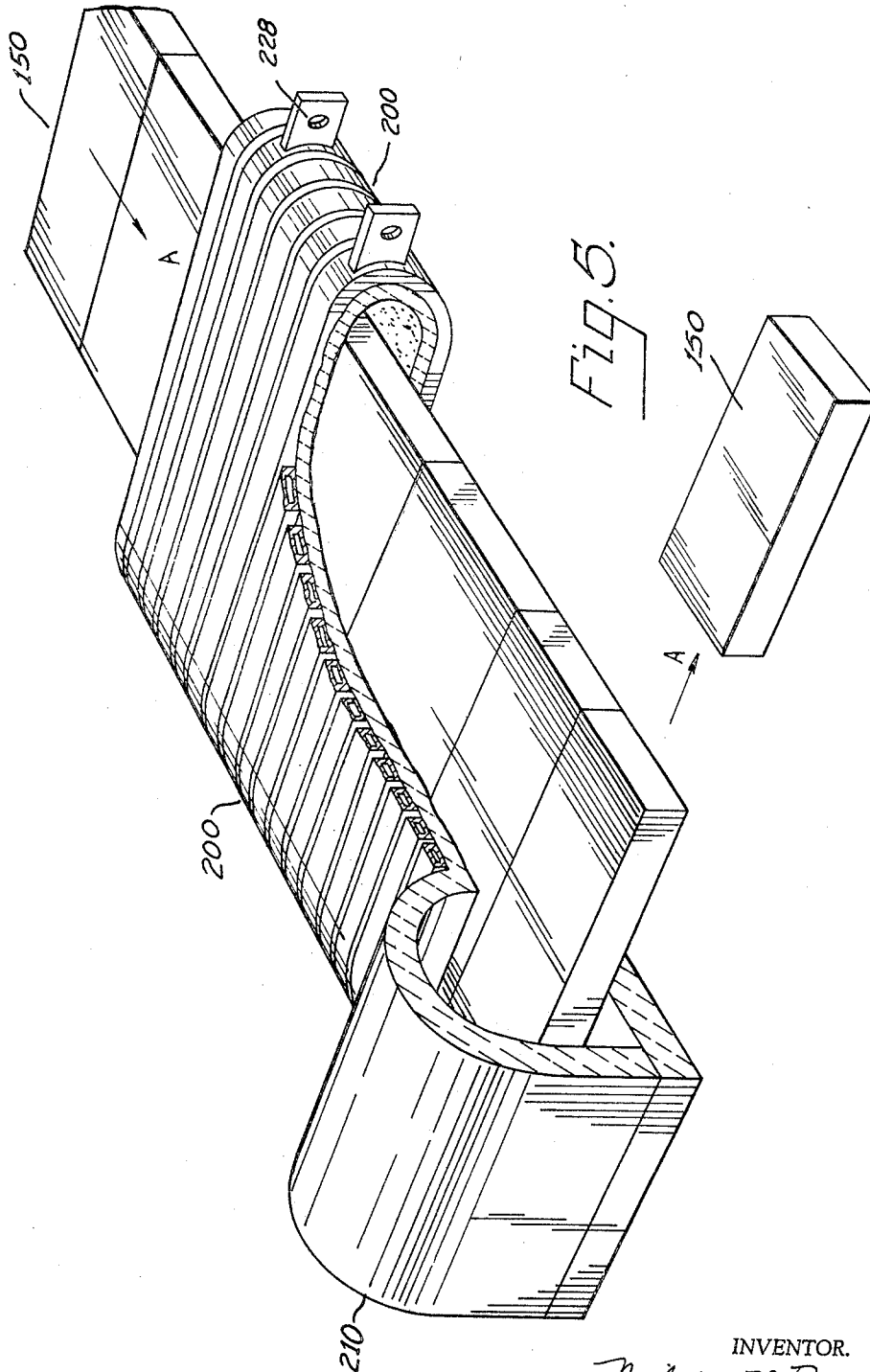
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APPARATUS FOR INDUCTION HEATING OF SLABS

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5 Sheets-Sheet 4



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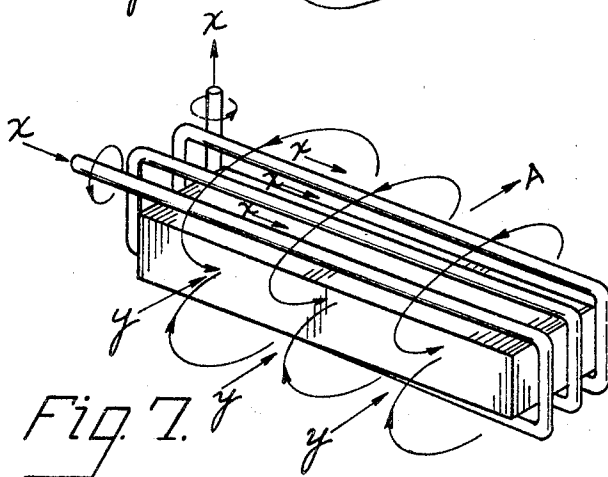
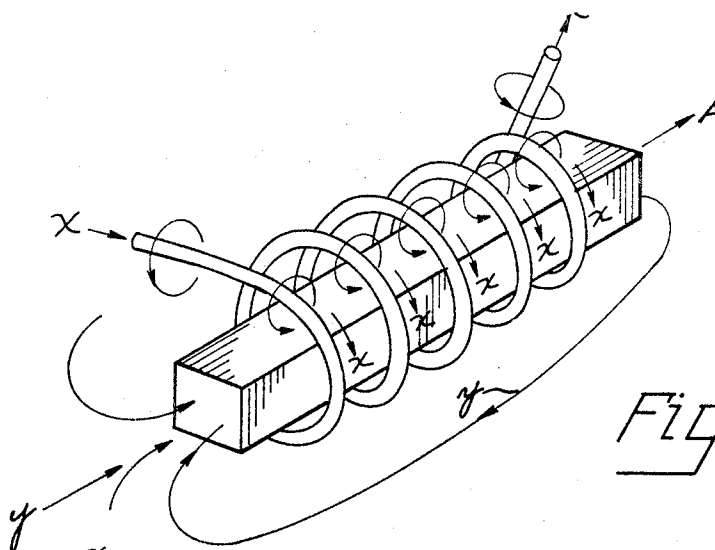
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APPARATUS FOR INDUCTION HEATING OF SLABS

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5 Sheets-Sheet 5



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3,489,875

APPARATUS FOR INDUCTION HEATING OF SLABS

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Original application Oct. 27, 1966, Ser. No. 589,974, now Patent No. 3,424,886, dated Jan. 28, 1969. Divided and this application July 22, 1968, Ser. No. 746,657

Int. Cl. H05b 5/00

U.S. Cl. 219—10.69

5 Claims

ABSTRACT OF THE DISCLOSURE

An induction heating coil for continuously heating parallelepiped slabs or the like wherein the magnetic field throughout said slabs is disposed at substantially right angles to the longest and shortest dimension of the slab and parallel to its width, etc., the coil being substantially rectangular in form and completely surrounding the said metal slabs during heating, the coil comprising relatively long straight conductors and relatively short end conductors, the relatively long conductors being disposed in a direction parallel to the longest dimension of each of the slabs.

This invention relates to improvements in induction heating and relates more particularly to improvements in induction heating devices for heating metal slabs whose length is substantially greater than its width and whose width is substantially greater than its thickness, and particularly for providing a large through-feed therein in a continuous heater.

This application is a division of application for U.S. Letters Patent Ser. No. 589,974 filed Oct. 27, 1966 now U.S. Patent No. 3,424,886.

An object is to provide an improved construction and shape of induction coil for induction furnaces.

In induction heating units of the through-feed or continuous type as shown in U.S. Letters Patent to Lackner et al., No. 2,676,234 dated Apr. 20, 1954, water cooled inductor coils connected to power leads are disclosed helically wound in contiguous lateral relation forming end-to-end a generally cylindrical open ended tube through which metal billets or other workpieces pass in a longitudinal direction, the billets or workpieces having a major portion of their length generally disposed in the longitudinal direction of the helical coil.

The present invention provides an inductor wherein metal objects to be inductively heated therein are oriented within a coil so disposed about the workpieces that they are substantially passed through the inductor with their portions of greatest length and shortest dimension disposed perpendicular to the direction of the magnetic field within the coil.

The inductor of this invention is capable of handling a large production with improved mechanical handling and greater efficiency and is able to inductively heat any type of ferrous or non-ferrous metal slab to be heated, thus avoiding the necessity of special coils for different shaped loads. The invention also provides more uniform heating and a greater electrical efficiency.

The present invention is particularly adapted for induction heating of slabs of considerable length, for example, slabs from ten to twenty feet in length; if such slabs are heated in a longitudinal direction in the conventional solenoid induction coil, several or more coils would be required to be aligned to heat the same with resultant gaps in heating between the coil sections. Continuous movement of such slabs through such coils could be resorted to but the length of such a line would be pro-

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hibitive. According to the present invention, such slabs may be heated by a single coil and adjustment means provided for the coil whereby the same could be adjusted to handle slabs of differing thickness with resulting economies and efficiency.

Other objects of my invention and the invention itself will become more readily apparent from the following description of the invention, illustrated in the accompanying drawings.

FIGURE 1 is a perspective view of an embodiment of the inductor of my invention, certain parts being cut away for clarity;

FIGURE 2 is an end view of a part of the inductor of FIGURE 1 showing water inlet and outlet means;

FIGURE 3 is a top view of the inductor with adjustability;

FIGURE 4 is a plan view of the adjustable inductor shown in FIGURE 6;

FIGURE 5 is a view of a heater employing the inductor of my invention, said heat being provided with a heat soaking chamber, workpieces passing therethrough indicated by arrows;

FIGURE 6 is a view showing a workpiece passing through a conventional helical induction coil and showing the direction of the workpiece and of the magnetic field passing through the longitudinal axis thereof;

FIGURE 7 is a view showing an induction coil according to the invention having a workpiece positioned therein with the magnetic field disposed perpendicular to the longitudinal axis of the workpiece; said view further indicating the direction of movement of the workpiece.

Referring now to the drawings, in all of which like parts are designated by like reference characters, in FIGURE 1 a typical slab 10 or workpiece is shown passing through an open end tubular inductor 15, said inductor comprising a substantially flat generally rectangular cross section helical wound conductor 20 having a number of turns therein formed of copper tubing or other conductive material; the turns of the tubing or conductor 20 being supported in turn-spaced insulated relation. The inductor 15 may be a single-turn coil or multi-turn coil. Said coil may be connected either in series or in parallel to a source of alternating power supply either multi-phase or single phase.

As shown in FIGURES 1 and 6, the conductor is rectangular in cross-section but, the inner and/or outer shape thereof may be varied. The coil is a rigid structure having relatively rigid bar characteristics adapted to be securely fastened to supports therefor to secure mechanical stability thereof.

The conductor being formed of tubing is preferably water cooled or other cooling medium is adapted to be passed therethrough entering in the form of FIGURE 2 through an inlet 26 and leaving through a fluid outlet 27. Power is supplied through connecting bars or coil taps 28 preferably welded to form an integral connection to the conductors.

The inductor coil is preferably provided as shown with a liner 34 of insulating refractory material or, for example, stainless steel of high temperature resistance and relatively high electrical resistivity and insulating material and it will be understood that rails, if desired, may be employed in the coil for passage of the workpiece, slab, etc., thereover. If refractory material is employed, I contemplate the provision of reinforcing preferably water cooled rods therein (not shown).

It is to be noted that the coil 15 is disposed with respect to the workpiece in a direction whereby heating current is supplied from end-to-end of the workpiece or load passing therethrough (see FIGURE 7) the direction of the current shown by arrows X. The direction of the

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magnetic field is shown by arrows Y at substantial right angles to the longitudinal axis of the workpiece. The direction of movement is shown by arrow A. FIGURE 6 illustrates in contrast thereto the conventional helical conductor coil of the prior art, the workpiece direction, magnetic field direction and current flow and similar indicia to that of FIGURE 7 is used therein.

A pusher element (not shown) having a relatively broad face may be adapted to be used to insert the workpieces within the heater and, in the modifications shown, would contact said faces of the workpieces. It will be readily understood that walking beams and other alternative means for moving the load through the coil may be employed.

Magnetic yokes and spacer members (not shown) are adapted in the forms of my invention to be disposed on the cross member on both sides of the coil and along the coil length and are employed where high magnetic forces are a factor as in low frequency installation acting to minimize stray heating of the supporting structure.

In FIGURES 3 and 4, I have disclosed a modification of the inductor of my invention providing close coupling for the load and adjustment means for compensating for differences in thickness of load. As shown, a plurality of tubular end conductors 90 are integrally secured as by welding (indicated at W) at one end to longitudinally disposed conductors 20 and adjustably as by setscrews 91 or other locking means at an opposite end by an end plug 92 to a longitudinal conductor 20 spaced from said first recited longitudinal conductor. Power leads and fluid inlet and outlet means are indicated at 28, 28' and 26 and 27 respectively. It will be understood that the terminal is of conductive material; the tubes are water cooled. The adjustment of such means compensates for variations in the thickness of the load, as may be required. Since the top conductor is adjustable, only one coil need be supplied for a range of slab thickness. It will be noted that the end conductors complete the adjustable rectangle while maintaining close proximity of all portions of the rectangle, i.e. longitudinal and end conductors, to the load to provide maximum efficiency, maximum power factor, and minimum volts per turn, regardless of load thickness.

FIGURE 5 shows workpieces 150 passing through inductor 200 of the form shown in FIGURES 1 and 2 and discloses radiant soaking chamber 210 provided at one end of the inductor into which workpieces heated thereby are delivered and remain until temperature differences which may occur between the edges and the center of a workpiece are minimized.

Depending upon the ratio of the billet diameter and/or slab thickness to depth of penetration and power density, the mean temperature at the edges or ends of the workpieces may be hotter or cooler than the mean temperature at the center. The soaking chamber 210 when employed with the inductor of my invention also minimizes temperature differences from billet-to-billet, workpiece-to-workpiece, etc. A pallet, chain conveyor or walking beam rather than a pusher member or pusher rod, as previously referred to could be employed in this modification for ejecting billets or heating objects from the inductor and it is to be noted in this modification the terminal passage of the workpieces is at right angles or transverse to the longitudinal movement of the same through the inductor.

The use of a radiant soaking chamber as shown in FIGURE 5 is of particular value when the heater or the inductor is placed in a "hold" cycle, as when tool changes in an extrusion forge press, etc., used herewith, are necessary.

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While I have described my invention in connection with a preferred embodiment therein, it is to be understood that various changes may be made therefrom without, however, departing from the spirit of my invention or the scope of the appended claims.

What I claim is:

1. Apparatus for continuously heating parallelepiped slabs passing therethrough, each of said slabs having a length substantially greater than its width and a width substantially greater than its thickness, an induction coil, said coil being substantially rectangular in form and completely surrounding the said metal slabs during heating, an alternating current power source energizing said coil, said power being delivered continuously while the slabs enter, pass through and leave the coil, said coil comprising relatively long straight conductors and relatively short end conductors, said relatively long conductors being disposed in a direction parallel to the longest dimension of each of said slabs, means for passing said slabs continuously through said induction coil with the magnetic field through each of said slabs being disposed at substantially right angles to the longest and shortest dimension of each of said slabs and substantially parallel to the width of each of said slabs.

2. An induction coil for heating metal slabs as claimed in claim 1 having a frame structure supporting said coil, said frame structure being secured externally to portions of said longitudinally extending conductor.

3. An induction coil for heating metal slabs as claimed in claim 1 wherein said conductor is tubular and is provided with integral wall portions relatively thickened on a side opposite thereto to which a supporting frame is secured.

4. An induction coil as claimed in claim 1 having conductors of substantially rigid bar characteristics.

5. Apparatus for continuously heating parallelepiped metal slabs passing therethrough comprising an induction coil, each of said slabs having a length substantially greater than its width and a width substantially greater than its thickness, an alternating current power source energizing said coil, said coil being substantially rectangular in form and including relatively long flat conductors and relatively short end conductors, means for passing said slabs continuously through the said coil with their longest dimension disposed parallel to said relatively long conductors, the direction of current flow being perpendicular to the direction of movement of said slabs through said coil, the magnetic field being perpendicular to the longest and to the shortest dimension of said slabs and substantially parallel to the width of each of said slabs.

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