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H. A. STRICKLAND, JR
INDUCTIVE HEATING APPARATUS
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2,400,660

FIG.1

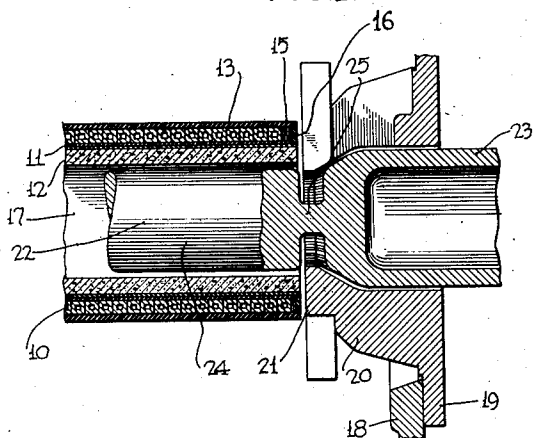


FIG.2

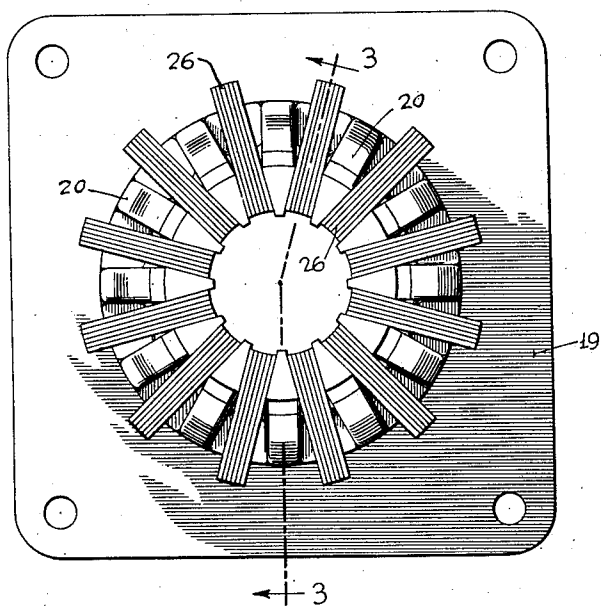
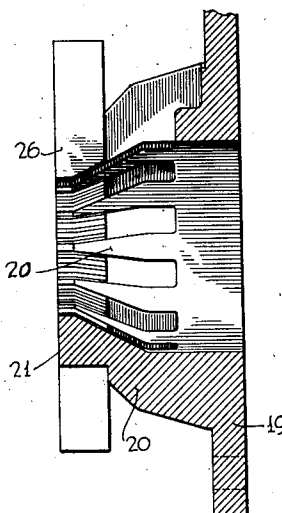


FIG.3



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2,400,660

INDUCTIVE HEATING APPARATUS

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Application October 13, 1943, Serial No. 506,016

6 Claims. (Cl. 219-13)

This invention relates to inductive heating apparatus and particularly to such apparatus as will insure uniform heating of a charge or bar throughout its entire length.

In my copending application Serial No. 500,903, filed September 2, 1943, I have disclosed an induction furnace having particular adaptation for the heat treatment of bars of excessive length. Frequently in the use of the furnace of this copending application, it is desirable to insert one-half of the workpiece within the heating chamber and subject it to the necessary temperatures and subsequent mechanical modifications, such as to a shell form, and subsequently insert the untreated other half of the workpiece for a similar heat treatment and mechanical modification. In carrying out the second step of this operation, however, complete insertion of the second half of the workpiece into the heating chamber is usually prevented from the fact that the modified end of the workpiece is enlarged beyond the furnace chamber diameter, thus preventing complete ingress of the second half, so that when the part of the second half of the workpiece which is within the furnace is heated to the desired temperature, the outer end section of the second half adjacent the modified first half is insufficiently heated. As a result, in the subsequent mechanical modification of the second half of the workpiece, the inner end thereof is malformed, thus making the second half of the original workpiece defective as a complete article of manufacture.

It is, accordingly, a primary object of the present invention to provide apparatus which will permit heating of a workpiece at the charge opening or mouth of the heating chamber at points adjacent and, if desired, external to the plane, including the outer end of the heating coil. Another object of the invention is to facilitate manufacture of completely formed articles on either end of a single workpiece without separation of the workpiece at an intermediate point. An object also following from the previously mentioned objects is to insure uniformity of heating in a workpiece throughout the heating chamber of an induction heating coil. Still another object is to provide means for forcing the magnetic flux developing from the application of alternating current to an inductive heating coil toward the axis of the coil adjacent the end thereof. Other objects, such as relate to detailed construction, will appear on consideration of the embodiment of the invention hereinafter described and illustrated in the accompanying drawing, in which:

Figure 1 is a section through the heating coil adjacent the charge opening showing a workpiece, one-half of which has been mechanically formed under heat treatment;

Figure 2 is an end view in plan showing the guide unit and flux diverting apparatus; and

Figure 3 is a section taken along lines 3-3 of Figure 2.

The induction furnace as shown in Figure 1 is in general similar to that shown in my copending application Serial No. 384,503, filed March 21, 1941, and includes a coil 10 of a tubular copper conductor which is rectangular in cross section so as to facilitate close placement of the turns each in relation to the other. The coil is mounted on an inner lining of mica sheets 11 which in turn overlie the supporting brickwork 12 held in position by supporting ribs or end plates as shown in my copending application hereinabove referred to.

Overlying the heating coil 10 is an outer layer 13 of insulation preferably having an asbestos base. The extreme outer end of the heating coil contacting with the outer turn thereof is formed of a plurality of annular insulation plates 15 terminating in a thicker annular strip 16 forming the end piece of the furnace coil. The mica casing 11, brick structure 12, and exterior casing 13 are all extended so as to terminate in the plane including the end annular insulation strip 16. The supporting mechanism for the heating coil may be of any desired form, such as for example shown in my copending application Serial No. 384,503 and is not shown because it forms no part of the invention. The end of the heating coil with its enclosed heating chamber 17 as shown in Figure 1 is adjacent the mouth, inlet, or charge opening of the furnace.

A section 18 of the front plate of the furnace casing is illustrated in Figure 1, the same having a charge opening in which is placed the mouthpiece 19 of the heating chamber. This mouthpiece consists of a non-magnetic metal plate having a flat base forming the outer surface, and extending inwardly a plurality of integral fingers 20 as more clearly shown in Figures 2 and 3. Toward the end of these fingers, the same turn radially inward toward the furnace coil axis bringing the terminals 21 thereof into proximity to the extreme outer end of the heating coil structure. It will be noted that these fingers 20, spaced as they are about the axis of the heating chamber, form a conical guide area for facilitating the insertion of a workpiece into the heating chamber. The terminals 21 of the fingers form a hol-

low ring having, in inner contour, a diameter approximately the same as the adjacent inner surface of the heating chamber 17 of the furnace.

With the construction as described, when a long workpiece, such as the cylindrical bar 22, is inserted within the heating chamber before any modification of the structure thereof, flux and consequent eddy currents in the workpiece appear with substantial uniformity throughout the bar length within the region defined by the inner and outer turns of the heating coil. The section 23 of the workpiece 22 which is first heated secures an adequate amount of heat for the full length desired in the treatment and, hence, lends itself properly to mechanical modification, such as the tubular shell form as illustrated in Figure 1. However, after this treatment of section 23 on insertion of the untreated end 24 of the workpiece 22 within the heating chamber, improper heating results. This is due to the fact that because of the increased diameter of the section 23 inward movement of the reversed workpiece unit is limited by the inwardly directed finger ends 21 of the furnace mouth, the section 23 coming into contact with these fingers at a point where the outer end of section 24 is substantially outside the effective heating range of the outer coil turns. Consequently, when the heating current is turned on, the flux coupling with the outermost part of bar section 24 will be enough less than that toward the inner part of the section that a lesser degree of heating results at that end.

The means employed to overcome this difficulty consists in a series of bars of laminated iron plates 26 forming a broken bar ring, as shown particularly in Figures 2 and 3, which are placed between the ends 21 of the furnace mouth fingers 20 and extend radially outward in a transverse plane with the surface of each plate parallel to the coil axis. In order to hold these plates in position, the bases thereof are brazed on the side away from the coil to or clamped between the finger terminals.

With this laminated construction as shown, there is provided a magnetic path which traverses a greater bar length but which is of lower magnetic reluctance than the path through air alone. As a consequence, the coil flux traverses the laminated structure instead of taking a shorter distance leakage path of greater reluctance. In this way the density of flux adjacent the area of the front end of the workpiece section 24 is maintained to such an extent that adequate heating is imparted thereto for a greater distance and satisfactory mechanical modification of the metal structure is accordingly made possible.

Advantages of the construction additional to that mentioned include the shielding action of the ferro-magnetic bar ring for the guide fingers; which without the ring, would absorb undesirably a substantial amount of stray energy from the flux field.

I have shown a form of my invention which may be preferred but it is obvious that modifications in the details entering into the structure may be made, and hence I do not desire to be

limited to the disclosed embodiment except as may be required by the scope of the claims here-to appended.

What is claimed is:

1. In inductive heating apparatus, a tubular induction heating coil forming a heating chamber adapted to receive a workpiece, a casing having a charge opening for said chamber, guide fingers of non-magnetic metallic material between said charge opening and chamber forming a constricted opening, and means for increasing the inductive flux density in the charge opening external to the heating chamber adjacent the axis thereof, said means comprising ferro-magnetic bars attached to and between said fingers.
2. In inductive heating apparatus, a tubular induction heating coil forming a heating chamber having an inlet opening, a casing having a charge opening for said chamber, non-magnetic metal guide means between said chamber and charge opening for guiding a workpiece into said chamber, and additional means secured to said guide means between the coil and guide means for directing the coil end flux toward the coil axis whereby the effective coil heating zone is extended centrally and outwardly of the coil opening and stray flux is reduced.
3. In inductive heating apparatus, a tubular induction heating coil forming a heating chamber, a casing having a charge opening for said chamber, guide fingers of non-magnetic metallic material between said casing and chamber adjacent said charge opening, and means including radial magnetic members secured to the inner ends of said guide fingers between the guide fingers and coil for spreading coil flux toward the coil axis adjacent the finger ends.
4. In inductive heating apparatus, a tubular induction heating coil forming a heating chamber, a casing having a charge opening for said chamber, radially extending circumferentially laminated ferro-magnetic plates positioned adjacent the end of said chamber between the chamber and charge opening and forming a broken ring therebetween and a non-magnetic metal support for said ring extending therefrom to the casing.
5. In inductive heating apparatus, a tubular induction heating coil forming a heating chamber having a charge opening, a non-magnetic metal workpiece guide adjacent said opening and means at the charge opening including radially extending magnetic material plates attached to said guide for centering the magnetic flux of said coil toward the coil axis and shielding the guide from stray flux.
6. A workpiece guide for coil induction furnaces comprising an annular metal base adapted for positioning adjacent the inlet opening of the coil chamber, non-magnetic metal fingers attached to said base and converging toward said coil inlet and means for shielding the fingers from the stray magnetic flux, said means comprising plural coplanar bars of ferro-magnetic metal attached to the finger tips.

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