

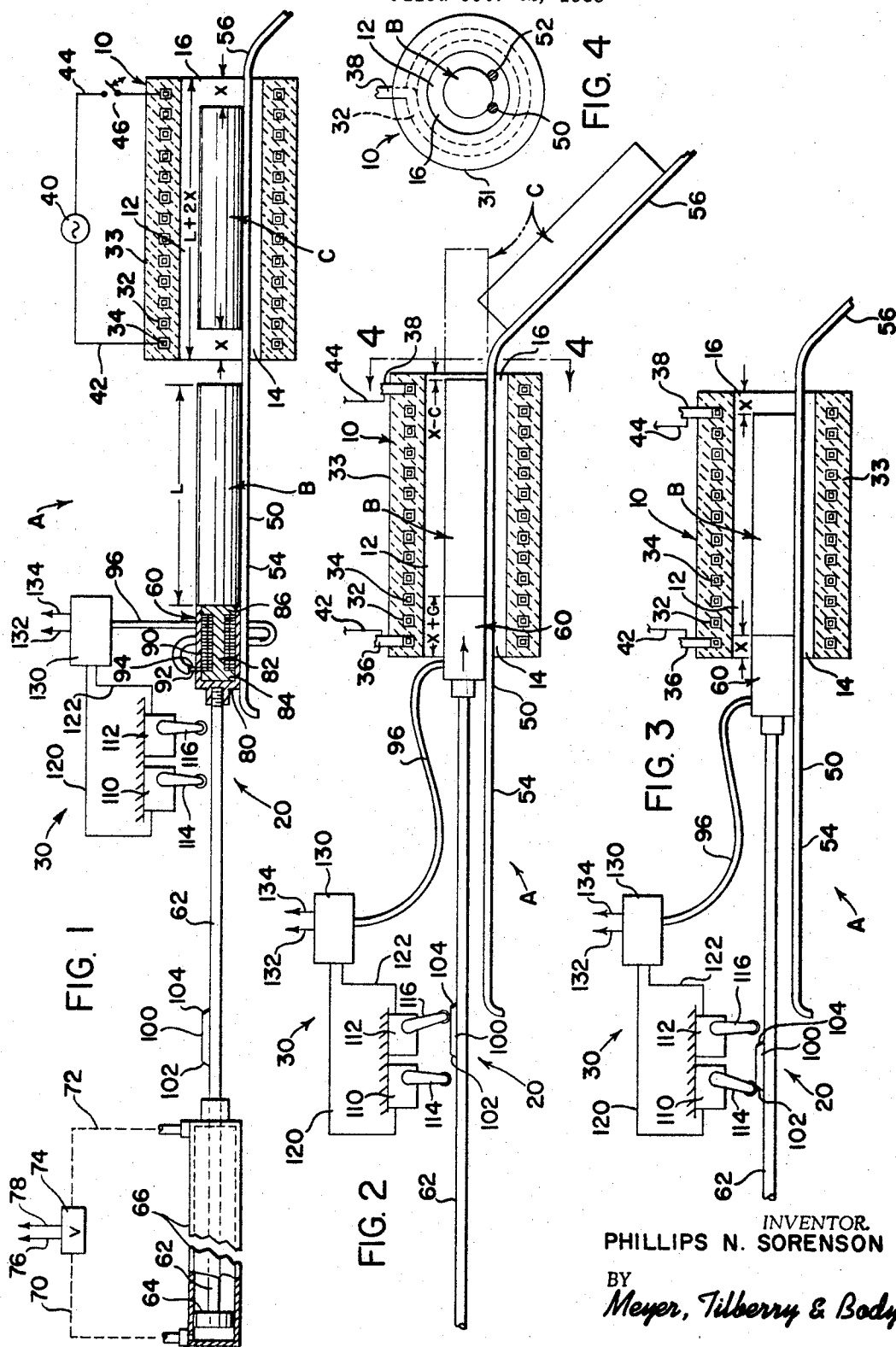
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APPARATUS AND METHOD FOR LOCATING AN ELONGATED WORKPIECE WITHIN A MULTITURN INDUCTION HEATING COIL

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ABSTRACT OF THE DISCLOSURE

There is provided a method and apparatus for pushing a billet from an induction heating coil and for positioning a successive billet in the center of this coil. A pusher rod is provided with a pole piece that can be selectively magnetized. This pole piece pushes the second billet into the coil and, then when magnetized, it pulls the successive billet back into the proper position within the coil. When the successive billet is in the proper position, the pole piece is demagnetized and removed from the coil.

The present invention pertains to the art of induction heating and more particularly to an apparatus and method for locating an elongated workpiece within a multiturn induction heating coil.

The invention is particularly applicable for heating a ferromagnetic billet preparatory to forging the same and it will be described with particular reference thereto; however, it will be appreciated that the invention has somewhat broader applications and may be used for heating various other elongated, ferromagnetic workpieces.

In forging ferromagnetic billets into various intricate shapes, the billet is first heated to the forging temperature and, then, placed between the moving dies of a forge. At one time, these billets were heated by placing them within a gas-fired furnace; however, this heating process proved to be relatively expensive because of the long time required for the workpiece to reach the forging temperature and, also, because of the high cost and extensive space required for the gas-fired furnace. Consequently, many of the forging installations have been, or are being, modified to use multiturn induction heating coils for heating of the billets to the required forging temperature. Heating the billets by induction heating has proven to be a substantial advance in the art.

At first, the induction heating equipment for use in a forging department included a multiturn heating coil having an opening at one end. The workpiece was placed through the opening into the coil, and it was removed from the same opening after the workpiece was heated to the desired forging temperature. Later, some induction heating equipment for a forging department included a multiturn induction coil having a passageway therethrough with both an entrant end and an exit end. A first billet was placed into the coil and heated to the forging temperature. Thereafter, a second workpiece was placed into the coil from the entrant end. This ejected the previously heated workpiece from the exit end of the passageway.

Although this last mentioned type of induction heating equipment substantially increased the productivity of the installation, there was one serious limitation. The passageway of the induction heating coil had an axial length substantially corresponding to the axial length of the workpieces or billet. When the subsequent billet was forced into the coil, it was moved to the exit end of the passageway to assure ejection of the previously heated billet. Consequently, the workpiece was not centered with-

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in the coil passageway. To the contrary, the billet was adjacent the exit end of the coil. This prevented efficient magnetic coupling between the coil and the billet, and somewhat reduced the over-all efficiency of the heating operation. In fact, sometimes the rearwardmost end of the billet was not heated to the desired temperature.

The present invention is directed toward an induction heating installation wherein a subsequent workpiece ejects a previously heated workpiece; however, in accordance with the present invention, the difficulties heretofore experienced when using this type of apparatus are completely overcome.

In accordance with the present invention, there is provided an improvement in the above-mentioned induction heating equipment. This improvement includes the provision of a pole piece on the abutment element of the pusher mechanism which forces a subsequent workpiece into the coil and, at the same time, ejects the previously heated workpiece. There is also provided a control means for selectively magnetizing and de-magnetizing the pole piece so that the unheated ferromagnetic workpiece may be magnetically attracted to the abutment element and positioned by the element within the coil after the unheated workpiece has ejected a previously heated workpiece. Since the workpieces are heated above the Curie temperature for the purpose of forging, the previously heated workpiece is not magnetically attracted to the magnetized pole piece. This feature allows accurate positioning of the unheated workpiece without affecting the ejection of the heated workpiece.

The primary object of the present invention is the provision of an improvement in an induction heating installation including a multiturn coil with a workpiece receiving passageway having an entrant end and an exit end and a pusher mechanism for forcing an unheated workpiece into the passageway while simultaneously ejecting a heated workpiece therefrom, which improvement allows proper placement of the unheated workpiece with respect to the coil.

Another object of the present invention is the provision of an improvement in an induction heating installation including a multiturn coil with a workpiece receiving passageway having an entrant end and an exit and pusher mechanism for forcing an unheated workpiece into the passageway while simultaneously ejecting a heated workpiece therefrom, which improvement includes a magnetic abutment element for the pusher mechanism to hold the unheated workpiece while it is being positioned subsequent to ejection of the heated workpiece.

Still another object of the present invention is the provision of a method for locating an unheated, elongated workpiece within the central passageway of a multiturn induction heating coil after a heated workpiece has been ejected therefrom, which method is efficient in operation and adapted for use by a slight modification of existing equipment.

These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment of the invention as read in connection with the accompanying drawing in which:

FIGURE 1 is a side plan view illustrating, somewhat schematically, a preferred embodiment of the present invention;

FIGURE 2 is a partial side elevational view showing the ejection operation of the present invention;

FIGURE 3 is a partial side elevational view showing the positioning operation of the present invention; and,

FIGURE 4 is a cross-sectional view taken generally along line 4—4 of FIGURE 2.

Referring now to the drawing wherein the showings are for the purpose of illustrating a preferred embodiment of

the invention only and not for the purpose of limiting same, FIGURE 1 shows an induction heating apparatus A for heating an unheated, elongated workpiece B and ejecting a heated, elongated workpiece C. Although the workpieces, when heated, may be used for various purposes, in accordance with the illustrated embodiment of the invention, the workpieces are billets to be forged after being ejected from apparatus A. Apparatus A comprises, as essential components, a coil assembly 10 having a central, axially extending workpiece receiving passageway 12 with an entrant end 14 and an exit end 16, a pusher mechanism 20 for sliding workpiece B into the passageway 12, and a control device 30 for controlling the pusher mechanism, in a manner to be hereinafter described in detail.

Referring now more particularly to the coil assembly 10, this assembly is a somewhat standard assembly in the induction heating art, and it includes a multiturn induction coil 32 embedded within a casing 33 and having an internal coolant passage 34 connected with an inlet conduit 36 and an outlet conduit 38, as best shown in FIGURES 2-4. The coil 32 is energized by high frequency power supply, schematically represented as a generator 40 connected by lines 42, 44 with opposite terminal ends of the coil. A switch 46 is utilized for selectively energizing the coil 32. It is appreciated that this disclosure is only a schematic representation; therefore, various components such as power factor correcting capacitors and controls for the generator have been eliminated for the purpose of simplicity. It should be appreciated that the power supply may deliver power to the coil at various frequencies, i.e. line frequency to radio frequency.

The coil assembly 10 includes a workpiece guide means taking the form of spaced rails 50, 52 having a loading end 54 and an ejecting chute 56. The guide means for the workpiece as it passes into and out of the passageway 12 may take a variety of other forms without departing from the intended spirit and scope of the present invention.

The pusher mechanism 20 includes an abutment element 60 connected onto the outermost end of a rod 62. The rod is secured onto a piston 64 slidably received within a fluid actuated cylinder 66. By introducing fluid, such as oil or air on opposite sides of the pistons through control lines 70, 72, the piston 64 and, thus, abutment element 60 may be moved axially with respect to the passageway 12 in a controlled manner. To control the movement of the abutment element, there is illustrated a valve mechanism 74 having electrical input lines 76, 78. The valve mechanism 74 is controlled by a known arrangement so that the piston 64 moves in a controlled manner with respect to the passageway 12.

As so far described, apparatus A does not differ from previous mechanisms for loading and unloading coil assembly 10. A workpiece B is fed by an appropriate escapement arrangement onto the loading end 54 of the guide means, and the abutment element 60 forces the unheated workpiece B into the opening 12. This ejects the heated workpiece C. As illustrated, the workpieces have a length L and the passageway 12 has a length $L+2x$. Heretofore, the ejection of the heated workpiece C resulted in the workpiece B being positioned adjacent the exit end of the passageway 12. This can be seen in FIGURE 2. The spacing of the workpiece B from the entrant end of the passageway 12 is $(x+c)$ while the spacing of the workpiece B from the exit end of the passageway is $(x-c)$. If the workpiece is heated in this position, the rearwardmost end of the workpiece is inefficiently coupled with the magnetic field within the passageway 12, and uneven heating results. The present invention is directed toward an arrangement for locating the workpiece B within the passageway 12 so that an equal spacing x may be provided on each end of the workpiece. See FIGURE 3. In accordance with the invention, the pusher mechanism 20 includes a control device 30. The abutment element 60 includes a ferromagnetic casing formed from a high permeability metal, such as soft iron, and an internal spool 82

formed from a similar metal. The spool is provided with axially spaced pole pieces 84, 86 and is surrounded by an electromagnetic coil 90 having input lines 92, 94. These lines are fed through an insulating tube 95 to an element of the control device 30.

A cam 100 having a rearward shoulder 102 and a forward shoulder 104 is secured onto rod 62 so that movement of the rod actuates spaced switches 110, 112 as the shoulders pass followers 114, 116 on these switches. Movement of the followers causes a signal which is conveyed through lines 120, 122 to a relay box 130. The box includes relays, not shown, for connecting power leads 132, 134 onto the lines 92, 94 for energizing the electromagnetic coil 90.

In operation, after the unheated workpiece B is positioned in front of the heated workpiece C, piston 64 is moved within cylinder 66. This forces the workpiece B into the position shown in FIGURE 2. This ejects the heated workpiece C down the ejecting chute 56. At this time, the follower 116 contacts the shoulder 104 and energizes the electromagnetic coil 90. This magnetizes pole piece 86 so that the unheated workpiece B is magnetically attracted to the pole piece. Thereafter, the piston 64 starts movement away from the coil assembly 10. This pulls the workpiece B toward the entrant end 14 of passageway 12. When the workpiece is centrally located within the passageway with the distance between both the entrant end and exit end being x , the shoulder 102 of cam 100 actuates follower 114 which, through relay box 130, disconnects power leads 132, 134 from the lines 92, 94. This de-energizes the electromagnetic coil 90 and substantially de-magnetizes the pole piece 86. Continued movement of the abutment 60 rearwardly by the piston 64 does not pull the workpiece B. Consequently, the workpiece remains centrally disposed within the workpiece receiving passageway 12. After the workpiece B is heated to the forging temperature, the operation is repeated to locate a subsequent workpiece within the passageway and heat the same.

Even though the workpieces are formed from ferromagnetic material, the heated workpiece C is above the Curie point; therefore, it will not be magnetically attracted by the pole piece 86. For this reason, the pole piece may be magnetized as soon as the rod 62 starts its forward movement, or any time during the forward movement. In practice, the pole piece 86 is magnetized slightly before the start of the rearward or retracting movement of the rod. This prevents control difficulties and allows use of magnetic coil having lesser field strength. If the pole piece shifts from the unheated billet before the coil is energized, a considerable field strength would be required to pull the workpiece B toward the pole piece.

The present invention has been described in connection with a structural embodiment; however, it should be appreciated that various changes may be made in this embodiment without departing from the intended spirit and scope of the present invention as defined in the appended claims.

Having thus described my invention, I claim:

1. A method of heating a succession of elongated ferromagnetic workpieces in a multiturn induction heating coil having a central workpiece receiving passageway with an entrant end and an exit end, said method comprising the following steps:

- (a) sliding a first workpiece axially into said passageway from said entrant end;
- (b) heating said first workpiece by said coil to a temperature above the Curie point of said first workpiece;
- (c) sliding a second workpiece axially into said passageway from said entrant end until said first workpiece is ejected from the exit end of said passageway by said second workpiece;
- (d) pulling said second workpiece toward said entrant

end until the second workpiece is properly positioned in said passageway for optimum heating; and

- (e) heating said second workpiece by said coil to a temperature above the Curie point of said second workpiece.

2. A method of heating a succession of elongated ferromagnetic workpieces in a multiturn induction heating coil having a central workpiece receiving passageway with an entrant end and an exit end, said method comprising the following steps:

- (a) sliding a first workpiece axially into said passageway from said entrant end;
 (b) heating said first workpiece by said coil to a temperature above the Curie point of said first workpiece;
 (c) sliding a second workpiece axially into said passageway from said entrant end until said first workpiece is ejected from the exit end of said passageway by said second workpiece;
 (d) magnetically attracting said second workpiece to a movable member;
 (e) pulling said movable member, and thus said second workpiece, toward said entrant end until the second workpiece is properly positioned in said passageway for optimum heating;
 (f) then releasing said second workpiece from said member; and,
 (g) removing said member from said passageway.

3. A device for moving an elongated ferromagnetic workpiece axially within the workpiece receiving passageway of a multiturn induction heating coil, said device comprising: an abutment element, means for moving said element axially into and out of said passageway, a pole piece on said abutment and adapted to contact said workpiece, and means for selectively magnetizing said pole piece whereby said workpiece may be magnetically attracted to said pole piece while said workpiece is being positioned within said passageway.

4. In an induction heating apparatus comprising a multiturn induction heating coil with a central workpiece receiving passageway, guide means within said passageway and coextensive therewith for supporting an elongated workpiece in said passageway, said coil passageway having an entrant and an exit end, and a workpiece pusher mechanism having a forwardmost abutment element movable in a first and second direction, said element pushing an unheated workpiece axially into said passageway when

moved in said first direction with the workpiece moving into said passageway causing a heated workpiece to be forced from said exit end of said passageway before said abutment element is moved in said second direction, the improvement comprising: said abutment element including a pole piece, control means for selectively magnetizing and demagnetizing said pole piece, said control means including a first device for magnetizing said pole piece at least before said element starts movement in said second direction whereby said unheated workpiece is attracted to said abutment element and a second device for demagnetizing said pole piece after said abutment element has pulled said unheated workpiece in said second direction to the proper heating position within said passageway.

5. The improvement as defined in claim 4 including an electromagnet for magnetizing said pole piece, said first device being a means for energizing said electromagnet and said second device being a means for de-energizing said electromagnet.

6. The improvement as defined in claim 5 wherein said devices are each switches for selectively connecting said electromagnet onto a power supply.

7. The improvement as defined in claim 6 wherein said switches are operated in response to the position of said abutment element within said passageway.

8. The improvement as defined in claim 4 wherein said first device magnetizes said pole piece before movement of said abutment element in said first direction stops.

9. The improvement as defined in claim 4 wherein said passageway has a length only slightly greater than the length of said unheated workpiece, and said proper heating position is generally a position with said workpiece centered in said passageway.

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