

Feb. 13, 1951

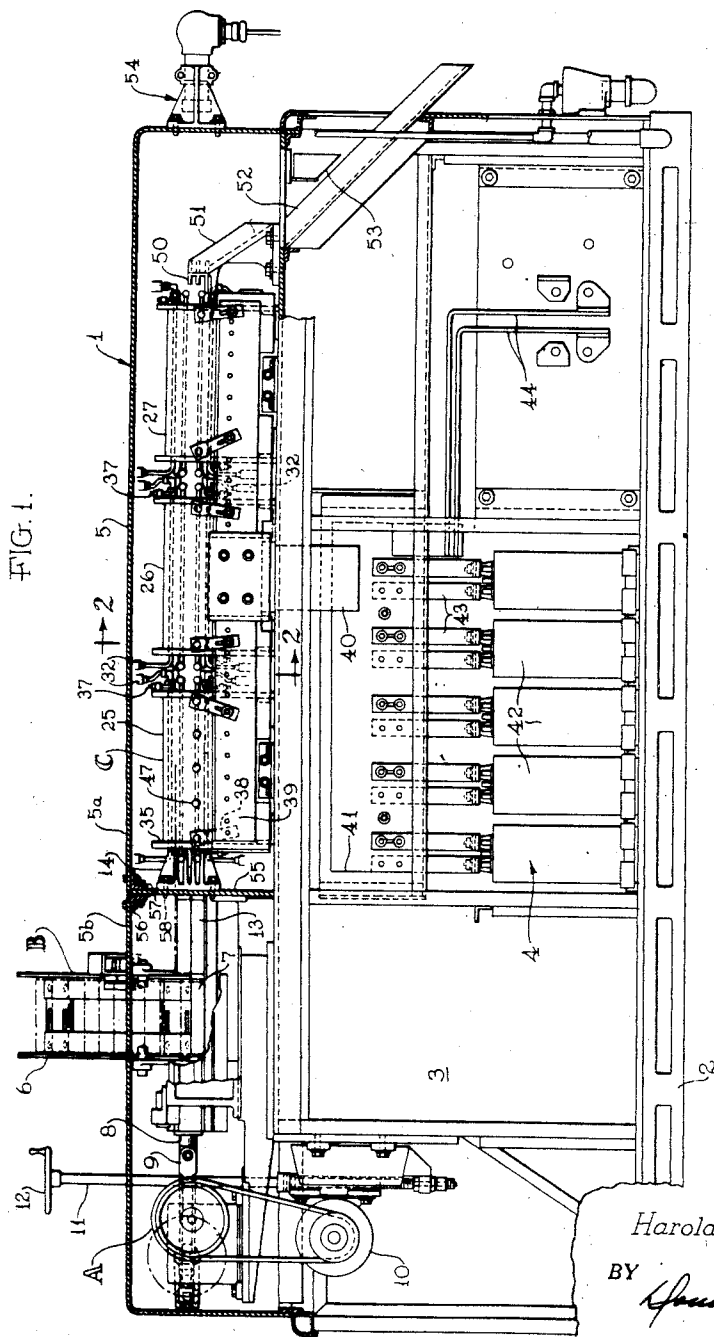
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2,541,123

CONTROL SYSTEM FOR INDUCTION-HEATING APPARATUS

Original Filed May 17, 1945

4 Sheets-Sheet 1



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CONTROL SYSTEM FOR INDUCTION-HEATING APPARATUS

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4 Sheets-Sheet 2

FIG. 2.

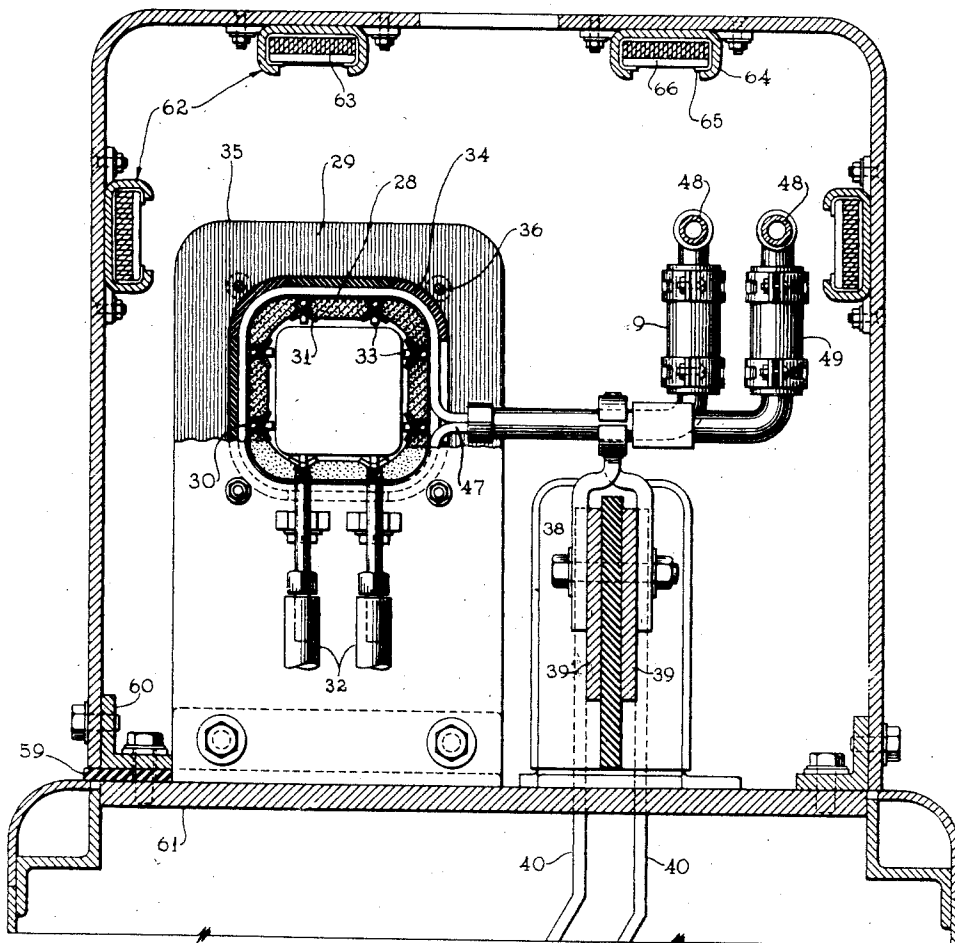
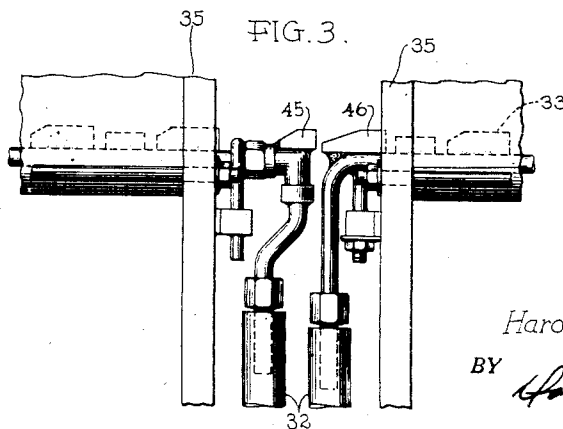


FIG. 3.



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FIG. 5.

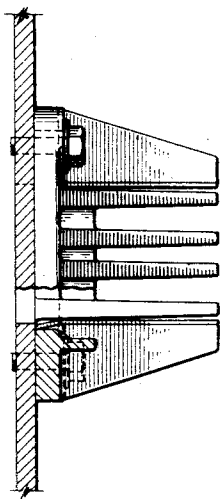


FIG. 4.

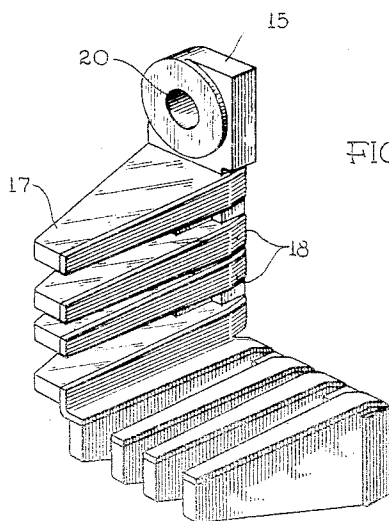
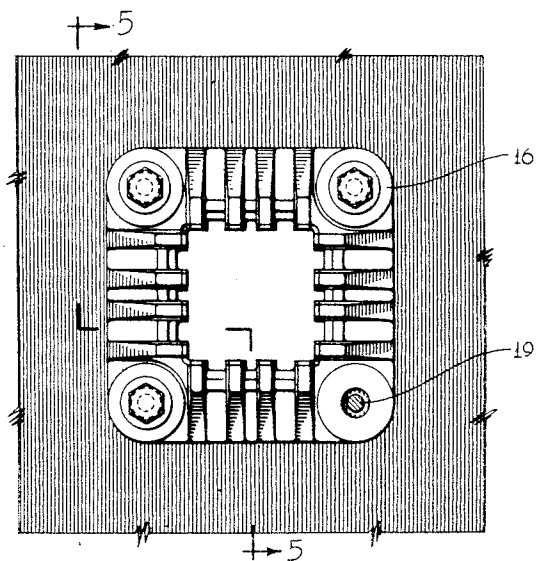


FIG. 6.

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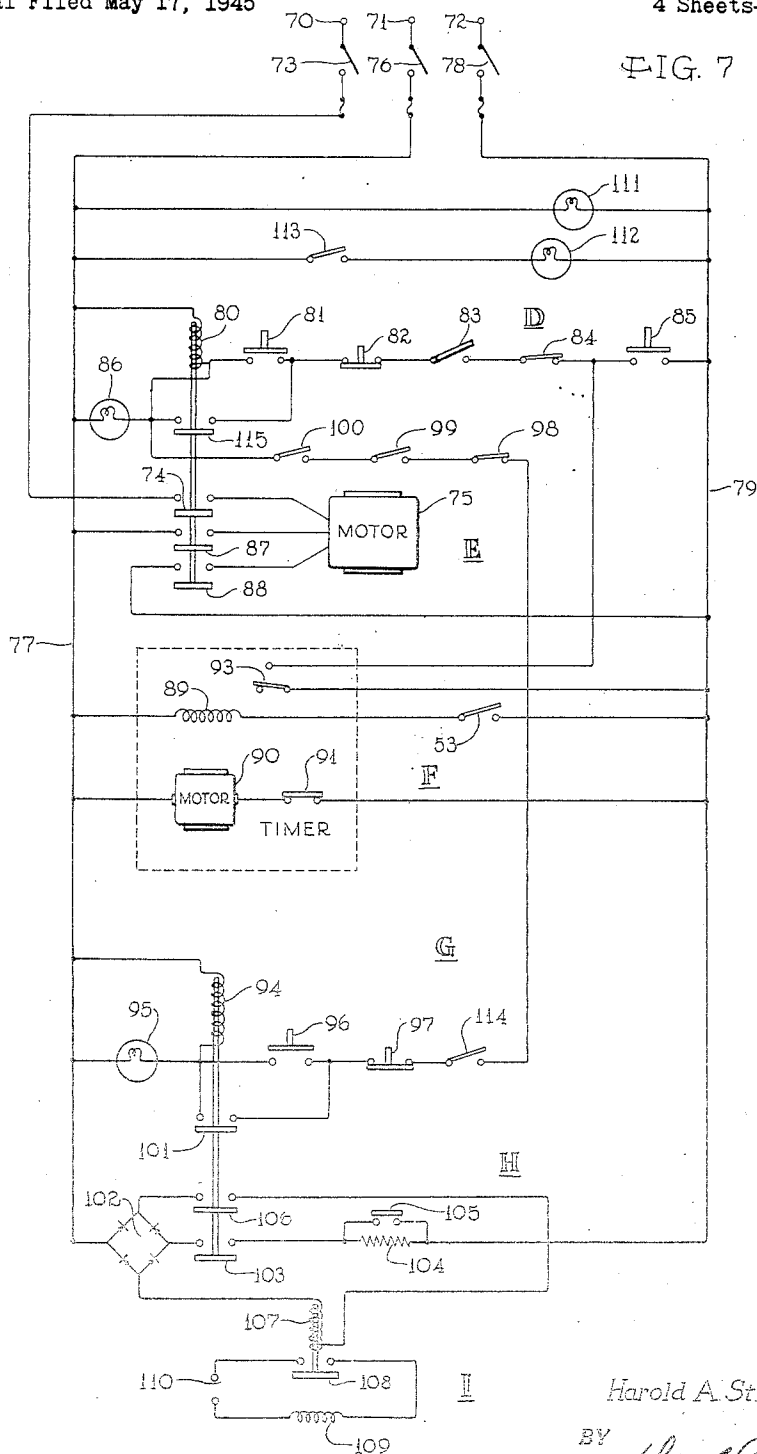
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CONTROL SYSTEM FOR INDUCTION-HEATING APPARATUS

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FIG. 7



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CONTROL SYSTEM FOR INDUCTION-
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Original application May 17, 1945, Serial No.
594,329. Divided and this application July 8,
1946, Serial No. 681,996

2 Claims. (Cl. 219—13)

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This invention relates to apparatus for heating inductively workpieces adapted to move progressively through the heating coil of the apparatus and is an improvement over the apparatus shown in applicant's Patent No. 2,325,638, filed September 19, 1941. This application is a divisional of Serial No. 594,329, filed May 17, 1945, now abandoned.

An object of this invention is to provide a high-frequency induction furnace of the type shown in said patent but provided with an improved electrical circuit with associated apparatus for the furnace equipment for opening the power circuit driving the workpieces through the furnace chamber in the event an accidental stoppage of the workpiece movement occurs.

Additional objects will be apparent upon consideration of the following description of the invention and of the accompanying drawings, in which:

Figure 1 is an elevation of the apparatus partly in section showing the relationship of the heating coil or furnace and the feeding mechanism, power mechanism and the exterior block;

Figure 2 is a section of the furnace taken along the line 2—2 of Figure 1;

Figure 3 is a view indicating the transfer point between coil sections in the furnace;

Figure 4 is an end view of the workpiece guide element;

Figure 5 is a side view of the workpiece guide;

Figure 6 is a view of a part of the workpiece guide; and

Figure 7 is a wiring diagram.

The sectional elevation of Figure 1 illustrates the general setup and arrangement of the apparatus for machine generally designated by the numeral 1. On the base 2 there is mounted a frame 3 for enclosure of the capacitor bank 4 and for support of the induction furnace workpiece feed apparatus and power means. For aid in description the power mechanism will be designated by the letter A, the workpiece feed apparatus by the letter B, and the induction furnace by the letter C, these units being positioned as shown in Figure 1 from left to right of the machine. These various units A, B and C are enclosed by a casing 5 preferably of non-magnetic material, as aluminum, the casing extending from end to end of the machine and on both sides

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and ends as shown in Figures 1 and 2. Preferably the casing is divided transversely into sections 5a and 5b, section 5a enclosing the induction furnace and section 5b the feed mechanism and power unit.

Referring first to the workpiece feeding unit B there is provided a chute 6 which extends angularly from the top casing 5 in position to receive a number of workpieces which for purposes of description will be referred to as billets. These billets have a length corresponding to the width of the chute and are adapted for placement side by side in the chute for feeding into the billet channel 7 at the base of the chute. A supply chute switch 83 opens the power circuit when the supply of billets fails. As fully described in applicant's patent above-mentioned the channel 7 is open at either end and from the power side is adapted to receive power application from the

A unit including the plunger element 8 pivotally connected to a connecting rod 9 adapted for reciprocation by the pulley and belt mechanism shown. A motor 10 is connected to the shaft of the lower pulley, the screw shaft 11 and hand wheel 12 affording means for adjusting the tension of the belt.

On the side of the billet channel 7 adjacent the furnace a channel extension 13 is provided into which billets are moved by the projector 8 from the channel 7 as they are fed downwardly in the chute 6 by gravity. This feeding action is intermittent in accordance with the reciprocation of the plunger 8 and the projected billets are lined by this action of the mechanism end to end in the channel 13. As the movement continues the billets are moved through the guide grid 14 to the heating chamber of the furnace. The guide grid is of special construction comprising two right angled sections 15 and 16, one of which is shown in Figure 6, which, on being united, form a member with a square contour having a solid base of flat stock from which extend projecting fingers 17. These fingers are roughly triangular in shape with the flattened sides of the plates in a given unit each parallel with each other. The inner edge 18 of these plates is preferably formed of hardened material as these edges constitute the bearing surface of the grid and may be formed of separate strips attached to the plates 17. The bearing edge of the plate 17 is substantially

parallel with the axis of the furnace and so positioned relative to this axis that the center of the exit opening of the grid is coincident with the heating channel axis. Adjustment of the grid, so as to permit centering thereof in relation to the coil axis, is possible from the construction of the grid in two sections, the attachment bolts 19 being of lesser diameter than the attachment apertures 20 on the grid to permit relative movement of the sections with reference to each other. By such movement the center of the grid axis opening may be shifted laterally.

The induction furnace C is positioned in extension of the grid 14 as shown in Figure 1. This unit includes three sections 25, 26 and 27 in common alignment and formed as complete units independent of each other and separably removable. Each unit comprises a heating coil 28 wound in square formation of square sectioned copper tubing, the turns of the coil being insulated from each other. Interiorly of the coil are a plurality of insulation blocks 29 (Fig. 2) supported in place by metal tubes or rails 30 provided with butterfly supporting plates 31. These plates are attached to the rails 30 on the inner sides thereof with lateral extensions adapted to overlie the adjacent edges of the refractory fire brick or other material used as heating insulation material, thus retaining this material in place.

The rails 30 function as cooling means, the projecting ends thereof being outturned and attached to supply sources 32 of a coolant. The rails also serve to support lugs 33 consisting of small plates edge-attached at displaced points along the inner surface of the rails as shown in my co-pending application Serial No. 384,503, filed March 21, 1941, now Patent No. 2,408,350 dated September 24, 1946. As will be seen from inspection of Figure 2 the lugs 33 are in close proximity to the billets on all sides thereof so that buckling of the train of billets in movement through the furnace chamber is prevented. The lugs 33 should be of heat resistant metal so as to withstand high temperatures present in the furnace during operation.

External to the coil 28 there is a layer of insulating slabs 34 which may be of Transite. At the ends of the coil, support plates 35 are provided to which the heating coil unit is attached by means of rods 36, there being four of these rods shown in Figure 2 extending external to the coil from end to end and retained by means of hooked supports 37 on the outer face of the end plates 35.

Coil connections from each coil for supply of electrical power is by means of the coil taps 41, connecting straps 38 and bus bars 39, 40 and 41. The capacitors 42 are connected by straps 43 to the bus bar 41 in order to tune the power circuit. External bus connections and terminals are indicated by the numeral 44. Coil taps 41 have connection to coolant sources 48 through couplings 49.

It has been mentioned that the furnace C is in sections 25, 26 and 27. In order to insure continuity in the support of the billets in the movement between sections, I have provided lugs 45 and 46 mounted on the coolant tubing intermediate the end plates 35 of adjacent sections (Fig. 3). These lugs are in general similar to the lugs 33 with a cut off corner on the end at which the billet approaches but the lug 46 is formed with a flatter and more extended face on the cut off edge to provide for variation in distance between adjacent sections.

At the rear or exit end of the section 27 of the furnace a second guide grill 50 is provided leading into a chute section 51. A further chute section 52 at the end of the first chute section provides a channel for carrying the heated billet to a receptacle external of the machine. A door switch 53 comprising a pivoted plate hinged on the side of the channel so as to be actuated by the movement of a passing billet is provided. Also in line with the axis of the furnace a photo-cell unit 54 containing switch means 98 (Fig. 7) is secured to the casing section 5a at the end of the machine, an aperture being made in the casing so that light from the furnace may penetrate the unit to modify the resistance of the cell.

It has been previously mentioned that the casing 5 has been divided into two sections 5a and 5b. The inner ends of these two casings adjoin each other and are supported by an intercepting transverse plate 55 extending across the upper casing chamber. This plate also supports the grid 14. Connection between the plate 55 and the casing ends is by means of brackets 56 and 57 which are bolted respectively to the plate and casing. The plate is lined, preferably with insulation material in the form of insulation sheets, the upper edge of which extends between the adjoining edges of casings 5a and 5b and between the bracket 56 and the plate 55 so as to insulate electrically both casings from each other and from the brackets 56. Insulation also surrounds the bolts 58 securing the bracket 56 to the plate 55. Additional insulation of the casing is provided in an insulation strip 59 placed between the bracket 60 and the casing plate 61 as shown in Figure 2. The attaching screw bolt is also insulated from the bracket 60. In this manner the electrical circuit including the casing and the plate 51 is interrupted whereby eddy currents, due to flux transmitted by the heating coils, are eliminated.

It is pointed out further as shown in Figure 2 that there is provided flux return paths for the coil in the units 62 secured along the inner surface of the casing 5a. These flux return units comprise laminated strips 63 placed in slotted tubes 64 where they are retained by the fiber lining 65 and plate 66. These units extend longitudinally of the casing parallel to the heating coil and reduce the eddy currents in the casing to such an extent that heating effects therein are practically eliminated. Without these flux return units the casing becomes so hot that it is a source of danger to the attendants.

In Figure 7 of the drawing is indicated a wiring diagram of the circuit which is applicable to the machine as hereinabove described. The use of three-phase alternating current is indicated as being applied to inlet source terminals 70, 71 and 72. From source 70 the circuit leads through a main manual switch 73, and a relay switch 74 to the motor 75 for operating the equipment. From source 71 the circuit leads through manual switch 76 to the main conductor 77 and from source 72 through manual switch 78 to the main conductor 79. The circuit involves six sections referred to as sections D, E, F, G, H and I. Section D comprises the motor pilot circuit and includes the pilot relay coil 80, the manual motor start switch 81, the manual motor stopping switch 82, the normally open supply chute switch 83, the normally closed line switch 84 and the normally open timer chute manual switch 85. A pilot lamp 86 is provided also in parallel with the pilot coil 80 to indicate current flow in this branch circuit. Also, a lock-in relay switch 115 shunted around

manual switch 81 is provided. The E branch circuit includes the motor 75, the relay switch 74, the relay switch 87 between the motor and the main conductor 77 and the relay switch 88 between the motor and the main conductor 79. These switches are normally open and on closure cause the motor to function.

Branch F of the circuit is the timer section. The timer may be of any known construction such as the Eagle timer and includes a clutch coil 89, a motor 90 and a normally closed relay switch 91, the motor and switch being in series across the main conductors 77 and 79. The clutch coil is in series with the normally open delivery switch 53 between the conductors 77 and 79. The timer circuit also includes the timer switch 93 which normally is open but remains closed during the operation of the machine unless the movement of billets is interrupted.

Branch G of the circuit includes the intermediate contactor coil 94 in parallel with the indicating lamp 95, the normally open manual switch 96, the normally closed manual switch 97, the normally open door switch 114, the normally closed photo-cell switch 98, the normally open coolant pressure switch 99 and the normally open flow switch 100, each of these elements being connected in series from the conductor 77 to a point between the pilot coil 80 in the D circuit and the manual motor starting switch 81. A normally open relay switch 101 shunts the manual switch 96 in the intermediate contactor circuit.

The main contactor circuit H includes the bridge rectifier 102 connected directly to the conductor 77 and, through the relay switch 103 and resistor 104, to the conductor 79. A normally open relay switch 105 by-passes the resistor 104. The rectified circuit comprises the normally open relay switch 106 and the main contactor coil 107 which functions to close the heating circuit. The armature of this coil when closing also closes switch 105 after the first current surge through the H circuit. The heating circuit I includes the normally open relay switch 108 and the heating coil 109 energized from the high frequency power source 110.

Additionally, the circuit includes the lamp indicator 111 to indicate power in mains 77 and 79, and lamp 112 and normally open pressure switch 113 to indicate proper coolant pressure in the furnace tubing.

In operation, with the door switch 114 closed, the coolant circuits for the support rails and heating coils are supplied with coolant under pressure thereby causing closure of pressure and flow switches 99, 100 and 113 in the G branch circuit. Billets are placed in billet chute 6, closing switch 83. The motor switch 81 is then closed manually thereby completing a circuit through the pilot coil 80 and lamp 86. Energization of coil 80 closes relay switch 115 locking the coil 80 and permitting starting switch 81 to be opened. Also relay contacts 74, 87 and 88 are closed to energize the motor 75 and start the feeding mechanism. Billets are consequently intermittently moved from the base of the chute into the furnace for heating by the heating coil. Simultaneously the intermediate contactor manual switch 96 is closed energizing coil 94 and causing closure of relay switch 101 to lock in the coil circuit. Also the contact switches 103 and 106 are closed in the H contactor circuit supplying direct current to contactor coil 107 to close switch 105 and the heating circuit I. If there is no obstruction in the movement of the billets it will be con-

tinuous and uniform and as each successive billet leaves the exit grid 50 and moves down the chute 52 it will operate the stock delivery switch 53 causing closure of the same and energization of the timer clutch coil 89. Thereupon timer switch 93 closes and the timer begins a cycle which is substantially in excess of the time necessary to bring a billet to the required temperature in moving through the furnace. Consequently the billet will pass out of the furnace and down chute 53 before the timer cycle is completed and in so doing operates the delivery switch 53 to cause a resetting of the timer, the timer switch 93 remaining closed. After another time interval and before the timer completes its new cycle another billet emerges from the exit grid and operates the chute stock delivery switch. This sequence of operations will continue indefinitely as long as the supply of billets in the supply chute is maintained and as long as there is no interruption in the movement of billets through the furnace. Should the supply of billets fail or should a stoppage occur in the furnace for any reason or should the power mechanism for supplying billets to the furnace be interrupted the timer will then tune out, switch 93 will open and motor 75 will stop through opening of the associated switches 74, 87 and 88. On the opening of timer switch 93 timer motor switch 91 also opens.

After stoppage due to any of the causes mentioned, a restarting of the machine can be accomplished only by actuating the stock delivery switch 53, assuming that the supply, pressure and flow switches are closed. When this occurs timer switches 91 and 93 close and the timer resets for a new cycle.

In the event that through excess voltages or other causes the heat in the furnace becomes excessive the photo-cell switch 98 opens thereby deenergizing the heating circuit but not interrupting the motor circuit so that the billet movement continues until the temperature has fallen in the furnace to a normal value.

Modifications in structure and circuit may be made within the scope of the claims hereto appended.

What is claimed is:

1. In a machine for progressive heating of a train of workpieces; an induction heating chamber therefor, means for supplying a train of individual workpieces, power means for moving said train through said chamber, a high-frequency power source for heating workpieces in said chamber, means for interrupting the power means and power source on failure of said train of workpieces to move upon actuation by said power means, and additional means for interrupting the power source alone on development of abnormal heat in said chamber, said last-mentioned means comprising controls actuated in response to the temperature of emerging workpieces.

2. In a machine for progressive heating of a train of workpieces; an induction heating chamber therefor, means for supplying a train of individual workpieces, power means for moving said train through said chamber, a high-frequency power source for heating workpieces in said chamber, means for interrupting the power means and power source on failure of said train of workpieces to move upon actuation by said power means, and additional means for interrupting the power source alone on development of abnormal heat in said chamber and for connecting the power supply on reduction of heat to normal in said chamber, said last-mentioned means com-

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prising controls actuated in response to the temperature of emerging workpieces.

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