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BILLET HANDLING DEVICE

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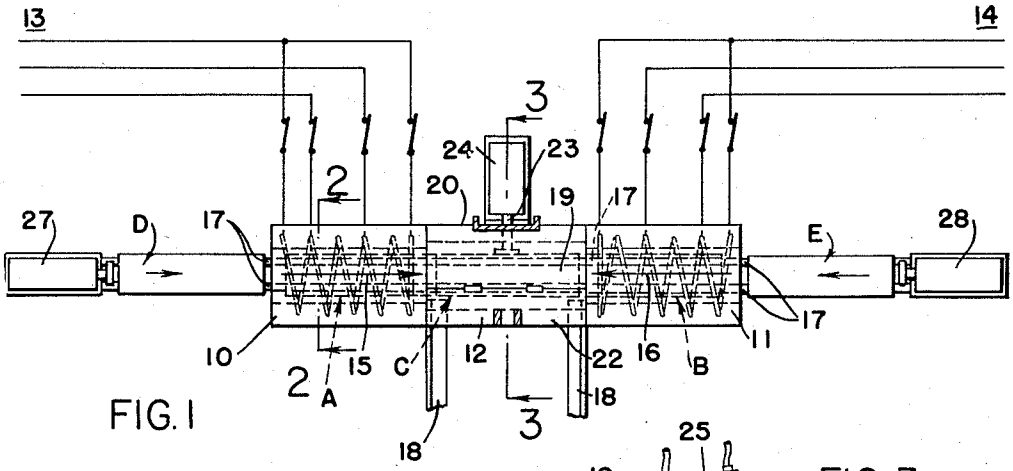


FIG. 1

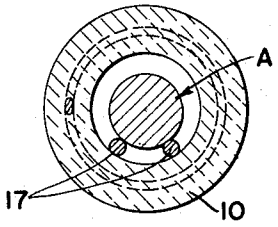


FIG. 2

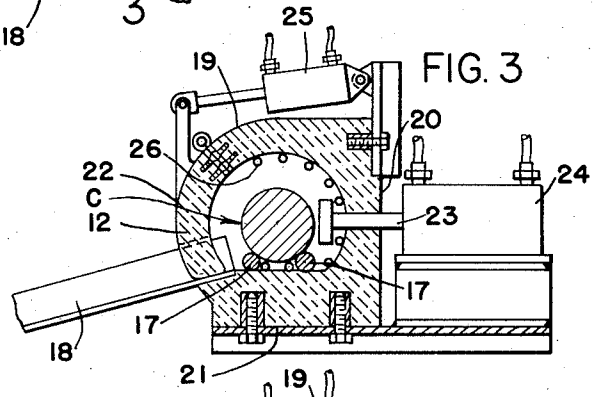


FIG. 3

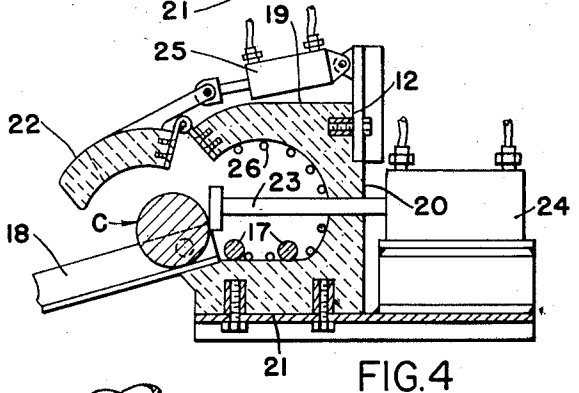
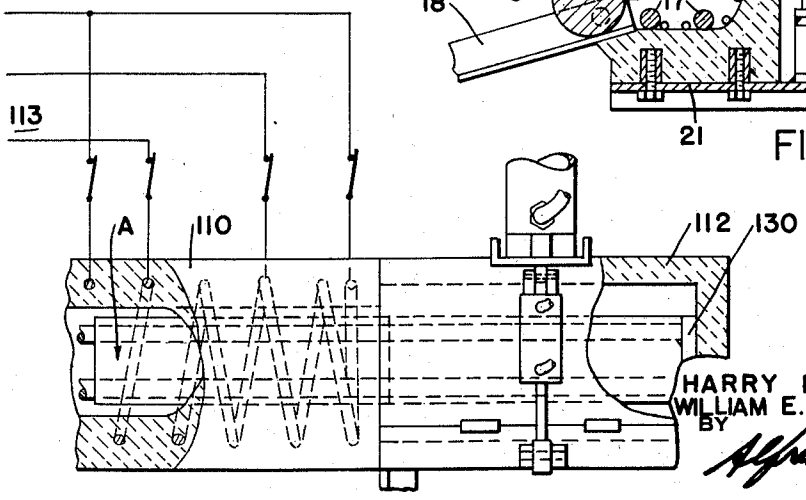


FIG. 4

FIG. 5



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BILLET HANDLING DEVICE

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The present invention pertains to the art of induction heating and, more particularly to apparatus for induction heating using polyphase induction heating coils.

In the art of induction heating, it is well known that induction heating coils energized from a polyphase alternating current source exert a magnetic force on the billet being heated which tends to move the billet lengthwise of, or axially out of the coil. Because of this, many elaborate stops and means have been devised to prevent the billet from being forced out of the coil by the magnetic field established by the coil. Attempts have also been made to neutralize the magnetic forces established by the coil by having part of the coil establish magnetic forces in a direction opposite those established by another part of the coil. These various attempts in the past have provided means to keep the billet in the coil but at the same time have added unnecessary structure to the equipment or have slightly changed the heating pattern in the billet. For example, if stops were used to prevent the billet moving out of the coil while the coil was energized, it was necessary to remove the stops in order to take the billet out of the coil after it is heated. Such stops had to be provided with cooling systems and means for moving them out of the way.

The present invention contemplates an extremely simplified billet heating and handling device wherein no stops or other means outside of the heating coils are required to hold the billets within the coils.

In accordance with the invention, a pair of polyphase induction heating coils are arranged in a spaced end-to-end relationship in such manner that the magnetic force exerted by the coils on the billets therein is in opposite directions so that each coil, operating through the billet contained therein, holds the billet in the other coil while it is energized.

Further, in accordance with the invention, the coils may be positioned on one or opposite sides of a common post heating or soaking chamber, or the like, so that each billet in turn may be allowed to soak after it has been heated by a coil. This soaking chamber may be provided with a door in the side thereof and a track, or other suitable means, so that the billets may be easily removed therefrom. The billets may be alternately heated in the coils and then moved into the soaking chamber in a timed relationship wherein the billets in the coils receive induced heat therein simultaneously, with the billet in one coil reaching its maximum heating temperature or full heat, while the billet in another coil is in its initial heating stage. The coils are connectable through suitable contactors to a power source of induction heating energy to energize them for heating of the billets by the induction heating process.

Auxiliary controls and the turning on and off of the power source to the coils may be hand operated or automatically operated. It is understood that these controls may be operated in a timed relationship with each other by means of a time clock device or other suitable means or that they may be operated in accordance with the temperature of the billet itself. When they are operated in accordance with the temperature of the billet itself, suitable temperature responsive devices and temperature measuring devices would be associated with the induction heating apparatus, or furnace, or billet heating apparatus illustrated and described herein.

Therefore, one of the objects of the present invention is to provide an induction heating furnace or apparatus which is novel in arrangement and is highly efficient in operation, by eliminating down-time or waste time during the cycle of operation.

A further object of the invention is to provide an induction heating apparatus in which induction heating coils are placed in end-to-end relationship so that the magnetic force of one coil keeps a billet in the other coil.

A still further object of the invention is to provide an induction heating arrangement wherein billets may be longitudinally fed alternately from two heating coils into a common soaking chamber and then ejected from the soaking chamber transversely to the longitudinal movement.

Still a further object of the invention is to provide a novel method of heating billets by using a pair of induction heating coils positioned in end to end relationship, and on opposite sides of a common soaking chamber; the method comprising the steps of simultaneously heating one of the billets for the first half of its heating cycle in one coil and another billet for the second half of its heating cycle in the other coil, while a third billet is soaking in the soaking chamber, removing the billet from the soaking chamber and inserting the heated billet into the soaking chamber, placing an unheated billet in the coil where the heated billet was and again energizing the coils so that the billet which was previously heated during the first half cycle, is now heated for the second half of its heating cycle and the newly added billet is heated for the first half of its heating cycle.

Further objects and other modifications of the invention relating to the art of heating billets and induction heating apparatus will become more apparent from the following description of one of the preferred embodiments of the invention where taken in conjunction with the accompanying drawings in which:

Figure 1 is a top plan view of the billet heating apparatus,

Figure 2 is a sectional view taken approximately along the line 2—2 of Figure 1,

Figure 3 is a cross-sectional view taken approximately along the line 3—3 of Figure 1,

Figure 4 is a sectional view similar to Figure 3 but with the door of the soaking chamber in open position and illustrating the removal of the billet therefrom, and

Figure 5 is a top plan view partly in section of the modification of the invention.

The invention pertains to an induction heating apparatus for heating billets wherein the billet is heated by an induction heating coil and immediately moved into a soaking chamber which is also heated so that the heat pattern throughout the cross section of the billet will become uniform. The invention also pertains to the novel arrangement of induction heating coils for heating billets wherein the heating coils establish magnetic fields of force opposing each other so that stops are not required to hold the billets within the heating coil during the heating theerof.

The preferred embodiment of the invention and one of the ways in which the invention may take physical form is illustrated in Figure 1. The heating apparatus in Figure 1 comprises induction heating coils 10 and 11 arranged in substantially coaxial longitudinal alignment or in end to end relationship and spaced apart by means

of a soaking chamber 12 which is positioned between the mean ends of the coils 10 and 11. The induction heating coils 10 and 11 are connectable to a source of power or, as illustrated, to respective sources of power 13 and 14 which are a multiphase or preferably a three-phase source of alternating current in such manner that the magnetic field of the coils oppose each other. The magnetic field of the coil 10 exerts a force in the direction of the arrow 15 on a billet in that coil and the magnetic field of the coil 11 exerts a force in the direction of the arrow 16 on a billet in that coil. The magnetic forces of both coils, as indicated by the arrows 15 and 16, are directed towards the soaking chamber 12.

The soaking chamber 12 is provided with end openings and a side opening so that billets may be moved endwise from either coil into the soaking chamber and then moved in a side-ways direction therefrom. In other words, the billets are moved through the coils in the direction of the arrows 15 and 16, into the soaking chamber 12, and then are moved out of the soaking chamber 12 in a direction transverse to the direction of the arrows 15 and 16.

The coils 10 and 11 and the soaking chamber 12 may be provided with a pair of skid rails 17 which extend longitudinally through the coils and the soaking chamber. These skid rails 17 support the billets during the heating, post heating, or soaking periods of time and permit much easier handling of the billets with less force required than if no skid rails were used. However, it is understood that other suitable means may be employed in place of the skid rails, if desired. It has been found desirable to provide a track 18 or other suitable means extending transversely to the skid rails 17 and outwardly from the soaking chamber 12 and on which the billet moves when it is removed from the soaking chamber 12. Only one billet is shown in each coil and in the soaking chamber. Obviously more than one could be so located.

The soaking chamber 12 which is positioned between the mean or adjacent ends of the induction heating coils 10 and 11, is best illustrated in cross section Figures 3 and 4. The chamber may be formed of any suitable material such, for example, a heat insulation material constructed into a unitary structure on the top 19, back 20 and bottom sides 21, and having a door 22 on the front side thereof. The door 22 is hinged at the top edge thereof to the top 19 so that it may be opened when a billet is to be ejected or removed from the soaking chamber. In Figure 3 a billet is illustrated on the rails 17 and in Figure 4 the billet is illustrated as having been moved from the rails 17 onto the track 18 and through the opened door by means of a piston 23 of an air cylinder 24 or the like. Door 22, in this instance, was opened by an air cylinder 25 mounted on top of the chamber. However, it is understood that other suitable means including manual opening of the door may be used in place of the air cylinder 25 if desired, and that other suitable means may be used in place of the air cylinder 24 and piston 23 which move the billet from the rails 17 to the track 18. It is understood other suitable devices, such as motor driven means or solenoid motored devices may be used in place of the air cylinders, if desired. The soaking chamber 12 may also be provided with auxiliary heating elements 26 if desired to keep the temperature of the atmosphere or air immediately surrounding the billet soaking therein at an elevated temperature. Such elements 26 may be gas burners or induction heating coils but are shown as resistance heating coils.

The billet handling device illustrated in Figures 1 to 4 inclusive, operates as follows: Assume that there is a billet A in coil 10, a billet B in coil 11, a billet C in the soaking chamber 12, a billet D ready to be inserted in the coil 10 and a billet E ready to be inserted in the coil 11. Also assume that the billet A has been heated to desired or full temperature by the coil 10, that billet B has received part of its heat so that it is heated partly to its full temperature by coil 11 and that billet C has been fully heated and is soaking in the chamber 12 to obtain a uniform heat pattern throughout its cross section. Also assume that at this particular instance, the power has been shut off from the power sources 13 and 14 by suitable contactors or other similar means so that the induction heating coils 10 and 11 are de-energized.

With these assumptions forming a starting point, the first step in the operation is to energize the air cylinder 24 and the air cylinder 25 to remove the billet C from the soaking chamber 12 or to move it from the rail 17 onto the track 18 in a transverse direction relative to the coils 10 and 11. After the billet C has been removed from the soaking chamber 12 and the air cylinders 24 and 25 de-energized so that they return to their normal position and the door 22 is closed, the coil 10 is connected to the power source 13. Energization of the coil 10 establishes a magnetic field forcing the billet A in the direction of the arrow 15 from the coil 10 and into the soaking chamber 12 until it bumps against the billet B in coil 11. This positions the billet A in the soaking chamber. At the same time an air cylinder 27 mounted on the skid rails 17 may be powered to push billet D into the extreme end of the coil 10 and until the billet B abuts against billet A which is now in the soaking chamber 12.

Next, the coil 11 is connected to the power source 14 so that it is energized to continue the heating of the billet B. Both coils are energized until the billet B reaches its full temperature and billet D reaches partially towards its full temperature. Simultaneously, the heat pattern in the billet A, which is now in the soaking chamber, gains a uniform heat pattern so that the center of the billet is at about the same temperature as the outside of the billet. When the billet B has reached its full temperature, both coils 10 and 11 are de-energized. The billet A is then removed from the soaking chamber 12 by energizing air cylinder 24. The billet B is inserted into the soaking chamber 12 and a new billet E inserted into the coil 11 by energizing coil 11 and air cylinder 28. Coil 10 is next energized so that billet D will be heated to full temperature while billet E is heated to partial temperature and billet B soaks in chamber 12. This cycle of operation may be continued on succeeding billets.

It is noted that while the coils 10 and 11 are energized, the magnetic force urges the billets therein towards the soaking chamber and against the billet which is in the soaking chamber. It is also noted that each time the power is turned on or both coils are energized, they heat the billet contained therein partially towards its full heating temperature. Thus the billets in the coils 10 and 11 are alternately heated to their full heating temperature and then moved into the soaking chamber so that a billet in the soaking chamber remains there for a period of time equal to, or approximately equal to, a definite part of the total heating cycle and a definite part of the time during which the billet is heated by its respective coil. Generally, a billet remains in the soaking chamber a period of time equal to about one half of the length of time required to induce the heat into the billet while it is within the induction heating coil.

A modification of the invention is illustrated in Figure 5. In this modification, one of the induction heating coils has been eliminated. The modified structure includes a heating coil 110 and a soaking chamber 112, the induction heating coil 110 being connectable to a suitable source of power 113. The soaking chamber 112 is constructed very similar to the soaking chamber 12 with the exception that the end furthest from the end of the coil 110 is provided with a stop 130 against which the billet bumps when it is ejected from the coil 110 into the soaking chamber 112.

In this modified device, a billet may be left in the soaking chamber the full length of time that the coil 110 is

energized to heat another billet. In operation, the coil A is energized until the billet therein becomes heated. Then the power is turned off, or coil A de-energized. A previously heated billet in the chamber **112** is then pushed out sideways. Next, the coil **110** is again energized to move the billet therein endwise into the chamber **112** so that a new billet may be inserted in the coil. This entire cycle may be automatic by providing suitable current controls between the power source **113** and the coil **10** and on the air cylinders which move the billet out of the soaking chamber **112**. These controls may be integrally joined together and operated by a temperature measuring device either positioned in the stop **130** or engageable with a billet at another desired location in the coil **110** or the soaking chamber **112**. When such mechanisms are used, the temperature responsive device would operate the controls when the billets were heated to their desired temperature so that each succeeding billet would be heated uniformly.

In both the main embodiment of the invention, as illustrated in Figures 1 to 4 inclusive, and in the modification of Figure 5, it is noted that there are no stops which have to be moved out of the way so that a billet may be removed from the induction heating coil. In each instance the billet has induced in it, in a relatively short period of time, the heat required to heat the billet by the induction heating coil. Then the billet is moved into the soaking chamber to allow the heat to obtain a uniform heat pattern throughout the billet. In both instances, it is noted that every coil exerts a magnetic force on the billet within it in a direction towards the soaking chamber. In the preferred embodiment of the invention, the forces inserted on the billets from the coils are in opposite directions and in both modifications of the invention it is noted that the billets are removed from the soaking chamber in a direction transverse to their path of movement in an endwise direction through the induction heating coil.

It is understood that other details or modifications of the invention may be made without departing from the spirit and the scope of the invention as hereinafter claimed.

Having thus described our invention, we claim:

1. A pair of induction heating coils in end-to-end relationship and spaced apart, means for moving billets in opposite direction into the extreme ends of said coils and out of the adjacent ends of said coils, and means connecting each coil to a multiphasee source of electric power.

2. A structure as defined in claim 1 wherein the induction heating coils are connected so that their magnetic fields of force oppose each other and urge billets in the coils toward said adjacent ends of the coils.

3. In a billet heating apparatus, a heating chamber, induction heating coils, one on either side of said chamber, means for moving billets into extreme ends of said induction heating coils, said chamber having openings in the walls thereof for passing billets from the induction heating coils into the heating chamber, said chamber having an opening in a wall thereof and provided with a closable door through which billets may be ejected from the heating chamber in a direction transverse to the movement of the billets from the induction heating coils into the chamber, and means for connecting each coil to a multiphase source of power.

4. A structure as defined in claim 3 wherein the induction heating coils are connected so that their magnetic fields of force oppose each other and urge billets in the coils towards said heating chamber.

5. In a billet heating apparatus, the provision of an induction heating coil adapted to be connected to a multiphase power source for heating a billet placed in the coil, a soaking chamber on one end of said coil, said chamber having an opening therein aligned with the passageway of said coil, and having stop means abuttable by a billet moving from the heating coil to the soaking chamber to position the billet in the chamber, billet supporting means extending through said coil into said chamber, and means for removing the billet from the chamber in a direction transverse of the direction of moving the billet through the induction heating coil and into the chamber.

6. The structure of claim 1 including rail means extending continuously through said coils and track means extending from the adjacent ends of said coils in a direction transverse to said rail means.

7. The structure of claim 3 including rail means extending continuously through said coils and said chamber and track means extending from said chamber in a direction transverse to said rail means.

8. Method of heating billets by means of a pair of induction heating coils and a soaking chamber positioned therebetween, said method comprising the steps of heating a first billet the second part of a billet heating period in one coil, and simultaneously heating a second billet the first part of a heating period in the other coil, placing the first billet in the soaking chamber and a third billet in the induction heating coil for heating, heating the second billet the second part of its heating period and the third billet the first part of its heating period while the first billet remains in the soaking chamber, removing the first billet from the soaking chamber and placing the second billet in the soaking chamber, placing a fourth billet in the heating coil just previously heating the second billet and repeating the operation on succeeding billets.

9. The method as defined in claim 8 wherein the first part of the heating period and the second part of the heating period are equal in time length.

10. The method of heating billets using two induction heating coils and a common post heating soaking chamber positioned between the adjacent ends of the coils, said method comprising the steps of energizing the heating coils simultaneously to simultaneously partially heat the billets in both coils in such manner that one billet is heated to its full heating temperature prior to the heating of the other billet to its full heating temperature, and alernately removing the billets from the heating coils into the soaking chamber as they are heated and leaving each billet in the soaking chamber until another billet has been heated to its full heating temperature.

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