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DOOR MECHANISM FOR INDUCTION HEATING APPARATUS

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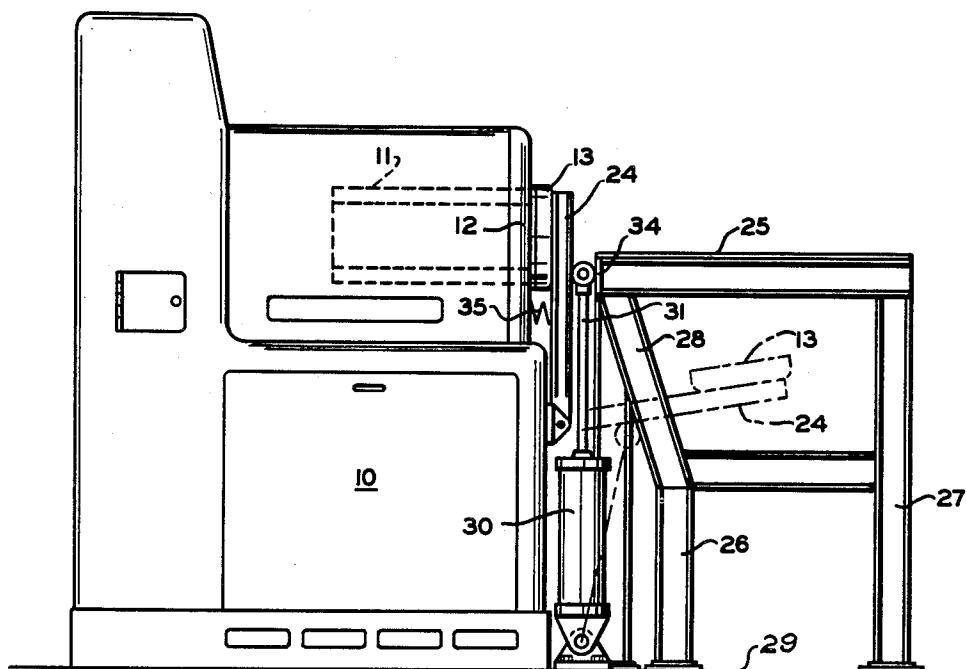


Fig 1

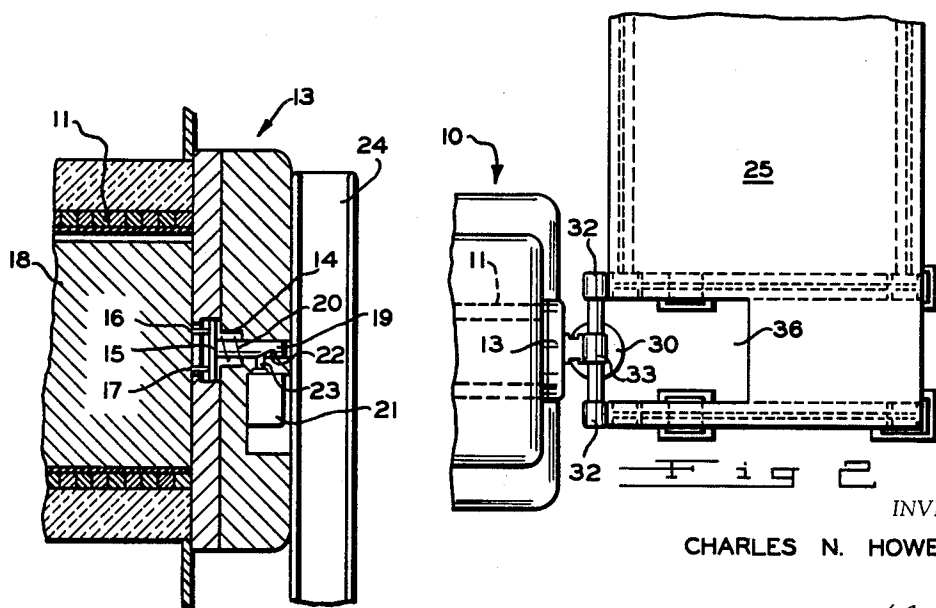


Fig 2

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DOOR MECHANISM FOR INDUCTION HEATING APPARATUS

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The present invention relates to induction heating apparatus, and more particularly to an improved and simplified power mechanism for opening and closing the work-retaining door of an induction billet heater, for example.

In the practice of heating cylindrical billets, for example, by electric induction processes it is common to provide a relatively heavy door or other work-retaining means at the open end of the induction coils of the heater so that upon application of electric energy to the heater coils the work being heated will not be propelled out of the heater by a so-called "motor action" which is caused by the creation of opposing electric fields in the coils and work. Often the propelling force exerted upon a billet being heated is of considerable magnitude. And, accordingly, the work-retaining door must be relatively strong and arranged to be firmly held in closed position during heating operations.

Thus, it is a primary object of the present invention to provide an automatic mechanism for opening and closing a work retaining door of an induction heating device which mechanism is characterized by simplicity of construction and operation, high strength and positiveness of action.

It has also been proposed to the induction heating art to provide heating apparatus of the type herein contemplated with a suitable control device, such as a thermocouple for example, which device is mounted in the work-retaining door of the heating apparatus and thus maintained in contact with the work to be heated during the entire heating operation. This arrangement is advantageous in that the thermocouple or other device may be utilized to automatically initiate and/or terminate heating operations in accordance with the condition of the work.

Specifically, it has been proposed to resiliently mount a thermocouple device in the work-retaining door of an induction billet heater and to condition energization of the induction coils of the heater upon contact of the thermocouple with the work upon closing of the work-retaining door. This arrangement insures that the work-retaining door will be properly closed before energization of the coils, and also that the thermocouple will be in proper contact with the work before a heating operation may be initiated so that uniformly accurate control of the heating operation may be provided.

In heater installations where a thermocouple or other control device is provided in the work-retaining door as set forth above it is necessary that the door be closed gently so that the control device is not damaged and additionally so that the work is not jarred away from the device. Accordingly, it is another object of the present

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invention to provide an automatic mechanism for closing the work-retaining door of an induction heating device which, in addition to having the characteristics of simplicity and ruggedness, is operative to ease the work-retaining door into fully closed position, and to lock the same in such position, all in accordance with the desired operation of the apparatus.

More specifically, it is an object of the invention to provide an automatic door operating mechanism of the type herein contemplated which may advantageously utilize a conventional hydraulic cylinder, for example, as a source of motive power, and in combination therewith a simplified arrangement for effecting a continuously decelerating closing movement of the door whereby the same may be eased into closed position in the manner desired.

A further object of the invention resides in the provision of an automatic door operating mechanism as above characterized wherein an operative component of the mechanism comprises a part or parts of a loading table, conveyor device or other service structure for the induction heating device. A loading table, conveyor device or other service structure being commonly employed along with such heating apparatus, the apparatus or mechanism of the present invention is materially simplified by the incorporation therein of such device or structure as will appear.

The above and other objects and advantages of the invention will become apparent upon full consideration of the following detailed specification and accompanying drawing wherein is disclosed a preferred embodiment of the invention.

In the drawing:

Figure 1 is a side elevation of an induction billet heating device having a work-retaining door and automatic door operating mechanism constructed in accordance with the teachings of my invention;

Figure 2 is a fragmentary top plan view of the apparatus of Figure 1; and

Figure 3 is an enlarged fragmentary view of the induction heating device of Figure 1, illustrating details of construction of the work-retaining door thereof, including a representative arrangement for mounting a thermocouple or other control device therein.

Referring now to the drawing, the numeral 10 designates, generally, a conventional electric induction heating furnace of a type commonly employed for heating cylindrical billets of metal. In accordance with conventional practice the furnace 10 is provided with a horizontally disposed work receiving coil 11 having a front opening 12 for loading and unloading billets of material, and having a suitable door 13 for closing off the opening 12 during heating operations. Suitable electrical circuitry, not shown, is also conventionally provided for connecting the work receiving coil 11 to a source of alternating energy as will be understood.

Details of construction of a work-retaining door 13 of a preferred type are shown in Figure 3, and it will be observed therein that the door 13 is provided centrally with a recess 14 for receiving and movably mounting a conventional thermocouple device 15. Preferably, the thermocouple device 15 is of a type disclosed in U. S. Patent No. 2,466,137, comprising a pair of spaced probes 16 and 17 of dissimilar metal, which probes are provided with pointed outer end portions and suitable circuit connections, not shown, leading to a voltage

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responsive meter or control device, also not shown. The arrangement is such that in operation of the thermocouple device the pointed probes 16 and 17 penetrate the outer surface of material (a billet 18, for example) under observation whereupon an electric potential is generated by the probes which is in proportion to the temperature of the material. The potential thus generated may be utilized to energize a temperature-calibrated meter, for example, or to perform a control function, or both as the case may be.

Control arrangements including the above described type of thermocouple have been found to be particularly desirable in the induction heating of aluminum workpieces since the probes 16 and 17 are caused to penetrate through the oxide film which is invariably present on the surface of aluminum material. And the current conductive properties of aluminum are such that the material itself comprises an electrical junction for the probes. More commonly, such junctions are provided by directly connecting (by welding or brazing, for example) the dissimilar metals.

In the illustrated arrangement probes 16 and 17 are movably carried in the door 13 by means of a rod 19 which is slidably received in the recess 14. As contemplated, the structure is such that the pointed outer ends of the probes 16 and 17 project somewhat from the inner face of the door 13 whereby upon closing of the door against the forward end of a billet 18 the probes 16 and 17 will be brought into resilient but forceful engagement with the end of the billet. Initial penetration of the probes through the oxide film of the material and subsequent maintenance of proper electrical contact between the probes and the material is effected through the use of a suitable spring 20 as will be apparent.

In addition to the use of the particular type of thermocouple device described above, in the manner above explained, it has been further proposed to condition energization of the heating coil 11 upon prior proper contact of the thermocouple with the billet 18. A representative arrangement for accomplishing this mode of operation is also illustrated in Figure 3 and comprises a suitable sensitive switching device 21 which is mounted on the door 13 adjacent the slidably retained rod 19 mounting the thermocouple device 15. In the particular embodiment illustrated the rod 19 is provided with a suitable cam surface in the form of a notch 22 which is adapted to engage an operator 23 for the switch 21 whereby upon movement of the thermocouple device against the action of spring 20 the switch 21 will be closed, energizing coil 11, or conditioning it for energization as the case may be. Thus, it will be understood that proper positioning of the thermocouple device 15 in relation to the billet 18 is necessary to condition the apparatus 10 for operation. And this in turn assures that the door 13 will be properly closed prior to energization of the coil 11 so that it is impossible to propel the billet 18 out of the furnace 10 by accidental or inadvertent energization of the coil 11 with the door 13 in an open position, for example.

Upon consideration it will be apparent that in order to properly and effectively operate an induction furnace in which the above described control instrumentalities are incorporated it is necessary that care be exercised in the closing of the door 13 and that the same be maintained firmly closed during heating operations. Thus, it will be readily understood that if the door 13 is closed too rapidly the relatively delicate components of the thermocouple device 15 may be damaged and/or the billet 18 may be jarred away from the face of the door in which case energization of the furnace is precluded by failure to close switch 21. Accordingly, the present invention is primarily concerned with the provision of automatic mechanism of a simplified character which is operative to assure proper closing of the door 13 and subsequent maintenance of the same in a closed condition throughout the heating operation.

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Referring particularly to Figures 1 and 2 it will be observed that the door 13 is hinged to the main frame of the furnace 10 by means of an elongated arm member 24, which should be of relatively rigid construction. The arm 24 is pivotally secured to the furnace 10 at a point located substantially below the door 13. The construction is such that the door 13 may be moved from a closed position, as illustrated, to an open position as indicated in Figure 1 by broken lines.

Positioned opposite the front face of the furnace 10 closely adjacent thereto is a loading table 25, for example, or other service structure such as may be conveniently utilized in assisting the loading and removing of workpieces from the furnace. In accordance with the teachings of the invention the table 25 is of rigid construction, utilizing a plurality of I-beam members 26 and 27 for supporting legs. And further in accordance with the invention the front supporting legs are provided with upper portions 28 which incline upwardly and outwardly of the table 25 toward the front face of the furnace. Preferably two such supporting legs 26 are provided, and as shown in Figure 2 these are positioned in straddling relation to the arm 24 so that the arm and door carried thereby may be pivoted between the legs 26 between open and closed positions.

Pivotally mounted on the floor or supporting base 29 for the apparatus is a hydraulic cylinder 30, preferably of a double acting type, which has an elongated piston rod 31 carrying a plurality of rollers 32 and 33 at its upper end. The center roller 33, of the plurality thereof, is adapted to engage the outer face of the arm 24 in the manner shown in Figure 1. Likewise, the outer rollers 32 are adapted to engage the outer surfaces of the inclined portions 28 of spaced legs 26. The arrangement is such that as the piston rod 31 is extended from cylinder by suitable application of fluid pressure the rollers 32 and 33 will act oppositely upon the inclined surfaces 28 and arm member 24 whereby to force the door 13 into a closed position.

Preferably the upper end portions 34 of the inclined surfaces 28 are vertically disposed and positioned substantially directly opposite the door 13 so that outward pressure upon the door while the same is in a fully closed position is resisted directly by the rigid frame structure of the table 25 rather than by the cylinder 30.

It should be particularly noted in Figure 1 that when the cylinder 30 is retracted and the door 13 in fully open position roller 33 will act upon arm member 24 at a short distance from its pivotal support, and that the direction of extending movement of the rod 31 is substantially at right angles to the arm. Thus, it will be understood that the initial closing movement of the door 13 will take place at a relatively rapid rate.

However, as the piston rod 31 becomes further extended roller 33 acts upon arm member 24 at a progressively increasing distance from its pivotal support. And, in addition, the component of movement of the piston rod 31 acts at a progressively decreasing angle to the axis of the arm member 24. The combination of these above mentioned effects causes the closing movement of the door 13 to be rapidly decelerated from its initially fast movement so that a gentle closing movement is obtained which will neither cause damage to the thermocouple device 15 nor cause the billet 18 to be jarred away from the face of the door. And when the door 13 is in a fully closed position any opening forces exerted thereon act directly against the frame structure of the table 25 rather than through the cylinder. Thus the cylinder 30 may be of a relatively low power type as will be readily appreciated.

Opening of the door 13 after a heating operation is effected by retracting the piston rod 31, whereupon the door 13 is urged outwardly of the opening 12 by means of a suitable spring 35, for example. Or in some instances the door 13 and arm 24 may be so arranged that the weight of the door acts to effect opening movement

upon retraction of the rod 31. A suitable recess 36 is of course provided in the surface of table 25 so that the door 13 may be moved to a fully open position as shown in Figure 1.

The advantages of the invention should now be readily apparent. The apparatus is of ultimate simplicity and is easily and inexpensively constructed, yet provides a substantially improved arrangement for the purpose intended. With a conventional hydraulic actuator and other elementary components I have been able to effect a door closing movement which is rapid during the initial portion of the movement while being slow and gentle at the end of the movement. Thus, while the door 13 is slowly eased into closed position to prevent damage to the control devices carried on the door, the overall time of closing movement is maintained at a minimum so that rapid production rates may be obtained.

The invention is further advantageous in that the incorporation thereof into conventional induction heating apparatus requires an absolute minimum of additional apparatus. And in many instances the loading table or other service structure utilized in conjunction with the furnace may be readily modified to provide an inclined cam surface for translating the extending movement of cylinder 30 into the desired closing movement of the furnace door.

The invention is, of course, not restricted to the specific embodiment thereof herein illustrated. For example, in many instances it may be desirable to utilize means other than a door, as such, for retaining a billet within the coil 11.

Other possible modifications of the specific apparatus illustrated herein include arrangements wherein the initiating switch is eliminated and the functions thereof are carried out by suitable control means, not shown, acting in response to an electric circuit being completed upon contact of the thermocouple probes 15 and 16 with a billet 18. Thus, reference should be had to the following appended claims in determining the true scope of the invention.

I claim:

1. In an induction furnace of the type having induction coils and a work-retaining door adjacent said induction coils, and control means carried by the door and adapted to have contact with work contained in said furnace; the combination of means comprising an arm for pivotally mounting said door at a point substantially below said door, said arm being of relatively rigid construction and having an outer bearing surface, a hydraulic cylinder pivotally mounted adjacent said furnace and below said door, said cylinder having an elongated piston rod carrying a plurality of rollers at its upper end, one of said rollers being adapted to engage said bearing surface, means positioned adjacent said cylinder and on the opposite side thereof from said cylinder comprising an inclined bearing surface extending upwardly and inwardly toward said furnace, others of said plurality of rollers being adapted to engage said inclined bearing surface, the arrangement being such that upon extension of said piston rod said rollers move along said first mentioned and inclined bearing surface to impart an initially rapid but progressively decelerating closing pivotal movement to said door.

2. Apparatus according to claim 1 further characterized by said means comprising said inclined bearing surface including a bearing portion disposed in spaced substantially parallel relation to said arm when said door is in fully closed position, the space between said door and said last mentioned bearing portion being substantially equal to the diameter of said rollers whereby opening forces against said door are transmitted directly through said rollers to said last mentioned bearing portion.

3. Apparatus according to claim 1 further including a loading table for said furnace positioned adjacent the front face thereof, and further characterized by said in-

clined bearing surface comprising supporting means for said table.

4. In an induction furnace of the type having induction coils and a work-retaining door adjacent said induction coils, and control means carried by the door and adapted to have contact with work contained in said furnace; the combination of means comprising an arm for pivotally mounting said door at a point substantially below said door, said arm being of relatively rigid construction and having an outer bearing surface, a hydraulic cylinder pivotally mounted adjacent said furnace and below said door, said cylinder having an elongated piston rod carrying a plurality of rollers at its upper end, one of said rollers being adapted to engage said bearing surface, means positioned adjacent said cylinder and on the opposite side thereof from said furnace for engaging others of said plurality of rollers, said last mentioned means comprising a cam surface whereby upon extending movement of said piston rod said rollers will act upon said cam and bearing surfaces to move said door into a closed position.

5. Apparatus according to claim 4 further characterized by said cam surface comprising a portion disposed in spaced substantially parallel relation to said bearing surface when said door is in a closed position whereby opening forces on said door are transmitted directly through said rollers to said cam surface portion.

6. In an induction furnace of the type having induction coils and a work-retaining door adjacent said induction coils; the combination of means comprising an arm for pivotally mounting said door at a point substantially removed therefrom, said arm being of relatively rigid construction and having an outer bearing surface, a cam surface positioned adjacent said door in spaced relation thereto and comprising a bearing surface inclined toward said furnace from a point adjacent the point of pivotal mounting for said door to a point adjacent said door, means comprising a plurality of rollers and carrier means therefor for cooperatively engaging said bearing surfaces, and means to move said rollers along said inclined bearing surface.

7. In an induction furnace of the type having induction coils and a work-retaining door adjacent said induction coils; the combination of door operating means comprising an arm for pivotally mounting said work retaining door at a point substantially removed therefrom, said arm being of relatively rigid construction and having a bearing surface, means comprising a roller and carrier means therefor for engaging said bearing surface, means to move said rollers along said bearing surface, and means to confine movement of said rollers to a predetermined path whereby said arm is caused to pivot about said mounting to move said door into a closed position.

8. Apparatus according to claim 7 further characterized by said path of movement of said rollers when effecting a closing movement of said door leading progressively away from said pivotal mounting.

9. Apparatus according to claim 7 further characterized by said path being inclined toward said furnace in a direction from the point of pivotal mounting of said door to a point adjacent said door.

10. In an induction furnace of the type having induction coils and a work-retaining door adjacent said induction coils; the combination of means for pivotally mounting said work retaining door at a point substantially removed therefrom, door operating means comprising an arm rigidly attached to said door, said arm having a bearing surface, follower means adapted to engage said bearing surface, and means to move said follower means along a predetermined path leading progressively away from the point of pivotal mounting of said door whereby an initially rapid but progressively decelerating closing movement may be imparted to said door.

11. Apparatus according to claim 10 further characterized by said means to move comprising a hydraulic

actuator and means to mount said actuator adjacent said furnace.

12. Apparatus according to claim 11 further characterized by said follower means comprising a roller carried by said actuator, and said means to move said follower means along a predetermined path including a cam surface, a service structure for said furnace positioned adjacent the front face thereof, said cam surface comprising a portion of said service structure.

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