Jan. 13, 1942. W. L. WROBLEWSKI 2,269,838

SINTERING FURNACE

Filed March 29, 1941 3 Sheets-Sheet 1

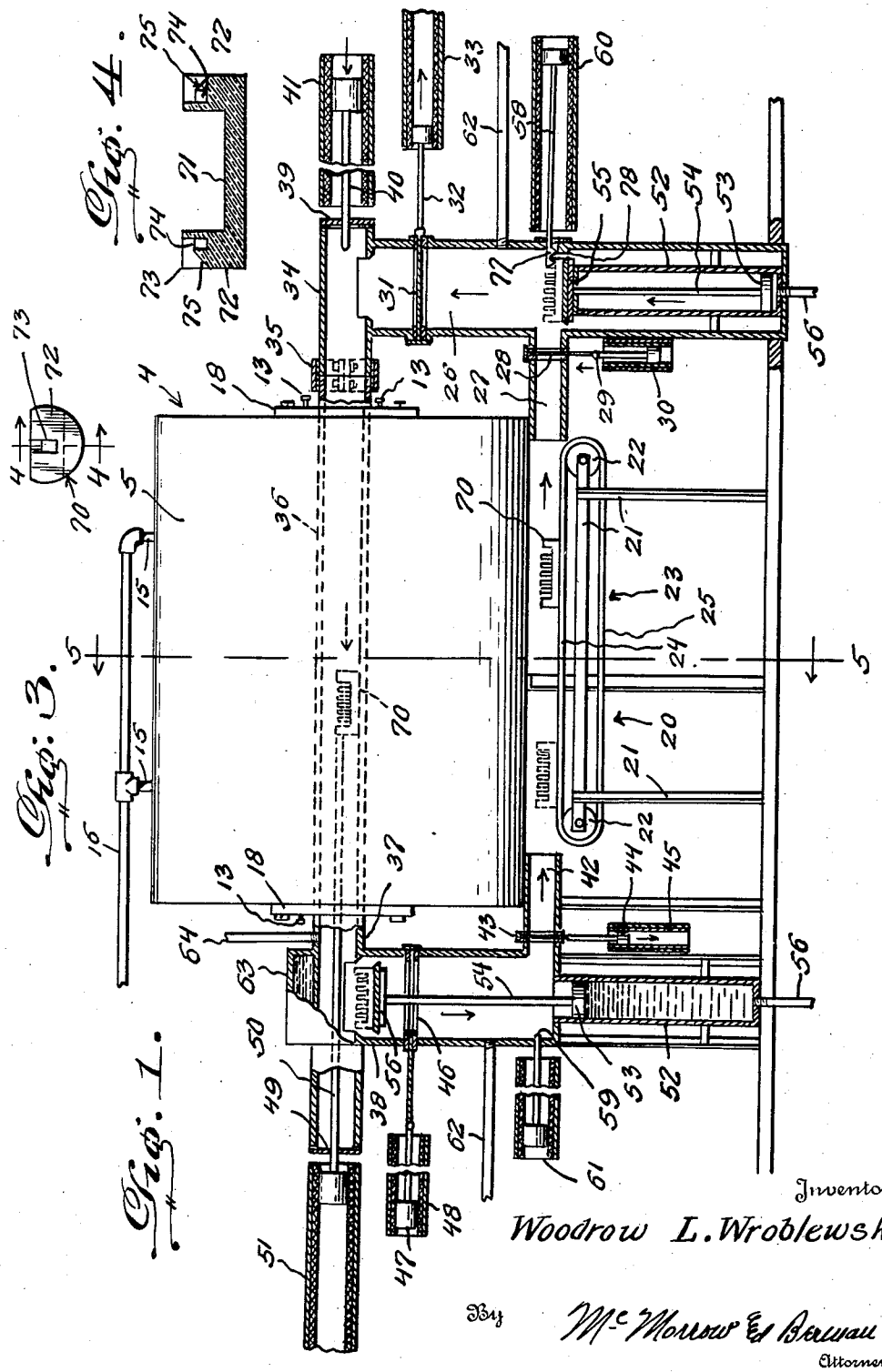

Fig. 4.

Fig. 3.

Fig. 1.

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Filed March 29, 1941 3 Sheets-Sheet 2

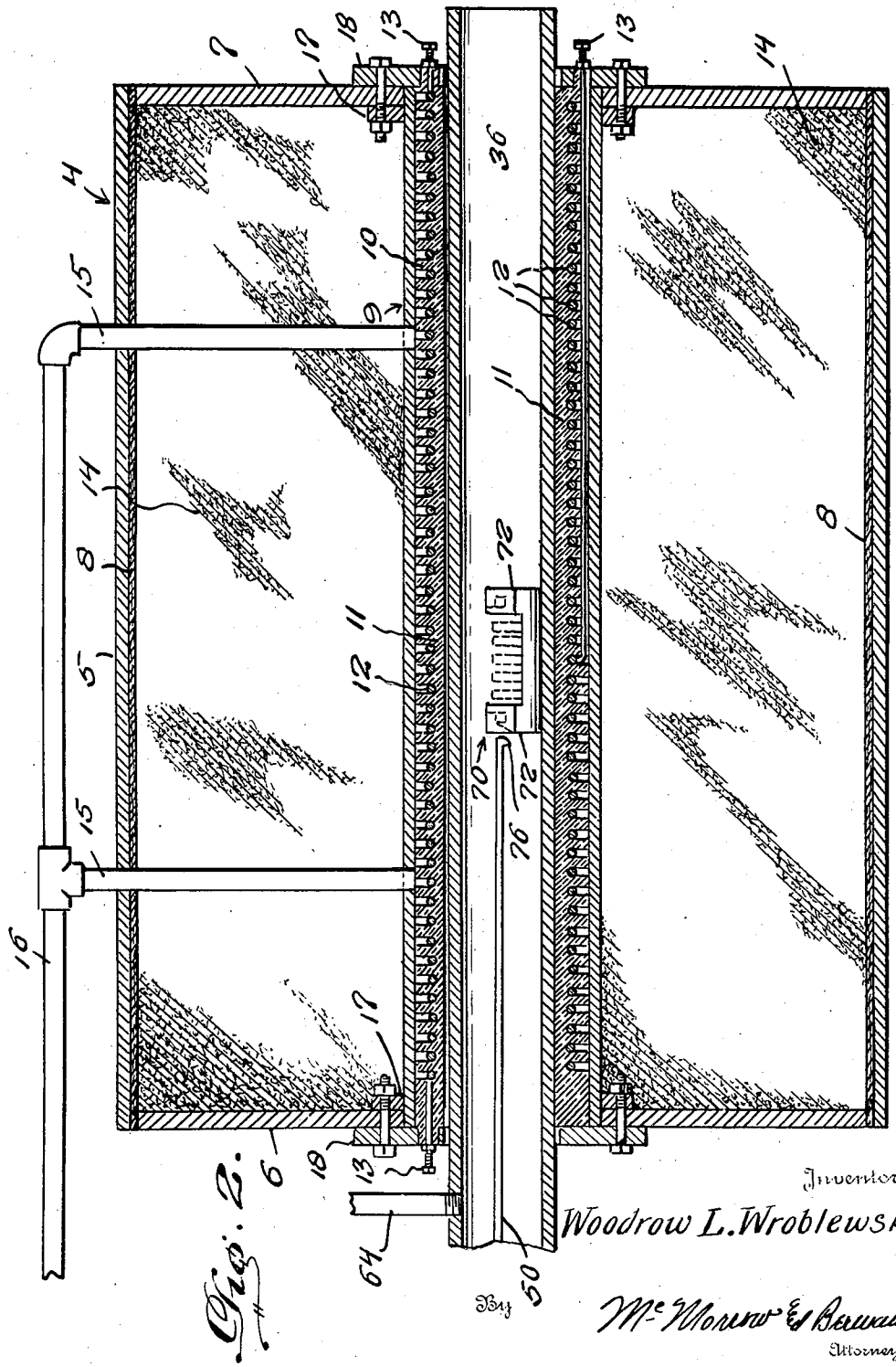

Fig. 2.

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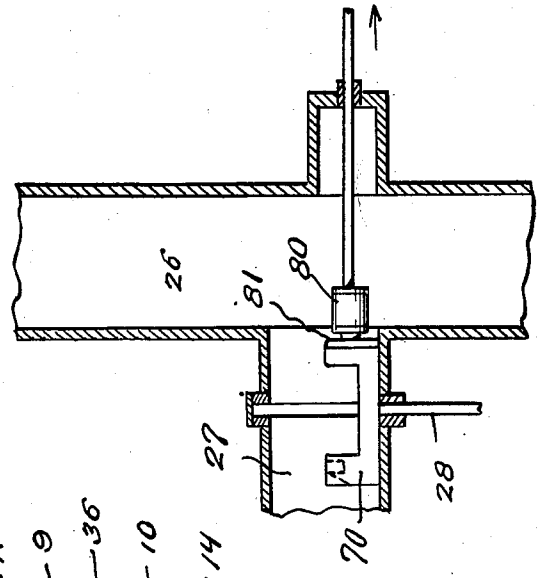
SINTERING FURNACE

Filed March 29, 1941 3 Sheets-Sheet 3

Fig. 6.



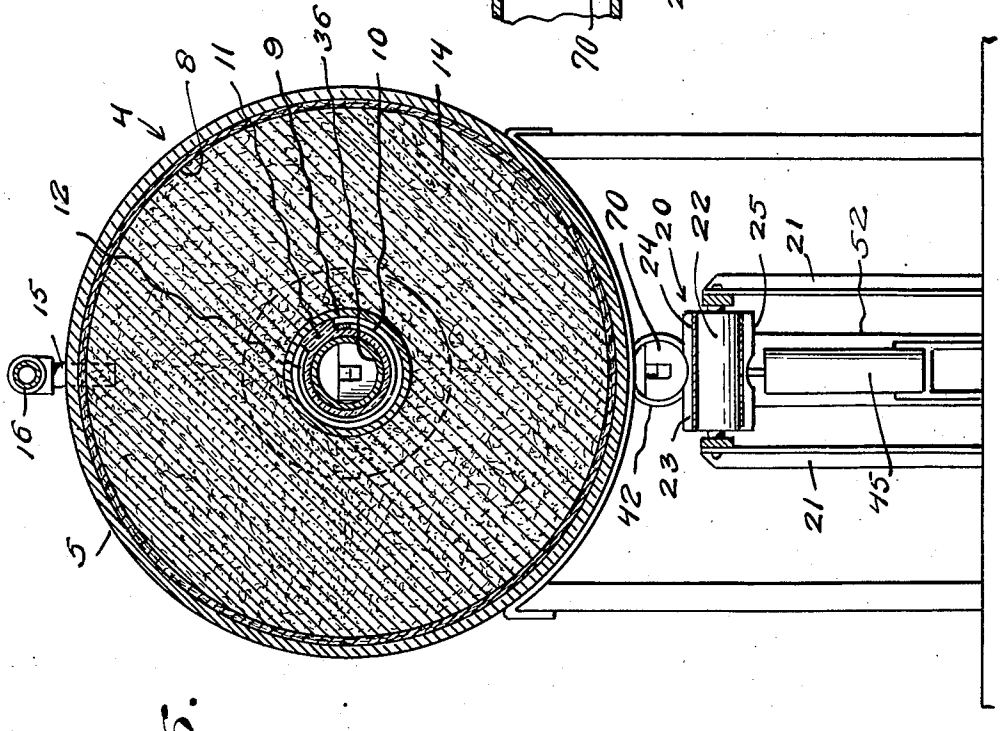


Fig. 5.

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2,269,838

UNITED STATES PATENT OFFICE

2,269,838

SINTERING FURNACE

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Application March 29, 1941, Serial No. 385,939

3 Claims. (Cl. 263—6)

My invention relates to heating apparatus and more particularly to sintering furnaces.

One of the principal objects of my invention is to provide a sintering furnace assembly so constructed and arranged whereby the products to be sintered, for instance, magnets and the like, are progressively subjected to treatment by the furnace assembly to effect quantity production.

An important object of my invention is to provide a sintering furnace assembly of the character described which is simple in construction, durable in use, efficient in operation and economical in manufacture.

With the above and other objects in view, as will hereinafter appear, the invention consists in the combination, and arrangement of parts hereinafter set forth and illustrated in the accompanying drawings, from which the several features of the invention and the advantages attained thereby will be readily understood by those skilled in the art.

Referring to the drawings wherein like reference characters designate like parts throughout the several views:

Figure 1 is a side elevation, partly in section, of my sintering furnace assembly.

Figure 2 is a vertical sectional view of the furnace.

Figure 3 is an end elevation of one of the boats.

Figure 4 is a sectional view taken on the line 4—4 of Figure 3.

Figure 5 is a sectional view taken on the line 5—5 of Figure 1.

Figure 6 is a side elevation of a modified form of means for removing the boats from the endless conveyor and positioning said boats on the elevating means.

As illustrated in the drawings, I provide a hydrogen furnace 4 comprising a cylindriform shell or wall 5 having secured within its ends a pair of end walls 6 and 7 respectively. The inner face of the wall 5 is equipped with asbestos material 8 constituting a seal. The end walls 6 and 7 are formed with central apertures in which are disposed the ends of a metallic casing 9 surrounding a tubular heating unit 10 extending axially through the shell. The heating unit 10 comprises an elongated hollow cylindriform body 11 of refractory material and which is formed on its periphery with a spiral groove in which is mounted an electric heating coil 12, the ends of said coil extending outwardly through opposite ends of the body and are equipped with electric terminal connections 13 adapted to be connected to a source of electrical energy (not shown) for operating the unit.

The furnace contains aluminium oxide powder 14 (Al_2O_3) which is disposed about the casing 9, the latter serving to preclude contact of the powder with the heating unit 10 and to maintain the same within the furnace. Extending through the powder, the top of the wall 5 and the casing 9, are a pair of pipes 15 connected to a hydrogen supply pipe 16 whereby the interior of the casing 9 about the unit 10 is supplied with hydrogen (H_2) when the furnace is in a cool or cold condition. The inner faces of the end walls, adjacent the apertures, have welded thereto flanges 17, while the outer faces have secured thereto collars 18, the latter having their inner margins maintaining the ends of the heating unit 10 within the casing 9.

Subjacent the furnace 4, the assembly is provided with an endless conveyor 20, the latter comprising a supporting frame 21 having upper horizontally extending end portions on which are rotatably mounted rollers 22 over which are trained an endless belt 23 having upper and lower horizontal runs 24 and 25 respectively. Adjacent the end wall 7 of the furnace, the assembly is provided with a vertically disposed conduit 26, the latter formed on one side, interjacent its upper and lower ends, with a lower horizontal inlet branch 27 having its outer open end terminating adjacent the conveyor 20. The branch 27 is provided, interjacent its ends, with a vertically sliding gate valve 28, the latter being connected to the plunger 29 of a solenoid 30 whereby said valve 28 is operated to open and closed positions as hereinafter set forth.

The conduit 26, subjacent its upper end and superjacent the branch 27, is provided with a horizontally sliding gate valve 31 of a similar construction as the valve 28 and said valve 31 is connected to the plunger 32 of a solenoid 33 whereby said valve is operated to open and closed positions as hereinafter set forth. The upper end of the conduit 26 is provided with an upper horizontal outlet branch 34 having an open end connected by means of a coupling 35 to the inlet end of a tube 36 extending through said heating unit 10, the opposite end of said tube 36 being connected to an upper horizontal branch 37 provided on the upper end of a vertical conduit 38 disposed adjacent the wall 6 and of a similar construction as the conduit 26. The opposite end of the branch 34 is closed by a wall 39 which has slidably extending therethrough one end of the plunger

rod 40 of a solenoid 41 for a purpose hereinafter described.

As in the instance of the conduit 26, the conduit 38 is formed on one side, interjacent its upper and lower ends, with a lower horizontal branch 42 having its open end terminating adjacent the opposite end of the conveyor 20. The branch 42 is provided, interjacent its ends, with a vertically sliding gate valve 43 connected to the plunger 44 of a solenoid 45, while the conduit 38, between the branches 37 and 42 is provided with a horizontally sliding gate valve 46 connected to the plunger 47 of a solenoid 48, said solenoids 45 and 48 serving to operate their respective valves to open and closed positions as hereinafter set forth. The opposite end of the branch 37 is closed by a wall 49 which has slidably extending therethrough the plunger rod 50 of a solenoid 51 for a purpose hereinafter described.

The conduits 26 and 38 are equipped, subjacent their lower branches 27 and 42 respectively, with hydraulic cylinders 52 in which are reciprocally mounted pistons 53 having connected thereto the lower ends of piston rods 54, the upper ends of said piston rods being connected to platforms 55 and 56 disposed in the conduits 26 and 38 respectively whereby to raise and lower said platforms into discharging and receiving positions with respect to the upper and lower horizontal branches of the conduits for a purpose hereinafter set forth. The cylinders 52, subjacent the pistons 53, have connected thereto pipes 56 whereby fluid may be introduced into and discharged from the cylinders to effect raising and lowering of the pistons.

The walls of the conduits 26 and 38, oppositely disposed from the lower horizontal branches, have slidably extending therethrough the outer ends of piston rods 58 and 59 of solenoids 60 and 61 respectively. Each of said conduits have communicating therewith between their gate valves, hydrogen supply pipes 62 whereby to supply the conduits with hydrogen, it being understood that the gate valves constitute locks and said conduits between their gate valves constitute hydrogen chambers. The branch 37 of the conduit 38 is formed about its upper portion with a reservoir 63 containing liquid for cooling the branch and products introduced therein, said branch constituting a cooling chamber for cooling products introduced therein as hereinafter set forth. The branch 37, adjacent the tube 36, has connected thereto a hydrogen supply pipe 64 coacting with the pipe 62 to maintain a supply of hydrogen within the tube 36, it being understood that it is desirable, in order to effect proper sintering of the products by the furnace, that the tube 36 be supplied with hydrogen at all times.

In order that products, for instance, magnets and the like, may be continuously and progressively moved through the tube 36 for sintering, I provide a plurality of carriers or boats 70 and inasmuch as the boats are of identical constructions, a detailed description of one will suffice, it being understood that the reference characters indicative of parts of one boat are indicative of like parts of the other boats. Each boat 70 is constructed of refractory material and formed with bottom and end walls 71 and 72 respectively. The outer end faces of the end walls 72 are provided with recesses 73 and formed with detents 74 extending upwardly between the sides defining said recesses and terminating an appreciable distance subjacent the upper ends of said walls 72. The outer end faces of the detents 74 incline upwardly and inwardly to provide cam surfaces 75 for engagement with depending hook-like portions 76 formed on the outer ends of the rods 50 and 58 of the solenoids 51 and 60 respectively for a purpose hereinafter made apparent.

The outer end of the rod 58, adjacent the hook-like portion 76, is formed with a depending lip 77 having an inclined face for engagement with a projection 78 carried on the adjacent face of the wall of the conduit 26 whereby to effect raising of the hook-like portion 76 to disengage the same from the detent 74 when said rod is actuated to retracted position within the solenoid 60 for a purpose hereinafter made apparent. The bottom wall 71 of each boat is provided with a convex lower face having a contour similar to the contour of the tube 36, it being understood that the faces of the upper and lower branches of the conduit the platforms and conveyor runs on which the boats are moved are of a similar contour as that of the tube 36.

In operation the parts being in the positions illustrated in Figure 1, a boat is deposited on the run 24 of the conveyor 20 and moved by said conveyor into the branch 27. As the boat is moved into the branch 27, the solenoid 30 is operated to actuate the valve 28 to open position while, at substantially the same time, the solenoid 60 is operated to actuate its rod 58 to projected position within the branch 27 and effect locking engagement of the portion 76 with the detent 74 of the boat, whereupon, said rod 58 is operated towards retracted position thereby moving the boat onto the platform 55 and disengaging the portion 76 with the detent 74 through the medium of the lip 77 and projection 78. When the boat is thus disposed onto the platform 55, the piston 53 connected to the platform 55 is operated upwardly to position the boat within the upper branch 34 of the conduit 26 it being understood that when the boat is moved upon the platform 55, the valve 28 is actuated to closed position by the solenoid 30 and the valve 31 to open position by the solenoid 33. When the boat has been positioned with the branch 34, the rod 40 is reciprocated by the solenoid 41 and thereby engages and moves the boat into the tube 36 and centrally within the furnace 5 as illustrated in dotted lines in Figure 1. Upon movement of the boat into the tube 36, the platform 55 is actuated to its lower position by means of its piston 53 while the valve 31 is closed by the solenoid 33. When the products or magnets contained on the boat have been sufficiently treated by the furnace, the solenoid 51 is operated to actuate its rod 50 to projected position to effect engagement of the portion 76 with the detent 74 of the boat whereupon said rod is actuated by the solenoid 51 towards retracted position to move the boat into the branch 37 and onto the platform 56 and thus subject the products to the cooling influences of the liquid contained into the reservoir 63. When the boat is disposed on the platform 56, the latter is lowered by discharging the liquid from within the subjacent cylinder 52 thereby positioning the boat adjacent the inner end of the lower branch 42. When the boat is thus positioned, the valve 46 is actuated to closed position and the valve 43 to open position by their respective solenoids. When the valve 43 is actuated to open position, the solenoid 31 is operated to reciprocate its rod 59 and thus engage and move the boat out of the branch 42 onto the conveyor 20 for removal therefrom.

By continuously depositing boats upon the conveyor **20**, and operating the parts in the foregoing described manner, it will be apparent that a plurality of the boats containing their products may be continuously and progressively operated through the foregoing described cycle of operation thus contributing to quantity production. It is to be understood that the various solenoids and pistons are to be operated in a predetermined timed relation and in a manner whereby the valves serve to maintain sufficient hydrogen within the tube **36**.

As illustrated in Figure 6 of the drawings, the outer end of the rod **58** of the solenoid **60** may be equipped with a magnet **80** in lieu of its portion **76** and the boats provided with metallic end plate **81** for engagement with the magnet whereby when said magnet is energized and the rod **58** operated to retracted position the boat will be moved onto the platform **55** and released from the rod **58** when the magnet is deenergized. Similarly, if desired, the outer end of the rod **50** of the solenoid **51** may be constructed in the same manner.

While I have disclosed the valves **28, 31, 43** and **46** and the boats **70** as being operated or moved by solenoids, it is to be understood that other operating means may be substituted in lieu thereof, for instance, hydraulic cylinder and piston assemblies. Furthermore, it is to be understood that should a process of sintering pressed material require hydrogen circulation, the hydrogen may be introduced, under a desired circulating pressure, into the tube **36** through the pipe **64** and be discharged from said tube at its opposite end into a dehydrator to remove water vapor from the hydrogen whereupon said hydrogen may be conveyed, under pressure, to the pipe **64** for recirculation through the tube. It will be apparent that when hydrogen is so circulated and thus utilized economy in operation is effected. If desired, the hydrogen may be introduced into one end of the heater unit and circulated through the spiral groove in which the heating element is disposed. When hydrogen is thus circulated it may be burnt at the other end of the unit or conveyed to a cooling coil, purified and recirculated thereby reducing hydrogen loss to a minimum.

From the foregoing, it will be apparent that my invention not only lends itself to quantity production in the sintering of products but also comprehends many advantages and desirable features not obtainable in other sintering apparatus, for instance, (*a*) simplicity of construction and a minimum of operating parts; (*b*) the employment of air locked chambers to preclude overheating of material and resultant oxidation; (*c*) the maintaining of a hydrogen pressure, above atmospheric pressure, in the furnace tube **10** in a manner to preclude air leaking therein through the medium of the air locks; (*d*) of continuously and progressively introducing moving the boats through the furnace from an endless conveyor; (*e*) replacement of the tube **36** by merely disconnecting the coupling **35** and withdrawing the tube axially out of the heating unit; (*f*) automatically moving the material from the heating tube **36** into a cooling chamber; (*g*) and utilizing a substantially cylindrical heating tube whereby maximum strength is maintained at high temperatures.

Without further elaboration the foregoing will so fully explain the invention that others may, by applying current knowledge, readily adapt the same for use under various conditions of service. Moreover, it is not indispensable that all the features of the invention be used conjointly since they may be employed advantageously in various combinations and sub-combinations.

It is obvious that the invention is not confined to the herein described use therefor as it may be utilized for any purpose to which it is adaptable. It is therefore to be understood that the invention is not limited to the specific construction as illustrated and described as the same is only illustrative of the principles of operation, which are capable of extended application in various forms, and that the invention comprehends all construction within the scope of the claims.

What I claim is:

1. In an apparatus of the character described, a pair of conduits arranged at opposite ends of a furnace and including vertical portions, upper and lower horizontal portions and having the lower horizonal portions arranged in a plane below the furnace and having the upper horizontal portions connected to said furnace for guiding article carrying boats into and out of said furnace, an endless conveyor operating between said lower horizontal portions of the conduits to receive boats from one of said lower horizontal portions and to deliver boats to the other lower horizontal portion, means for moving the boats in the horizontal portion of one of said conduits from its vertical portion to the conveyor, means for moving boats from said conveyor through the lower horizontal portion of the other conduit to the vertical portion thereof, means for moving the boats through the vertical portions of the conduits, means for moving the boats from the upper horizonal portion of one of the conduits into the furnace, means for moving boats from the furnace into the upper horizontal portion of the other conduit.

2. In an apparatus of the character described, a pair of conduits arranged at opposite ends of a furnace and including vertical portions, upper and lower horizontal portions and having the lower horizontal portions arranged in a plane below the furnace and having the upper horizontal portions connected to said furnace for guiding article carrying boats into and out of said furnace, an endless conveyor operating between said lower horizontal portions of the conduits to receive boats from one of said lower horizontal portions and to deliver boats to the other lower horizontal portion, means for moving the boats in the horizontal portion of one of said conduits from its vertical portion to the conveyor, means for moving boats from said conveyor through the lower horizontal portion of the other conduit to the vertical portion thereof, means for moving the boats through the vertical portions of the conduits, means for moving the boats from the upper horizontal portion of one of the conduits into the furnace, means for moving boats from the furnace into the upper horizontal portion of the other conduit, means for cooling the upper horizontal portion of one of the conduits for cooling articles of the boats while in said latter-named horizontal portion and after leaving the furnace, and means for introducing hydrogen into said last-named horizontal portion.

3. In an apparatus of the character described, a pair of conduits arranged at opposite ends of a furnace and including vertical portions, upper

and lower horizontal portions and having the lower horizontal portions arranged in a plane below the furnace and having the upper horizontal portions connected to said furnace for guiding article carrying boats into and out of said furnace, an endless conveyor operating between said lower horizontal portions of the conduits to receive boats from one of said lower horizontal portions and to deliver boats to the other lower horizontal portion, means for moving the boats in the horizontal portion of one of said conduits from its vertical portion to the conveyor, means for moving the boats from said conveyor through the lower horizontal portion of the other conduit to the vertical portion thereof, means for moving the boats through the vertical portions of the conduits, means for moving the boats from the upper horizontal portion of one of the conduits into the furnace, means for moving boats from the furnace into the upper horizontal portion of the other conduit, means for cooling the upper horizontal portion of one of the conduits for cooling articles of the boats while in said latter-named horizontal portion and after leaving the furnace, means for introducing hydrogen into said last-named horizontal portion, gates controlling the lower horizontal portions and the vertical portions of the conduits, means for operating the gates to permit the boats to pass through said conduits, and means for admitting hydrogen into the conduits between said gates.

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