Sept. 30, 1930. D. L. SUMMEY 1,776,823

HEATING APPARATUS

Filed May 31, 1923 7 Sheets-Sheet 1

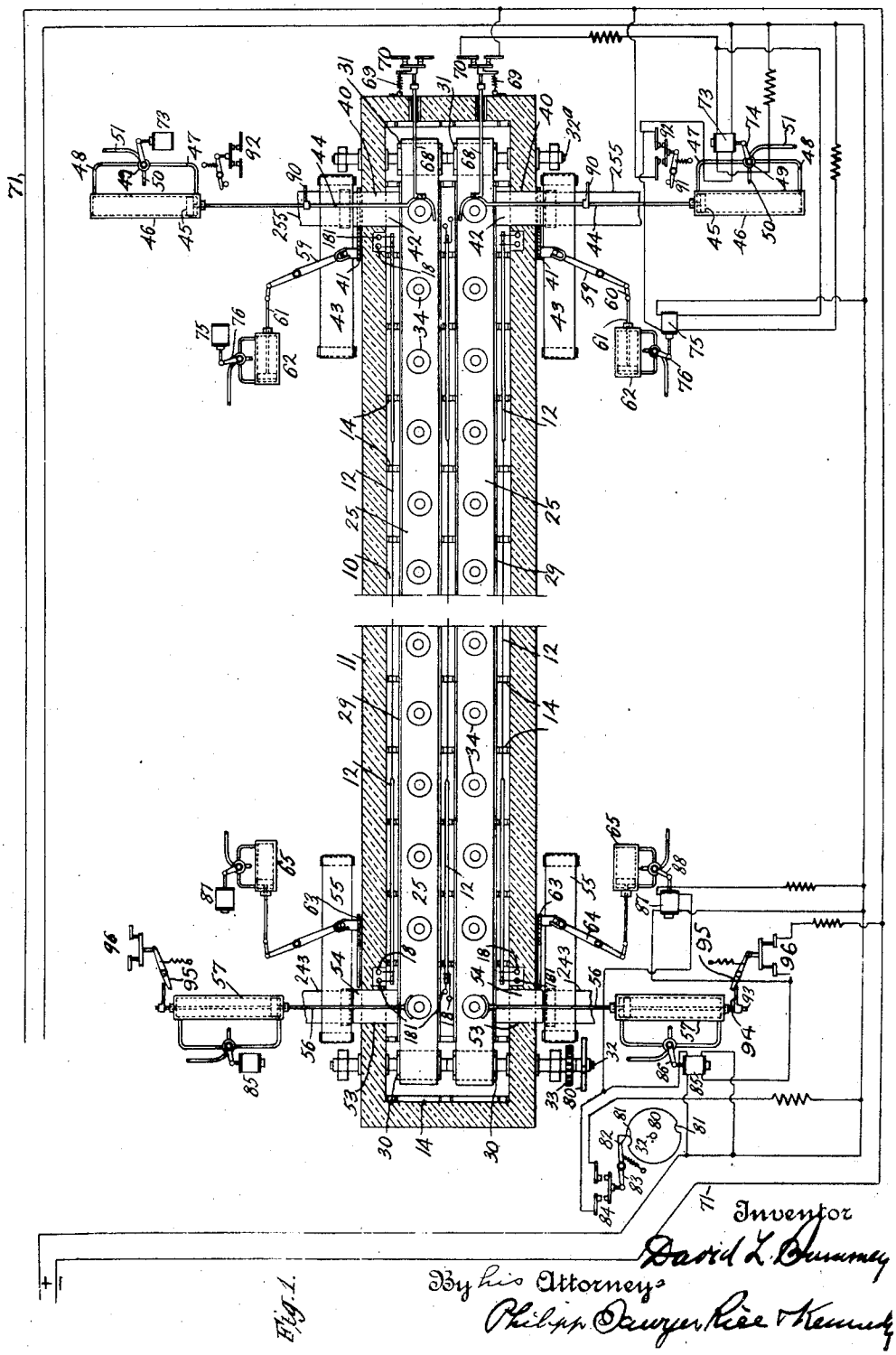


Fig. 1.

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HEATING APPARATUS

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Fig. 2.

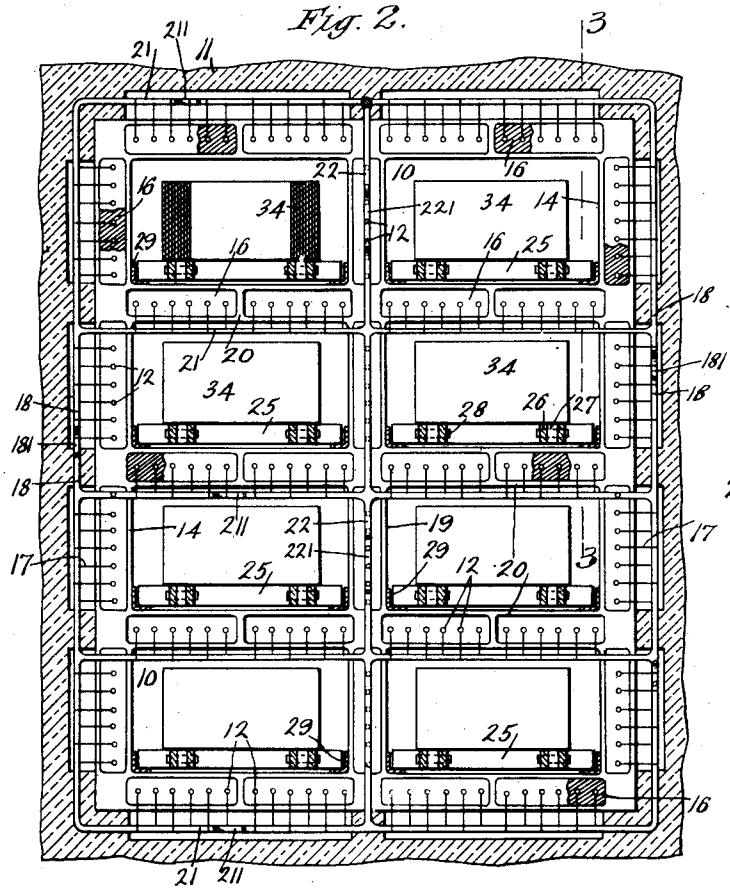


Fig. 3.

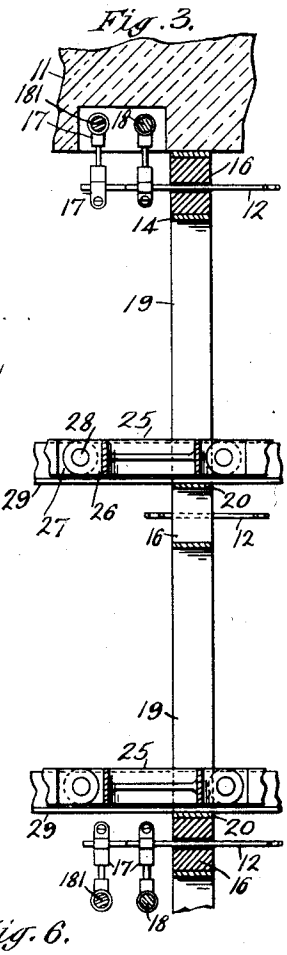


Fig. 7.

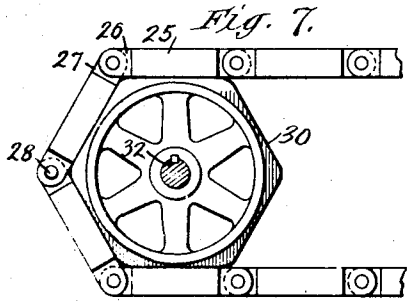


Fig. 6.

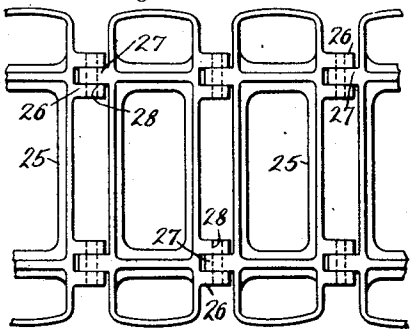
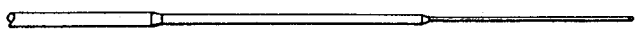


Fig. 4



Fig. 5.



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HEATING APPARATUS

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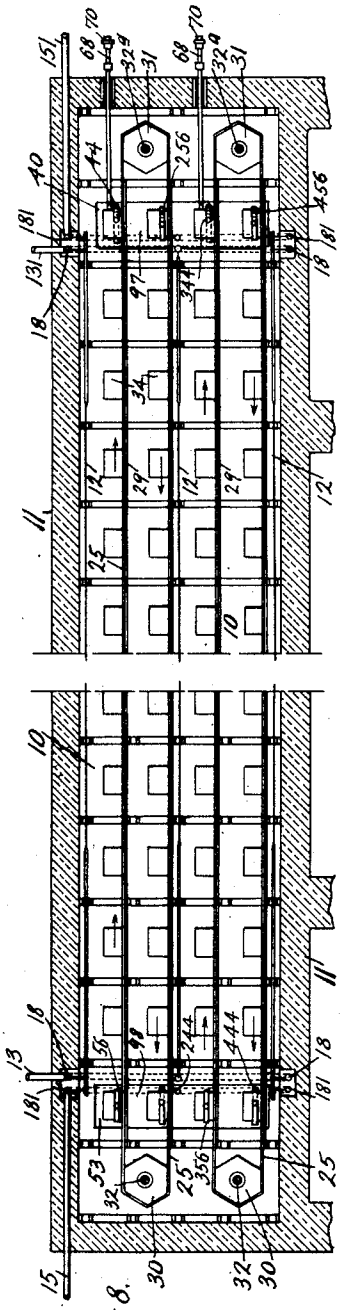


Fig. 8.

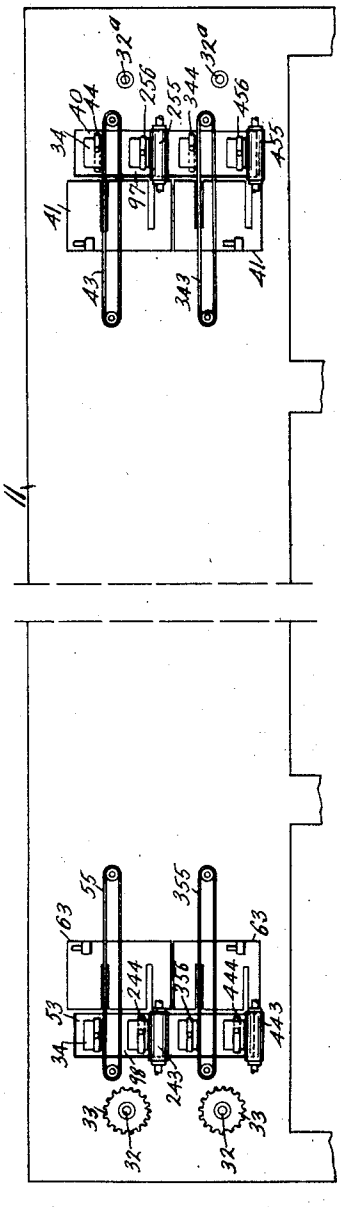


Fig. 9.

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HEATING APPARATUS

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Fig. 10.

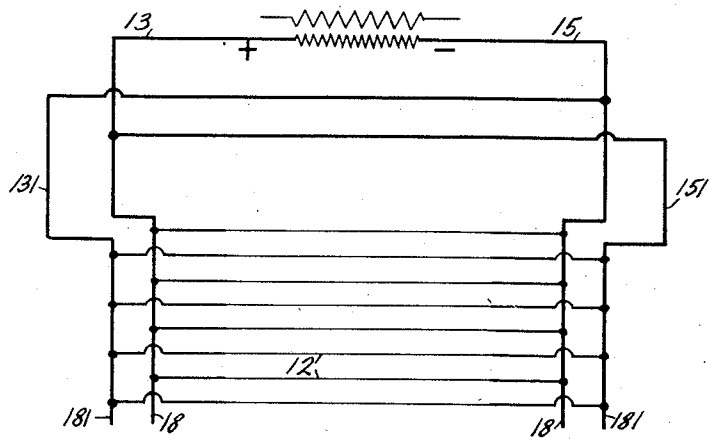


Fig. 11.

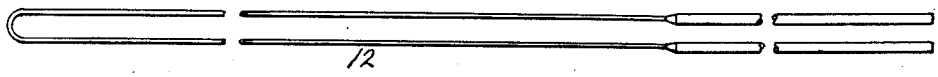
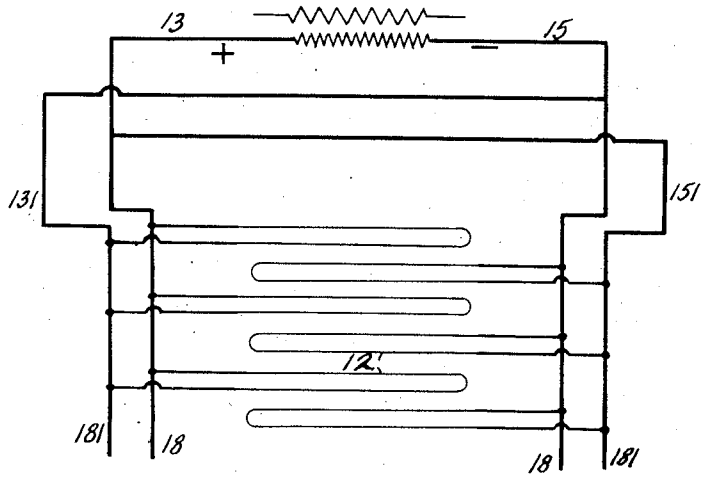


Fig. 12.



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HEATING APPARATUS

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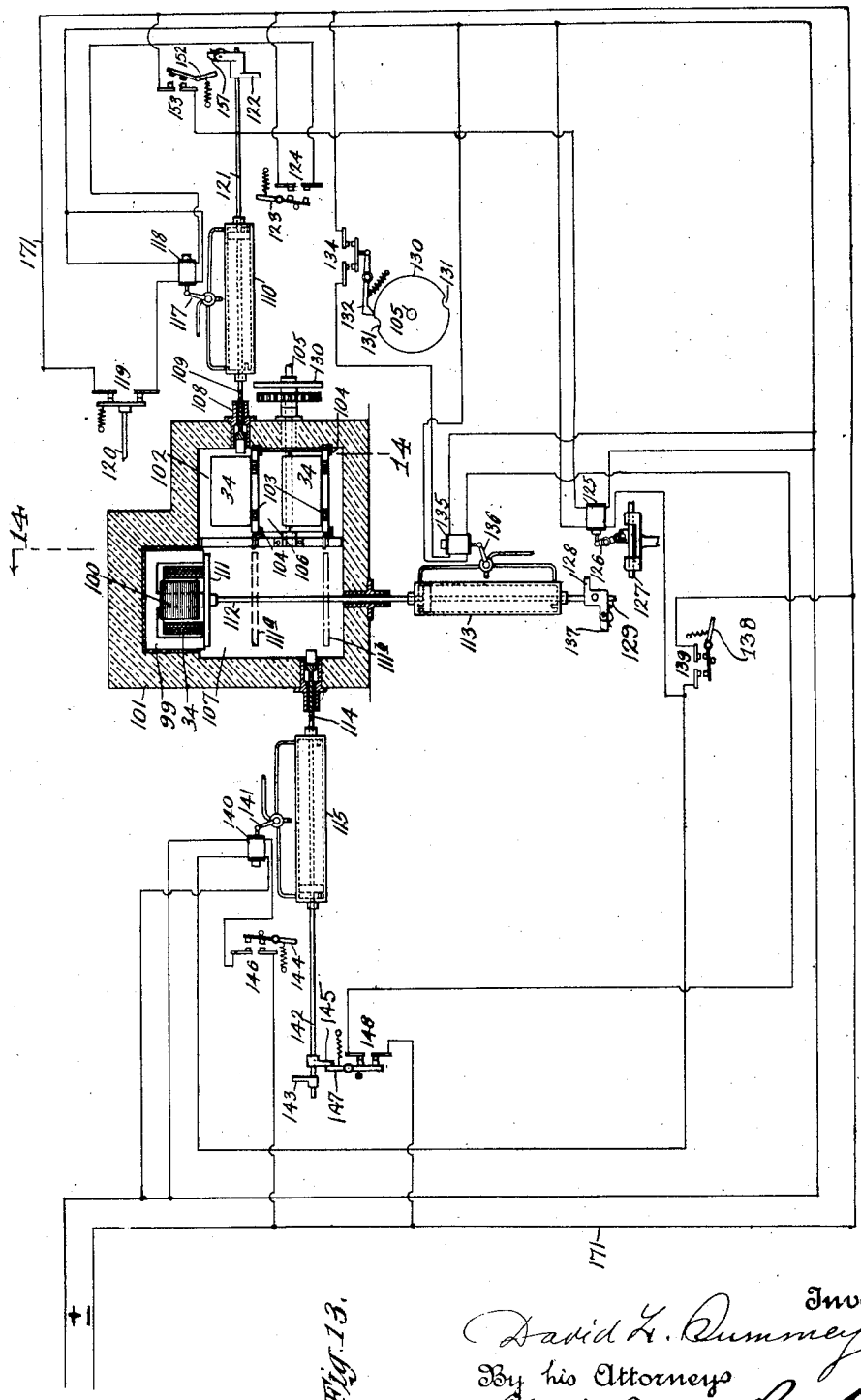


Fig. 13.

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HEATING APPARATUS

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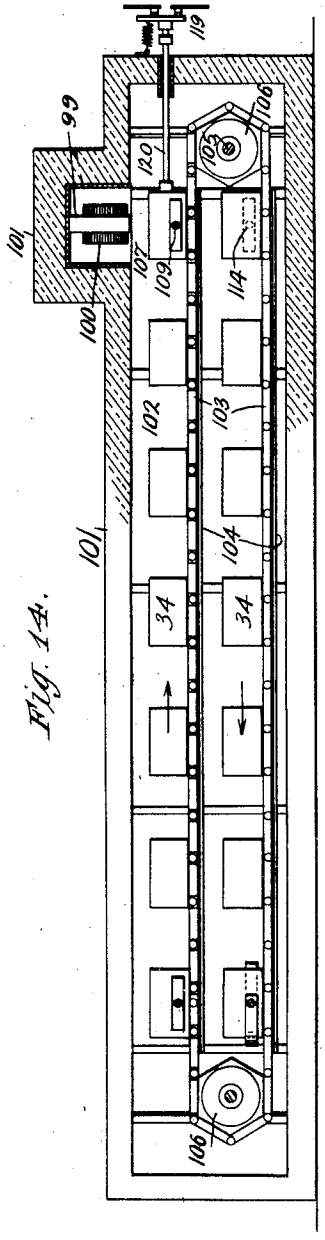


Fig. 14.

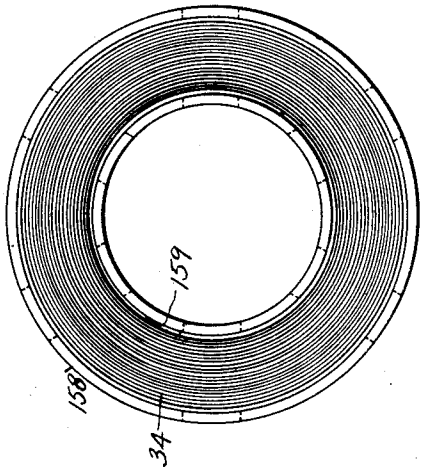


Fig. 16.

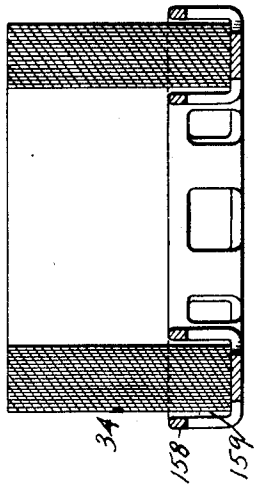


Fig. 15.

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HEATING APPARATUS

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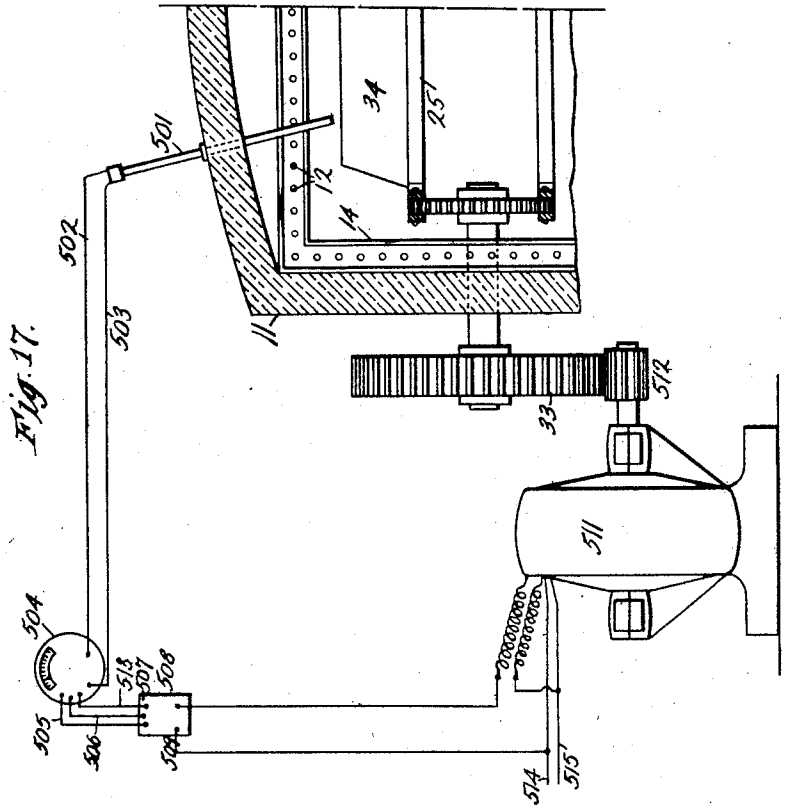


Fig. 17.

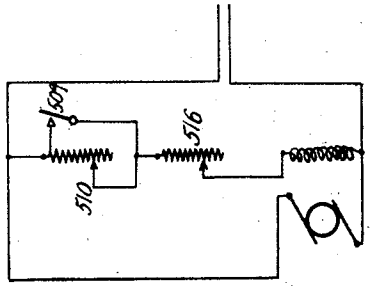


Fig. 18.

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UNITED STATES PATENT OFFICE

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HEATING APPARATUS

Application filed May 31, 1923. Serial No. 642,411.

This invention relates to heating apparatus and more particularly to annealing furnaces.

It is one of the principal objects of the invention to provide an efficient electric heating furnace that is economical as to the consumption of electric current for heating the furnace and the material placed therein.

It is a further object of the invention to provide a heating apparatus capable of a large output, that requires a minimum of manual labor.

It is still a further object of the invention to provide an efficient heating apparatus utilizing electric resistance heating elements in which the heating elements may be removed and replaced without any material tearing down of the furnace.

With these general objects in view, the invention consists in the features, combinations, details of construction and arrangement of parts which will first be described in connection with the accompanying drawings and then more particularly pointed out.

In the drawings—

Fig. 1 is a view, partly in longitudinal section and partly diagrammatic of a heating apparatus constructed in accordance with the invention;

Fig. 2 is a vertical transverse sectional view through the heating chamber;

Fig. 3 is an enlarged cross-sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is a plan view of a resistance wire removed, with part broken away;

Fig. 5 is a similar view of a modified form of resistance wire;

Fig. 6 is a detail view showing part of a conveyor chain in plan;

Fig. 7 is a detail view showing part of a conveyor and its pulley in side elevation;

Fig. 8 is a longitudinal vertical sectional view of the heating chamber;

Fig. 9 is a view of the same in side elevation;

Fig. 10 is a schematic view showing the alternate arrangements of the wire connections;

Fig. 11 is a plan view of a hair pin form of wire;

Fig. 12 is a schematic view showing the connections and arrangements of the hair pin wires;

Fig. 13 is a view, partly in vertical transverse section and partly diagrammatic of a modified form of apparatus in which the coils are heated inductively;

Fig. 14 is a view of the same partly in longitudinal vertical section;

Figs. 15 and 16 are views in vertical section and plan of a coil of material and a binder;

Fig. 17 is a diagrammatic view showing a pyrometer control; and

Fig. 18 is a wiring diagram for the same.

Referring to the drawings, the apparatus illustrated as an example in Figs. 1–10 comprising a long furnace chamber 10 enclosed by a housing 11 of brick and fire brick or other suitable material.

There is provided heat supplying means, such, for example, as electric resistance elements, and in structures embodying the invention to the best advantage these elements are arranged to supply heating zones of varying degree. Although capable of various constructions, in the embodiment illustrated, supported and distributed as hereinafter described, are a plurality of long, straight nickel-chromium wires 12 running lengthwise of the furnace and extending almost the entire length of the enclosed chamber 10. In order to provide zones of varying degrees of heat, for a purpose later referred to, the individual wires 12 have a varying cross-section. In the particular embodiment illustrated each wire is formed with a small or high resistance cross-section at its central portion and a large or low resistance cross-section at its ends. With this construction the heating effect of the wires at the ends of the chamber is substantially immaterial and at the central part of the chamber it is relatively high, the length of the hot zone being determined by the length of the small cross-section portion of the wire. It will be understood that the extent of the various cross-sections may be varied as desired and that while the wires shown are all alike as to cross-sectional arrangement, the various wires may differ in this respect. Further, by stepping

down the cross-section, the heating effect can be gradually increased and decreased. Such a stepped cross-section is shown in Fig. 5.

Means is provided for supporting the resistance wires, and in structures embodying the invention to the best advantage, the supporting means is such as to permit the heating units to be individually removable for repair and the like, without any material tearing down of the furnace. Although capable of various constructions, in the embodiment illustrated, set at spaced intervals along the chamber 10, are a plurality of transverse supporting frames 14, which are seated in the chamber walls. These frames are of skeleton construction and carried thereby are perforate blocks 16 of insulating material, such as tile. The perforations of the similarly located blocks of the several frames are lined up lengthwise of the chamber so that the resistance wires 12 may be threaded through them in a straight line. The frames themselves are made of a material capable of withstanding continued high temperatures without structural deformation and without oxidizing. For this purpose, nickel-chromium and similar alloys have been found suitable. That is, the frames may be made of a metal having substantially the same heat resisting characteristics as the metal of the wires.

The wires 12 terminate just beyond the final frame at each end of the chamber and the ends are connected in circuit. To neutralize the fields created by the current in wires 12, thus avoiding inductive effects, in the embodiment shown, alternate wires are connected at one end, to one bus bar and the other wires are connected to a second bus bar, the direction of flow being reversed in the two sets. As shown in Figs. 2 and 3 the ends of one set of wires are connected by detachable clamps 17 with bus bars 18 carried by the housing walls and running around the four sides thereof. The ends of the alternate wires are connected by detachable clamps 17 with bus bars 181 similar to bus bars 18 and arranged alongside the latter. The clamps 17 are shown diagrammatically only in Fig. 2, the full constructions being shown in Fig. 3. The bus bars 18 and 181 are connected to main leads 13, 15 and 131, 151, in such manner that the plus ends of the wires of one set are at the same end of the furnace as the minus ends of the wires of the other set. Fig. 10 illustrates the circuit scheme for the wires and bus bars.

While round wires and round holes in the insulators have been shown, it is to be understood that other cross-sectional shapes may be used, such, for example, as ribbon or triangular shapes.

There is provided conveyor means for moving the material to be heated through the furnace chamber. In structures embodying the invention to the best advantage, the conveyor means comprises an endless chain, and where the type of material permits, the conveyor is arranged to carry material on both strands. While capable of various constructions, in that here shown as an example, which is particularly adapted for heating large coils of metal, such, for example, as brass, the chain is made up of flat, skeleton links 25 which are functionally reversible. That is, coils may be carried on either face of the chain. Each link has, at one side, two double lugs 26 and at the other side, two single lugs 27. The links being assembled, they are connected up into a chain by pins 28 passing through suitable holes in lugs 26, 27. The chain runs over pulleys 30, 31 on shafts 32. 32^a and shaft 32 carries, outside the chamber, a gear wheel 33 to which power for driving the chain may be applied in any suitable manner.

As in the case of the frames 14, the chain links and pins in the present embodiment, are made of nickel chromium alloy. The pulleys and shafts being in the relatively cool zones may be made of ordinary steel.

While one conveyor chain only may be used, in the embodiment illustrated four chains are provided, arranged in nested relation. That is, there are two bottom chains side by side, and two top chains above them. The several conveyor elements are duplications in the present constructions. With four conveyor elements in nested relation, a large conveyor capacity is obtained with a relatively small housing and there is marked economy in heating, as the loss of heat by radiation per unit conveyor is relatively small.

In order to provide effective and economical heating, provision is made whereby each strand of each conveyor is surrounded by resistance elements. To this end, as here shown as an example, the supporting frames 14 have central legs 19 and three cross bars 20, skeleton in form and carrying perforate insulating blocks 16. Through these blocks are threaded additional resistance wires 12 like those already described. As appears in Fig. 2, the wires supported by the cross bars of the frames are alternately connected by clamps 17 with cross bus bar extensions 21 and 211, connected respectively with the bus bars 18 and 181. The wires supported by the vertical legs of the frames are similarly connected with vertical bus bar extensions 22 and 221 also connected to bus bars 18 and 181.

With the construction described, the connections to the bus bars, the bus bars themselves and the take out leads to the supply circuit are all located in the relatively cool zones of the furnace and loss of heat through the wires, buses and passages is avoided. In this connection, it is noted that the walls of the housing at the hot zone have no openings or passages.

While the wires are shown as all connected in a single supply circuit, it will be understood that they may be grouped for a number of transformers, which also makes possible a heat control by voltage regulation.

The cross bars 20 of the frames 14 also serve as support for rails or angle pieces 29 which serve as tracks on which the conveyor chains run and which are suitably made of the same metal as the chains, e. g. nickel-chromium alloy.

If desired, the frames 14 may be grouped in two sets, alternate frames serving only to support the rails 29, the other frames serving only to carry the insulating blocks 16. That is, in the construction referred to, the frames which support the chains do not support the wires and the wire supporting frames do not support the rails, and chains. With such a construction, vibration of the insulating blocks is avoided and there is little or no danger of current leakages.

With the construction above described, coils of material to be heated, indicated at 34, being loaded and unloaded as later described, are carried in one direction on the top strand of each chain and in the opposite direction on the bottom strand of each chain. Thus there are eight rows of conveyed material moving through the furnace chamber, four in one direction and four in the opposite direction. As appears more clearly in Fig. 2, each row of moving material, i. e., each strand of each chain, is surrounded by resistance heating wires. Considering any one conveyor as an example, as the coils on the top strand leave the central hot zone of the furnace chamber, they meet the oppositely moving cold coils on the bottom strand in the relatively cool end zone. The heat given off from the hot coils gives the cold coils a preheating and thus an economy in heat supply is effected. The same preheating takes place at the other end of the furnace chamber, the incoming cold coils on the top strand being preheated by the outgoing hot coils on the bottom strand.

Electricity as a heating medium gives the advantage, among others, of an accurate and uniform heating effect and, due to the construction described, high furnace efficiency is made possible and the furnace is consequently economical as to the heating medium, even with electricity. Both strands of the conveyor chains move through the heating zone and the temperature of the chains always remains much higher than atmosphere. With a double duty chain the dead load is reduced to a minimum, heat is economized and the investment cost of material is substantially reduced.

Should any resistance element break down, its removal and replacement can be accomplished without taking down the furnace or substantial portions thereof. A workman can enter the relatively cool end of the furnace through doors hereinafter described, detach the clamp 17 of the wire in question and draw out the wire. The wire may be removed from the chamber through a normally closed hole in the end wall of the housing, for example, a hole provided by the removal of one or more of the bricks that make up the wall. In the same manner a new or repaired wire can be threaded through the supports and connected up in circuit. In this connection it is noted that the walls of the furnace form merely a housing, the heating elements being supported independently of the housing walls. A further advantage of the construction described is that it makes possible the use of standard sizes of insulating blocks instead of numerous special sizes.

There is provided means for removing the material to be heated, such as coils, from the conveyor and means for feeding material to the conveyors, and in structures embodying the invention to the best advantage, these feeding and discharging means include automatically controlled fluid pressure units. Although capable of various constructions, in that here illustrated as an example, at one end of the furnace is a discharge opening 40 in which is set a platform 42 extending inwardly to the top strand of the conveyor chain and outwardly to a discharge conveyor 43. Normally extending into the furnace chamber, through opening 40 is a hooked rod 44 so positioned that its hook receives a coil as the latter is advanced by the conveyor. The rod 44 is connected to a piston 45 working in a cylinder 46. Opening into opposite ends of the cylinder 46 are pipes 47, 48, connected by a 4-way valve 49 with an exhaust pipe 50 and a supply pipe 51. Pipe 51 leads to any suitable source of fluid pressure, such as compressed air, not shown.

When the hooked rod 44 receives a coil (as appears in Fig. 1) the valve 49 is operated, by means hereinafter described, to admit air through pipe 47, thus causing piston 45 to withdraw the rod 44, the cylinder exhausting through pipe 48, valve 49 and pipe 50. By this operation, the coil is drawn out of the furnace chamber across platform 42 onto the conveyor 43, which carries it away. When valve 49 is reversed, as later described, the piston has a reverse movement and the rod 44 is replaced in position in the chamber to receive the next coil.

The discharge conveyor 43 is shown diagrammatically as a short endless belt or chain. It will be understood that it may be extended to carry the discharged coil to any point desired. Instead of a discharge conveyor, there may be used an elevator or the like to carry the removed coil to a quenching pit.

At the opposite end of the furnace is an opening 53 having a platform 54 like plat-

form 42. Coils are brought up to the platform 54 by a conveyor 55 like conveyor 43. The coils are pushed across platform 54 onto the conveyor chain by a push rod 56 having a curved end to embrace a coil. The push rod 56 is connected with the piston of a fluid pressure unit 57 that is like the unit just described. By the operation of the valve of this unit 57, the rod 56 is caused to push a coil onto the conveyor chain in the furnace and is withdrawn for the next loading operation.

Doors are provided for openings 40 and 53 and there is provided means for operating these doors. Although capable of various constructions, in the present embodiment, the opening 40 is normally closed by a sliding door 41, notched or slotted to accommodate the platform 42 and the rod 44. This door is operated by a lever 59 connected by a link 60 with the piston rod 61 of a fluid pressure unit 62, like the units above described. By operation of the valve of fluid pressure unit 62, the door 41 is caused to open and close. A similar door 63 closes opening 53 and is operated by lever 64 and fluid pressure unit 65 that are duplicates of the similar elements associated with door 41.

There is provided means for operating the several valves of the fluid pressure units above referred to and in constructions embodying the invention to the best advantage this operation is automatic and is controlled by the movement of either the conveyor chain or the coils carried thereby. Although capable of various constructions, in that here shown as an example, in line with the conveyor chain at the discharge end, is a contact plunger 68 slidable in the end wall of the furnace and normally held by a spring 69 in a position to be engaged by a coil as the latter moves into the embrace of the hooked rod 44. The other end of plunger 68 carries the contact member of a relay 70. This relay is located in a shunt across a main line wire 71, and in which is connected one winding of a reversely or doubly wound solenoid 73. The main line 71 is connected with any suitable source, not shown. The core of solenoid 73 is connected by a lever 74 with the valve 49 of the fluid pressure unit that actuates the discharge rod 44. In parallel with this shunt is a loop including one winding of a reversely wound solenoid 75, connected by lever 76 with the valve of fluid pressure unit 62 that operates door 41. When a coil of material is moved into contact with plunger 68, relay 70 is closed and through the connections described the fluid pressure units are operated to open the door and withdraw the discharge rod, thus removing the coil as above described.

In the present embodiment the feeding operation is controlled by the chain movement, so that the coils will be fed in properly spaced relation to the conveyor chain. To this end, as here shown as an example, on the shaft 32, which drives the chain pulley, is a ratchet wheel 80 having a plurality of notches 81. Riding on the periphery of the wheel 80 is a pivotally mounted detent 82, which drops into the notches 81 as the wheel rotates. The notches are so spaced that one is presented to the detent each time it is desired to feed a coil. The detent carries an arm 83 on which is mounted the contact member of a relay 84 located in a shunt across the main line wire 71, and in which is connected one winding of a reversely wound solenoid 85. The core of this solenoid is connected by lever 86 with the valve of fluid pressure unit 57. In parallel with the shunt just described is a loop including one winding of a reversely wound solenoid 87, the core of which is connected by lever 88 with the valve of fluid pressure unit 65. When the detent 82 drops into a notch 81, the relay 84 is closed. Solenoids 85, 87 being thus actuated operate the valves of fluid pressure units 57, 65, to cause door 63 to be opened and pusher 56 to push a coil onto the conveyor chain.

Provision is made for automatically causing the return movements of the rods 44, 56 and the doors 41, 63. To this end, as here shown as an example, carried by the hooked rod 44 is a trip arm 90 positioned to trip a spring pressed lever 91 as the rod 44 reaches the end of the discharge stroke. This lever 91 is connected with the contact member of a relay 92 located in a shunt across the main line wire 71, and in which is connected the second or reverse winding of solenoid 73. In parallel with this shunt is a loop including the second or reverse winding of solenoid 75. When trip arm 90 causes the closing of relay 92 the cores of the two solenoids are reversed, thus reversing the valves of the two fluid pressure units and the rod 44 is returned to normal position and the door 41 is closed.

The piston of fluid pressure unit 52 has a back extension 93 carrying a trip arm 94 located to trip a spring pressed lever 95 as the pusher rod 56 reaches the end of its feeding stroke. This lever 95 is connected with the contact member of a relay 96 in a shunt across the main line wire 71, and in which is connected the second or reverse winding of solenoid 85. In parallel with this shunt is a loop including the second or reverse winding of solenoid 87. When the relay 96 is closed, the cores of solenoids 85, 87 are reversed, thus reversing the valves of fluid pressure units 57, 65 and the rod 56 is withdrawn and door 63 is closed.

In the above description of the loading, unloading and control features, reference has been made to the top strand of the right hand, top conveyor chain of Fig. 2. For the lower strand of this chain, the loading and unload-

ing ends are reversed. Below the discharge opening 40 for the top strand, in the present embodiment, is a feeding opening 97 for the bottom strand, this being a continuation of opening 40. Loading of coils is carried on by means of apparatus that is a duplication of the loading means described, except that the coils are brought up by a conveyor 255 that is located at right angles to the furnace instead of alongside, as in the case of conveyor 55. Figs. 8 and 9 indicate a push rod 256 that is a counterpart of push rod 56.

At the other end of the furnace, below feeding opening 53 is a discharge opening 98 for the bottom strand, this being shown as a continuation of opening 53. Unloading of coils is carried on by means of apparatus that is a duplication of the unloading means described except that the coils are carried off by a conveyor 243 that is at right angles to the furnace instead of alongside as in the case of conveyor 43. Figs. 8 and 9 indicate a hooked rod 244 that is a counterpart of hooked rod 44 except that it faces the opposite way in view of the reverse direction of the conveyed coils.

For the lower conveyor chains, the above described pairs of loading and unloading units are duplicated.

Figs. 8 and 9 indicate the push rod 356 and the discharge rod 344 of the top strand and the push rod 456 and discharge rod 444 of the bottom strand. These figures also show the conveyors 355, 343 and 443 and 455 for the top and bottom strands, of this lower chain. It will be seen that there are on one side of the furnace four loading and four unloading units. These units are duplicated on the other side of the furnace for the other two conveyor chains and no further reference thereto is necessary.

In Figs. 13 and 14 there is illustrated a modification in which the coils of material are heated inductively. In the exemplification shown, there is provided a long housing 101 similar to the housing already described except that it is of one-conveyor size. Moving in the chamber 102 formed by this housing is a conveyor chain 103 for carrying coils, this chain being like the conveyor chains already described, and running on suitably supported rails or angle pieces 104. It is driven by a shaft 105 which rotates the pulley 106. Coils of material are loaded onto the top strand and unloaded from the bottom strand at the end of the chamber 102 shown at the left in Fig. 14 by apparatus and in the manner above described in connection with the resistance type of furnace.

Communicating with the chamber 102 at the opposite end, is a heating chamber 107 enclosed by an affset and enlarged portion of the housing 101. Located within this heating chamber are transformer elements including an E-shaped core 99 and a primary coil 100 wound around the central leg of the core, the primary coil being connected with any suitable source, not shown.

There is provided means for causing relative movement between a coil of material and the transformer elements to place the coil of material in inductive relation with the transformer elements. In the present embodiment the transformer elements (except a part of the core later referred to) are stationary and the coil of material is moved. To this end, as here shown as an example, slidable in a thimble 108 located in the side wall of housing 101, opposite the heating chamber 107, is a ram or pusher 109. This pusher is connected to the piston of a fluid pressure unit 110 like the fluid pressure units described, the valve being operated as hereinafter described.

The pusher 109 is positioned to transfer coils of material from the top strand of the conveyor chain onto a table 111 located in the heating chamber 107. This table is mounted on a rod or plunger 112 connected to the piston of a fluid pressure unit 113 like unit 110, the valve being operated as hereinafter described. At the time of transfer of the coil from the conveyor chain, the table 111 is in the dotted line position indicated at 111^a in Fig. 13. After receiving a coil the table is elevated to a position just beyond the full line position of Fig. 13. In this position, the table 111 makes contact with the legs 99 of the core and becomes the fourth leg of the core, and the coil of material is between the primary coil 100 and the legs of the core. Suitable current being supplied to the primary 100, the coil of material acts as a secondary and the metal is heated by the induced currents set up therein. The primary coil and the core may be protected by suitable insulation from the heat generated in the coil of material and may be air cooled if desired.

After the coil is heated, the table 111 is lowered by means of its fluid pressure unit to the dotted line position 111^b of Fig. 13, in which position the coil is in line with the bottom strand of the conveyor chain. From the table, the coil of material is transferred onto the conveyor by a pusher or ram 114 like the pusher 109. This pusher 114 is connected to the piston of a fluid pressure unit 115 like the unit 110, the valve being operated as hereinafter described. Pusher 114 is then withdrawn, and pusher 109 having been withdrawn meanwhile, the table 111 is returned to position 111^a ready to receive the next coil of material.

While the valves of the fluid pressure units just described may be operated in any suitable manner, in the present embodiment provision is made for an automatic control. In the exemplification here shown, the valve of unit 110 is connected by a lever 117 with the core of a reversely wound solenoid 118. One winding of this solenoid is connected in a

shunt, which includes a relay 119, across a main line 171, connected with a suitable source not shown. The contact member of relay 119 is carried on the end of a spring pressed plunger 120, similar to plunger 68, and slidable in the end wall of the housing 101. When a coil of material reaches proper position to be transferred to table 111, it actuates the plunger 120 and closes relay 119. Thus solenoid 118 operates the valve of fluid pressure unit 110 to cause pusher 109 to move the coil onto table 111.

To reverse the valve in order to cause return of pusher 109, the piston of unit 110 has, as here shown, a rear extension 121 carrying a trip arm 122 positioned to trip, as the piston reaches the end of its transfer or pushing stroke, a spring pressed lever 123. This lever is connected with a contact member of a relay 124 located in a shunt across the main line 171 and in which is connected the second winding of solenoid 118. When relay 124 is closed the valve of fluid pressure unit 110 is reversed and pusher 109 is withdrawn. At this period in the cycle of operations, fluid pressure unit 113 is tending to elevate table 111, but the parts are held against such movement until the table receives a coil of material. To this end, as here shown as an example, an arm 128 on a rear extension 129 carried by the piston of unit 113 is arranged to be engaged by a sliding stop 127, to hold the table in position 111^a. To release this stop, on the extension 121 of unit 110, is a trip arm 151 positioned and arranged to trip momentarily a spring-pressed lever 152, after the piston of unit 110 has withdrawn the pusher 109 from the path of the table and nearly reached the end of its back stroke. This lever carries the contact element of a relay 153 located in shunt across the main line 171 and in which is connected one winding of a reversely wound solenoid 125. The core of this solenoid is connected by a lever 126 with sliding stop 127. When relay 153 is closed, therefore, the stop 127 is withdrawn and unit 113 is free to complete the elevation of table 111 to coil heating position. It will be apparent that, following this operation of solenoid 125 and stop 127 by the momentary closing of relay 153, the solenoid and stop retain their position by the inertia of the parts until again moved as later described.

Provision is made for lowering the table to remove the coil from heating position after a given time interval. To this end, as here shown as an example, mounted on shaft 105 is a wheel 130 having a plurality of spaced notches 131. Riding on the periphery of wheel 130 is a spring-pressed pivoted detent 132, which carries the contact member of a relay 134. This relay is located in a shunt across the main line 171, in which shunt is connected one winding of a reversely wound solenoid 135, the core of which is connected by a lever 136 with the valve of fluid pressure unit 113. When the detent 132 drops into a notch 131, relay 134 is closed and through solenoid 135 the valve of unit 113 is operated to cause the table 111 to be lowered to position 111^b. The heated coil is now positioned to be transferred back to the conveyor chain but onto the other strand. To effect operation of pusher 114, as here shown, on the extension 129 of table unit 113 is a trip arm 137 located and arranged to trip momentarily a spring pressed lever 138 as the piston of unit 113 reaches or nearly reaches the end of its withdrawal stroke. This lever carries the contact element of a relay 139 that is located in a shunt across the main line 171, in which shunt is connected one winding of a reversely wound solenoid 140. The core of this solenoid is connected by a lever 141 with the valve of fluid pressure unit 115. When relay 139 is closed, the valve of unit 115 is operated to cause pusher 114 to transfer the heated coil from the table 111 to the bottom strand of the conveyor chain. As in the case of the momentary trip above described, the parts are held in moved position, following the momentary energizing of solenoid 140, by inertia.

To reverse the valve of unit 115, thereby to cause return of pusher 114, as here shown as an example, the piston of unit 115 carries a rear extension 142 on which is a trip arm 143 arranged to trip a spring pressed lever 144 as the piston completes its pushing stroke. This lever 144 carries the contact element of a relay 146 that is located in a shunt across the main line 171, and in which is connected the reverse winding of solenoid 140. When relay 146 is closed the valve of unit 115 is reversed and pusher 114 is withdrawn.

To reverse the valve of unit 113, thereby to cause the table to be elevated, following withdrawal of pusher 114, extension 142, as here shown as an example, carries a second trip arm 145 arranged to trip, as the pusher 114 reaches withdrawn position, a spring pressed lever 147. This lever carries the contact element of a relay 148 that is located in a shunt across the main line 171 and in which is connected the reverse winding of solenoid 135. When relay 148 is closed, therefore, the valve of unit 113 is reversed and the table 111 is raised.

Meanwhile stop 127 has been returned to stopping position in order to hold the table in line with the top strand of the conveyor so as to receive a new coil of material. To this end, in the embodiment illustrated, the second winding of solenoid 125 is connected in a loop in parallel with the shunt controlled by relay 139. When this relay is closed as above described, stop 127 is returned to stop position and, consequently, upon reversal of the valve of unit 113 the table is

raised only as far as position 111ª until the stop is again released.

As in the case of the resistance type of furnace, a preheating and recuperative effect is obtained with this induction type of furnace. That is, the incoming cold coils on the conveyor chains are preheated by the heat given off by the outgoing hot coils and the induction type is capable of a high efficiency and economy.

Although in the case of both types of furnace, fluid pressure units having four-way valves, operated by reversely wound solenoids have been shown, it is to be understood that other arrangements may be used. For example, the fluid pressure units may have four one-way valves operated by a singly wound solenoids.

Referring again to the resistance type of furnace, in place of the single straight wires above described, wires of hair pin form may be used. Such a wire is shown in Fig. 11. In the exemplification illustrated, the loop of the wire is of small or high resistance cross section, the ends being of large or low resistance cross section. These wires are supported as the single wires are, the two branches taking the place of two single wires in being threaded through or removed from the perforate insulating blocks. In order to economize in wire material, the loops may be alternately reversed so that the complete hair pin wire does not extend the whole length of the furnace chamber. Such an arrangement is shown schematically in Fig. 12, which also illustrates the manner of connecting the wires in circuit. As shown in Fig. 12, each hair pin wire extends from one end of the chamber to the opposite end of the hot zone.

With the construction described the fields set up by the current in the several wires are neutralized and loss by induction is reduced to a minimum.

In handling coils of metal such as those above described, at least in the case of metal of the lighter gauges, it has been found advisable to firmly bind the coils to prevent them from uncoiling. While the conveyor chains may have ribs or the like in which the coils seat, such a construction is considered impracticable with the type of loading and unloading apparatus above described. There is provided a binder suitable for use with the present handling apparatus. For example, the coils may be bound by plain, broad bands of a metal like the conveyor metal, in this instance, nickel chromium alloy. In Figs. 15 and 16 is illustrated a skeleton frame 158 having an annular channel 159 for receiving one end of the coil. This frame may be made of nickel-chromium alloy or the like. With either type of binder, each coil is firmly bound during its entire process through the apparatus described. With a metal such as nickel chromium alloy there is no danger of the binders breaking down under continued high temperature and consequently the binders are reliable, and lasting.

While nickel chromium alloy has been recited in the specification and claims in connection with various metal parts, it is to be understood that other metals having similar heat resisting characteristics may be used as equivalents without departing from the invention.

There is provided means for controlling the heating temperature of the resistance type of furnace above described. This may be accomplished, for example, by providing a constant heat input and varying the conveyor speed in accordance with temperature changes. Although capable of various constructions, in that here illustrated, inserted in the top wall of the furnace housing is a pyrometer 501, its inner end being located adjacent the path of the material on the conveyor. The pyrometer is connected by wires 502, 503 with a pyrometer dial 504 of any suitable construction, comprising a pointer that makes contact, at upper and lower limits, with the usual temperature control points.

The pyrometer dial has a three wire connection 505, 506, 513 with a relay, indicated at 507, on a control panel 508. This relay operates a contactor 509, arranged to move an adjustable field resistance 510. Main line wires 514, 515 lead from the armature brushes of a motor 511 to any suitable power source. The motor drives a pinion 512 meshing with the gear 33 that rotates the conveyor pulley.

When the temperature at the pyrometer falls to the lower limit, current through wires 505, 506 opens relay 507 and through the consequent operation of contactor 509 the field resistance 510 is moved in such manner that the motor field is changed to slow down the motor and the conveyor. Assuming a constant input of heat at the furnace resistance wires, when the speed of the conveyor is decreased the material to be heated carries away less heat and the furnace temperature rises. When, on the other hand, the temperature at the pyrometer reaches the upper limit, current through wires 506, 513 operates relay 507 and contactor 509 in the reverse direction, whereby the field resistance is moved to change the motor field in a manner to speed up the motor. The consequent increased conveyor speed results in more heat being carried away by the material to be heated and the temperature in the furnace falls.

With a constant heat input and automatic control of the conveyor speed the temperature of the material to be heated is automatically controlled within close limits.

There is provided in the motor field circuit a field rheostat 516 which can be set by hand to give the approximate motor speed desired for the volume of material to be heated. Cur-

rent is passed through the resistance heating wires 12 at such a rate as to bring the furnace up to the desired temperature. The contact points on the pyrometer dial are set for the desired limits and thereafter the temperature control is automatic as above described.

While a control for only one conveyor has been described it will be apparent that it may be duplicated for other conveyors.

The operation of the several forms of apparatus will be clear from the above without further description.

Certain features above described are claimed in a divisional application Ser. No. 178,645, Patent No. 1,748,465.

What I claim is:—

1. In a heating apparatus, and in combination, a furnace chamber, conveyor means including an endless conveyor for simultaneously moving material through said chamber in opposite directions, and electric resistance elements surrounding the several paths of the material moved by said conveyor means.

2. In a heating apparatus, and in combination, a furnace chamber, a plurality of conveyor means including an endless conveyor for moving a plurality of rows of material through said chamber, and electric resistance elements surrounding the paths of the material moved by said conveyor means.

3. In a heating apparatus, and in combination, a furnace chamber, an endless conveyor for moving material through said chamber, electric resistance elements above said conveyor and electric resistance elements between the oppositely moving strands of the conveyor.

4. In a heating apparatus, and in combination, a furnace chamber, an endless conveyor for moving material through said chamber, and electric resistance elements arranged above and below said conveyor and between the strands thereof.

5. In a heating apparatus, and in combination, a furnace chamber, a plurality of endless conveyors for moving material through said chamber, and a plurality of electric resistance elements so arranged that each strand of each conveyor is surrounded by resistance elements.

6. In a heating apparatus, and in combination, a furnace chamber, four conveyor units for moving material through the chamber and arranged with two units above the other two units, and electric resistance elements associated with the chamber for supplying the heat thereto.

7. In a heating apparatus, and in combination, a furnace chamber, four conveyor units for moving material through the chamber and arranged with two units above the other two units, and electric resistance elements around the four walls of the chamber, between each pair of conveyor units vertically and between each pair of units horizontally, whereby each conveyor unit is surrounded by electric resistance elements.

8. In a heating apparatus, and in combination, a furnace chamber, four endless conveyors in nested relation for moving material through the furnace, and electric resistance elements surrounding each strand of each conveyor.

9. In a heating apparatus, and in combination, a furnace chamber, perforate supporting means within the chamber and a plurality of electric resistance elements comprising long straight wires, each resistance element being removably threaded through the perforations of said supporting means.

10. In a heating apparatus, and in combination, a furnace chamber, a plurality of spaced supporting frames in said chamber, insulating blocks carried by said frames, and having perforations in alinement lengthwise of the chamber, and electric resistance elements comprising long straight wires threaded through said perforations.

11. In a heating apparatus, and in combination, a furnace chamber, supporting means in the chamber, a plurality of electric resistance elements comprising long, straight wires, threaded through holes in said supporting means and individually removable therefrom, a bus bar carried by the chamber walls, and detachable connections between said resistance elements and said bus bar.

12. In a heating apparatus, a furnace chamber, electric resistance wires in said chamber for supplying heat thereto, a conveyor chain for moving material through the furnace chamber and a plurality of frames in the chamber for supporting said wires and said chains, the frames and conveyor chain being made of an alloy having substantially the same heat resisting characteristics as the resistance wires.

13. In a heating apparatus, a furnace chamber, electric resistance wires in the furnace chamber having a high resistance cross section at the central part of the chamber and low resistance cross section at the end thereof, thereby to provide a central heating zone, bus bars, connections between the bus bars and the resistance wires and bus bar leads, said bus bars, connections and leads being located in the relatively cool end portions of the furnace chamber.

14. In a heating apparatus, and in combination, a furnace chamber, heat supplying means, and an endless conveyor chain having reversibly functioning links, whereby both strands of said chain are available for receiving material to be moved through the chamber.

15. In a heating apparatus, and in combination, a furnace chamber, an endless conveyor in the chamber, openings in the chamber walls for feeding articles to one strand of the conveyor at one end of the chamber

and to the other strand of the conveyor at the other end of the chamber and for discharging articles from the first named strand at the second named end of the chamber and from the second named strand at the first named end of the chamber, doors for normally closing said openings, and electric resistance elements arranged to supply heat in zones of varying degree.

16. In a heating apparatus, and in combination, a furnace chamber, conveyor means therein, heat supplying means associated with the chamber, means for feeding material to said conveyor, automatically controlled by the movement of the conveyor, and means for discharging material from the conveyor, automatically controlled by the movement of the conveyed material.

17. In a heating apparatus, and in combination, a furnace chamber, conveyor means therein, heat supplying means associated with the chamber, openings in the chamber walls for feeding material to and discharging it from the conveyor, feeding means, discharging means, doors for said openings, door operating means, and an automatic control for said feeding, discharging and operating means.

18. In a heating apparatus, and in combination, a furnace chamber, conveyor means therein, heat supplying means associated with the chamber, openings in the chamber walls for feeding material to and discharging it from the conveyor, feeding means including a fluid pressure unit, discharging means including a fluid pressure unit, doors for said openings, door operating means including a fluid pressure unit, solenoids for operating the valve mechanisms of said fluid pressure units and automatically operated relays for controlling said solenoids.

19. In a heating apparatus, and in combination, a furnace chamber, conveyor means therein, heat supplying means associated with the chamber, openings in the chamber walls for feeding material to and discharging it from the conveyor, a supply conveyor, means for bringing material up to the feeding opening, a delivery conveyor, means for carrying material away from the discharge opening, doors for said openings, door operating means, means for feeding material from the supply conveyor to the furnace conveyor, means for discharging material from the furnace conveyor to said delivery conveyor and automatic controls for said door-operating means, feeding means and discharging means.

20. In a heating apparatus, a furnace chamber, heat supplying means, a conveyor for moving material through the furnace chamber, an electric motor for driving said conveyor, a variable resistance for controlling the field of said motor and heat controlled means for varying said resistance.

21. In a heating apparatus, a furnace chamber, electric resistance elements for supplying heat thereto, a conveyor for moving material through the furnace chamber, an electric motor for driving said conveyor, a pyrometer located adjacent the path of the material in the furnace chamber, a pyrometer dial connected with said pyrometer, and means controlled by limiting contacts at said dial for varying the field of said motor thereby to vary the speed of the conveyor.

In testimony whereof, I have hereunto set my hand.

DAVID L. SUMMEY.