

Jan. 14, 1969

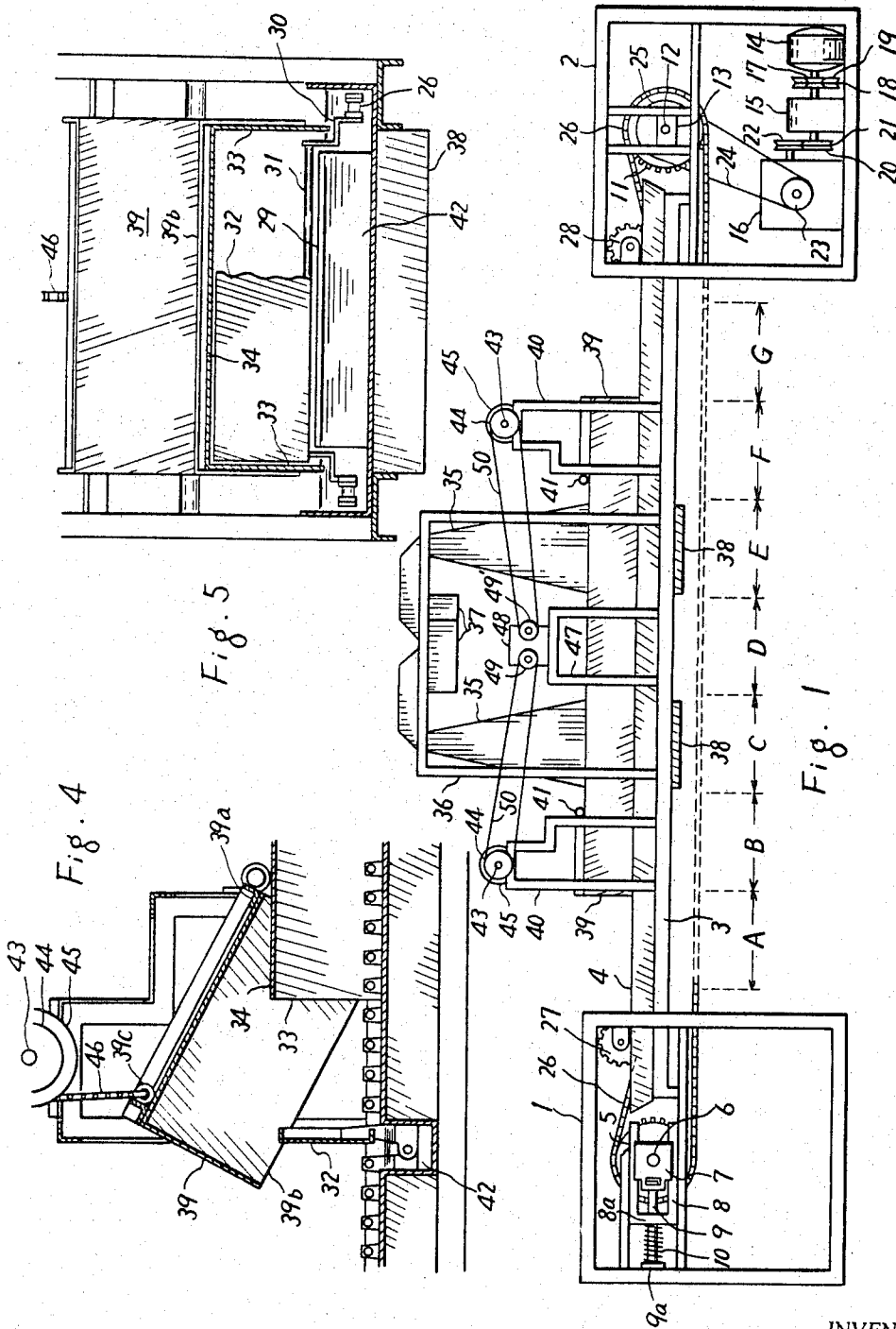
ETSUTARO MIYATA

3,422,242

HIGH FREQUENCY HEATING DEVICE

Filed Aug. 30, 1965

Sheet 1 of 4



INVENTOR.
ETSUTARO MIYATA
BY *Eugene H. Hays*
ATTORNEY

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ETSUTARO MIYATA

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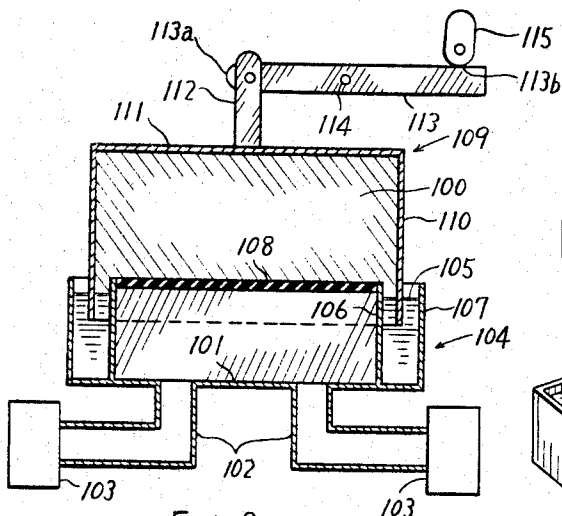


Fig. 8

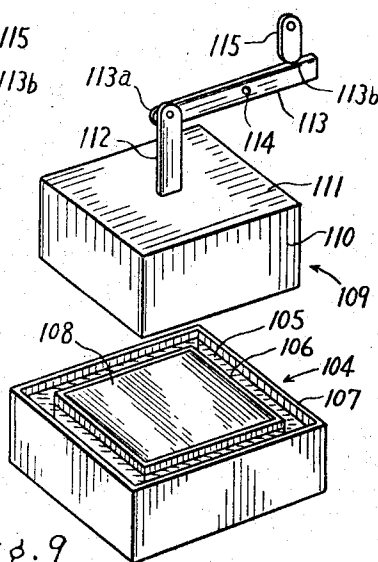


Fig. 9

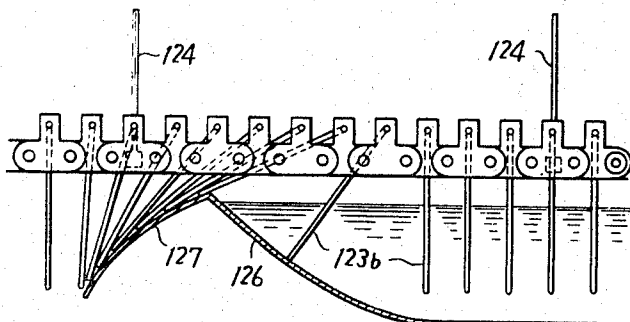


Fig. 10

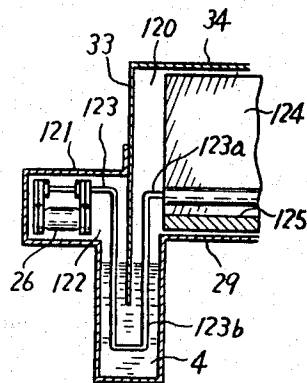
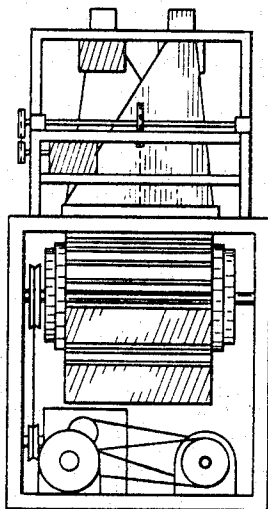


Fig. 11



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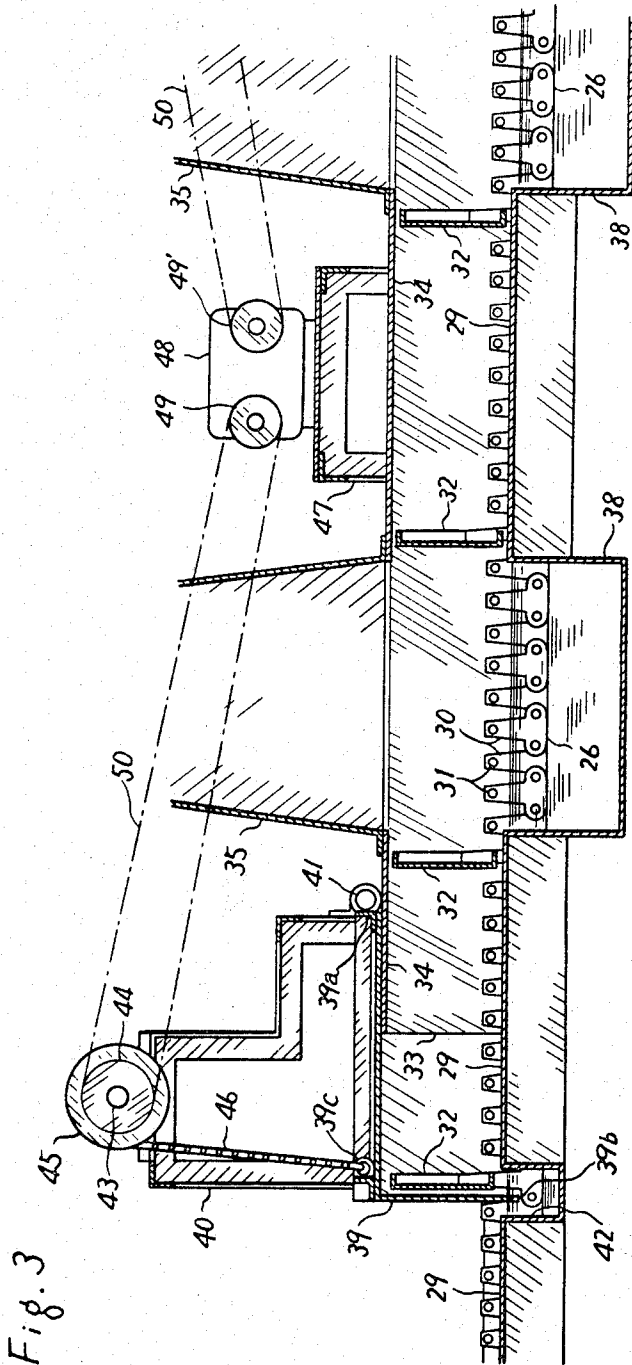
ETSUTARO MIYATA

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HIGH FREQUENCY HEATING DEVICE

Filed Aug. 30, 1965

Sheet 3 of 4



INVENTOR.
ETSUTARO MIYATA
BY *Eugene C. Coffey Jr.*
ATTORNEY

Jan. 14, 1969

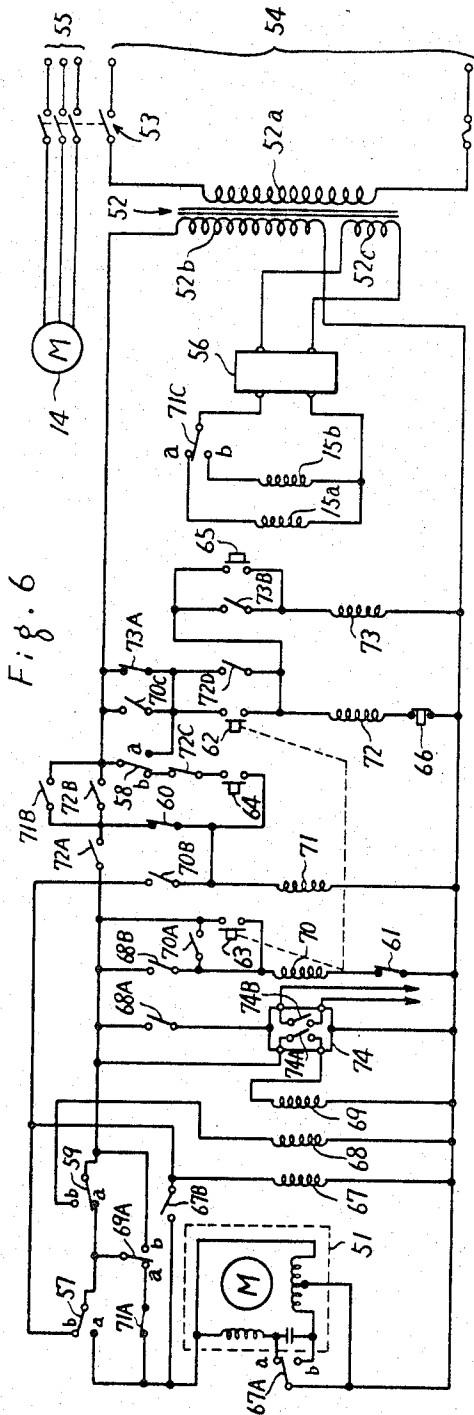
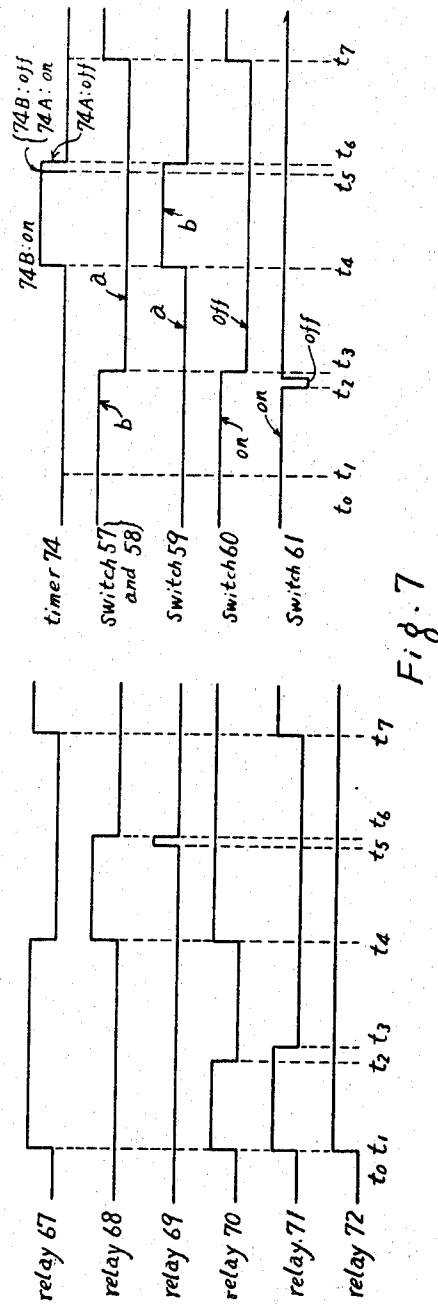
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3,422,242

HIGH FREQUENCY HEATING DEVICE

Filed Aug. 30, 1965

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3,422,242

HIGH FREQUENCY HEATING DEVICE

Etsutaro Miyata, Sakai-shi, Osaka-fu, Japan, assignor to Hayakawa Denki Kogyo Kabushiki Kaisha, Osaka, Japan, a company of Japan

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Claims priority, application Japan, Aug. 31, 1964, 39/49,744, 39/49,746, 39/49,747, 39/49,749, 39/49,750; Sept. 15, 1964, 39/52,941; Sept. 24, 1964, 39/54,974; Oct. 22, 1964, 39/60,201

U.S. Cl. 219—10.55

Int. Cl. H05b 9/00; G21d 1/00; G21d 3/00

7 Claims

ABSTRACT OF THE DISCLOSURE

A high frequency heating device having cooperating housing sections with one section having peripheral channels and the other section having walls extending into the channels and a conductive liquid filling the channels to a level above the side walls to seal the housings against loss of radiant energy introduced into the housing.

The present invention pertains to high frequency heating devices, particularly to apparatus for successively heating large amounts of food.

The high frequency power employed in cooking may involve energy as great as the output of a radio broadcasting station. Accordingly, if the high frequency radiation employed for heating is allowed to leak even partially to the outside, there may be substantial danger to the health of the operator and interference with proper operation. In conventional devices of this nature, the practice in most cases has been to provide the metallic heating chamber unit with a metal door, in order to prevent leakage. However, in such practice gaps have often been present between the main chamber structure and the door. The high frequency used in the process, which latter for brevity may be termed radio cooking, lies in the microwave region, so that even a small gap acts as a slit antenna, allowing a powerful stream of radiation to escape.

An object of the present invention is to prevent such leakage of the high frequency energy as the above mentioned, by sealing at least the door portion of the heating chamber with a conductive liquid. As to the sealing liquid, water is suitable in general, but in case maximum shielding against leakage is desired, a substantially harmless electrolyte such as a salt solution may be used.

Such sealing of at least a portion of the heating chamber with a conductive liquid presents various advantages in addition to preventing leakage of the high frequency radiation. In the first place, it is not necessary to press the door firmly against the fixed portion of the chamber structure, so that the opening and closing of the door can be effected smoothly and with small power requirement. Secondly, as the volume of the chamber can be varied easily, the resonant mode of the chamber with respect to the heating high frequency can be varied, and thereby the magnitude, direction and distribution of the potential or current of the high frequency wave effect produced in each portion of the heated object can be varied. Accordingly, by varying the chamber volume while the object is exposed to high frequency wave energy all portions of the object can be heated uniformly. Thirdly, the conductive liquid itself provides a degree of loading at all times, preventing "no-load" troubles such as damage to or destruction of the generating oscillator by high voltage in case of operation with no material in the chamber for processing. Fourthly, in case a chain conveyor is used, the chain can be shielded from the high frequency waves by means of the conducting liquid, thereby preventing such troubles as rapid erosion of the chain and contamination of the heating chamber due to sparking between links or links and pins as a

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result of potential differences set up by direct exposure to the high frequency electric field, burning or evaporation of chain lubricant with resultant contamination of food in process, and the like.

Other objects of the invention are to provide a flow or production line operation of high frequency wave heating using a conveyor; to improve heating efficiency by limiting the application of high frequency wave energy to the heating region only; to interlock the opening and closing of the doors with the turning off and on respectively of the high frequency oscillator, so that oscillation is stopped while the doors are opened; and to render the operation of each machine portion completely automatic in conjunction with the movement of the conveyor.

The above mentioned and other features of the invention will be clearly understood by reference to the following detailed explanation in connection with the accompanying drawings, in which

FIGURE 1 is a front side view of a conveyor type device embodying the invention.

FIGURE 2 is a right hand end elevation of the same.

FIGURE 3 is an enlarged longitudinal sectional view of the tunnel portion of the device shown in FIGURE 1, with the door in closed position.

FIGURE 4 is a side view of a fragmentary portion of FIGURE 3 showing the door in opened position.

FIGURE 5 is a left hand transverse sectional view with the apparatus positioned as in FIGURE 4.

FIGURE 6 is an electrical connection diagram applying to the embodiment shown in FIGURES 1 to 5.

FIGURE 7 is a time diagram illustrating the sequential operations of the switches and relays shown in FIGURE 6.

FIGURE 8 is a vertical sectional view of an embodiment in which the heating chamber is closed.

FIGURE 9 is a perspective view of the device of FIGURE 8 with the chamber open.

FIGURE 10 is a transverse sectional partial view of the conveyor arrangement in another example of the invention.

FIGURE 11 is a longitudinal section showing the depending conveyor parts entering the liquid tank or trough in the embodiment shown in FIGURE 10, and

FIGURE 12 is a view similar to FIGURE 10 but showing a further alternative arrangement of the conveyor.

The embodiment of the invention shown in FIGURES 1 to 5 has two square end frames 1 and 2, with two laterally spaced longitudinal beams 3 and 3 bridged therebetween. On these beams long liquid tanks or troughs 4 and 4 are mounted, extending between the end frames 1 and 2. Laterally spaced chain sprockets 5 and 5 are supported in alignment with the left end of each liquid trough by a common shaft 6 within the frame 1. The bearing member 7 of the shaft 6 is slidably supported in a U-shaped rail member 8 fixed to the frame 1. The sprockets 5 are urged longitudinally away from the troughs 4 by a compression spring 10 guided on a rod 9 extending from the bearing 7 through the central connecting portion 8a of the rail member 8, the spring 10 being interposed between said portion 8a and a head portion 9a of the rod 9. At the right end of each liquid trough similar sprockets 11 and 11 are secured on a common shaft 12, the shaft 12 being journaled in a bearing 13 which is fixed to the frame 2. Below the frame 2 there are provided a motor 14, a clutch 15 with a brake, and a speed reducer 16. The drive from the motor 14 is transmitted through a pulley 17, a belt 18 and a pulley 19 to the clutch 15. From the clutch the drive is transmitted through a pulley 20, a belt 21 and a pulley 22 to the speed reducer 16, thence via a pulley 23, a belt 24 and a pulley 25 to the rotary shaft 12.

Conveyor chains 26 and 26 are spanned between the

sprockets 5, 5 and 11, 11 in their respective alignments, the upper reaches of the chains being depressed within the liquid tanks or troughs 4 and 4 respectively by idler sprockets 27 and 27 supported by the frame 1 and similar sprockets 28, 28 supported by the frame 2. Accordingly, the upper reaches of the chains 26, 26 are made to run in the liquid within the troughs by the above-described drive from the motor 14.

The portion of the apparatus between the frames 1 and 2 along the conveyor is divided into sections or stations A to G of equal lengths. A is the station in which material to be heated is loaded on the conveyor; B the station wherein the material is led to the chamber for heating; C is a station in which the material is heated by the high frequency radiation; D is the station in which carry-over heating is accomplished, that is, wherein local over heat due to partial adaptability of material with respect to the high frequency heating is diffused; E is a second station in which reheating is applied by high frequency radiation; F is the station through which the heated material is led to the exterior, and G is the station in which the material is unloaded from the conveyor. In the stations A, B, D, F and G, laterally extending metal floors 29, FIGURES 3 and 5, are disposed between the troughs 4, 4 and slightly above the liquid level therein. In all except the end stations, that is, in stations C, D, E and a part each of B and F, there are provided metal side walls 33 and 33, the lower edges of which are immersed in the liquid in the respective troughs 4, 4. In the stations B, D, and F, ceilings 34 of metal connect the upper ends of the two side walls, thus defining a tunnel-like passage. In the stations C and E, downwardly directed electromagnetic horns 35 and 35 are provided at the tops instead of ceilings. These horns are, respectively coupled with magnetron oscillators 37 and 37, which latter are supported on a frame 36 assembled on the beams 3 and 3 as illustrated in FIGURE 1. The oscillators are adapted to supply high frequency wave energy at about 2450 mc. via the horns 35 to the material in process. Beneath the stations C and E, there are provided transverse liquid tanks 38 and 38 which are in communication with the side troughs 4 and 4. The liquid in these tanks 38 acts as a load on the oscillators at all generating times by absorbing a portion of the wave energy, and thereby prevents the "no-load trouble" with the oscillators which otherwise would occur in the absence of goods to be heated in the said heating stations.

In the above described manner, a tunnel type heating furnace is formed, extending from the station B to the station F. The lower ends of the horns 35 are preferably closed with plates of suitable material which causes but little loss of the high frequency energy passing therethrough, but which is capable of blocking water vapor produced by the heat from reaching the oscillators. On the other hand, the side walls 33 or the ceilings 34 are preferably provided with a large number of perforations too fine to allow leakage of the 2450 mc. radiation, but adapted to permit escape of the vapor.

The conveyor chains 26 and 26 are equipped at close intervals throughout their lengths with arms 30 which protrude above the liquid surface when the chains are in the troughs 4 and 4. Between opposite arms on the two chains lateral rods 31 are attached thereto at a level slightly above the floors 29, FIGURES 3 and 5, forming a grid to support the goods to be heated. At longitudinal intervals each equal to the length of a processing station, screens 32 are attached to opposite arms 30 instead of rods 31. Each screen 32 is but slightly smaller than the interior section of the tunnel formed by the walls 33, 33 and the ceilings 34, 34, so that the energy of the oscillators 37, 37 does not leak seriously from the stations C or E to the adjacent stations. The relation between the tunnel and the lateral rods and screens is shown most clearly in FIGURE 5.

In the stations B and F, doors 39 and 39 are provided at the entrance and exit of the tunnel. These doors are of a generally box-like formation except for omission of bottoms and inner transverse walls. Frames 40 and 40 are mounted on the beams 3 and 3 at both sides of the tunnel entrance and exit, and the inner ends 39a and 39a of the upper faces of the doors are joined by hinges to these frames. At the border between stations A and B and at that between stations F and G, there are provided respective cross liquid channels 42 and 42 connecting the side troughs 4 and 4, so that all lower edges 39b and 39b of the doors are immersed in the liquid within channels 42 or troughs 4 when the doors are closed. By the liquid sealing thus provided, any high frequency wave energy which leaks from the heating stations C and E through narrow crevices around the screens 32 is completely contained, and thus does not escape to the exterior.

Rotary shafts 43 and 43, each carrying a sprocket 44 and a winding drum 45, are mounted on the tops of the two frames 40 and 40 respectively, as shown in FIGURES 1 and 3. In each of these two sub-assemblies the lower end of a chain 46, part of which latter is wound on the drum 45, is coupled to the upper front corner 39c of the door 39, as shown in FIGURE 4. A driving mechanism 48, of the type including a built-in reversible motor, is mounted on a frame 47 which is assembled on the beams 3 and 3 in vertical alignment with the station D. This mechanism has two chain sprockets 49 and 49' adapted to be driven in mutually opposite directions. Chains 50 and 50 respectively connect these sprockets 49, 49' with one each of the sprockets 44 and 44. Accordingly, when the reversible motor is made to rotate in one direction the two doors 39 and 39 are opened simultaneously, and when the motor is operated in the reverse direction the doors simultaneously close.

In FIGURE 6, are shown the electrical connections of the embodiment illustrated in FIGURES 1 through 5. The reversible motor 51, previously mentioned as included in the driving mechanism 48 to operate the same, is connected, in cooperative relation with a relay circuit hereinafter described, to a secondary winding 52b of a power transformer 52. The primary winding 52a of said transformer is connected through a multi-pole main switch 53 to a suitable source 54 of alternating current. The conveyor driving motor 14 is also connected through the multi-pole switch 53 to the terminals 55 of a suitable source of power which may preferably be three phase alternating current. Another secondary winding 52c of the transformer 52 is adapted to supply direct current through an AC-DC converter or rectifier 56, and a double-throw switch contact arm 71c selectively to a brake coil 15a or clutch coil 15b of the previously mentioned clutch 15.

In the following description and as shown in FIGURE 6, the opposite contact positions of each double-throw switch are designated as "a" side and "b" side respectively. The previously mentioned relay circuit includes switches 57 to 61, responsive to various mechanical movements of the machine as hereinafter set forth; push button switches 62 to 66, relays 67 to 73, and a timer 74. The switches 57 and 58 normally rest in the "a" side position; when the door 39 is raised to completely open position these switches in response thereto are thrown to the "b" side. The switch 59 is normally on the "a" side, and only as the door is completely closed is this switch thereby thrown to the "b" side. The switch 60 is normally closed, but is opened when the screens 32 are on the border between sections. The switch 61 is normally closed but is opened immediately before the screens reach the station borders. The push button switches 62 to 65 are normally open, and close only when their respective buttons are pushed. On the other hand, the button switch 66 is normally closed, opening only when pressed. The relays 67 to 73 and the timer 74 have various combinations of operating contact points designated A, B, C and D, the designation 71c,

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for example, representing the third contact of the relay 71.

In the above mentioned embodiment illustrated in FIGURES 1 to 5, under normal idling conditions, the doors 39 and 39 are completely open, the conveyor motor 14 is stopped, the conveyor is in such position that the screens 32 are midway in the stations, and the state of the circuits is that shown in FIGURE 6. FIGURE 7 shows the states of the switches 57 to 61, the relays 67 to 72, and the timer 74 at the points of time hereinafter explained.

To initiate operation, the main switch 53 is closed at the time t_0 , starting the conveyor motor 14 and placing the relay circuit in ready state. As no relay has yet been energized at this time, each of the relays remains in the state of FIGURE 6.

As time t_1 , the push button switches 62 and 63 are pushed for starting. As the contact point 73A remains closed, the relay 72 is energized, its self retention circuit being completed by the holding contact point 72D, while the contact points 72A and 72B are closed, and 72C is opened. The switch 60 being closed because the screens 32 are midway in the stations as previously noted, the relay 71 is energized by the closing of the contact point 72B, resulting in the opening of the contact point 71A, closing of 71B, and switching of 71C to the clutch side "b." As a result, the clutch coil 15b is energized, and the driving connection from the motor 14 is completed, starting the conveyor. At this time the reversible motor 51 does not start because the contact point 71A is open and the electric path is thus cut off. However, as the relay 67 is energized and its contact point 67A moves to "b" side, the motor 51 is set in the ready state for reverse rotation.

The push button switch 63 having been closed momentarily at the time t_1 , the relay 70 is energized through the closed switch 61, its contact points 70A, 70B and 70C are closed, and this relay maintains this state because of its holding circuit through the contact 70A. However, at the time t_2 , which is immediately before the screens 32 reach the station borders, the switch 61 opens, the relay 70 is thereby de-energized, and its contact points 70A, 70B, and 70C are all opened.

As time t_1 , the push button switches 62 and 63 are borders, the switch 60 opens, whereby the relay 71 is de-energized, causing the contact point 71C to move to "a" side. As a result, the clutch coil 15b is de-energized and at the same time the brake coil 15a is energized, so that the conveyor stops instantly. At the same time, the contact point 71A is closed to start the motor 51 which is in the reverse ready state. By the reverse rotation of this motor, the doors 39 start downward toward closed position. When the doors have lowered a short distance the switches 57 and 58 return to "a" side, but the relay 67 is not deactivated because of its holding circuit through the contact point 67B, so that the motor 51 continues its reverse rotation.

At the time t_4 , as the door 39 completely closes, the switch 59 is thrown to "b" side, cutting off the power supply to the motor 51, causing it to stop, and at the same time, the relay 67 is deactivated and its contact point 67A moves to the forward rotational "a" side. As the switch 59 switches to "b" side at the same time, the relay 68 is energized, and the contact point 68A in the starting circuit of the timer 74 is closed. It will be understood that the diagrammatic rectangle designated 74 in FIGURE 6 is representative not of electrical conductors but rather of the timer as a whole; furthermore, since magnetron oscillator circuits are well known they are not shown per se in the interest of simplicity, their presence being indicated by the two vertical arrows directed from the timer. By closing the contact point 74B during the period for which it is set, the timer 74 causes the magnetron oscillators 37 and 37 to oscillate during said period, whereby high frequency wave energy is supplied to the stations C and E. As there are screens 32 at both ends of the

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stations C and E, this energy does not leak in great part to other stations, and accordingly, objects in stations C and E can be heated effectively. Furthermore, as the entrance and exit of the stations B and F respectively are completely closed electrically by the doors 39 and the liquid sealing their lower edges, no part of said energy leaks to the exterior.

At the time t_5 at which the set period of the timer 74 terminates, the timer contact point 74B opens to terminate the high frequency wave heating, the contact point 74A closes to energize the relay 69, and thereby the latter's contact point 69A is moved to "b" side. Thereupon, current is again supplied to the motor 51 which is in forwardly rotational setting, and the doors 39 are opened.

At the time t_6 at which the doors 39 are raised to some extent, the switch 59 is switched from "b" to "a" contact point, deactivating the relay 68 and the contact point 68A in the timer circuit; thereby the timer is caused to open its contact point 74B, so that the relay 69 is de-energized.

At the time t_7 , at which the doors arrive at fully open position, the contact arm of the switch 57 is thrown to "b" side, causing the motor 51 to stop, and at the same time the relay 67 is energized to throw its contact 67A to "b" side, whereby the motor 51 is reset to reverse ready state. The state of the relay circuit at this time is the same throughout as that at time t_1 as previously described. Accordingly, the relay 71 is again energized, the conveyor is restarted, and the described operational cycle from time t_1 to t_7 is repeated.

As is apparent from the above cyclic operation, the conveyor is advanced intermittently throughout a distance of one station per cycle. Consequently, an object loaded on the conveyor in station A is thereafter advanced at the intermittent rate of one section per cycle throughout all successive stages of the process. When the object is in station C the high frequency radiation is applied thereto, the object being quickly heated. In the next operational cycle, wherein the object occupies station D, no additional heat is applied, so that the object undergoes carry-over heating, i.e., unevenness of temperature caused by local differences in adaptability of the object to the previously applied high frequency are averaged by thermal diffusion. In the next operation cycle, the object is finally heated in the station E. The station F, while serving its primary function of preventing leakage of high frequency energy by means of the liquid-sealed door 39, also contributes to final carry-over heating or equalization in the manner described for station D. In the final cycle, the heat treatment having been completed, the object is carried to the open station G, whence it may be unloaded from the conveyor. By loading a succession of objects on the conveyor in station A at the rate of a load per operation cycle, these objects are caused to be treated in direct succession as they pass through the heating stations, so that after treatment they emerge for unloading in directly successive cycles, i.e., in production line relation.

When the processing operation is being initiated, it is advantageous to move or step the conveyor forward until the first object reaches the station C. For this purpose, the button switch 64 is pushed, so that only the relay 71 is energized, its contact 71C being moved to the clutch side "b" whereby the conveyor is started. However, as the contact points 70B and 72A are still open, current is not supplied to the motor 51, the doors 39 remain open, and the high frequency wave is not generated because the timer is not started. When the conveyor has traveled one station length, the switch 60 opens to deactivate the relay 71, and the conveyor is stopped. Thus, the conveyor can be stepped forward by one station length at a time by use of the push button switch 64 as described.

When the normal operation of the apparatus is to be terminated, the button switch 65 is pushed. If the doors 39 are completely open at this time and the switch 58 is at "b" side, the contact point 73A opens due to energization of the relay 73, causing the relay 74 to be deactivated,

whereby the conveyor is stopped. In case the doors 39 are not completely open when the switch 65 is pushed, self retention is established by the holding contact point 73B as the relay 73 is energized, the contact 73A being thereby held open; at the instant that the doors 39 move to completely open position and the switch 58 thereby is thrown away from "a" side, the relays 72 and 73 are de-energized and the conveyor is stopped. In case of emergency, on the other hand, the switch 66 is pushed to deactivate the relay 72, whereby the device is stopped at once, regardless of its operational position.

In the above described embodiment of the invention, the object in process is heated by the high frequency irradiation applied from above, but the irradiation alternatively may be accomplished from below. In the example shown in FIGURES 8 and 9, the heating chamber 100 has wave guide tubes 102 and 102 directed upwardly into the bottom 101 thereof, and these wave guides are respectively connected with superhigh frequency oscillators 103 and 103. The wall closure structure surrounding the heating chamber is composed of a lower and an upper portion, as shown in FIGURE 9. The lower portion 104 consists of spaced inner and outer walls 106 and 107 spanned by a bottom 101, thus forming a peripheral trough for liquid 105. A chamber floor 108 is provided at the upper end of the inner wall 106. As material for the floor, a heatproof synthetic such as silicone resin, strengthened with such inorganic insulating material as glass or glass fibre, is suitable. Such material as the above is adapted to transmit high frequency wave energy applied from below the floor 108 to the object in the chamber with low loss. The upper closure portion 109 consists of a peripheral wall 110 having structural plan dimensions intermediate those of the lower walls 106 and 107, and a ceiling 111. A bracket 112, which extends upwardly from the upper face of the ceiling 111, is pivotally supported on the front end 113a of a lever 113. The lever 113 is mounted on a fulcrum 114, with its rear end 113b bearing against an overlying cam 115.

When the cam 115 pushes down the rear end 113b of the lever 113 as shown in FIGURE 9, the front end 113a is raised, pulling up the upper closure portion 109 and thereby opening the heating chamber 100. When the cam 115 is revolved, allowing the lever end to rise as shown in FIGURE 8, the upper closure portion 109 is lowered, so that the lower edge of the peripheral wall 110 is immersed in the liquid 105. As a result, in the same manner as previously described, the high frequency heating wave energy is shielded by the conductive liquid and thus does not leak between the upper and lower closure portions to the exterior. The operation of the cam 115 can conveniently be carried out by means of a suitable foot pedal. In this embodiment, it is necessary that the operational control of the high frequency oscillators be interlocked with the operation of the cam 115, so that oscillation occurs only when the chamber 100 is closed.

In connection with the embodiment shown in FIGURES 8 and 9, a conveyor such as that shown in FIGURES 1 to 5 can be used. In this case the longitudinally directed sides of the double-walled lower closure portion are elongated, and the chains are arranged within the liquid in the manner shown in FIGURE 5. In this combination the cam 115 may be operated by the door driving mechanism 48 shown in FIGURES 1 and 3. In case the conveyor is included as noted, the floor 108 is not necessarily required.

An advantage of the embodiment shown in FIGURES 8 and 9 lies in the fact that the volume of the heating chamber can be adjusted. More specifically, the heating chamber acts as a cavity resonator with respect to the high frequency radiation, and by variation of the chamber volume the resonant mode therein is also varied. As the variation of the resonant mode causes variation in the distribution, magnitude and direction of high frequency wave potential and current in the heated object, variation in volume by appropriate control of the cam 115 may be carried out during irradiation to achieve uniform heating in the

object in process. In the present example, as the upper casing portion 109 is coupled to the lower portion 104 by the liquid only, the chamber volume variation can be made smoothly with practically negligible mechanical resistance, and the variation in operational volume of the chamber can be carried out throughout the vertical range in which the lower edge of the upper casing portion 109 remains immersed in the liquid.

The conveyor chains shown in FIGURES 1 to 5, as noted, are shielded against the high frequency electric field by being immersed in the liquid. However, in certain cases wherein smooth running and/or rust prevention call for application of lubricating oil to these chains, it is desirable that the chains themselves be kept out of the sealing liquid. FIGURES 10 and 11 show a means by which this result is achieved in the present invention by locating the chains in individual side chambers which are themselves sealed from the heating chambers by liquid.

In FIGURES 10 and 11, the device includes side liquid tanks or troughs 4, floors 29, side walls 33 and ceilings 34 similar to those shown in FIGURES 1 to 5. At each side of a tunnel-like heating chamber 120 which is defined by the floor 29, side walls 33 and the ceiling 34, there is formed an elongated small chamber 122, extending longitudinally parallel to the heating chamber and hermetically closed from the exterior by a wall 121 which connects the outer face of the side wall and the outer wall of the liquid tank or trough 4. In the same manner as that explained with reference to FIGURES 1 to 5, each conveyor chain 26 is made to run in its respective small chamber 122. A large plurality of lateral rods 123 are end supported by and between the chains, thus providing a grid for carrying the material in process. Each of the lateral rods 123 is formed on each side with a depending U-shaped portion 123b between its middle or grip portion 123a and its pivotal junction with the respective chain 26. The U-shaped portions 23 straddle the lower borders of the chamber walls 35, which latter extend downward below the liquid level, as shown in FIGURE 10. At longitudinal intervals equal to the station length shown in FIGURE 1, an appropriate one of the rods 123 has rotatably mounted on its middle portion 123a a screen 124, a bottom weight 125 being provided to hold the screen normally upright. Each end of each tank or trough 4 is constructed with a pair of joined ramps 126 and 127 extending above the liquid level as shown in FIGURE 11, these ramp combinations being adapted to guide the U-shaped rod portions 123b smoothly into and out of the troughs in the manner illustrated.

In the modification shown in FIGURE 12, each conveyor chain 26 is contained in a side chamber 126 which is directly connected with the heating chamber 120, and straight transverse rods 127 are provided to form the grid connecting the two side chains. In this arrangement, the apparatus is so proportioned that the lateral distance between the inner border 128 of each of the two side chambers 126 and its respective chain 26 is $\frac{1}{4}$ of the wavelength of the heating high frequency wave within its tube. As a result, the impedance of the side chamber 126 viewed from the border 128 is very high, because the outer side of the side chamber is short circuited by the chain 26, so that the high frequency wave cannot substantially penetrate the side chamber. In such case as the above example wherein the conveyor chains are employed without requiring side liquid tanks 4, it is nevertheless desirable that the doors at the entrance and exit of the processing tunnel be sealed with liquid in the manner previously described, in order that leakage of high frequency radiation at these points be prevented as set forth.

What is claimed is:

1. A high frequency heating device comprising a first housing section formed of conductive material and having channels on the periphery thereof, a second housing section of conductive material and having side walls extending into said channels, said housing sections together

forming a closed chamber, a conductive liquid filling said channels to a level above the bottom edges of said side walls and means for feeding high frequency energy into said closed chamber, said conductive liquid sealing said sections and minimizing the loss of radiant energy from said chamber.

2. A high frequency heating device according to claim 1 wherein at least one of said housing sections is vertically adjustable to modify the volume therein and thereby the resonant mode of said device.

3. A high frequency heating device according to claim 1 wherein one said housing section is provided with removable opposing wall portions forming an entrance and exit for said housing sections, a conveyor extending through said housing sections, power driven means externally of said housing and coupling means carried by said power driven means and extending through said conductive liquid and into said housing sections, said coupling means engaging said conveyor for moving the latter through said housing sections when the entrance and exit are opened.

4. A high frequency heating device according to claim 1 wherein at least one of said housing sections is provided with at least one removable wall portion, a conveyor for moving articles to be heated into and out of said housing sections, and means within said channels and coupled to said conveyor for operating said conveyor.

5. A high frequency heating device according to claim 1 wherein at least one of said housing sections is provided with at least one removable wall portion, a conveyor for moving articles to be heated into and out of

said housing sections, closed channels extending from the walls of said one housing section adjoining the removable wall portion, and power driven means within said closed channels and coupled to said conveyor, each of said power driven means being spaced from the adjoining wall of said one housing section a distance equal to $\frac{1}{4}$ wavelength of the energy introduced into said housing sections.

6. A high frequency heating device according to claim 4 wherein two opposing walls of said one housing section are removable to form an entrance and exit, said conveyor extends through said housing sections and said device includes energy blocking screens carried by said conveyor at spaced intervals, said screens being disposed on each side of an article to be heated and said energy being introduced into said housing sections between pairs of spaced screens.

7. A high frequency heating device according to claim 1 wherein one of said housing sections includes energy absorbing means to maintain a load on said high frequency supply when an article is not disposed in said housing sections.

References Cited

UNITED STATES PATENTS

3,335,253 8/1967 Jeppson et al. ----- 219—10.55

RICHARD M. WOOD, *Primary Examiner*.

L. H. BENDER, *Assistant Examiner*.

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