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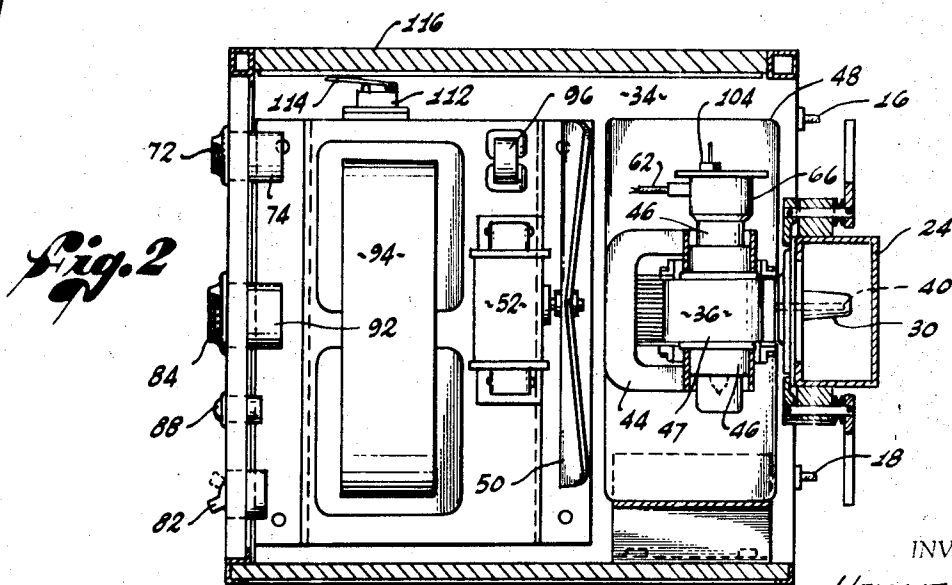
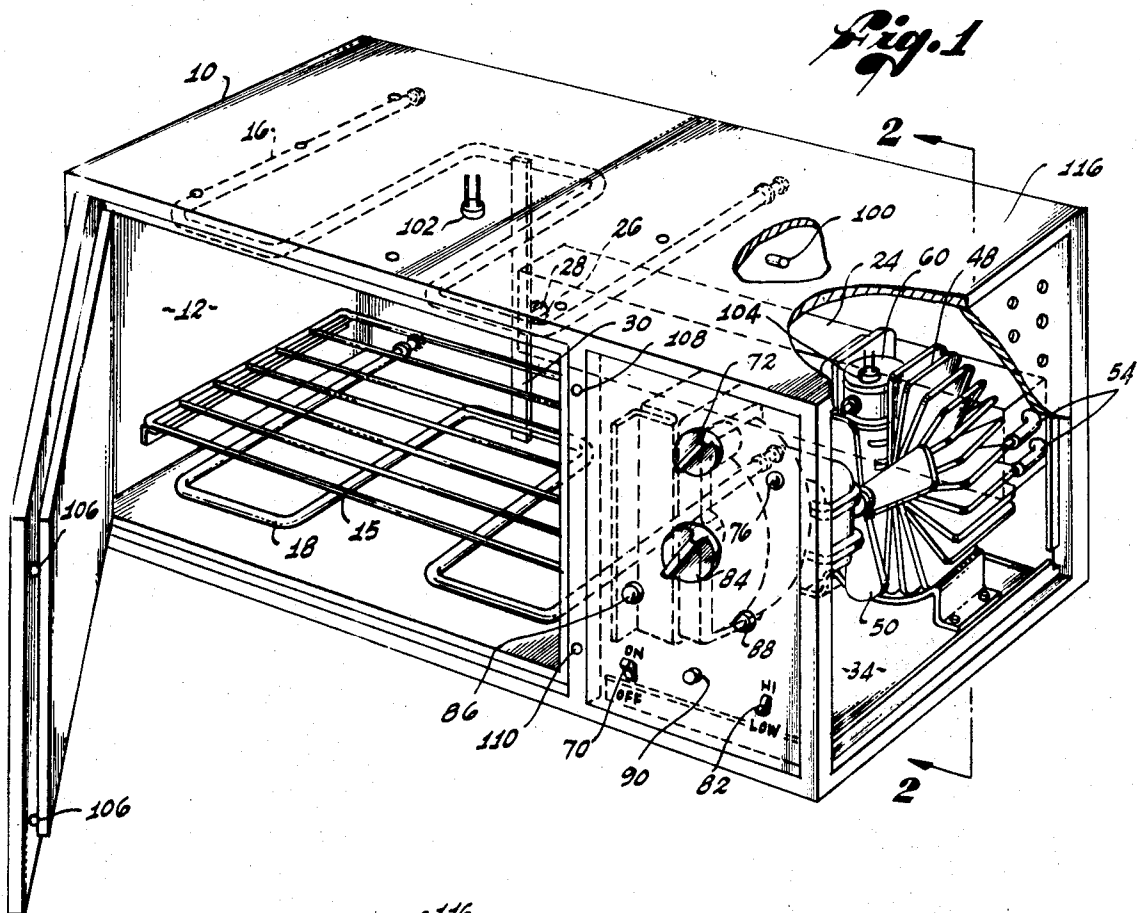
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3,523,170

CONTROL SYSTEM FOR MICROWAVE HEATER APPARATUS

Filed Oct. 27, 1967

2 Sheets-Sheet 1



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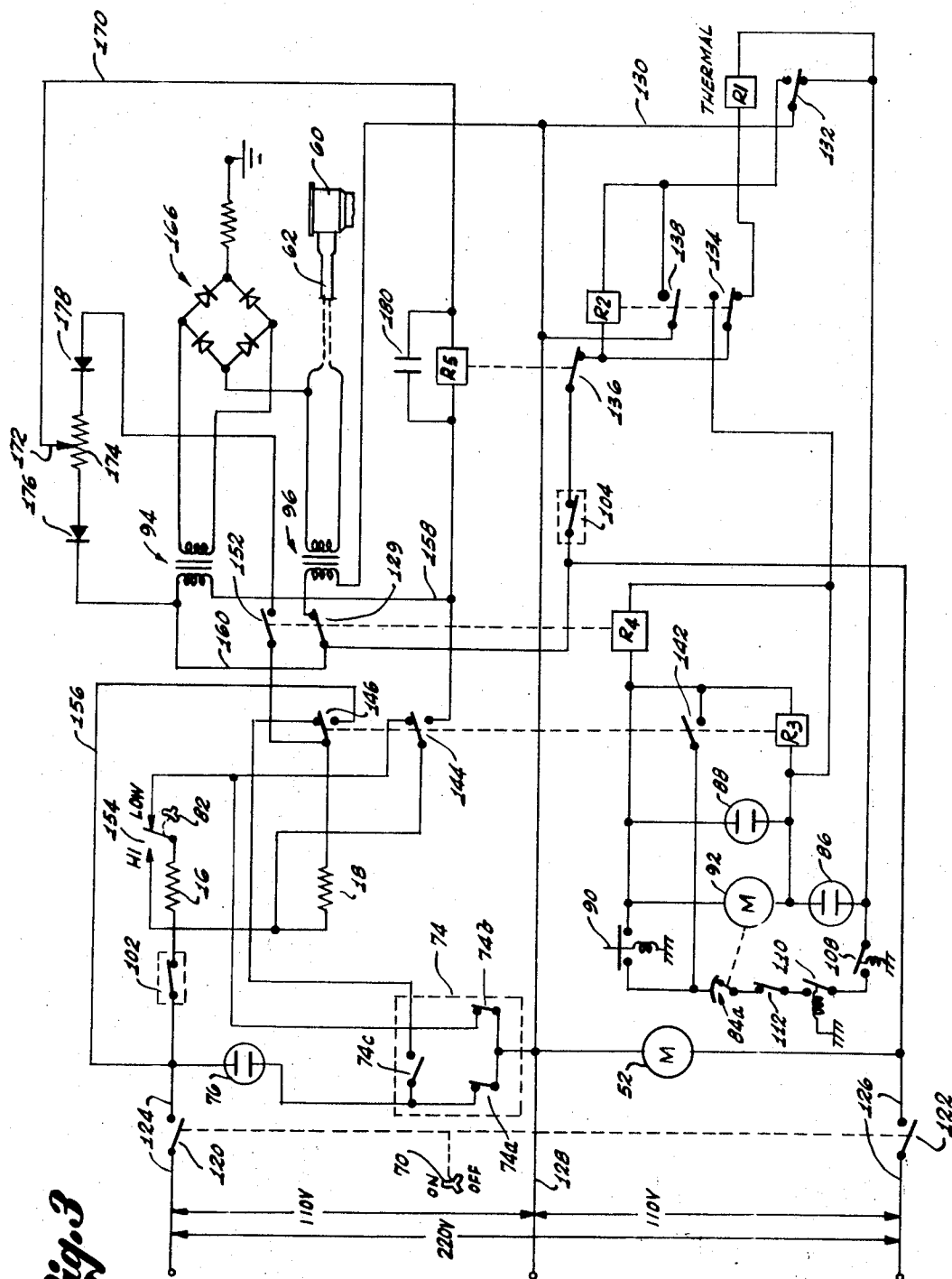
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CONTROL SYSTEM FOR MICROWAVE HEATER APPARATUS

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U.S. Cl. 219—10.55

8 Claims

ABSTRACT OF THE DISCLOSURE

A microwave oven has heater elements adapted for conventional thermal heating and to be excited via a waveguide by a magnetron. For a microwave operation, a thermal relay prevents such operation until the filament has been heated for a predetermined period. Then a network of relays can be rendered operable to disconnect the filament transformer and connect the power transformer to the magnetron.

A bridge is formed of the power transformer primary, one or both heater elements, and respective portions of a potentiometer, with a relay connected to the wiper and operable to disconnect such primary in response to a predetermined load unbalance.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to microwave heater apparatus, and more particularly to electrical control systems therefor.

Description of the prior art

Magnetrons used in microwave heater apparatus are well known. Considerable time, effort and expense have been devoted to adapting them for use in cooking foodstuffs. However, microwave ovens for home use have had a number of drawbacks. The magnetrons must, of course, operate from high voltage power supplies, e.g., transformers which supply 2,500 volts or more. Considerable damage to such a magnetron occurs whenever the high power is applied when its filament has not reached a proper temperature, or for any reason that allows the magnetron to exceed its breakdown voltage. Heretofore, there has been no effective way to stop operation of a magnetron, once started, in time to prevent undesired damage. Also, there has been no effective way to assure that magnetron operation does not start, initially and following a momentary power interruption, unless the filament has heated for a sufficient time to reach the proper temperature.

SUMMARY OF THE INVENTION

The invention is directed to a unique control system for a magnetron power supply, to effect excitation of and radiation of microwave energy by heater elements in a cavity. Means for applying power to the magnetron is prevented from operation until the filament thereof has been heated for a period sufficient to heat it to correct temperature. Means for connecting the power transformer and one or both elements to a voltage source is automatically made inoperative upon any significant change in magnetron load.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of microwave cooking apparatus, showing the arrangement of basic elements incorporated in the control system of the invention;

FIG. 2 is a sectional view taken along the lines 2—2 of FIG. 1; and

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FIG. 3 is a schematic diagram of the control system of the invention for applying microwave and/or thermal energy to the heater elements and for protecting critical parts from possible damage.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1 and 2 illustrate microwave cooking apparatus of the type covered in a copending application, "Microwave Heating Apparatus," Ser. No. 595,995, filed Nov. 21, 1966 now Pat. No. 3,440,386, and assigned to the same assignee as this application. As shown in FIG. 1, a cabinet 10 for microwave cooking apparatus has an oven chamber 12 and a door 14 through which to insert and remove foodstuffs. Foodstuffs are supported on a rack 15 in the chamber. Positioned above and below the rack 15, and adjacent the top and bottom surfaces within the chamber, are elements 16, 18, which are adapted to be used for both microwave and thermal cooking. For microwave operation, the elements function as traveling wave antennas for radiating microwave energy throughout the resonant cavity defined by the oven chamber 12 and the closed door 14.

In this latter connection, a waveguide 24 extends along the outer wall at the back of the cabinet 10, and has an opening in which a sleeve 26 is secured. The sleeve 26 forms part of a coaxial line, and is in electrical contact at its inner end with the back wall of the cavity. An output probe 28 extends from the interior of the waveguide 24, through the sleeve 26, and into the interior of the chamber 12, where it is connected to a vertical metal bar 30 that has its upper and lower ends conductively connected to the elements 16, 18.

The waveguide 24 extends along the exterior of the back wall of the cabinet 10 and past the chamber 12 to the rear of a compartment 34. This compartment houses a magnetron structure 36 wherein the shield 38 that surrounds the output probe 40 extends into the waveguide 24. The magnetron 34 is suitably clamped to the waveguide.

As shown, the magnetron structure 36, including the U-shaped permanent magnet 44 that extends between the pole pieces 46 on either end of its anode 47, is located in a cooling fin structure 48. Located next to the cooling fin structure 48 is a fan 50 and the motor 52 therefor, for use in blowing air through the cooling fin structure 48.

One or more inlet pipes 54 (see FIG. 1) extend from the end of the waveguide 24 and toward the interior of the compartment 34. Thus, air from the fan 50 passes through the cooling fin structure and enters the waveguide through the pipes 54. As explained in the above-mentioned copending application, air blown past the cooling fin structure is utilized both to enhance dissipation of heat from the magnetron through the fins, and also to project air through the waveguide 24 and into the interior of the oven chamber 12.

Power is supplied to the magnetron 36 through a connector 60, via which a cable 62 is adapted to supply energy for heating the filament (not shown), and for supplying energy to the cathode for effecting magnetron operation to propagate energy down the waveguide 24. Energy so propagated is coupled to the elements 16, 18 via the output probe 26 and the metal bar connector 30, whereby to cause foodstuffs placed on the rack 15 to be cooked by microwave energy radiated by the elements 16, 18.

Referring to FIG. 1, controls for effecting thermal and/or microwave cooking are mounted on the panel in front of the compartment 34. In the particular arrangement shown, an "on-off" switch control element 70 is located in the lower left-hand corner of the panel, and is provided for supplying power to the control system of the invention. Near the top of the panel is a manual

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control knob or dial 72 for a thermostat 74 mounted on the back of the panel (FIG. 2), the knob 72 being rotatable against a temperature scale. A lamp 76 is mounted near the knob 72, and is included in circuit with the thermostat 74.

The remaining controls shown are utilized in connection with microwave cooking. In the lower right-hand corner of the panel is a "hi-low" switch control element 82, the position of which determines whether one or both of the heater elements 16, 18 are used in microwave cooking. Below the knob 72 is a second manual control knob 84, which is rotated against a time scale to indicate the time in seconds or minutes for microwave cooking. Below the knob 84, and on opposite sides of the panel, are respective lamps 86, 88. One lamp 86 is a "standby" indicator, and signifies that the magnetron circuitry is in readiness for microwave cooking. As will be seen, the standby lamp 86 does not light until a predetermined delay after the switch 70 is turned on.

The other lamp 88 is an "on" indicator to signify when microwave cooking is in process. To initiate microwave cooking, a pushbutton 90 is provided at the bottom of the panel between the switch control elements 70, 82. Assuming the standby lamp 86 is illuminated, depressing the pushbutton 90 initiates microwave cooking, and the lamp 88 lights to visually indicate that microwave cooking is in process.

Again referring to FIG. 2, the control knob 84 is adapted to set a timer motor 92 that is carried on the inside of the panel in the compartment 34. Also contained in the compartment 34 is a large transformer 94 that serves as the power supply for the magnetron during its operation for propagating microwave energy through the waveguide 24, and a small filament transformer 96. Various relays, switches and wiring illustrated in FIG. 3 are also contained in the compartment 34. However, for purposes of simplicity, such components are not illustrated in FIG. 2.

Before proceeding to the description of FIG. 3, reference will be made to FIGS. 1 and 2 for the locations of certain other components to be referred to in describing the circuit operation. A thermostat bulb 100 for the thermostat 74 is shown extending from the compartment 34 into the oven cavity 12. Another thermostat 102 is positioned on top of the oven, and still another thermostat 104 is positioned on top of the connector 60. Also, the outer end of the door 14 carries a pair of spaced projections 106 which are adapted, upon closing the door, to enter aligned openings and press the plungers of respective door interlock switches 108, 110. Finally, and referring to FIG. 2, a cover interlock switch 112 is carried in the upper portion of the compartment 34. As shown, the switch 112 has an actuating lever 114 which, when the cover 116 of the oven is set in place, is depressed to close the switch 112.

Referring now to FIG. 3, switch control member 70 operates ganged switches 120, 122, which are connected in lines 124, 126 of a voltage supply, e.g., 220-volt lines of a house supply.

For controlled thermal heating thereof, the elements 16, 18 are adapted to be connected across lower voltage lines, e.g., between one of the lines 124 and a reference or neutral line 128 such that a predetermined voltage, e.g., 110 volts, exists between the lines 124, 128 and 126, 128. As will be noted, the fan motor 52 is connected across the lines 126, 128. Hence, immediately upon closing the switches 120, 122, the motor 52 is set into operation, and the fan runs continuously during thermal cooking and microwave cooking.

The lower 110-volt lines 126, 128 are utilized to supply power to means for controlling operation of the magnetron and exciting one or both elements 16, 18 for microwave cooking. The primary winding of the filament transformer 96 is connected across the lines 126, 128 via a normally closed switch 129, to be heated for a

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minimum period determined by the cycle of heating and cooling of a relay R1. In this connection, the line 128 is connected at 130 to the movable contact of a single-pole, double-throw switch 132 of the relay R1. The relay R1 is a thermal relay, and its switch 132 is a snap-action switch. As shown, one of the fixed contacts of the switch 132 is connected to one end of the coil of the relay R1. The other end of the coil of the relay R1 is connected to one fixed contact of a single-pole, double-throw switch 134 of a relay R2. The movable contact of the switch 134 normally engages the fixed contact thereof which is connected to the coil of the relay R1. Further, the movable contact of the switch 134 is connected to a normally closed switch 136. As shown, the thermostat 104, which is a normally closed switch, is connected between the line 126 and the switch 136.

Accordingly, when power is turned on, the thermal relay R1 is connected across the lines 126, 128 and is energized. After a predetermined delay, the thermal relay R1 is heated sufficiently to actuate its switch 132, whereupon its movable contact snaps over to the other fixed contact thereof. When this occurs, the coil of the relay R2 is connected across the lines 126, 128. This will be seen by tracing through the line 128, the connection 130, the upper position of the movable contact of the thermal relay R1, the coil of the relay R2, and the switches 136, 104 to the line 126.

As shown, the relay R2 also has a normally open single-throw switch 138. When the relay R2 is energized switch 138 closes and the movable contact of the switch 134 is moved to its other fixed contact. Switch 138 constitutes self-holding means for the relay R2. As will be observed, the movable contact of the switch 138 is connected to one end of the coil of the relay. Accordingly, closure of the switch 138 connects the coil of the relay R2 between the lines 126, 128, thus keeping the relay R2 energized after the thermal relay R1 cools down.

In this latter connection, when the thermal relay R1 heats up sufficiently to actuate its snap switch 132, such action automatically disconnects the coil of the relay R1 from the power source. Accordingly, the thermal relay cools down, and after a predetermined period its switch 132 snaps back to its original position. When this occurs, the thermal relay is not again re-energized, because once the relay R2 is energized, the coil of the thermal relay is no longer connected across the lines through the switch 134.

From the time power is initially turned on, the total delay occasioned by the heating up and the cooling down of the thermal relay R1 is sufficient to permit the magnetron filament, via filament transformer 94, cable 62 and connector 60, to be brought up to correct temperature for magnetron operation. Only after the thermal relay has cooled down, and its switch 132 has snapped back to its normal position, is the circuit in readiness for magnetron operation. When the relay R1 has thus cooled down, the standby light 86 turns on to indicate that microwave cooking can be instituted. To this end, it will be noted that when the relay R2 is energized, and the movable contact of its switch 134 is brought up against its upper fixed contact, the standby light 86 is connected across the lines 126, 128. The circuitry involved is traceable through the line 128, connection 130, the switch 132, the standby light 86, and switches 134, 136, 104 to the line 126.

After the standby light 86 turns on, and the door of the cavity is closed, thereby to close the door interlock switches 110, 112, microwave operation is instituted by pressing the pushbutton 90. Prior to this, of course, the timer motor 92 is set for the desired time for microwave cooking. As shown in FIG. 3, a rotary switch 84a (which is operated by the control knob 84 shown in FIG. 1) has its movable contact coupled to the timer motor 92,

thereby to set the timer motor for operation for a period of time depending upon the angular position of the movable contact of the switch 84a.

Closing the pushbutton 90 simultaneously starts the timer motor 92, turns the lamp 88 on, and energizes a pair of relays R3, R4. The circuitry through which each of these devices is traceable includes switches 132, 108, 110, 112, 84a, 90, 134, 136 and 104.

As shown, the relay R3 has a normally open switch 142 and a pair of single-pole, double-throw switches 144, 146, in which the normal positions of the movable contacts thereof are shown in their upper positions in FIG. 3. When the relay R3 is energized, the movable contacts of its switches 142, 144, 146 are closed against their lower fixed contacts, in which case the relay R3 is made self-holding via switch 142, and one or both elements 16, 18 (depending upon the position of the switch control element 82) are connected to the primary of the transformer 94.

At this point, it should be noted that the relay R4 controls the normally closed switch 129 that connects the primary of transformer 96 across lines 126, 128, and a normally open switch 152 which has its movable contact connected to that of the switch 146. Upon the relay R4 being energized, its switch 129 opens to disconnect the filament transformer 96 from the filament of the magnetron, and to permit the magnetron to be connected to the secondary of the high voltage transformer 94.

Again referring to the switch control element 82, it controls the position of the movable contact of a single-pole, double-throw switch 154, and the position of such movable contact determines whether one or both of the elements 16, 18 are connected in circuit with the primary of the high voltage transformer 94. In the position shown, the switch 154 is set in the "low" position. As will be observed, the upper element 16 and the thermostat 102, which is a normally closed switch, are connected in series between the lines 124 and the movable contact of the switch 154. In the "low" position of such movable contact, the adjacent end of the element 16 is connected to the upper fixed contact of the switch 144. However, since the movable contact of the switch 144 is not in its lower position, the upper element 16 is disconnected from the transformer 94. However, the lower element 18 is connected to the transformer 94. As will be observed, the lower element 18 has its ends connected to the movable contacts of the respective switches 144, 146; the lower fixed contact of the switch 146 is connected at 156 to the line 124; the lower fixed contact of the switch 144 is connected at 158 to one end of the primary of the transformer 94; and the other end of the primary of the transformer 94 is connected at 160, 162 to the line 126. Thus, in the "low" position of the switch 154, the lower element 18 and the primary of the transformer 94 are connected in series across the high voltage lines 124, 126.

When the switch 154 is connected in its "hi" position, the elements 16, 18 are connected in parallel, and this parallel combination is connected in series with the primary of the transformer 94 between the high power lines 124, 126. For this purpose, the "hi" fixed contact of the switch 154 is connected to the movable contact of the switch 144. Accordingly, in addition to the previously described path in which the lower element 18 and the primary of the transformer 94 are connected in series across the lines 124, 126, a parallel path is established in which the upper element 16 is connected in series with the primary of the transformer 94 across the same lines. This latter circuit is traced through line 124, switch 102, the upper element 16, switches 154 and 144, the connection 158, the primary of the transformer 94, and connections 160, 162 to the line 126.

The elements 16, 18 have substantially equal values of resistance, e.g., 10 ohms. Accordingly, with the elements 16, 18 connected in parallel as above described, there is half the value of resistance in series with the transformer

94 as is the case with only one element 18 connected therewith. Thus, more effective microwave heating occurs in the "hi" position of the switch 154 than in the low position thereof.

As will now be apparent, microwave heating when initiated will continue until the timer motor 92 causes the switch 84a to open. When this happens, relays R2-R4 are de-energized, transformer 94 is disconnected, and filament transformer 96 is reconnected. Also, lamps 86, 88 are extinguished.

This invention includes unique safety features to prevent damage to the magnetron during microwave heating and also for preventing operation of the magnetron at any time until after the filament has been heated to the correct temperature for magnetron operation. As will be observed in FIG. 3, the output of the secondary of the high voltage transformer 94 is rectified via a full-wave rectifier 166, for applying between the anode and cathode a voltage pulsing at a ripple frequency that is twice the frequency (60 cycles) of the applied voltage. As is well known, a magnetron operates at a very high applied voltage, e.g., 2,500 volts. Further, a properly operating magnetron has a Zener type voltage-current characteristic at the desired operating voltage. As is also well known, such a magnetron is susceptible to damage from a number of causes, e.g., applying high voltage to the magnetron before its filament is heated to the correct temperature (as may result from a filament transformer having shorted turns in its secondary winding), a bad diode in the rectifier 166, a shorted secondary winding in the transformer 94. In prior art practices, the approach has been to use fuses as protective devices in selected locations. However, such precautions at best are aimed only at minimizing damage to a magnetron. Since fuses take a finite time before melting, one is unable to avoid damage to a magnetron with their use.

Unique means incorporated in the control system of this invention is effective to avoid damage to a magnetron from any of the various causes heretofore experienced. To this end, a unique bridge is provided. As shown, a relay R5, which controls the normally closed switch 136, has one end of its coil connected to the lower fixed contact of the switch 144, and also to one end of the primary winding of the transformer 94. The other end of the coil of the relay R5 is connected at 170 to the wiper 172 of a potentiometer 174. One end of the potentiometer resistor is connected through a diode 176 to the remaining end of the primary winding of the transformer 94, and the other end of the potentiometer resistor is connected through a diode 178 to the fixed contact of the switch 152. If desired, a single diode placed in the lead 170 can be used in lieu of the two diodes 176, 178. As shown, the coil of the relay R5 is shunted by a capacitor 180.

Thus, a bridge is formed in which the primary winding of the transformer 94 forms one leg; one or both elements 16, 18 (depending upon the position of the switch 154) forms a second leg; and the remaining legs are formed by the portions of the potentiometer resistor and diodes 176, 178 on either side of the wiper 172. The function of the diodes is to supply D-C current to the relay R5. Initially, and with the magnetron operating, the wiper 172 is adjusted to a position in which no current flows through the relay, i.e., the potentiometer is adjusted so that the voltage between one end of the potentiometer resistor and the wiper balances the voltage drop across the element 18 (or elements 16, 18 in parallel), and so that the voltage drop between the other end of the potentiometer resistor and the wiper balances the voltage drop across the primary winding of the transformer 94.

The above-described bridge is one which is extremely fast acting, because any changes in magnetron operation are instantaneously reflected in one leg of the bridge, i.e., in the primary side of the transformer 94. The relay R5 is set, via its shunting capacitor 180, to respond to a bridge unbalance of only a few volts, e.g., seven volts. The magnetron would be damaged if its breakdown volt-

age were exceeded by a few hundred volts. However, all that is needed to energize the relay R5 is that excess which reflects a 7-volt unbalance in the bridge. Immediately upon the relay R5 being energized, it opens its switch 136, and thereby cuts off power to the transformer 94.

Regarding the amount of voltage change reflected in the primary winding of the transformer 94 which is sufficient to unbalance the bridge, it should be noted that in switching between low and high microwave operation, the unbalance resulting from the change in resistance (in switching from the element 18 to the elements 16, 18 in parallel) is not sufficient to trigger the relay R5. While putting these resistances in parallel reduces the resistance in that leg, the magnetron load prevents the bridge from being upset sufficiently to trigger the relay R5. In this connection, it should be noted that the magnetron is a load with a Zener curve, and hence there is present a breakdown voltage that regulates the voltage drop across the primary of the transformer 94. In fact, one can monitor the voltage drop across the relay R5 when switching from the low to the high microwave positions, and observe a change of only two or three volts.

If a power failure occurs during microwave heating, further microwave operation cannot be reinstituted, even though power is immediately restored, until after the full delay occasioned by heating and cooling of the thermal relay R1. It will be recalled that magnetron operation could be started only after the thermal relay R1 had cooled back down, and its snap switch 132 had returned to its normal position. If power is cut off momentarily, relays R2, R3 and R4 are de-energized, whereupon the primary winding of the filament transformer 96 is again connected across the lines 128-126. Since the thermal relay R1 has cooled down, the entire cycle of heating and cooling of the thermal relay must occur before the magnetron can again be set into operation.

For thermal heating, power is supplied across the lines 124, 128. When the switch 120 is closed, the lamp 76 and the thermostat 74 are connected across these lines. The thermostat 74 is a conventional one commonly employed in switching between a pair of heater elements for thermal cooking. As shown in FIG. 3, the thermostat has a pair of temperature sensitive switches 74a, 74b, which are closed when power is initially applied. The control knob 72, of course, is set at the temperature desired for thermal cooking. In this latter connection, the control knob 72 can be set at a "bake" position and a "broil" position. The thermostat 74 has a normally open switch 74c which is closed only when the control knob is moved to the "bake" position. In both the bake and broil positions, the upper element 16 is connected across the lines 124, 128 through switch 74b, and in the bake position the elements 16, 18 are connected in series across the lines 124, 128 through switches 74c, 74a. Inspection of FIG. 3 will show that the elements are connected in this same fashion regardless of the position of the switch 154.

The thermostats 102, 104 previously mentioned provide additional safety features. In the event the oven cavity heats beyond a safe temperature, the thermostat 102 on the top of the cavity opens up and prevents power from being supplied for thermal and high microwave cooking. In such a situation, low microwave operation is still possible, but this will not overheat the cavity. In the event the magnetron overheats, the thermostat 104 opens to prevent further application of power to the transformer 94.

The invention operates the same for a multiple pushbutton array for selecting different times of operation of a timer motor. For example, pushbutton switch 90 and switch 84a (and control knob 84) may be replaced with an array of pushbutton switches of the type that are operated by cams controlled by the timer motor. In such

case, the relay R3 need not be self-holding, i.e., switch 142 would not be needed. When any such switch opens, the relays are deenergized and primary windings 96, 94 are disconnected and connected as previously described. In either or both arrangements, a buzzer may provide audible indication when the cooking period is ended.

From the foregoing, it will be apparent that various modifications can be made in the circuits illustrated and described without departing from the spirit and scope of this invention. Accordingly, it is not intended that the invention be limited, except in accordance with a reasonable interpretation of the appended claims.

I claim:

1. In combination:

an oven cavity;

a transformer having primary and secondary windings; a microwave generator load coupled to said secondary winding;

an element to be excited by energy from said generator load for radiating energy into said cavity;

a pair of voltage lines;

means for connecting said primary winding and said element across said lines, and including a normally closed switch; and

means responsive to voltage changes of predetermined magnitude in said load as reflected in said primary winding to open said switch and disconnect said primary winding and said element from across said lines, including:

a relay for operating said switch, said primary winding and said element forming two arms of a bridge, said relay having a coil with one end connected between said primary winding and said element, and

a potentiometer having a resistor and wiper, said wiper being connected to the other end of the relay coil, said resistor having its ends coupled to said lines, whereby the portions of said resistor between the wiper and said lines form the other legs of the bridge.

2. In combination:

a cavity;

microwave generator means;

a power transformer having a primary winding for connection to a voltage source, and a secondary winding for connection to said generator means;

a pair of A-C voltage lines;

a normally closed switch connected between one end of said primary winding and one of said lines;

an element in said cavity to be excited by energy from said generator means;

means for connecting said element between the other end of said primary winding and the other line;

a relay for operating said switch and having a coil, one end of said coil being connected between said element and the other end of said primary winding; potentiometer means having a resistor and wiper, said wiper being coupled to the other end of said relay coil, and the ends of said resistor being coupled to said lines; and

respective diodes connected between the ends of said resistor and said lines, said diodes being connected in the same direction.

3. The combination of claim 2, wherein said generator means is a magnetron having a filament;

a filament transformer having primary and secondary windings, said filament being connected to the secondary winding of said filament transformer;

means for connecting the primary winding of said filament transformer to a voltage source; and

means to disconnect the primary winding of said filament transformer from such voltage source and to effect connection of said element and the primary winding of said power transformer between said voltage lines.

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4. The combination of claim 3, wherein the voltage source includes one of said lines and a third line at a potential intermediate the potential between said lines, and wherein said disconnect and connect means includes delay means to prevent operation thereof for a predetermined period following connection of the filament transformer primary winding between said one and third lines.

5. The combination of claim 4, wherein said element is in an oven chamber, the oven having a door to be closed to form said microwave cavity therewith;

a waveguide externally of the oven having an output probe connected to said element,

said magnetron having an excitation probe extending into the waveguide;

normally open switch means being closed when said door is closed;

normally open pushbutton switch means in series with the door controlled switch means;

relay means in circuit with said pushbutton and door controlled switch means to be connected upon closure of both switch means between said one and third lines after said predetermined period; and

switches controlled by said relay means and in circuit with said connecting means and said disconnect and connect means for connecting said element and primary winding of the power transformer across said voltage lines and disconnecting the primary winding of said filament transformer from between said one and third lines.

6. The combination of claim 5, wherein said delay means includes a thermal relay, said thermal relay preventing operation of said relay means and the switches thereof for said predetermined period.

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7. The combination of claim 6, including a second element connected to the output probe of said waveguide, and switch means cooperable with switches of said relay means to selectively connect either said second element in parallel with said first-mentioned element, or said first-mentioned element alone, in series with the primary winding of said power transformer.

8. The combination of claim 2, including a diode connected between said wiper and the other end of said relay coil.

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