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POWER SUPPLY FOR A MAGNETRON

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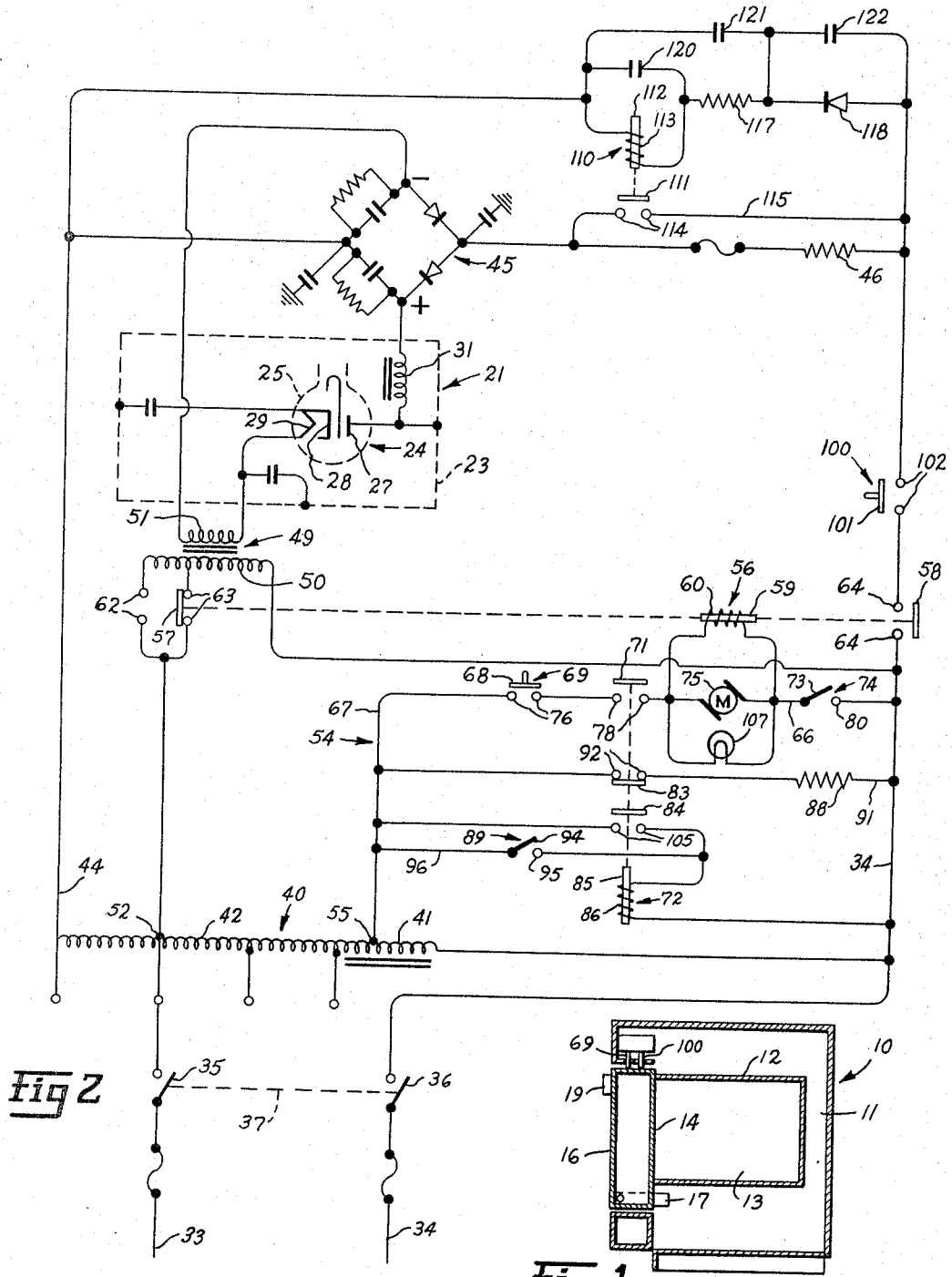


Fig 2

Fig. 1

INVENTOR.
DONALD F. HELFER

BY David M. Schiller

ATTORNEY

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POWER SUPPLY FOR A MAGNETRON

Donald F. Helfer, Evergreen Park, Ill., assignor to General Electric Company, a corporation of New York

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This inventon relates to power supplies for magnetrons and has particular relation to a power supply including a low voltage control circuit for controlling application of filament and anode voltage to a magnetron.

Magnetrons are employed in many applications including for example, electronic ovens for heating food by electromagnetic energy. In installations utilizing magnetrons it is desirable to make provision for assuring that the anode voltage cannot be applied until a predetermined time after application of the filament voltage. Such an arrangement minimizes the possibility of damage to the magnetron which might otherwise occur if the anode voltage were applied prior to sufficient heating of the filament. It is also desirable that the magnitude of filament voltage which is initially applied during the filament heating period be subsequently reduced to a lower operating magnitude when voltage is applied to the anode.

In the event of a power failure the respective circuits which apply voltage to the filament and anode of the magnetron are of course deenergized. As a result, the filament will cool and if anode voltage is applied upon restoration of power following the failure, the magnetron could possibly be damaged. It is therefore desirable to provide for delaying application of voltage to the anode after restoration of power following a power failure so as to prevent application of anode voltage when the filament is cold.

The control circuit for effecting the above-described functions should be connected to the low voltage side of the power supply. This permits utilization of a minimum number of conventional and inexpensive parts which contributes to a compact, low cost design. Although magnetron power supplies of previous design have incorporated one or more of the above desirable features, such power supplies have in the main not been entirely satisfactory due to their bulky, multipart and expensive design. Further, prior power supplies have failed to incorporate all of the above enumerated features in a single design.

It is therefore an object of the present invention to provide a novel and improved power supply for controlling application of voltage to the filament and anode of a magnetron which is of compact design employing a minimum number of conventional and inexpensive parts.

It is another object of the invention to provide a novel and improved power supply including a low voltage control circuit for positively preventing application of voltage to the anode of a magnetron until a predetermined time after application of voltage to the filament thereof.

It is a further object of the invention to provide a novel and improved power supply including a low voltage control circuit for delaying initial application of voltage to the anode of a magnetron a preselected time after application of voltage to the filament thereof and for also delaying application of the anode voltage after restoration of power following a power failure.

It is still another object of the invention to provide a novel and improved power supply including a control circuit for delaying application of voltage to the anode of a magnetron a predetermined time after application of voltage to the filament thereof and for reducing the magnitude of the filament voltage after the delay period.

It is a still further object of the invention to provide an electronic oven having a food receiving cavity closed by a door and having a time switch and a magnetron with a novel and improved power supply for permitting application of voltage to the anode of the magnetron only when a preselected time has elapsed after voltage is applied to the filament and only when the door is closed and the time switch is set.

In carrying out the invention in one form, a power supply for a magnetron is provided for controlling application of voltage to the filament and anode of the magnetron. The power supply includes supply circuits to be energized from a power source for supplying voltage to the filament and anode. Means are provided for effecting initial energization of the filament supply circuit to apply an initial magnitude of voltage to the filament. The power supply includes a low voltage control circuit for preventing application of voltage to the anode until a predetermined time after application of the filament voltage. The arrangement is such that when the filament heating period has elapsed and voltage is permitted to be applied to the anode of the magnetron, the voltage applied to the filament is reduced from its initial magnitude to a smaller operating magnitude. The time delay is introduced by a time delay device which is energizable under control of a control relay the energization of which is in turn controlled by the time delay device. The arrangement is such that after a predetermined period of energization of the time delay device, the control relay is energized to effect deenergization of the time delay device. In the event of a power failure, the control relay is deenergized to condition the time delay device for energization when power is restored following a power failure. This arrangement assures a delay in the application of voltage to the anode of the magnetron when power is restored following a power failure.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing, in which—

FIGURE 1 is a diagrammatic vertical section view of an electronic oven illustrating in particular the door switches thereof; and

FIGURE 2 is a schematic diagram of a power supply designed in accordance with the present invention.

The invention described herein is capable of a wide variety of applications and is described by way of example in association with a microwave oven employed to heat food. Referring now to the drawing, there is shown in FIGURE 1 an electronic or microwave oven **10** including a casing **11** containing a metal liner **12** defining a cavity **13** adapted to receive food to be heated. The liner **12** has an open end **14** at its left hand side as viewed in FIGURE 1, and the casing **11** has a door **16** in a front opening thereof at the left as viewed in FIGURE 1 and cooperating with the open end **14**. The door **16** is mounted adjacent its lower end upon a hinge structure **17** to be movable between a closed position wherein it extends vertically as illustrated, and an open position wherein the door extends substantially horizontally. A handle **19** is affixed to the door to facilitate movement thereof.

In order to effect heating of food placed in the cavity **13** the oven **10** includes a magnetron tube structure **21** (FIG. 2) comprising a metal housing **23** containing magnetron tube **24** which includes an evacuated envelope **25** containing an anode structure **27**, a cathode **28**, and a filament **29** for heating the cathode. The magnetron structure **21** includes a conventional coil **31** having terminals connected to a source of direct voltage and to the anode **27** for providing a magnetic field as understood by those skilled in the art. The anode **27** and the cathode **28** are electrically connected to the housing **23**. The output circuit and the transmission line structure conventionally associated with a magnetron in electronic oven applica-

tions are not shown. Suffice it to say that electromagnetic energy derived from the magnetron is directed to the cavity **13** to heat food placed in the cavity. The magnetron structure **21** forms no part of the present invention and therefore will not be described in further detail.

In accord with the present invention a novel and improved power supply is provided including a control circuit for controlling application of voltage to the anode and filament of the magnetron in a manner to positively prevent application of voltage to the anode until after voltage has been applied to the filament thereof for a predetermined minimum time. The arrangement is such that when the circuit is conditioned to permit application of anode voltage, the magnitude of voltage initially applied to the filament during the filament heating period is reduced to a smaller operating magnitude.

In order to effect energization of the power supply a source of alternating voltage is provided represented by the conductors **33** and **34** including respectively contacts **35** and **36** of a line switch **37**. The magnitude of voltage across conductors **33** and **34** may be of the order of 230 volts. An autotransformer **40** is connected for energization from the source and includes a winding **41** having end terminals connected to the conductor **34** and to a conductor **44**. The power supply includes voltage supply circuits for supply voltage to the anode **27** and filament **29** of the magnetron. In the illustrated embodiment, the supply circuit for the anode includes the conductors **34** and **44** and a voltage doubler network **45** connected for energization from the conductors **34** and **44** through a resistor **46**. The magnitude of voltage across conductors **34** and **44** approximates 245 volts. The network **45** has positive and negative terminals with the positive terminal connected to the anode **27** through the coil **31**. The supply circuit for the filament **29** in the embodiment illustrated includes a transformer **49** having a primary winding **50** and a secondary winding **51**, the primary winding having terminals connected respectively to the conductor **34** and to a tap **52** on the secondary winding **42** of the transformer **40**. Conductor **33** is connected to the tap **52** so that about 230 volts is applied to the primary winding **50**. The secondary winding **51** of transformer **49** has terminals connected respectively to the filament **29** and to the negative terminal of the network **45**. It is understood that the voltage supply circuits may assume forms other than those shown.

In order to control energization of the voltage supply circuits the power supply includes a low voltage control circuit **54** connected between a 115 volt tap **55** on the winding **41** of transformer **40** and the conductor **34**. The circuit **54** is arranged to delay energization of the voltage supply circuit for the anode of the magnetron until after the filament voltage has been applied for a time sufficient to properly heat the filament. For this purpose, the control circuit **54** includes an electromagnetic relay **56** having movable contacts **57** and **58** associated respectively with the filament and anode voltage supply circuits and mechanically connected to a magnetic plunger **59** surrounded by a coil **60**. The contact **57** cooperates with two sets of spaced fixed contacts **62** and **63** in separate energizing circuits for the primary winding **50** of transformer **49**, and the contact **58** cooperates with fixed spaced contacts **64** included in the conductor **34** forming part of the anode voltage supply circuit. The coil **60** is connected to a conductor **66** which is connected between conductor **34** and a conductor **67** leading to the tap **55**. The relay **56** is shown in a deenergized condition wherein contact **57** bridges contacts **63** and contact **58** is spaced from contacts **64**. The relay **56** is effective when energized to move its contacts **57** and **58** from the positions shown to positions wherein the contact **57** bridges contacts **62** and contact **58** bridges contacts **64**.

In order to control operation of the relay **56** a plurality of control elements are provided each in series with the coil **60** of relay **56**. These control elements include the movable contact **68** of a door switch **69** operated by the door **16** of the oven **10**, a normally open contact **71** of a control relay **72**, and a normally open contact **73** of a time switch **74** operated by a timer motor **75** connected in parallel with the coil **60** of relay **56**. The door switch **69** includes a pair of spaced fixed contacts **76** in the conductor **66** which co-operate with the movable contact **68** so that when the door **16** is closed, the contacts **68** and **76** engage, and when the door **16** is open, these contacts are disengaged. The movable contact **71** of relay **72** cooperates with a pair of spaced fixed contacts **78** included in conductor **66**, and the movable contact **73** of the time switch **74** cooperates with a fixed vontact **80** also in conductor **66**. The time switch **74** is designed to be manually setable from an "off" position wherein contacts **73** and **80** are spaced or open to a timing position wherein the contacts **73** and **80** are engaged or closed. When the motor **75** is energized, the time switch times out from its set position to its "off" position at which time the contacts **73** and **80** open.

The relay **72**, in addition to controlling operation of the relay **56**, also controls operation of a time delay device which introduces the time delay in the application of the anode voltage and which also controls operation of the relay **72**. For this purpose the relay **72** includes, in addition to the movable contact **71**, a normally closed contact **83** and a normally open contact **84** all of which are mechanically connected to a magnetic plunger **85** surrounded by a coil **86**. The contact **83** controls energization of the time delay device which may be of any suitable construction. In the preferred embodiment, the time delay device includes an energizable element **88** in the form of a heater which controls operation of a thermally responsive switch **89**. The heater **88** is included in a conductor **91** which is in parallel with conductor **66** and which includes a pair of spaced fixed contacts **92** engageable by the contact **83** of relay **72**. The switch **89** controlled by heater **88** includes a movable contact **94** cooperating with a fixed contact **95** included in a conductor **96** which also includes the coil **86** of relay **72** and which is in parallel with the conductors **66** and **91**.

In order to provide an additional control of the voltage supply circuit for the anode of the magnetron the invention provides an additional door switch **100** including a movable contact **101** cooperating with a pair of spaced fixed contacts **102** in series with the fixed contacts **64**. The door switch **100** operates in the manner of the door switch **69** in that its movable contact **101** is disengaged from the fixed contacts **102** when the door **16** is open, and is in engagement with the fixed contacts **102** when the door **16** is closed. By way of example as shown in FIG. 1, the switches **69** and **100** are mounted above the door **16** with their operating members in engagement with the upper surface of the door **16** so as to be depressed to cause engagement of their movable and fixed contacts. The movable contacts may be spring biased so that when the door **16** is open, the movable contacts are urged out of engagement with the associated fixed contacts. With the described arrangement, the voltage supply circuit for the anode of the magnetron cannot be energized until the relay **56** is energized to effect engagement of its contacts **58** and **64**, and also until the contacts **101** and **102** of the door switch **100** are closed by closing the door **16** of the oven.

Operation of the power supply may now be described. All relays are shown in their deenergized condition and the door **16** of the oven is normally closed so that the door

switches 69 and 100 are in positions wherein their contacts are closed. The time switch is in its "off" position wherein the switch 74 is open as shown. In order to initiate operation the main line switch 37 is closed to effect energization of the primary winding 50 of transformer 49 and energization of the heater 88 of the time delay device. The primary winding 50 is energized through the closed contacts 57 and 63 whereby a maximum voltage of approximately 5 volts is initially applied to the filament 29 of the magnetron from the secondary of transformer 49. The heater 88 is energized through the normally closed contacts 83 and 92. The time delay device is selected so that operation of its switch 89 to the closed condition is delayed a predetermined time which is sufficient to assure proper heating of the filament 29. For example, the time delay device may be designed so that the switch 89 is operated to its closed condition approximately three minutes after energization of the heater 88.

When the switch 89 is operated, contact 94 moves into engagement with contact 95 to thereby effect energization of coil 86 of relay 72. When coil 86 is energized, contact 71 moves into engagement with contacts 78, contact 83 moves out of engagement with contacts 92, and contact 84 moves into engagement with a pair of spaced fixed contacts 105 disposed in a sealing circuit which shunts the switch 89. Closure of contacts 71 and 78 prepares for energization the coil 60 of relay 56, the motor 75 of the time switch, and an indicating lamp 107 in parallel with motor 75. Opening of contacts 83 and 92 deenergizes the heater 88, and closure of contacts 84 and 105 establishes the sealing circuit to maintain energization of coil 86 of relay 72 after opening of switch 89 in response to deenergization of heater 88. If desired, a suitable signal may be provided for operation in response to energization of relay 72 to alert the attendant that the oven is prepared for reception of a food load. At this time, the door 16 is opened and a food load is placed in the cavity 13. The door 16 is then closed and the time switch is set for the desired timing period which results in closure of contacts 68 and 76 of the door switch 69 and contacts 73 and 80 of the time switch. When this occurs, the coil 60 of relay 56 is energized and the motor 75 and the indicating lamp 107 are also energized. Energization of coil 60 results in movement of contact 57 out of engagement with contacts 63 and into engagement with contacts 62, and movement of contact 58 into engagement with contacts 64. Closure of contacts 57 and 62 results in application to filament 29 of a smaller operating voltage of the order of 3 volts. Closure of contacts 58 and 64 effects energization of the voltage doubler circuit 45 to apply voltage to the anode 27 inasmuch as the contacts 101 and 102 of door switch 100 are closed at this time. When the motor 75 is energized, the time switch begins to time out from its predetermined time setting. Energization of the lamp 107 provides an indication that the oven is in its operating condition.

With the described arrangement it is observed that the heater 88 is deenergized at all times except during the filament heating period. This arrangement is very desirable in that it contributes to a very long heater life. Also, it should be pointed out that a sequence of operation other than that described is possible. Such other sequence involves placing the food load in the cavity 13, closing the door 16, setting the time switch, and then closing the line switch 37. With this sequence, when relay 72 is subsequently energized, voltage is applied to the anode 27 without any further operation by the attendant.

Preferably, voltage is applied to the anode 27 of the magnetron in a stepped pattern so that a relatively low voltage is initially applied to the anode followed by application of a higher final operating voltage. For this purpose means are provided to remove the resistor 46 from the energizing circuit of the network 45 a preselected time after energization of the network 45. This is accomplished in the illustrated embodiment by means of a direct current relay 110 which operates to shunt the resistor 46, and a delay network for delaying operation of the relay 110 after energization of the network 45. The relay 110 includes a normally open movable contact 111 mechanically connected to a magnetic plunger 112 surrounded by a coil 113. The contact 111 cooperates with spaced fixed contacts 114 in a conductor 115 which shunts the resistor 46. The coil 113 of relay 110 is connected for energization from the conductors 34 and 44 through a resistor 117 and a diode rectifier 118. A capacitor 120 is connected in parallel with coil 113, a capacitor 121 is connected in parallel with the series combination of coil 113 and resistor 117, and a capacitor 122 is connected in parallel with diode 118.

Voltage to the coil 113 is retarded by the inductance of the coil and by the resistor 117 in series therewith. Charging of capacitor 120 also serves to retard voltage to coil 113. After a predetermined time delay which may be of the order of ninety milliseconds, the coil 113 is energized sufficiently to close contacts 111 and 114 to thereby shunt resistor 46 and effect application of full voltage to the network 45. The full voltage is approximately 620 volts as compared to a voltage of the order of 340 volts which is applied to the anode when resistor 46 is in the circuit.

While I have shown and described particular embodiments of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects, and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A circuit for controlling application of voltage to the filament and anode of a magnetron comprising in combination, supply circuits to be energized from a power source for supplying voltage to the filament and anode of the magnetron, means for effecting initial energization of said filament supply circuit to supply an initial magnitude of voltage to said filament, means for controlling energization of said anode and filament supply circuits including control switch means, a time delay device to be energized from said power source simultaneously with energization of said filament supply circuit and operable a preselected time after energization thereof, and relay means energizable only in response both to actuation of said control switch means and operation of said time delay device, said relay means being effective when energized simultaneously to reduce to a finite magnitude the initial magnitude of voltage supplied by said filament supply circuit, to effect energization of said anode supply circuit, and to deenergize said time delay device.

2. A circuit for controlling application of voltage to the filament and anode of a magnetron comprising in combination, supply circuits to be energized from a power source for supplying voltage to the filament and anode of the magnetron, means for effecting initial energization of said filament supply circuit to supply voltage to said filament, first means including an energizable first relay for controlling energization of said anode supply circuit, second means including an energizable second relay for controlling energization of said first relay, an energizable time delay device for controlling energization of said second relay, and means for energizing said time delay device from said power source simultaneously with energization of said filament supply circuit, said time delay device being operable a preselected time after energization thereof to effect energization of said second relay, said second relay being operable when energized to permit energization of said first relay, to deenergize said time delay device, and to permit maintenance of its own energization after deenergization of said time delay device.

3. A circuit as defined in claim 2 wherein said first means includes first switch means in said anode supply

circuit, said second means including second switch means, said first relay being energized only in response both to energization of said second relay and operation of said second switch means, said anode supply circuit being energized only in response both to energization of said first relay and operation of said first switch means.

4. A circuit as defined in claim 2 wherein said second means also includes an energizable time switch, and a motor for controlling operation of said time switch, said motor being controlled by said second relay.

5. A circuit for controlling application of voltage to the filament and anode of a magnetron comprising in combination, supply circuits to be energized from a power source for supplying voltage to the filament and anode of the magnetron, means for effecting initial energization of said filament supply circuit to supply an initial magnitude of voltage to said filament, first means including an energizable first relay for controlling energization of said supply circuits, said first relay being effective when energized to reduce to a finite magnitude the initial magnitude of voltage supplied by said filament supply circuit, and to permit energization of said anode supply circuit, second means including an energizable second relay for controlling energization of said first relay, a time delay device including an energizable heater and a switch operated by the heater for controlling energization of said second relay, and means for energizing said heater from said power source simultaneously with energization of said filament supply circuit, said switch being closed a preselected time after energization of said heater to effect energization of said second relay, said second relay being operable when energized to condition said first relay for energization, to deenergize said heater, and to permit maintenance of its own energization after deenergization of said heater and resultant opening of said switch.

6. A circuit for controlling application of voltage to the filament and anode of a magnetron comprising in combination, supply circuits to be energized from a power source for supplying voltage to the filament and anode of the magnetron, means for effecting initial energization of said filament supply circuit to supply an initial magnitude of voltage to said filament, means including an energizable first relay for controlling energization of said supply circuits, said first relay being effective when energized to reduce to a finite magnitude the initial magnitude of voltage supplied by said filament supply circuit, and to permit energization of said anode supply circuit, an energizing circuit for said first relay, a second relay having a normally open contact in the energizing circuit for said first relay, an energizing circuit for said second relay, a time delay device having a normally open switch in the energizing circuit for said second relay, an energizing circuit for said time delay device, and means for energizing the energizing circuit for said time delay device simultaneously with energization of said filament supply circuit, said time delay device being operable a preselected time after energization thereof to close its switch and complete the energizing circuit for said second relay, said second relay having a normally closed contact in the energizing circuit for said time delay device, and having a normally open contact in parallel with said normally open time delay switch.

7. An electronic oven comprising a housing, a magnetron in said housing having a filament and an anode, a cavity in said housing for receiving food to be exposed to electromagnetic radiation from said magnetron, a door for said housing effective when open to expose said cavity and effective when closed to conceal said cavity, supply circuits to be energized from a power source for supplying voltage to said filament and anode, means for effecting initial energization of said filament supply circuit to supply voltage to said filament, first and second switches operated by said door having open conditions when said door is open and having closed conditions when said door is closed, first control means including a first relay and said first switch for controlling energization of said anode supply circuit, said first relay having an energizing coil and having a normally open contact in series with said first switch in the anode supply circuit, second control means including a second relay and said second switch for controlling energization of said first relay, said second relay having an energizing coil and having a normally open contact in series with the coil of said first relay and with said second switch, and a time delay device to be energized from said power source simultaneously with energization of said filament supply circuit for controlling energization of said second relay, said time delay device having a normally open switch in series with the coil of said second relay which closes a preselected time after energization of the time delay device.

8. An electronic oven comprising a housing, a magnetron in said housing having a filament and an anode, a cavity in said housing for receiving food to be exposed to electromagnetic radiation from said magnetron, a door for said housing effective when open to expose said cavity and effective when closed to conceal said cavity, supply circuits to be energized from a power source for supplying voltage to said filament and anode, means for effecting initial energization of said filament supply circuit to supply an initial magnitude of voltage to said filament, first and second switches operated by said door having open conditions when said door is open and having closed conditions when said door is closed, said first switch being included in the supply circuit for said anode, a first relay having a first normally open contact in series with said first switch, and having a second contact in the supply circuit for said filament, said first relay being effective when energized to move its first normally open contact to a contact closed position and to move said second contact for reducing the magnitude of voltage supplied by the supply circuit to said filament, an energizing circuit for said first relay, a second relay having a third normally open contact in the energizing circuit for said first relay and in series with said second switch, an energizing circuit for said second relay, a time delay device having a normally open third switch in the energizing circuit for said second relay, and an energizing circuit for said time delay device, said time delay device being operable a preselected time after energization therefore to close its third switch to complete the energizing circuit for said second relay, said second relay having a fourth normally closed contact in the energizing circuit for said time delay device, and having a fifth normally open contact in parallel with said normally open time delay switch.

9. An electronic oven as defined in claim 8 including a transformer having primary and secondary windings adapted for energization from said power source, said supply circuits being connected to said secondary winding, the energizing circuits for said first and second relays and for said time delay device being connected to said primary windings.

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RICHARD M. WOOD, *Primary Examiner.*

L. H. BENDER, *Assistant Examiner.*