ABSTRACT: A microwave oven power supply circuit includes a transformer having a primary, high voltage secondary, and a tapped low voltage secondary winding. The start side of the high voltage secondary winding is grounded and the other side of the high voltage secondary winding is connected in series with a capacitor, the normally open contacts of a second hot wire relay, and a diode to ground; with the negative polarity diode terminal facing ground. A magnetron includes an anode connected to ground and a filament connected in series between the tap on the low voltage secondary winding and one side of the low voltage secondary. A connection is made between the positive polarity diode terminal and the magnetron filament. The heater coil of a first hot wire relay is connected across the low voltage secondary winding. Additionally, a set of normally open contacts in the first hot wire relay and the heater coil of the second hot wire relay are connected in series across the low voltage secondary winding.
MICROWAVE OVEN POWER SUPPLY CIRCUIT HAVING HOT-WIRE RELAYS

This invention relates to microwave ovens and, more particularly, to a novel microwave oven power supply having simple and effective construction to ensure reliable operation and long oven life.

Microwave ovens use high frequency or microwave frequency energy to heat or cook foodstuffs. Contemporary ovens employ the conventional type of electron tube termed the magnetron for generating microwave energy. In turn, the energy generated by that source is passed from the magnetron output through suitable microwave passages or waveguide into the cooking chamber or oven cavity, as may be variously termed. The magnetron is connected to a power supply which in turn is connected to the house or line current. The power supply converts the line voltage into both the high voltage necessary for the magnetron anode and the low voltage output necessary to energize the magnetron filaments. Suitable controls and interlocks are provided in conventional ovens to regulate the application of power to the magnetron. One such control is the interlock which prevents the application of power from the power supply to the magnetron should the oven door be open. Other controls include the on-off switch and the overload controls which permit the completion of the power supply circuit during the cooking interval. Further, forms of internal protection are provided to prevent permanent damage to the oven components, such as fuses, or to ensure proper operation of the components so as to enhance component life, such as a filament high voltage power sequence circuit.

The latter circuit ensures that the magnetron filaments are heated with suitable current from a low voltage source for a predetermined interval prior to the application of high voltage to the magnetron anode. This avoids application of high voltage to the magnetron while the filament is cold preventing internal arcing or operation detrimental to the magnetron or components.

Hereinafter this sequencing circuit has been used in oven power supplies in various forms but complicated and expensive devices, such as cam motor switches, electromagnetic relay, etc., have been used for this purpose. In operation the sequencing has been functionally independent of the actual filament winding and has generally required the use of a separate filament transformer. Should the filament winding of the transformer be such circuit or the filament winding in a separate filament transformer in the general circuit develop a high resistance which lowers the filament voltage and current below recommended levels, the sequencing circuits continued to permit the application of high voltage to the magnetron.

Accordingly, it is an object of this invention to provide a novel magnetron power supply for use in a microwave oven;

It is a further object of the invention to provide a microwave oven power supply which ensures proper operation of the magnetron;

and it is a still further object of the invention to provide a sequencing circuit in the magnetron power supply which is simple, inexpensive, reliable, and which does not require a separate filament transformer.

Briefly, the invention encompasses a transformer having a primary winding, a high voltage secondary winding and tapped low voltage secondary winding; a magnetron includes an anode connected electrically to ground potential and has a filament connected between the tap and one side of the low voltage secondary winding; a first hot-wire relay has a heater coil connected across the low voltage secondary winding; a second hot-wire relay, substantially identical to the first, has a heater coil connected in series with the normally open contacts of the first hot-wire relay across the low voltage secondary winding; a capacitor, the normally open set of contacts of the second hot-wire relay, and a rectifier diode are connected in series across the high voltage secondary winding of the transformer, with the start end of that secondary connected to the negative polarity terminal of the diode and such juncture being connected to ground, and, in addition, the positive polarity diode terminal is connected to the electron emitting element of the magnetron, the filament or cathode.

The foregoing and other advantages and features which are believed to be characteristic of the invention both as to its organization and method of operation together with further objects and advantages thereof are better understood from the following description considered in connection with the accompanying drawing in which:

The FIGURE of the drawing illustrates by way of example one embodiment of the invention.

The preferred embodiment includes a transformer 1 which has a primary winding 2, a high voltage secondary winding 5, and a tapped low voltage winding 9 wound on an iron core 11. Transformer 1 is preferably of the conventional voltage regulating variety in which the primary and secondary windings are loosely coupled together by winding them side by side on a common leg of the iron core 11 so that a leakage flux path exists between the primary and secondary windings and the other core legs. Such leakage flux is increased to meet the needs of particular circuits in the conventional manner by the inclusion of magnetic material termed a shunt leg between the primary and secondary windings and the other core legs which acts as a magnetic shunt. Secondary winding 9 is connected between the start terminal 4 and end terminal 3. The term start refers to the windings of the secondary winding closest to core 11.

Primary winding 2 is connected in series with a circuit breaker 12, the door interlock switch 13, timer switch 14 to a source of 115 volt, 60-cycle live current.

A magnetron 17 includes an anode 18, and a filament 19. Filament 19 includes two leads 20 and 21, and an electro-magnetic coating which permits the filament to function as the cathode. The anode is connected to a common electric potential termed the chassis ground represented by the symbol 22. The two filament leads are connected between the tap 6 of the low voltage windings and end 7 of low voltage secondary winding 9. Suitably the voltage which appears between leads 6 and 7 is the voltage specified for filament 19.

A first hot-wire relay includes a heater winding 24 and a set of normally open contacts 25. The heater winding is connected between lead 8 and lead 7 of low voltage secondary winding 9. This type of hot-wire relay is commercially available and is illustrated in the product catalogue of the King-Scaly Thermos Company.

The contacts 25 of the first hot-wire relay are connected between lead 7 and lead 8 of low voltage winding 9 in series with the heater coil 26 of a second hot-wire relay. The second hot-wire relay is of substantially identical construction as the first hot-wire relay and includes a second set of normally open contacts 27.

The positive (+) polarity terminal of a rectifier diode 28 is connected to one side of normally open contacts 27, and to filament lead 21. The negative (-) polarity diode terminal is connected to the chassis ground 22. A high value resistor 29 is placed across contacts 27 to form a relatively high resistance bypass. Start lead 4 of high voltage secondary winding 5 is connected to chassis ground. A capacitor 30 is connected between the end lead 3 and to the other contact of normally open contacts 27 in the second hot-wire relay.

In normal operation the oven door, not illustrated, is closed. Hence, interlock 13 is closed. Circuit breaker 12 is closed. The timer is operated by the operator and timer contacts 14 are closed to permit current to flow through primary winding 2 for the predetermined cooking interval as determined by the setting of a conventional timer mechanism. The primary voltage 115 volts is stepped up in transformer 1 and appears as a high voltage of about 2,200 volts across secondary winding 5. The primary voltage is additionally stepped down to a low voltage of about 9 volts which appears across winding 9. The filament voltage for magnetron 17 is about 4.6 volts and appears between the tap 6 and 7 of winding 9.
Filament current flows in a path from secondary winding 9, the lead 7, the filament 20 and 21 and back to the transformer winding through tap 6.

Concurrently current flows from lead 8 through heater coil 24 and back through lead 7. The voltage which appears between leads 7 and 8 is greater than the filament voltage. With the hot-wire relays commercially available a voltage greater than the filament voltage is necessary for operation. However, it is understood that with nonstandard hot-wire relays or in an oven with a magnetron which requires a larger filament voltage then an intermediate tap would be unnecessary on winding 9 and the relay heater 24 and the second hot-wire relay circuit with the lead 20 from filament 21 being connected to the winding end and could be placed directly across filament winding 9.

The hot-wire relay is of a construction in which the normally open contacts are supported by high expansion wires. These are temperature responsive. Heat sufficiently generated in wire heater 24 causes the wire to expand. With the requisite degree of expansion and, accordingly, after the lapse of a predetermined time interval contacts 25 close. The hot-wire relay is selected with the criteria that the filament 19 is heated to proper levels during the aforementioned time interval.

Closure of contacts 25 permits current to flow from lead 7 to lead 8 through heater coil 26 of the second hot-wire relay. Operation of hot-wire relay contacts 27 is similar to that of 25, however, since very high voltages are present across contacts 27 current flows prematurely due to arcing across the contacts prior to actual contact closure. By itself the second hot-wire relay cannot be used for providing significant or consistent time delays necessary for proper warming of the magnetron filament.

Considering closure of contacts 27 a circuit is completed in which the secondary winding 5, capacitor 30, diode 28, and magnetron 17 appears as the familiar half-wave voltage doubler circuit in which the half-wave-rectifying properties of the magnetron, here the power supply load, is utilized as one of the half-wave rectifiers. This rectifier arrangement is described in the Radio Engineers Handbook, Terman, 1943 and in U.S. Patent No. 3,265,850. Thus, the voltage generated between the end of capacitor 30 and chassis ground is approximately twice that across high voltage winding 5. On one-half cycle of AC diode 28 conducts and charges capacitor 30 in one direction. On the other half cycle the polarity across winding 5 reverses placing that voltage in series with that across the capacitor and magnetron 17 conducts current of that voltage on this half cycle. This process is repeated in each half cycle. The magnetron generates microwave energy which is conducted away in a conventional manner to an oven cavity, not illustrated. Reference is again made to resistor 29. This resistor absorbs some of the energy that would otherwise be dissipated in an arc across contacts 27 prior to closure. Additionally, when the power supply is off, resistor 29 bleeds off any charge retained in capacitor 30.

At the completion of the timing interval timer contacts 14 open and interrupt the flow of current to the transformer. Likewise, relays 24 and 26 cool and restore their contacts to the normally open condition.

In addition to the foregoing sequence of operation provided by the hot-wire relays should the filament winding 9 be shorted or, alternatively, become highly resistive to a degree insufficient to cause operation of circuit breaker 12, the current through relay heater coil 24 is reduced. Accordingly, the hot-wire relay coil 24 does not generate sufficient heat and cannot close its contacts 25. Hence, the high voltage cannot be applied to the magnetron. In this instance failure of the most expensive oven component, the magnetron, is not only avoided but with this indication the cause of the trouble attributed to the filament winding of the transformer can be quickly located and remedied to the closed position.

It is understood that the foregoing description and illustration are presented as illustrative of the invention and not by way of limitation. Inasmuch as numerous modifications and equivalents suggest themselves to those skilled in the art it is expressly understood that the invention is to be broadly construed within the spirit and scope of the appended claims.

What I claim is:

1. A power supply for use in a microwave oven comprising:
a. A magnetron for generating microwave energy, said magnetron including an anode and a first and second filament leads;
b. a power transformer having a high voltage secondary winding with a start and end lead, and a tapped low voltage secondary winding with first, second, and top leads, and a primary winding;
c. a rectifier diode having a positive polarity terminal and a negative polarity terminal;
d. a capacitor;
e. a first hot-wire relay which includes a first heater winding and a first set of normally open contacts, said contacts responsive to a predetermined high temperature generated by said heater winding for a predetermined period of time for opening the closed position;
f. a second hot-wire relay which includes a second heater winding and a second set of normally open contacts, said contacts responsive to a predetermined high temperature generated by said heater winding for a predetermined period of time for operation to the closed position;
g. means connecting said first filament lead to said top lead of said low voltage secondary winding;
h. means connecting said second filament lead to said first lead of said low voltage secondary winding;
i. means connecting said anode, said negative polarity diode terminal, and said start lead of said high voltage secondary winding to a common electrical potential or ground;
j. means connecting said positive polarity diode terminal, said second filament lead and one side of said second normally open contacts;
k. means connecting said capacitor between said end lead of said high voltage secondary winding and the other side of said second normally open contacts;
l. means connecting said first heater winding between said first and second leads of said low voltage secondary winding;
m. means connecting said first normally open contacts and said second heater winding in series between said first and second leads of said low voltage secondary winding;
2. The invention as defined in claim 1 further comprising a high resistance connected across said second normally open contacts.