A power supply for varying the power output of a heating magnetron which includes a variable resistance in series with said magnetron and a source of power for said magnetron, and where the lowest resistance section of said variable resistance is designed to carry more current than the other resistance sections.

13 Claims, 3 Drawing Figures
POWER SUPPLY FOR HEATING MAGNETRON

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of my copending application, U.S. Ser. No. 841,507, filed July 14, 1969, and relates to my copending application, U.S. Ser. No. 739,778, filed June 25, 1968.

BACKGROUND OF THE INVENTION

Present domestic microwave ovens are powered by magnetrons operating at one or two fixed power levels. In fixed power level ovens, foodstuffs must be specially prepared to cook properly and exact timing is mandatory. These ovens can not be employed to simmer foodstuffs nor can they be used for holding ovens. Rather than adapting a foodstuff to an oven's fixed power level, this invention and my previous invention, U.S. Ser. No. 841,507, concern circuitry to permit a microwave oven to adapt to the foodstuff to be cooked.

In my copending application, U.S. Ser. No. 841,507, there is described how a variable inductance can be used to vary the power output of a heating magnetron. A variable inductance provides wattless power control and, hence, is excellent for high power industrial applications where the cost of electricity is a predominant factor. Others vary the power output of commercial microwave ovens by varying the magnetic field of magnetrons. And, still others, in the primary of HV transformers, employ variable resistances and inductances, variacs, saturable reactors and transistorized circuits to vary power. All these aforementioned means are expensive and bulky and have serious drawbacks (e.g., transistor control absorbs power and is subject to failure from transient voltage spikes; the variable inductance and variacs are subject to arcing at their movable contacting surfaces; etc.). The limited utility of these devices result from their employment in the primary, high-current, low-voltage circuit of high-power, HV transformers with no consideration of exponential magnetron action.

I have discovered that a simple variable resistance, a rheostat, placed directly in series with the small, HV-transformer-secondary current passing through a magnetron, provides rugged, inexpensive and complete power control for a domestic microwave oven.

SUMMARY OF INVENTION

Accordingly, it is an object of this invention to create a compact power supply for a microwave heating oven whose variable output, which is in control of an operator, can be adjusted to workloads of various sizes and materials as well as the changing characteristics of a heating workload.

It is still another object of this invention for an operator to cause a flow of selected desired power output from a heating magnetron by means of operating a variable resistance in series with said magnetron.

Broadly, the invention is combined with a circuit for providing variable control over the power output of a magnetron and includes a source of power, a magnetron discharging in response to said source of power, a variable resistance in series with the source of power and the magnetron and means for controlling the resistance of the variable resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of a microwave oven power supply.

FIG. 2 is an alternate circuit diagram of a microwave oven power supply.

FIG. 3 illustrates an improved rheostat.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, an illustrative heating magnetron power supply circuit, power mains 1—1 supply conventional AC power to HV transformer 2 and to LV-filament transformer 4. The dual output of transformer 4 supplies I) filament voltage to heating magnetron 6 and 2) via DC power supply 8, field current for field coil 7 of magnetron 6. The output of HV transformer 2 is rectified by full wave rectifier 9 and applied across the series circuit of magnetron 6, variable resistance 11 and meter 10.

It is preferred to use a permanent magnet to provide the required magnetic field for magnetron 6. But, a magnetron 6, employing a field coil 7, is illustrated as such magnetron is also useful and a study of its circuit helps set forth the invention. Transistor current regulator circuit 12 represents one means of regulating magnetron 6's output power when field coil 7 is subject to variations of applied line voltage and when field coil 7's resistance changes as it heats. In conventional regulator circuit 12, zener diode 14 and resistance 15 fix a bias from base to ground on power transistor 16 which, in turn, fixes the emitter to ground voltage across variable resistance 17. Variable resistance 17's function is to set the magnetron's electric field to a design maximum. If means of regulation was employed for the plate voltage, variable resistance 17 could be used to control the power output of magnetron 6, but, without the convenience, efficiency and utility of the instant invention as field currents are large. Transistor current regulator circuit 12 is employed to maintain a desired power level once said desired power level is selected. It is an established fact that, for satisfactory operation of heating magnetron 6, some means must be employed to hold magnetron 6's plate current substantially constant notwithstanding variations in the supply voltage which normally occurs across conventional power mains 1—1 during operation. My related copending application, U.S. Ser. No. 739,778 concerns improved circuits to provide said substantially constant plate current by the employment of a capacitive reactance 5 in series with magnetron 6's plate current. The size of capacitive reactance 5 is specially chosen to limit the change in current passing through magnetron 5 during normal voltage variations in AC input voltage to provide regulation — substantially constant current. Capacitive reactance 5 is an AC operating device and magnetron 6 is a DC operating device. Diode 13 is disposed to conduct on the alternating half cycle when magnetron 6 does not conduct and is necessary to make the operation of said AC operating capacitance and said DC operating magnetron compatible. FIG. 2 illustrates a combination of inventions regulation plus variable power control, and shows a parallel circuit of variable resistance 11 in series with
magnetron 6 across diode 13 all in series with capacitance 5 and the secondary winding of transformer 2. I discovered that a variable resistance 11, combined in the same low-current, high-voltage circuit as magnetron 6 is highly suitable to vary the power of heating magnetron 6. At full magnetron 6's power, variable resistance 11 is at minimum (i.e. a short) and draws no power. At minimum magnetron 6's power, negligible current flows through variable resistance 11, and variable resistance 11, with a nominal expenditure of energy, effectively turns off magnetron 6. At intermediate power, the wattage expended by variable resistance 11 to control magnetron 6 peaks. For example, in one test, the wattage expended by a 10,000 ohm variable resistance 11 and the corresponding power output of a 2.5 KW magnetron follows:

<table>
<thead>
<tr>
<th>Magnetron output</th>
<th>variable resistance watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 KW</td>
<td>no watts</td>
</tr>
<tr>
<td>2.0 KW</td>
<td>75 watts</td>
</tr>
<tr>
<td>1.5 KW</td>
<td>90 watts</td>
</tr>
<tr>
<td>1.0 KW</td>
<td>80 watts</td>
</tr>
<tr>
<td>0.5 KW</td>
<td>40 watts</td>
</tr>
</tbody>
</table>

In this case a 100 watt size variable resistance fully controlled a 2.5 KW magnetron. Small domestic microwave ovens require proportionally smaller wattage variable resistances. I believe that the reason that a small, low-wattage, variable resistance is able to control so disproportionately high wattage magnetron is because a magnetron is an exponentially operating device which discharges only over a portion of each cycle and is highly voltage sensitive. This is more fully discussed in my copending application, U.S. Ser. No. 841,507.

Because, at high power, magnetron current is large and falls off exponentially as the power is decreased, common, standard variable resistances are not preferred as they must be constructed too large physically to accommodate a small segment of the low resistance section. I prefer a variable resistance of special manufacture whose low resistance winding 18 can carry a higher current than the high resistance winding 19. It must be understood that many standard high wattage rheostats are wound with heavier low resistance windings, but what is preferred is a resistor whose power handling taper compliments the exponential curve of a magnetron.

With grounded plate magnetrons, I prefer a rheostat, as variable resistance 11, whose movable arm 20 is at ground potential. Hence, an operator manipulating said movable arm 20 can do so without fear of electric shock if resistance 11 becomes defective.

FIG. 3 illustrates another embodiment of variable resistance 11 shown as a rheostat whose movable arm 20 is a grounded metal conductor. Movable arm 20's contact surface 21 at maximum counterclockwise position, rests on insulating rest 22 and insulating stop 23. When resting on insulating stop 23 movable arm 20 by means of switch activating arm 24 opens normally closed main power switch 3. When oven operation is desired, movable arm 20 is rotated clockwise, switch activating arm 24 no longer holds main power switch open and power is supplied to high voltage transformer 2. But, as contact surface 21 is still riding on insulating rest 22, the oven is in standby. In operation, movable arm 20 is moved to that point on the low resistance winding 18 or the high resistance winding 19 which meter 10 indicates to operator is the desired magnetron power output level. If maximum power is desired, movable arm 20 is rotated fully clockwise until it engages electrical conductive stop 25 where variable resistance 11 is electrically shorted out of the circuit.

Movable arm 20 is shown incorporating a conventional ratchet and ratchet release assembly 26 and coil return spring 27. A ratchet release 28 is attached remotely to an oven timer (not shown), and, where said timer (not shown) releases ratchet release 28 at the end of each cook cycle. Rather than the instantaneous interruption of power, at the end of each cook cycle, which at high power levels is associated with large transients, arcing and pitting of contacts, etc., with a ratchet release assembly 26, the oven is turned off speedily and gently by return spring 27 returning movable arm 20 to insulating stop 23. The ratchet assembly 26 also requires the inexperienced operator to consider the power level each time he energizes the oven.

Variable resistance 11, with and without integral switching means, has utility when magnetron 6 is operated directly off a public utility service without an intervening HV transformer.

Variable resistor 11 can only lower the power output of magnetron 6 to a point that it is effectively off, for, without insulating rest 22 or main switch 3, negligible power will continue to flow. It is expected that some will use variable resistance 11 to establish control over only a limited portion of magnetron 6's output without the exercise of invention.

Variable resistance 11, when placed in the primary circuit of a magnetron high voltage transformer, can be improved by designing the low resistance section of said variable resistance to handle more power than the other resistance sections. Since wattage varies as the square of current, large primary currents are more severe than small secondary transformer currents.

Although this invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention.

I claim:

1. A microwave oven power supply circuit comprising a source of high-voltage, low-current power and a magnetron discharging from said source of power, means to maintain said low-current at a substantially constant current notwithstanding normal variations in the voltage of said power source and an improved variable resistance for varying the power output of said magnetron, said improved variable resistance comprising in combination:

- a structure to permit control of said variable resistance by an operator of said oven, and
- where said low-current flowing through said magnetron flows through said variable resistance.

2. In one circuit, according to claim 1, where said structure to permit manual control includes means to turn off the power output of said magnetron at the high resistance end of said variable resistance.

3. A microwave oven power supply circuit comprising a source of high-voltage, low-current power and a magnetron discharging from said source of power, an improved variable resistance for varying the power out-
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5 put of said magnetron, said improved variable resistance comprising in combination:

structure to permit control of said variable resistance,

where said low-current flowing through said magnetron flows through said variable resistance, and

where the low resistance section of said variable resistance is designed to handle more power than the other resistance sections.

4. In one circuit, according to claim 3, where the variable resistance is a rheostat.

5. In one circuit, according to claim 4, where the moving arm of said rheostat is at ground potential and said magnetron has its anode grounded.

6. In one circuit of a microwave oven power supply circuit comprising a source of high-voltage, low-current power, a magnetron discharging from said power, and an improved rheostat for varying the power output of said magnetron, said improved rheostat comprising in combination:

a low resistance section of said rheostat designed to handle more power than the other resistance sections,

a ground connection to the moving contacting arm of said rheostat where said magnetron has one side of its cathode-plate circuit grounded, and

where the plate current flowing through said magnetron flows through said rheostat.

7. In one circuit, according to claim 6, where the variable resistance includes means to turn off the power output of said magnetron at the high resistance end of said variable resistance.

8. A circuit to provide control over the power output of a magnetron which comprises:

a source of alternating power,

a magnetron which discharges in response to less than twice the voltage of said source of alternating power,

a variable resistance in series with said magnetron, a conductive means, to conduct in a direction opposite to said magnetron, in parallel with said magnetron-variable resistance series, and

a capacitance where said capacitance and said source of alternating power are in series and also in series with said parallel circuit of magnetron-variable resistance and conducting means.

9. A circuit, according to claim 8, where said variable resistance’s low resistance section is designed to handle more power than the other resistance sections.

10. A circuit, according to claim 8, where said variable resistance includes means for turning off the power output of said magnetron at the high resistance end of said variable resistance.

11. A circuit to provide control over the power output of a magnetron comprising a source of power, a magnetron discharging from said source of power, an improved variable resistance for varying the power output of said magnetron, said improved variable resistance comprising in combination:

structure-to-permit-control of said variable resistance by an operator of said circuit, and

where the low resistance section of said variable resistance is designed to handle more power than the other resistance sections.

12. A circuit, according to claim 11, where said structure-to-permit-control includes a ratchet and ratchet release structure, means to return said structure-to-permit-control to the high resistance end of said variable resistance when said ratchet release releases said ratchet.

13. A circuit, according to claim 11, where said structure-to-permit-control includes means for turning off the power output of said magnetron at the high resistance end of said variable resistance.

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