

[54] **POWER SUPPLY CIRCUIT FOR A HEATING MAGNETRON**

[76] Inventor: **Melvin L. Levinson, 1 Meinzer
Street, Avenel, N.J. 07001**

[22] Filed: **July 14, 1969**

[21] Appl. No.: 841,507

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 608,886, Jan. 12, 1967, abandoned.

[52] U.S. Cl. 331/86, 219/10.55, 323/90,
323/91, 331/71, 331/185, 336/118, 336/149

[51] Int. Cl. H03b 9/10

[58] **Field of Search**.....331/71, 182, 86-91,
331/185, 186; 328/170, 172, 253, 258, 268,
262; 315/284, 285; 219/10.55; 336/118, 149,
150, 223; 323/90, 91

[56] **References Cited**

UNITED STATES PATENTS

2,839,718	6/1958	Luftman et al.	336/149 X
2,921,171	1/1960	Long	219/10.55
2,976,477	3/1961	Carpenter	323/47
3,396,342	8/1968	Feinberg	328/262

FOREIGN PATENTS OR APPLICATIONS

1,072,336	12/1959	Germany.....	219/10.55
-----------	---------	--------------	-----------

Primary Examiner—Roy Lake

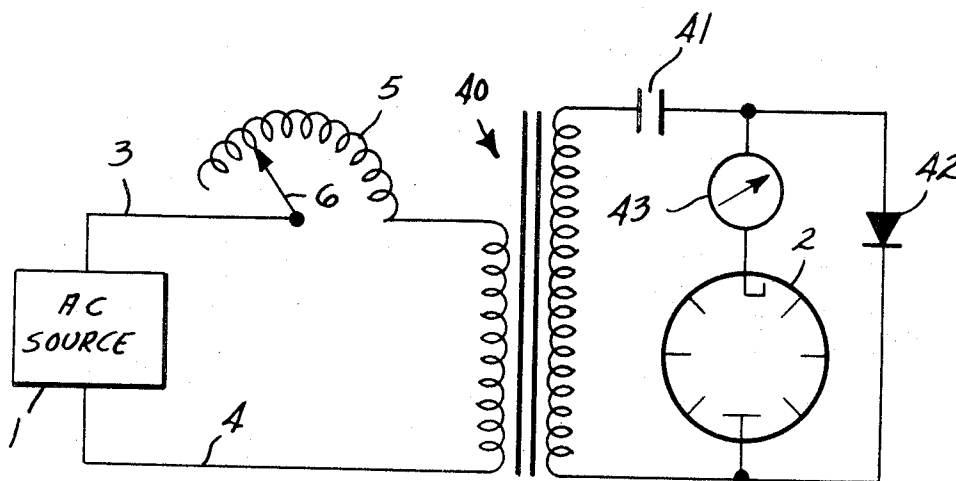
Assistant Examiner—Siegfried H. Grimm

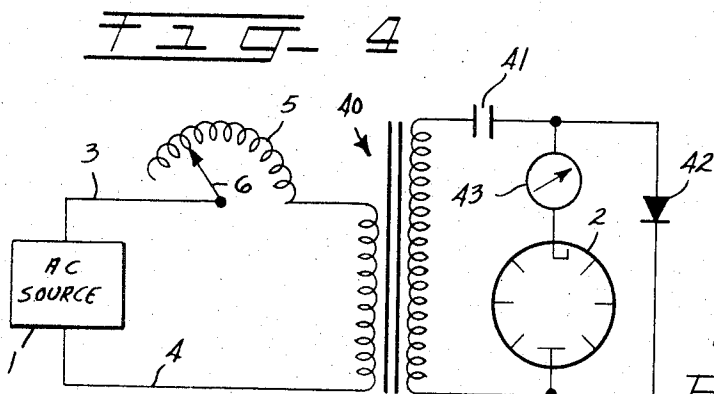
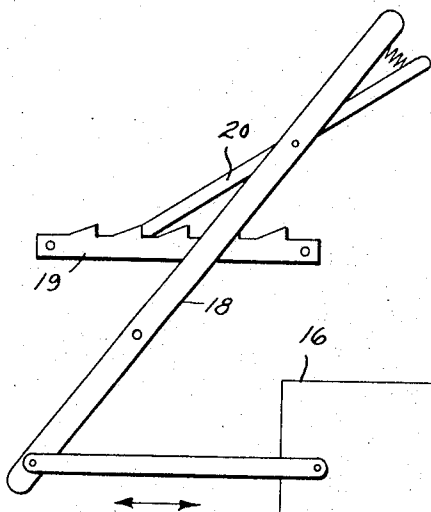
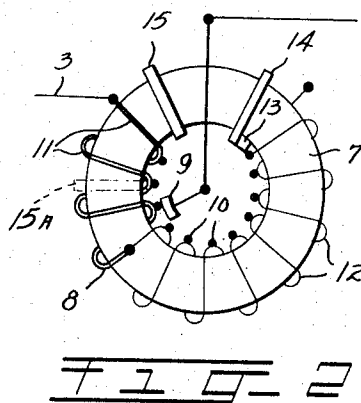
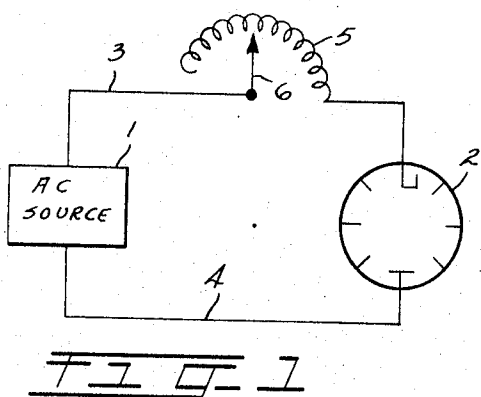
Attorney—Melvin L. Levinson

[57] **ABSTRACT**

A power supply circuit for varying the power output of a heating magnetron which includes controlling a variable inductance to tune a capacitance to resonance to vary the power, and which comprises a variable inductance in series with the magnetron.

4 Claims, 4 Drawing Figures





INVENTOR
M. L. LEVINSON
BY *[Signature]*
ATTORNEY

POWER SUPPLY CIRCUIT FOR A HEATING MAGNETRON

CROSS-REFERENCE TO RELATED APPLICATIONS

This application relates to my copending application, "A System to Power a Microwave Oven," U.S. Ser. No. 739,778, filed June 25, 1968.

This application is a continuation-in-part application of my copending application, "A System to Power a Microwave Oven," U.S. Ser. No. 608,886, filed Jan. 12, 1967, and now abandoned.

BACKGROUND OF THE INVENTION

Various systems have been employed to adjust the power output of a magnetron power supply designed for microwave heating ovens. In prior art variacs, saturable reactors, transformer taps, and means for adjusting the magnetron's magnetic field have been used to vary a heating magnetron's power output. An improved system is required since variacs, saturable reactors and transformers are costly and space consuming; transformer taps are of no use in transformerless power supplies; and means, added to adjust the magnetron's magnetic field, have limited utility.

Microwave ovens are in competition with conventional gas and electric ovens. The gas and electric ovens both have a major advantage since, they, by simple control, can be made to operate in small increments from low to high. This invention provides a microwave oven with a variable inductance which is as simple and as useful a control as the variable gas control on a conventional gas range. By controlling this variable inductance the operator is afforded manual control of a microwave generator, from no output to maximum design output. The operator is able to select a microwave power output level which both complements the individual workloads characteristics, and which allows normal internal conducted and convected heat transfer to assist in equalizing microwave spot and selective heating. The ability to select the proper microwave power level can mean: gently frying an egg to provide a soft, liquid, cooked yolk vs. a similar fried egg with a hard boiled yolk; a foodstuff held at a simmer vs. uncontrolled boiling or no heating; the ability to use a microwave oven first to rapidly cook a food then to hold it in a hot ready state for subsequent service; drying wet clay by microwaves as fast as water vapor can normally exit vs. the clay piece exploding.

The manually variable inductance of this invention is shown in combination with the novel circuitry described in my aforementioned copending invention U.S. Ser. No. 739,778. The variable inductance tunes the system to achieve more efficiency. This planned tuning to electrical resonance permits control of the full gamut of a magnetron's power while operating from a transformer whose output power connected across the magnetron is insufficient to cause the magnetron to operate.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to formulate a new method for heating a workload by electromagnetic wave radiation emanating from an electromagnetic wave source.

It is another object of this invention to formulate a new method for heating a workload with a microwave heating magnetron acting as a load of a tuneable electrically resonant circuit.

It is still another object of this invention to cause a flow of selected desired power output from a heating magnetron by means of operating a controllable, variable inductor in series with the heating magnetron.

It is still another object of this invention to create a compact power supply for a microwave heating oven whose output can be fully controlled by the operator in response to the temperature and changing characteristics of a workload.

And, for a heating magnetron, it is an object of this invention to provide a controllable, tuneable resonant circuit which affords a resonant plate voltage across the magnetron in excess of a source voltage.

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

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawings:

FIG. 1 is a variable inductance power supply for a magnetron;

FIG. 2 is a diagrammatic drawing of one embodiment of the variable inductance of FIG. 1 where the number of effective turns are mechanically varied to vary the variable inductance;

FIG. 3 is a diagrammatic drawing of another embodiment of the variable inductance of FIG. 1 where the permeability or size of the core is varied to vary the variable inductance; and

FIG. 4 is an improved power supply circuit for a microwave oven which shows this invention in combination with my copending invention U.S. Ser. No. 739,778.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, an AC voltage source 1 is connected across magnetron 2 in series with variable inductance 5 by means of wires 3 and 4. By conventional means, the varying means 6 of the variable inductance 5 is so constructed and so positioned as to be controllable by an operator. In this embodiment, magnetron 2 is designed to operate from one of the voltages normally delivered by a local electric utility. For instance, AC source 1 voltage may be a conventional 4,160 v, 13,200 v, or 26,400 v power line.

In operation, when the half cycle of the AC voltage source 1 applied across magnetron 2 is negative plate, positive cathode, nothing happens. On the alternate half cycle, plate positive, cathode negative, magnetron 2 discharges and current passes thru the inductance set on variable inductance 5.

Magnetron 2 is a voltage sensitive device which, on discharging, responds to a small voltage rise with an exponentially rising current. Variable inductance 5 is a current sensitive device responsive in proportion both to the amount of change of current and the amount of

current, i.e. Faraday's Law and Ampere's Law, discharging thru magnetron 2. Variable inductance 5 by its nature, first resists the discharge of current thru magnetron 2 and then resists the cessation of such discharge.

The action of variable inductance 5 combined with a discharge device, as magnetron 2, is different from such variable inductance in series with a conventional load. In a conventional load, a variable inductance starts to build up a charge, a voltage drop, from the beginning of each half cycle in competition with all other components in series with it. In contrast to a conventional load, sufficient voltage must appear across magnetron 2 to enable it to discharge and, only as a result of the discharge of current of magnetron 2 can the variable inductance 5 be effective.

In FIG. 2 the variable inductance 5 is shown as a wire helix 8 formed of turns 11—11 and 12—12 wrapped around a circular core 7, the number of effective turns being varied by a sweeping contact arm 9 which, to provide operator control, may be preferable of conventional design to rotate and make contact with individually exposed contact points 10—10 sequentially placed on each turn of wire.

Turns 11—11 preferably are heavier than turns 12—12 to complement the exponential current changes inherent in the discharge of magnetron 2. For example, magnetron 2 may pass 20 amps, at full "on," low inductance of variable inductance 5, as opposed to magnetron 2 passing only 2 amps, at almost "off," high inductance of variable inductance 5. Thus, if the wire of variable inductance 5 is designed to handle 20 amps thru its complete range, variable inductance 5 may be unnecessarily large; and, if the wire of variable inductance 5 is designed to handle only 2 amps thru its complete range, the wire may melt.

The current carrying capacity of one heavy gauge wire is created from the low inductance end of variable inductance 5 by winding a double wire, turns 11—11, side by side around circular core 7 for a suitable distance, thence terminating one wire and continuing winding the remaining wire, turns 12—12, to the high inductance end. The double wire is made to serve as one wide, flat wire, electrically equivalent to a heavier gauge wire, by joining it at its inception, each contact point, and at the termination of the double winding. The double wiring thus described is preferable since its use negates the necessity of undercutting the circular core 7 for evenly positioning the contacting surface of a heavier gauge wire flush with the contacting surface of a lighter gauge wire so as to permit a free path of movement of contact arm 9.

At the high inductance end of variable inductance 5 is located an insulator 13 and "off" stop 14. Thus as contact arm 9 moves from turns 12—12, it may further be moved over insulator 13 until it reaches stop 14. While on insulator 13, contact arm 9 opens the circuit to magnetron 2, thereby turning magnetron 2 off.

The "off" stop 7 is placed at the highest inductance of variable inductance 5 to minimize not only the destructive arcing prevalent in switch and relay contacts of the prior art but also to minimize the high switching transients associated with the off-on switching of a high power magnetron operating at full power. Full "on" stop 15, also shown at another loca-

tion in phantom as stop 15a, can be removably placed anywhere along wire helix 8 to fix the lowest desired inductance or as will be described, placed at the resonant point of a special tuned circuit.

In FIG. 3, another embodiment is illustrated to vary the inductance of variable inductance 5. As depicted, wire helix 8 is a fixed coil of wire wrapped on a magnetic core 16 which is constructed to mechanically move in and out of wire helix 8 for varying its inductance. As shown, a non magnetic metal guide frame 17 guides magnetic core 16 as it moves in and out of wire helix 8. A conventional lever arm 18, ratchet 19 and pawl release mechanism 20 is shown as a means for affording the operator control of the variable inductance.

One way to arrive at the proper electrical specifications for a suitable variable inductance is to connect the varying low voltage secondary of a conventional variac transformer (a secondary capable of handling the large input current associated with a high power magnetron power supply) in series with the primary of a magnetron high voltage transformer. The magnetron is energized into its designed load with the variac winding presenting a short circuit in series with the primary, the variac being gradually turned up until the magnetron stops oscillating. At this point the variac is observed, marked and disconnected. Next, the inductance of the variac winding that resulted in the cut-off of the magnetron is measured on an inductance bridge. It is with this predetermined cut-off measurement, the variable inductance of this invention is designed and constructed.

FIG. 4 shows the variable inductance 5 of this invention and a condenser 41 of my aforementioned copending invention U.S. Ser. No. 739,778 combined so as to create a tuneable resonant circuit whose load is magnetron 2. A transformer 40, condenser 41 and diode 42 of my copending invention are added to FIG. 1. The value of variable inductance 5 required to turn (via mutual inductance) the secondary of transformer 40 to make it resonate with condenser 41 may be ascertained empirically in the same manner as was described in the preceding paragraph. Optionally, a DC ammeter 43 may be added (a) to aid in finding resonant components, (b) for use by the operator to provide a visual check of the resonant peak, (c) to monitor the response of loaded magnetron 2 to control, and (d) to ascertain the power output of magnetron 2.

The advantages of a tuned circuit are numerous. For example, since the resonant circuit affords a higher voltage across magnetron 2 than the non resonating secondary of transformer 40 is able to supply, an electrically smaller, hence a physically smaller, transformer can be employed.

The resonant point is best chosen to occur with the heavier wire at the low inductance side of the variable inductance 5. Full "on" stop 15a is placed at this resonant point. Thence, contact arm 6 passing from "on" stop 15a to "off" stop 14 will control, in small increments, the power output of magnetron 2 from maximum output directly to no output. It is also useful to have the variable inductance tune a section of the slope of a resonant curve rather than tune thru resonance.

With the foregoing and other objects in view, this invention resides in the novel arrangement and combina-

5

tion of parts and in the detail of construction here described and claimed, it being understood that changes in the precise embodiment of the invention here disclosed and claimed may be made within the scope of what is claimed without departing from the spirit of the invention.

I claim:

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

a transformer,

a source of alternating power across the primary of the transformer,

a variable inductance in series with the source of alternating power and the primary of the transformer,

control means for varying the inductance of the variable inductance,

a magnetron which discharges in response to less than twice the secondary voltage of the transformer,

a capacitance where the capacitance is in series with

6

the magnetron and also in series with the secondary of the transformer, and,

a rectifier which includes a cathode and an anode, said rectifier cathode being connected to the anode of said magnetron, and said rectifier anode being connected to the cathode of said magnetron.

2. A circuit, according to claim 1, where the variable inductance includes:

a wire helix wound on a fixed magnetic core, and

a varying means for varying the number of effective turns of the wire helix.

3. A circuit, according to claim 2, where at least one turn of the low inductance end of the variable inductance is capable of carrying more current than the other helix turns.

4. A circuit, according to claim 2, where the means varying the number of turns, includes means for turning off the power output of the magnetron at the high inductance end of the variable inductance.

* * * * *

25

30

35

40

45

50

55

60

65