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ADJUSTABLE VOLTAGE TRANSFORMER FOR MICROWAVE OVEN APPARATUS

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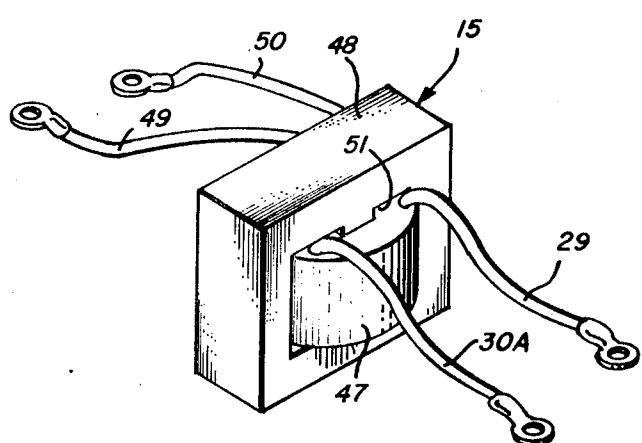
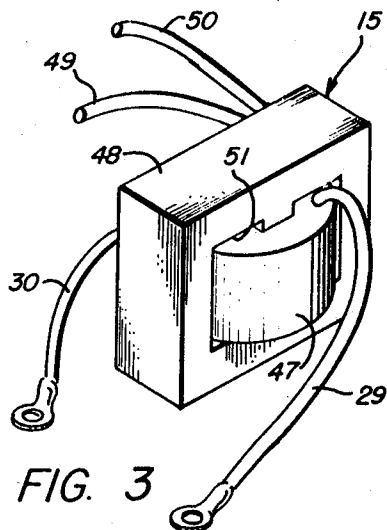
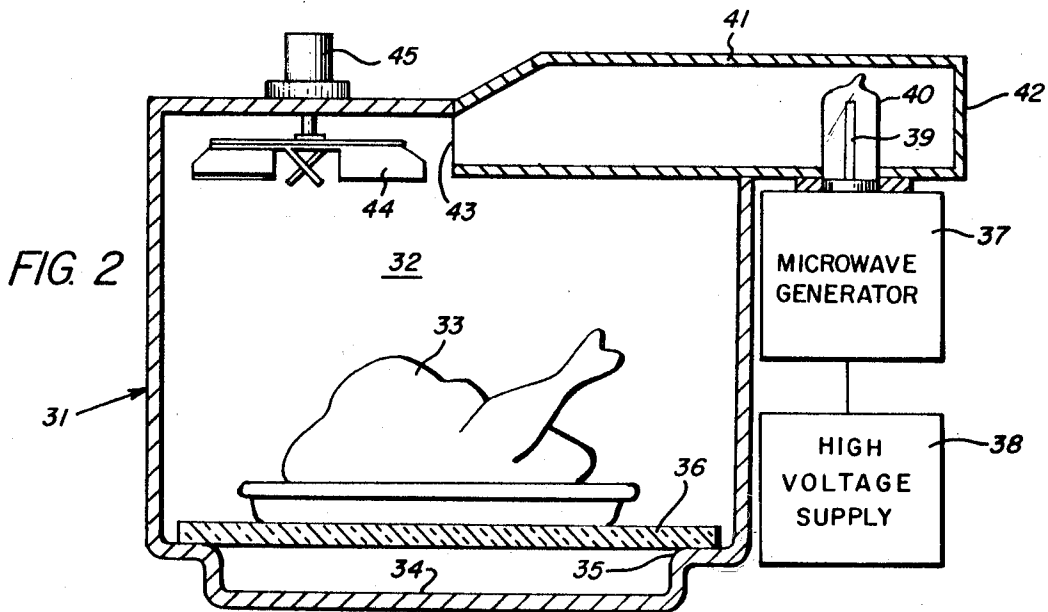
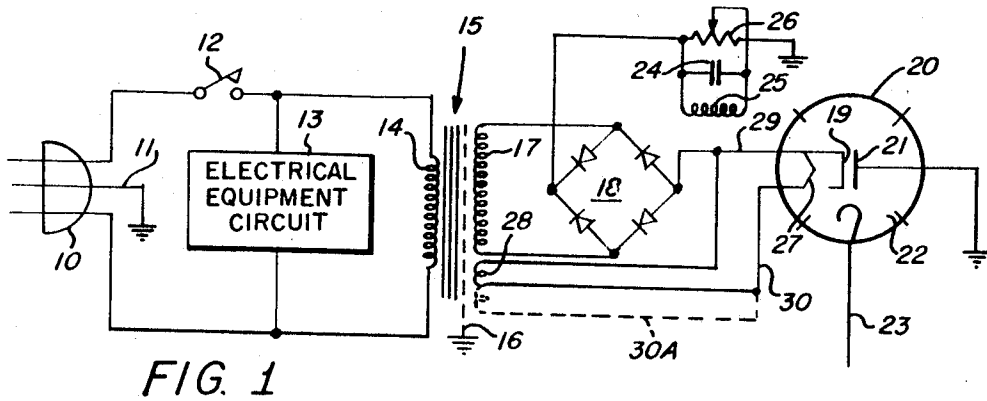


FIG. 3

FIG. 4

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ADJUSTABLE VOLTAGE TRANSFORMER FOR MICROWAVE OVEN APPARATUS

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1 Claim

ABSTRACT OF THE DISCLOSURE

A high voltage transformer for an electrical energy generator having a supplementary winding capability in the secondary winding circuit. Low input line voltage conditions can be compensated for by mutually inductively coupling the supplementary winding to the transformer magnetic field flux lines.

BACKGROUND OF THE INVENTION

The utilization of electromagnetic electrical energy in domestic cooking apparatus has encountered varying voltage conditions at the point of installation. The source of such energy in microwave ovens is the magnetron type device found in radar systems and described explicitly in the text "Microwave Magnetrons," vol. 6, Radiation Laboratory Series, McGraw-Hill Book Company, Inc., 1948, by G. B. Collins. The device conventionally includes an anode defining a plurality of cavity resonators, a central oxide-coated cathode defining with the cavity resonators an electron interaction region. A heater for the cathode is also required together with magnetic field producing means. To provide the operating voltages for the appropriate electrical fields between the cathode and anode which is customarily at ground potential the line voltage is stepped up by a suitable high voltage transformer to values of from 3 to 6 kilovolts. The conventional line voltage for which the microwave energy generator is designed is 115 volts appearing across the transformer primary terminals. With a ratio of windings in the secondary to provide, for example, one volt per turn at the secondary, an approximation of 4000 turns will result in the secondary. If the value of house current at a particular installation is below the 115 volts, or, for example, 105 volts, then a drop of almost 10% will take place to an approximate value of 3500-3600 volts.

In addition to the establishment of the high voltage electrical fields the cathode heater filament is coupled to the transformer by means of the secondary winding to supply illustratively 3-4 volts. The aforescribed under-voltage condition of 10% would mean a voltage of only approximately 2.5-3.5 volts at the cathode heater filament. This voltage generally results in erratic performance of the magnetron tube with a corresponding overall reduction in efficiency and life. The present invention seeks to compensate for all such low voltage conditions involved in high voltage transformer applications.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention a high voltage transformer is disclosed having a secondary winding circuit with a terminal lead adapted to provide a supplementary trimming winding. At the time of installation the supplementary winding can be inserted back through the magnetic circuit of the transformer to provide additional mutual inductance to thereby increase the induced voltage in the secondary. As a result, with the low voltage conditions of illustratively 105 volts and a reduced output from the secondary winding circuit leading to the cathode filament the extra

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winding provided by the invention now restores a full voltage condition and thereby avoids erratic performance of the magnetron generator.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, as well as a specific illustrative embodiment, will now be described, reference being directed to the accompanying drawings in which:

FIG. 1 is a schematic circuit diagram of an exemplary apparatus utilizing the embodiment of the present invention;

FIG. 2 is a vertical sectional view of the apparatus utilizing the illustrative embodiment;

FIG. 3 is a perspective view of an illustrative embodiment of the invention for use under normal voltage conditions; and

FIG. 4 is a perspective view of the illustrative embodiment shown in FIG. 3 adapted for low voltage conditions.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 a schematic circuit diagram of a microwave oven apparatus utilizing the embodiment of the present invention is shown. A conventional connector 10 having a grounded lead 11 connects the circuit to the line voltage through switch 12. All electrical equipment including lights, interlock switches, timers as well as motors for auxiliary equipment such as fans, have not been specifically illustrated and are collectively referred to by numeral 13. Upon closure of the switch 12 the line voltage is impressed on suitable terminals across the primary winding 14 of a step-up transformer 15 which is grounded as at 16. The secondary winding 17 is connected through a full wave rectifier network 18 to the cathode 19 terminal lead of the magnetron power generator 20. This device also conventionally includes an anode 21 which is grounded and defines a plurality of cavity resonators 22 circumferentially disposed about the cathode 19. The microwave oscillations are coupled to the oven apparatus through a coupling loop or antenna 23 and fed into the cooking chamber in the manner to be hereinafter described.

A branch of the full wave rectifier 18 is connected through a capacitor 24 which smooths out and filters the rectified DC current applied to the coil 25 of the magnetic field producing means, illustratively an electromagnet. Additionally, field adjustment resistors are provided to enhance the electromagnet efficiency. The magnetron cathode 19, commonly of the oxide-coated type, is indirectly heated by a filament 27. Electrical current for the filament 27 is provided by secondary coil windings 28 connected through a lead 29 which is tied in common with the cathode lead fed by the full wave rectifier network 18. Another lead 30 is connected to the other end of the filament to complete the circuit.

The transformer 15 has a two-fold function. The standard line voltage of illustratively 115 volts AC is stepped up to a voltage of approximately 4000 volts AC which is then subsequently rectified to DC and applied as the electric field of the magnetron generator. The second function is the provision of the filament voltage of approximately 3.1 volts AC to operate the cathode of the magnetron. The full wave rectifier which may comprise solid state devices converts the alternating current into direct current. One pole of the rectifier network is connected directly to the magnetron anode while the remaining lead is coupled to the electromagnet means.

Before proceeding to the detailed description of the embodiment of the invention the overall microwave oven apparatus shown in FIG. 2 will now be described. A hollow conductive enclosure 31 provides a cavity 32

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which serves as the oven for the cooking of the articles of food 33. A conventional door (not shown) provides for access to the interior of the oven. A bottom wall 34 of the oven enclosure provides by means of shoulders 35 support for a dielectric plate member 36 on which the articles of food are disposed.

A microwave generator 37 which may comprise a magnetron tube is coupled to a conventional high voltage supply circuit 38 including the transformer embodying the present invention together with the components of the circuit described in relation to FIG. 1. The electromagnetic energy from the generator 37 is coupled by means of antenna 39 within the dielectric dome member 40 to a waveguide section 41 adapted to propagate the energy of the desired frequency into oven cavity 32. The waveguide section is closed at one end by wall 42 and is open at the inner end 43. Upon energizing of the microwave generator the electromagnetic waves radiating within the oven cavity are uniformly distributed by stirrer 44 driven by a fractional horsepower motor 45. The stirrer means are well known and described in detail in Pat. No. 2,813,185 issued Nov. 12, 1957 to Robert V. Smith and assigned to the assignee of the present invention.

The high voltage step-up transformer as aforementioned is designed primarily for a standard electrical current of 115 volts. The windings on the primary and secondary coils are determined accordingly. In some prior art microwave oven apparatus operation at 230 volts has been required due to the extremely heavy load and large amount of current drawn by the magnetron together with all the ancillary electrical equipment. It also has been customary in the past to provide a separate terminal board for the filament leads as a tap-off from the secondary coil. In view of the fact that a 4000 volt above ground potential is provided in the secondary leads relatively expensive porcelain insulators are required in any separate terminal loop. Such tap-off terminal boards draw additional current and the overall current is limited to approximately 15 amperes in a standard 115 volt oven apparatus. The total demand of the magnetron generator is between 12 and 13 amperes or 1250 watts and with the additional electrical equipment including timers, motors, controls, safety interlock switches and other ancillary equipment it is not difficult to reach the upper electrical limits.

Referring to FIGS. 3 and 4, high voltage step-up transformer 15 is of the conventional construction fabricated with a large number of windings of copper wire on a magnetic core material such as iron. The weight of an average transformer having a 4000 volt capability can run as high as 20 to 30 pounds. In the illustrations the coil 47 suitably insulated to provide the primary and secondary windings is mounted on an iron core 48 comprising a plurality of stacked laminations in the manner well known in the art to provide the magnetic flux lines. The line voltage of approximately 115 volts AC is connected to the primary windings by means of leads 49 and 50 to the transformer. The filament voltages from the secondary are carried by lead 29 to one end of the magnetron filament and cathode and in FIG. 3 the other lead from the secondary coupled to the filament is designated by the numeral 30. In this configuration it will be noted that the secondary leads 29 and 30 extend from opposing sides of the transformer core 48. This condition will be referred to as the normal voltage operation. Two additional leads, one connected to the rectifier network 18 and one in common with lead 29 to the cathode and filament to carry the very high voltages of approximately 4000 volts have been omitted for clarity in these views and have been shown in FIG. 1.

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Where a low voltage condition exists below the design value or 105 volts, for example, the voltage impressed on the cathode filament will show a corresponding decrease. Erratic performance of the magnetron may then result which requires correction in the manner provided by the invention. As shown in FIG. 4, one of the terminal leads of the secondary winding is provided with a sufficient length to be looped back through the magnetic field circuit. The insertion of the supplementary lead back through the window or opening 51 to traverse the magnetic field flux lines provided by iron core 48 will thereby have the effect of an additional winding on the secondary circuit with an increase in the induced voltages in the secondary circuit. The additional winding which is designated 30A is also shown in FIG. 1 as a dotted line. The additional mutual inductance will restore the filament voltage back to the preferred value and thereby enhance magnetron operation. The disclosed adjustment may be readily made by the installer of the microwave oven apparatus after the measurement of the line voltage conditions reveals the low voltage condition.

There has thus been disclosed an efficient structure and method of adjusting a high voltage transformer to meet low electrical line voltage conditions. It is intended that this description of a preferred embodiment be considered as illustrative only without limiting in any way the interpretation of the broadest aspects of the scope of the invention as set forth in the appended claims.

What is claimed is:

1. In combination:

a microwave oven apparatus defining a hollow metallic enclosure;

an electrical energy generator adapted to propagate energy within said enclosure; and

a high voltage circuit including a transformer electrically connected to said generator for supplying operating voltages thereto;

said transformer comprising a plurality of windings mutually inductively coupled to define a primary and first and second secondary circuits and magnetic flux producing means defining a window;

a portion of said first secondary circuit terminating in said second secondary circuit with low voltage leads disposed on opposing sides of said magnetic means window providing voltages below the primary voltage value;

one of said low voltage leads having a sufficient length to loop said lead through said magnetic means window to the opposite side thereof to mutually inductively couple an additional winding in said second secondary circuit and compensate for variations in the primary voltage values below a predetermined value at the point of installation of said oven apparatus by an increase in the induced voltage output.

References Cited

UNITED STATES PATENTS

2,284,406	5/1942	D'entremont	336—172 X
2,648,772	8/1953	Dawson et al.	219—10.55 X
3,302,060	1/1967	Blok et al.	219—10.55 X

FOREIGN PATENTS

547,018	8/1942	Great Britain.
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