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54 Microwave ovens and methods of cooking food.

57 A microwave oven has a magnetron (44) for supplying microwave power to the oven cavity and a fan and electrical resistance heating element (32) for supplying a forced flow of recirculating hot air through the oven cavity. To increase the penetration of microwave power into the food, and thereby shorten the cooking time, the magnetron (44) has an operating frequency such as 896 or 915 Megahertz which is lower than is conventionally used in microwave ovens.

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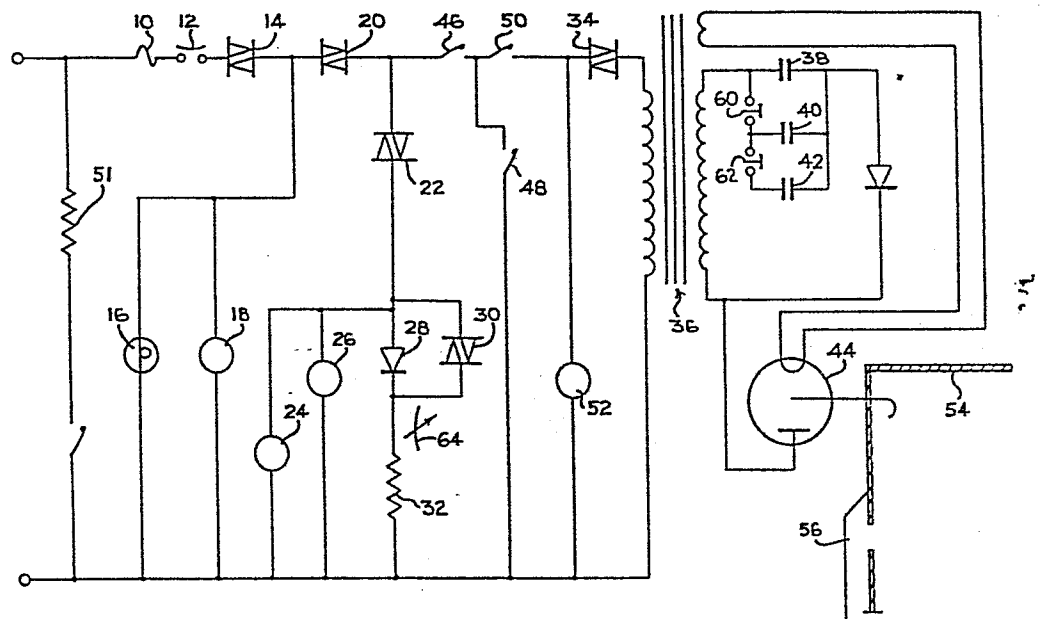


Fig.1

DESCRIPTION

Title: Microwave ovens and methods of cooking food

Field of the invention

This invention relates to microwave ovens and to methods of cooking food.

Background to the invention

Our co-pending UK Application No. 8307123 (Publication No. 2137860) discloses a microwave oven having a microwave
5 generator for supplying microwave power to a cavity of the oven, and thermal heating means for supplying thermal power to the cavity simultaneously with the microwave power. Temperature sensing means sense the temperature within the cavity and are associated with control means
10 which, when the cavity temperature reaches a predetermined level, are operative to reduce the amount of thermal power produced by the thermal heating means and increase the amount of microwave power produced by the microwave generator.

15 For portable domestic microwave ovens having fairly modest power ratings, for example those intended for the US or Japanese markets, it has been found that for most small or medium food items cooking is completed before the cavity temperature rises sufficiently high for the thermal
20 heating means to be reduced in power. In other words, the cavity temperature reaches its final desired maximum temperature, suitable for browning of the food, when the

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required cooking time has elapsed.

A portable domestic microwave oven made for the UK market has a higher power rating and there is therefore more power available to supply to the cavity, than is the case
5 with ovens made for the Japanese or US markets. However, it has been found that this increase in available power does not automatically mean a shorter cooking time and a better result. Any increase in the thermal power delivered to the cavity causes the cavity temperature to
10 rise more quickly and for the temperature sensing means to cause the thermal heating means to cycle on and off. For satisfactory cooking it is important to maintain a balance between the thermal power and the microwave power. An increase in microwave power does not, beyond certain
15 limits, decrease the cooking time. The main limitation on reducing cooking times is the thermal conductivity of the food. Microwave energy at the conventional oven frequency of 2450 Megahertz has a penetration into the food of only a few centimetres, so whatever microwave power is used
20 this factor places a limit on reducing cooking times. The invention aims to overcome this problem by using a lower microwave frequency.

Summary of the invention

According to one aspect of the invention a microwave oven comprises a microwave generator for supplying microwave
25 power to a cavity of the oven, thermal heating means for supplying thermal power to the cavity simultaneously with the microwave power, the thermal heating means including an electrical heating element and a recirculating fan for recirculating air over the heating element and through the
30 cavity, wherein the microwave generator has an operating

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frequency of less than 1000 Megahertz. This lower microwave frequency has a greater penetration into the food items being cooked, typically around 10 centimetres. This means that even large food items having a total thickness of 20 centimetres are penetrated by the microwave energy, so that heating and therefore cooking are extremely rapid.

The generation of thermal power is arranged to match the microwave power, preferably so that the temperature/time curve rises steadily from zero (corresponding to a cold start) and reaches the desired maximum temperature at the completion of the cooking time, without interruption or reduction in the supply of thermal power.

According to another aspect of the invention a method of cooking food in a microwave oven comprises delivering thermal power and microwave power simultaneously into a cavity of the oven, the thermal power being delivered by hot air recirculated by a fan over an electrical heating element, and wherein the microwave power is delivered at an operating frequency of less than 1000 Megahertz.

Preferably, the microwave power is produced by a magnetron or klystron having a frequency of 915 Megahertz (suitable for the USA) or 896 Megahertz (suitable for the United Kingdom and mainland Europe). It is possible for the magnetron or klystron to have an operating frequency which lies between 915 Megahertz and 896 Megahertz and which is suitable for use either in the USA or in the UK or mainland Europe.

The invention may be applied to a portable domestic microwave oven intended to be powered from a domestic plug/socket, but the invention is also applicable to full

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size domestic ovens and to large commercial ovens having higher power ratings.

In all cases, the lower microwave frequency increases penetration into the food items being cooked, thereby
5 enabling higher thermal power to be applied by the recirculated hot air, whilst retaining the necessary balance between thermal power and microwave power.

A microwave oven according to the invention will now be described, by way of example, with reference to the
10 accompanying drawings, in which:-

Figure 1 is a circuit diagram of the oven, and

Figure 2 is a temperature/time graph for explaining the operation of the oven.

Detailed description of the drawings

Referring to Figure 1, mains power (from a 35A cooker
15 input) is applied from the left hand side of Figure 1 through a fuse 10 and a magnetron thermostat 12. A triac 14 controlled by a first timer governs the supply of power to a cavity lamp 16 and a blower 18 for the magnetron. Beyond the triac 14 is a further triac 20 which is
20 controlled by another timer and through which current must pass before reaching a triac 22 and a parallel network comprising a convection motor 24, a relay 26 for operating a flap or damper, a diode 28 in parallel with a triac 30, and a thermal heating element 32. The convection motor 24
25 drives a fan for blowing air over the element 32, this forced flow of hot air being recirculated through the oven cavity so as to produce thermal power for browning the

food to supplement the microwave power.

A triac 34 forms a microwave on/off switch, and inductive coils 36 transmit power through one or more capacitors 38, 40 and 42 to the magnetron 44. The oven has the usual 5 door-latch switch 46, monitor switch 48, and cook/start switch 50. A turntable motor 52 is provided to drive a rotating turntable on which the food is placed in the oven cavity. The oven may also have a radiant grill element 51 at the top of the oven cavity. A portion of the oven 10 cavity is shown schematically at 54, the cavity 54 being vented through a moisture vent 56.

Figure 2 is a plot of air temperature (at a location immediately downstream of the element 32) against time. Curve A shows the temperature/time variation for an empty 15 oven. After time x from a cold start, the air temperature has reached a predetermined threshold T1 (e.g. 250°C), at which point the oven is switched off. Curve A represents one extreme in that it is not possible for the air temperature to reach T1 in a time less than x. Curve B 20 shows the temperature/time variation when the oven is heavily loaded, e.g. by a dense joint of meat. For curve B, the predetermined threshold temperature T1 is reached after time y from a cold start. Curve B represents the other extreme and for all other food items in the oven the 25 temperature/time curve will be somewhere between curve A and curve B and the temperature T1 will be reached (and therefore cooking completed) at a time intermediate x and y.

The predetermined threshold temperature T1 is detected by 30 temperature sensing means in the form of a thermistor 64 which, when temperature T1 is attained, produces an

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electrical signal to switch off power to the element 32 and to the magnetron 44 to signify the end of cooking. Hence, all food items are cooked when temperature T1 is reached, commencing with the oven in a cold condition.

- 5 The triacs shown in Figure 1 are connected to a microprocessor control circuit to which the thermistor 64 is also connected. The operation of the microprocessor control circuit is governed by manually operated control pads of the oven.
- 10 In use food is placed in the oven and the door closed. The oven has a control panel with touch sensitive pads, one of which marked "COM" (for combined microwave and thermal power) is touched. This turns on the triac 14 which in turn energises the magnetron blower 18 and the
15 cavity lamp 16. At the same time triacs 22, 30 and 34 are gated on. When a pad marked "COOK/START" is touched the triac 20 is turned on, door-latch 46 and cook/start switch being closed and monitor switch 48 being open. Power thus flows through the triacs 22 and 30 to energise the heating
20 element 32 with full wave a.c. current. The motor 52 is energised and the turntable rotates. Also, the convection motor 24 and the relay 26 will be energised, the latter closing the flap or damper to divert cooling air from the magnetron blower away from the oven cavity.
- 25 The triac 34 is also closed and current flows through the coils 36, the magnetron 44 being operated at its low power level through the capacitor 38 because switches 60, 62 are open.

The heating element 32 delivers thermal power (1000)
30 watts) and the magnetron delivers microwave power (250

watts). The temperature time variation is shown by curve C in Figure 2, the temperature rising steadily from zero as the thermal power and the microwave power are applied simultaneously and continuously until the thermistor 64 registers that temperature T1 has been attained at time z. A signal is sent to the microprocessor control circuit which switches off the gate supply to triac 20, thereby causing simultaneous cessation of thermal and microwave power and leaving the oven in a stand-by mode. Cooking is then complete. In this stand-by mode, the damper relay 26 is opened and cooling air from the magnetron blower 18 is directed into the oven cavity to cool the latter. A further pad marked RESET/OFF must be touched to turn the oven off completely.

15 The capacitor 40 and switch 60 enable an intermediate level of microwave power to be selected, and the capacitor 42 and switch 62 are provided to enable a third, higher level of microwave power to be selected for microwave only operation.

20 Whilst triacs have been described, other switching devices like relays could be used.

CLAIMS

1. A microwave oven comprising a microwave generator for supplying microwave power to a cavity of the oven, thermal heating means for supplying thermal power to the cavity simultaneously with the microwave power, the thermal
5 heating means including an electrical heating element and a recirculating fan for recirculating air over the heating element and through the cavity, wherein the microwave generator has an operating frequency of less than 1000 Megahertz.
- 10 2. A microwave oven according to claim 1, wherein the generation of the thermal power is arranged to match the microwave power, so that the temperature/time curve rises steadily from zero (corresponding to a cold start) and reaches the desired maximum temperature at the completion
15 of the cooking time, without interruption or reduction in the supply of thermal power.
3. A microwave oven according to claim 1 or 2, wherein the microwave power is produced by a magnetron or klystron having a frequency of 915 Megahertz suitable for the
20 USA.
4. A microwave oven according to claim 1 or 2, wherein the microwave power is produced by a magnetron or klystron having a frequency of 896 Megahertz, suitable for the United Kingdom and mainland Europe.
- 25 5. A microwave oven according to any of the preceding

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claims and in the form of a portable domestic microwave oven intended to be powered from a domestic plug/socket.

6. A microwave oven according to any of claims 1 to 4 and in the form of a full size oven intended to be powered
5 from a cooker power supply.

7. A method of cooking food in a microwave oven, comprising delivering thermal power and microwave power simultaneously into a cavity of the oven, the thermal power being delivered by hot air recirculated by a fan
10 over an electrical heating element, and wherein the microwave power is delivered at an operating frequency of less than 1000 Megahertz.

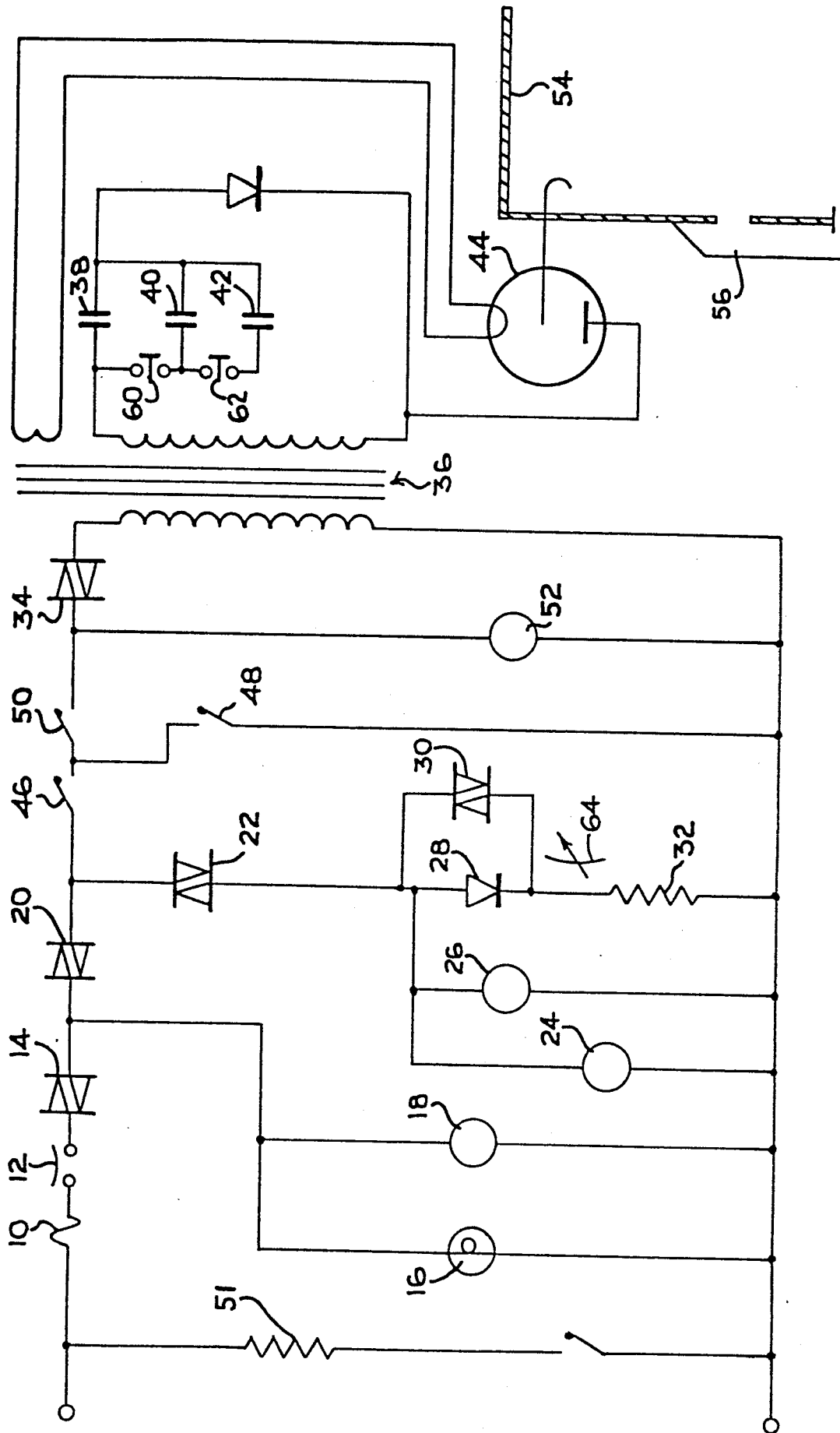
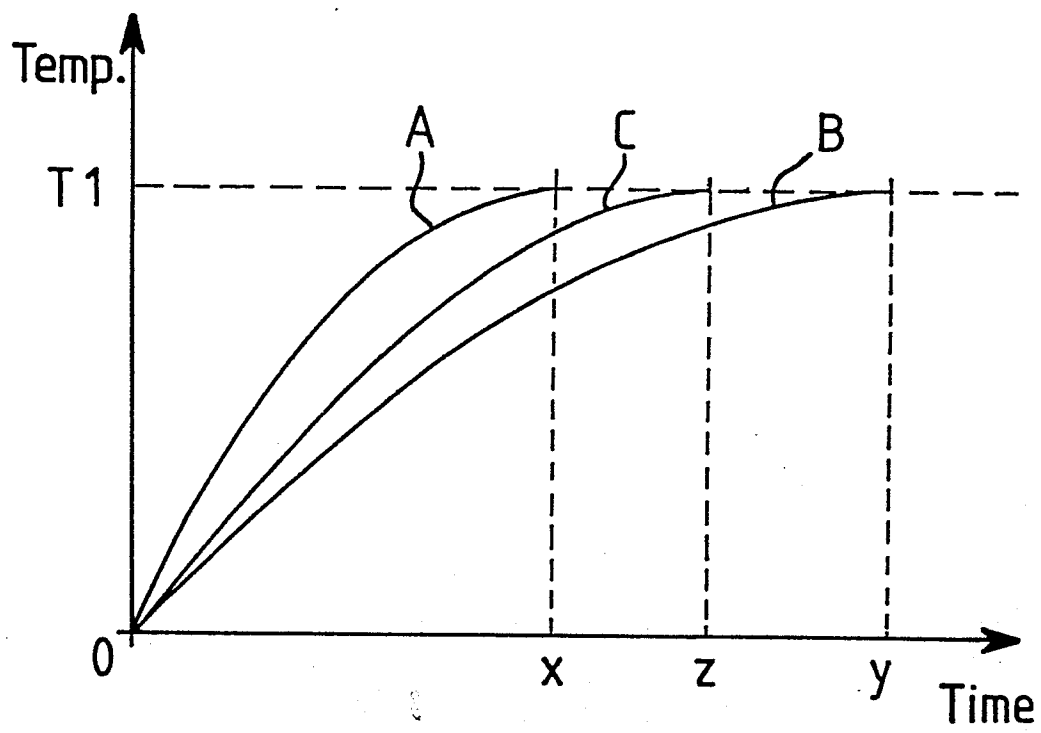


Fig. 1

*Fig.2*