(12) UK Patent Application (19) GB (11) 2 367 196 (13) A

(43) Date of A Publication 27.03.2002

(21) Application No **0128031.2**

(22) Date of Filing **22.12.2000**

Date Lodged **22.11.2001**

(30) Priority Data
(31) **00043477** (32) **27.07.2000** (33) **KR**

(62) Divided from Application No **0031547.3** under Section **15(4)** of the Patents Act 1977

(51) INT CL[7]
H05B 6/68 , H02M 5/458

(52) UK CL (Edition T)
H2H HB8 HHM H25G
H2F FMAT F9J20 F9K12 F9S1 F9T1 F9T2 F9T4A F91WW

(56) Documents Cited
None

(58) Field of Search
UK CL (Edition T) **H2F FMAS FMAT FMAX , H2H HHM**
INT CL[7] **H02M 5/458 7/537 , H05B 6/66 6/68**
ONLINE:EPODOC, JAPIO, WPI

(71) Applicant(s)
Samsung Electronics Co., Ltd.
(Incorporated in the Republic of Korea)
416 Maetan-dong, Paldal-gu, Suwon-city, Kyungki-do, Republic of Korea

(72) Inventor(s)
Young-won Cho
Sung-ho Lee
Tae-soo Kim

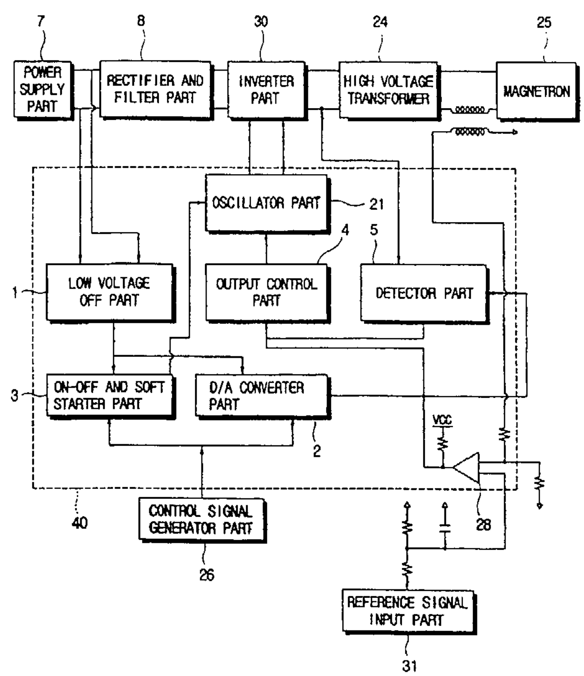
(74) Agent and/or Address for Service
Venner Shipley & Co
20 Little Britain, LONDON, EC1A 7DH, United Kingdom

(54) Abstract Title
Microwave oven having a switching power supply

(57) A microwave oven has a mains AC power input 7, a full-wave rectifying means 8, a magnetron 25, a high voltage transformer 24 and a switching power supply 40 for powering the magnetron via the high voltage transformer. The switching power supply includes a variable frequency oscillator 21, configured such that its frequency varies in dependence on the output of the full wave rectifying means.

An integrating circuit may also be provided to convert a PWM signal into a DC signal, wherein the output of the integrator circuit is connected to supply a control voltage to the oscillator to control its frequency.

FIG. 1



GB 2 367 196 A

FIG. 1

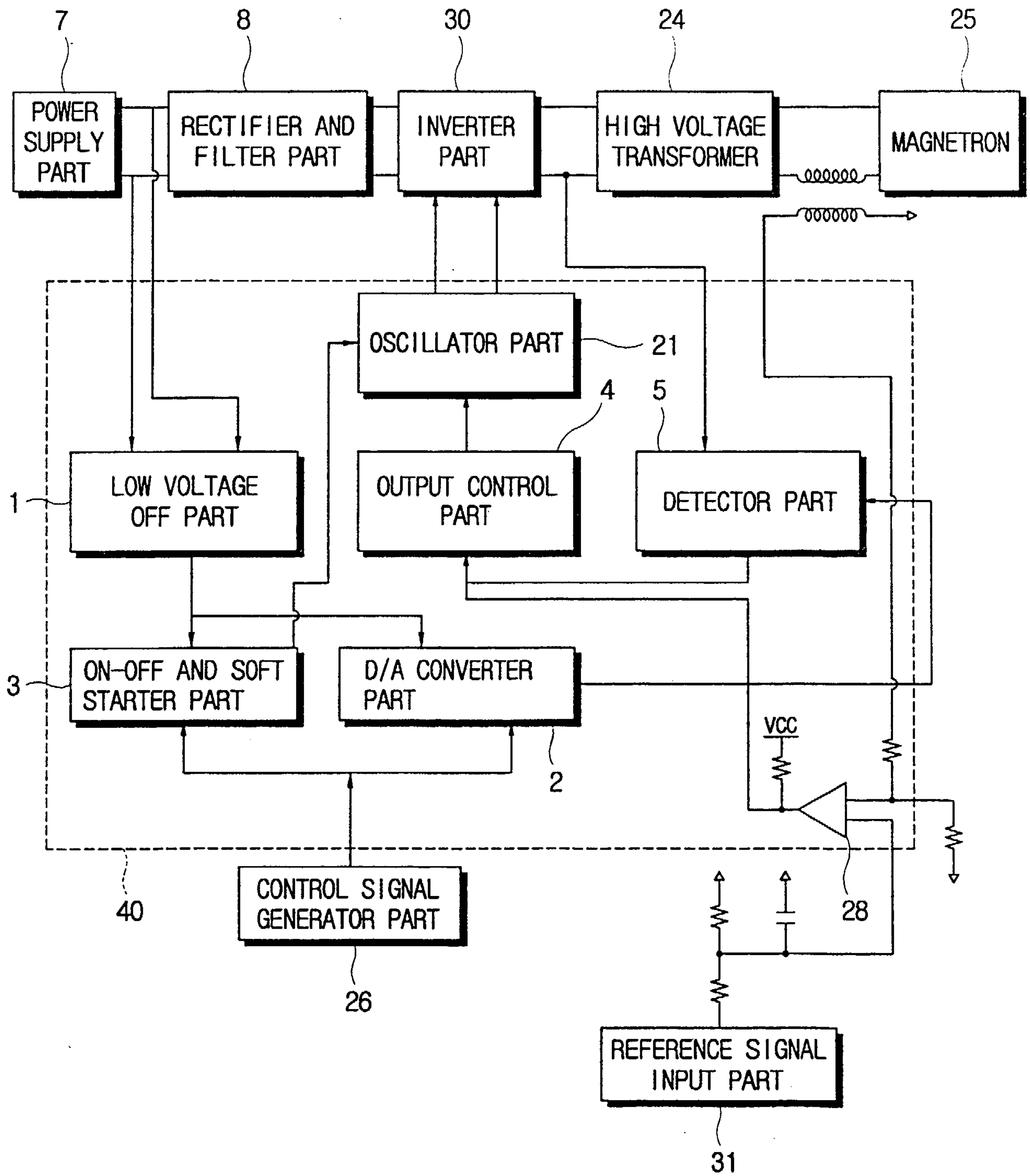
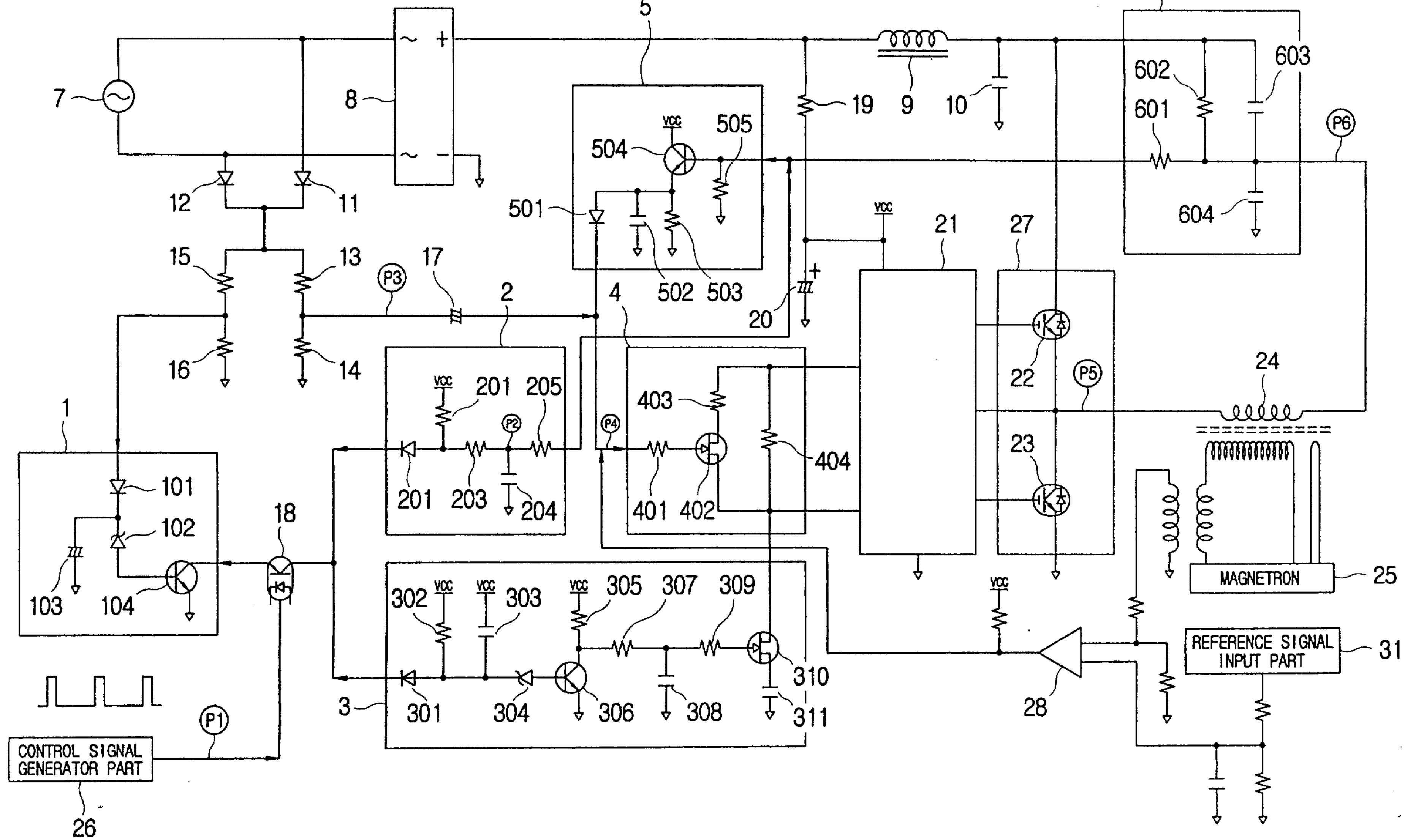

7
8
30
24
25
POWER SUPPLY PART
RECTIFIER AND FILTER PART
INVERTER PART
HIGH VOLTAGE TRANSFORMER
MAGNETRON
OSCILLATOR PART
21
4
5
1
LOW VOLTAGE OFF PART
OUTPUT CONTROL PART
DETECTOR PART
3
ON-OFF AND SOFT STARTER PART
D/A CONVERTER PART
2
VCC
28
40
CONTROL SIGNAL GENERATOR PART
26
REFERENCE SIGNAL INPUT PART
31

FIG. 2



MAGNETRON
REFERENCE SIGNAL INPUT PART
CONTROL SIGNAL GENERATOR PART
VCC
P1
P2
P3
P4
P5
P6

FIG. 3

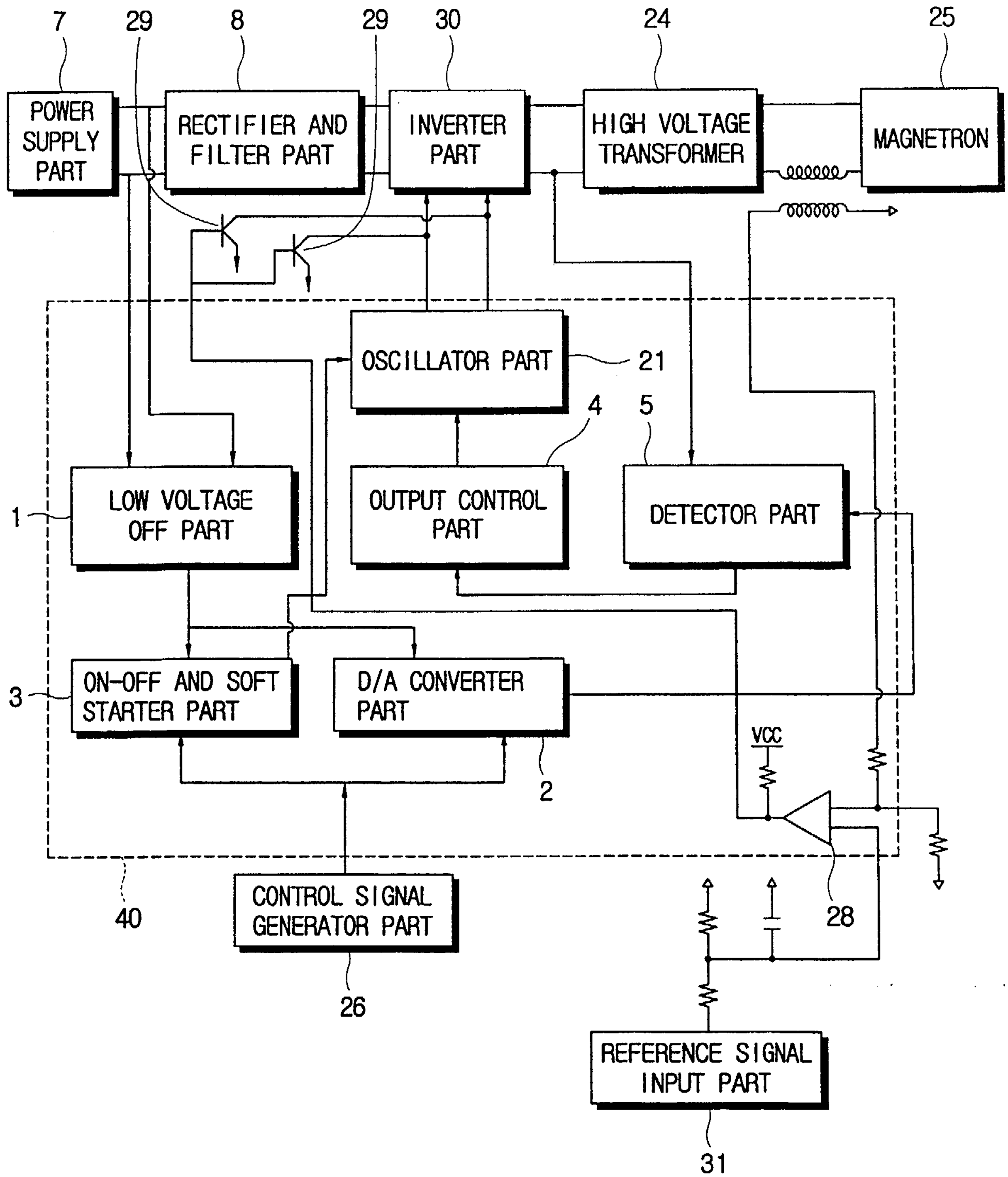
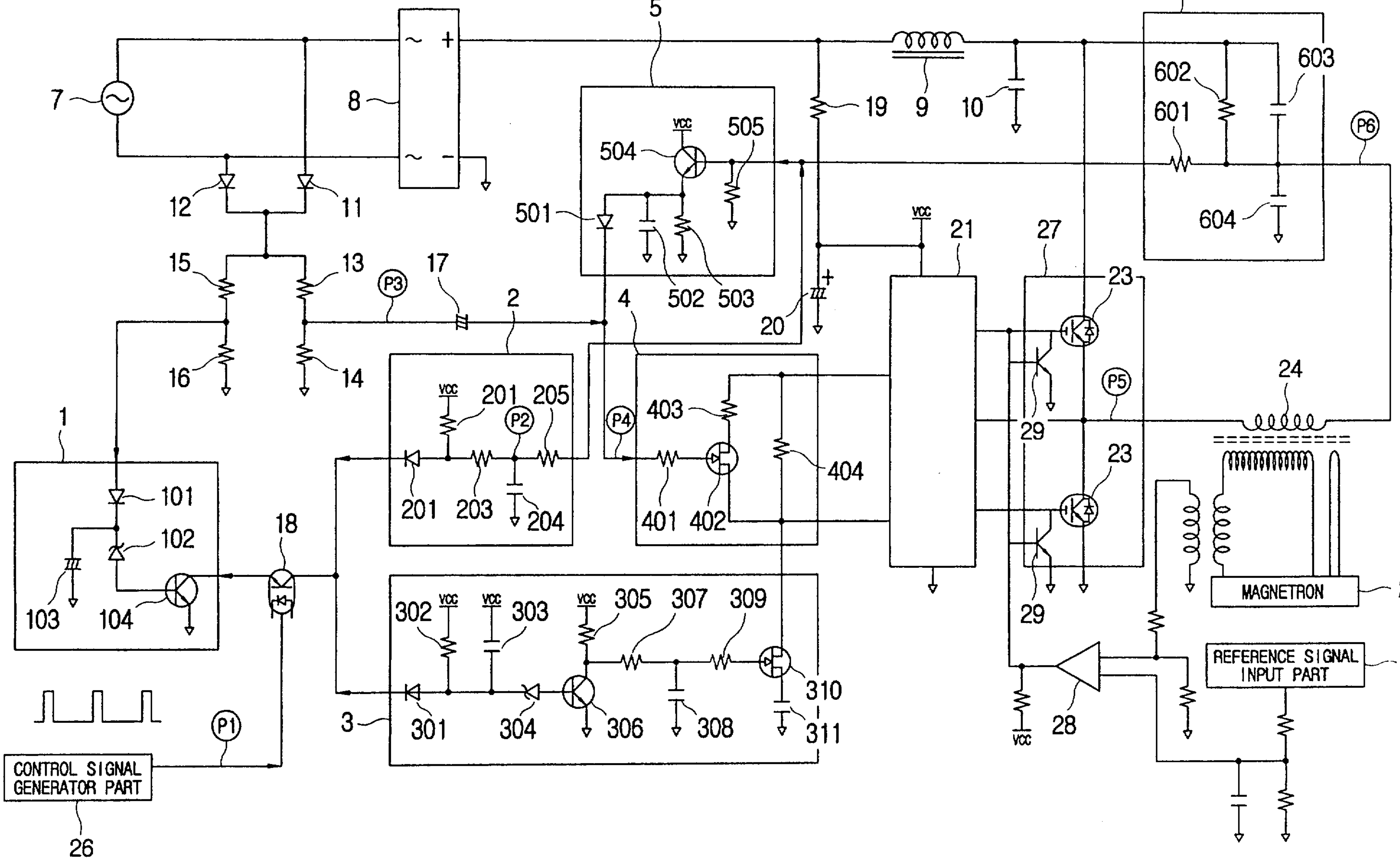
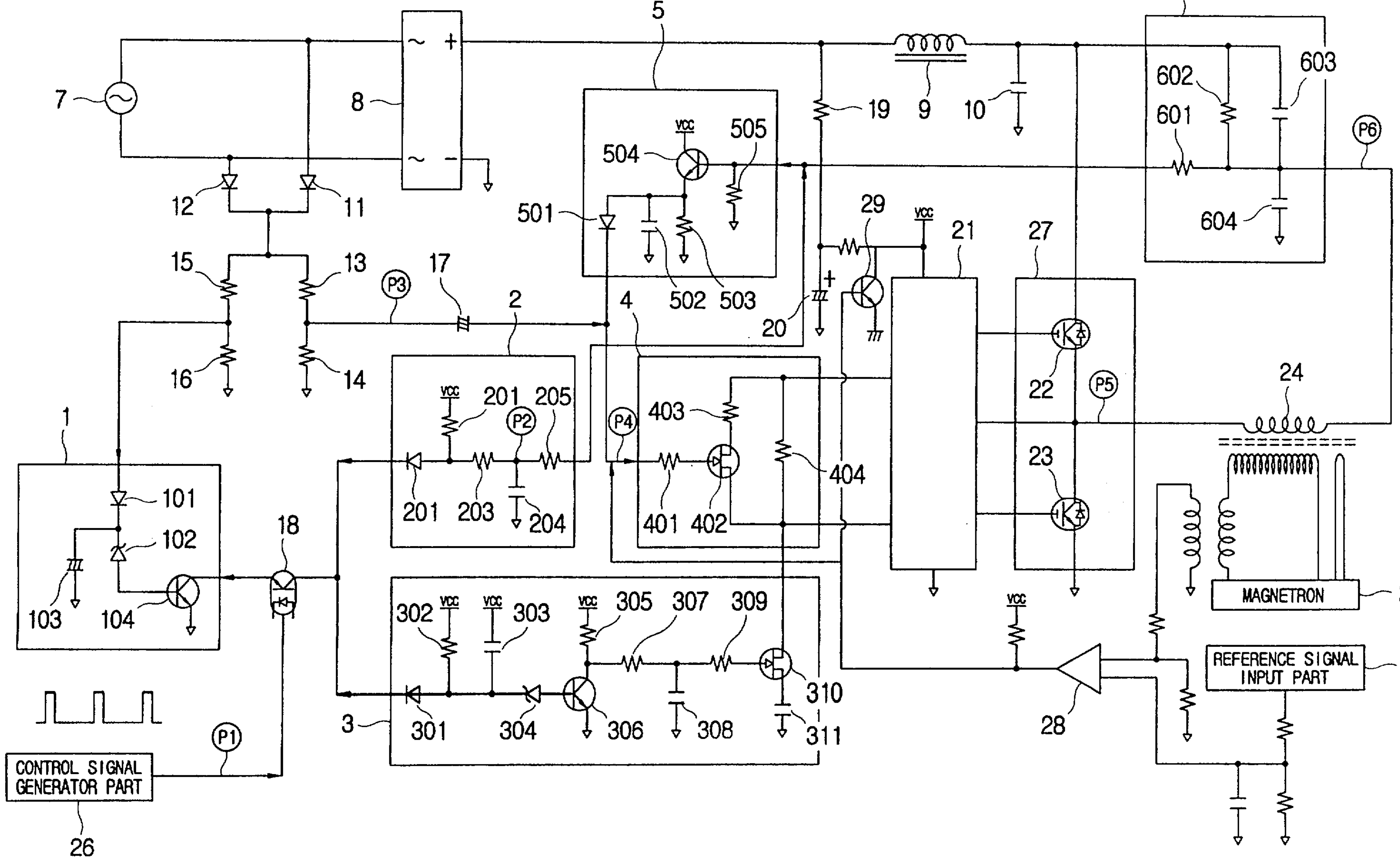

7
29
8
29
30
24
25
POWER SUPPLY PART
RECTIFIER AND FILTER PART
INVERTER PART
HIGH VOLTAGE TRANSFORMER
MAGNETRON
OSCILLATOR PART
21
4
5
1
LOW VOLTAGE OFF PART
OUTPUT CONTROL PART
DETECTOR PART
3
ON-OFF AND SOFT STARTER PART
D/A CONVERTER PART
2
VCC
28
40
CONTROL SIGNAL GENERATOR PART
26
REFERENCE SIGNAL INPUT PART
31

FIG. 4



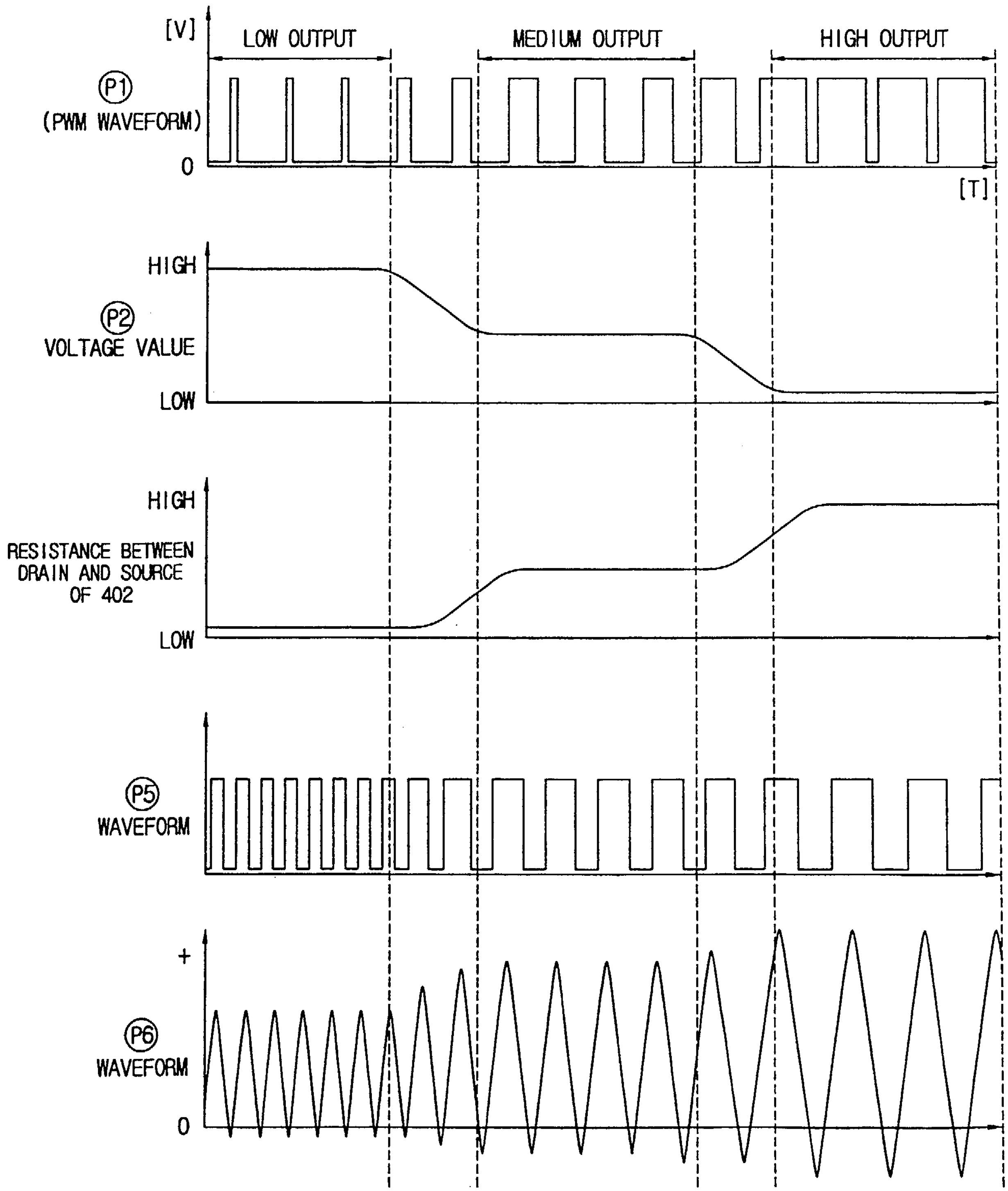
7
8
5
6
504
505
501
502
503
19
9
10
602
601
603
604
P6
12
11
15
13
16
14
P3
17
2
4
20
21
27
23
29
P5
24
1
101
102
103
104
18
201
205
P2
203
204
P4
403
404
401
402
MAGNETRON
25
302
303
305
307
309
310
311
301
304
306
308
3
REFERENCE SIGNAL INPUT PART
31
28
VCC
P1
CONTROL SIGNAL GENERATOR PART
26

FIG. 5



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
31
101
102
103
104
201
201
203
204
205
301
302
303
304
305
306
307
308
309
310
311
401
402
403
404
501
502
503
504
505
601
602
603
604
P1
P2
P3
P4
P5
P6
VCC
MAGNETRON
REFERENCE SIGNAL INPUT PART
CONTROL SIGNAL GENERATOR PART

FIG. 6



[V]
LOW OUTPUT
MEDIUM OUTPUT
HIGH OUTPUT
P1
(PWM WAVEFORM)
0
[T]
HIGH
P2
VOLTAGE VALUE
LOW
HIGH
RESISTANCE BETWEEN DRAIN AND SOURCE OF 402
LOW
P5
WAVEFORM
+
P6
WAVEFORM
0

FIG. 7

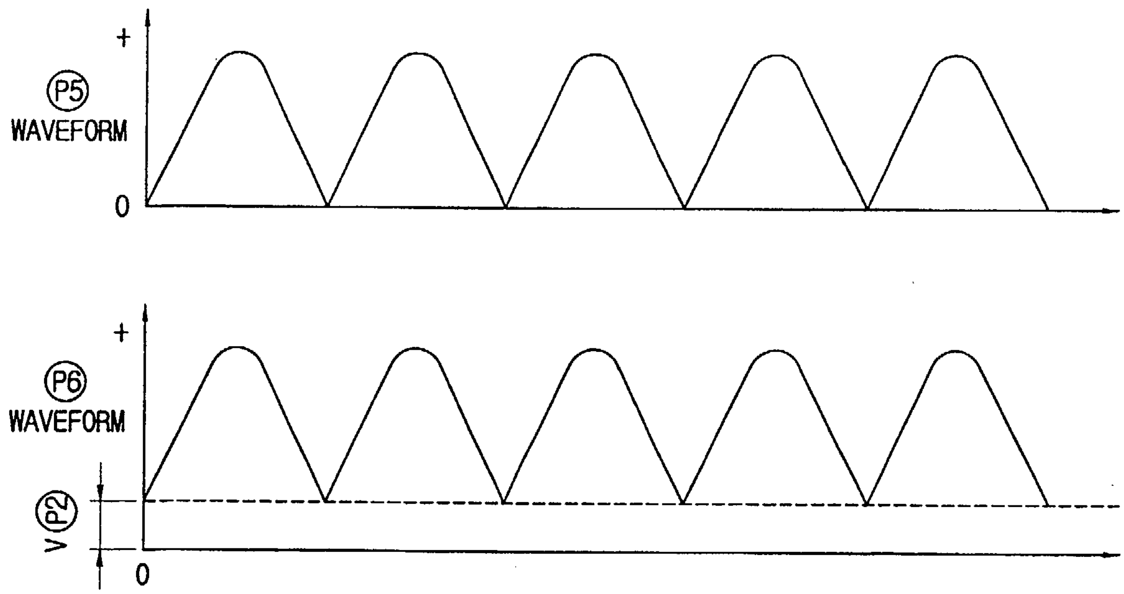


FIG. 8

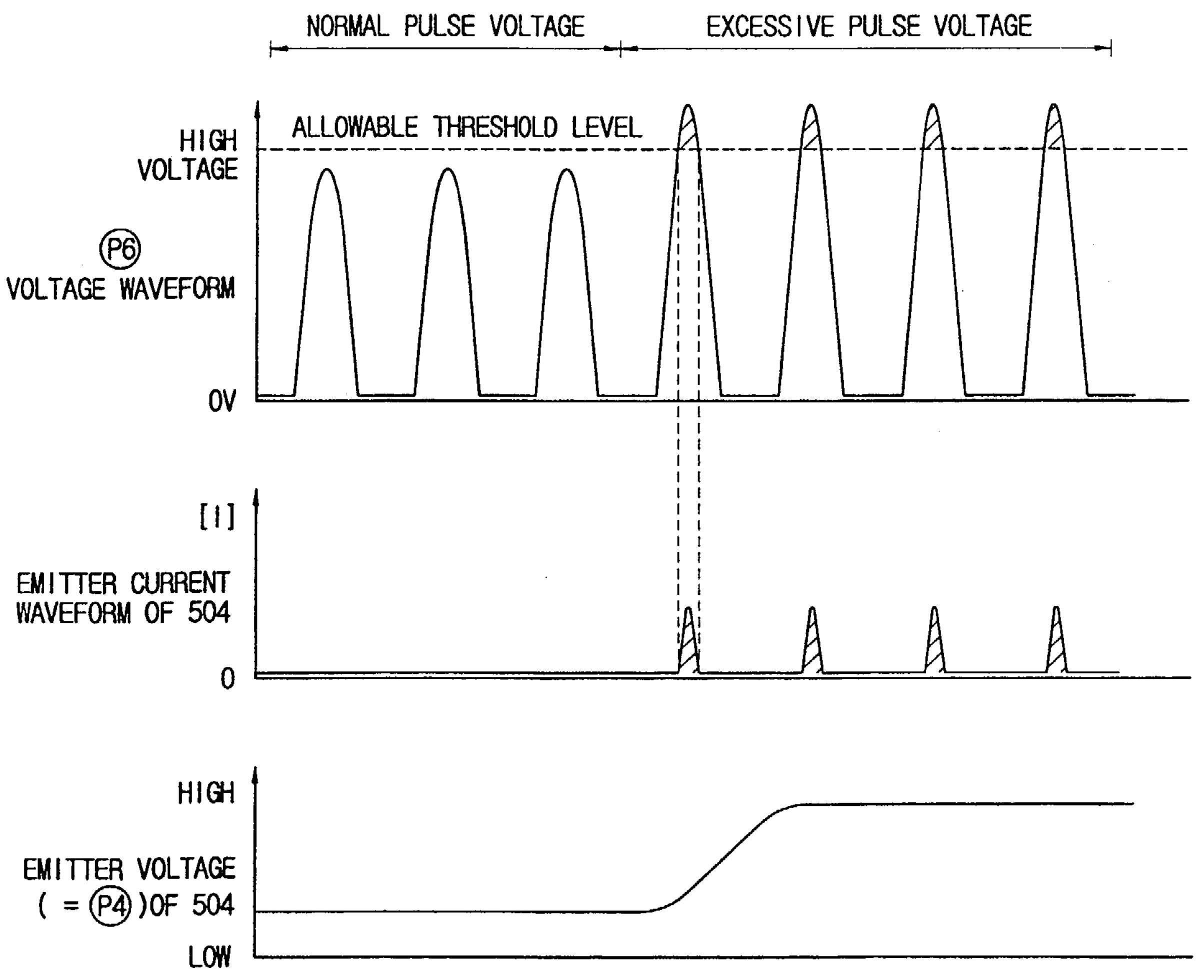
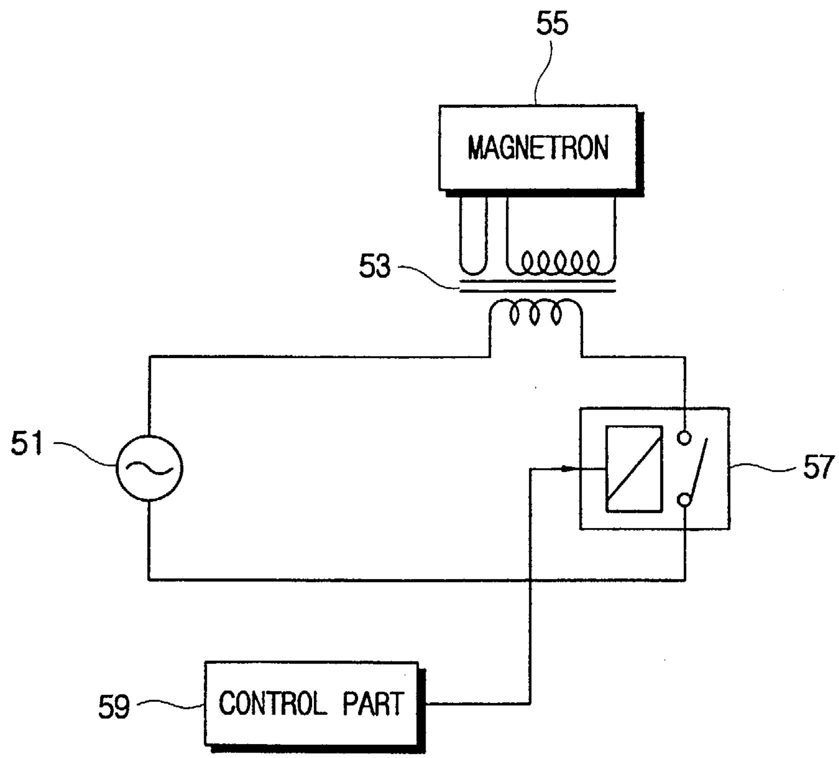

NORMAL PULSE VOLTAGE
EXCESSIVE PULSE VOLTAGE
HIGH VOLTAGE
ALLOWABLE THRESHOLD LEVEL
P6
VOLTAGE WAVEFORM
0V
[I]
EMITTER CURRENT WAVEFORM OF 504
0
HIGH
EMITTER VOLTAGE (= P4)OF 504
LOW

FIG. 9
(PRIOR ART)



2367196

Microwave Oven Having a Switching Power Supply

Description

The present invention relates to a microwave oven having a switching power supply.

Conventionally, the magnetrons of microwave oven have been powered by applying an alternating mains voltage to high-voltage transformers to produce the high anode voltages required by the magnetrons.

Figure 9 is a block diagram of a control system of a conventional microwave oven.

Referring to Figure 9, a conventional microwave oven is comprised of a power supply part 51, a high-voltage transformer 53 generating a high voltage from the current supplied from the power supply part 51, a magnetron 55, powered by the high-voltage transformer 53, for generating microwaves, a relay switching part 57 for the magnetron 55 on and off, and a control part 59 for controlling the operation of the high-voltage transformer 53, the magnetron 55 and the relay switching part 57, on the basis of the power from the power supply part 51 and an external signal inputted into the controlling part 59.

With this configuration, when electric power is supplied from the power supply part 51, the control part 59 closes the relay switching part 57 in response to the external signal, thereby supplying the electric power to the primary winding of the high-voltage transformer 53. When mains electric power is supplied to the primary winding of the high-voltage transformer 53, thousands of volts are generated across the main secondary winding of the high-voltage transformer 53.

However, since the core of the high-voltage transformer 53 used in the conventional microwave oven is made of a silicon steel sheet, it is heavy and bulky, and makes the microwave oven inconvenient for consumers to handle.

Furthermore, the bulk of the high-voltage transformer 53 is also a result of the large number of secondary winding turns required to produce the necessary high-voltage.

Conventional microwave ovens control the duty cycle of the current fed to the high-voltage transformer to adjust the magnetron anode voltage. In the duty cycle control method, if the on-time of the maximum rated output is short and the off-time thereof is long, a low output is generated, whereas a high output is generated if the on-time of the maximum rated output is long and the off-time is short. Where the output is adjusted by the duty cycle control method, there is a great variation in temperature affecting cooking of food, which may lower an efficiency in cooking and further cause the food to be ill-tasting.

According to the present invention, there is provided a microwave oven including a magnetron, a high-voltage transformer, a switching power supply for powering the magnetron via the high-voltage transformer and a current sensor for sensing the current in a high-voltage secondary winding of the high-voltage transformer, wherein the switching power supply is responsive to the output of the current sensor falling outside a predetermined range to cease its switching operation.

Preferably, the power supply includes rectifying means for rectifying input mains AC to produce DC and switch means for chopping said DC and thereby effecting said switching operation.

Preferably, the power supply includes a variable frequency oscillator, for example a voltage-controlled oscillator. More preferably, an integrator circuit is included for converting a PWM signal into a DC signal and the output of the integrator circuit is connected to supply a control voltage to said oscillator for controlling the frequency thereof. More preferably also a mains AC power input and full-wave rectifying means for rectifying AC from said AC power input are included and the oscillator is configured such that its frequency varies in dependence on the output of said full-wave rectifying means.

Embodiments of the present invention will now be described, by way of example, with reference to Figures 1 to 8 of the accompanying drawings, in which:

Figure 1 is a block diagram of a control part of a first microwave oven according to the present invention;

Figure 2 is a detailed circuit diagram of Figure 1;

Figure 3 is a block diagram of a control part of a second microwave oven according the present invention;

Figure 4 is a detailed circuit diagram of Figure 3;

Figure 5 is a detailed circuit diagram of a third microwave oven according the present invention;

Figure 6 shows plots of electric potentials and waveforms at several points in Figure 2;

Figure 7 shows plots waveforms of source signals for improving a power factor;

Figure 8 is a plot showing operational characteristics of a detector part; and

Figure 9 is a block diagram of a control part according to a conventional microwave oven.

Referring to Figures 1 and 2, a microwave oven according to the present invention comprises a power supply part 7 supplying mains AC power, a control signal generator part 26 for generating a control signal, an inverter part 30 for converting mains AC power into high-frequency AC power in dependence on the control signal, a magnetron 25 for generating microwaves and powered from the inverter part 30, a rectifier and filter part 8 for rectifying and filtering the power supplied from the power supply part 7, a high-voltage transformer 24 for generating a high voltage from the supplied power, a reference voltage signal input part 31 for inputting a reference voltage signal to determine whether the control signal input to the magnetron 25 is within a predetermined range, and a control part 40 for blocking the control signal from being inputted to the magnetron 25 where the control signal input from the control signal generator part 26 is outside the predetermined range. The inverter part 30 is provided with a resonator part 6 (see Figure 2) connected in series with a primary winding of the high-voltage transformer 24.

The control part 40 comprises a D/A converter 2 converting a control signal input from the control signal generator 26 into an analogue signal, a detector part 5 for detecting whether the control signal converted by the D/A converter part 2 is abnormal, and an output control part 4 for outputting the control signal to the inverter part 30 if the control signal is not abnormal.

The control part 40 also comprises an variable frequency oscillator part 21, provided between the output control part 4 and the inverter part 30, whose frequency is controlled by the control signal from the output control part 4. The oscillator part 21 is connected to a switching part 27 (see Figure 2) for chopping the DC from the rectifier and filter part 8 to produce AC. The switching part 27 has a pair of switching power elements 22, 23.

The control part 40 is further comprised of an on-off and soft starter part 3 for controlling on-off and soft start operations of the oscillator part 21 based on the control signal from the signal generator part 26, and a low voltage off part 1 for outputting a stop signal to the on-off and soft starter part 3 and the D/A converter part 2 when the power input through the power supply part 7 is determined to be abnormal. The control part 40 further comprises a comparator part 28 for comparing a voltage representing the output current of the high-voltage transformer 24 ("the sense voltage") via the high-voltage transformer 24 with the reference voltage signal from the signal input part 31.

The rectifier and filter part 8 is connected to an inductor 9 (see Figure 2) and a capacitor 10 (also see Figure 2), to prevent noise from the inverter propagating to the mains wiring. A resistor 19 and a filter capacitor 20 connected to the rectifier and filter part 8 drops the high DC voltage, approximately 310V, from the rectifier and filter part 8 about 15V suitable for powering the semiconductor components of the oven.

The control part 40 compares the sense voltage with the reference voltage signal from the reference voltage signal input part 31 using the comparator part 28. If it is determined that the sense voltage is higher than the reference voltage signal, the control part 40 prevents the control signal from returning to the inverter part 30. If it is determined that the sense voltage is not above the reference voltage signal, the control signal is allowed to be fed back to an input terminal of the output control part 4.

As in a second embodiment of the present invention which is depicted in Figures 3 and 4, transistors 29 are connected to the outputs of the oscillator part 21. The transistors 29 prevents the control signals being input into the switching part 27 when the control signal is higher than the reference voltage signal.

In a third embodiment of the present invention which is shown in Figure 5, a transistor 29 is connected to the input terminal of the oscillator part 21.

When the signal from the comparator part 28 is input into the output control part 4, the signal can be repeatedly input along with the control signal from the control signal generator part 26, thereby adjusting the output within shortened driving times.

The high-voltage transformer 24 employed in the microwave oven according to the present invention is driven with a high frequency (about 20kHz) and, therefore, a ferrite core is used in order to reduce losses. The high-voltage transformer 24 decreases the transformer volume by 75% and reduces weight by 95% compared with conventional iron-cored high-voltage transformers. Since the high-voltage transformer of the present invention is driven with the high frequency by means of oscillation, it does not need to increase the number of turns of the secondary winding thereof.

With this configuration, the control part 40 divides the digital control signal generated by the control signal generator part 26 and inputs the divided signals into the D/A converter 2 and the on-off and soft starter part 3 respectively. The flow of the divided control signal inputted to the D/A converter 2 will be described in more detail hereinbelow.

The divided control signal inputted to the D/A converter 2 is converted into an analogue signal and input into the detector part 5. The control part 40 determines whether the control signal input into the detector part 5 is within a predetermined control range. If the control signal is determined to be outside the predetermined control range, the control part 40 stops the control signal from being applied to the output control part 4.

If the control signal is determined to be within the predetermined control range, a control signal is output to the inverter part 30 from the oscillator part 21, and the inverter part 30 converts the DC power supplied from the power supply part 7 into high-frequency AC power. The high-frequency AC power is supplied to the magnetron 25 through the primary and secondary windings of the high-voltage transformer 24, so that the magnetron 25 generates electromagnetic waves.

The signal supplied to the primary winding of the high-voltage transformer 24 from the inverter part 30 is sensed by the detector part 5. The control part 40 determines again whether the signal sensed by the detector part 5 is within the predetermined control range. If the sensed signal is determined to be within the predetermined control range, a control signal is applied to the input terminal of the output control part 4. If the sensed signal is determined to be outside the predetermined control range, the control part 40 stops the control signal from being applied to the input terminal of the output control part 4, thereby resulting in stabilizing the circuit system.

The powering signal applied to the magnetron 25 via the high-voltage transformer 24 is sensed and the sense voltage is aupplied to the comparator part 28. The comparator part 28 compares the sense voltage applied thereto and the reference voltage signal from the signal input part 41. If the sense voltage applied to the comparator part 28 is not in a predetermined range of the reference voltage signal, the control part 40 stops the control signal from being applied to the output control part 4. Where sense voltage applied to the comparator part 28 is in the predetermined range of the reference voltage signal, the control signal is inputted to the output control part 4.

Respective elements constituting the control part 40 including the D/A converter part 2, the on-off and soft starter part 3, the oscillator part 21 and the output control part 2 will now be described in more detail.

When the power is initially supplied to the microwave oven from the power supply part 7 or when the microwave oven is on standby, a control signal is not input into the input terminal of a photo-coupler 18, connected to the control signal generator part 26, from the signal generator part 26 and, therefore, the inverter part 30 does not operate. This means that the inverter part 30 does not output an AC waveform. To operate the inverter part 30, pulse width modulation (PWM) waveforms are continuously applied through an input terminal (P1) of the photo-coupler 18 from the control signal generator part 26.

The PWM signal applied to the photo-coupler 18 control the output of the inverter part 30 by varying the frequency of the oscillator part 21 depending upon changes in the pulse width of the PWM signal.

When the PWM signal is not applied to the on-off and soft starter part 3, a transistor 306, biased by a resistor 302 and a capacitor 303 and constituting the on-off and soft starter part 3, turns on. When the transistor 306 is turned on, a gate potential of a field effect transistor (FET) 310 becomes minimum and the resistance between a drain and a source of the FET 310 becomes infinitely great. When the resistance between the drain and the source of the FET becomes infinitely great, a capacitor 311 is electrically separated from the oscillator part 21, causing the oscillation of the oscillator part 21 to stop. Thus, the inverter part 30 stops operating.

Conversely, where the PWM signal is applied to the on-off and soft starter part 3, the base bias of the transistor 306 is drained out through an orientation diode 301, thereby causing the transistor 306 to turn off. A zener diode 304 interrupts the residue base bias of the transistor 306, allowing the transistor to maintain a certain state. When the transistor 306 turns off, a filter capacitor 308 is slowly charged with a VCC voltage through the resistor 305 and the gate resistor 307. Accordingly, the resistance between the drain and the source of the FET 310 slowly decreases, and the oscillating capacitor 311 is electrically connected into the oscillator part 21, thereby initiating oscillation.

When the PWM signals are applied to the input terminal of the photo-coupler 18, the values of the analogue voltage of the D/A converter 2 are determined depending upon the relation between high values and low values in the PWM signals.

When the voltage value (P2) is lowered, the value of resistance between the drain and the source of the FET 402 is increased to allow the oscillating part's frequency to be lowered and the output of the inverter part 30 to be increased. A resistor 201 provides a gate bias voltage of the FET 402; and the resistors 203, 205 and the capacitor 204 are a filter, converting digital PWM waveforms into analogue waveforms, which are applied to the FET 310 through a gate resistor 401.

As described above, the element coupling and separating the oscillator part 21 and the oscillating capacitor 311 is the resistance between the drain and the source of the FET 310. When the resistance between the drain and the source is high, the capacitor 311 is isolated, thereby increasing the oscillating frequency. Conversely, where the resistance between the drain and the source is so low as to be ignored, the capacitor 311 is connected into the oscillating part 21 lowering its frequency.

Where the frequency is high, the output of the inverter part 30 is decreased. Thus, when the inverter part 30 starts to oscillate, it is desirable to increase the oscillating frequency as high as possible to allow the output to be at a minimum, and then to slowly lower the frequency until the desired output is obtained, thereby giving no burden to the various electric elements. The soft start operation considers all the properties of the oscillating frequency and the inverter part 30. The present invention realizes the soft start by means of the resistance property between the drain and the source of the FET 310.

Hereinbelow, the output control part of the present invention will be described in more detail.

The oscillator part 21 oscillates by itself, when an external resistor (RT) and a capacitor (CT) are connected, generating gate pulses for the switching elements 22, 23.

The frequency Fo of the oscillator part 21 is obtained from the equation:

$$F_0 = \frac{1}{4(1.4 \times (RT + 75) \times CT)}$$

where the external resistance(RT)=resistance(404)/{resistance(403)+ the resistance (402) between the drain and the source and the capacitor (CT) = capacitor(311).

The frequency can be changed by changing the value of external resistance (RT). The inverter part the resistance properties between the drain and the source of the FET 402 to change the external resistance value.

The variation of frequency aims at improving the power factor of the inverter part 30, in addition to controlling the output of the inverter part 30. Where an output is made from the inverter part 30 considering no improvement of the power factor, the voltage of the secondary winding of the high-voltage transformer 24 is determined in proportion to the voltage supplied through the power supply part. The supplied voltage has a waveform resulting from rectification of the commercial AC power, the secondary high voltage has also the same waveform as the rectified waveform. Consequently, the magnetron 25 is operated in proximity to top points

(90°and 270°of the commercial AC signal) of the secondary high voltage. In reverse, the operation of the magnetron 25 stops in proximity to zero crossing points (0°and 180°of the commercial AC signal) because the secondary high voltages is low, which shortens the durability of the oscillating element of the magnetron and deteriorates the efficiency of electric energy. Therefore, it is preferable to provide the oscillating element of the magnetron with a load property similar to that of the possible resistance over the whole range of the commercial AC power waveforms.

As shown in Figure 6 which shows graphs for an electric potentials and waveforms at several points of Figure 2, the improvement of the power factor is to allow the magnetron 25 to have a uniform load over the full cycle of the AC signal. However, it is not easy for the magnetron 25 to have a uniform load over the whole section of the DC signal under the non-linear load structure, which is merely possible in pure resistance load. Thus, to operate the magnetron 26 to have the uniform load properties, the operational voltage must be calibrated reversely.

The reverse calibration of the operational voltage is accomplished by lowering the high voltage supplied to the magnetron, in proximity to 90°and 270°, at which the magnetron is the most actively operated, and enhancing the high voltage in proximity to 0°and 180°, at which the magnetron is the least actively operated. Hence, electric current approximate to the pure resistance load may be obtained.

Diodes 11, 12 are full-wave rectifier circuit elements to obtain an DC signal waveform necessary for improving the power factor and operating the low voltage off part 1. The obtained waveform signal is converted into a low voltage by attenuator resistance elements 13, 14 and transmitted into the gate of the output control part 4 through the capacitor 17. The capacitor 17 transmits only the AC component of the rectified signal without lowering gate bias voltage of the output control part 4, thereby allowing the FET 402 to be always in the operable range.

Where the phase angles are 90° and 270°, the strength of the gate bias voltage (P4) is obtained by superimposing a sine wave over the reference bias voltage (P2), so that the resistance value between the drain and the source of the FET 402 is changed, allowing the output of the inverter part 30 to vary. That is, where the phase angles are 90° and 270°, the resistance value between the drain and the source of FET 402 becomes the least and the oscillating frequency of the oscillator unit 21 becomes the maximum accordingly, thereby lowering the output of the inverter part. Figure 7 shows graphs for waveforms of source signals for improving the power factor with DC. As described above, the reference source for improving the power factor is obtained from the mains AC power; and to improve the power factor, the variation in resistance between the drain and the source of the FET is used.

The low voltage off part 1 is used so as to protect the various power elements by suspending the operation of the inverter part 30, when the AC input voltage is extremely low because of abnormal power lines or lightning. The filter capacitor 103 is charged with the AC signal converted into a low voltage by the attenuation resistors 15, 16 through the diode 101 of the low voltage off part 1. When the AC signal charging the filter capacitor 103 are lower than the predetermined value of the zener diode 102, the transistor 104 is off, to erase the PWM waveforms applied to the photo coupler 18 and suspend the oscillation of the inverter part 30. The photo coupler 18 and the transistor 104 of the low voltage off part 1 are connected in series to each other, and thus these elements are in the form of logic product, that is, AND, so that the resultant turns off if either of them turns off.

Where a resonance voltage generated in the resonance part 6 is higher than a predetermined value, the detector part 5 applies the resonance voltage to the base of the transistor 504 through voltage-dividing resistors 601, 505. After an emitter resistor 503 and a charging capacitor 502 are charged with the resonance voltage applied to the transistor 504, the resonance voltage is applied to the input terminal of the output control part 4 through the diode 501.

The resonance voltage of the resonance part 6 is abnormally risen because it is affected by surge noises entering over the power line. To protect the circuits from the surge noises, according to the present invention, the abnormal resonance voltage is converted into normal voltage by means of a transistor employing an emitter-floor mechanism, and the converted normal voltage is fed back to the input terminal of the output control part 4, thereby allowing the resonance part to operate in a closed-loop.

As shown in Figure 8 which is a graph showing operational characteristics of a detector part, before the inverter part 30 starts to operate, that is, when the central voltage (P6) of the resonance part 6 is V/2 during suspension of the inverter part 30, the optimum soft start is realized. Here, "V" means the DC voltage applied to a collector of the switching power element 22 and a resonance capacitor 602 through a reactor 9. Where the commercial AC power supply is 220V, V is about 310V, and thus, V/2 is about 155V.

To adapt the voltage (P6) to the level of V/2, the value of a pull-up resistor 502 should be equal to the sum of the value of the resistor 601 and the resistor 505. However, the value of the resistor 505 is so small as to be ignorable, in comparison with the resistor 601, the resistor 502 has the same value as that of the resistor 601, thereby allowing the DC bias of V/2 level to be supplied the central point (P6) of the resonance part 6.

The main feature of the inverter for the microwave oven according to the present invention is to generate a high voltage through an oscillation of semiconductor, and further, to enhance or lower the strength of the high voltage obtained from the semiconductor oscillation by varying the oscillating frequencies. If the oscillating frequencies are lowered, the resonance current is increased, thereby increasing the high voltage. Conversely, if the oscillating frequencies are heightened, the secondary high voltage is lowered.

The output of the microwave oven, that is, of the magnetron, is proportional to the strength of the secondary high voltage of the high-voltage transformer, and therefore, the output of the microwave oven is controlled by controlling the secondary high voltage.

As stated above, a microwave oven according to the present invention enables precision control and output control by feeding back a control signal. By detecting an abnormal status of the control signal, the circuit system is protected, thereby enhancing the stability thereof.

Claims

1. A microwave oven including a mains AC power input, full-wave rectifying means for rectifying AC from said AC power input, a magnetron, a high-voltage transformer, and a switching power supply for powering the magnetron via the high-voltage transformer, wherein the power supply includes a variable frequency oscillator, configured such that its frequency varies in dependence on the output of said full-wave rectifying means.

2. A microwave oven according to claim 1, including an integrator circuit for converting a PWM signal into a DC signal, wherein the output of the integrator circuit is connected to supply a control voltage to said oscillator for controlling the frequency thereof.

Application No: GB 0128031.2
Claims searched: All

Examiner: Rowland Hunt
Date of search: 21 January 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H2F (FMAS, FMAT, FMAX); H2H (HHM)

Int Cl (Ed.7): H02M 5/458, 7/537; H05B 6/66, 6/68

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		