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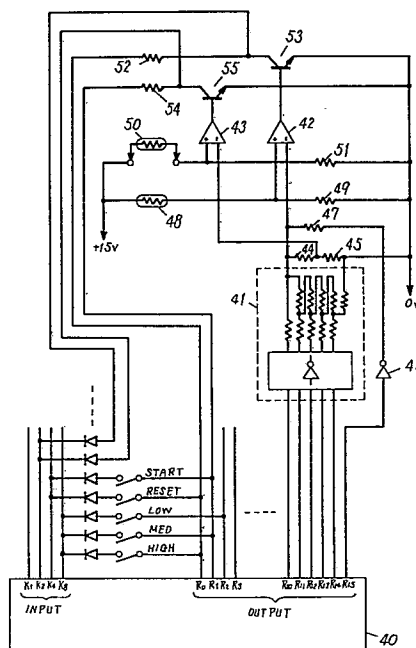
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54 TEMPERATURE CONTROL DEVICE FOR HEAT COOKER.

57 A temperature control device for a heat cooker which employs a single heating chamber to enable high-frequency induction heating as well as heating through means of a heater adapted to elevate the atmospheric temperature within the heating chamber to a high level which is suited for cooking, the temperature control device effecting temperature control through a combination of a microcomputer and two or more temperature sensors having different temperature characteristics and working temperature ranges. The two or more temperature sensors deliver signal voltages, representative of temperature, which are compared with the output voltage of a single reference voltage generator, and the microcomputer processes the result. This enables automation of the cooking operation, recognition of proper sensor installation and malfunction, simplification, of the control circuitry, a reduction in the number of parts, and an improvement in safety and reliability.



SPECIFICATION

TITLE: Temperature control for cooking appliances

5 TECHNICAL FIELD

This invention relates to a temperature control for cooking appliances having a single heating chamber in which a food is cooked by high-frequency dielectric heating as well as by heating ambient air therein with a
10 heater means which comprises a plurality of sensors and a microcomputer in combination.

BACKGROUND ART

With the development and decrease of cost of micro-
15 computers, there has recently been a vogue of micro-computer-controlled cooking appliances having a variety of control functions. However, so long as a cooking program is inputted on a manual mode, the inputting operation is complicated, the user being forced to follow a
20 series of setting procedures so that the multiple functional capabilities of a microcomputer cannot be fully utilized.

It has, thus, become necessary to develop an automatic cooking system incorporating a number of sensors adapted
25 to detect the current status of cooking, to improve the manipulability of the appliance and further to broaden the scope of "menu" which the appliance is capable of

taking care of.

Further, as cooking is automated more and more, it has become difficult to predict the end point of cooking, with the result that a keep-warm function for maintaining the cooked food at a palatable temperature has become
5 an essential requisite.

However, from technical and economic points of view, the microcomputer has its own limitations as to memory capacity and the available number of input and output
10 terminals and these must be utilized with efficiency. Moreover, the use of a plurality of sensors requires an interface circuit and other elements for each sensor and this means an inevitable increase in the number of circuit elements, complexity of the circuit and a re-
15 duced reliability of functions.

Moreover, when a temperature sensor probe adapted to directly detect the temperature of food is employed as sensor means, the probe must be detachable and the cooking program must be changed after judging if the probe
20 is on the food or not. As means for this judgement, there has for example been employed a change-over switch associated with the attachment and detachment of the sensor probe.

However, this method entails an increase of cost
25 and a decrease of reliability, due to the increased number of parts required, and moreover, has the problem that the association of the change-over switch with the

presence or absence of the sensor probe in the food demands an increased force for an attachment or detachment of the probe, thus detracting from the ease of using the appliance.

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DISCLOSURE OF INVENTION

It is a principal object of this invention to provide a temperature control comprising a combination of a microcomputer with a plurality of temperature sensors having different characteristics, said temperature control being such that the detection temperature signals from the respective temperature sensors are compared with the output voltage of a reference voltage generator to judge the presence or absence of the sensor probe in the food and the presence or absence of a failure of other sensors according to the reference voltage level to thereby realize a simplification of the required circuitry, a decrease of production cost and an increase of reliability.

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It is another object of this invention to improve the safety of a cooking appliance without entailing increases in the number of parts and in production cost.

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It is still another object of this invention to further improve the accuracy of control of the air temperature in the heating chamber and of the temperature of a cooking load (food) by the incorporation of an attenuator in the control circuit.

This invention will hereinafter be described in further

detail by way of a preferred embodiment depicted in the accompanying drawings.

BEST DESCRIPTION OF DRAWINGS

5 Fig. 1 is a perspective view showing a cooking appliance as an embodiment of this invention;

 Fig. 2 is an enlarged front view showing a control segment as a principal part of the same appliance;

10 Fig. 3 is a perspective view showing a temperature sensor probe;

 Fig. 4 is an electric circuit diagram of the same cooking appliance; and

15 Fig. 5 is a circuit diagram of a control circuit which constitutes a principal part of the same cooking appliance.

BEST MODE FOR CARRYING OUT THE INVENTION

20 In Fig. 1 there is shown a cooking appliance having a body 1 defining a heating chamber (1) (not shown) therein and a door 2 fitted across the front opening of said heating chamber in such a manner that it may be opened or closed with respect to the heating chamber.

25 There is further disposed an operation panel 3 on the front of the body 1 and alongside the door 2, and the top face of the body 1 is provided with vents 4 and 5 for letting out the air from the heating chamber.

 As illustrated in Fig. 2, said operation panel 3 has

a display segment 6 in a top position thereof for displaying 4-digit figures. The figure 12:59 represents 12 minutes and 59 seconds. There are also disposed time setting keys 7a, 7b, 7c and 7d in positions corresponding to digits for entering a 4 digit figure into the display segment at the corresponding digital positions. Thus, 7a represents the 10-minute digit, 7b the one-minute digit, 7c the 10-second digit, and 7d the one-second digit.

The operation panel 3 further carries output selection keys 8a, 8b and 8c. Entries can be made with these keys, i.e. 8a representing a high output (HIGH), 8b an intermediate output (MED) and 8c a low output (LOW).

There are further provided a temperature setting key 9, a heater key 10 which is used only on the heater-cooking mode; a keep-warm key 11, a reset key 12 for stopping or cancelling the cooking, a start key for initiating a cooking operation and a door button 14 for opening and closing the door 2.

When the high frequency heating mode only is employed, the output is selected by depressing one of the output selection keys 8a, 8b and 8c, then the time setting keys 7a through 7b are respectively depressed to set the cooking time and have the time displayed in the display segment 6, and the start key 13 is finally depressed to initiate cooking.

For high frequency cooking through direct detection

of the temperature of the cooking load with the temperature sensor probe of Fig. 3 fitted into the cooking load (not shown), a plug 16 of the probe 15 is set in a jack 17 disposed in the heating chamber, then an
5 output selection is made with output selection keys 8a to 8c, the temperature setting key 9 is tapped until a desired temperature is displayed in the display segment 6, and the start key 13 is depressed to start cooking.

When cooking is to be carried out with the heater,
10 the heater key 10 is tapped to set the temperature and have the temperature in the heating chamber displayed in the display segment 6. Then, the cooking time is set by tapping the time setting keys 7a through 7b, whereupon the temperature display disappears from the
15 display segment 6 and, instead, the cooking time is displayed in said segment 6. As illustrated in Table 1, temperatures from 100°C to 230°C can be displayed at intervals of 10°C. For example, cooking with the heater can be carried out at 200°C for one hour. As to the keep-
20 warm setting, the keep-warm temperature can be controlled over the range of 40°C to 95°C at intervals of 5°C as will be more fully described hereinafter.

When heating with the heater is to be controlled with the temperature sensor probe 15, the heating chamber temperature is set by tapping the heater key 10 and the desired
25 temperature of food is then set by tapping the temperature setting key 9. Thus, by way of illustration, cooking can

be carried out at the heating chamber temperature of 200°C and the internal food temperature of 80°C. When the food is cooked with the temperature sensor probe 15, the range of temperatures that can be set with the temperature setting key 9 is 40°C to 95°C at intervals of 5°C.

Cooking with the temperature sensor probe 15 is convenient in that the setting can be made in disregard of the weight of food but has the disadvantage that it is then difficult to predict the time of completion of cooking, and it is necessary that the cooked food be kept warm until it is taken out from the heating chamber. In such cases, by inputting the keep-warm key 11 immediately following the temperature setting with the temperature setting key 9, the cooked food is maintained at the temperature designated by the temperature setting key 9 until the door 2 is opened.

As regards the method of keeping food warm, the food cooked by high frequency heating can be easily kept warm by making and breaking the high frequency energy in response to the detection temperature of the temperature sensor probe. This is because high frequency heating causes the inside of food to be simultaneously heated and, therefore, ensures a good thermal response of the probe.

On the other hand, it is very difficult to keep warm the food cooked with the heater just because of the reverse

of the above-mentioned reason.

Therefore, in accordance with this invention, it is ensured that the heating chamber temperature may be automatically set at the temperature set by the temperature sensor probe 15.

In Fig. 4, there is illustrated an electric circuit of the cooking appliance depicted in Fig. 1., showing the condition after closure of the door 2 and before start of cooking. The main circuit of the cooking appliance comprises a current fuse 18, a first latch switch adapted to open and close in association with the operation of the door 2, a power relay contact 20, a second latch switch 21, a bilateral control rectifying element 22 and a high-voltage transformer having a primary winding 24 connected in series with an AC power source. A secondary side 25 of said high-voltage transformer 23 is connected to a magnetron 28 through a voltage doubling rectifying circuit consisting of a high-voltage capacitor 26 and a diode 27, and the heater of the magnetron 28 is connected to a heater winding 29 of the high-voltage transformer 23. For cooking with the heater means, there is provide a heater 30 one end of which is connected to an end of said AC source, with the other end of the heater being connected to the connection between the second latch switch 21 and the anode of the bilateral control rectifying element 22. There also is provided a fan motor 32, one end of which is connected to one end of the AC source

with the other end being connected to the anode side of the bilateral control rectifying element 31. There is also disposed a short switch 31, one end of which is connected to one end of the AC power source, with the other end being connected to the connection between the power relay contact 20 and second latch switch 21, and its ON-and OFF-operation is reversely associated with said first and second latch switches 19 and 21.

Thus, it is opened on closure of the first and second latch switches 19 and 21, while it is closed as the latter switches are opened. When at least one of said first latch switch 19 and said power relay contact 20 is fused, the main circuit is short-circuited to break the current fuse 16. An oven lamp is connected via a lamp switch 35 which is operatively associated with said first and second latch switches 19 and 21. The primary side of low-voltage transformer 36 is connected to one end of the AC source and between the current fuse 18 and first latch switch 19, while its secondary side is connected as a power source to a control circuit 37. The control circuit 37 controls the power relay contact 20 and bilateral control rectifying elements 22 and 31 to thereby control the output of the magnetron 28. The control circuit 37 has a door switch associated with said first and second latch switches 19 and 21, and the operation signal from the door 2 is detected and inputted by said door switch 38. Connected in parallel with the primary side of said low-voltage

transformer 36 is a variable resistor 39 for the purpose of preventing erratic actions due to noise.

In the above arrangement, the control circuit 37 is supplied with power from the low-voltage transformer 36 at all times, and as a cooking program is set by the procedure explained with reference to Fig. 2 and the start key 13 is depressed, the power relay contact 20 is closed because the signal of the door 2 has been inputted by door switch 38 into the control circuit 37, whereupon the main circuit is closed, the oven lamp 34 is lit through the lamp switch 35 and the fan motor 32 starts rotating. And on the high-frequency heating mode, the bilateral control rectifying element 22 becomes ON to supply power to the high-voltage transformer 23 so that the magnetron 28 is excited.

Therefore, the high frequency output is controlled as the bilateral control rectifying element 22 is turned ON and OFF by the control circuit 37.

Then, on the heater cooking mode, the output is controlled as the bilateral control rectifying element 31 is turned ON and OFF by the control circuit 37.

Fig. 5 shows a schematic view of the control circuit 37. The operation of the circuit 37 will now be described below. In response to a 5-bit signal of outputs R_{10} to R_{14} of a microcomputer 40, a reference voltage generator 41 which is formed by matrixing on inverter and resistors generates a voltage variable in 32 steps by a combination

of inputs. The voltage is directly fed to the minus (-) input of a comparator 42, while it is divided by resistors 44 and 45 and fed to the minus (-) input of a comparator 43. Moreover, the minus (-) input voltage of the comparator 42 can be tapped through a resistor 47 by the output R_{15} of the microcomputer 40 and an inverter 46.

The reference numeral 48 designates a high-temperature thermister (temperature sensor) for detecting the internal temperature of the heating chamber and is connected to the plus (+) input of the comparator 42 in voltage-dividing relation with a resistor 51.

When the internal temperature of the heating chamber is controlled in the above arrangement, the temperature signal divided by the high-temperature thermister 48 and resistor 49 and the output of the reference voltage generator 41 are compared by the comparator 42 and the result is read into K_2 through resistor 52 and transistor 53 at the timing of R_0 output of the microcomputer 40, whereby the heater 30 is controlled.

When temperature control is effected with the temperature sensor probe 15, the temperature signal voltage divided by low-temperature thermister 50 and resistor 51 and the output voltage of the reference voltage generator 41 via an attenuator consisting of resistors 44 and 45 are compared by the comparator 43 and the result of comparison is read into K_2 at the timing of R_1 output of the microcomputer 40 via resistor 54 and transistor 55

whereby the output of the heater 30 or magnetron 28 is controlled. As previously mentioned, the temperature control range of the low-temperature thermister 50 is 40°C to 95°C and that of the high-temperature thermister
5 is 100°C to 230°C. However, when the cooked food is to be kept warm by the heater 30, the temperature must be controlled at 40°C to 95°C with the high-temperature thermister 48. In this case, the R_{15} output of micro-computer 40 is HIGH, the output of the inverter 46 is
10 LOW and the resistor 47 is connected in parallel with the output of the reference voltage generator 41 so that it functions as an attenuator. Temperature control at 40°C to 95°C is thus enabled by comparing this voltage with the temperature signal of the high-temperature
15 thermister 48. The relationship of such reference voltage steps with temperature signals is set as shown in Table 1.

Table 1

Reference voltage step	Low-temperature thermister	High-temperature thermister	
		R ₁₅ Low	R ₁₅ HIGH
0	Without probe	Broken wire trouble	-
1	With probe	-	-
2	.	-	-
3	.	-	.
4	.	.	.
5	40°C	.	.
6	45°C	.	.
7	50°C	.	.
8	55°C	.	-
9	60°C	.	-
10	65°C	.	40°C
11	70°C	-	45°C
12	75°C	100°C	50°C
13	80°C	110°C	55°C
14	85°C	120°C	60°C
15	90°C	130°C	65°C
16	95°C	140°C	70°C
17	.	150°C	75°C
18	Short-circuit trouble	160°C	80°C
19	.	170°C	85°C
20	.	180°C	90°C
21	.	190°C	95°C
22	.	200°C	-
23	.	210°C	-
24	.	220°C	.
25	.	230°C	.
26	.	.	.
27	.	Short-circuit trouble	.
28	.	.	.
29	.	.	.
30	.	.	-
31	.	.	-

It will be seen from Table 1 that by programming the microcomputer with such parameters as the presence or absence of the temperature sensor probe in food and broken-wire and short-circuit troubles, the corresponding
5 detection functions can be imparted to the control. It is for preventing erroneous operations due to an overshoot of food, etc. that in Table 1, the temperature control range and the trouble detection range are not adjacent but are separated discretely.

10 Table 1 shows a continuous array of temperature steps in line with reference voltage steps but such an arrangement is not essential. Particularly because the high-temperature thermister 48 effects control by detecting the temperature in the neighborhood of the heater and
15 estimates the temperature in the central zone of the heating chamber, the relationship between detection signal and temperature is complicated by the influence of a difference between the temperature detected by the thermister and the temperature in the central zone of the heating chamber.
20 To solve this problem, the temperature setting may be made discontinuous with respect to the reference voltage steps. A glance at Table 1 might suggest that the characteristics of a single thermister, i.e. the high-temperature thermister, are sufficient to cover the func-
25 tion of the low-temperature thermister for the temperature sensor probe but, actually, there would arise the problem of inferior temperature accuracy. Thus, the low-temperature

thermister for setting the end-point temperature of food must be very high in accuracy while the high-temperature thermister is selected with reference to high-temperature characteristics. Therefore, these thermisters are preferably used in the manner described hereinbefore.

INDUSTRIAL APPLICABILITY

As described hereinbefore, this invention ensures an automation of cooking through a combined use of a microcomputer with a plurality of temperature sensors having dissimilar characteristics and a comparison of the temperature signals detected by the respective temperature sensors with the output voltage of a single reference voltage generator. And the presence or absence of the temperature sensor probe in the food and the presence or absence of a trouble at a different temperature sensor can be judged according to reference voltage levels. In this manner, it is now possible to simplify the control circuit, decrease the number of necessary parts, reduce the cost of production and improve the safety and reliability of the control system.

It should be understood that by incorporating an attenuator in the control circuit for the microcomputer, the accuracy of control over the internal temperature of the heating chamber and over the food can both be improved.

CLAIMS:

1. A temperature control for cooking appliances equipped with high frequency heating means and heater means, characterized by comprising a removable temperature sensor probe adapted to be brought into contact with a cooking load (food) so as to detect the temperature of the load, a temperature sensor disposed in a heating chamber for detecting the internal temperature of said heating chamber and a control circuit including a microcomputer for controlling high frequency heating means or heater means in response to a signal from said temperature sensor probe or said temperature sensor, said control circuit comprising said microcomputer, a reference voltage generator adapted to generate a reference voltage according to an output of said microcomputer, a first comparator for comparing a reference voltage from said reference voltage generator with a signal voltage from said temperature sensor probe and a second comparator for comparing said reference voltage with a signal voltage from said temperature sensor so that the temperature of the cooking load and the internal temperature of the heating chamber are controlled in accordance with an output voltage step of said reference voltage generator and the presence or absence of said temperature sensor probe is judged by said microcomputer.
2. A temperature control according to Claim 1 wherein signal voltage from said temperature sensor probe and

temperature sensor are compared by a comparator in accordance with the output voltage step of said reference voltage generator and the comparison signal is processed by said microcomputer to judge the state of a trouble.

- 5 3. A temperature control according to Claim 1 wherein the temperature signal from said temperature sensor and the output voltage of said reference voltage generator are compared by the comparator through an attenuator whereby the temperature detection range and the width of
- 10 temperature detection are made variable.
4. A temperature control according to Claim 1 which further comprises means for controlling temperature by comparing the temperature signal voltage from at least one of said temperature sensor probe and temperature sensor
- 15 directly with the output voltage from said reference voltage generator, and means for controlling the temperature by comparison through an attenuator, wherein the temperature detection range or width of temperature detection is made variable by selective use of one of said two means.

LIST OF REFERENCE NUMBER IN THE DRAWINGS

- 1.....Body
- 2.....Door
- 3.....Operation panel
- 4.....Vent
- 5.....Vent
- 6.....Display segment
- 7a, 7b, 7c, 7d.....Time setting keys
- 8a, 8b, 8c.....Output selection keys
- 9.....Temperature setting key
- 10.....Heater key
- 11.....Keep-warm key
- 12.....Reset key
- 13.....Start key
- 14.....Open/close button
- 15.....Temperature sensor probe
- 16.....Plug
- 17.....Jack
- 18.....Current fuse
- 19.....First latch switch
- 20.....Power relay contact
- 21.....Second latch switch
- 22.....Bilateral control rectifying element
- 23.....High voltage transformer
- 24.....Primary coil
- 25.....Secondary coil
- 26.....High voltage capacitor

- 27.....Diode
- 28.....Magnetron
- 29.....Heater coil
- 30.....Heater
- 31.....Bilateral control rectifying element
- 32.....Fan motor
- 33.....Short switch
- 34.....Oven lamp
- 35.....Lamp switch
- 36.....Low voltage transformer
- 37.....Control circuit
- 38.....Door switch
- 39.....Variable resistor
- 40.....Microcomputer
- 41.....Reference voltage generator
- 42.....Comparator
- 43.....Comparator
- 44.....Resistor
- 45.....Resistor
- 46.....Inverter
- 47.....Resistor
- 48.....High-temperature thirmister
- 49.....Resistor
- 50.....Low-temperature thirmister
- 51.....Resistor
- 52.....Resistor
- 53.....Transistor

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- 6 -

54.....Resistor

55.....Transistor

- 1 -

Fig. 1

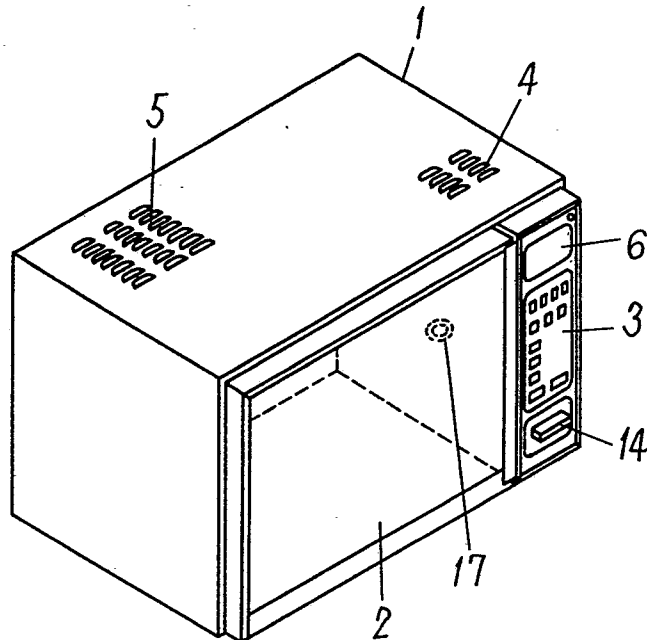


Fig. 2

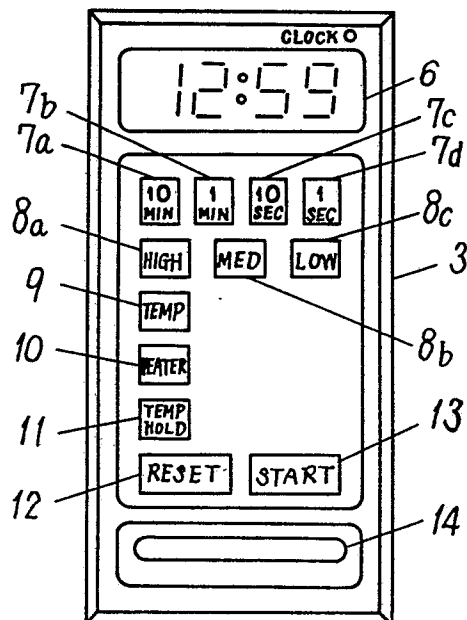
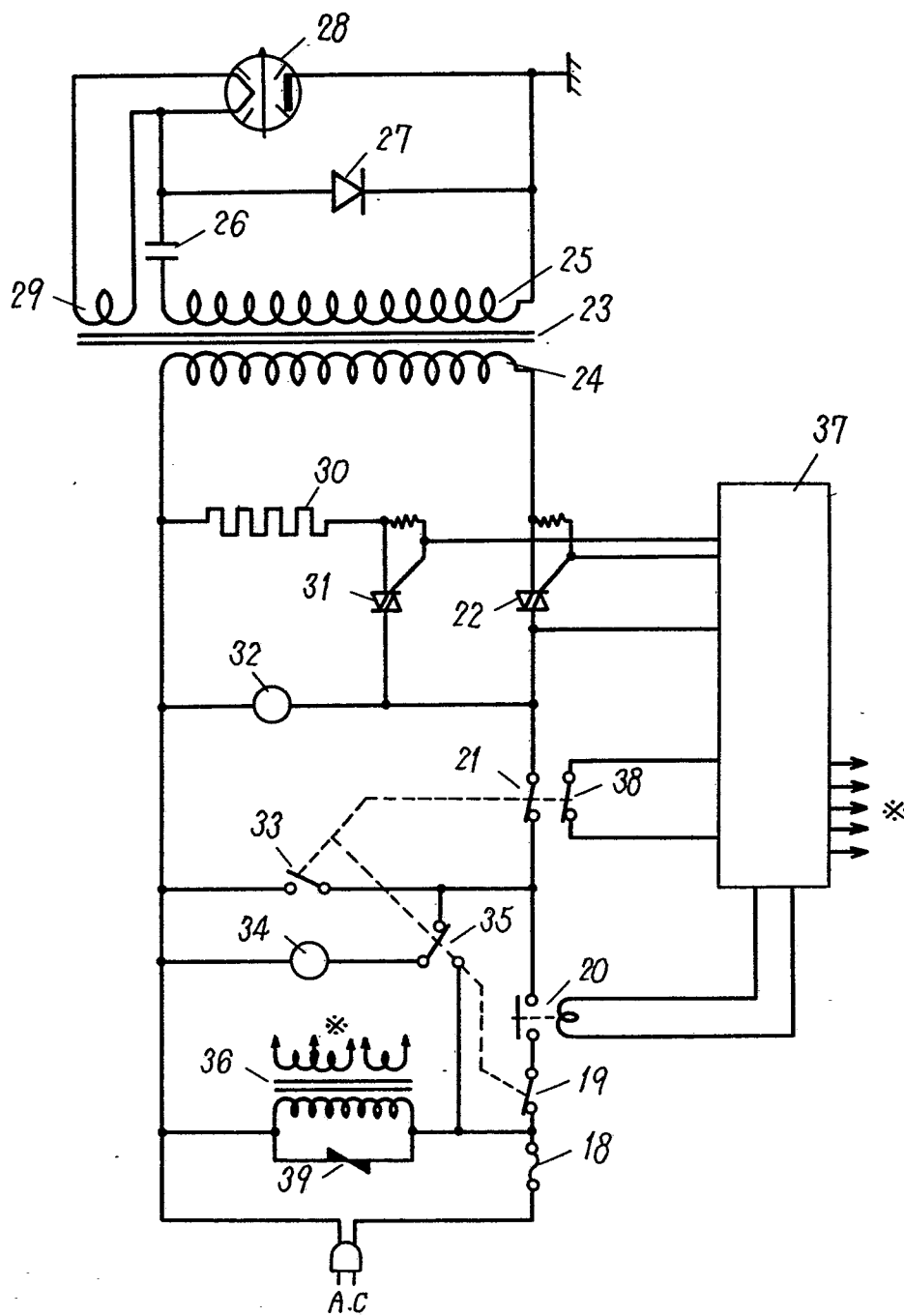


Fig. 3



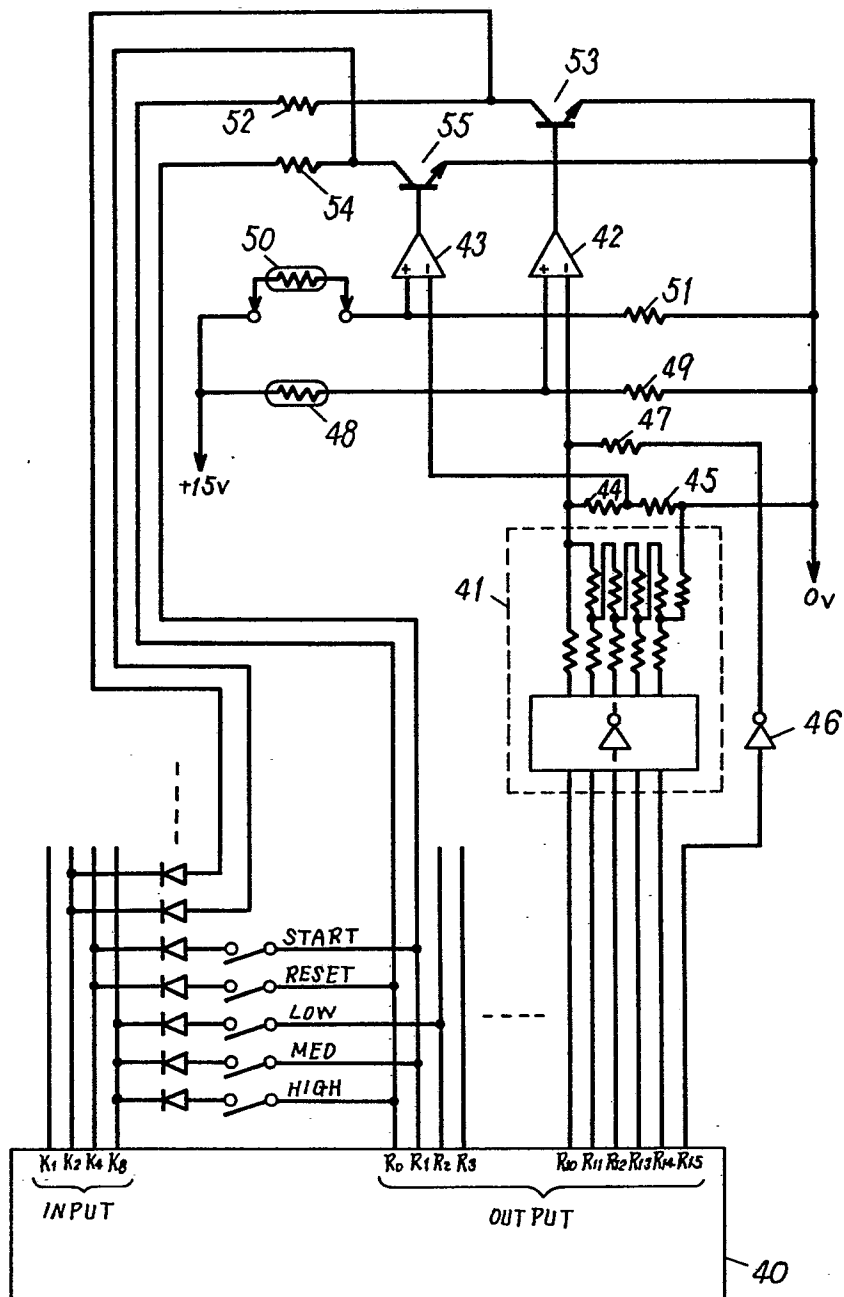
- 2 -

Fig. 4



- 3 -

Fig. 5



INTERNATIONAL SEARCH REPORT

International Application No. **PCT/JP80/00284**
0040638

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl. ³ H05B 11/00, F24C 7/08		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
I P C	F24C 7/08, G05B 1/01, G05B 11/32, G05B 21/00, G05D 23/20, H05B 6/68, H05B 11/00	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
Jitsuyo Shinan Koho	1970 - 1980	
Kokai Jitsuyo Shinan Koho	1972 - 1980	
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	RADIO-ELECTRONICS, Vol. 49, No. 9 (1978-9), K. SAVON "Microprocessors are inching their way into home appliances applications. Here's a look at how the TMS1100 is teamed up with traice to control a microwave oven.", P.78-79, FIG. 1	1, 2
X	US, A, 3320396, 1967-5-16, FIG. 1, 5, 6 Technology Instrument Corporation	1
P	JP, A, 54-162247, 1979-12-22 SANYO ELECTRIC CO., LTD.	2, 3
X	JP, A, 53-52332, 1978-5-12 Hitachi, Ltd.	2 - 4
• Special categories of cited documents: ¹⁵ "A" document defining the general state of the art "E" earlier document but published on or after the international filing date "L" document cited for special reason other than those referred to in the other categories "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but on or after the priority date claimed "T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention "X" document of particular relevance		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ¹⁹		Date of Mailing of this International Search Report ²⁰
February 9, 1981 (09.02.81)		February 16, 1981 (16.02.81)
International Searching Authority ¹		Signature of Authorized Officer ²⁰
Japanese Patent Office		