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(54) **A control circuit for a heating unit.**

(57) A control circuit, for a heating unit including two or three lamps (11,12,13) emissive of infra-red radiation, includes a microprocessor (20) for selectively effecting phase and burst-fire control of power supplied to the lamps (11,12,13), to generate a desired heat output set by user-operable controls (21). The circuit also includes switching means (30) to achieve series and/or parallel arrangements of the lamps (11,12,13) to generate different power outputs. The microprocessor (20) is also arranged to provide phase control of power to the lamps - (11,12,13) intermediate periods of energisation of the lamps during burst-fire control or to alternate between two different power outputs generated by series and/or parallel arrangements of the lamps (11,12,13) to achieve an average output.

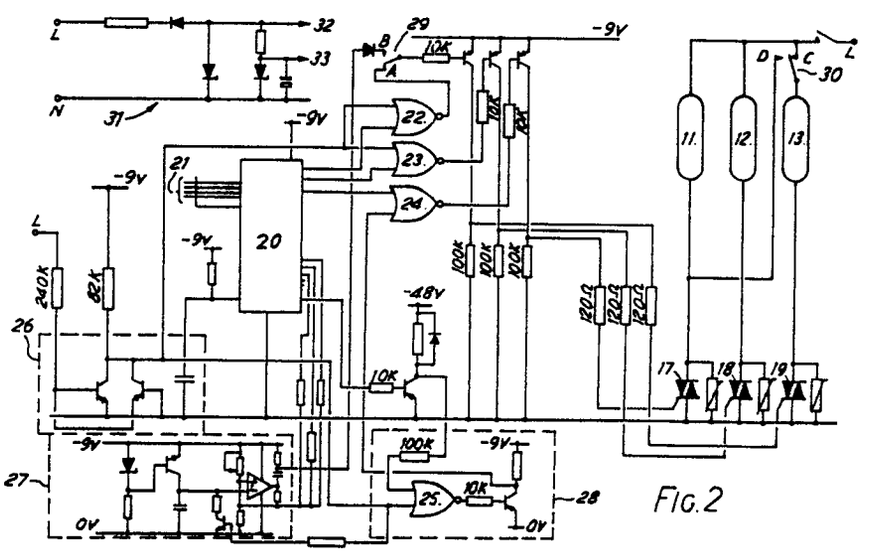

Fig.2

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A CONTROL CIRCUIT FOR A HEATING UNIT

This invention relates a control circuit for a heating unit and particular, though not exclusively, to a unit arranged to be mounted in a cooking hob to form a hotplate area of a glass ceramic cook-top of the hob.

Heating units of this type are disclosed in our corresponding U.K. Patent Application No. 2132060A, wherein, in a preferred embodiment, each unit includes four tungsten-halogen lamps supported above a shallow metallic tray containing a layer of non-metallic, thermally-insulative material. A temperature control arrangement is capable of switching the lamp filaments into a number of series and/or parallel combinations providing a corresponding number of discrete power outputs of the lamps to achieve an optimised characteristic heat output curve. Other temperature controls may also be used, such as phase control of the lamp filaments below a power level of 200W and/or burst-fire or mark-space control above this power level, because it has been found that the use of burst-fire control at lower power levels causes visual flickering effects of the lamps, which can be disturbing to a user of the cooking hob.

However, the above-mentioned temperature control of the lamp filaments may be disadvantageous if less than four lamps are required, because the possible number of series and/or parallel combinations of the lamp filaments is reduced, thereby reducing undesirably the number of possible temperature settings on the cooking hob.

Furthermore, it is also desirable to maintain a balanced output from the lamp arrangement over the whole hotplate area, which becomes increasingly difficult as the number of lamps is reduced.

It is therefore an object of the present invention to provide a heating unit including a more flexible control arrangement, which enables an increased number of heat outputs to be achieved from a reduced number of lamps.

It is a further object of the invention to provide a heating unit including a control arrangement, which alleviates the problem of disturbing flickering of the lamps when burst-fire control is used at relatively low power levels.

According to one aspect of the present invention there is provided a control circuit for a heating unit including a number of lamps emissive of infra-red radiation, said circuit including switching means for selectively switching said lamps into a number of series and/or parallel arrangements, each having a respective power output, and user-operable means for setting a desired heat output from said lamps, characterised in that said circuit also includes processor means to effect switching between at least two of said arrangements for predetermined proportions of a burst-fire cycle to achieve said desired heat output.

According to a second aspect of the invention there is provided a control circuit for a heating unit including at least one lamp emissive of infra-red radiation, said circuit including processor means for effecting burst-fire control and phase control of power supplied to said at least one lamp and characterised in that said processor means is also arranged to effect phase control of said at least one lamp intermediate periods of continuous energisation of said at least one lamp during burst-fire control.

The present invention will now be further described by way of example only with reference to the accompanying drawings, wherein:-

Figure 1 shows a plan view of a heating unit including three infra-red lamps,

Figure 2 shows a circuit for controlling the heat output of the lamps shown in Figure 1,

Figure 3 shows a table illustrating the various configurations of the lamps in Figures 1 and 2,

Figure 4 shows an alternative circuit to that shown in Figure 2 for controlling the heat output from a heating unit incorporating two lamps, and

Figure 5 shows another circuit for controlling the heat output from a heating unit incorporating two lamps.

Referring to Figure 1, a heating unit includes a generally circular shallow tray 1, preferably made of metal, having a layer 2 of thermally-insulative material, such as a microporous material known as Microtherm, disposed therewithin. Three infra-red lamps 3 to 5 are supported above the layer 2 by two suitably-shaped pieces 6, 7 of thermally-insulative material located respectively adjacent the ends of the lamps 3 to 5.

Each infra-red lamp 3 to 5 consists of a halogenated, quartz, tubular envelope 8 to 10 respectively, within which a single coil or coiled coil tungsten filament, 11 to 13 respectively, is supported. Each end of each lamp 3 to 5 consists of a pinch seal (not shown), having electrical connections to the respective end of the lamp filament sealed therein, and each pinch seal is enclosed by a ceramic end cap, such as at 14, to protect the pinch seals.

The heating unit, preferably together with three other heating units, is preferably mounted adjacent the underside of a glass ceramic cook-top (not shown) of a cooking hob (also not shown), so as to form a number of hotplate areas of the cook-top.

The heating unit also includes a thermal limiting device 15, which is arranged to monitor the operating temperature of the glass ceramic cook-top, to ensure that it is not damaged by overheating. The device 15 is arranged to activate a microswitch 16, which disconnects the power supply to the lamps 3 to 5, if the operating temperature of the glass ceramic exceeds a predetermined temperature.

Figure 2 shows a circuit for providing at least fifteen temperature settings of the heating unit, as shown in the table in Figure 3, from only the three lamps 3 to 5, shown in Figure 1. To this end, the circuit enables the heat output of the lamps to be varied by selectively using either phase control, wherein power is supplied to one or more of the lamps for variable proportions of each positive half cycle of the supply waveform or burst-fire control, wherein power is supplied intermittently to the lamp or lamps for a predetermined number of cycles of the supply waveform.

The circuit shown in Figure 2 includes the three lamp filaments 11 to 13, the power supplied to which is controlled by three triacs 17 to 19, respectively.

Overall control of the circuit is governed by a microprocessor 20, preferably of type TMS 1000, which has inputs at 21 to user-operable temperature setting controls and may also include temperature feedback controls for monitoring the temperature of cooking utensils on the hotplate area of the cooking hob.

Outputs from the microprocessor 20 control a number of gates 22 to 25, and gates 22 to 24 control respectively activation of the triacs 17 to 19. The microprocessor 20 is also connected to a zero cross-over detecting circuit 26, a phase control generating circuit 27, and a triac inhibit circuit 28. The three gates 22 to 24, and thus triacs 17 to 19, are arranged to effect burst-fire control of the power supplied to each of the lamp filaments 11 to 13, in dependence on the setting of the user-operable control and corresponding output of the microprocessor 20.

The circuit also includes a relay consisting of switches 29 and 30. With switch 29 in position A, as shown, triac 19 will effect burst-fire control of power supplied to filament 13. However, if switch 29 is changed to position B, triac 19 will be connected to the phase control generating circuit 27, so that power supplied to filament 13 will be phase controlled.

Switch 29 therefore enables the output of filament 13 to be selectively controlled by either phase control or burst-fire control. Switch 30 is arranged to connect filaments 11 and 13 in series when phase control is used, as described hereinafter.

A voltage divider circuit 31 provides the appropriate voltage for operation of the relay, from output 32, and of the logic components, from output 33.

Figure 3 shows lamp filament configurations, provided by the circuit in Figure 2, to achieve fifteen heat outputs of the heating unit, with the maximum power of each lamp preferably being 600W.

Setting no. 15 generates the highest power output of 1800W by having all three filaments 11 to 13 connected in parallel at maximum power level, i.e. continuously energised.

Setting nos. 14 to 12 each have filaments 11 and 13 at maximum power and triac 18 is arranged to control power to filament 12 by burst-firing. Setting nos. 14 and 13 generate power outputs of 1600W and 1400W, respectively, by filament 12 being energised for 66% and 33%, respectively, of each burst-fire cycle, and setting no. 12 generates an output of 1200W with filament 12 continuously de-energised.

Setting no. 11 generates an output of 1000W by controlling all three filaments 11 to 13 by burst-firing, with filaments 11 and 13 energised for 58.3% of the cycle and filament 12 energised for 50% of the cycle. It may be preferable to stagger the energisation periods of one or more of the filaments 11 to 13, to even out the load distribution on the mains supply and ensure that at least one lamp is on at any given time.

Setting nos. 10 to 6 provide phase control of power supplied to filaments 11 and 13 and burst-fire control of power supplied to filament 12. The phase control is achieved by switching switch 29 to position B and also switch 30 from position C as shown, wherein filaments 11 and 13 are in parallel, to position D, to connect filaments 11 and 13 in series. Triac 17 is then inhibited by triac inhibit circuit 28, which is connected to an input of gate 24, so that the outputs of both filaments 11 and 13, in series, are controlled by activation of triac 19. Triac 18 is activated, as before, to achieve burst-fire control of the output of filament 12. Filaments 11 and 13 are phase controlled for each setting 10 to 6 at 200W, and settings 10 to 6 generate outputs of 800W, 600W, 450W, 350W and 250W respectively by burst-firing filament 12 for 100%, 70%, 45%, 30% and 12% of the cycle, respectively.

Setting nos. 5 to 1 generate outputs of 180W, 140W, 100W, 80W and 60W, respectively by appropriate phase controlling of the power supplied to filaments 11 to 13, connected in series, and having filament 12 continuously de-energised.

It can be seen that, in each of the configurations, filaments 11 and 13 are arranged to generate the same outputs and filament 12 generates a lower output than filaments 11 and 13, thereby ensuring that a balanced visual effect of the three lamps is maintained and also enabling more uniform cooking of certain foods, such as pancakes, which tend to require more intense heat around the periphery of the hotplate area.

Figure 4 shows an alternative circuit, which can be used to control the heat output of a heating unit accommodating only two lamps having filaments 34, 35. The circuit includes a microprocessor 36, which has inputs 37 from user-operable temperature setting controls and possibly also temperature feedback controls, and also an input from zero cross-over detector circuit 38. The microprocessor 36 has outputs 39, 40 to control operation of triacs 41, 42 respectively, which are connected respectively to the lamp filaments 34, 35. It may also be necessary to include RFI components 43, 44 to reduce undesirable disturbances in the power supply to the filaments 34, 35.

The microprocessor 36 is arranged to select either phase control or burst-fire control of the power supplied to the filaments 34, 35, thereby reducing the number of circuit components required and also simplifying the circuit lay-out.

The circuit shown in Figure 4 could, of course, be modified so as to control a heating unit including more than two lamps simply by providing additional triacs and corresponding outputs from the microprocessor 36.

From the two described circuits, it can thus be seen that the present invention provides selectable burst-fire and phase controls of the outputs of the lamp filaments, thereby providing a flexible arrangement that is capable of generating a substantial number of different heat outputs from the heating unit.

It is also possible with the present invention to alternate these selectable controls by phase controlling power to a filament, preferably at 200W, intermediate periods of energisation of the filament during burst-fire control. In this way, however low the power output, the lamp remains visibly energised, thereby alleviating flickering problems of the lamps at low power settings, which can be disturbing to a user of the heating unit. Furthermore, by varying the proportion of burst-fire control to phase control, a large number of different heat outputs can be obtained.

When a number of heating units are mounted in a cooking hob, the microprocessor of the circuits could be used to control the outputs of more than one of the units, as shown in Figure 4 by additional outputs 45 from microprocessor 36 to the lamp filaments of another heating unit.

Figure 5 shows a control circuit for controlling the power outputs of two heating units, each including two tungsten-halogen lamps and each forming a hotplate area of a cooking hob (not shown).

In the circuit, the four lamp filaments 50 to 53 are each connected in series with a triac 54 to 57, respectively. Filaments 50 and 51 are provided to heat hotplate A and filaments 52 and 53 are to heat hotplate B. Triacs 55 and 57 are connected in series with RFI components 58, 59, respectively, as shown in the circuit in Figure 4.

A microprocessor 60 controls conduction of the triacs 54 to 57, and thus energisation of the filaments 50 to 53, in accordance with user-operable switches S_A and S_B, which set the required heat outputs from hotplates A and B, respectively. Switches S_A and S_B preferably each consist of a Gray Code slider or rotary switch, which generates a binary output directly readable by the microprocessor 60 and is advantageous in that only one digit changes on any transition from one setting to another.

Switches S_A and S_B have inputs I_1 to I_4 into the microprocessor 60 and, if both switches S_A and S_B are on simultaneously, ie. heat output is required from both hotplates A and B, the microprocessor 60 selectively samples, via outputs O_1 and O_2, the respective inputs from switches S_A and S_B.

The microprocessor 60 is also connected to a zero-crossover detector circuit 61, via output O_3 and input I_1, and to a triac firing circuit, via outputs O_4 to O_7, which respectively operates triacs 54 to 57.

Relays R_{A1} and R_{A2} are included in the circuit for hotplate A and relays R_{B1} and R_{B2} for hotplate B, so as to switch the filaments 50 and 51 in hotplate A and filaments 52 and 53 in hotplate B into series or parallel arrangements, such that, when filaments 50 and 51 are in series, power to both of them is controlled by triac 55, and, when filaments 52 and 53 are in series power to both of them is controlled by triac 57.

Outputs O_8 and O_9 from microprocessor 60 control a relay protection and drive circuit 63, which operates the relays R_{A1} and R_{A2} and/or R_{B1} and R_{B2} and prevents arcing through the circuit when the relays are changed.

Inputs I_5 to I_9 to the microprocessor 60 control the clock frequency of the microprocessor.

Different power outputs from the filaments of each hotplate can thus be achieved by phase control, series connection of the filaments, parallel connect of the filaments, series connection in combination with a diode, and parallel connection in combination with one or more diodes.

Power outputs below 200W can be achieved by phase control alone. To alleviate the aforementioned flickering effect of the lamps, above 200W, outputs are preferably achieved by switching the filaments between a number, preferably two, of the above connections, with or without diodes, for proportions of a predetermined burst-fire cycle.

The diodes are provided by the triacs 54 to 57, which are caused to function as diodes by the microprocessor 60.

A specific example of power outputs achieved by the circuit is shown below, wherein fifteen temperature settings are provided with two lamp filaments, each of 900W.

SETTING NO.	PHASE CONTROL OF FILAMENT ARRANGEMENT FOR % AGE OF CYCLE	APPROX. POWER OUTPUT (W)
1	Phase control	60
2	Phase control	76
3	Phase control	98
4	Phase control	124
5	Phase control	159
6	Phase control	200
7	Phase control-54%. Series with diode-46%	260
8	Series with diode-93%. Series 7%	350
9	Series with diode 69%. Series 31%	419
10	Series with diode-28%. Series - 72%	534
11	Series - 84% Parallel with diodes 16%	681
12	Series - 40% Parallel with diodes 60%	868
13	Parallel with diodes - 90%. Parallel - 10%	1107
14	Parallel with diodes - 51%. Parallel - 49%	1411
15	Parallel - 100%	1800

If, for example, setting no. 9 is required for hotplate A, this setting is set on switch S_A, which passes the correct signal to the microprocessor 60, via inputs I_1 to I_4. The microprocessor then positions relays R_{A1} and R_{A2}, via outputs O_8 and O_9 and relay protection and drive circuit 63, so that filaments 50 and 51 are in series and power to the two filaments is then controlled, via output O_5 by triac 55, which operates as a diode for 69% of a burst-fire cycle pre-set by the microprocessor 60 and continuously conducts for the remaining 31% of the cycle.

The filament arrangements are preferably only switched between two arrangements having power outputs adjacent each other in order of magnitude of the power outputs of all the arrangements, so that any undesirable flickering of the lamps is minimised.

It can be seen that, by this circuit, it should be possible to achieve an infinite number of temperature settings by varying the proportions of the cycle occupied by each filament arrangement.

However, usually less than fifteen settings are, in fact, required, the respective outputs of which can be selected as required.

Although the circuit in Figure 5 is intended to control the filaments for two hotplates, only a simple modification would be required to enable the circuit to control only one or more than two hotplates by changing the number of triacs, switches, relays, etc.

Furthermore, by changing the number of triacs and relays, the circuit could easily be modified to control one or more heating units, each including more than two lamps, which would then be capable of providing other arrangements consisting of combinations of series and parallel connections, as shown, for example, in Figure 3.

Claims

1. A control circuit for a heating unit including a number of lamps (11,12,13) emissive of infra-red radiation, said circuit including switching means (30) for selectively switching said lamps (11,12,13) into a number of series and/or parallel arrangements, each having a respective power output, and user-operable means (21) for setting a desired heat output from said lamps (11,12,13), characterised in that said circuit also includes processor means (20) to effect switching between at least two of said arrangements for predetermined proportions of a burst-fire cycle to achieve said desired heat output.

2. A circuit as claimed in claim 1 wherein the difference between the respective power outputs of said at least two arrangements is minimised whilst still achieving said desired heat output.

3. A circuit as claimed in claim 1 or 2 wherein said processor means (20) is arranged to effect burst-fire control of power supplied to said lamps (11,12,13) via at least one triac (17,18,19), said processor means - (20) being capable of causing each triac (17,18,19) to function as a diode for connection into at least one of said arrangements.

4. A control circuit for a heating unit including at least one lamp (11,12,13) emissive of infra-red radiation, said circuit including processor means (20) for effecting burst-fire control and phase control of power supplied to said at least one lamp (11,12,13), and characterised in that said processor means (20)is also arranged to effect phase control of said at least one lamp (11,12,13) intermediate periods of continuous energisation of said at least one lamp (11,12,13)during burst-fire control.

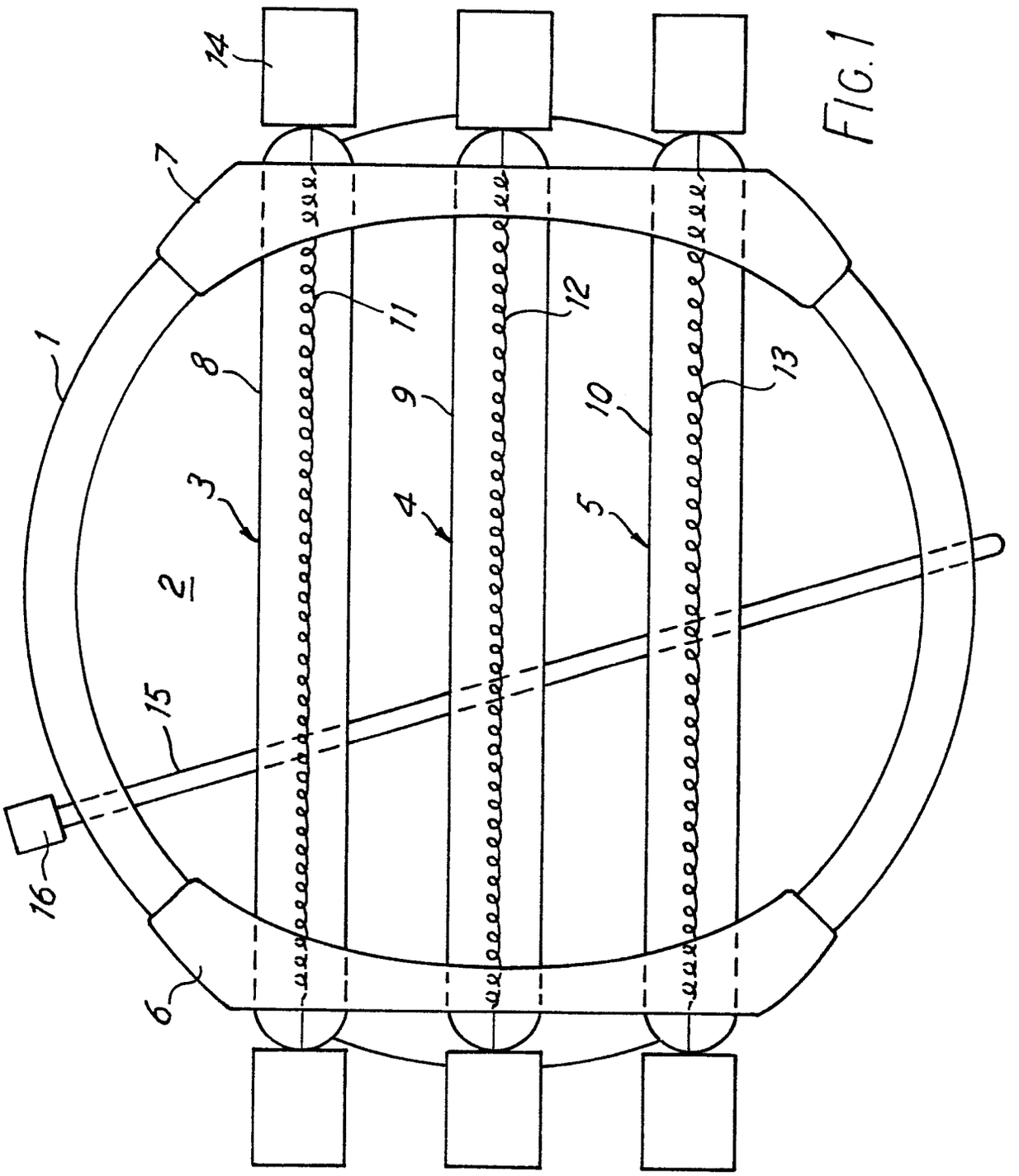

FIG. 1

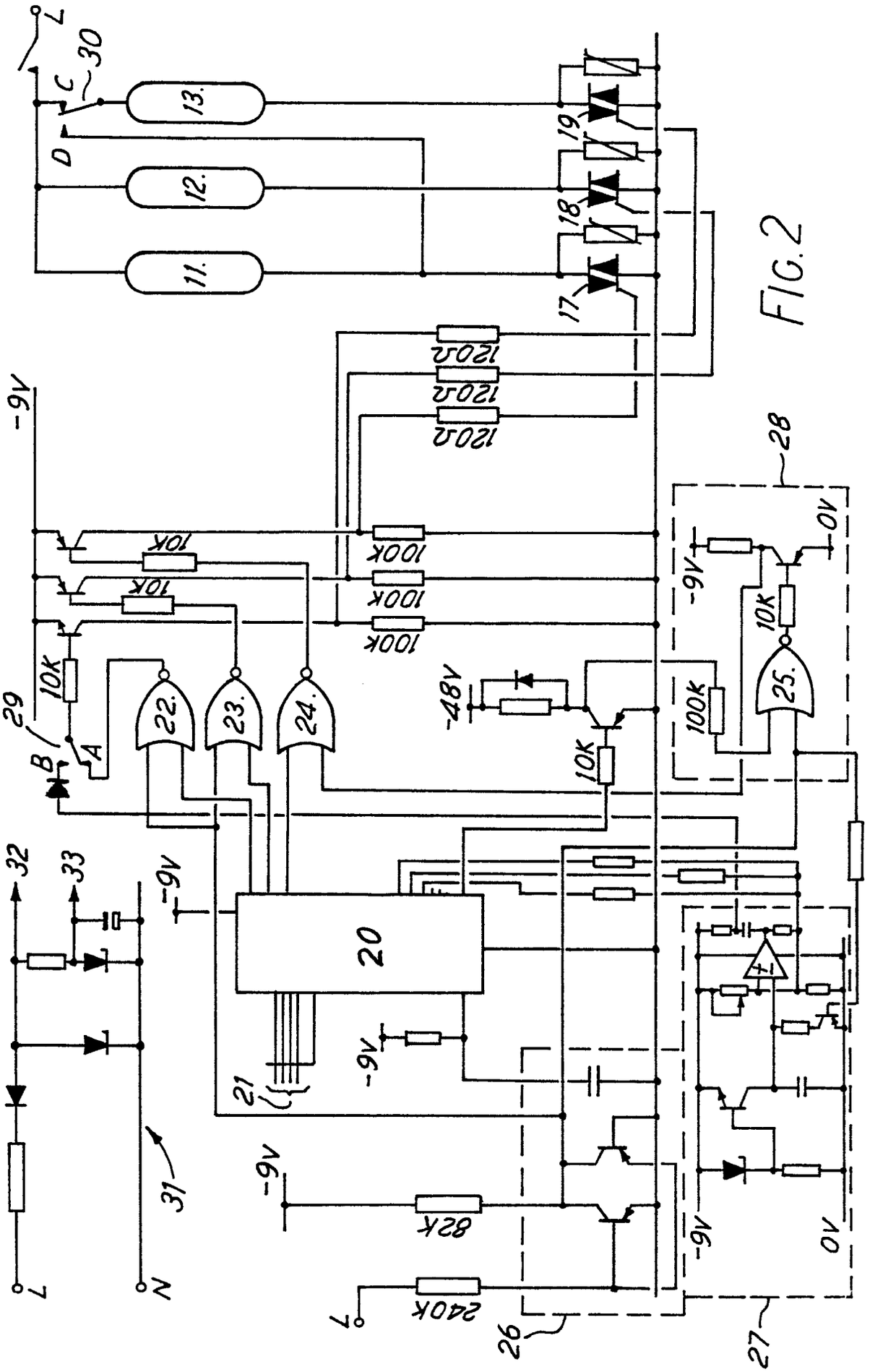
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FIG.2

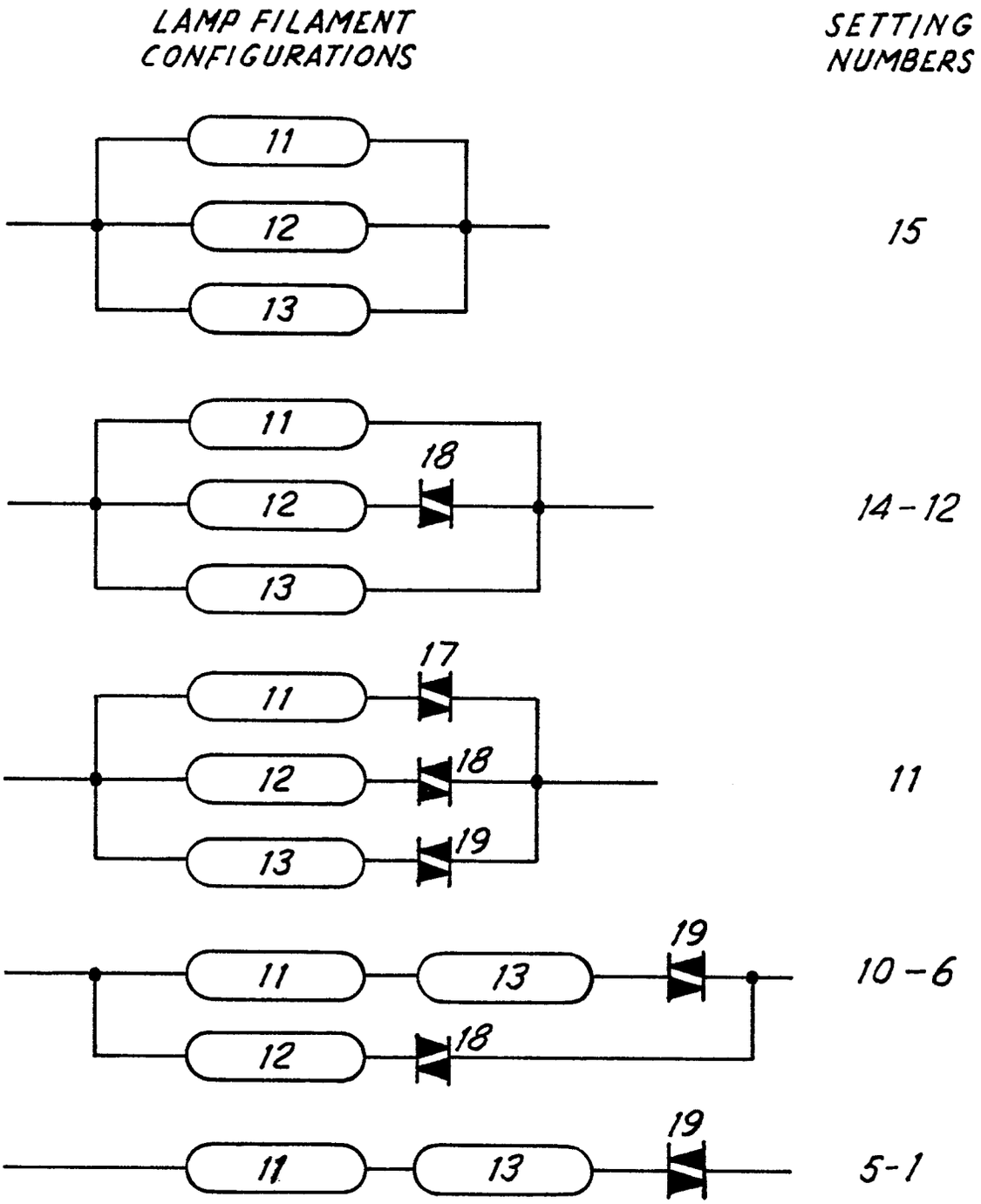
LAMP FILAMENT CONFIGURATIONS
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FIG. 3

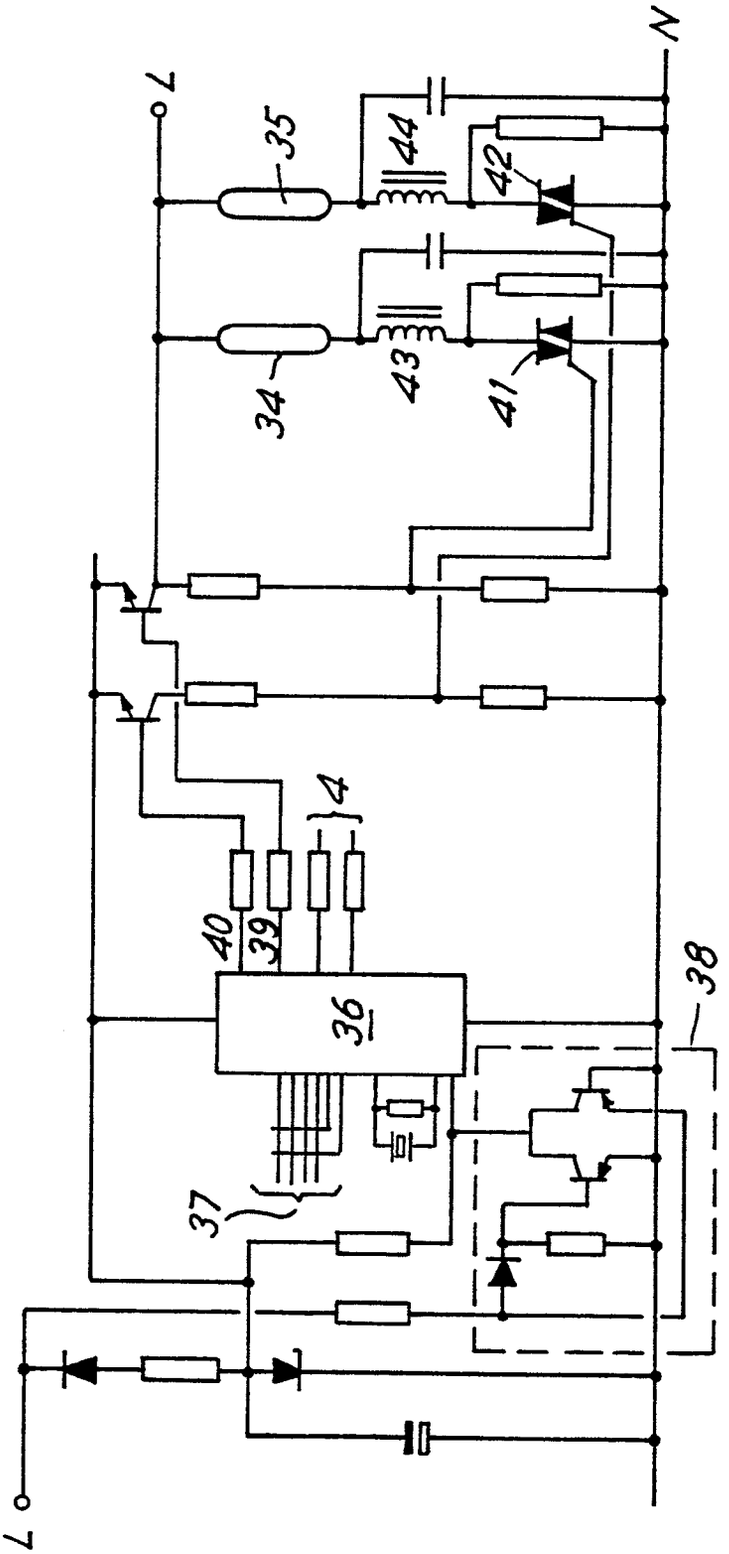

FIG. 4

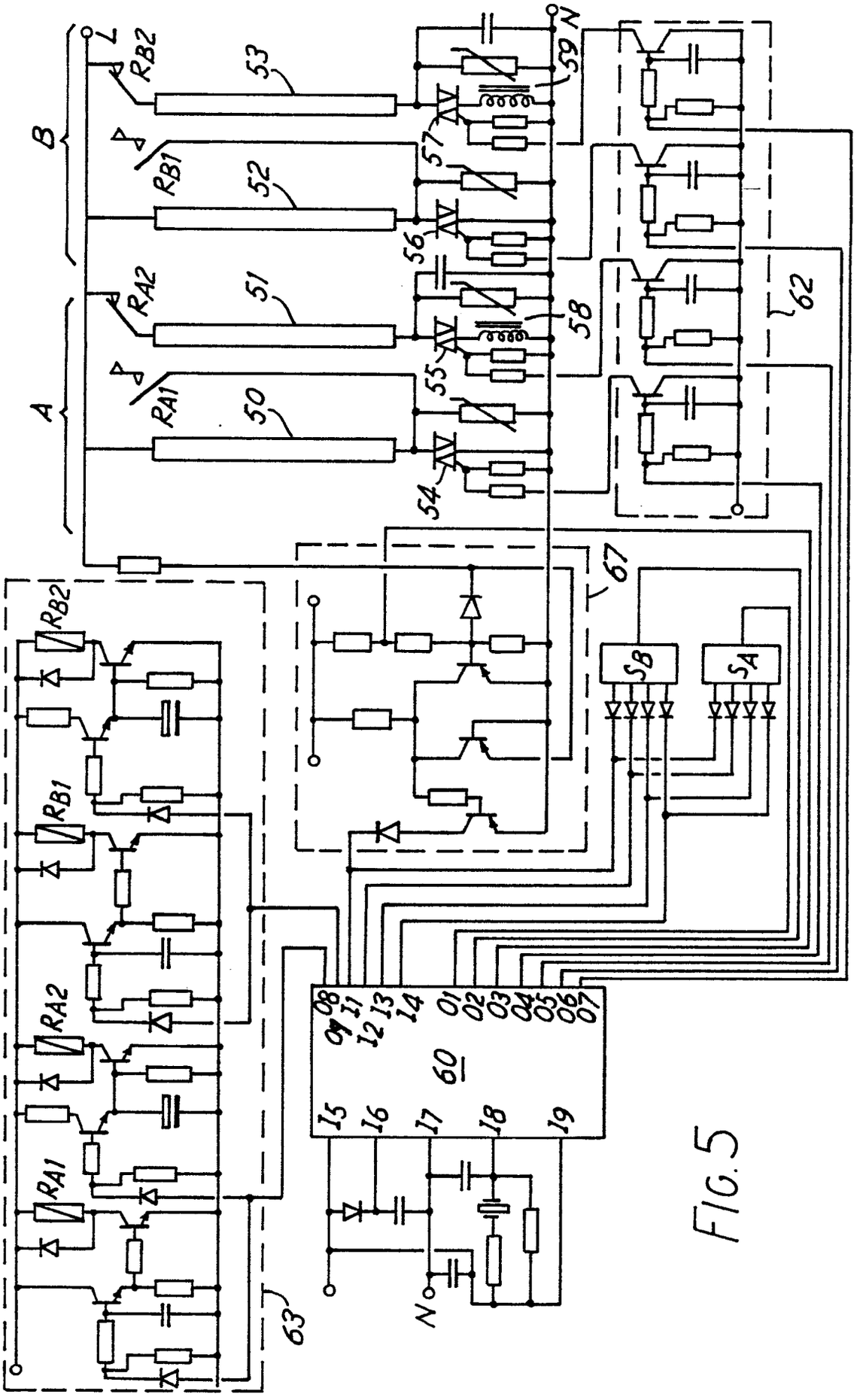
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FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86 30 8615

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-4 443 690 (PAYNE et al.) * Column 4, line 1 - column 5, line 4 *	1,3,4	H 05 B 3/74 F 24 C 15/10
A	DE-A-3 334 425 (LICENTIA) * Page 5, line 31 - page 6, line 11 *	1	
P,X	EP-A-0 174 774 (THORN EMI) * Page 3, line 24 - page 4, line 21 *	1,2,4	
P,X	GB-A-2 170 665 (THORN EMI) * Page 1, lines 77-124; figures 2,3 *	1,2,4	
A	GB-A-2 114 829 (BOSCH-SIEMENS)		TECHNICAL FIELDS SEARCHED (Int. Cl.4) H 05 B 3/00 F 24 C 15/00
A	GB-A-2 060 329 (THORN DOMESTIC)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-02-1987	RAUSCH R.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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