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Heating device and roaster

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ABSTRACT

[Problem] To provide a heating device that implements countermeasures against harmonics and flicker with simple temperature control without degrading food roasting performance.
[Solution] The present invention provides a heating device for heating food, comprising a heating section and a control section. The heating section is configured to be driven by an AC power supply. The control section is configured to control a duty ratio, which is a ratio of energization time of the heating section within a predetermined control cycle, and the control cycle is 15 seconds or more.

Figure 4

Figure 4A

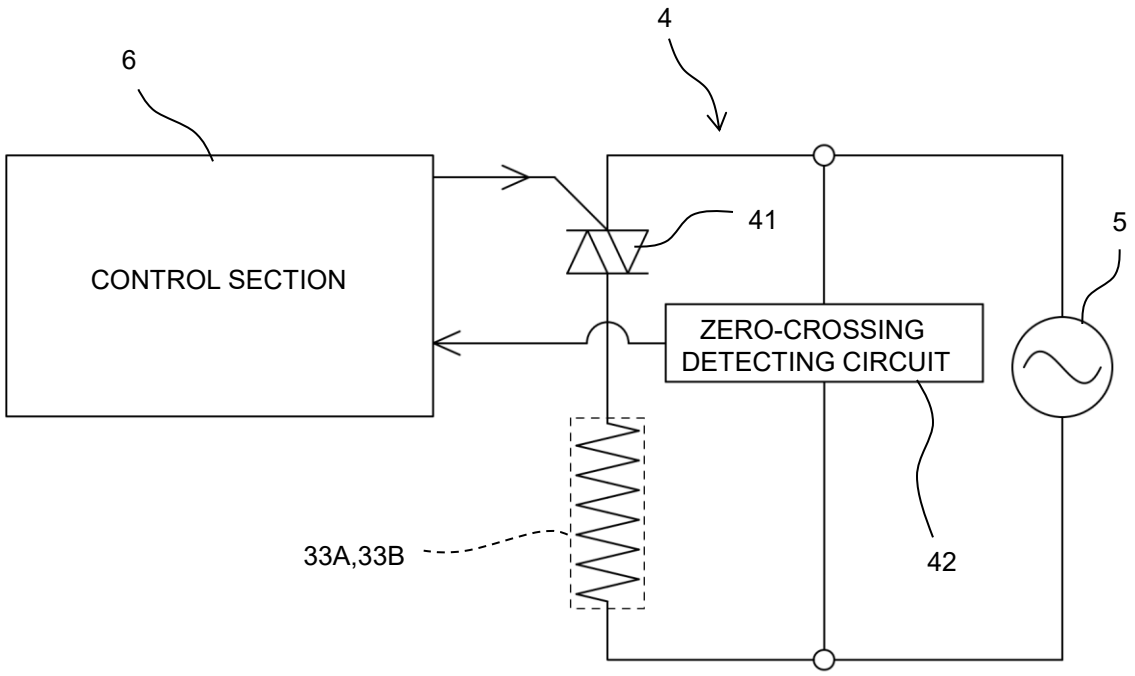
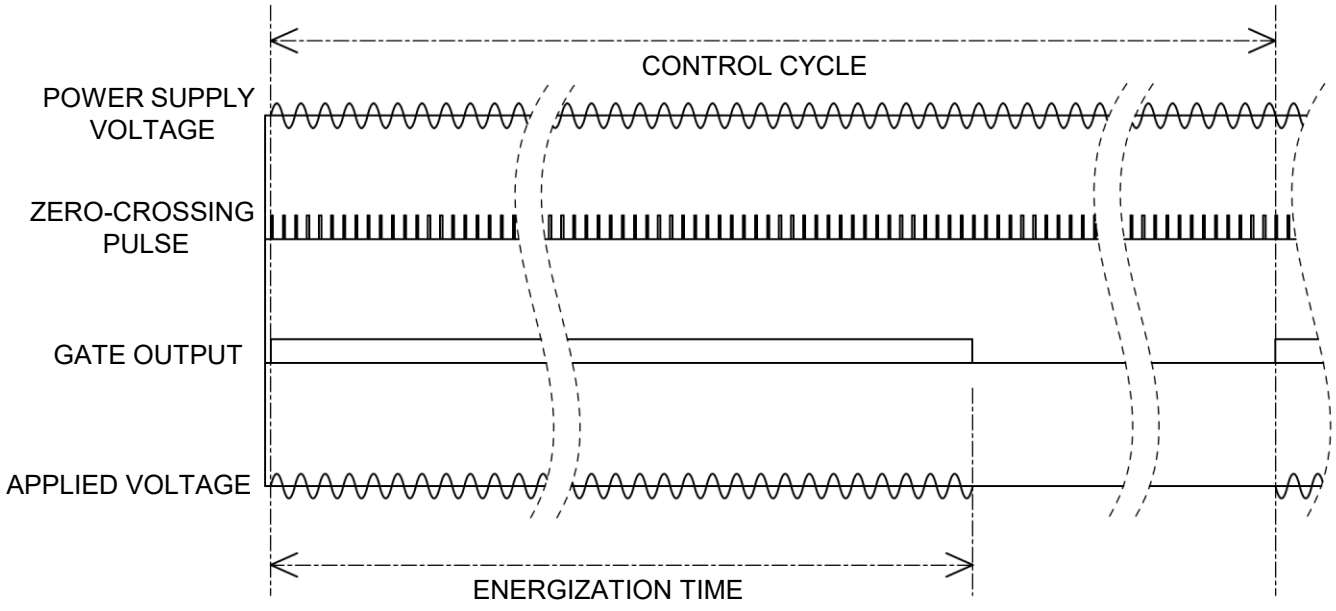


Figure 4B



HEATING DEVICE AND ROASTER

TECHNICAL FIELD

[0001]

The present invention relates to a heating device for cooking food such as meat and vegetables, and to a roaster including the heating device.

BACKGROUND ART

[0002]

Gas burners have been commonly used for heating devices for cooking, but in recent years, electric heaters have been increasingly used in heating devices. Such heating devices are often driven by AC power and use a certain amount of power. It is thus important to take countermeasures against harmonics and flicker as in other home appliances that consume a large amount of power.

[0003]

Patent Document 1 discloses a digital power supply for an electric grill that aims to reduce harmonics and flicker by causing voltage changes at a higher frequency beyond human perception levels by use of phase angle control technique that allows an AC waveform to be cut at a desired phase angle.

[Citation List]

[Patent Literature]

[0004]

[Patent Literature 1] JP6890166B2

SUMMARY OF INVENTION

[Technical Problem]

[0005]

It is known that, depending on illumination intensity and individual differences, humans feel uncomfortable with flicker at such a level that the number of occurrences of changes in illumination intensity is approximately 8.8 per second (i.e., at a frequency of 8.8 Hz) (on a graph per minute as illustrated in Figure 11 of Patent Document 1, the number of occurrences of changes is doubled because on and off signals are counted separately, and a minimum value of the graph appears around at 8.8 x 2 x 60 = 1056. In the conventional technique as described above, therefore, voltage changes are more likely to be caused in a frequency range perceptible to humans by any slight increase in length of control cycle due to an improvement in accuracy of temperature adjustment (e.g., subdivided heater output setting levels). If the number of occurrences of switching between heater conduction states is to be further increased, furthermore, temperature control becomes more complicated.

[0006]

The present invention is intended to solve the foregoing problems of the conventional techniques. An object of the present invention is to provide a heating device that implements countermeasures against harmonics and flicker with simple temperature control without degrading food roasting performance.

[Solution to Problem]

[0007]

The present invention provides the following inventions:

[1] a heating device for heating food, comprising a heating section and a control section,

wherein the heating section is configured to be driven by an AC power supply,

wherein the control section is configured to control a duty ratio, which is a ratio of energization time of the heating section within a predetermined control cycle, and

wherein the control cycle is 15 seconds or more;

[2] the heating device according to Item [1], further comprising a heat reflecting member,

wherein the heating section has an electric heater, and

wherein the heat reflecting member is configured to cover a lower side of the electric heater, and has on top thereof a support configured to support a food placing member;

[3] a roaster for cooking food, comprising:

the heating device according to Item [2], and

a food placing member placed on the support,

wherein the roaster is configured to cook food on the food placing member by using the heating device;

[4] the roaster according to Item [3], further comprising a switching section,

wherein the switching section is configured to allow switching between energization and de-energization of the heating section,

wherein the switching between energization and de-energization of the heating section is timed to coincide with a zero-crossing point of the AC power supply, and

wherein the roaster performs at least one of power control in which the heating section is energized at beginning of the control cycle and de-energized after a lapse of energization time corresponding to the duty ratio and power control in which the heating section is de-energized at beginning of the control cycle and energized after a lapse of predetermined time corresponding to the duty ratio;

[5] the roaster according to Item [3] or [4], wherein the control cycle is 15 seconds or more and 60 seconds or less; and

[6] the roaster according to Item [3] or [4], further comprising a detecting section,

wherein the detecting section is configured to detect temperature of the heating section, and

wherein the control section is configured to control the duty ratio based on detection result of the detecting section.

[Advantageous Effects of Invention]

[0008]

In the heating device of the present invention, the heating section driven by an AC power supply is temperature-controlled according to a ratio (duty ratio) of energization time of the heating section within a long control cycle of 15 seconds or more (usually 1 second or less). Therefore, voltage changes occur at an extremely low frequency beyond human perception levels, resulting in little effects of flicker. Also, the heating device eliminates the need for cutting the AC voltage waveform at a desired phase angle, and facilitates switching between energization and de-energization of the heating section at a time when the AC voltage waveform crosses zero (also referred to as a zero-

crossing point). Thus, repetitive waveforms other than sine waves, in other words, harmonics also, are less likely to be generated. Additionally, Applicants have proved by experiments that a food placing member such as a roasting rack and a grate does not show such a sudden drop in temperature for a considerable time that affects roasting performance, and adoption of a long control cycle of 15 seconds or more is thus unlikely to degrade roasting performance. Therefore, the heating device implements countermeasures against harmonics and flicker with simple temperature control while heating food such as meat and vegetables suitably.

[BRIEF DESCRIPTION OF DRAWINGS]

[0009]

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a perspective view illustrating an external appearance of a roaster 1 according to an embodiment of the present invention;

Figure 2A is a perspective view illustrating an external appearance of a heating device 3, and Figure 2B is an exploded perspective view illustrating the heating device 3 from another angle;

Figure 3A is a perspective view illustrating configuration of a heater unit 33, a food placing member 34, and a heat reflecting member 35, and Figure 3B is a perspective view illustrating a state in which the food placing member 34 is separated from the heater unit 33 and the heat reflecting member 35;

Figure 4A is a schematic diagram illustrating configuration of a temperature control section for a first electric heater 33A and a second electric heater 33B, and Figure 4B is a diagram of waveforms illustrating an example of temperature control for the first electric heater 33A and the second electric heater 33B;

Figure 5 is a diagram illustrating short-term flicker values (Pst) obtained when drive voltage, control cycle, and duty ratio are varied; and

Figure 6 is a diagram illustrating a modified example of the temperature control section for the first electric heater 33A and the second electric heater 33B.

DESCRIPTION OF EMBODIMENTS

[0010]

Described below are embodiments of the present invention. The characteristic matters shown in the embodiments described below can be combined with each other. Moreover, each characteristic matter independently constitutes an invention.

[0011]

[Summary of Roaster 1]

As shown in Figure 1, a roaster 1 is an apparatus for cooking food such as meat and vegetables, and includes a table 2 and a heating device 3. The table 2 includes a top plate 21 and a support 22. With an opening 21A in the center thereof, the top plate 21 is configured in such a manner that a top portion of the heating device 3 is exposed through the opening 21A. The support 22 has a hollow structure,

and is configured in such a manner as to allow an internal space to be opened by removing a side panel thereof. Housed in the internal space are a power unit for supplying power to the heating device 3, a control unit for overall control of the operation of the roaster 1, various wirings, and the like.

[0012]

The table 2 also includes an operating portion 23. The operating portion 23 has a volume controller 23A that allows a user to adjust heating power (also referred to as heat generation amount) of the heating device 3. The volume controller 23A preferably has such a configuration as to allow desired heating power to be obtained for example by a user rotating a knob for heating power adjustment. Extent of rotation of the knob is preferably detected by a resistance value of an internal variable resistor. However, means for adjusting heating power of the heating device 3 is not limited to the volume controller 23A, and other known adjustment means can be used as appropriate.

[0013]

[Heating Device 3]

As shown in Figures 2A and 2B, the heating device 3 has a casing 31 and a top cover 32. Housed inside the casing 31 are a heater unit 33, a food placing member 34, a heat reflecting member 35, a drain pan 36, a filter 37, and the like. The heater unit 33, the food placing member 34, and the heat reflecting member 35 will be described later.

[0014]

The drain pan 36 is supported by an inner circumference of the casing 31, and also functions as an inner casing surrounding a food cooking area. A lower portion of the drain pan 36 in the casing 31 is connected to an exhaust section (not shown) via the filter 37. The exhaust section has a connecting tube and an exhaust duct, and is configured to suction smoke, oil droplets, and the like generated in the heating device 3, for example by use of suction force of an exhaust fan in the exhaust duct. Therefore, smoke, oil droplets, and the like generated when food is cooked are discharged to the outside of the roaster 1 via through holes in the top cover 32 and exhaust passages formed in the casing 31. The connecting tube is preferably provided with a fire damper, a fall prevention net, and the like.

[0015]

[Heater Unit 33: Heating Section]

As shown in Figures 3A and 3B, the heater unit 33 includes a first electric heater 33A and a second electric heater 33B, both of resistance heating type. The first electric heater 33A and the second electric heater 33B are, for example, sheathed heaters having a heating element such as a nichrome wire, and each have a rod shape. However, the shape of the electric heater mounted in the heater unit 33 is not limited to a rod shape. For example, a heater can be used that has a U-shape in which straight portions and an arc-shaped portion (e.g., a semicircular portion) are continuous with each other. Alternatively, a heater can be used that has a shape in which a plurality of U-shaped portions are continuous with one another, a shape composed only of curved portions, or other complex shapes. The heater unit 33 radiates heat from the first electric heater 33A and the second electric heater 33B, and heats air around the first electric heater 33A and the second electric heater 33B as well as the heat reflecting member 35, and thereby generates hot air. Also, radiant heat from the first electric heater

33A and the second electric heater 33B reaches the food placing member 34 and food directly and indirectly after being reflected by the heat reflecting member 35. As a result, the food placing member 34 and food are heated by the hot air and the radiant heat.

[0016]

In the embodiment, the food placing member 34 is a stainless-steel mesh (also referred to as a roasting rack). However, a grate or the like can be used instead of the mesh. In addition, iron material is a preferable alternative for stainless steel. A material of the food placing member 34 preferably has as high heat capacity as possible in order for the food placing member 34 to resist temperature changes even when a relatively long control cycle (e.g., 15 seconds or more) is adopted.

[0017]

The heat reflecting member 35 is configured to cover lower sides of the first electric heater 33A and the second electric heater 33B, and has on top thereof a support 35A configured to support the food placing member 34. Since respective sides of the first electric heater 33A and the second electric heater 33B opposite to the food placing member 34 are surrounded by the heat reflecting member 35, heat can be efficiently transmitted to the food placing member 34. Furthermore, the food placing member 34 is prevented from undergoing a decrease in temperature even when a relatively long control cycle (e.g., 15 seconds or more) is adopted as described later. In the embodiment, the heat reflecting member 35 is made of, but not limited to, stainless steel with No. 2B surface finish. A material of the heat reflecting member 35 also preferably has as high heat capacity as possible in order for the food placing member 34 to resist temperature changes even when a relatively long control cycle (e.g., 15 seconds or more) is adopted.

[0018]

[Power Control of First Electric Heater 33A and Second Electric Heater 33B]

Next with reference to Figures 4A and 4B will be described power control of the first electric heater 33A and the second electric heater 33B. The first electric heater 33A and the second electric heater 33B are each driven by an AC power supply 5. More specifically, the first electric heater 33A and the second electric heater 33B are configured in such a manner that an alternating current is applied thereto from the AC power supply 5 via a semiconductor relay 4.

[0019]

The semiconductor relay 4 is for example a solid-state relay (SSR), and, in the embodiment, is configured to operate based on a control signal from a control section 6. The semiconductor relay 4 has a triac 41 and a zero-crossing detecting circuit 42. The triac 41 is configured to allow switching between energization and de-energization of the first electric heater 33A and the second electric heater 33B based on a control signal (gate output) from the control section 6. In the embodiment, the triac 41 corresponds to a switching section of the present invention. The zero-crossing detecting circuit 42 is configured to send a zero-crossing pulse to the control section 6 when detecting a zero-crossing point of the AC power supply 5.

[0020]

The control section 6 is configured to control a ratio (duty ratio) of energization time of the first electric heater 33A and the second electric heater 33B within a predetermined control cycle. The

control cycle is preferably 15 seconds or more, and more preferably about 15 to 60 seconds. More specifically, the control cycle is 15, 20, 25, 30, 35, 40, 45, 50, 55, or 60 seconds, for example, and may be within a range between any two of the values exemplified above (e.g., 15 to 40 seconds, 20 to 35 seconds, etc.).

[0021]

If the control cycle as shown in Figure 4B is 20 seconds, for example, the energization time is set to 10 seconds when the duty ratio is 50%, and is set to 16 seconds when the duty ratio is 80%. The control section 6 determines the duty ratio as appropriate according to a set value of the volume controller 23A. Here, the control section 6 performs such power control as to turn on gate output at beginning of the control cycle and thereby make the triac 41 conductive and to turn off the gate output after a lapse of energization time corresponding to the duty ratio and thereby cut power supply to the first electric heater 33A and the second electric heater 33B. Alternatively, the control section 6 may perform such power control as to turn off gate output at beginning of the control cycle and thereby make the triac 41 non-conductive and to turn on the gate output after a lapse of a predetermined time corresponding to the duty ratio (time obtained by subtracting energization time from the control cycle) and thereby start power supply to the first electric heater 33A and the second electric heater 33B. The foregoing power control methods may also be used in combination. In either case, the switching between energization and de-energization of the first electric heater 33A and the second electric heater 33B is minimized (once during the control cycle).

[0022]

In addition, the control section 6 times on/off switching of the triac 41 (on/off switching of power supply to the first electric heater 33A and the second electric heater 33B) to coincide with a zero-crossing point of the AC power supply 5. This eliminates the need for cutting an AC voltage waveform of the AC power supply 5 at a desired phase angle, and repetitive waveforms other than sine waves, in other words, harmonics also, are thus less likely to be generated. Furthermore, the on/off switching performed only at the zero-crossing point of the AC power supply 5 allows the power supply voltage to be used directly as a sine wave, which is advantageous in terms of minimizing power loss.

[0023]

Figure 5 shows measurement results of short-term flicker value (Pst) compliant with the international standard (IEC61000-3-3) for voltage fluctuation/flicker when drive voltage, control cycle (also referred to as drive cycle), and duty ratio (duty) are varied. In the experiment was used an electric heater that outputs 1700W when driven by a 240V AC voltage. When the duty ratio is 100%, on/off control is not performed, and control frequency was thus set to 0. In other cases, control frequency (also referred to as drive frequency) was set to the reciprocal of the control cycle.

[0024]

When the duty ratio is 100%, as shown in Figure 5, on/off control is not performed, and a fairly low short-term flicker value (Pst) (less than 0.03) is thus obtained. When the duty ratio was varied within a range of about 30% to 80%, further, no correlation was observed among the drive voltage, the duty ratio, and the short-term flicker value (Pst). Applicants found that there is a strong correlation between the control cycle and the short-term flicker value (Pst). More specifically, Applicants found that if the

control cycle is 15 seconds or more, i.e., the drive frequency is 0.067 or less, the short-term flicker value (Pst) is 1 or less and that if the control cycle is 20 seconds or more, i.e., the drive frequency is 0.05 or less, the short-term flicker value (Pst) is 0.9 or less. IEC61000-3-3 defines the limit of the short-term flicker value (Pst) as 1, and it is important to keep the short-term flicker value (Pst) at 1 or less.

[0025]

Considering the short-term flicker value (Pst), the control cycle of each of the first electric heater 33A and the second electric heater 33B may be preferably 15 seconds or more, more preferably 20 seconds or more, and even more preferably 30 seconds or more. Since uneven cooking and the like is not desirable when roasting food (meat, etc.), however, the upper limit of the control cycle is preferably set as appropriate considering the heat capacity of the food placing member 34, the heat reflecting member 35, and the like. Even when a stainless-steel roasting rack with a relatively low heat capacity was used as the food placing member 34 for use in the roaster 1, uneven cooking was not caused when roasting food (meat, etc.) in a control cycle of about 40 to 60 seconds.

[0026]

Simultaneously with visual checking of food for doneness, in experiments to evaluate roasting performance, the temperature of the stainless-steel roasting rack is measured with thermocouples brazed at nine points of the roasting rack. Even when on/off control with a duty ratio of 50% was performed in a control cycle of 40 to 60 seconds from a state where the temperature of the roasting rack was about 240 to 320°C, the temperature at each point of the roasting rack did not decrease by 20°C or more. Even when the first electric heater 33A and the second electric heater 33B are driven at a duty ratio of 100%, in the roaster 1, the temperature of the roasting rack may fluctuate by about 20°C. If the control cycle is about 60 seconds, therefore, it can be said that the food roasting performance is comparable to that at a duty ratio of 100%. It is particularly noteworthy that the temperature fluctuation of the roasting rack was almost the same in the case of a control cycle of 40 to 60 seconds and in the case of a control cycle of 0.5 seconds. If the control cycle is in the range of 15 to 60 seconds, therefore, good roasting performance can be achieved regardless of the configuration and material of the food placing member 34 and the heat reflecting member 35.

[0027]

[Modified Example of Power Control of First Electric Heater 33A and Second Electric Heater 33B]

In the foregoing embodiment, an example was described in which the duty ratio is appropriately determined by the control section 6 based on setting value of the volume controller 23A and the like. However, this is not a limitation, but a temperature detecting section 6A, for example, may be additionally provided as shown in Figure 6. The temperature detecting section 6A is configured to detect surface temperatures of the first electric heater 33A and the second electric heater 33B. In this case, the control section 6 may control the duty ratio in consideration of detection result of the temperature detecting section 6A as well as the setting value of the volume controller 23A and the like.

[0028]

[Other Embodiments]

In the foregoing embodiment, the first electric heater 33A and the second electric heater 33B are less frequently switched on and off. Thus, the semiconductor relay 4 can be substituted with a mechanical relay, for example.

[Reference Signs List]

[0029]

1: roaster
2: table
3: heating device
4: semiconductor relay
5: AC power supply
6: control section
6A: temperature detecting section
21: top plate
21A: opening
22: support
23: operating portion
23A: volume controller
31: casing
32: top cover
33: heater unit
33A: first electric heater
33B: second electric heater
34: food placing member
35: heat reflecting member
35A: support
36: drain pan
37: filter
41: triac
42: zero-crossing detecting circuit

Claims

1. A heating device for heating food, comprising a heating section and a control section,

wherein the heating section is configured to be driven by an AC power supply,

wherein the control section is configured to control a duty ratio, which is a ratio of energization time of the heating section within a predetermined control cycle, and

wherein the control cycle is 15 seconds or more.

2. The heating device according to claim 1, further comprising a heat reflecting member,

wherein the heating section has an electric heater, and

wherein the heat reflecting member is configured to cover a lower side of the electric heater, and has on top thereof a support configured to support a food placing member.

3. A roaster for cooking food, comprising:

the heating device according to claim 2; and

a food placing member placed on the support,

wherein the roaster is configured to cook food on the food placing member by using the heating device.

4. The roaster according to claim 3, further comprising a switching section,

wherein the switching section is configured to allow switching between energization and de-energization of the heating section,

wherein the switching between energization and de-energization of the heating section is timed to coincide with a zero-crossing point of the AC power supply, and

wherein the roaster performs at least one of power control in which the heating section is energized at beginning of the control cycle and de-energized after a lapse of energization time corresponding to the duty ratio and power control in which the heating section is de-energized at beginning of the control cycle and energized after a lapse of predetermined time corresponding to the duty ratio.

5. The roaster according to claim 3 or 4, wherein the control cycle is 15 seconds or more and 60 seconds or less.

6. The roaster according to claim 3 or 4, further comprising a detecting section,

wherein the detecting section is configured to detect temperature of the heating section, and

wherein the control section is configured to control the duty ratio based on detection result of the detecting section.

Figure 1

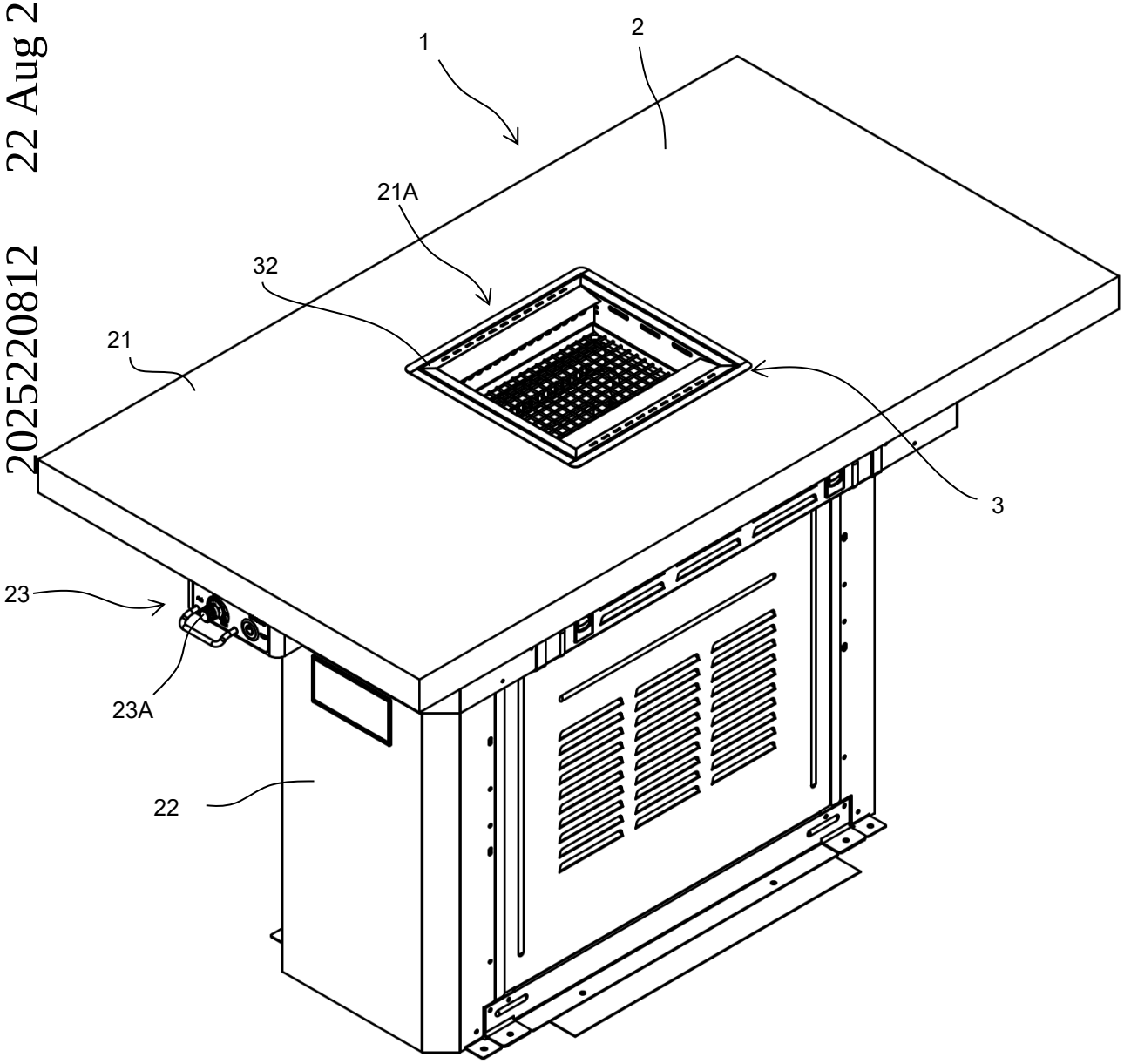


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Figure 2A

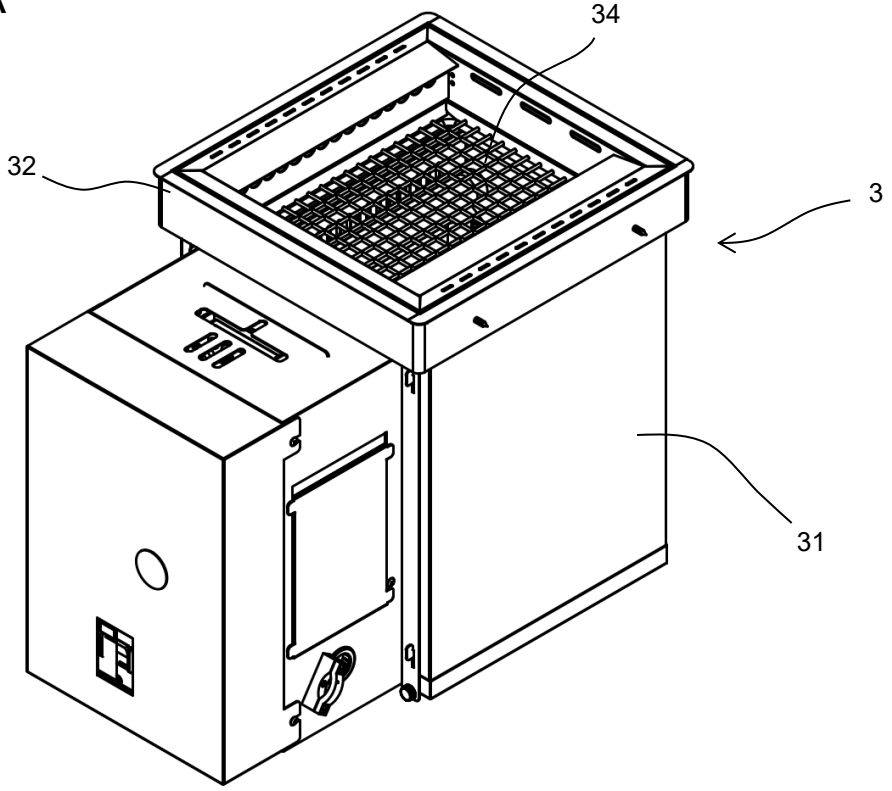

Figure 2B

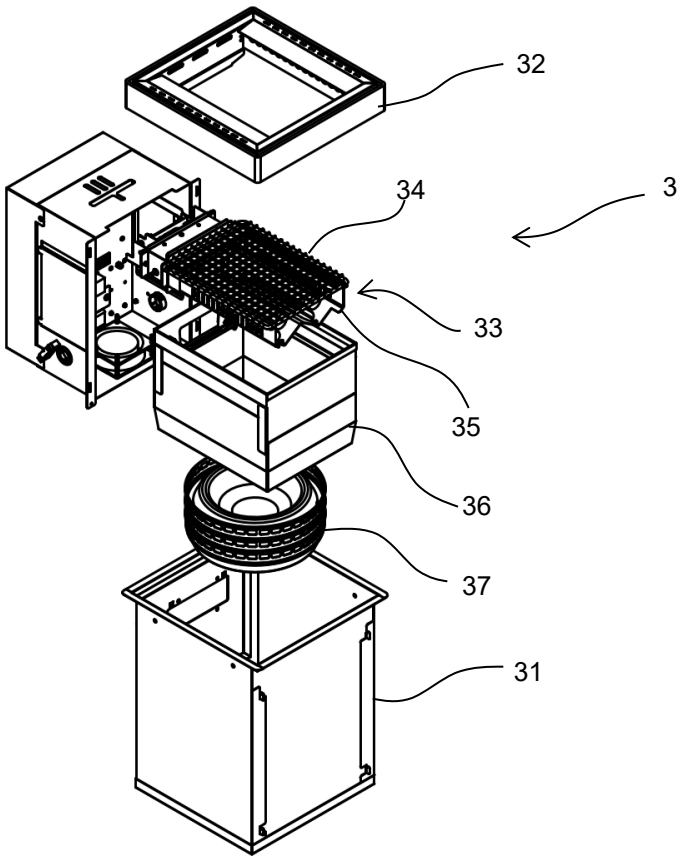

Figure 3A

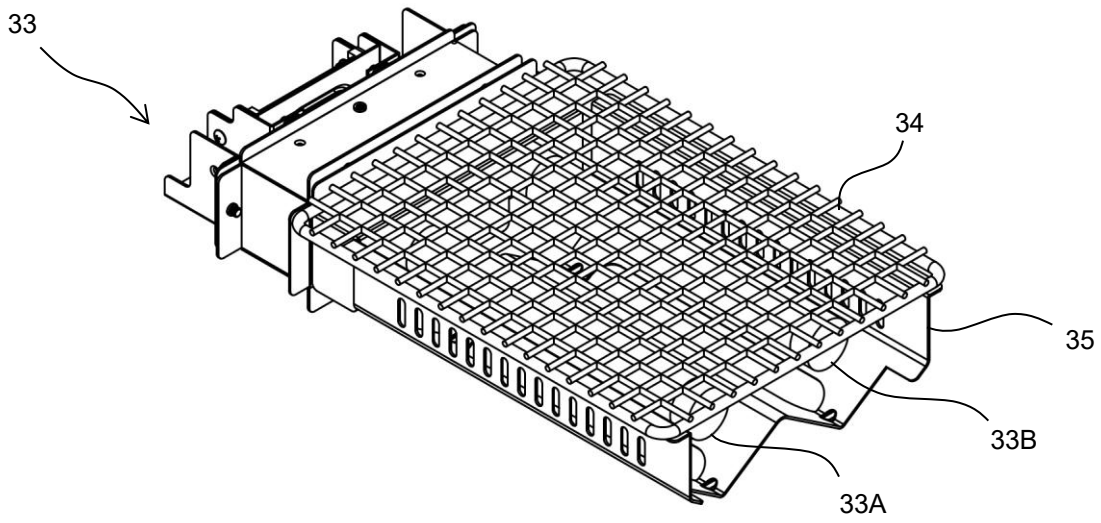

Figure 3B

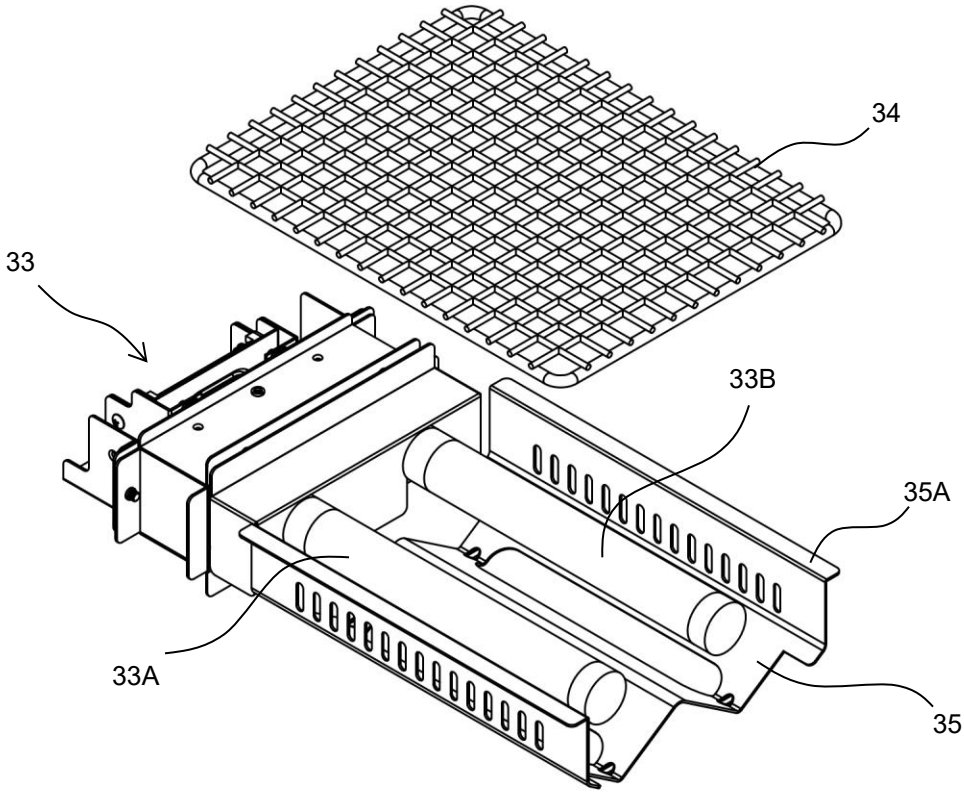

Figure 4A

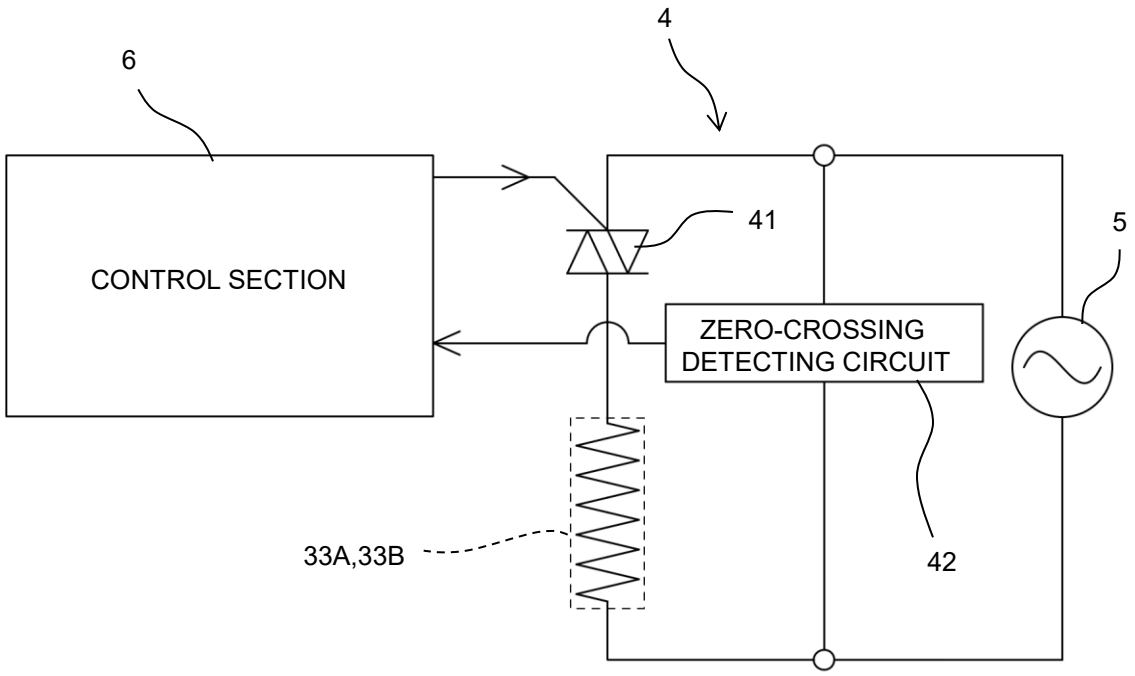

Figure 4B

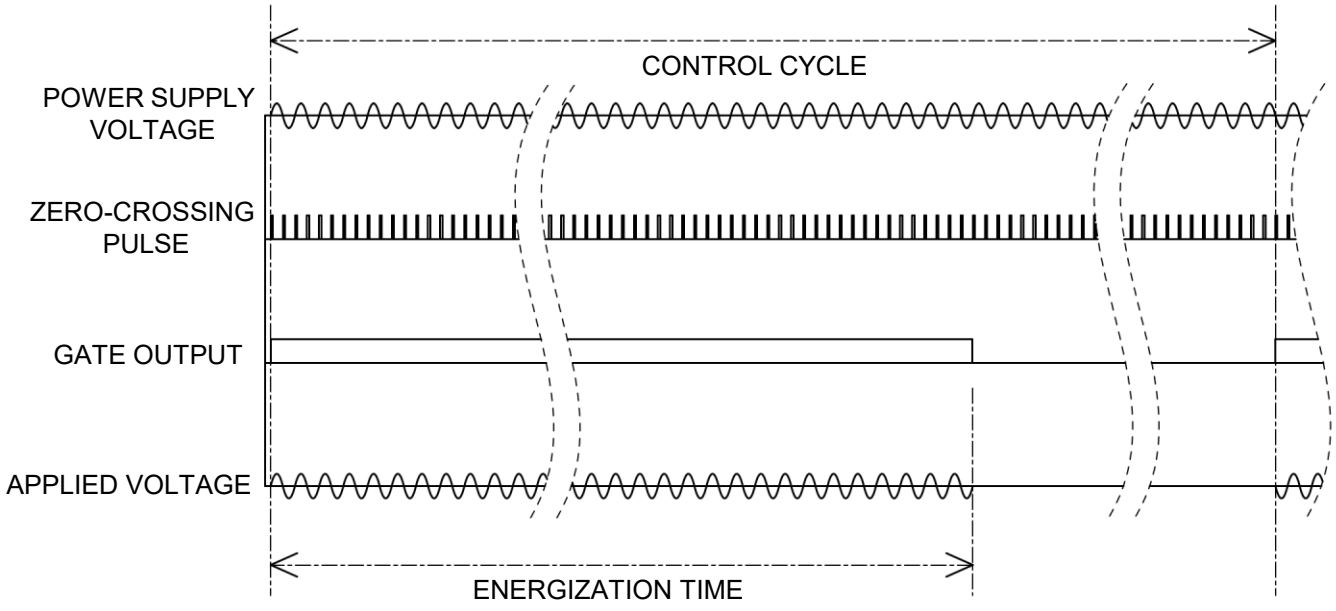

Figure 5

DRIVE VOLTAGE	CONTROL CYCLE	CONTROL FREQUENCY	duty	Pst
240	0.5	0	100	0.001
240	0.5	2	80	3
240	5	0	100	0.028
240	5	0.2	80	1.389
240	10	0.1	80	1.139
240	15	0.066667	80	0.991
240	15	0.066667	70	1
230	15	0.066667	70	0.991
230	18	0.055556	70	0.933
240	20	0.05	80	0.896
240	20	0.05	56	0.898
240	30	0.033333	80	0.776
240	30	0.033333	50	0.78
240	30	0.033333	30	0.768

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Figure 6