(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 226 788 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
16.08.2023 Bulletin 2023/33

(21) Application number: **21926564.2**

(22) Date of filing: **18.02.2021**

(51) International Patent Classification (IPC):
A24F 40/465 *(2020.01)*

(52) Cooperative Patent Classification (CPC):
A24F 40/465

(86) International application number:
PCT/JP2021/006193

(87) International publication number:
WO 2022/176129 (25.08.2022 Gazette 2022/34)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

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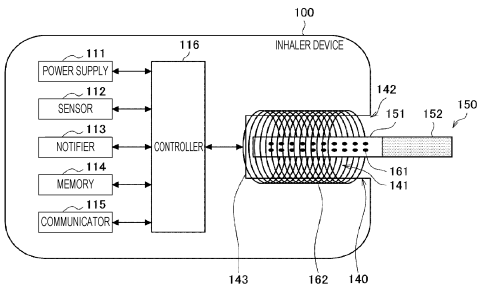
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(54) **INHALATION DEVICE, PROGRAM, AND SYSTEM**

(57) [Problem] To provide a structure that enables preferential generation of aerosol in an induction heating-type inhalation device. [Solution] An inhalation device includes: a power supply unit; an electromagnetic induction source that uses electric power supplied from the power supply unit to generate a fluctuating magnetic field; a control unit that controls a supply of power to the electromagnetic induction source; a holding unit that holds a substrate which has been inserted into an internal space through an opening and which contains an aerosol source; a response unit that is disposed at a position where the fluctuating magnetic field generated from the electromagnetic induction source intrudes and that generates heat when the fluctuating magnetic field intrudes; and a temperature sensor that detects a temperature of the response unit. The electromagnetic induction source is disposed at a position where the fluctuating magnetic field intrudes in a susceptor that is disposed thermally near the aerosol source contained in the substrate held by the holding unit and that generates heat when the fluctuating magnetic field intrudes. The control unit controls the supply of power to the electromagnetic induction source on the basis of the temperature of the response unit detected by the temperature sensor.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an inhaler device, a program, and a system.

Background Art

[0002] Inhaler devices, such as e-cigarettes and nebulizers, for generating a substance to be inhaled by users are widespread. For example, the inhaler devices generate an aerosol having a flavor component imparted thereto, by using a substrate including an aerosol source for generating the aerosol, a flavor source for imparting the flavor component to the generated aerosol, and the like. Users can enjoy the flavor by inhaling the aerosol having the flavor component imparted thereto, which is generated by the inhaler devices. An action of a user inhaling an aerosol is hereinafter referred to as a puff or a puff action.

[0003] Inhaler devices using an external heat source such as a heating blade had been dominant until recently. In recent years, however, inhaler devices of induction heating type have been attracting attention. For example, Patent Literature 1 below discloses a technique of estimating a temperature of a susceptor included in a substrate from an apparent ohmic resistance when the susceptor is heated by induction heating.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 6623175 B2

Summary of Invention

Technical Problem

[0005] Inhaler devices using an external heat source measure and control a temperature of the external heat source to implement appropriate generation of an aerosol. In contrast, inhaler devices of induction heating type have difficulty in directly measuring and controlling the temperature of the susceptor and thus in implementing appropriate generation of an aerosol. As disclosed in Patent Literature 1 above or the like, the technique of estimating a temperature of a susceptor has been developed. However, there is room for improvement in the accuracy of such a technique.

[0006] Accordingly, the present invention has been made in view of the issue described above, and it is an object of the present invention to provide a mechanism that enables an inhaler device of induction heating type to appropriately generate an aerosol.

Solution to Problem

[0007] To overcome the issue described above, an aspect of the present invention provides an inhaler device including: a power supply configured to supply electric power; an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply; a controller configured to control electric power supply to the electromagnetic induction source; a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold a substrate inserted into the internal space through the opening, the substrate including an aerosol source; a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and a temperature sensor configured to detect a temperature of the responder, in which the electromagnetic induction source is disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to the aerosol source included in the substrate held by the holder, the susceptor is configured to produce heat upon being penetrated by the varying magnetic field, and the controller is configured to control the electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor.

[0008] A Curie point of the susceptor and a Curie point of the responder may be substantially equal.

[0009] The responder may be made of a material that is paramagnetic within a range of a temperature reachable by the responder through induction heating using the electromagnetic induction source.

[0010] A Curie point of the susceptor may be lower than a highest temperature reachable by the susceptor through induction heating using the electromagnetic induction source, and the controller may be configured to estimate a tem-

perature of the susceptor by using different temperature estimation algorithms before and after the Curie point of the susceptor.

[0011] The susceptor and the responder may be each made of one or more materials selected from a material group including aluminum, iron, nickel, cobalt, conductive carbon, copper, and stainless steel.

[0012] The responder may be disposed between the electromagnetic induction source and the holder.

[0013] The responder may be a cylindrical member that covers at least a portion of an outer circumference of the holder.

[0014] The responder may be at least a portion of the holder.

[0015] The inhaler device may further include a magnetic shield configured to shield a magnetic field, in which the magnetic shield may be disposed between the electromagnetic induction source and a housing that is a re-outer shell of the inhaler device, and the responder may be a portion of the magnetic shield.

[0016] The controller may be configured to estimate a temperature of the susceptor, based on the temperature of the responder, and control the electric power supply to the electromagnetic induction source, based on the estimated temperature of the susceptor.

[0017] The controller may be configured to control the electric power supply to the electromagnetic induction source, based on the estimated temperature of the susceptor and the temperature of the responder detected by the temperature sensor.

[0018] The controller may be configured to control, based on a heating profile, the electric power supply to the electromagnetic induction source, the heating profile being information that defines a time-series change in a target temperature that is a target value of the temperature of the susceptor.

[0019] The controller may be configured to change the heating profile to be used, and a temperature estimation algorithm for use in estimating the temperature of the susceptor based on the temperature of the responder may be different for each heating profile to be used.

[0020] The controller may be configured to control the electric power supply to the electromagnetic induction source, based on a temperature of an operating environment of the inhaler device.

[0021] The controller may be configured to control the electric power supply to the electromagnetic induction source, based on a type of the substrate held by the holder.

[0022] The controller may be configured to control the electric power supply to the electromagnetic induction source, based on an operation history of the inhaler device.

[0023] The controller may be configured to control the electric power supply to the electromagnetic induction source, based on a number of times of electric power supply to the electromagnetic induction source and/or an interval of electric power supply to the electromagnetic induction source.

[0024] Controlling the electric power supply to the electromagnetic induction source may include stopping the electric power supply to the electromagnetic induction source.

[0025] To overcome the issue described above, another aspect of the present invention provides a program to be executed by a computer that controls an inhaler device, the inhaler device including: a power supply configured to supply electric power; an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply; a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold a substrate inserted into the internal space through the opening, the substrate including an aerosol source; a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and a temperature sensor configured to detect a temperature of the responder, the electromagnetic induction source being disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor disposed in thermal proximity to the aerosol source included in the substrate held by the holder, the susceptor being configured to produce heat upon being penetrated by the varying magnetic field, and the program causing controlling electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor to be performed.

[0026] To overcome the issue described above, another aspect of the present invention provides a system including: an inhaler device; and a substrate, the substrate including an aerosol source, the inhaler device including: a power supply configured to supply electric power; an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply; a controller configured to control electric power supply to the electromagnetic induction source; a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold the substrate inserted into the internal space through the opening; a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and a temperature sensor configured to detect a temperature of the responder, in which the electromagnetic induction source is disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to the aerosol source included in the substrate held by the holder, the susceptor is configured to produce heat upon being penetrated by the varying magnetic field, and the controller is

configured to control the electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor.

Advantageous Effects of Invention

[0027] As described above, the present invention provides a mechanism that enables an inhaler device of induction heating type to appropriately generate an aerosol.

Brief Description of Drawings

[0028]

[Fig. 1] Fig. 1 is a schematic diagram of an inhaler device according to a configuration example.
[Fig. 2] Fig. 2 is a graph illustrating an example of a time-series change in an actual temperature of a susceptor 161 heated by induction heating based on a heating profile presented by Table 1.
[Fig. 3] Fig. 3 is a diagram schematically illustrating an example of a physical configuration inside the inhaler device according to the present embodiment.
[Fig. 4] Fig. 4 is a graph for describing an example of a susceptor temperature estimation algorithm according to the present embodiment.
[Fig. 5] Fig. 5 is a flowchart illustrating an example of a procedure of a process performed by the inhaler device according to the present embodiment.
[Fig. 6] Fig. 6 is a diagram schematically illustrating an example of a physical configuration inside an inhaler device according to a first modification.

Description of Embodiments

[0029] A preferred embodiment of the present invention will be described in detail below with reference to the accompanying drawings. In the specification and the drawings, structural elements having substantially the same functional configuration are denoted by the same reference numerals, and redundant description thereof will be omitted.

<1. Configuration example of inhaler device>

[0030] An inhaler device according to the present configuration example heats a substrate including an aerosol source by induction heating (IH) to generate an aerosol. The present configuration example will be described below with reference to Fig. 1.

[0031] Fig. 1 is a schematic diagram of the inhaler device according to the configuration example. As illustrated in Fig. 1, an inhaler device 100 according to the present configuration example includes a power supply 111, a sensor 112, a notifier 113, a memory 114, a communicator 115, a controller 116, a susceptor 161, an electromagnetic induction source 162, and a holder 140. A user performs inhalation while a stick substrate 150 is held by the holder 140. Each structural element will be sequentially described below.

[0032] The power supply 111 stores electric power. The power supply 111 supplies electric power to each structural element of the inhaler device 100. The power supply 111 may be, for example, a rechargeable battery such as a lithium ion secondary battery. The power supply 111 may be charged by being connected to an external power supply through a Universal Serial Bus (USB) cable or the like. In addition, the power supply 111 may be charged, by using a wireless power transmission technology, without being connected to a power-transmitting device. Further, the power supply 111 alone may be removed from the inhaler device 100 and replaced with a new power supply 111.

[0033] The sensor 112 detects various items of information regarding the inhaler device 100. The sensor 112 outputs the detected items of information to the controller 116. In an example, the sensor 112 may be a pressure sensor such as a condenser microphone, a flow sensor, or a temperature sensor. In response to detecting a numerical value in accordance with inhalation performed by a user, the sensor 112 outputs information indicating that the user has performed the inhalation to the controller 116. In another example, the sensor 112 may be an input device that receives information input by the user, such as a button or a switch. In particular, the sensor 112 may include a button for inputting an instruction to start/stop generation of an aerosol. The sensor 112 outputs the information input by the user to the controller 116. In another example, the sensor 112 may be a temperature sensor that detects a temperature of the susceptor 161. The temperature sensor detects the temperature of the susceptor 161 based on, for example, an electrical resistance value of the electromagnetic induction source 162. The sensor 112 may detect the temperature of the stick substrate 150 held by the holder 140, based on the temperature of the susceptor 161.

[0034] The notifier 113 notifies the user of information. In an example, the notifier 113 may be a light-emitting device

such as a light-emitting diode (LED). In this case, the notifier 113 emits different patterns of light when the power supply 111 needs to be charged, when the power supply 111 is being charged, when the inhaler device 100 has an anomaly, and so on. The pattern of light is a concept including a color, turn-on/turn-off timings, and so on. The notifier 113 may be, along with or instead of the light-emitting device, a display device that displays an image, a sound output device that outputs sound, or a vibration device that vibrates. In addition, the notifier 113 may notify the user of information indicating that the user can perform inhalation. The user is notified of the information indicating that the user can perform inhalation, in response to the temperature of the stick substrate 150 that produces heat by electromagnetic induction reaching a predetermined temperature.

[0035] The memory 114 stores various items of information for operation of the inhaler device 100. The memory 114 may be a non-volatile storage medium such as a flash memory. An example of the items of information stored in the memory 114 is items of information related to an operating system (OS) of the inhaler device 100, such as details of control performed on the various structural elements by the controller 116. Another example of the items of information stored in the memory 114 is items of information related to inhalation performed by the user, such as the number of times of inhalation, an inhalation time, and an accumulated inhalation time period.

[0036] The communicator 115 is a communication interface for transmitting and receiving information between the inhaler device 100 and another device. The communicator 115 performs communication in conformity with any wired or wireless communication standard. Such a communication standard may be, for example, a wireless local area network (LAN), a wired LAN, Wi-Fi (registered trademark), or Bluetooth (registered trademark). In an example, the communicator 115 transmits the items of information related to inhalation performed by the user to a smartphone to cause the smartphone to display the information related to inhalation performed by the user. In another example, the communicator 115 receives information of a new OS from a server to update the information of the OS stored in the memory 114.

[0037] The controller 116 functions as an arithmetic processing unit and a control circuit, and controls the overall operations of the inhaler device 100 in accordance with various programs. The controller 116 is implemented by an electronic circuit such as a central processing unit (CPU) or a microprocessor, for example. In addition, the controller 116 may include a read-only memory (ROM) that stores a program to be used, an arithmetic parameter, and the like, and a random access memory (RAM) that temporarily stores a parameter that changes as appropriate and the like. The inhaler device 100 performs various processes under the control of the controller 116. Electric power supply from the power supply 111 to each of the other structural elements, charging of the power supply 111, detection of information by the sensor 112, notification of information by the notifier 113, storage and reading of information to and from the memory 114, and transmission and reception of information by the communicator 115 are an example of the processes controlled by the controller 116. Other processes performed by the inhaler device 100, such as input of information to each structural element and a process based on information output from each structural element are also controlled by the controller 116.

[0038] The holder 140 has an internal space 141, and holds the stick substrate 150 in a manner such that the stick substrate 150 is partially accommodated in the internal space 141. The holder 140 has an opening 142 that allows the internal space 141 to communicate with outside. The holder 140 holds the stick substrate 150 that is inserted into the internal space 141 through the opening 142. For example, the holder 140 may be a tubular body having the opening 142 and a bottom 143 that is a bottom surface, and may define the pillar-shaped internal space 141. The holder 140 has, in at least a portion of the tubular body in the height direction, an inside diameter that is smaller than an outside diameter of the stick substrate 150 to be able to hold the stick substrate 150 by pressing the stick substrate 150 inserted into the internal space 141 from the outer circumference. The holder 140 also has a function of defining a flow path of air that passes through the stick substrate 150. For example, the bottom 143 has an air inlet hole that is an inlet of air into the flow path. On the other hand, the opening 142 serves as an air outlet hole that is an outlet of air from the flow path.

[0039] The stick substrate 150 is a stick-shaped member. The stick substrate 150 includes a substrate 151 and an inhalation port 152.

[0040] The substrate 151 includes an aerosol source. The aerosol source is heated to be atomized, so that an aerosol is generated. The aerosol source may be a material derived from tobacco, such as shredded tobacco or a processed material obtained by forming a tobacco raw material into a granular, sheet-like, or powdery shape. In addition, the aerosol source may include a material that is not derived from tobacco, such as a material made from a plant other than tobacco (for example, mint or an herb). In an example, the aerosol source may include a flavor component such as menthol. For the inhaler device 100 that is a medical inhaler, the aerosol source may include a medicine to be inhaled by a patient. The aerosol source is not limited to a solid and may be a liquid such as polyhydric alcohol and water. Examples of the polyhydric alcohol include glycerine and propylene glycol. At least a portion of the substrate 151 is accommodated in the internal space 141 of the holder 140 when the stick substrate 150 is held by the holder 140.

[0041] The inhalation port 152 is to be held in a mouth of the user during inhalation. At least a portion of the inhalation port 152 protrudes from the opening 142 when the stick substrate 150 is held by the holder 140. When a user performs inhalation while holding, in their mouth, the inhalation port 152 protruding from the opening 142, air flows into the holder 140 through the air inlet hole (not illustrated). The air that has flowed in passes through the internal space 141 of the

holder 140, that is, the substrate 151, and reaches the inside of the mouth of the user together with the aerosol generated from the substrate 151.

[0042] The stick substrate 150 further includes the susceptor 161. The susceptor 161 produces heat by electromagnetic induction. The susceptor 161 may be made of a conductive material such as metal. In an example, the susceptor 161 is a piece of metal. The susceptor 161 is disposed in proximity to the aerosol source. In the example illustrated in Fig. 1, the susceptor 161 is included in the substrate 151 of the stick substrate 150.

[0043] The susceptor 161 is disposed in thermal proximity to the aerosol source. The susceptor 161 being in thermal proximity to the aerosol source means that the susceptor 161 is disposed at a position where heat produced by the susceptor 161 is transferred to the aerosol source. For example, the susceptor 161 is included in the substrate 151 along with the aerosol source and is surrounded by the aerosol source. This configuration enables the heat produced by the susceptor 161 to be efficiently used for heating the aerosol source.

[0044] Note that, the susceptor 161 may be untouchable from outside of the stick substrate 150. For example, the susceptor 161 may be distributed in a central part of the stick substrate 150, but does not have to be distributed near the outer circumference of the stick substrate 150.

[0045] The electromagnetic induction source 162 causes the susceptor 161 to produce heat by electromagnetic induction. For example, the electromagnetic induction source 162 is a coiled conductive wire wound around the outer circumference of the holder 140. Upon being supplied with an alternating current from the power supply 111, the electromagnetic induction source 162 generates a magnetic field. The electromagnetic induction source 162 is disposed at a position where the internal space 141 of the holder 140 overlaps with the generated magnetic field. Thus, when a magnetic field is generated while the stick substrate 150 is held by the holder 140, an eddy current is generated in the susceptor 161 to generate Joule heat. The aerosol source included in the stick substrate 150 is heated by the Joule heat to be atomized, so that an aerosol is generated. In an example, when the sensor 112 detects a predetermined user input, electric power may be supplied and an aerosol may be generated. When the temperature of the stick substrate 150 that is heated by induction heating using the susceptor 161 and the electromagnetic induction source 162 reaches a predetermined temperature, the user can perform inhalation. When the sensor 112 detects a predetermined user input thereafter, electric power supply may be stopped. In another example, electric power may be supplied and an aerosol may be generated, while the sensor 112 detects inhalation performed by the user.

[0046] Fig. 1 illustrates an example of the susceptor 161 included in the substrate 151 of the stick substrate 150. However, the present configuration example is not limited to such an example. For example, the holder 140 may function as the susceptor 161. In this case, the magnetic field generated by the electromagnetic induction source 162 generates an eddy current in the holder 140, so that Joule heat is generated. The aerosol source included in the stick substrate 150 is heated by the Joule heat to be atomized, so that an aerosol is generated.

[0047] The combination of the inhaler device 100 and the stick substrate 150 may be regarded as a single system because an aerosol can be generated by combining the inhaler device 100 and the stick substrate 150.

<2. Induction heating>

[0048] Induction heating will be described in detail below.

[0049] Induction heating is a process of heating a conductive object by causing a varying magnetic field to penetrate the object. Induction heating involves a magnetic field generator that generates a varying magnetic field, and a to-be-heated object that is conductive and is to be heated when exposed to the varying magnetic field. An example of the varying magnetic field is an alternating magnetic field. The electromagnetic induction source 162 illustrated in Fig. 1 is an example of the magnetic field generator. The susceptor 161 illustrated in Fig. 1 is an example of the to-be-heated object.

[0050] The magnetic field generator and the to-be-heated object are disposed at relative positions such that a varying magnetic field generated from the magnetic field generator penetrates the to-be-heated object. When a varying magnetic field is generated from the magnetic field generator in this state, an eddy current is induced in the to-be-heated object. The eddy current flows through the to-be-heated object, which produces Joule heat according to the electrical resistance of the to-be-heated object, so that the to-be-heated object is heated. Such heating is also referred to as Joule heating, ohmic heating, or resistive heating.

[0051] The to-be-heated object may be magnetic. In this case, the to-be-heated object is further heated by magnetic hysteresis heating. Magnetic hysteresis heating is a process of heating a magnetic object by causing a varying magnetic field to penetrate the object. When a magnetic field penetrates a magnetic body, magnetic dipoles included in the magnetic body are aligned along the magnetic field. Thus, when a varying magnetic field penetrates a magnetic body, the orientation of the magnetic dipoles changes in accordance with the applied varying magnetic field. Such reorientation of the magnetic dipoles produces heat in the magnetic body, so that the to-be-heated object is heated.

[0052] Magnetic hysteresis heating typically occurs at a temperature of the Curie point or lower and does not occur at a temperature higher than the Curie point. The Curie point is the temperature at which a magnetic body loses magnetic properties thereof. For example, when the temperature of a to-be-heated object that is ferromagnetic at a temperature

of the Curie point or lower exceeds the Curie point, a reversible phase transition from ferromagnetism to paramagnetism occurs in the magnetism of the to-be-heated object. When the temperature of the to-be-heated object exceeds the Curie point, magnetic hysteresis heating no longer occurs. Thus, the temperature increase rate slows down.

[0053] The to-be-heated object is desirably made of a conductive material. Further, the to-be-heated object is desirably made of a ferromagnetic material. This is because the combination of resistive heating and magnetic hysteresis heating can increase the heating efficiency in the latter case. For example, the to-be-heated object may be made of one or more materials selected from a material group including aluminum, iron, nickel, cobalt, conductive carbon, copper, and stainless steel.

[0054] In both resistance heating and magnetic hysteresis heating, heat is produced inside the to-be-heated object rather than by thermal conduction from an external heat source. This thus can implement a rapid temperature increase and a uniform heat distribution in the to-be-heated object. This can be implemented by appropriately designing the material and shape of the to-be-heated object and the magnitude and direction of the varying magnetic field. That is, a rapid temperature increase and a uniform heat distribution can be implemented in the stick substrate 150 by appropriately designing the distribution of the susceptor 161 included in the stick substrate 150. This thus can reduce the time for preheating and improve the quality of a flavor tasted by the user.

[0055] Since induction heating directly heats the susceptor 161 included in the stick substrate 150, the substrate can be heated more efficiently than when the stick substrate 150 is heated from the outer circumference or the like by an external heat source. When heating is performed using an external heat source, the temperature of the external heat source inevitably becomes higher than that of the stick substrate 150. In contrast, when induction heating is performed, the temperature of the electromagnetic induction source 162 does not become higher than that of the stick substrate 150. Thus, the temperature of the inhaler device 100 can be maintained to be lower than that in the case of using an external heat source. This is a great advantage in terms of user safety.

[0056] The electromagnetic induction source 162 generates a varying magnetic field by using electric power supplied from the power supply 111. In an example, the power supply 111 includes a direct current (DC) power supply and a DC/alternate current (AC) inverter, and supplies an alternating current to the electromagnetic induction source 162. In this case, the electromagnetic induction source 162 can generate an alternating magnetic field.

[0057] The electromagnetic induction source 162 is disposed at a position where the varying magnetic field generated from the electromagnetic induction source 162 penetrates the susceptor 161 disposed in thermal proximity to the aerosol source included in the stick substrate 150 held by the holder 140. The susceptor 161 produces heat upon being penetrated by the varying magnetic field. The electromagnetic induction source 162 illustrated in Fig. 1 is a solenoid coil. The solenoid coil is disposed such that the conductive wire is wound around the outer circumference of the holder 140. When a current is applied to the solenoid coil, a magnetic field is generated in a central space surrounded by the coil, that is, the internal space 141 of the holder 140. As illustrated in Fig. 1, the susceptor 161 is surrounded by the coil when the stick substrate 150 is held by the holder 140. Thus, the varying magnetic field generated from the electromagnetic induction source 162 penetrates the susceptor 161 and heats the susceptor 161 by induction heating.

<3. Technical features>

(1) Heating profile

[0058] The inhaler device 100 controls electric power supply to the electromagnetic induction source 162 based on a heating profile. The heating profile is information that defines a time-series change in a target temperature that is a target value of the temperature. The inhaler device 100 controls electric power supply to the electromagnetic induction source 162 such that a real temperature (hereinafter, also referred to as an actual temperature) of the susceptor 161 changes in the same manner as the time-series change in the target temperature defined in the heating profile. An example of the target to be controlled is a voltage. Consequently, an aerosol is generated as planned in the heating profile. The heating profile is typically designed to optimize a flavor tasted by a user when the user inhales the aerosol generated from the stick substrate 150. Thus, by controlling the operation of the electromagnetic induction source 162 based on the heating profile, the flavor tasted by the user can be optimized.

[0059] The heating profile includes one or more combinations of an elapsed time from the start of heating and a target temperature to be reached at the elapsed time. The controller 116 controls the temperature of the susceptor 161, based on a deviation of the current actual temperature from the target temperature corresponding to the current elapsed time from the start of heating in the heating profile. Control of the temperature of the susceptor 161 can be implemented by known feedback control, for example. In the feedback control, the controller 116 may control electric power to be supplied to the electromagnetic induction source 162, based on a difference between the actual temperature and the target temperature or the like. The feedback control may be, for example, a proportional-integral-differential controller (PID controller). Alternatively, the controller 116 may simply perform ON-OFF control. For example, the controller 116 may supply electric power to the electromagnetic induction source 162 until the actual temperature reaches the target tem-

perature, and may interrupt electric power supply to the electromagnetic induction source 162 upon the actual temperature reaching the target temperature.

[0060] A time section from the start to the end of a process of generating an aerosol by using the stick substrate 150, more specifically, a time section in which the electromagnetic induction source 162 operates based on the heating profile, is also referred to as a heating session hereinafter. The start of the heating session is a timing at which heating based on the heating profile is started. The end of the heating session is a timing at which a sufficient amount of aerosol is no longer generated. The heating session is constituted by a preheating period which is a first part and a puffable period which is a latter part. The puffable period is a period in which a sufficient amount of aerosol is expected to be generated. The preheating period is a period from the start of heating to the start of the puffable period. Heating performed in the preheating period is also referred to as preheating.

[0061] Table 1 below presents an example of the heating profile.

[Table 1]

[0062]

Table 1. Example of heating profile

Time section	Elapsed time from start of heating	Target temperature
Initial temperature rise section	25 s	295°C
	35 s	295°C
Intermediate temperature drop section	45 s	230°C
Temperature re-rise section	180 s	230°C
	260 s	260°C
	355 s	260°C
Heating termination section	Thereafter	-

[0063] A time-series change in the actual temperature of the susceptor 161 when the controller 116 controls electric power supply to the electromagnetic induction source 162 in accordance with the heating profile presented by Table 1 will be described with reference to Fig. 2. Fig. 2 is a graph illustrating an example of a time-series change in the actual temperature of the susceptor 161 heated by induction heating based on the heating profile presented by Table 1. The horizontal axis of this graph represents time (seconds). The vertical axis of the graph represents the temperature of the susceptor 161. A line 21 in this graph represents a time-series change in the actual temperature of the susceptor 161. Points 22 (22A to 22F) in this graph each correspond to a target temperature defined in the heating profile. As illustrated in Fig. 2, the actual temperature of the susceptor 161 changes in the same manner as the time-series change in the target temperature defined in the heating profile.

[0064] As presented by Table 1, the heating profile first includes an initial temperature rise section. The initial temperature rise section is a time section included at the beginning of the heating profile, and is a section in which the target temperature set at the end of the section is higher than an initial temperature. The initial temperature is a temperature expected as the temperature of the susceptor 161 before heating is started. An example of the initial temperature is any temperature such as 0°C. Another example of the initial temperature is a temperature corresponding to an ambient temperature. As illustrated in Fig. 2, according to the target temperature set in the initial temperature rise section, the actual temperature of the susceptor 161 reaches 295°C after 25 seconds from the start of heating, and is maintained at 295°C until after 35 seconds from the start of heating. Accordingly, the temperature of the stick substrate 150 is expected to reach a temperature at which a sufficient amount of aerosol is to be generated. Since the actual temperature quickly rises to 295°C immediately after the start of heating, preheating can be finished early and the puffable period can be started early. Fig. 2 illustrates an example in which the initial temperature rise section coincides with the preheating period. However, the initial temperature rise section and the preheating period may differ from each other.

[0065] As presented by Table 1, the heating profile next includes an intermediate temperature drop section. The intermediate temperature drop section is a time section after the initial temperature rise section, and is a time section in which the target temperature set at the end of the time section is lower than the target temperature set at the end of the initial temperature rise section. As illustrated in Fig. 2, according to the target temperature set in the intermediate temperature drop section, the actual temperature of the susceptor 161 drops from 295°C to 230°C from 35 seconds to 45 seconds after the start of heating. In this section, electric power supply to the electromagnetic induction source 162 may be stopped. Even in such a case, a sufficient amount of aerosol is generated by residual heat of the susceptor 161

and the stick substrate 150. If the susceptor 161 is maintained at a high temperature, the aerosol source included in the stick substrate 150 is rapidly consumed. This may cause inconvenience that a flavor tasted by the user becomes too strong. However, by providing the intermediate temperature drop section in midstream, such inconvenience can be avoided and the quality of the user's puff experience can be improved.

[0066] As presented by Table 1, the heating profile next includes a temperature re-rise section. The temperature re-rise section is a time section after the intermediate temperature drop section, and is a time section in which the target temperature set at the end of the time section is higher than the target temperature set at the end of the intermediate temperature drop section. As illustrated in Fig. 2, according to the target temperature set in the temperature re-rise section, the actual temperature of the susceptor 161 increases stepwise from 230°C to 260°C from 45 seconds to 355 seconds after the start of heating. If the temperature of the susceptor 161 is continuously decreased, the temperature of the stick substrate 150 also decreases. Thus, the amount of generated aerosol decreases, and the flavor tasted by the user may deteriorate. However, by causing the actual temperature to re-rise after dropping, deterioration of the flavor tasted by the user can be prevented even in the latter part of the heating session.

[0067] As presented by Table 1, the heating profile lastly includes a heating termination section. The heating termination section is a time section after the temperature re-rise section, and is a time section in which heating is not performed. No target temperature may be set. As illustrated in Fig. 2, the actual temperature of the susceptor 161 drops after 355 seconds from the start of heating. Electric power supply to the electromagnetic induction source 162 may be terminated after 355 seconds from the start of heating. Even in such a case, a sufficient amount of aerosol is generated for a while by residual heat of the susceptor 161 and the stick substrate 150. In the example illustrated in Fig. 2, the puffable period, that is, the heating session ends after 365 seconds from the start of heating.

[0068] The user may be notified of the start timing and the end timing of the puffable period. The user may also be notified of a timing that is before the end of the puffable period by a predetermined time (for example, the end timing of the temperature re-rise section). In this case, the user can perform a puff in the puffable period with reference to the notification.

(2) Control of electric power supply involving estimation of temperature of susceptor 161

[0069] Fig. 3 is a diagram schematically illustrating an example of a physical configuration inside the inhaler device 100 according to the present embodiment. In the example illustrated in Fig. 3, the power supply 111 is a battery, the controller 116 is a circuit substrate, the electromagnetic induction source 162 is a solenoid coil, and the holder 140 is a cylindrical chamber. An airflow path 170 is coupled to the holder 140. The re-outer shell of the inhaler device 100 is a housing 101, which has the opening 142 of the holder 140 and an air intake hole 171 of the airflow path 170. Air is taken in and ejected through the opening 142 and the air intake hole 171. The airflow path 170 has a function of supplying air taken in from the air intake hole 171 to the internal space 141 of the holder 140 through a hole (not illustrated) provided at the bottom 143 of the holder 140. When the user inhales while holding, in their mouth, the inhalation port 152 of the stick substrate 150 held by the holder 140, the air supplied from the airflow path 170 to the internal space 141 reaches the inside of the mouth of the user together with the aerosol generated from the stick substrate 150.

[0070] The inhaler device 100 further includes a responder 119. The responder 119 produces heat upon being penetrated by a varying magnetic field. That is, the responder 119 is an example of a to-be-heated object heated by induction heating. The responder 119 is disposed at a position where the varying magnetic field generated from the electromagnetic induction source 162 penetrates the responder 119. In the example illustrated in Fig. 3, the responder 119 is disposed between the electromagnetic induction source 162 and the holder 140. When a current is applied to the electromagnetic induction source 162 that is a solenoid coil, a magnetic field is generated in a space surrounded by the coil and including the responder 119. As a result, the varying magnetic field penetrates the responder 119, so that the responder 119 produces heat.

[0071] The inhaler device 100 includes, as the sensor 112, a temperature sensor 118 that detects a temperature of the responder 119. An example of the temperature sensor 118 may be a thermistor. In the example illustrated in Fig. 3, the temperature sensor 118 is disposed in contact with the responder 119, and detects the temperature of the responder 119.

[0072] The temperature sensor 118 is desirably disposed at a position where there is a less overlap with the position of the susceptor 161 included in the stick substrate 150 held by the holder 140 in an insertion direction of the stick substrate 150. For example, when the distribution of the susceptor 161 is small on a leading end portion (that is, adjacently to the bottom 143) in the insertion direction of the stick substrate 150, the temperature sensor 118 is desirably disposed adjacently to the bottom 143 as illustrated in Fig. 3. Such an arrangement can reduce an adverse effect on heating of the susceptor 161 due to penetration of the magnetic field to the temperature sensor 118. The same applies to the responder 119. For the same reason, the temperature sensor 118 may be disposed outside the coil that is the electromagnetic induction source 162.

[0073] The responder 119 and the susceptor 161 are disposed at positions where the varying magnetic field generated

from the electromagnetic induction source 162 penetrates in the same manner. Thus, a certain correspondence relation expressed by a function such as a linear function is considered to be maintained between the temperature of the responder 119 and the temperature of the susceptor 161. Accordingly, the controller 116 controls electric power supply to the electromagnetic induction source 162, based on the temperature of the responder 119 detected by the temperature sensor 118. For example, the responder 119 and the susceptor 161 may have the same configuration. In this case, the temperature of the responder 119 and the temperature of the susceptor 161 are considered to be equal. In this case, the controller 116 controls the electric power supply to the electromagnetic induction source 162 based on the heating profile by using the temperature of the responder 119 instead of the temperature of the susceptor 161. With such a configuration, even the inhaler device 100 of induction heating type, which has difficulty in directly detecting the temperature of the susceptor 161, can appropriately generate an aerosol.

[0074] Controlling the electric power supply to the electromagnetic induction source 162 in accordance with the temperature of the responder 119 includes adjusting an amount of electric power to be supplied to the electromagnetic induction source 162. With such a configuration, an amount of heat to be produced by the susceptor 161 can be appropriately controlled. Controlling the electric power supply to the electromagnetic induction source 162 in accordance with the temperature of the responder 119 includes stopping the electric power supply to the electromagnetic induction source 162. With such a configuration, overheating of the susceptor 161 or the responder 119 can be prevented and the user safety can be ensured.

[0075] The controller 116 may estimate the temperature of the susceptor 161 based on the temperature of the responder 119, and control the electric power supply to the electromagnetic induction source 162 based on the estimated temperature of the susceptor 161. For example, when the responder 119 and the susceptor 161 have different configurations, the temperature of the responder 119 may differ from the temperature of the susceptor 161. In this case, the controller 116 estimates the temperature of the susceptor 161 based on the temperature of the responder 119, and controls electric power supply to the electromagnetic induction source 162 based on the estimated temperature of the susceptor 161 and the heating profile. With such a configuration, an aerosol can be appropriately generated even when the temperature of the responder 119 and the temperature of the susceptor 161 are different from each other.

[0076] The Curie point of the susceptor 161 and the Curie point of the responder 119 may be substantially equal. In an example, the susceptor 161 and the responder 119 may be made of the same material. With such a configuration, a decrease in the temperature increase rate due to a magnetic phase transition occurs at the same timing since the magnetic phase transition occurs at the same temperature in the susceptor 161 and the responder 119. Thus, a decrease in the accuracy of estimating the temperature of the susceptor 161 can be reduced compared with the case where timings at which the decrease in the temperature increase rate due to the magnetic phase transition occurs are shifted from each other.

[0077] The Curie point of the responder 119 may be higher than a highest temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. The highest temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162 is determined based on the specifications of the inhaler device 100, such as an output voltage from the power supply 111 and characteristics of the responder 119. With such a configuration, the magnetic phase transition does not occur in the responder 119 within a range in which the inhaler device 100 normally operates. Thus, a decrease in the accuracy of estimating the temperature of the susceptor 161 caused by a decrease in the temperature increase rate in the responder 119 due to the magnetic phase transition in the responder 119 can be avoided.

[0078] The responder 119 may be made of a material that is paramagnetic within a range of the temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. An example of such a material is a paramagnetic body such as aluminum. The range of the temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162 is a range that is lower than or equal to the highest temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. With such a configuration, the magnetic phase transition does not occur in the responder 119 within a range in which the inhaler device 100 normally operates. Thus, a decrease in the accuracy of estimating the temperature of the susceptor 161 caused by a decrease in the temperature increase rate in the responder 119 due to the magnetic phase transition in the responder 119 can be avoided.

[0079] The Curie point of the susceptor 161 may be lower than the highest temperature reachable by the susceptor 161 through induction heating using the electromagnetic induction source 162. In this case, the controller 116 estimates the temperature of the susceptor 161 by using different temperature estimation algorithms before and after the Curie point of the susceptor 161. The highest temperature reachable by the susceptor 161 through induction heating using the electromagnetic induction source 162 is determined based on the specifications of the inhaler device 100 and the stick substrate 150, such as an output voltage from the power supply 111 and characteristics of the susceptor 161. With such a configuration, a decrease in the accuracy of estimating the temperature of the susceptor 161 caused by a decrease in the temperature increase rate of the susceptor 161 due to the magnetic phase transition in the susceptor 161 can be reduced. This will be described in detail with reference to Fig. 4.

[0080] Fig. 4 is a graph for describing an example of the temperature estimation algorithm of the susceptor 161 according to the present embodiment. The horizontal axis of the graph represents the temperature of the responder 119, and the vertical axis of the graph represents the temperature of the susceptor 161. $T1_{MAX}$ represents the highest temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. $T2_{MAX}$ represents the highest temperature reachable by the susceptor 161 through induction heating using the electromagnetic induction source 162. T2c represents the Curie point of the susceptor 161. $T1_{C'}$ represents the temperature of the responder 119 at the timing when the temperature of the susceptor 161 reaches the Curie point T2c. When the temperature of the susceptor 161 is lower than the Curie point T2c, a relationship of a ratio R1 holds between the temperature of the responder 119 and the temperature of the susceptor 161. Thus, when the temperature of the responder 119 is lower than the temperature $T1_{C'}$, the controller 116 estimates the temperature of the susceptor 161 based on the temperature of the responder 119 and the ratio R1. On the other hand, when the temperature of the susceptor 161 is higher than the Curie point T2c, since the temperature increase rate of the susceptor 161 slows down due to the magnetic phase transition, a relationship of a ratio R2 different from the ratio R1 holds between the temperature of the responder 119 and the temperature of the susceptor 161. Thus, when the temperature of the responder 119 is higher than the temperature $T1_{C'}$, the controller 116 estimates the temperature of the susceptor 161 based on the temperature of the responder 119 and the ratio R2. As described above, the temperature of the susceptor 161 can be accurately estimated by using the different ratios R1 and R2 before and after the magnetic phase transition occurs in the susceptor 161.

(3) Procedure of Process

[0081] Fig. 5 is a flowchart illustrating an example of a procedure of a process performed by the inhaler device 100 according to the present embodiment.

[0082] As illustrated in Fig. 5, first, the sensor 112 receives a user operation for a heating start instruction (step S102). An example of the operation for instructing the start of heating is pressing of a button of the inhaler device 100.

[0083] Subsequently, the controller 116 estimates the temperature of the susceptor 161, based on the temperature of the responder 119 detected by the temperature sensor 118 (step S104). At this time, as described above with reference to Fig. 4, the controller 116 estimates the temperature of the susceptor 161 by using different temperature estimation algorithms depending on whether the temperature of the responder 119 is higher or lower than the temperature $T1_{C'}$ corresponding to the Curie point T2c of the susceptor 161.

[0084] Subsequently, the controller 116 controls electric power supply to the electromagnetic induction source 162, based on the estimated temperature of the susceptor 161 and the heating profile (step S106). For example, the controller 116 controls electric power supply to the electromagnetic induction source 162 such that the estimated temperature of the susceptor 161 changes in the same manner as the time-series change in the target temperature defined in the heating profile.

<4. Modifications>

(1) First modification

[0085] Fig. 6 is a diagram schematically illustrating an example of a physical configuration inside the inhaler device 100 according to a first modification. As illustrated in Fig. 6, the responder 119 may be a cylindrical member that covers at least a portion of the outer circumference of the holder 140. Even with such a configuration, as in the example described above with reference to Fig. 3, an aerosol can be appropriately generated by controlling electric power supply to the electromagnetic induction source 162 based on the temperature of the responder 119.

[0086] Further, the responder 119 according to the present modification may function as an external heat source that heats the stick substrate 150 held by the holder 140. That is, the inhaler device 100 according to the present modification may heat the stick substrate 150 from the inside and from the outer circumference by heating the susceptor 161 and the responder 119 by induction heating. With such a configuration, an aerosol can be efficiently generated.

[0087] The controller 116 may control electric power supply to the electromagnetic induction source 162, based on the estimated temperature of the susceptor 161 and the temperature of the responder 119 detected by the temperature sensor 118. In an example, the controller 116 controls electric power supply to the electromagnetic induction source 162 such that the temperature of the susceptor 161 and/or the temperature of the responder 119 change(s) in the same manner as the time-series change in the target temperature defined in the heating profile. A first heating profile that defines a time-series change in the target temperature of the susceptor 161 and a second heating profile that defines a time-series change in the target temperature of the responder 119 may be provided. In this case, the controller 116 controls electric power supply to the electromagnetic induction source 162 such that the temperature of the susceptor 161 changes in the same manner as the time-series change in the target temperature defined in the first heating profile and the temperature of the responder 119 changes in the same manner as the time-series change in the target temperature

defined in the second heating profile. With such a configuration, an aerosol can be efficiently and appropriately generated by using two heat sources.

(2) Second modification

[0088] The responder 119 may be at least a portion of the holder 140. For example, at least a portion of the holder 140 may be a to-be-heated object that produces heat upon being penetrated by a varying magnetic field. Even in such a case, the same operation and effect as those of the first modification example can be obtained.

(3) Third modification

[0089] For example, the inhaler device 100 may further include a magnetic shield that shields a magnetic field. The magnetic shield is disposed between the electromagnetic induction source 162 and the housing 101 that is the re-outer shell of the inhaler device 100. With such a configuration, the magnetic field generated from the electromagnetic induction source 162 is not prevented from penetrating the susceptor 161 while being prevented from reaching the housing 101 and other devices located in the vicinity of the inhaler device 100. Furthermore, the magnetic shield is desirably disposed between the electromagnetic induction source 162 and an electronic component such as the controller 116. This is to prevent an adverse effect of the varying magnetic field on the electronic component.

[0090] The magnetic shield has a function of restricting passage of the magnetic field from the inside (that is, the side adjacent to the electromagnetic induction source 162) to the outside (that is, the side adjacent to the housing 101) of the magnetic shield. The magnetic shield is made of any material having a function of shielding a magnetic field. Furthermore, the magnetic shield is preferably made of a material having a high magnetic permeability. Examples of such a material include new metal and permalloy. For example, the magnetic shield may be a film wound around the electromagnetic induction source 162 from the outside. With such a configuration, the magnetic field generated from the electromagnetic induction source 162 can be shielded before the magnetic field diffuses.

[0091] When the inhaler device 100 includes a magnetic shield, the responder 119 may be a portion of the magnetic shield. In other words, the responder 119 may function as the magnetic shield. With such a configuration, both a reduction of the adverse effect of the varying magnetic field and appropriate generation of an aerosol can be achieved.

(4) Fourth modification

[0092] The temperature estimation algorithms based on the correspondence relation between the temperature of the responder 119 and the temperature of the susceptor 161, such as the ratios R1 and R2 illustrated in Fig. 4, are determined in advance in a standard environment and is used for estimating the temperature of the susceptor 161 based on the temperature of the responder 119.

[0093] The standard environment is a standard operating environment of the inhaler device 100. The operating environment of the inhaler device 100 is a concept that includes a surrounding environment of the inhaler device 100 such as temperature, humidity, and pressure, a state of the inhaler device 100 such as an operation history of the inhaler device 100, and a state of the stick substrate 150 subjected to induction heating. The standard environment is defined by a set of parameters including a plurality of parameters that indicate the operating environment of the inhaler device 100 and each have a tolerance. The plurality of parameters are the temperature, the humidity, the pressure, the state of the inhaler device 100, the state of the stick substrate 150 subjected to induction heating, and the like.

[0094] In the standard environment, the actual temperature of the susceptor 161 can be accurately estimated based on the temperature of the responder 119. However, the operating environment of the inhaler device 100 may deviate from the standard environment because of the presence of a disturbance factor. In an operating environment that deviates from the standard environment, the temperature of the susceptor 161 estimated based on the temperature of the responder 119 deviates from the actual temperature of the susceptor 161. This consequently makes it difficult to appropriately generate an aerosol.

[0095] Accordingly, the controller 116 according to the present modification controls electric power supply to the electromagnetic induction source 162 further based on the disturbance factor in addition to the temperature of the responder 119. For example, the controller 116 estimates the temperature of the susceptor 161 further based on the disturbance factor in addition to the temperature of the responder 119, and controls electric power supply to the electromagnetic induction source 162 such that the temperature of the susceptor 161 changes in the same manner as the time-series change in the target temperature defined in the heating profile. With such a configuration, appropriate generation of an aerosol can be implemented even when a disturbance factor is present.

[0096] The disturbance factor and control of electric power supply based on the disturbance factor will be described below.

- Temperature of operating environment

[0097] An example of the disturbance factor is a temperature of the operating environment of the inhaler device 100. An example of the temperature of the operating environment of the inhaler device 100 is an ambient temperature. Another example of the temperature of the operating environment of the inhaler device 100 is a temperature inside the inhaler device 100. The inhaler device 100 includes, as the sensor 112, an environmental temperature sensor that detects the temperature of the operating environment of the inhaler device 100. The controller 116 controls electric power supply to the electromagnetic induction source 162, based on the temperature of the operating environment of the inhaler device 100 detected by the environmental temperature sensor. Specifically, the controller 116 corrects the temperature of the susceptor 161 estimated based on the temperature of the responder 119, based on the temperature of the operating environment of the inhaler device 100, and controls electric power supply to the electromagnetic induction source 162, based on the corrected temperature of the susceptor 161. In an example, when the temperature of the operating environment of the inhaler device 100 is higher than the temperature of the standard environment, the controller 116 corrects the temperature of the susceptor 161 to be higher. On the other hand, when the temperature of the operating environment of the inhaler device 100 is lower than the temperature of the standard environment, the controller 116 corrects the temperature of the susceptor 161 to be lower.

[0098] With such a configuration, an error in the estimated temperature of the susceptor 161 due to the temperature of the operating environment of the inhaler device 100 can be reduced. Consequently, appropriate generation of an aerosol can be implemented.

- Operation history

[0099] Another example of the disturbance factor is an operation history of the inhaler device 100. The controller 116 controls electric power supply to the electromagnetic induction source 162, based on the operation history of the inhaler device 100. Specifically, the controller 116 corrects the temperature of the susceptor 161 estimated based on the temperature of the responder 119, based on the operation history of the inhaler device 100, and controls electric power supply to the electromagnetic induction source 162, based on the corrected temperature of the susceptor 161. In an example, the controller 116 corrects the temperature of the susceptor 161 to be higher when the actual temperature of the susceptor 161 is predicted to be higher than the expected temperature, based on the deviation of the actual operation history of the inhaler device 100 from the operation history in the standard environment. On the other hand, the controller 116 corrects the temperature of the susceptor 161 to be lower when the actual temperature of the susceptor 161 is predicted to be lower than the expected temperature, based on the deviation of the actual operation history of the inhaler device 100 from the operation history in the standard environment.

[0100] With such a configuration, an error in the estimated temperature of the susceptor 161 due to the operation history of the inhaler device 100 can be reduced. Consequently, appropriate generation of an aerosol can be implemented.

[0101] The operation history of the inhaler device 100 may be stored in the memory 114. The controller 116 updates the operation history stored in the memory 114 each time induction heating based on the heating profile is performed on the stick substrate 150.

[0102] An example of the operation history of the inhaler device 100 is the number of times of electric power supply to the electromagnetic induction source 162. The number of times of electric power supply to the electromagnetic induction source 162 is the number of times induction heating based on the heating profile is performed. The controller 116 controls electric power supply to the electromagnetic induction source 162, based on the number of times of electric power supply to the electromagnetic induction source 162. Specifically, the controller 116 corrects the temperature of the susceptor 161 estimated based on the temperature of the responder 119, based on the number of times of electric power supply to the electromagnetic induction source 162, and controls electric power supply to the electromagnetic induction source 162, based on the corrected temperature of the susceptor 161. It is considered that as the number of times of electric power supply to the electromagnetic induction source 162 increases, the electromagnetic induction source 162 and the circuit elements including the DC/AC inverter deteriorate and the electrical resistance value increases. Consequently, the actual temperature of the susceptor 161 is considered to decrease for the same amount of supplied electric power. That is, when the actual number of times of electric power supply is less than the number of times of electric power supply in the standard environment, the actual temperature of the susceptor 161 is predicted to be higher than the target temperature. In this case, the controller 116 corrects the temperature of the susceptor 161 to be higher. On the other hand, when the actual number of times of electric power supply is greater than the number of times of electric power supply in the standard environment, the actual temperature of the susceptor 161 is predicted to be lower than the target temperature. In this case, the controller 116 corrects the temperature of the susceptor 161 to be lower.

[0103] With such a configuration, an error in the estimated temperature of the susceptor 161 due to the number of times of electric power supply to the electromagnetic induction source 162 can be reduced. Consequently, appropriate generation of an aerosol can be implemented.

[0104] Another example of the operation history of the inhaler device 100 is an interval of electric power supply to the electromagnetic induction source 162. The interval of electric power supply to the electromagnetic induction source 162 is a time length from previous induction heating based on the heating profile to current induction heating based on the heating profile. The controller 116 controls electric power supply to the electromagnetic induction source 162, based on the interval of electric power supply to the electromagnetic induction source 162. Specifically, the controller 116 corrects the temperature of the susceptor 161 estimated based on the temperature of the responder 119, based on the interval of electric power supply to the electromagnetic induction source 162, and controls electric power supply to the electromagnetic induction source 162, based on the corrected temperature of the susceptor 161. It is considered that as the interval of electric power supply to the electromagnetic induction source 162 becomes shorter, more heat from the previous induction heating is left and thus the actual temperature of the susceptor 161 increases for the same amount of supplied electric power. That is, when the actual interval of electric power supply is shorter than the interval of electric power supply in the standard environment, the actual temperature of the susceptor 161 is predicted to be higher than the target temperature. In this case, the controller 116 corrects the temperature of the susceptor 161 to be higher. On the other hand, when the interval of electric power supply is longer than the interval of electric power supply in the standard environment, the actual temperature of the susceptor 161 is predicted to be lower than the target temperature. In this case, the controller 116 corrects the temperature of the susceptor 161 to be lower.

[0105] With such a configuration, an error in the estimated temperature of the susceptor 161 due to the interval of electric power supply to the electromagnetic induction source 162 can be reduced. Consequently, appropriate generation of an aerosol can be implemented.

- Type of substrate

[0106] An example of the disturbance factor is the type of the stick substrate 150. Depending on the type of the stick substrate 150, the material, shape, content, and distribution of the susceptor 161 and the type of the aerosol source may change. Accordingly, the controller 116 controls electric power supply to the electromagnetic induction source 162, based on the type of the stick substrate 150 held by the holder 140. Specifically, the controller 116 corrects the temperature of the susceptor 161 estimated based on the temperature of the responder 119, based on the type of the stick substrate 150, and controls electric power supply to the electromagnetic induction source 162, based on the corrected temperature of the susceptor 161. In an example, the actual temperature of the susceptor 161 is sometimes predicted to be higher than the expected temperature because of a difference between the type of the stick substrate 150 held by the holder 140 and the type of the stick substrate 150 in the standard environment. In this case, the controller 116 corrects the temperature of the susceptor 161 to be higher. On the other hand, the actual temperature of the susceptor 161 is sometimes predicted to be lower than the expected temperature because of a difference between the type of the stick substrate 150 held by the holder 140 and the type of the stick substrate 150 in the standard environment. In this case, the controller 116 corrects the temperature of the susceptor 161 to be lower.

[0107] With such a configuration, an error in the estimated temperature of the susceptor 161 due to the type of the stick substrate 150 held by the holder 140 can be reduced. Consequently, appropriate generation of an aerosol can be implemented.

[0108] The type of the stick substrate 150 held by the holder 140 is identifiable by various methods. In an example, identification information such as a two-dimensional code indicating the type of the stick substrate 150 may be given to the stick substrate 150. In this case, the type of the stick substrate 150 can be identified by performing image recognition or the like on the identification information given to the stick substrate 150 held by the holder 140. In another example, different types of the stick substrate 150 may include different types of the susceptor 161. The electrical resistance value of a closed circuit including the power supply 111 and the electromagnetic induction source 162 when electric power is supplied to the electromagnetic induction source 162 may vary depending on the type of the susceptor 161 included in the stick substrate 150 held by the holder 140. In this case, the type of the stick substrate 150 can be identified based on the electrical resistance value of the closed circuit including the power supply 111 and the electromagnetic induction source 162.

- Supplementary description

[0109] The controller 116 may change the heating profile to be used. The temperature estimation algorithm for use in estimating the temperature of the susceptor 161 based on the temperature of the responder 119 may be different for each heating profile to be used. For example, an amount by which the temperature of the susceptor 161 estimated based on the temperature of the responder 119 is corrected based on the disturbance factor may be different for each heating profile to be used. That is, the correction amount based on the temperature of the operating environment of the inhaler device 100, the operation history of the inhaler device 100, and/or the type of the stick substrate 150 held by the holder 140 may be different for each heating profile to be used. This is because the target temperatures are different for different

heating profiles, and the estimation error caused by the disturbance factor may differ accordingly. With such a configuration, the temperature of the susceptor 161 can be accurately estimated even when the heating profile is changed. Consequently, appropriate generation of an aerosol can be implemented.

<5. Supplementary description>

[0110] While the preferred embodiment of the present invention has been described in detail above with reference to the accompanying drawings, the present invention is not limited to such examples. Obviously, a person with an ordinary knowledge in the technical field to which the present invention pertains can conceive various modifications and corrections within the scope of the technical spirit described in the claims. It should be understood that these modifications and corrections naturally pertain to the technical scope of the present invention.

[0111] For example, in the embodiment described above, the example has been described in which the magnetic phase transition does not occur in the responder 119 within the range of the temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. However, the present invention is not limited to such an example. The magnetic phase transition may occur in the responder 119 within the range of the temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. That is, the Curie point of the responder 119 may be lower than the highest temperature reachable by the responder 119 through induction heating using the electromagnetic induction source 162. In this case, the correspondence relation between the temperature of the responder 119 and the temperature of the susceptor 161 changes before and after the Curie point of the responder 119. Accordingly, the controller 116 estimates the temperature of the susceptor 161 by using different temperature estimation algorithms before and after the Curie point of the responder 119. With such a configuration, a decrease in the accuracy of estimating the temperature of the susceptor 161 caused by a decrease in the temperature increase rate of the responder 119 due to the magnetic phase transition in the responder 119 can be reduced because of a reason similar to that described in the example above with reference to Fig. 4.

[0112] For example, in the embodiment described above, the example has been described in which the temperature sensor 118 is a thermistor. However, the present invention is not limited to such an example. In an example, the responder 119 may have an electrical resistance value that changes according to the temperature, and may be supplied with electric power from the power supply 111. In this case, the temperature sensor 118 estimates the temperature of the responder 119, based on the electrical resistance value of a closed circuit including the power supply 111 and the responder 119. The temperature sensor 118 may be disposed to be separate from the responder 119, or the controller 116 may also function as the temperature sensor 118.

[0113] For example, in the embodiment described above, an example has been described in which the substrate 151 includes the susceptor 161. However, the present invention is not limited to such an example. That is, the susceptor 161 may be disposed at any location where the susceptor 161 is in thermal proximity to the aerosol source. In an example, the susceptor 161 may have a blade-like shape, and may be disposed so that the susceptor 161 protrudes from the bottom 143 of the holder 140 toward the internal space 141. When the stick substrate 150 is inserted into the holder 140, the susceptor 161 having the blade-like shape may be inserted so as to pierce the substrate 151 from the end portion of the stick substrate 150 in the insertion direction. In another example, the susceptor 161 may be disposed on an inner wall of the holder 140 that forms the internal space 141.

[0114] The series of steps performed by the individual devices described in this specification may be implemented by using any of software, hardware, and a combination of software and hardware. Programs constituting software are, for example, stored in advance in recording media (non-transitory media) provided inside or outside the individual devices. Each program is, for example, at the time of being executed by a computer that controls each of the devices described in this specification, loaded into a RAM and executed by a processor such as a CPU. The recording media are, for example, a magnetic disk, an optical disc, a magneto-optical disk, a flash memory, and the like. The computer programs may be distributed, for example, via a network without using recording media.

[0115] The steps described using a flowchart and a sequence diagram in this specification need not necessarily be executed in the order illustrated. Some of the process steps may be executed in parallel. An additional process step may be adopted, or one or some of the process steps may be omitted.

[0116] Configurations below also pertain to the technical scope of the present invention.

(1) An inhaler device including:

a power supply configured to supply electric power;
an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply;
a controller configured to control electric power supply to the electromagnetic induction source;
a holder having an internal space and an opening that allows the internal space to communicate with outside

and configured to hold a substrate inserted into the internal space through the opening, the substrate including an aerosol source;
a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and
a temperature sensor configured to detect a temperature of the responder,
the electromagnetic induction source is disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to the aerosol source included in the substrate held by the holder,
the susceptor is configured to produce heat upon being penetrated by the varying magnetic field, and
the controller is configured to control the electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor.

(2) The inhaler device according to (1), in which
a Curie point of the susceptor and a Curie point of the responder are substantially equal.
(3) The inhaler device according to (1) or (2), in which
a Curie point of the responder is higher than a highest temperature reachable by the responder through induction heating using the electromagnetic induction source.
(4) The inhaler device according to (1), in which
the responder is made of a material that is paramagnetic within a range of a temperature reachable by the responder through induction heating using the electromagnetic induction source.
(5) The inhaler device according to any one of (1) to (4), in which

a Curie point of the susceptor is lower than a highest temperature reachable by the susceptor through induction heating using the electromagnetic induction source, and
the controller is configured to estimate a temperature of the susceptor by using different temperature estimation algorithms before and after the Curie point of the susceptor.

(6) The inhaler device according to any one of (1) to (5), in which
the susceptor and the responder are each made of one or more materials selected from a material group including aluminum, iron, nickel, cobalt, conductive carbon, copper, and stainless steel.
(7) The inhaler device according to any one of (1) to (6), in which
the responder is disposed between the electromagnetic induction source and the holder.
(8) The inhaler device according to any one of (1) to (7), in which
the responder is a cylindrical member that covers at least a portion of an outer circumference of the holder.
(9) The inhaler device according to any one of (1) to (6), in which
the responder is at least a portion of the holder.
(10) The inhaler device according to any one of (1) to (6), further including:

a magnetic shield configured to shield a magnetic field, in which,
the magnetic shield is disposed between the electromagnetic induction source and a housing that is a re-outer shell of the inhaler device, and
the responder is a portion of the magnetic shield.

(11) The inhaler device according to any one of (1) to (10), in which
the controller is configured to estimate a temperature of the susceptor, based on the temperature of the responder, and control the electric power supply to the electromagnetic induction source, based on the estimated temperature of the susceptor.
(12) The inhaler device according to (11), in which
the controller is configured to control the electric power supply to the electromagnetic induction source, based on the estimated temperature of the susceptor and the temperature of the responder detected by the temperature sensor.
(13) The inhaler device according to (11) or (12), in which
the controller is configured to control, based on a heating profile, the electric power supply to the electromagnetic induction source, the heating profile being information that defines a time-series change in a target temperature that is a target value of the temperature of the susceptor.
(14) The inhaler device according to (13), in which

the controller is configured to change the heating profile to be used, and

a temperature estimation algorithm for use in estimating the temperature of the susceptor based on the temperature of the responder is different for each heating profile to be used.

(15) The inhaler device according to any one of (1) to (14), in which
the controller is configured to control the electric power supply to the electromagnetic induction source, based on a temperature of an operating environment of the inhaler device.
(16) The inhaler device according to any one of (1) to (15), in which
the controller is configured to control the electric power supply to the electromagnetic induction source, based on a type of the substrate held by the holder.
(17) The inhaler device according to any one of (1) to (16), in which
the controller is configured to control the electric power supply to the electromagnetic induction source, based on an operation history of the inhaler device.
(18) The inhaler device according to (17), in which
the controller is configured to control the electric power supply to the electromagnetic induction source, based on a number of times of electric power supply to the electromagnetic induction source and/or an interval of electric power supply to the electromagnetic induction source.
(19) The inhaler device according to any one of (1) to (18), in which
controlling the electric power supply to the electromagnetic induction source includes stopping the electric power supply to the electromagnetic induction source.
(20) A program to be executed by a computer that controls an inhaler device,

the inhaler device including:

a power supply configured to supply electric power;
an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply;
a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold a substrate inserted into the internal space through the opening, the substrate including an aerosol source;
a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and
a temperature sensor configured to detect a temperature of the responder,
the electromagnetic induction source being disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to the aerosol source included in the substrate held by the holder,
the susceptor being configured to produce heat upon being penetrated by the varying magnetic field, and

the program causing
controlling electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor
to be performed.

(21) A system including: an inhaler device; and a substrate,

the substrate including an aerosol source,
the inhaler device including:

a power supply configured to supply electric power;
an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply;
a controller configured to control electric power supply to the electromagnetic induction source;
a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold the substrate inserted into the internal space through the opening;
a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and a temperature sensor configured to detect a temperature of the responder, in which

the electromagnetic induction source is disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to the aerosol source included in the substrate held by the holder,
the susceptor is configured to produce heat upon being penetrated by the varying magnetic field, and
the controller is configured to control the electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor.

(22) The system according to (21), in which
the susceptor is included in the substrate.

Reference Signs List

[0117]

100	inhaler device
101	housing
111	power supply
112	sensor
113	notifier
114	memory
115	communicator
116	controller
118	temperature sensor
119	responder
140	holder
141	internal space
142	opening
143	bottom
150	stick substrate
151	substrate
152	inhalation port
161	susceptor
162	electromagnetic induction source
170	airflow path
171	air intake hole

Claims

1. An inhaler device comprising:

a power supply configured to supply electric power;
an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply;
a controller configured to control electric power supply to the electromagnetic induction source;
a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold a substrate inserted into the internal space through the opening, the substrate including an aerosol source;
a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and
a temperature sensor configured to detect a temperature of the responder, wherein
the electromagnetic induction source is disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to the aerosol source included in the substrate held by the holder,
the susceptor is configured to produce heat upon being penetrated by the varying magnetic field, and
the controller is configured to control the electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor.

2. The inhaler device according to claim 1, wherein
a Curie point of the susceptor and a Curie point of the responder are substantially equal.

3. The inhaler device according to claim 1, wherein
the responder is made of a material that is paramagnetic within a range of a temperature reachable by the responder through induction heating using the electromagnetic induction source.

4. The inhaler device according to any one of claims 1 to 3, wherein

a Curie point of the susceptor is lower than a highest temperature reachable by the susceptor through induction heating using the electromagnetic induction source, and
the controller is configured to estimate a temperature of the susceptor by using different temperature estimation algorithms before and after the Curie point of the susceptor.

5. The inhaler device according to any one of claims 1 to 4, wherein
the susceptor and the responder are each made of one or more materials selected from a material group including aluminum, iron, nickel, cobalt, conductive carbon, copper, and stainless steel.

6. The inhaler device according to any one of claims 1 to 5, wherein
the responder is disposed between the electromagnetic induction source and the holder.

7. The inhaler device according to any one of claims 1 to 6, wherein
the responder is a cylindrical member that covers at least a portion of an outer circumference of the holder.

8. The inhaler device according to any one of claims 1 to 5, wherein
the responder is at least a portion of the holder.

9. The inhaler device according to any one of claims 1 to 5, further comprising:

a magnetic shield configured to shield a magnetic field, wherein
the magnetic shield is disposed between the electromagnetic induction source and a housing that is a re-outer shell of the inhaler device, and
the responder is a portion of the magnetic shield.

10. The inhaler device according to any one of claims 1 to 9, wherein
the controller is configured to estimate a temperature of the susceptor, based on the temperature of the responder, and control the electric power supply to the electromagnetic induction source, based on the estimated temperature of the susceptor.

11. The inhaler device according to claim 10, wherein
the controller is configured to control the electric power supply to the electromagnetic induction source, based on the estimated temperature of the susceptor and the temperature of the responder detected by the temperature sensor.

12. The inhaler device according to claim 10 or 11, wherein
the controller is configured to control, based on a heating profile, the electric power supply to the electromagnetic induction source, the heating profile being information that defines a time-series change in a target temperature that is a target value of the temperature of the susceptor.

13. The inhaler device according to claim 12, wherein

the controller is configured to change the heating profile to be used, and
a temperature estimation algorithm for use in estimating the temperature of the susceptor based on the temperature of the responder is different for each heating profile to be used.

14. The inhaler device according to any one of claims 1 to 13, wherein
the controller is configured to control the electric power supply to the electromagnetic induction source, based on a temperature of an operating environment of the inhaler device.

15. The inhaler device according to any one of claims 1 to 14, wherein
the controller is configured to control the electric power supply to the electromagnetic induction source, based on a type of the substrate held by the holder.

16. The inhaler device according to any one of claims 1 to 15, wherein
the controller is configured to control the electric power supply to the electromagnetic induction source, based on an operation history of the inhaler device.

17. The inhaler device according to claim 16, wherein
the controller is configured to control the electric power supply to the electromagnetic induction source, based on a number of times of electric power supply to the electromagnetic induction source and/or an interval of electric power supply to the electromagnetic induction source.

18. The inhaler device according to any one of claims 1 to 17, wherein
controlling the electric power supply to the electromagnetic induction source includes stopping the electric power supply to the electromagnetic induction source.

19. A program to be executed by a computer that controls an inhaler device,

the inhaler device including:

a power supply configured to supply electric power;
an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply;
a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold a substrate inserted into the internal space through the opening, the substrate including an aerosol source;
a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and
a temperature sensor configured to detect a temperature of the responder,
the electromagnetic induction source being disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor disposed in thermal proximity to the aerosol source included in the substrate held by the holder,
the susceptor being configured to produce heat upon being penetrated by the varying magnetic field,

the program causing
controlling electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor
to be performed.

20. A system comprising: an inhaler device; and a substrate,

the substrate including an aerosol source,
the inhaler device including:

a power supply configured to supply electric power;
an electromagnetic induction source configured to generate a varying magnetic field by using the electric power supplied from the power supply;
a controller configured to control electric power supply to the electromagnetic induction source;
a holder having an internal space and an opening that allows the internal space to communicate with outside and configured to hold the substrate inserted into the internal space through the opening;
a responder disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates the responder and configured to produce heat upon being penetrated by the varying magnetic field; and
a temperature sensor configured to detect a temperature of the responder, wherein
the electromagnetic induction source is disposed at a position where the varying magnetic field generated from the electromagnetic induction source penetrates a susceptor that is disposed in thermal proximity to

the aerosol source included in the substrate held by the holder,
the susceptor is configured to produce heat upon being penetrated by the varying magnetic field, and
the controller is configured to control the electric power supply to the electromagnetic induction source, based on the temperature of the responder detected by the temperature sensor.

FIG. 1

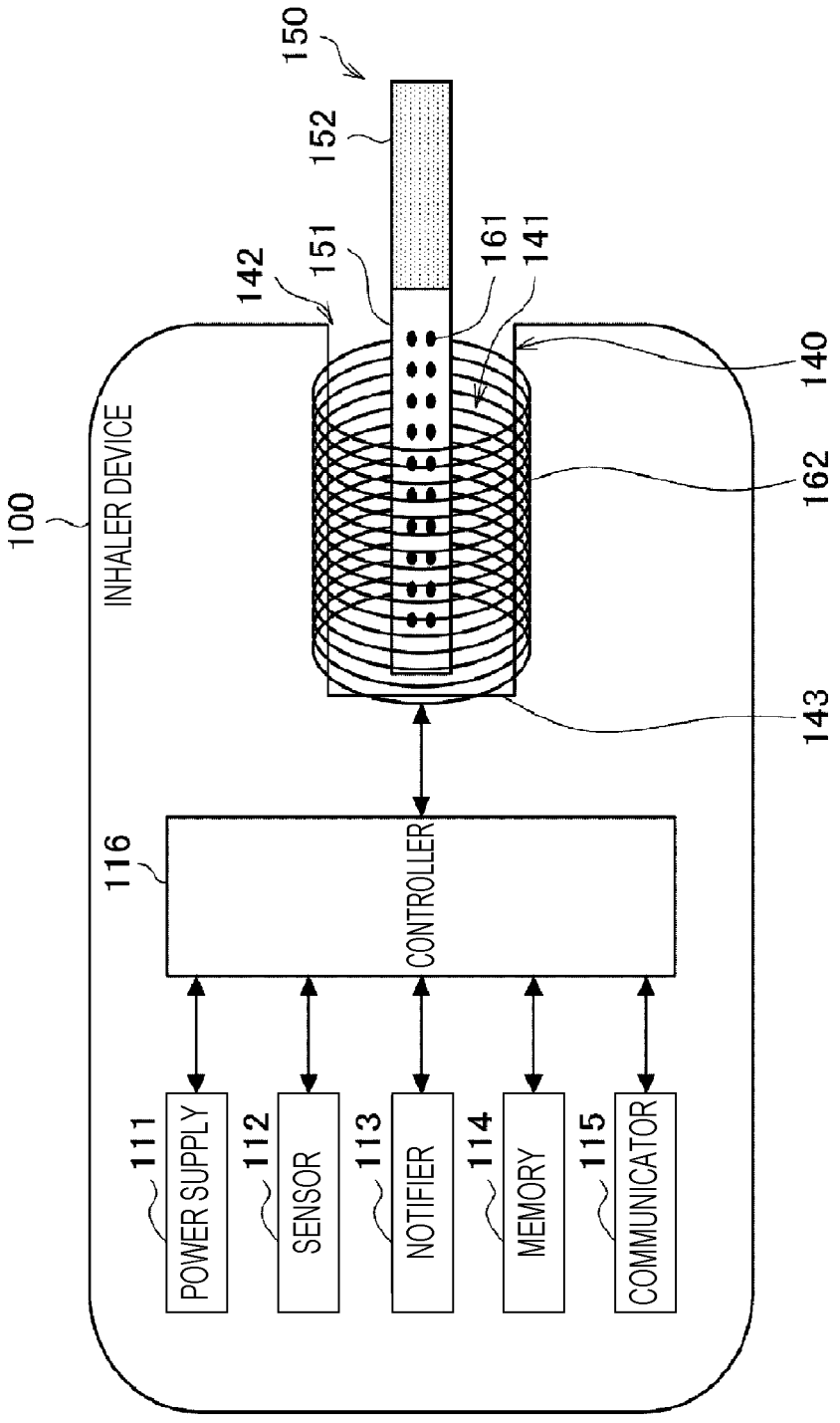

150
152
151
142
161
141
140
162
143
100
INHALER DEVICE
116
CONTROLLER
111
POWER SUPPLY
112
SENSOR
113
NOTIFIER
114
MEMORY
115
COMMUNICATOR

FIG. 2

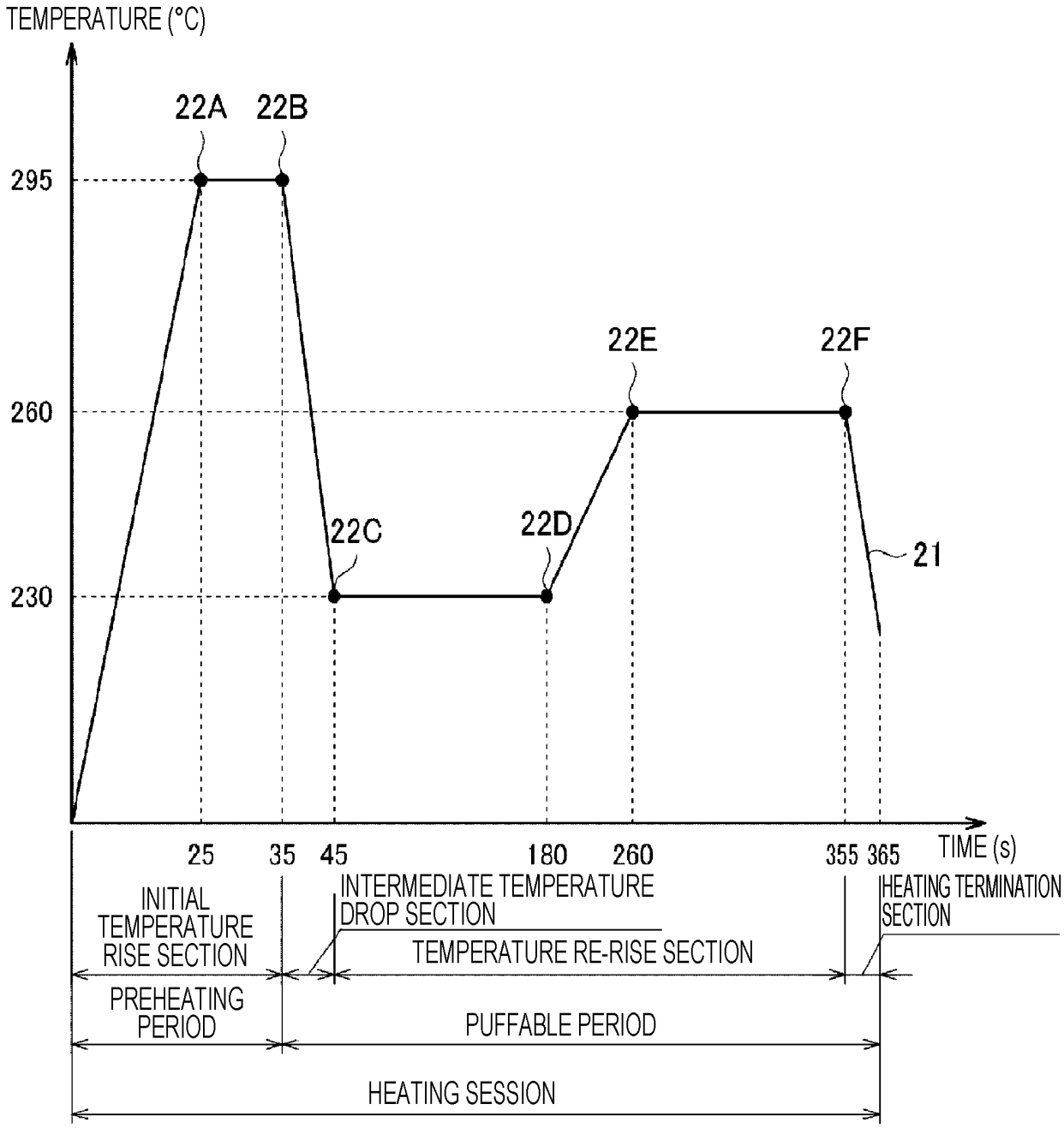

TEMPERATURE (°C)
22A
22B
295
260
230
22E
22F
22C
22D
21
25
35
45
180
260
355
365
TIME (s)
INITIAL TEMPERATURE RISE SECTION
INTERMEDIATE TEMPERATURE DROP SECTION
TEMPERATURE RE-RISE SECTION
HEATING TERMINATION SECTION
PREHEATING PERIOD
PUFFABLE PERIOD
HEATING SESSION

FIG. 3

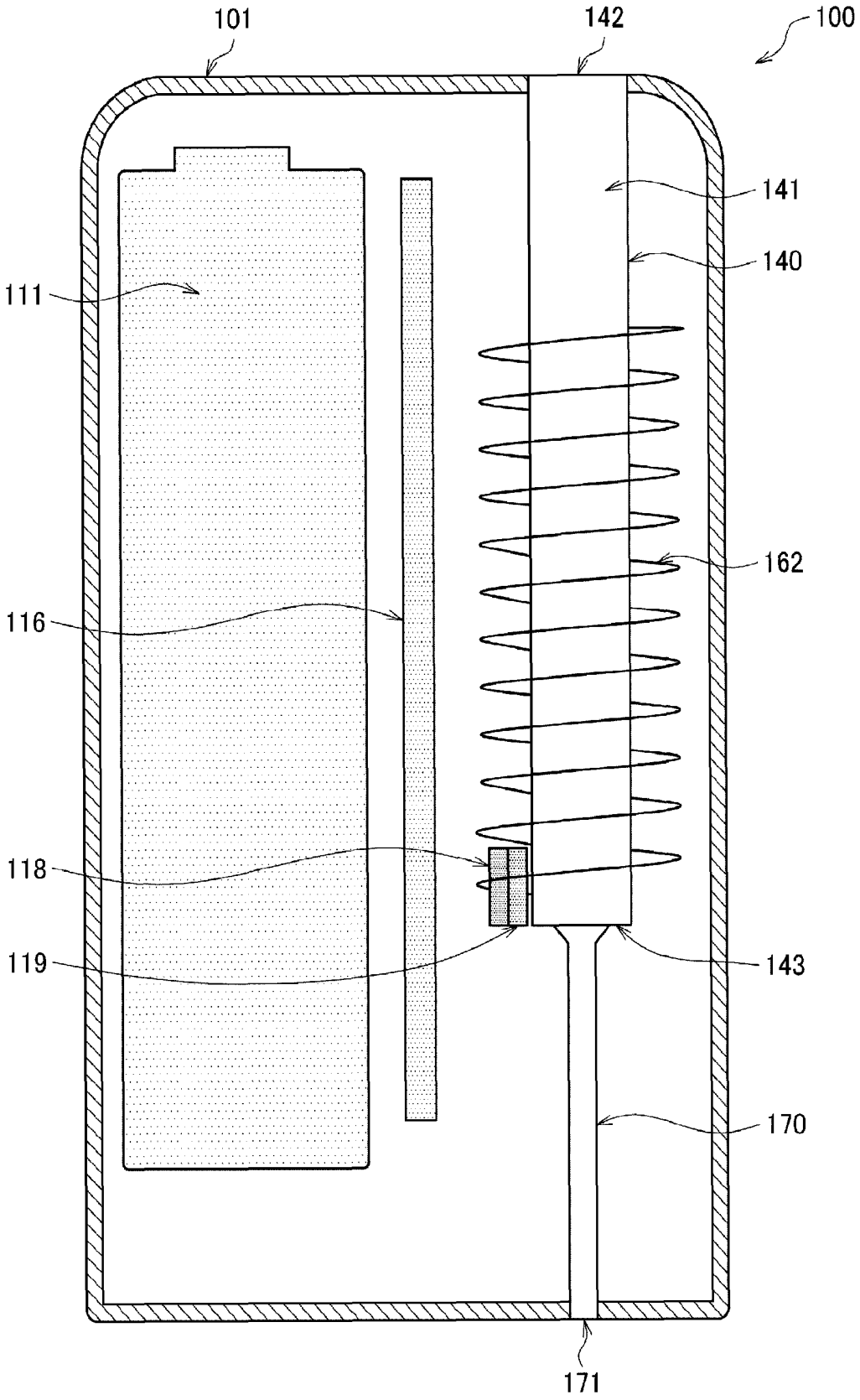


FIG. 4

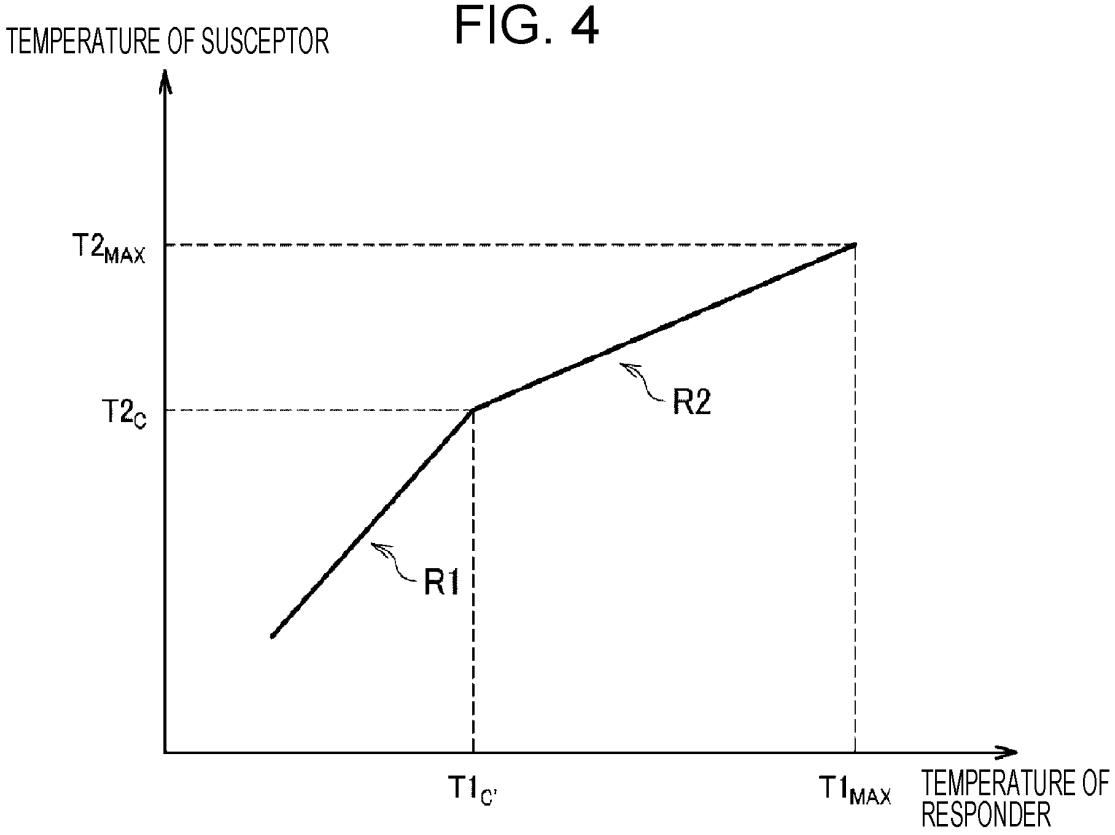

TEMPERATURE OF SUSCEPTOR
T2MAX
T2C
R2
R1
T1C'
T1MAX
TEMPERATURE OF RESPONDER

FIG. 5

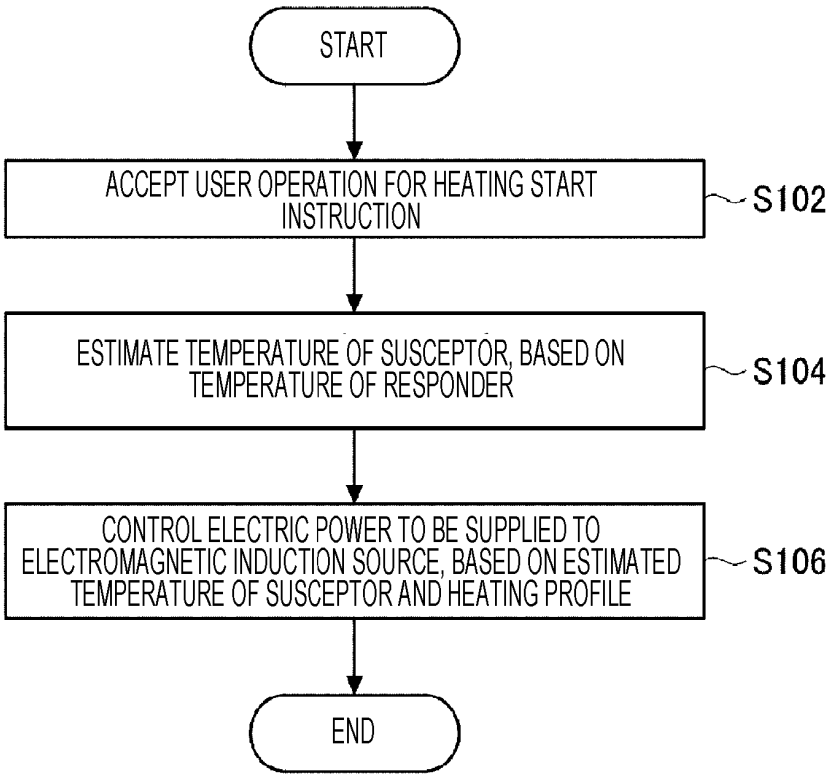
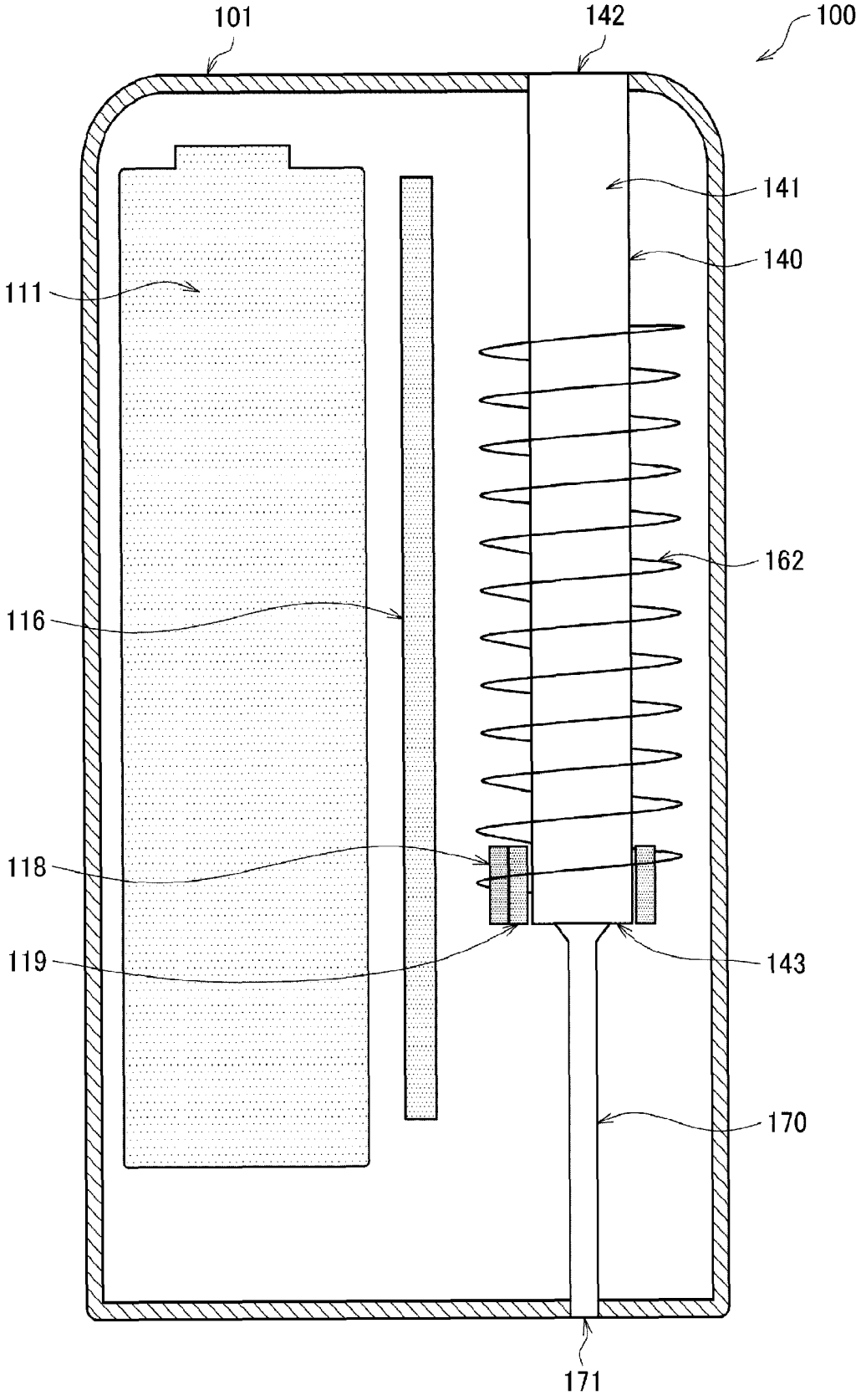

START
ACCEPT USER OPERATION FOR HEATING START INSTRUCTION
S102
ESTIMATE TEMPERATURE OF SUSCEPTOR, BASED ON TEMPERATURE OF RESPONDER
S104
CONTROL ELECTRIC POWER TO BE SUPPLIED TO ELECTROMAGNETIC INDUCTION SOURCE, BASED ON ESTIMATED TEMPERATURE OF SUSCEPTOR AND HEATING PROFILE
S106
END

FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/006193

A. CLASSIFICATION OF SUBJECT MATTER
A24F 40/465(2020.01)i
FI: A24F40/465
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A24F40/465

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2019-524079 A (BRITISH AMERICAN TOBACCO (INVESTMENTS) LIMITED) 05 September 2019 (2019-09-05) paragraphs [0069]-[0097], fig. 8-9	1-20
A	JP 2016-525341 A (PHILIP MORRIS PRODUCTS SA) 25 August 2016 (2016-08-25) entire text, all drawings	1-20
A	JP 2020-505011 A (BRITISH AMERICAN TOBACCO (INVESTMENTS) LIMITED) 20 February 2020 (2020-02-20) paragraphs [0081]-[0082], [0094], fig. 8-9	9
A	JP 2020-526865 A (LOTO LABS, INC.) 31 August 2020 (2020-08-31) paragraphs [0118]-[0120]	12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 April 2021 (12.04.2021)	20 April 2021 (20.04.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/006193

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2019-524079 A	05 Sep. 2019	US 2019/0239555 A1 paragraphs [0078]-[0106], fig. 8-9 WO 2018/002084 A1 EP 34 78103 A1 KR 10-2019-0014535 A CN 109414073 A	
JP 2016-525341 A	25 Aug. 2016	EP 2996504 A1 entire text, all drawings KR 10-2015-0143877 A CN 105407750 A	
JP 2020-505011 A	20 Feb. 2020	US 2019/0364973 A1 paragraphs [0083]-[0085], [0108], fig. 8-9 WO 2018/138072 A1 EP 3574710 A1 KR 10-2019-0090070 A CN 110199569 A	
JP 2020-526865 A	31 Aug. 2020	WO 2018/195335 A1 paragraphs [0126]-[0128] EP 3613258 A1 CN 110679202 A	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6623175 B **[0004]**