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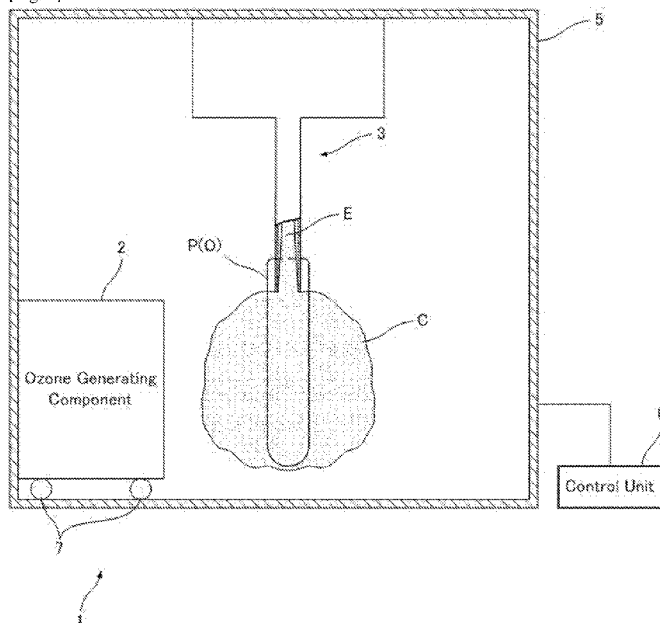
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(54) Title: ELECTRON BEAM STERILIZATION EQUIPMENT WITH A SELF-GENERATED STERILE-IN-PLACE UNIT

[Fig. 1]



(57) Abstract: Electron beam sterilization equipment (1) sterilizes a sterilization object (O), e.g., a preform (P) by exposure to electron cloud (C) formed using an electron beam (E). It (1) includes an electron beam generator (3) that generates the electron beam (E) into electron cloud (C) and a housing (5) that accommodates the electron beam generator (3). It (1) further includes an ozone generating component (2) and a drive unit (7) that are stored in the housing (5), and a control unit (6). The ozone generating component (2) is located in a position so as to enable surface interaction with the electron cloud (E) when the preform (P) is not sterilized. The surface interaction generates secondary electrons, consequently ozone generation is significantly enhanced using the secondary electrons. The drive unit (7) moves the ozone generating component to the location while the control unit (6) controls ozone in the housing (5).

Description

Title of Invention: ELECTRON BEAM STERILIZATION EQUIPMENT WITH A SELF-GENERATED STERILE-IN-PLACE UNIT

Technical Field

[0001] The present invention relates to electron beam sterilization equipment that sterilizes containers for foods, beverages, and pharmaceutical with electron beams.

Background Art

[0002] Packaging materials are sterilized by different methods in order to deactivate or destroy microorganisms and bioburdens contained in the packages during forming and transport through the machine prior to filling. Each method provides different levels of sterility. The level of sterility of the machine components as well as the containers plays an important role in the consumer product safety. The product composition, container material, storage condition before consumption and the shelf life are some of the parameters to consider for identifying the requirement for level of sterility and sterilization process.

Therefore, choosing the right method of sterilization by the beverage, food and pharmaceutical industries, is of great importance.

[0003] At present, devices using electron beams instead of chemicals for sterilization are adopted to sterilize containers. Electron beam sterilization equipment including such a device is free of chemicals and thus leaves no chemicals in sterilized containers, achieving high safety.

[0004] However, like other kinds of sterilization equipment, typical electron beam sterilization equipment needs to be stopped every several days during a normal operation so as to be sterilized with chemicals during sterilizing in place (SIP), a process for automatic sterilization without major disassembly and assembly work. Thus, in a strict sense, chemicals are used in the electron beam sterilization equipment and a risk that the chemicals could be left in sterilized containers or seeping through the container walls cannot be completely eliminated.

[0005] Thus, currently, as electron beam sterilization equipment that requires no chemicals in the sterilization of the equipment, the proposed equipment is sterilized using ozone generated by electron beams (e.g., Patent Literature 1).

Citation List

Patent Literature

[0006] Patent Literature 1: U.S. Patent No. 8373138, Description

Summary of Invention

Technical Problem

[0007] The sterilization of the equipment requires an ozone concentration of several thousands of ppm. On the other hand, in the equipment of Patent Literature 1, electron beams (primary electrons) are directly emitted to gas and thus have an insufficient ozone concentration of several hundreds of ppm. For this reason, in the case of the above equipment, in order to generate ozone with a concentration required for the sterilization of the equipment, electron beams emitted in the equipment need to be considerably intensified, that considerably exceed an intensity level required for container sterilization (normal operation). Electron beams emitted with this intensity may excessively generate X-rays harmful to a human body, reducing safety. Thus, the safety of the above equipment requires a large shield for blocking the above excessive X-rays, leading to a complicated configuration.

An object of the present invention is to provide electron beam sterilization equipment that can improve safety with a simple configuration for chemical-free sterilization of the equipment.

Solution to Problem

[0008] In order to solve the problem, electron beam sterilization equipment according to a first invention is electron beam sterilization equipment that sterilizes a sterilization object by exposure to electron cloud formed using an electron beam,

the electron beam sterilization equipment comprising:

- an electron beam generator that generates the electron beam into the electron cloud;
- an ozone generating component located in a position so as to enable surface interaction with the electron cloud when the sterilization object is not sterilized, the ozone generating component generating secondary electrons, electrons generated as ionization products called 'secondary' because they are generated by other radiation (the primary radiation), using the surface interaction and then significantly enhancing the ozone generation using the secondary electrons;
- a drive unit that changes a positional relationship between the electron beam generator and the ozone generating component with a relative movement, the positional relationship being changed from a state in which the ozone generating component does not interfere with the sterilization of the sterilization object to a state in which the surface interaction with the electron cloud on the ozone generating component is capable of being enabled;
- a housing that accommodates the electron beam generator, the ozone generating component, and the drive unit; and
- a control unit that controls ozone in the housing.

- [0009] Electron beam sterilization equipment according to a second invention, in the electron beam sterilization equipment according to the first invention, wherein the ozone generating component has a surface that exhibits the surface interaction with the electron cloud, the surface having an irregular shape and/or a through hole.
- [0010] Electron beam sterilization equipment according to a third invention, in the electron beam sterilization equipment according to the first invention, further comprising a temperature regulator that adjusts a temperature of a surface of the ozone generating component, the surface exhibiting the surface interaction with the electron cloud.
- [0011] Electron beam sterilization equipment according to a fourth invention, wherein the sterilization object of the electron beam sterilization equipment according to any one of the first to third inventions has an inner surface that is accessible through an opening,
- the electron beam generator includes an internal electron beam generator that exposes the inner surface of the sterilization object to the electron cloud,
 - the internal electron beam generator has a nozzle that is inserted into the opening of the sterilization object so as to generate the electron cloud from a transmission window on a distal end of the nozzle,
 - the ozone generating component is shaped like a cup with a side part and a bottom part so as to cover the transmission window of the nozzle inside the bottom part,
 - the surface interaction with the electron cloud on the ozone generating component so as to be enabled is located in a position to cover the transmission window of the nozzle inside the bottom part, and
 - the drive unit retracts the ozone generating component relative to the nozzle so as to allow convection of generated ozone.
- [0012] Electron beam sterilization equipment according to a fifth invention, wherein the electron beam generator of the electron beam sterilization equipment according to any one of the first to third inventions includes an external electron beam generator that exposes an outer surface of the sterilization object to the electron cloud,
- the ozone generating component is shaped so as to cover the external electron beam generator, and
 - the surface interaction with the electron cloud on the ozone generating component so as to be enabled is located in a position between the sterilization object with the outer surface exposed to the electron cloud and the external electron beam generator,
 - the electron beam sterilization equipment further including a fan for convection of ozone between the ozone generating component and the external electron beam generator.

Advantageous Effects of Invention

- [0013] According to the electron beam sterilization equipment, sterilizing in place can be

performed using ozone generated without setting the intensity of an electron beam considerably higher than in a normal operation. This can improve safety with a simple configuration for chemical-free sterilization of the equipment.

Brief Description of Drawings

- [0014] FIG. 1 is a schematic diagram in a normal operation of electron beam sterilization equipment according to an embodiment of the present invention.
- [0015] FIG. 2 is a schematic diagram in an operation of sterilizing in place (SIP) in the electron beam sterilization equipment.
- [0016] FIG. 3 is a plane cross section showing the overall configuration of the electron beam sterilization equipment according to an example of the present invention.
- [0017] FIG. 4 is a plane cross section showing an external electron beam generator and a plate component in an SIP operation in the electron beam sterilization equipment.
- [0018] FIG. 5 is a side cross section showing an internal-sterilization turning table and an internal electron beam generator in a normal operation of the electron beam sterilization equipment.
- [0019] FIG. 6 is a partially cut enlarged view of the lower part of an emitter in an SIP operation of the electron beam sterilization equipment.
- [0020] FIG. 7 is a partially cut enlarged view showing that ozone is generated by a movement of a cup component in an SIP operation of the electron beam sterilization equipment.
- [0021] FIG. 8 is a partially cut enlarged view showing convection of ozone according to a movement of the cup component in an SIP operation of the electron beam sterilization equipment.
- [0022] FIG. 9 is a block diagram showing a control unit in the electron beam sterilization equipment.
- [0023] FIG. 10 is a plane cross section of another configuration of the plate component.
- [0024] FIG. 11 is an enlarged side sectional view of another configuration of the cup component.

Description of Embodiments

- [0025] Electron beam sterilization equipment according to an embodiment of the present invention will be described below with reference to the accompanying drawings. Referring to FIG. 1, the technical idea of the electron beam sterilization equipment will be first discussed below.
- [0026] As shown in FIG. 1, in the electron beam sterilization equipment, a sterilization object O is sterilized by exposure to electron cloud C formed by an electron beam E. An electron beam sterilization equipment 1 includes an electron beam generator 3 that generates the electron beam E into the electron cloud C, an ozone generating

component 2 that generates ozone using surface interaction with the electron cloud C, a drive unit 7 that relatively moves the electron beam generator 3 and the ozone generating component 2, and a housing 5 that accommodates the electron beam generator 3, the ozone generating component 2, and the drive unit 7. The electron beam sterilization equipment 1 further includes a control unit 6 that controls ozone in the housing 5. The drive unit 7 adjusts the positional relationship between the electron beam generator 3 and the ozone generating component 2 so as not to prevent the sterilization object O from being sterilized and enables the surface interaction as shown in FIG. 2 when the sterilization object O is not sterilized. The ozone generating component 2 generates secondary electrons using the surface interaction and causes the generated secondary electrons to react with oxygen contained in gas in the housing 5, which generates ozone. The ozone generating component 2 reacts with, for example, oxygen ions generated by the action of the electron cloud C and ultraviolet rays (e.g., catalytic reaction), accelerating the ozone generation. The ozone generating component 2 is made of materials such as tungsten, titanium oxide, and/or zinc oxide. Alternatively, the ozone generating component 2 may be made of materials such as tungstic oxide, titanium, and/or ceramic. In this case, the surface interaction with the electron cloud C can be enabled in a position within the maximum range of electrons constituting the electron cloud C and in a position where the electron beam generator 3 (specifically, the transmission window of the electron beam E, which will be discussed in the following embodiment) is not damaged by electrons reflected from the ozone generating component 2. The maximum range varies according to a voltage for generating the electron beam E. For example, when the voltage is 125 kV, the maximum range of electrons is about 150 mm. Moreover, the position where the transmission window is not damaged by electrons reflected from the ozone generating component 2 changes according to the state of convection between the transmission window and the ozone generating component 2.

[0027] As shown in FIG. 1, the electron beam sterilization equipment 1 in a normal operation sterilizes a container as the sterilization object O, a preform P or the like by exposure to the electron cloud C. If the equipment needs to be sterilized after the normal operation is continued for several days, the normal operation is switched to an operation of sterilizing in place. The sterilizing in place does not need the disassembly of the equipment, and is abbreviated as SIP (Sterilize In Place).

[0028] In an SIP operation, as shown in FIG. 2, the drive unit 7 moves the ozone generating component 2 to a position where surface interaction with the electron cloud C can be enabled. The electron beam E is then generated by the electron beam generator 3 into the electron cloud C, accelerating the surface interaction. The electron beam E only needs to be as intensive as an electron beam in a normal operation. Secondary

electrons are generated from the ozone generating component 2 using the surface interaction and then are caused to react with oxygen contained in gas in the housing 5, which generates ozone. Moreover, the electron cloud C generates oxygen ions and ultraviolet rays using an action with the gas. The ozone generating component 2 located at the position enables the generation of ozone using a reaction (e.g., a catalytic reaction) with the oxygen ions and ultraviolet rays. In the housing 5, ozone is controlled suitably for SIP by the control unit 6.

[0029] In this way, the electron beam sterilization equipment 1 includes the ozone generating component 2, the drive unit 7, and the control unit 6, which are absent in conventional electron beam sterilization equipment, allowing SIP using ozone generated without setting the intensity of the electron beam E considerably higher than in a normal operation. This can improve safety with a simple configuration for the chemical-free sterilization of the equipment.

Example

[0030] The electron beam sterilization equipment 1 will be described below according to a specific example of the embodiment. In this example, the sterilization object O sterilized in a normal operation by the electron beam sterilization equipment 1 will be described as the preform P.

[0031] As shown in FIG. 3, which is a plane cross section of the electron beam sterilization equipment 1, the electron beam sterilization equipment 1 includes turning tables 10 that transport the preforms P, an external electron beam generator 32 that exposes the outer surface of the transported preform P to electron cloud, an internal electron beam generator (FIG. 5) 33 that exposes the inner surface of the transported preform P to electron cloud, and the housing 5 that accommodates the turning tables 10 and the electron beam generators 32 and 33.

[0032] As shown in FIG. 3, the turning tables 10 include an entrance turning table 11 that receives the preform P from outside the housing 5, an external-sterilization turning table 12 that receives the preform P from the entrance turning table 11 and expose the outer surface of the preform P to the electron cloud of the external electron beam generator 32, an internal-sterilization turning table (FIGS. 3 and 5) 13 that receives the preform P from the external-sterilization turning table 12 and exposes the inner surface of the preform P to the electron cloud of the internal electron beam generator 33, and an exit turning table 14 that receives the preform P from the internal-sterilization turning table 13 and delivers the preform P to outside the housing 5.

[0033] As shown in FIG. 3, the external electron beam generator 32 sterilizes the outer surface of the preform P transported along a circular passage on the external-sterilization turning table 12 with the outer surface thereof exposed to electron cloud. As shown in FIG. 5, the internal electron beam generator 33 sterilizes the inner surface of

the preform P transported along a circular passage on the internal-sterilization turning table 13 with the inner surface thereof exposed to electron cloud. At positions where surface interaction with the electron cloud C can be enabled on the electron beam generators 32 and 33, a plate-type ozone generating component 92 (FIG. 4) and a cup-shaped ozone generating component 82 (FIG. 6) are disposed respectively, which will be specifically described later. The ozone generating components 92 and 82 generate secondary electrons using the surface interaction and cause the generated secondary electrons to react with oxygen contained in gas in the housing 5, which generates ozone. Moreover, the ozone generating components 92 and 82 react with, for example, oxygen ions generated by the action of the electron cloud C and ultraviolet rays (e.g., catalytic reaction), accelerating the ozone generation.

[0034] As shown in FIG. 3, the housing 5 has an inlet port 51 that receives the preform P from the outside and an outlet port 54 that delivers the preform P to the outside. The inlet port 51 and the outlet port 54 are provided with gates 61 and 64, respectively. The gates 61 and 64 adjust the degrees of opening of the inlet port 51 and the outlet port 54 by using actuators or the like (not shown). The housing 5 contains fans 62 and 63 for the convection of ozone. In order to obtain efficient convection of ozone in the housing 5, the fans 62 and 63 are installed at positions where an ozone concentration is relatively high during SIP.

[0035] The electron beam sterilization equipment 1 includes a monitor 69 that monitors the concentrations of oxygen and ozone in the housing 5, an oxygen feeder 65 that supplies oxygen into the housing 5, and a temperature regulator 66 that adjusts the temperatures of the ozone generating components 92 and 82. The concentrations of oxygen and ozone in the housing 5 are monitored through the monitor 69 because the housing 5 needs to have an internal state suitable for the generation and use of ozone. The oxygen feeder 65 supplies oxygen into the housing 5 because ozone is efficiently generated with secondary electrons by increasing the concentration of oxygen in the housing 5. The oxygen feeder 65 supplies impurities such as nitrogen as well as pure oxygen into the housing 5 in order to more efficiently generate ozone using a catalytic reaction. The temperature regulator 66 adjusts the temperatures of the ozone generating components 92 and 82 so as to cool the ozone generating components 92 and 82 in contact with generated ozone. This prevents dissociation caused by heat from generated ozone, thereby efficiently generating ozone. In order to cool the ozone generating components 92 and 82 (at least the surfaces exhibiting surface interaction), the temperature regulator 66 also has the function of supplying a refrigerant to refrigerant passages 93 and 83 (will be discussed later) formed in the ozone generating component 92 (FIG. 4) and near the ozone generating component 82 (FIG. 6).

[0036] The electron beam sterilization equipment 1 includes a controller 70 that controls the

gates 61 and 64, the fans 62 and 63, the oxygen feeder 65, the temperature regulator 66, and a drive unit 67 (with a configuration corresponding to the drive unit 7 of the present embodiment, will be discussed later) based on data from the monitor 69. The gates 61 and 64, the fans 62 and 63, the oxygen feeder 65, the temperature regulator 66, and the drive unit 67 will be referred to as control devices 61 to 67. The control devices 61 to 67 and the controller 70 constitute the control unit 6 of the present embodiment.

The ozone generating components 92 and 82, a subject matter of the present invention, will be specifically described below.

First, the plate-type ozone generating component 92 (hereinafter will be abbreviated as the plate component 92) will be discussed below.

[0037] As shown in FIG. 3, when the outer surface of the preform P is sterilized (normal operation), the plate component 92 is located so as not to interfere with the sterilization. As shown in FIG. 4, when the outer surface of the preform P is not sterilized (SIP operation), the plate component 92 is located between the external-sterilization turning table 12 and the external electron beam generator 32. The position is changed by a drive unit (not shown, an example of the drive unit 7 shown in FIGS. 1 and 2). As shown in FIG. 4, the plate component 92 has the refrigerant passage 93 formed that allows the passage of a refrigerant. The refrigerant passage 93 allows the passage of a refrigerant so as to cool the surface of the plate component 92 near the external electron beam generator 32. The plate component 92 exhibits surface interaction with the electron cloud C near the external electron beam generator 32. The surface near the external electron beam generator 32 is shaped like a mesh or a honeycomb (an example of an irregular shape) to increase an area for the surface interaction. As shown in FIG. 4, a limited space is formed between the external electron beam generator 32 and the surface of the plate component 92 near the external electron beam generator 32, allowing surface interaction with electron cloud on the plate component 92 to generate ozone in the space. The ozone is discharged from the space with the fan 63. In other words, the fan 63 allows the convection of ozone.

[0038] The internal-sterilization turning table 13 having the cup-shaped ozone generating component 82 (hereinafter will be abbreviated as the cup component 82) and the cup component 82 will be discussed below.

[0039] As shown in FIG. 3, the internal-sterilization turning table 13 includes a rotating circular table plate 21 and grippers 8 spaced at regular intervals on the outer edge of the circular table plate 21. Specifically, the internal-sterilization turning table 13 transports the preforms P, which are held by the grippers 8, along the circular passage by rotating the circular table plate 21. As shown in FIG. 5, the internal-sterilization turning table 13 includes a mount plate 22 that is disposed in parallel with and above

the circular table plate 21 and a rotating shaft 23 that is connected to the center of rotation of the circular table plate 21 and the mount plate 22. The mount plate 22 has an emitter 34 disposed immediately above the gripper 8 so as to constitute the internal electron beam generator 33. The internal-sterilization turning table 13 includes elevating components 24, each moving up and down the gripper 8. The elevating component 24 lifts the gripper 8 so as to expose the inner surface of the preform P held by the gripper 8 to the electron cloud of the internal electron beam generator 33. The elevating component 24 lowers the gripper 8 so as to deliver the preform P to a gripper 9 of the exit turning table 14. Furthermore, the mount plate 22 has the drive unit 67 (an example of the drive unit 7 shown in FIGS. 1 and 2) that can move the cup component 82. When the inner surface of the preform P is sterilized (in a normal operation), the drive unit 67 retracts the cup component 82 to a position where the sterilization is not prevented. When the inner surface of the preform P is not sterilized (in an SIP operation), the drive unit 67 moves the cup component 82 close to the lower end (distal end) of a nozzle 36.

The emitter 34, the drive unit 67, and the cup component 82 that constitute the internal electron beam generator 33 will be described below.

[0040] As shown in FIG. 6, the lower part of the emitter 34 includes a vacuum chamber 35 that is placed on the mount plate 22 and is internally kept in a vacuum and the cylindrical nozzle 36 that is extended downward from the vacuum chamber 35. The vacuum chamber 35 contains an electron beam source (not shown) that generates numerous electrons to be accelerated downward. The numerous electrons to be accelerated downward, that is, the electron beam E is formed into a long and narrow shape by an electron beam shaper (e.g., an electrostatic lens, not shown). The extended electron beam E is formed so as to converge and then diffuse in the nozzle 36. The interior of the nozzle 36 communicates with the vacuum chamber 35 and is placed in a vacuum atmosphere. The lower end (distal end) of the nozzle 36 has a transmission window 37 that transmits the electron beam E into the electron cloud C. In other words, the nozzle 36 receives the electron beam E from the vacuum chamber 35 and then emits the electron beam E from the transmission window 37 into the electron cloud C.

[0041] As shown in FIG. 6, the drive unit 67 supports the cup component 82 and can retract the cup component 82 with respect to the nozzle 36. The drive unit 67 further includes the refrigerant passage 83 that allows the passage of a refrigerant. The passage of a refrigerant through the refrigerant passage 83 cools the inner surface of the cup component 82. Meanwhile, the cup component 82 includes a side part 82s and a bottom part 82b and exhibits surface interaction with the electron cloud C mainly inside the bottom part 82b. The inner surface of the bottom part 82b is shaped like a

mesh or a honeycomb (an example of an irregular shape) to increase an area for the surface interaction with the electron cloud C. As shown in FIGS. 7 and 8, the retraction allows the cup component 82 to repeatedly move to a covering position/uncovering position for the lower end (distal end) of the nozzle 36. At the covering position, the lower end (distal end) of the nozzle 36 is inserted into the cup component 82, whereas at the uncovering position, the lower end (distal end) of the nozzle 36 is not inserted into the cup component 82. At the covering position, as shown in FIG. 7, a limited space is formed between the transmission window 37 and the bottom part 82b, allowing surface interaction with the electron cloud C in the cup component 82 to generate ozone in the space. Meanwhile, at the uncovering position, as shown in FIG. 8, the movement of the cup component 82 guides ambient gas into the cup component 82, discharging ozone around the cup component 82 from the inside. In other words, the retraction allows the convection of ozone.

The controller 70 constituting the control unit 6 will be specifically described below.

[0042] As shown in FIG. 9, the controller 70 includes a switching unit 71 that switches between a normal operation/SIP operation in the electron beam sterilization equipment 1, a deciding unit 72 that receives data on the internal state of the housing 5 from the monitor 69 and makes a decision to change the state suitably for SIP, and an indicating unit 73 that indicates instructions to the control devices 61 to 67 based on contents determined in the deciding unit 72.

The operation of the electron beam sterilization equipment 1 will be described below.

A normal operation, that is, an operation for sterilizing the preform P will be first discussed below.

[0043] As shown in FIG. 3, the preform P is delivered to the entrance turning table 11 from outside the housing 5 through the inlet port 51 adjusted to an opening of 100% by the gate 61, and then the preform P is delivered to the external-sterilization turning table 12. The preform P delivered to the external-sterilization turning table 12 is externally exposed to electron cloud from the external electron beam generator 32, and then the preform P is delivered to the internal-sterilization turning table 13. The preform P delivered to the internal-sterilization turning table 13 is internally exposed to electron cloud from the internal electron beam generator 33, and then the preform P is delivered to the exit turning table 14. In this case, as shown in FIGS. 3 and 5, the ozone generating components 92 and 82, that is, the plate component 92 and the cup component 82 are located so as not to interfere with sterilization on the outer and inner surfaces of the preform P. This does not interfere with the sterilization and suppresses the generation of unwanted ozone from the ozone generating components 92 and 82 in a normal operation. The preform P delivered to the exit turning table 14 is delivered to outside the housing 5 through the outlet port 54 adjusted to an opening of 100% by the

gate 64.

The operation of SIP, that is, an operation for sterilizing the equipment will be discussed below.

- [0044] When a normal operation is switched to an SIP operation by the switching unit 71 shown in FIG. 9, the indicating unit 73 indicates instructions to the control devices 61 to 67 and the electron beam generators 32 and 33 in response to a decision of the deciding unit 72. These instructions reduce the openings of the inlet port 51 and the outlet port 54 at the gates 61 and 64, supply oxygen containing impurities such as nitrogen into the housing 5 from the oxygen feeder 65, and cause the drive unit 67 to locate the plate component 92 and the cup component 82 (that is, the ozone generating components 92 and 82) at positions where surface interaction with the electron cloud C can be enabled. In response to these instructions, the electron beam generators 32 and 33 generate the electron beams E into the electron cloud C and then surface interaction between the electron cloud C and the plate component 92 and the cup component 82 is enabled so as to generate ozone. Moreover, in response to these instructions, the fans 62 and 63 are started and the drive unit 67 retracts the cup component 82 with respect to the nozzle 36, allowing the convection of generated ozone. Furthermore, in response to these instructions, the temperature regulator 66 supplies a refrigerant to the refrigerant passages 93 and 83 and cools the plate component 92 and the cup component 82, preventing dissociation caused by heat from generated ozone. This can efficiently generate ozone.
- [0045] At this point, the concentrations of oxygen and ozone in the housing 5 are monitored by the monitor 69. The deciding unit 72 makes a decision based on data on the concentrations obtained by monitoring. Based on the decision result, the control devices 61 to 67 and the electron beam generators 32 and 33 are controlled in response to instructions from the indicating unit 73 such that the internal state of the housing 5 is suitable for the generation and use of ozone. The control involves, for example, the start/stop of the oxygen feeder 65 and the electron beam generators 32 and 33.
- [0046] As described above, according to the electron beam sterilization equipment 1 of the example, SIP can be performed using ozone generated without setting the intensity of the electron beam E considerably higher than in a normal operation. This can improve safety with a simple configuration for chemical-free sterilization of the equipment.
- [0047] Moreover, the surfaces exhibiting surface interaction with the electron cloud C on the ozone generating components 92 and 82 are shaped like meshes or honeycombs (an example of an irregular shape), increasing an area for the surface interaction. This can efficiently generate ozone so as to efficiently sterilize the equipment. It is needless to say that the surfaces may have irregular shapes other than meshes or honeycombs.
- [0048] Furthermore, the temperature regulator 66 cools at least the surfaces exhibiting

surface interaction on the ozone generating components 92 and 82. This can efficiently generate ozone so as to efficiently sterilize the equipment.

[0049] Additionally, the monitor 69, the control devices 61 to 67, and the controller 70 adjust the internal state of the housing 5 suitably for the generation and use of ozone, thereby efficiently sterilizing the equipment.

[0050] In this example, the plate component 92 and the cup component 82 having no holes (through holes) are illustrated. As shown in FIGS. 10 and 11, holes 92h and 82h (through holes) may be formed. The holes 92h and 82h facilitate flowing of ambient gas into a space for generating ozone. This allows the efficient convection of ozone so as to efficiently sterilize the equipment.

[0051] In this example, the gates 61 and 64, the fans 62 and 63, the oxygen feeder 65, the temperature regulator 66, and the drive unit 67 are discussed as the control devices 61 to 67. These components are merely exemplary and thus proper configurations are used as necessary.

[0052] Moreover, this example describes the refrigerant passages 93 and 83 that are formed in the plate component 92 (FIG. 4) and near the cup component 82 (FIG. 6), respectively, in order to cool the plate component 92 and the cup component 82 (that is, the ozone generating components 92 and 82). The cooling method is not particularly limited and thus other cooling methods such as impingement cooling may be used.

Additionally, this example describes the two ozone generating components 92 and 82 of the plate component 92 and the cup component 82. Only one of the ozone generating components may be used.

Claims

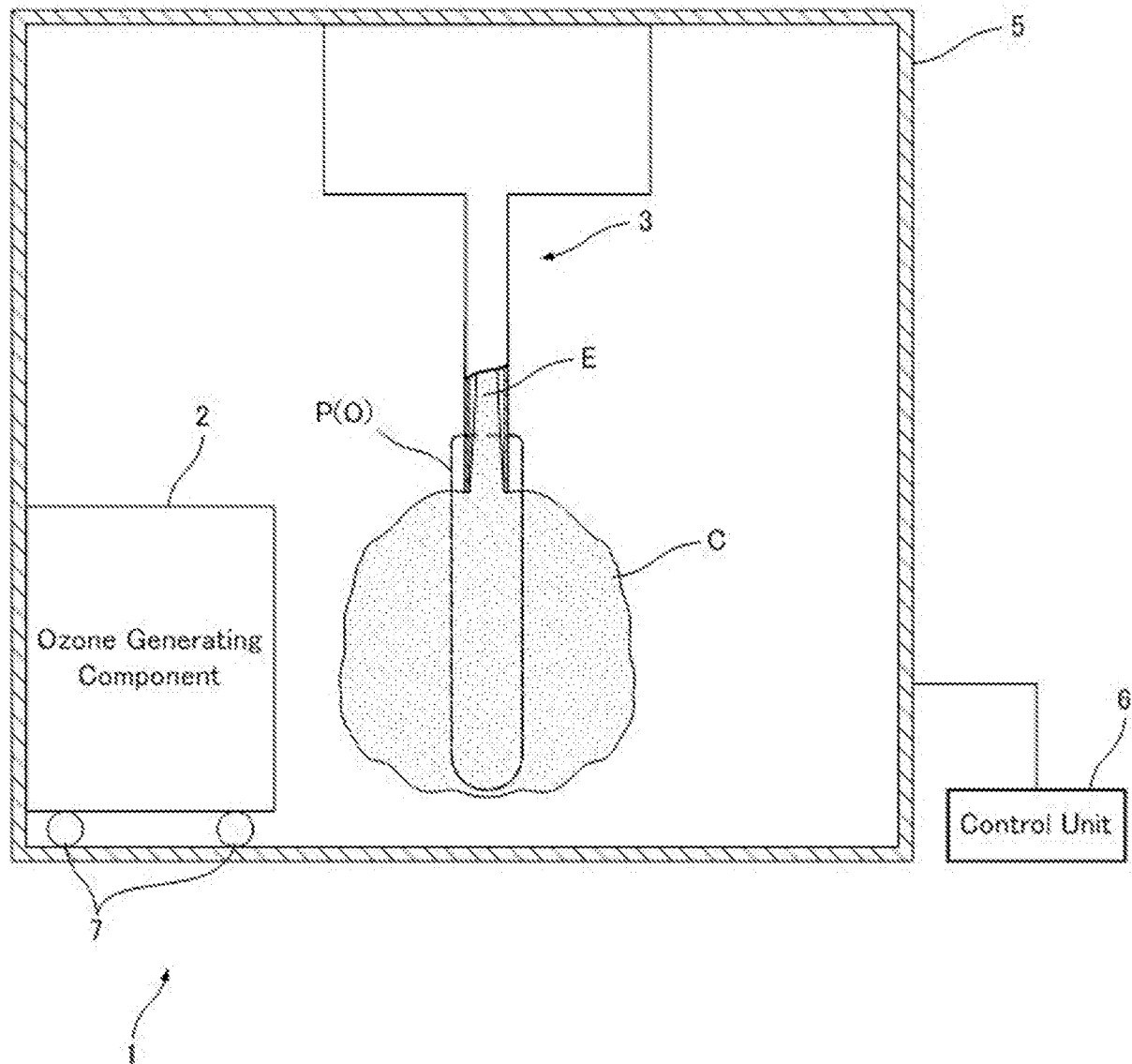
- [Claim 1] Electron beam sterilization equipment that sterilizes a sterilization object by exposure to electron cloud formed using an electron beam, the electron beam sterilization equipment comprising:
an electron beam generator that generates the electron beam into the electron cloud;
an ozone generating component located in a position so as to enable surface interaction with the electron cloud when the sterilization object is not sterilized, the ozone generating component generating secondary electrons using the surface interaction and then generating ozone using the secondary electrons;
a drive unit that changes a positional relationship between the electron beam generator and the ozone generating component with a relative movement, the positional relationship being changed from a state in which the ozone generating component does not interfere with the sterilization of the sterilization object to a state in which the surface interaction with the electron cloud on the ozone generating component is capable of being enabled;
a housing that accommodates the electron beam generator, the ozone generating component, and the drive unit; and
a control unit that controls ozone in the housing.
- [Claim 2] The electron beam sterilization equipment according to claim 1, wherein the ozone generating component has a surface that exhibits the surface interaction with the electron cloud, the surface having an irregular shape and/or a through hole.
- [Claim 3] The electron beam sterilization equipment according to claim 1, further comprising a temperature regulator that adjusts a temperature of a surface of the ozone generating component, the surface exhibiting the surface interaction with the electron cloud.
- [Claim 4] The electron beam sterilization equipment according to any one of claims 1 to 3, wherein the sterilization object has an inner surface that is accessible through an opening,
the electron beam generator includes an internal electron beam generator that exposes the inner surface of the sterilization object to the electron cloud,
the internal electron beam generator has a nozzle that is inserted into the opening of the sterilization object so as to generate the electron

cloud from a transmission window on a distal end of the nozzle,
the ozone generating component is shaped like a cup with a side part
and a bottom part so as to cover the transmission window of the nozzle
inside the bottom part,
the surface interaction with the electron cloud on the ozone generating
component so as to be enabled is located in a position to cover the
transmission window of the nozzle inside the bottom part, and
the drive unit retracts the ozone generating component relative to the
nozzle so as to allow convection of generated ozone.

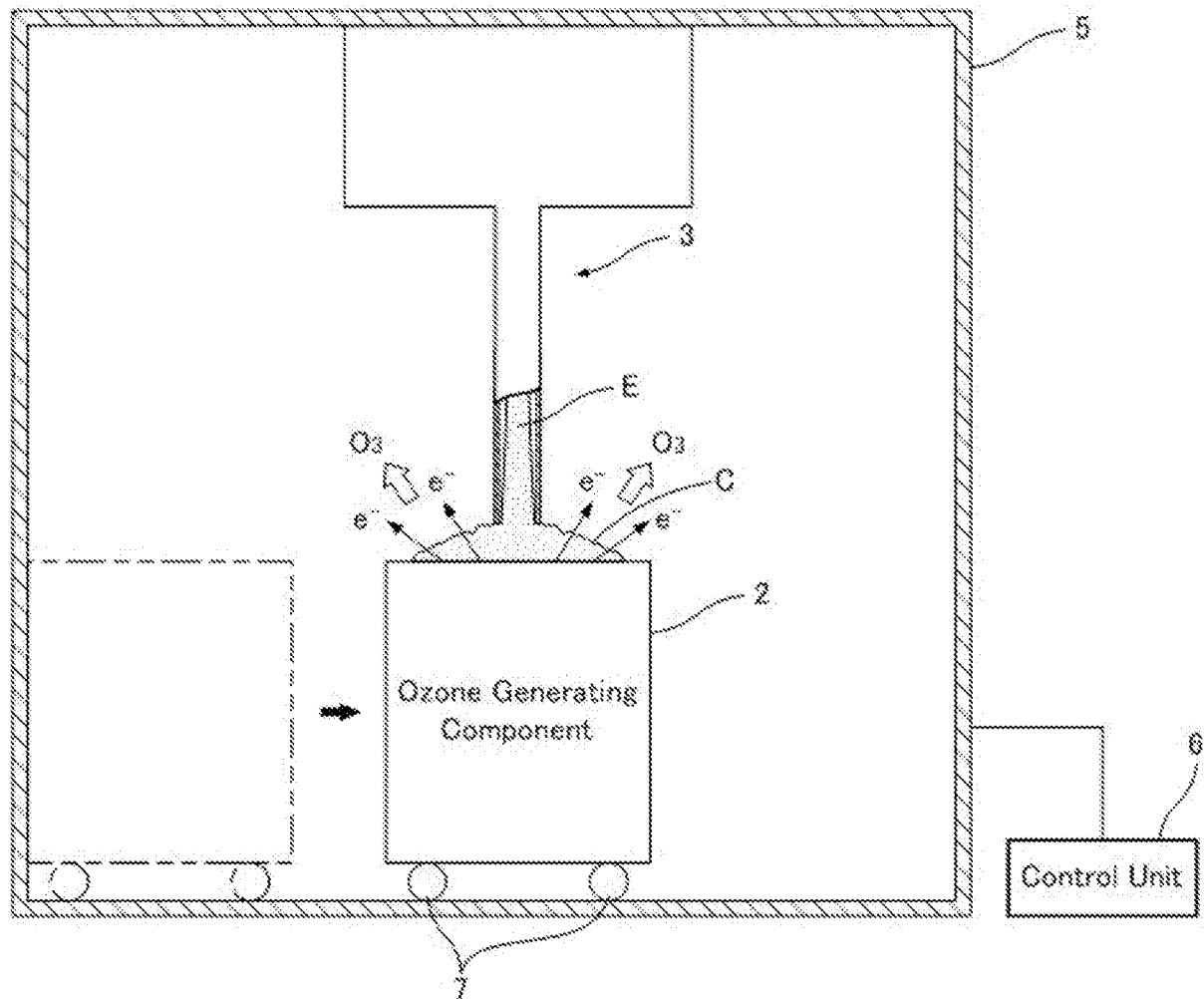
[Claim 5]

The electron beam sterilization equipment according to any one of
claims 1 to 3, wherein the electron beam generator includes an external
electron beam generator that exposes an outer surface of the ster-
ilization object to the electron cloud,
the ozone generating component is shaped so as to cover the external
electron beam generator, and
the surface interaction with the electron cloud on the ozone generating
component so as to be enabled is located in a position between the ster-
ilization object with the outer surface exposed to the electron cloud and
the external electron beam generator,
the electron beam sterilization equipment further including a fan for
convection of ozone between the ozone generating component and the
external electron beam generator.

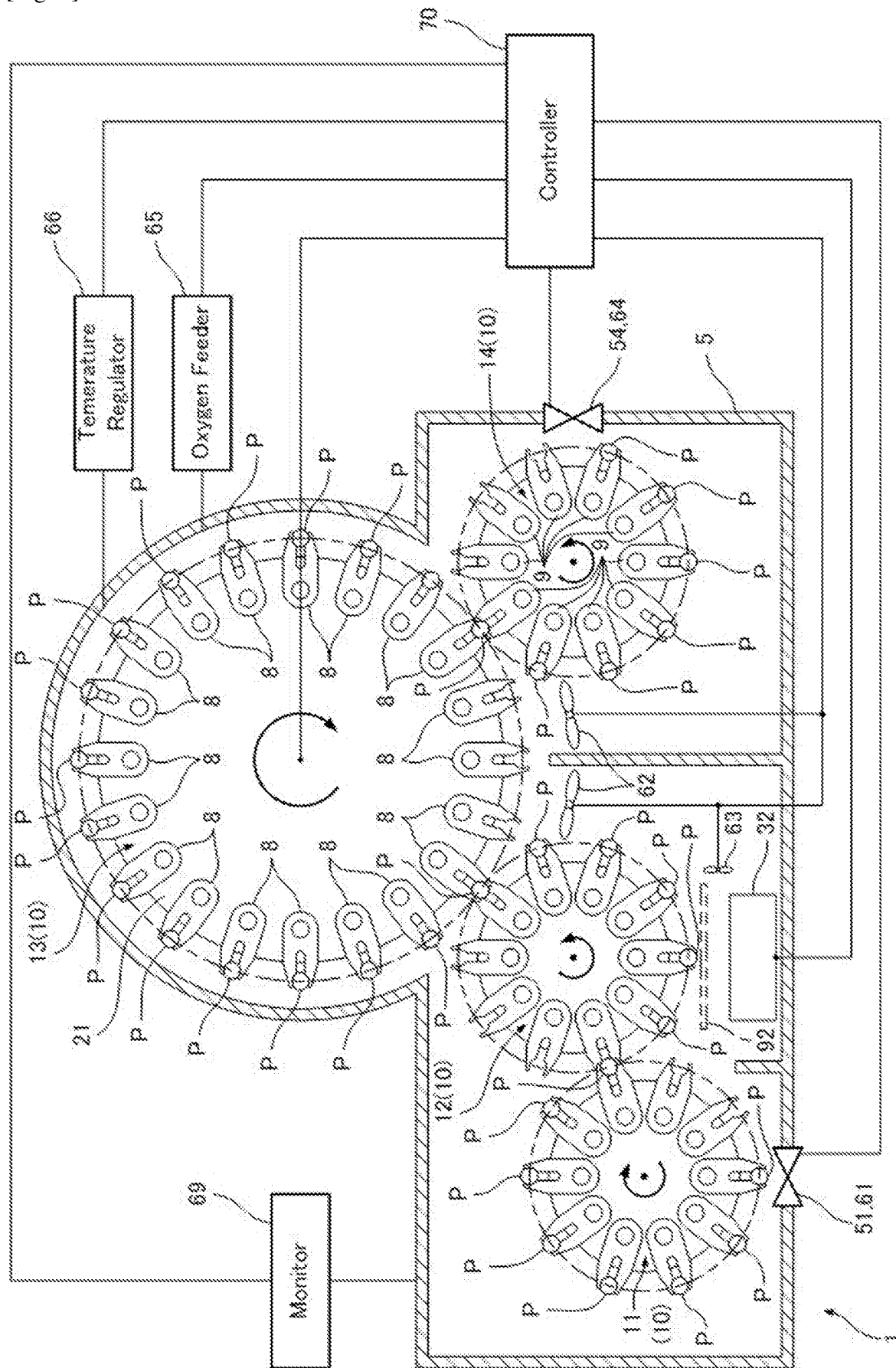
[Fig. 1]



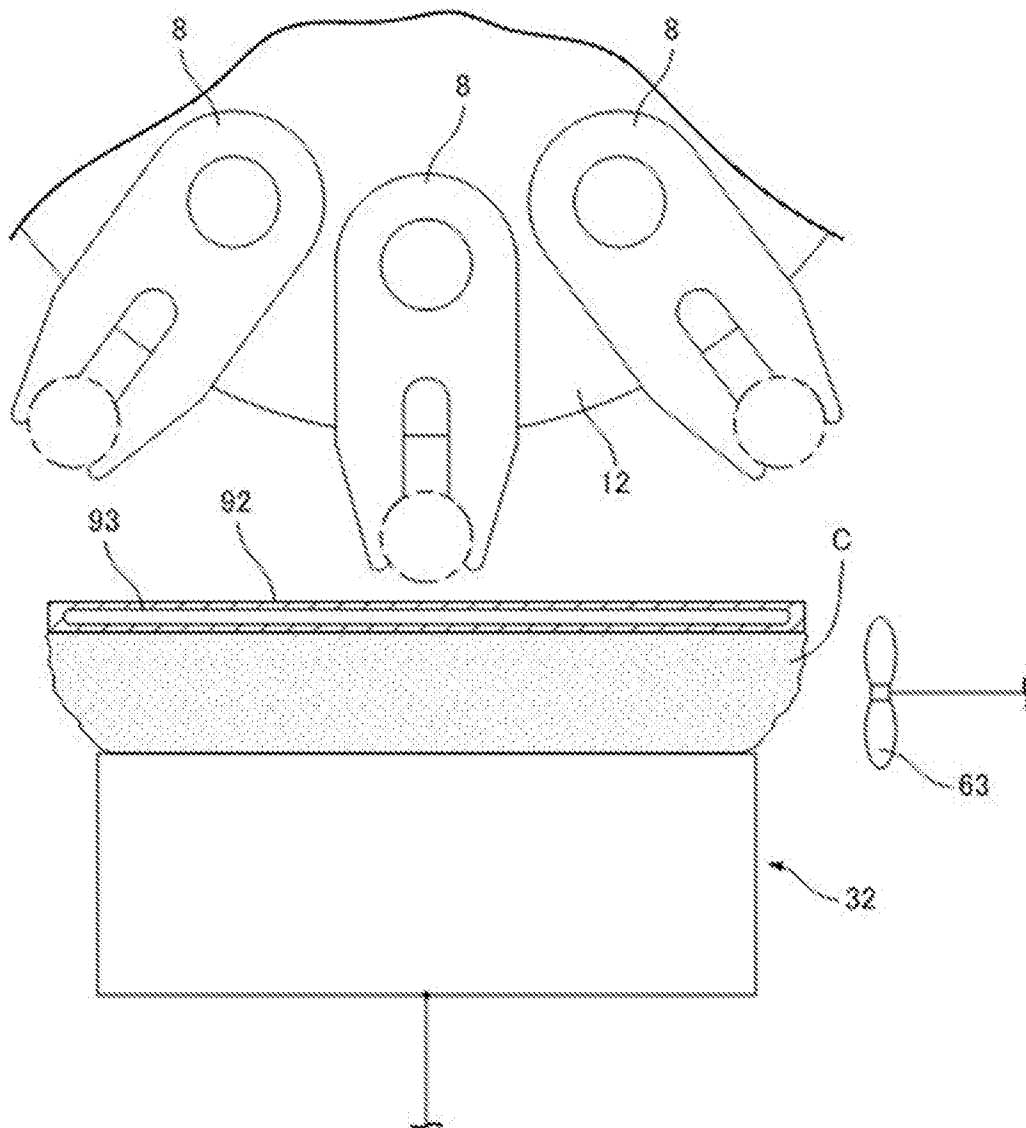
[Fig. 2]



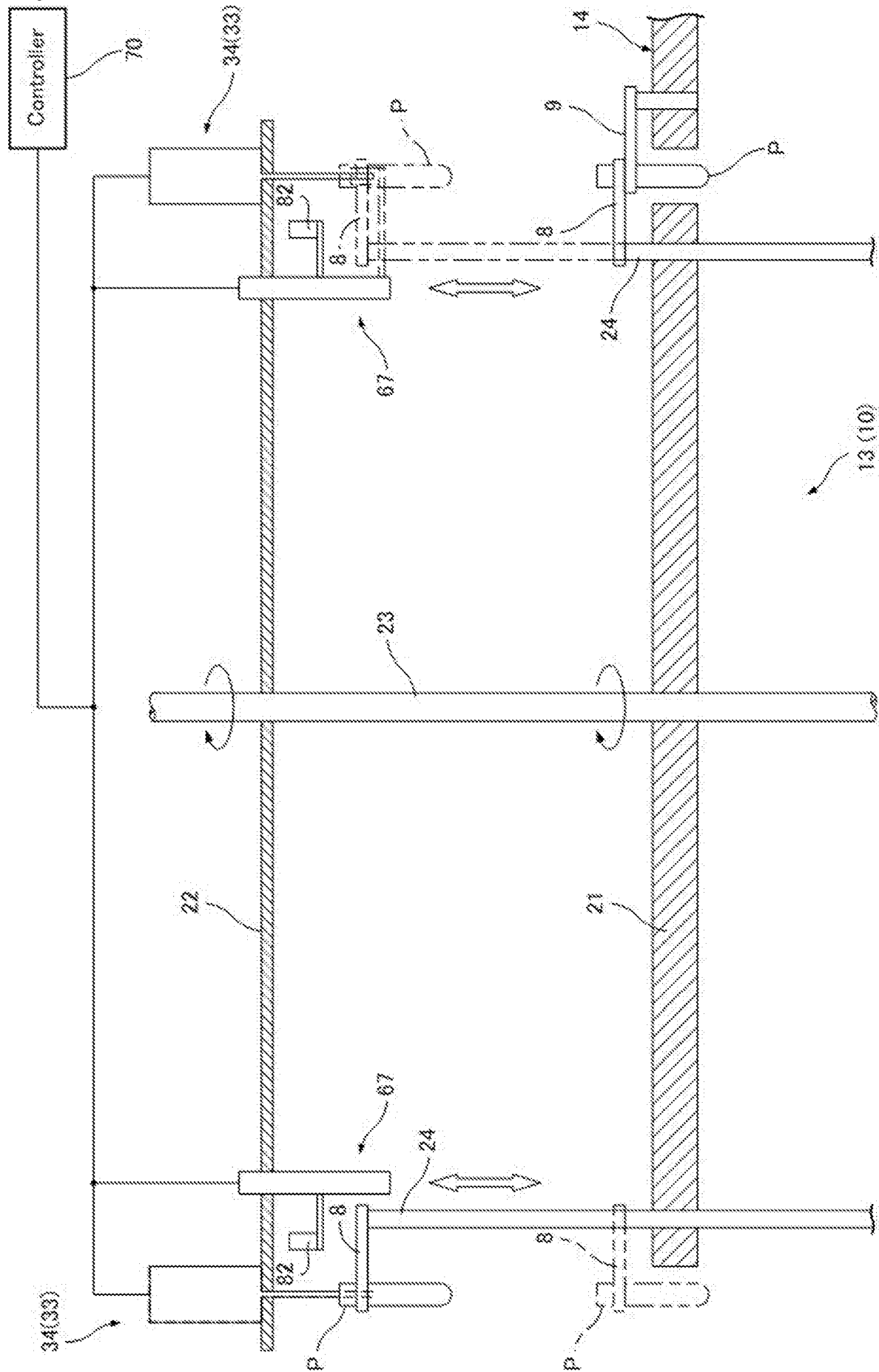
[Fig. 3]



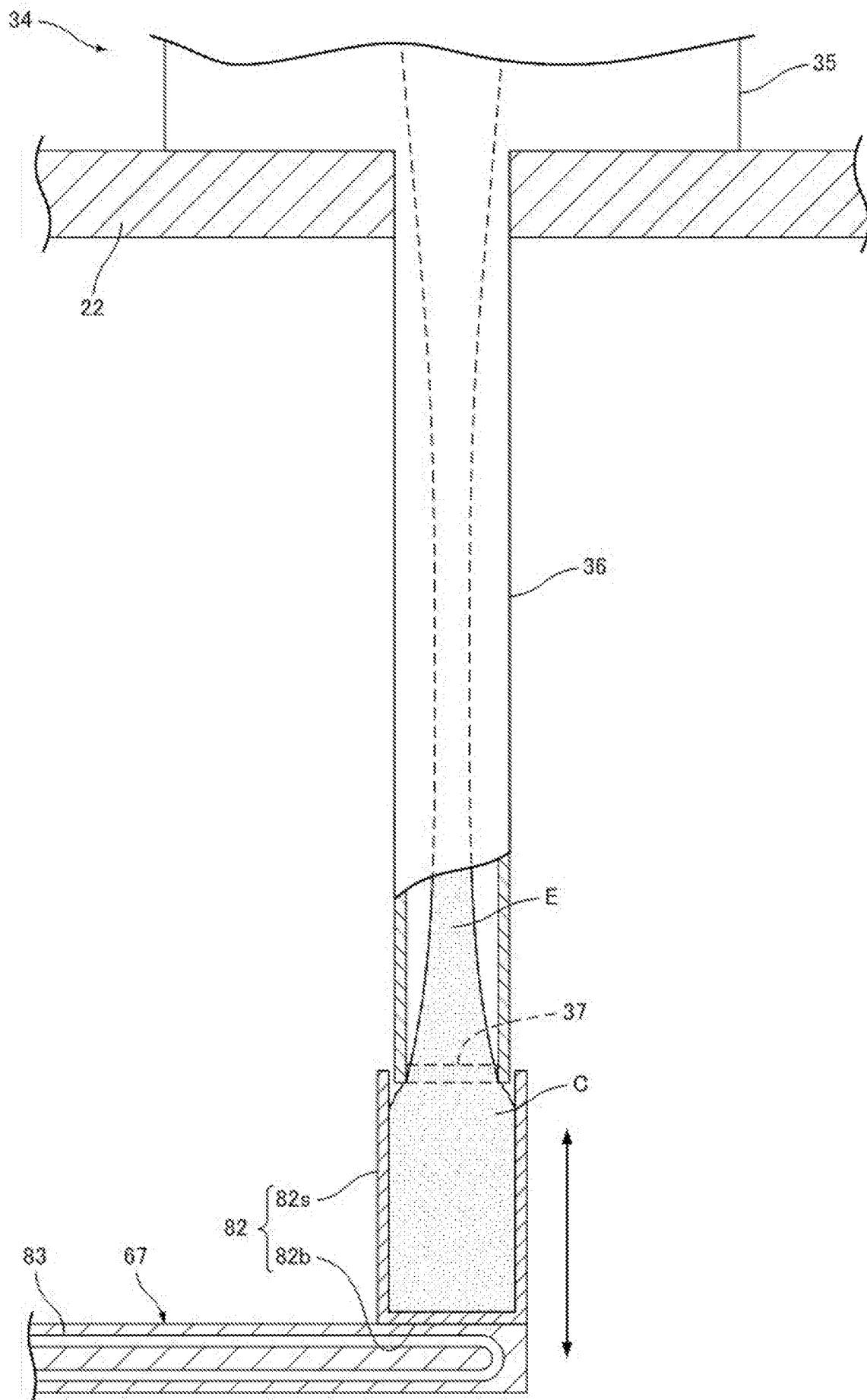
[Fig. 4]



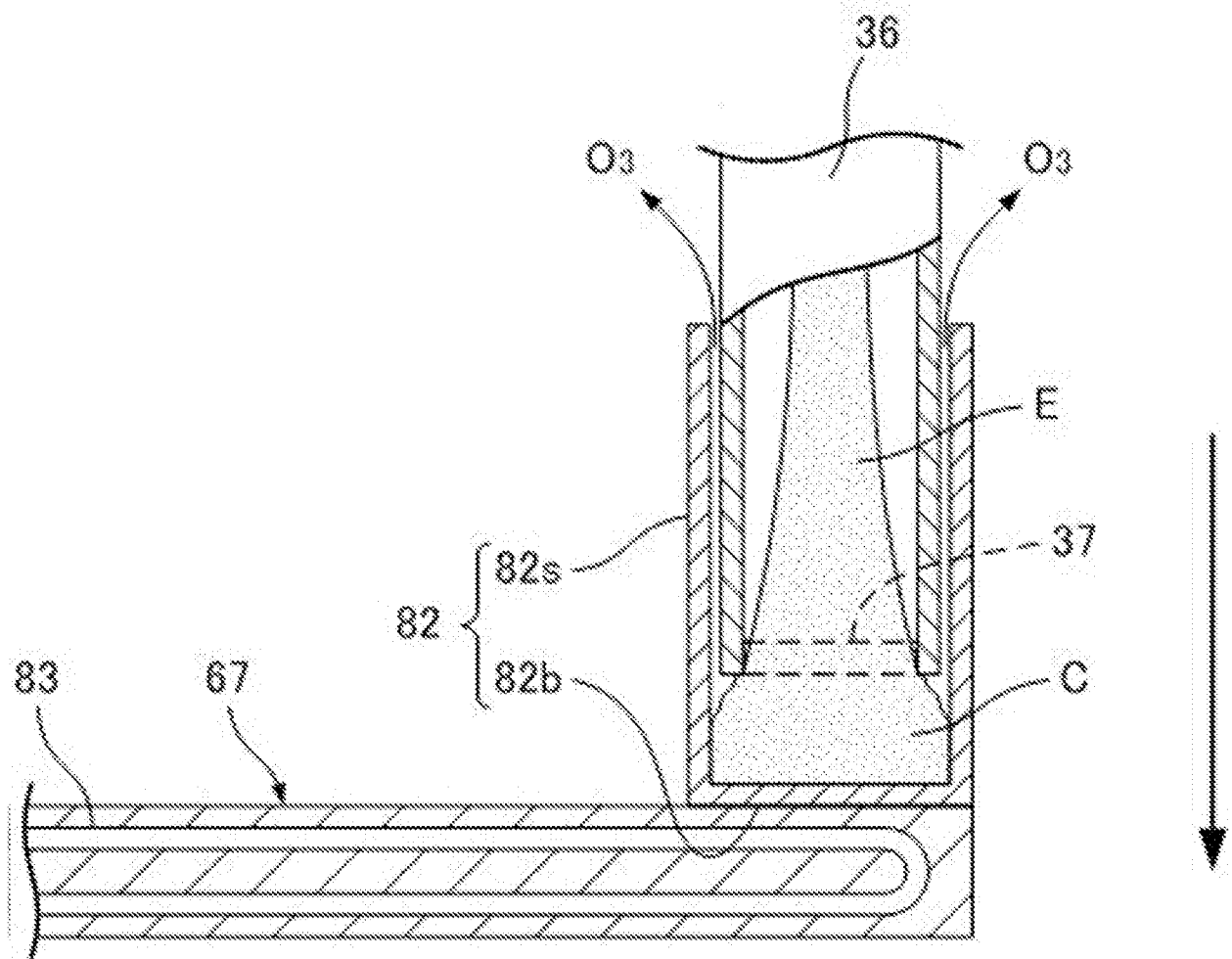
[Fig. 5]



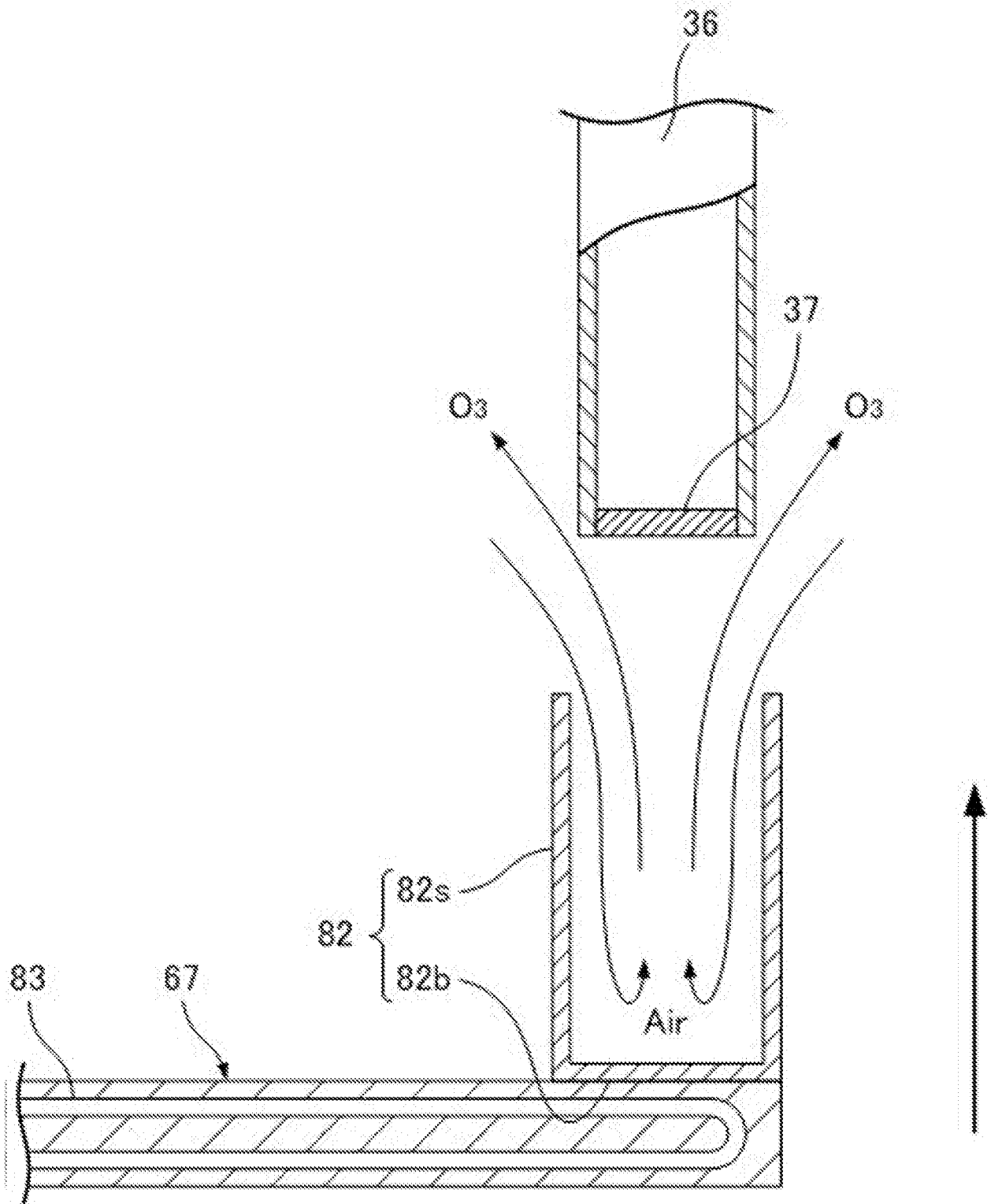
[Fig. 6]



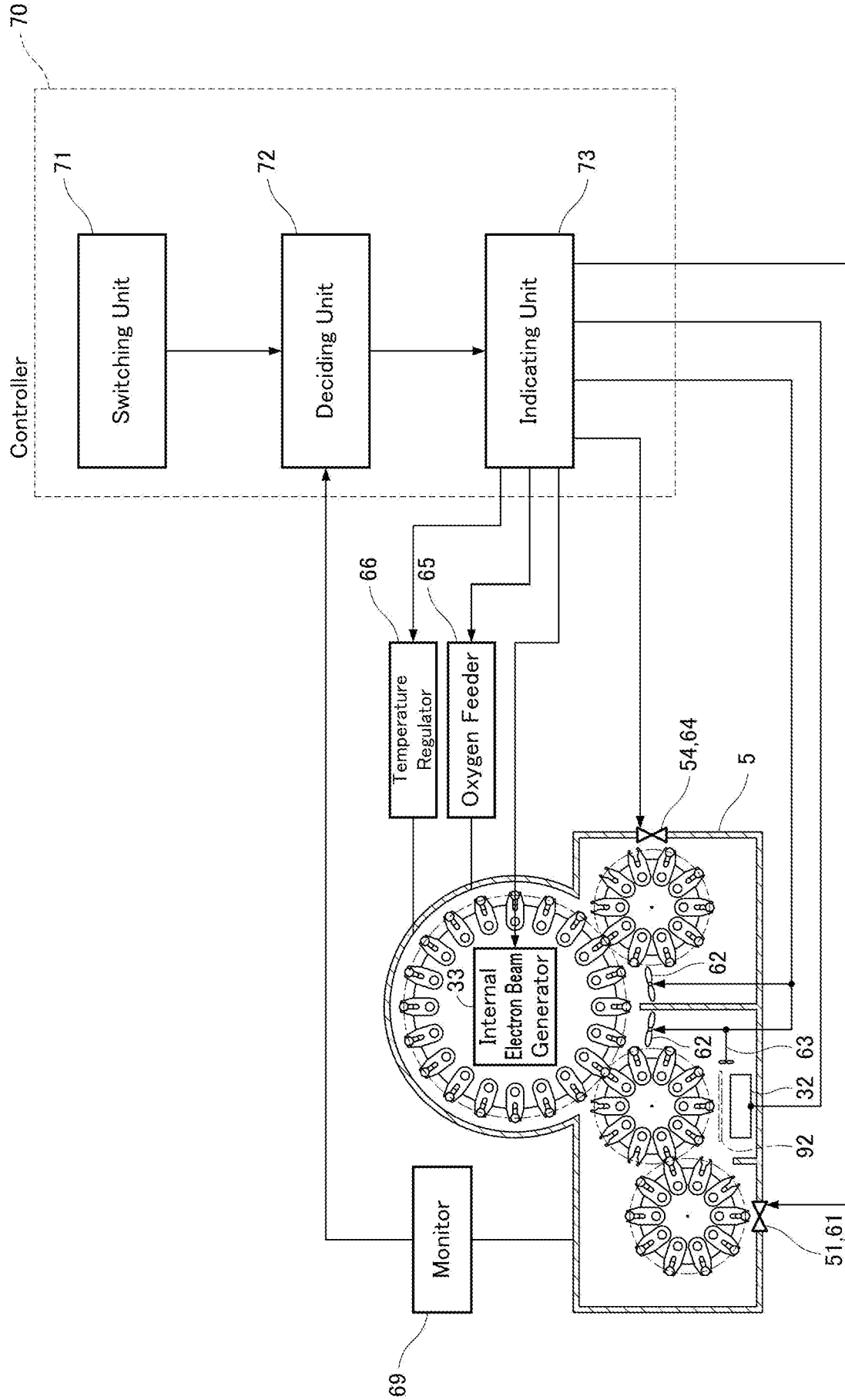
[Fig. 7]



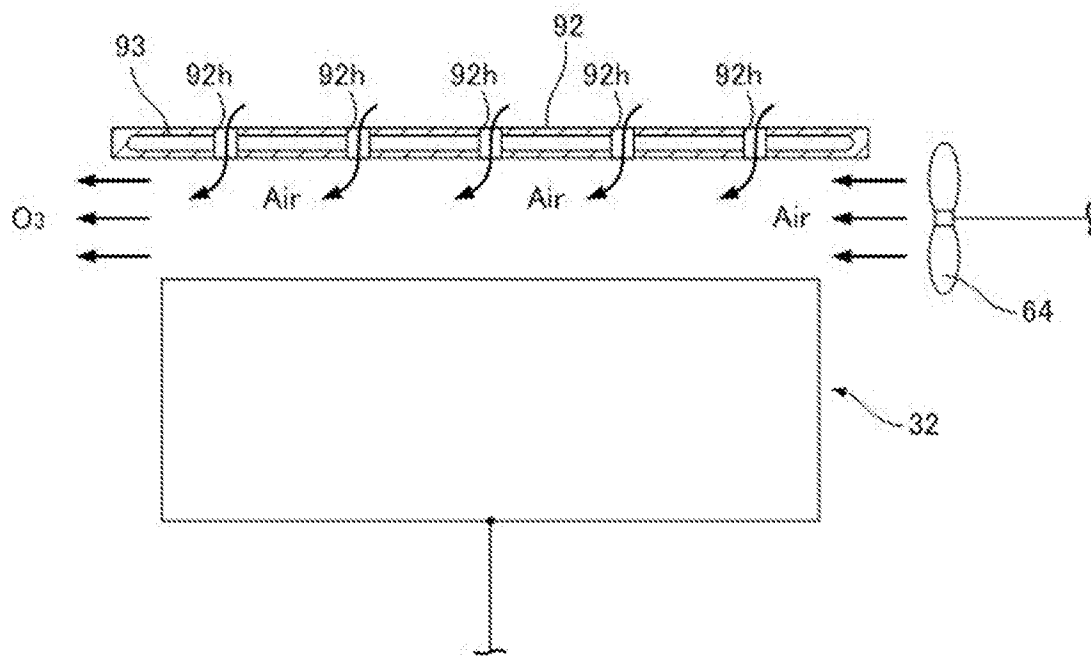
[Fig. 8]



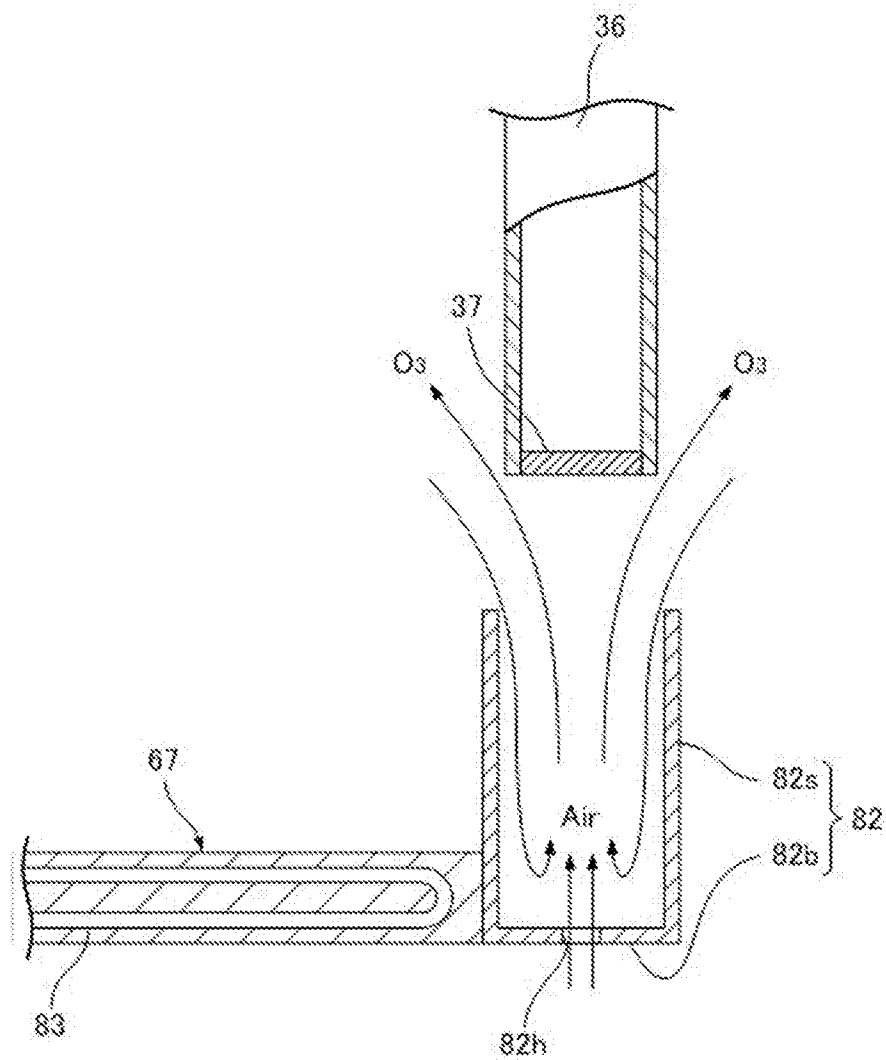
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[Fig. 10]



[Fig. 11]



INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2015/006340

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61L2/08 A61L2/20 B29C49/06
ADD.

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)

A61L B29C

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

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

EPO-Internal, WPI Data

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X	EP 2 100 814 A1 (SHIBUYA KOGYO CO LTD [JP]) 16 September 2009 (2009-09-16) paragraph [0023]; figure 2 ----- -/-	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

7 March 2016

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INTERNATIONAL SEARCH REPORT

International application No

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