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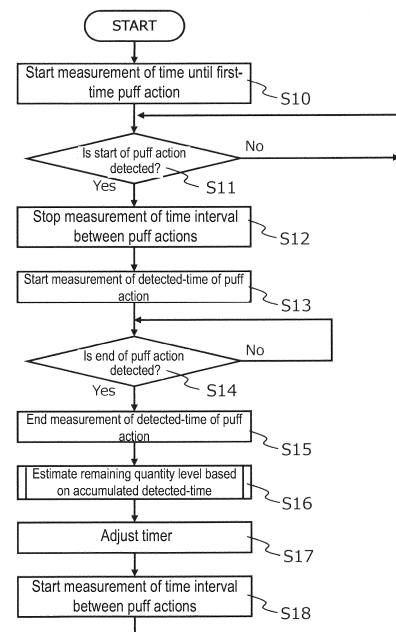
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(54) **OPERATION METHOD FOR INHALATION DEVICE, PROGRAM, AND INHALATION DEVICE**

(57) The present invention provides an operation method for an inhalation device by which it is possible to suitably ascertain the state of consumption of an inhalation component source in the inhalation device during use, while taking into consideration tendencies regarding inhalation actions by a user. Said method includes: causing a sensor to detect a series of puff actions by the user; measuring the time interval between a first puff action and an immediately preceding second puff action in order to acquire the value of a puff action interval pertaining to the first puff action; measuring a detection time, which is a puff action period during which the first puff action continues; using a time correction model associated with the puff action interval and the puff action period to correct the detection time; cumulatively adding the corrected detection time and calculating a cumulative detection time; and estimating the residual amount level of the inhalation component source on the basis of the cumulative detection time. The value of the puff action interval pertaining to the first puff action is acquired by adjusting the measurement of the time interval in accordance with the value of the puff action period that has been acquired pertaining to the second puff action.

Fig. 11



Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a method and a program for operating an inhaler, and the inhaler.

BACKGROUND ART

10 **[0002]** Inhalers for generating materials, that are to be inhaled by users, have been spread widely. Examples of inhalers are electronic cigarettes and nebulizers. An inhaler such as that explained above generates, for example, flavor-component-added aerosol by using an aerosol source used for generating aerosol and a base material including a flavor source and so on used for adding flavor components to generated aerosol. A user can taste flavor by inhaling flavor-component-added aerosol generated by an inhaler.

15 **[0003]** When inhaling action is performed by a user by using an inhaler, the inhaler performs control of heating operation for raising temperature of a heater by supplying electric power thereto for atomizing an inhaled component source. A method for grasping the quantity of consumption of an inhaled component source or judging a depletion state of an inhaled component source by using various kinds of data such as temperature of a heater, the quality of supplied electric power, electric resistance, and so on, that are obtained in relation to heating operation such as that explained above, has been known.

CITATION LIST

PATENT LITERATURE

25 **[0004]**

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SUMMARY OF INVENTION

TECHNICAL PROBLEM

40 **[0005]** It is desired to improve the quality of experience that the user is provided with when an inhaler is used.

[0006] Accordingly, the present disclosure is provided in view of the above matter; and an object of the present disclosure is to provide a construction that is able to improve the quality of experience that is provided when an inhaler is used (hereinafter, "inhalation experience"). Thus, an object of the present disclosure is to provide a construction that takes a tendency of inhalation action performed by a user into consideration, and, at the same time, is able to appropriately
 45 grasp the state of consumption of an inhaled component source in an inhaler which is being used.

SOLUTION TO PROBLEM

50 **[0007]** For achieving the above objects, a method for operating an inhaler is provided according to an aspect of the present disclosure. The method includes making a sensor detect a series of puff actions performed by a user; measuring a time interval between a first puff action and a second puff action just before the first puff action to obtain a value of a puff action interval relating to the first puff action; measuring detected-time of the first puff action to obtain a value of a puff action period during that the first puff action continues; correcting the detected-time by using a time correction model relating to the puff action interval and the puff action period; calculating accumulated detected-time by accumulating the
 55 corrected detected-time; and estimating a remaining quantity level of an inhaled component source, based on the accumulated detected-time; wherein the value of the puff action interval relating to the first puff action is obtained by adjusting, according to the value of the puff action period that has been obtained with respect to the second puff action,

measurement of the time interval.

[0008] According to the above method, it becomes possible to estimate an appropriate accumulated detected-time, and, accordingly, improve accuracy of estimating of the remaining quantity levels/level of the flavor source and/or the aerosol source. Further, appropriate grasping of a remaining quantity and notification relating thereto can be realized.

[0009] In the case that the value of the puff action period relating to the second puff action is shorter than predetermined first time, measurement of the time interval may be adjusted in such a manner that the measurement resumes from a point corresponding to the value of the puff action interval that has been obtained with respect to the second puff action. By adopting the above construction, it becomes possible to estimate appropriate accumulated detected-time, and, accordingly, further improve accuracy of estimating of the remaining quantity levels/level of the flavor source and/or the aerosol source.

[0010] The first time may be set to 0.5 seconds. By adopting the above construction, efficient estimating of the remaining quantity level(s) can be realized.

[0011] Said estimating the remaining quantity level of the inhaled component source may include judging that the remaining quantity of the inhaled component source is insufficient, in the case that the accumulated detected-time has reached predetermined second time. By adopting the above construction, appropriate detection relating to the life can be realized.

[0012] The method may further include making the inhaler output notification for informing insufficiency of the remaining quantity, in response to the judgment representing the matter that the remaining quantity of the inhaled component source is insufficient. By adopting the above construction, appropriate notification relating to the life can be realized.

[0013] The time correction model may be defined to include a characteristic that the detected-time to be corrected is maintained to be predetermined third time, in the case that the value of the detected-time is the third time. By adopting the above construction, it becomes possible to further improve accuracy of estimating of the remaining quantity level of the inhaled component source, by generating a more appropriate time correction model.

[0014] The time correction model may be defined to include a characteristic that the detected-time is shortened, in the case that the value of the detected-time is smaller than the third time. By adopting the above construction, it becomes possible to further improve accuracy of estimating of the remaining quantity level of the inhaled component source, by generating a more appropriate time correction model.

[0015] The third time may be set to 2.4 seconds. By adopting the above construction, it becomes possible to further improve accuracy of estimating of the remaining quantity level of the inhaled component source, by generating a more appropriate time correction model.

[0016] The time correction model may be defined to include a characteristic that the measured detected-time is increased by adding adjustment time, that is calculated based on the puff action interval, to the value of the measured detected-time, in the case that the value of the puff action interval is smaller than fourth time. By adopting the above construction, it becomes possible to further improve accuracy of estimating of the remaining quantity level of the inhaled component source, by generating a more appropriate time correction model.

[0017] The method may further include performing initial setting to set the value of the puff action interval, that relates to the second puff action, to the fourth time in the case that the second puff action is a first puff action. By adopting the above construction, an appropriate time correction model can be applied more effectively.

[0018] The fourth time may be set to 10 seconds. By adopting the above construction, it becomes possible to further improve accuracy of estimating of the remaining quantity level of the inhaled component source, by generating a more appropriate time correction model.

[0019] According to a different aspect of the present disclosure, a program which makes the inhaler perform the above-explained method is provided.

[0020] According to a further different aspect of the present disclosure, an inhaler is provided. The inhaler comprises a sensor for detecting a series of puff actions performed by a user; and a controller for making the inhaler perform operation for measuring a time interval between a first puff action and a second puff action just before the first puff action to obtain a value of a puff action interval relating to the first puff action detected by the sensor; measuring detected-time of the first puff action to obtain a value of a puff action period during that the first puff action continues; correcting the detected-time by using a time correction model relating to the puff action interval and the puff action period; calculating accumulated detected-time by accumulating the corrected detected-time; and estimating a remaining quantity level of an inhaled component source, based on the accumulated detected-time; wherein the value of the puff action interval relating to the first puff action is obtained by adjusting, according to the value of the puff action period that has been obtained with respect to the second puff action, measurement of the time interval.

[0021] According to the above inhaler, it becomes possible to estimate an appropriate accumulated detected-time, and, accordingly, improve accuracy of estimating of the remaining quantity levels/level of the flavor source and/or the aerosol source. Further, appropriate grasping of a remaining quantity and notification relating thereto can be realized.

[0022] As explained above, according to the present disclosure, a construction that makes it possible to further improve the quality of experience, that is gained when an inhaler is used, is provided.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

Fig. 1A is a schematic block diagram of a construction of an inhaler.
 Fig. 1B is a schematic block diagram of a construction of an inhaler.
 Fig. 2 is a schematic graph showing an example of relationship between the number of times of puffs and puff action periods.
 Fig. 3 is a schematic graph showing an example of an atomization characteristic 1 of an aerosol source.
 Fig. 4 is a schematic graph showing an example of an atomization characteristic 2 of an aerosol source.
 Fig. 5 is a schematic graph showing an example of an atomization characteristic 1a of an aerosol source.
 Fig. 6A is a schematic graph showing an example of a time correction model 1A_{IP} corresponding to the atomization characteristic 1a.
 Fig. 6B is a schematic graph showing an example of a time correction model 1A based on the atomization characteristic 1a.
 Fig. 7 is a schematic graph showing an example of an atomization characteristic 2a of an aerosol source.
 Fig. 8 is a schematic graph showing an example of a time correction model 2A corresponding to the atomization characteristic 2a.
 Fig. 9 is a schematic graph showing an example of a time correction model MD based on the atomization characteristics 1a and 2a.
 Fig. 10 is a schematic block diagram of an example of a construction of an inhaler according to an embodiment.
 Fig. 11 is a schematic flow chart of an example of an operation method of an inhaler according to an embodiment.
 Fig. 12 is a schematic flow chart relating to an example of a process for estimating, based on accumulated puff-action detected-time, the remaining quantity level.
 Fig. 13 is a schematic flow chart relating to an example of a process for correcting puff-action detected-time.
 Fig. 14 is a schematic flow chart relating to an example of a process of initial setting of the value of a puff-action interval.
 Fig. 15 is a schematic conceptual drawing showing an example of a detected series of puff actions.
 Fig. 16 is a schematic flow chart relating to an example of a process of adjustment of a timer according to a modification example.
 Fig. 17 is a schematic graph showing an example of a time correction model MD' according to a modification example.
 Fig. 18 is a schematic flow chart relating to an example of a process for correcting puff-action detected-time according to a modification example.

DESCRIPTION OF EMBODIMENTS

[0024] In the following description, respective embodiments of the present disclosure will be explained in detail with reference to the attached figures. It should be reminded that, although the embodiments of the present disclosure comprise an electronic cigarette and a nebulizer, the components are not limited to them. The embodiments of the present disclosure may comprise various inhalers for generating aerosol or flavor-added aerosol inhaled by users. Further, the generated inhaled components may include invisible vapor, in addition to aerosol. In the following description, inhalation action performed by a user is referred to as "puff action," or simply "puff," and one of or both an aerosol source and a flavor source is/are referred to as an "inhaled component source."

« 1. Construction Examples of Inhalers »

[0025] Fig. 1A is a schematic block diagram of a construction of an inhaler 100A according to each embodiment of the present disclosure. Fig. 1A is that schematically and conceptually showing respective components included in the inhaler 100A, and is not that showing precise positions, shapes, sizes, positional relationship, and so on of the respective components and the inhaler 100A.

[0026] As shown in Fig. 1A, the inhaler 100A comprises a first member 102 and a second member 104. As shown in the figure, in an example, the first member 102 may be an electric power source unit, and may comprise a controller 106, a notifier 108, a battery 110, a sensor 112, and a memory 114. Also, in an example, the second member 104 may be a cartridge, and may comprise a reservoir 116, an atomizer 118, an air taking-in flow path 120, an aerosol flow path 121, and a suction opening part 122.

[0027] Part of components included in the first member 102 may be included in the second member 104. Part of components included in the second member 104 may be included in the first member 102. The second member 104 may be constructed to be attachable/detachable to/from the first member 102. Alternatively, all components included in

the first member 102 and the second member 104 may be included in a single same housing in place of the first member 102 and the second member 104.

[0028] An electric power source unit, which is the first member 102, comprises the notifier 108, the battery 110, the sensor 112, and the memory 114, and is electrically connected to the controller 106. In the above components, the notifier 108 may comprise a light emitting element such as an LED or the like, a display, a speaker, a vibrator, and so on. It is preferable that the notifier 108 provide a user with notification in various forms, by light emission, display, vocalization, vibration, or the like, or a combination thereof, as necessary. In an example, it is preferable that the remaining quantity level or the replacement timing of an inhaled component source included in the reservoir 116 in the second member 104 be notified in various forms.

[0029] The battery 110 supplies electric power to the respective components, such as the notifier 108, the sensor 112, the memory 114, the atomizer 118, and so on, in the inhaler 100A. Especially, the battery 110 supplies electric power to the atomizer 118 for atomizing an aerosol source in response to puff action of a user. The battery 110 can be connected to an external electric power source (for example, a USB (Universal Serial Bus) connectable charger) via a predetermined port (which is not shown in the figure) installed in the first member 102.

[0030] It may be constructed in such a manner that the battery 110 only can be detached from the electric power source unit 102 or the inhaler 100A, and can be replaced by a new battery 110. Also, it may be constructed in such a manner that the battery 110 can be replaced by a new battery 110, by replacing the whole electric power source unit by a new electric power source unit.

[0031] The sensor 112 comprises various kinds of sensors. For example, the sensor 112 may comprise a suction sensor such as a microphone condenser, for precisely detecting puff action of a user. Further, the sensor 112 may comprise a pressure sensor for detecting change in the pressure or a flow rate sensor for detecting a flow rate in the air taking-in flow path 120 and/or the aerosol flow path 121. The sensor 112 may comprise a weight sensor for detecting the weight of a component such as the reservoir 116 or the like.

[0032] Further, the sensor 112 may be constructed to detect the height of a liquid surface in the reservoir 116. Further, the sensor 112 may be constructed to detect an SOC (State of Charge, charge state) of the battery 110, and a discharging state, an integrated current value, a voltage, or the like of the battery 110. The integrated current value may be obtained by using a current integration method, an SOC-OCV (Open Circuit Voltage, open circuit voltage) method, or the like. Further, the sensor 112 may comprise a temperature sensor for measuring the temperature of the controller 106. Further, the sensor 112 may be a manipulation button which can be manipulated by a user, or the like.

[0033] The controller 106 may be an electronic circuit module constructed as a microprocessor or a microcomputer. The controller 106 may be constructed to control operation of the inhaler 100A in accordance with computer-executable instructions stored in the memory 114. Further, the controller 106 may comprise a timer and may be constructed to measure (i.e. count), based on a clock, a desired period of time by use of the timer. In an example, the controller 106 may measure, by use of the timer, an action period during that puff action is being detected by the suction sensor and an action interval between successive puff actions.

[0034] The controller 106 reads data from the memory 114 and uses the data for controlling the inhaler 100A as necessary, and stores data in the memory 114 as necessary.

[0035] The memory 114 is a storage medium such as a ROM (Read Only Memory), a RAM (Random Access Memory), a flash memory, or the like. The memory 114 may store, in addition to computer-executable instructions such as those explained above, setting data and so on that are necessary for controlling the inhaler 100A and/or the electric power source unit 102, and may mainly be used by the controller 106. For example, the memory 114 may store various data such as methods for controlling the notifier 108 (modes of light emission, vocalization, vibration, etc., and so on), values detected by the sensor 112, information relating to an attached cartridge, history of heating relating to the atomizer 118, and so on.

[0036] Regarding the cartridge which is the second member 104, the reservoir 116 holds an aerosol source which is an inhaled component source. For example, the reservoir 116 comprises fibrous or porous material, and holds an aerosol source, which is in the form of liquid, by use of spaces between fibers or pores in the porous material. For example, cotton or glass fibers, or tobacco raw material, or the like, may be used as material of the fibrous or porous material. The reservoir 116 may be constructed as a tank for storing liquid. The aerosol source is liquid such as polyhydric alcohol, such as glycerin or propylene glycol, or water, or the like, for example.

[0037] In the case that the inhaler 100A is an inhaler for medical use, such as a nebulizer or the like, the aerosol source may also comprise a medicine that is to be inhaled by a patient. In a different example, the aerosol source may comprise a tobacco raw material or an extract originated from a tobacco raw material, which releases a fragrance-inhaling-taste component when it is heated. The reservoir 116 may have a construction which allows replenishment of a consumed aerosol source. Also, the reservoir 116 may be constructed in such a manner that the reservoir 116 itself is allowed to be replaced when the aerosol source is exhausted. Further, the aerosol source is not limited to that in a liquid form, and it may be solid. In the case that the aerosol source is solid, the reservoir 116 may be a hollow container which does not use fibrous or porous material, for example.

[0038] The atomizer 118 is constructed to generate aerosol from an aerosol source. In more detail, the atomizer 118 generates aerosol by atomizing or vaporizing an aerosol source. In the case that the inhaler 100A is a medical inhaler such as a nebulizer or the like, the atomizer 118 generates aerosol by atomizing or vaporizing an aerosol source including a medicine.

[0039] When puff action is detected by the sensor 112, the atomizer 118 generates aerosol by receiving supply of electric power from the battery 110 and heating the aerosol source thereby. For example, a wick (which is not shown in the figure) may be installed for connection between the reservoir 116 and the atomizer 118. In the above case, a part of the wick extends to the inside of the reservoir 116 and is in contact with the aerosol source. The other part of the wick extends toward the atomizer 118. The aerosol source is sent from the reservoir 116 to the atomizer 118 by capillary effect in the wick.

[0040] In an example, the atomizer 118 comprises a heater which is electrically connected to the battery 110. The heater is arranged to be in contact with or to be positioned close to the wick. When a puff action is detected, the controller 106 controls the heater in the atomizer 118 to heat an aerosol source, which is conveyed via the wick, to thereby atomize the aerosol source. The other example of the atomizer 118 may be an ultrasonic-type atomizer which atomizes the aerosol source by ultrasonic vibration.

[0041] The air taking-in flow path 120 is connected to the atomizer 118, and the air taking-in flow path 120 leads to the outside of the inhaler 100A. The aerosol generated in the atomizer 118 is mixed with air that is taken via the air taking-in flow path 120. The fluid mixture comprising the aerosol and the air is sent to the aerosol flow path 121, as shown by an arrow 124. The aerosol flow path 121 has a tubular structure for sending the fluid mixture comprising the air and the aerosol, that is generated in the atomizer 118, to the suction opening part 122.

[0042] The suction opening part 122 is constructed in such a manner that it is positioned at an end of the aerosol flow path 121, and makes the aerosol flow path 121 be opened toward the outside of the inhaler 100A. A user can take air including the aerosol into the user's mouth by holding the suction opening part 122 in the user's mouth and performing a suction action.

[0043] Fig. 1B is a schematic block diagram of a construction of an inhaler 100B according to each embodiment of the present disclosure. As shown in Fig. 1B, the inhaler 100B comprises a third member 126, in addition to the constructions included in the inhaler 100A in Fig. 1A. The third member 126 may be a capsule, and may comprise a flavor source 128. For example, in the case that the inhaler 100B is an electronic cigarette, the flavor source 128 may comprise a fragrance-inhaling-taste component included in tobacco. As shown in the figure, the aerosol flow path 121 extends across the second member 104 and the third member 116. The suction opening part 122 is installed in the third member 126.

[0044] The flavor source 128 is a component for adding flavor to aerosol. The flavor source 128 is positioned in the middle of the aerosol flow path 121. The fluid mixture comprising the air and the aerosol generated by the atomizer 118 (it should be reminded that the fluid mixture may simply be referred to as aerosol, hereinafter) flows to the suction opening part 122 through the aerosol flow path 121. In this manner, in the point of view of the flow of the aerosol, the flavor source 128 is arranged in a position downstream the atomizer 118. In other words, in the aerosol flow path 121, the position of the flavor source 128 is closer to the suction opening part 122 than the position of the atomizer 118.

[0045] Thus, the aerosol generated in the atomizer 118 passes through the flavor source 128 and thereafter arrives at the suction opening part 122. When the aerosol passes through the flavor source 128, fragrance-inhaling-taste components included in the flavor source 128 are added to the aerosol. For example, in the case that the inhaler 100B is an electronic cigarette, the flavor source 128 may be that which originates from tobacco, such as shredded tobacco, a product which is made by processing tobacco raw material to have a granular form, a sheet form, or a powder form, or the like.

[0046] The flavor source 128 may be that which does not originate from tobacco, such as that made by use of a plant other than tobacco (for example, mint, a herb, and so on). For example, the flavor source 128 comprises a nicotine component. The flavor source 128 may comprise a flavor component such as menthol or the like. In addition to the flavor source 128, the reservoir 116 may also have a material comprising a fragrance-inhaling-taste component. For example, the inhaler 100B may be constructed in such a manner that the flavor source 128 holds flavor material which originates from tobacco and the reservoir 116 includes flavor material which does not originate from tobacco.

[0047] In the manner explained above, a user can take air including the aerosol, to which the flavor has been added, into the mouth by holding the suction opening part 122 in the user's mouth and performing a suction action.

« 2. Technical Characteristics »

[0048] Operation of each of the inhalers 100A and 100B (hereinafter, they may collectively be referred to as an "inhaler 100") according to an embodiment of the present disclosure is controlled by the controller 106 by using various methods. In the following description, the inhaler and methods for operating the inhaler according to embodiments of the present disclosure will be explained in detail.

(1) Basic Method for Estimating Remaining Quantity Level of Inhaled Component Source

[0049] For providing a user with a comfortable inhalation experience and continuously providing the user with sufficient flavor-added aerosol, it is preferable to appropriately grasp the remaining quantity level (or the consumption level) of the aerosol source and/or the flavor source 128 stored in the reservoir 116 and/or the capsule. At that time, it is preferable to further appropriately grasp the remaining quantity level (or the consumption level) by especially taking a tendency and/or a characteristic of puff action performed by the user into consideration. Further, it is preferable to urge the user to replace the cartridge and/or the capsule at timing when it is judged that there is no remaining quantity. In an example for appropriately grasping the remaining quantity level, it is preferable that the controller 106 perform the grasping operation based on judgment as to whether the accumulated time has reached a predetermined threshold value, wherein the accumulated time is the time that has been spent by a user for performing puff action.

[0050] For example, regarding an aerosol source in the reservoir 116 held in the cartridge, the controller 106 may judge that the aerosol source has been exhausted, at the time when the accumulated time of puff action reaches a predetermined upper limit, after attaching of the cartridge (after the memory is reset to 0 second). Regarding the cartridge, the above predetermined upper limit is 1000 seconds, for example. In the inhaler 100B, regarding a flavor source held in the capsule, it may be judged, in a manner similar to the above manner, that the flavor source has been exhausted, at the time when the accumulated time of puff action reaches a predetermined upper limit, after attaching of the capsule (after the memory is reset to 0 second). Regarding the capsule, the above predetermined upper limit is 100 seconds, for example. Further, in the case that it is judged that the aerosol source and/or the flavor source have/has been exhausted, it is preferable to urge a user to replace the cartridge and/or the capsule which hold/holds the aerosol source and/or the flavor source.

[0051] The above matters are based on the technical idea that, during the period when a user is performing a series of puff actions and the inhaler 100 is accepting the puff actions stably, the quantities/quantity of consumption of the cartridge and/or the capsule are/is substantially proportional to an accumulated value of puff action periods. Further, by using the above matter as a premise, it becomes possible to define, by using the accumulated time as a parameter, the quantities/quantity of consumption of the aerosol source and/or the flavor source, and measure them/it easily.

[0052] Fig. 2 is a schematic graph showing an example of relationship between the number of times of puffs, puff action periods, and accumulated puff action periods, relating to consumption of a flavor source held in a capsule. The horizontal axis represents the number of times of puffs (n-th time) after attaching of a new capsule. Further, the left vertical axis represents a puff action period (in seconds) per single puff action, and the right vertical axis represents an accumulated puff action period (in seconds). Further, bars in the bar graph represent puff action periods (in seconds) measured with respect to respective numbers of times of puffs, and the line graph represents the accumulated puff action periods (in seconds).

[0053] In the example shown in the figure, a single puff action period is that in the range from 0.3 seconds to 2.4 seconds, approximately, and 65 times of puff actions are required for incrementing the accumulated puff action period (in seconds) to become 100 seconds. That is, regarding the capsule, in the case that the predetermined upper limit threshold value relating to the accumulated time of puff action has been set to 100 seconds, it is preferable to judge, in response to the 65th puff action, that the flavor source has been exhausted. Further, it is preferable that the consumption level be calculated based on the value of the accumulated puff action period. For example, in the case that the value of the accumulated puff action period until the 32th puff action is 50 seconds, it is preferable that the consumption level be inferred as 50 % (50 seconds / 100 seconds * 100). It should be reminded that, regarding the case of the inhaler 100B, the matter that "the upper limit threshold value of the accumulated time of puff action is 100 seconds" means that is based on the technical idea that the total quantity of aerosol, that has been generated by atomizing the aerosol source in response to puff action performed for 100 seconds, that is the accumulated time, and has passed through the flavor source, is the quantity that is sufficient to make the flavor source reach the end of its life. In this regard, "the flavor source reaches the end of its life" means that the state becomes that wherein sufficient flavor cannot be added to aerosol that is generated by consuming and atomizing the aerosol source.

[0054] In the following description, based on profound knowledge obtained by the inventors, a method for estimating a remaining quantity level, that is more precise than the above-explained basic method, will be suggested. According to an experiment performed by the inventors, it has been ascertained that, in the case that an estimation method including a process for associating an accumulated puff action period with a remaining quantity level is used, estimation accuracy can be further improved by incorporating, in the estimation method, a control technique for correcting, based on an atomization characteristic of an aerosol source, a value of a puff action period.

(2) Atomization Characteristics of Aerosol Source

[0055] Each of Fig. 3 and Fig. 4 is a schematic graph showing an atomization characteristic of an aerosol source, relating to puff action performed by a user by using the inhaler 100. By using each of the above graphs as the basis, a

basic atomization characteristic of an aerosol source in an atomization phenomenon in the inhaler 100 can be specified.

[0056] The graph in Fig. 3 relates to an atomization phenomenon in the inhaler 100 using a sample flavor source, and shows an example of relationship between a puff action period and an atomization quantity per single puff action. The horizontal axis represents a puff action period (in seconds) per single puff action. Specifically, a puff action period is a period from a start of a puff action to an end of the puff action. The vertical axis represents an atomization quantity per single puff action, that is, a consumption quantity (mg / puff action) of the aerosol source. Specifically, the atomization quantity is a quantity calculated by subtracting, from the weigh of the aerosol source at the time of a start of a puff action, the weigh of the aerosol source at the time of an end of the puff action.

[0057] In more detail, regarding the puff action period represented by the horizontal axis, data thereof can be obtained by detecting the time of a start of a puff action and the time of an end of the puff action by using a suction sensor, and measuring a continuous period between the start time and the end time of the puff action by the timer. Further, regarding the atomization quantity represented by the vertical axis, the data thereof can be obtained by measuring the weigh of the aerosol source at the time of a start of a puff action and the weigh of the aerosol source at the time of an end of the puff action by using, for example, a weight sensor, and calculating a difference in the weight.

[0058] In Fig. 3, 13 sample points that were measured in an atomization phenomenon are plotted. Also, an actual atomization curve line (a solid line), that is based on the above 13 sample points, and a theoretical atomization straight line (a broken line) are shown. The theoretical atomization straight line is drawn in such a manner that an origin and a sample point (2.4 seconds, the longest puff action period) that is the farthest from the origin are connected with each other by the straight line. The above is based on the idea that, in puff action, the atomization quantity increases in proportion to the suction time.

[0059] As shown in the figure, when the actual atomization curve line and the theoretical atomization straight line are compared, it can be understood that there is separation between them. Specifically, unlike the theoretical atomization straight line, the puff action period and the actual atomization quantity are not proportional to each other in the actual atomization curve line. Especially, regarding each of the puff action periods having lengths shorter than approximately 2.4 seconds, it can be seen, at least, that the actual atomization quantity is smaller than the theoretical atomization quantity. In more detail, the different between the above two quantities becomes larger as the time of the puff action period becomes longer, until the time reaches approximately 1 second (difference 1), and, thereafter, becomes smaller as the time of the puff action period further becomes longer (difference 2). The above matter occurs due to certain rise time that is required and so on, wherein the rise time is that from the time when heating operation of a heater is started at a start of a puff action to the time when the temperature reaches preferred temperature that makes it possible to perform atomization.

[0060] The graph in Fig. 4 relates to an atomization phenomenon in the inhaler 100 using a sample flavor source, and shows an example of relationship between an action interval between two successive puff actions and an atomization quantity atomized through the two successive puff actions. The horizontal axis represents a puff action interval (in seconds) between two successive puff actions. Specifically, a puff action interval is a period from an end of a first puff action to a start of a next, i.e., a second puff action. The vertical axis represents an atomization quantity, that is, a consumption quantity (mg / two puff actions), of an aerosol source atomized through two successive puff actions. Specifically, the atomization quantity of the aerosol source is a quantity calculated by subtracting, from the weigh of the aerosol source at the time of a start of a first puff action, the weigh of the aerosol source at the time of an end of a second puff action.

[0061] In more detail, regarding the puff action interval, data thereof can be obtained by detecting the time of a start of a puff action and the time of an end of a puff action by using a suction sensor, and measuring time between a period from the time of an end of the first puff action and the time of a start of the second puff action by the timer. Further, regarding the atomization quantity, the data thereof can be obtained by measuring the weigh of the aerosol source at the time of a start of the first puff action and the weigh of the aerosol source at the time of an end of the second puff action by using, for example, a weight sensor, and calculating a difference in the weight.

[0062] In Fig. 4, 9 sample points that were measured in an atomization phenomenon are plotted. Further, regarding 7 pieces of data relating to puff action intervals, each thereof is approximately equal to or shorter than 10 seconds, a regression line is shown; wherein the regression line is based on linear regression that uses a puff action interval as an explanatory variable and an atomization quantity as an objective variable. As shown in the figure, there is negative correlation in the present case. That is, in an actual atomization phenomenon, the atomization quantity of the atomized aerosol source becomes larger (approximately 8.8 mg - 9.3 mg) as the puff action interval becomes shorter. On the other hand, regarding the case wherein each of puff action intervals is longer than approximately 10 seconds, the atomization quantity of the aerosol source is generally constant and stabilized (approximately 8.1 mg: the dotted line). The above matter in the atomization phenomenon in the inhaler 100 occurs due to rise time, that is shorter than usual rise time, of the heater when a puff action subsequent to a previous puff action is started in the condition that the puff action interval is equal to or shorter than 10 seconds, and so on; wherein the reason that the rise time is shortened is that the heater heated during the previous puff action is not cooled sufficiently and residual heat remains in the heater.

As a result, the atomization quantity becomes larger compared with those in the stable state wherein each puff action interval is longer than 10 seconds.

[0063] In this manner, regarding the atomization phenomenon of an aerosol source, it is preferable to specify two atomization characteristics of the aerosol source in advance, and reflect them to controlling of estimation of the remaining quantity level. Specifically, by incorporating the control technique for correcting a value of a puff action period based on the above two atomization characteristics, it becomes possible to further improve accuracy of estimation of the remaining quantity of the aerosol source and/or the remaining quantity of the flavor source. In the following description, the two atomization characteristics (atomization characteristics 1 and 2) of the aerosol source are summarized.

[Atomization Characteristic 1]

[0064] The atomization characteristic 1 is defined based on relationship between sample action periods of puff action and atomization quantities (Fig. 3). In the present case, an actual atomization quantity of an aerosol source is lower than a theoretical atomization quantity. Further, regarding the case that a puff action period is approximately equal to or shorter than 1 second, the different between the theoretical value and the measured value becomes larger as the time of the puff action period becomes longer. On the other hand, regarding the case that a puff action period is approximately equal to or longer than 1 second, the different between the theoretical value and the measured value becomes smaller as the time of the puff action period becomes longer. In any of the above cases, if an actual value of a puff action period is applied as it stands to estimation of a remaining quantity level, a remaining quantity larger than an actual remaining quantity may be estimated; so that it is preferable to correct the value of the puff action period to make it somewhat smaller, and, thereafter, estimate the remaining quantity level of the aerosol source.

[0065] Similarly, as explained above, an actual atomization quantity of an aerosol source is lower than a theoretical atomization quantity. That is, regarding the case of the inhaler 100B in which the cartridge 104 and the capsule 126 are constructed by use of different components, an actual quantity of aerosol that passes through the flavor source held in the capsule 126 is smaller than a theoretical quantity of aerosol. That is, by adopting the construction for correcting the value of a puff action period to make it somewhat smaller and thereafter estimating a remaining quantity level of the flavor source, accuracy of estimation of the remaining quantity of the aerosol source and the remaining quantity of the flavor source can be further improved.

[Atomization Characteristic 2]

[0066] The atomization characteristic 2 is defined based on relationship between sample action intervals between respective two successive puff actions and atomization quantities of an aerosol source (Fig. 4). In the present case, there is negative correlation between puff action intervals and atomization quantities of the aerosol source in the case that each of the puff action intervals is approximately equal to or shorter than 10 seconds, so that the atomization quantity of the aerosol source becomes smaller as the puff action interval becomes longer. That is, regarding the case that the puff action interval is equal to or shorter than 10 seconds, if an actual value of a puff action period is applied as it stands to estimation of a remaining quantity level, a remaining quantity may be estimated as that smaller than an actual remaining quantity. Thus, it is preferable to correct the value of the puff action period to make it somewhat larger, and estimate the remaining quantity level of the aerosol source.

[0067] Similarly, as explained above, in the case that each of puff action intervals is equal to or shorter than 10 seconds (or is shorter than 10 seconds), if an actual value of a puff action period is applied as it stands to estimation of a remaining quantity level, a remaining quantity may be estimated as that smaller than an actual remaining quantity. That is, in the case of the inhaler 100B in which the cartridge 104 and the capsule 126 are constructed by use of different components, an actual quantity of aerosol that passes through the flavor source held in the capsule 126 may be estimated as that smaller than the actual quantity of aerosol. Thus, by adopting the construction for correcting the value of the puff action period to make it somewhat larger and estimating a remaining quantity level of the flavor source, accuracy of estimation of the remaining quantity of the aerosol source and the remaining quantity of the flavor source can be further improved.

[0068] Based on the atomization characteristics 1 and 2 of an aerosol source relating to puff action, the inhaler 100 according to the present embodiment is constructed to accurately estimate a remaining quantity level, through dynamic correction of detected-time that is the time during that a detected puff action is continued. That is, it becomes possible to estimate a puff action period and an accumulated puff action period more accurately, compared with detected-time of an actually detected puff action, so that appropriate estimation of the remaining quantity levels/level of the flavor source and/or the aerosol source is realized. By using the above technique, appropriate estimation of a consumption level, judgment with respect to replacement, and notification relating to a cartridge and/or a capsule is realized.

(3) Time Correction Model Defined Based on Atomization Characteristic

[0069] Methods for generating time correction models 1A and 2A for correcting detected-time of detected puff actions, according to the atomization characteristics 1a and 2a of an aerosol source will be explained respectively with reference to Fig. 5 to Fig. 9. The atomization characteristics 1a and 2a of an aerosol source are those defined by further studying the above-explained atomization characteristics 1 and 2. Fig. 5 to Fig. 7 are schematic figures for explaining the atomization characteristics 1a and 2a of the aerosol source. Fig. 6A and Fig. 6B are schematic figures for explaining time correction models 1A_{ID} and 1A, respectively, that are based on the atomization characteristic 1a of the aerosol source. Fig. 8 is a schematic figure for explaining a time correction model 2A that is based on the atomization characteristic 2a of the aerosol source. Fig. 9 is a schematic figure for explaining a time correction model MD that is based on the atomization characteristics 1a and 2a of the aerosol source.

[Time Correction Model 1A Based on Atomization Characteristic 1a]

[0070] Based on the above-explained atomization characteristic 1 of the aerosol source, the atomization characteristic 1a is further defined. Similar to the case of the atomization characteristic 1 of the aerosol source shown in Fig. 3, Fig. 5 is a graph that shows an actual atomization line as a polygonal line graph, by using 13 sample points of the puff action periods and the atomization quantities of the aerosol source (and/or the flavor source), and defines the atomization characteristic 1a. The value of the atomization quantity at each sample point is that obtained by performing plural number of times of measurement of the atomization quantities of the aerosol source during each predetermined puff action period by performing an experiment, and calculating an average thereof.

[0071] As studied in relation to the above-explained atomization characteristic 1, an actual atomization quantity of an aerosol source is smaller than a theoretical atomization quantity. That is, in the case that an actual value of the puff action period, as it stands, is applied to estimation of the remaining quantity level to calculate an ideal value, the atomization quantity may be estimated as that larger than an actual atomization quantity, so that there may be a case that the quantity larger than the estimated quantity of the aerosol source may remain. That is, it is preferable that the value of the puff action period be used, after correcting it to be somewhat smaller, in estimation of the remaining quantity level. In this regard, the maximum value of the puff action period is set to 2.4 seconds according to the atomization characteristic 1 of the aerosol source (Fig. 3), in the present embodiment. Regarding 2.4 seconds, it is the value with respect to that the consumption efficiency of the aerosol source in the inhaler is the highest. However, the above value is a mere example, and it is preferable to set, in accordance with a device characteristic and/or a design of an inhaler, an ideal value with respect to that the consumption efficiency of the aerosol source in the inhaler is the highest.

[0072] Fig. 6A shows an example of a time correction model 1A_{ID} based on the atomization characteristic 1a of the aerosol source. The time correction model 1A_{ID} corresponds to the atomization characteristic 1a that is shown in Fig. 5 and obtained by performing an experiment. In the graph shown in Fig. 6A, the horizontal axis (x axis) represents a puff action period (in seconds) and the vertical axis (y axis) represents a corrected puff action period (in seconds) relating to the puff action period.

[0073] Specifically, it is preferable that the corrected puff action period be determined in accordance with a relative atomization quantity ratio with respect to each predetermined puff action period, by using, as the basis, 2.4 seconds that is an ideal value with respect to that the consumption efficiency of the aerosol source is the highest, in accordance with the atomization characteristic 1a in Fig. 5. For example, regarding the atomization characteristic 1a in Fig. 5, the atomization quantity when the puff action period is 2.4 seconds is set to A_{2.4} mg, and the atomization quantity when the puff action period is 1.2 seconds is set to A_{1.2} mg. In the above case, in Fig. 6A, for example, it is preferable that the corrected puff action period (y) when the puff action period (x) is 1.2 seconds, for example, be calculated as $2.4 \cdot A_{1.2} / A_{2.4}$.

[0074] Fig. 6B shows an example of a time correction model 1A based on the atomization characteristic 1a. In contrast to the ideal time correction model 1A_{ID} in Fig. 6A, the time correction model 1A is that theoretically defined by using a mathematical formula(s). Similar to Fig. 6A, in the graph in Fig. 6B, the horizontal axis (x axis) represents a puff action period (in seconds) and the vertical axis (y axis) represents a corrected puff action period (in seconds) relating to the puff action period. That is, the time correction model 1A in Fig. 6B is a model based on puff action periods. Further, for maintaining the value of the corrected puff action period (y) to be 2.4 seconds when the puff action period (x) is 2.4 seconds, a function correlating to the time correction model 1A_{ID} in Fig. 6A is defined in the range $0 < x \leq 2.4$.

[0075] Specifically, as shown in Fig. 6B, a constant T₁₀, wherein y=0 holds when x=T₁₀, is adopted. Thus, the function of the time correction model 1A, $y=C_{10}(x)$, is represented by the following two linear functions (Formula 1) based on the puff action periods (x):

- The case of $0 < x \leq T_{10}$

$$y = 0$$

- The case of $T_{10} < x \leq 2.4$

$$y = m(x - T_{10}) \quad (\text{Provided that } m > 1)$$

In this regard, the slope $m (>1)$ is determined by using the formula " $m=2.4/(2.4-T_{10})$ " and set in the memory 114.

[0076] As explained above, by applying the time correction model 1A based on the puff action period, the value of the corrected puff action period (y) is made smaller than the value of the related puff action period (x). That is, the value of the puff action period (x) can be corrected appropriately to make it approach the ideal time correction model 1A_{ID} (the broken line). In this regard, it is preferable that the constant T_{10} be set to a value smaller than 1.0. Specifically, it is preferable that it be obtained experimentally by taking a device characteristic of the inhaler 100 into consideration, and set in the memory 114. The "device characteristic" in the present case may include a cartridge characteristic, a heating characteristic of a heater, and a loss characteristic relating to depositing of aerosol sources in a mouthpiece and/or a capsule; however, the characteristics included therein are not limited to the above listed characteristics.

[0077] In the present case, in the range near the point where the value of the puff action period (x) is T_{10} , the corrected puff action period (y) relating to the time correction model 1A is smaller than a corresponding value relating to the time correction model 1A_{ID} (the dotted line). However, according to an experiment performed by the inventors, it has been found that a puff action period having a value smaller than 1.0 second is rarely observed in puff action of a user and occurrence of such a case is rarely anticipated. That is, if T_{10} is set to a value smaller than 1.0, it is not originally necessary to consider effect due to correction (this will be explained later).

[Time Correction Model 2A Based on Atomization Characteristic 2a]

[0078] Based on the above-explained atomization characteristic 2 of the aerosol source, the atomization characteristic 2a is further defined. Similar to the case of the atomization characteristic 2 of the aerosol source shown in Fig. 4, Fig. 7 is a graph that shows an actual atomization line as a polygonal line graph, by using 5 sample points of the puff action intervals between respective predetermined two successive puff actions and the atomization quantities of the aerosol source (and/or the flavor source) through the respective predetermined two successive puff actions, and defines the atomization characteristic 2a. The value of the atomization quantity at each sample point is that obtained by performing an experiment to measure the atomization quantity of the aerosol source in relation to each puff action interval of 2 seconds. The puff action interval is measured by a sensor and a timer. In this regard, in Fig. 7, the puff action period is fixed to 2.4 seconds.

[0079] In this regard, the atomization quantity of the aerosol source relating to the puff action interval relates closely to a device characteristic, and there are large individual differences. Thus, in the example in Fig. 7, result of measurement using three individuals 1 to 3 (individual 1-3) has been plotted. Further, in the present case, the reference value of the puff action interval between two successive puff actions is set to 10 seconds, in accordance with the atomization characteristic 2 of the aerosol (Fig. 4). The above value, 10 seconds, is a value leading to the state wherein the consumed atomization quantity of the aerosol source, in relation to the puff action interval, is stabilized. However, the above value is a mere example, and it is preferable to set a preferred value that is determined by performing an experiment and in accordance with a device characteristic and/or setting of an inhaler.

[0080] As studied in relation to the above-explained atomization characteristic 2, negative correlation between puff action intervals and atomization quantities of the aerosol source (and/or the flavor source) occurs, in the case that the puff action interval is shorter than approximately 10 seconds. That is, the atomization quantity of the aerosol source becomes smaller as the puff action interval becomes longer. Specifically, in the case that the value of the puff action interval is smaller than 10 seconds, if an actual value of a puff action period is applied as it stands to estimation of a remaining quantity level, a remaining quantity may be estimated as that smaller than an actual remaining quantity, and, accordingly, shortage in the aerosol source, that is contrary to the estimate, may occur. Thus, it is preferable to correct the value of the puff action period to make it somewhat larger, and use it in estimation of the remaining quantity level.

[0081] Fig. 8 shows an example of the time correction model 2A based on the atomization characteristic 2a of the aerosol source in Fig. 7. In the graph shown in Fig. 8, the horizontal axis (v axis) represents a puff action interval (in seconds) between two successive puff actions, and the vertical axis (w axis) represents a corrected difference puff action period (in seconds) relating to the puff action period. In this regard, for simplicity, in Fig. 8, two data groups relating to the individuals 1 and 2 shown in relation to the atomization characteristic 2a in Fig. 7 only are shown (the dotted line and the broken line), and the data group relating to the individual 3 is omitted. In relation to the above data groups relating to the respective individuals, the time correction model 2A is defined (the solid line).

[0082] Specifically, it is preferable that the corrected difference puff action period (in seconds) of each individual, that is the sample point, be determined in accordance with a relative atomization quantity ratio with respect to each predetermined puff action interval, such as that shown in Fig. 7, by using, as the basis, the matter that the value of the puff action interval is 10 seconds. For example, regarding the atomization characteristic 2a relating to the individual 2 in Fig. 7, the atomization quantity when the puff action period is 10 seconds is set to B_{10} mg, and the atomization quantity when the puff action period is 2 seconds is set to B_2 mg. In the above case, in Fig. 8, it is preferable that the corrected difference puff action period when the puff action interval is 2 seconds be calculated as $10 \cdot (B_2 - B_{10}) / B_{10}$. In this regard, it is preferable that the corrected difference puff action period be set to 0, in the case that the value of the puff action interval is larger than 10 seconds.

[0083] The time correction model 2A in Fig. 8 is that for calculating, as adjustment time, the corrected difference puff action period calculated based on the puff action interval, based on the value of the puff action interval between two successive puff actions. In more detail, it is preferable that the time correction model 2A based on the atomization characteristic 2a be defined as a linear function for classifying an area including all sample points (data groups) of plural individuals and an area other than the above area, in the vw plane (the first quadrant) in Fig. 8. Specifically, the function $w = C_{20}(v)$ is defined in such a manner that $w=0$ when $v=10$, and represented by the following two linear functions (Formula 2) based on the puff action intervals:

- The case of $0 < v \leq 10$

$$w = p(v - 10) \quad (\text{Provided that } p < 0)$$

- The case of $10 < v$

$$w = 0$$

In this regard, the slope $p (< 0)$ is a constant that is determined in advance based on data groups of plural individuals and by using an arbitrary technique, and set in the memory 114.

[0084] By applying, as explained above, the time correction model 2A that is based on the atomization characteristic 2a, adjustment time, that is a corrected difference puff action period (w), relating to a value of a puff action interval (v) can be determined. Further, by combining the time correction model 2A with the above-explained time correction model 1A, a time correction model MD based on the atomization characteristics 1a and 2a, that will be explained next, is defined.

[Time Correction Model MD Based on Atomization Characteristics 1a and 2a]

[0085] Fig. 9 shows an example of the time correction model MD based on the atomization characteristics 1a and 2a explained above. The time correction model MD is defined by combining the time correction model 2A with the above-explained time correction model 1A. That is, time correction model MD is defined by further adding, to the value of the corrected puff action period (y) relating to the time correction model 1A, the corrected difference puff action period relating to the time correction model 2A.

[0086] Similar to Fig. 6B, in a graph in Fig. 9, the horizontal axis (x axis) represents a puff action period (in seconds) and the vertical axis (y axis) represents a corrected puff action period (in seconds) relating to the puff action period. In the present case, when the value of the puff action period (x) is 2.4 seconds, the value of the corrected difference puff action period (w), that is calculated based on the puff action interval (v) and in accordance with the time correction model 2A, is added as the adjustment time b to the puff action period having the value of 2.4 seconds. As a result, the value of the corrected puff action period (y) can be corrected to increase it. In this manner, the function of the time correction model 2A for calculating the value of the corrected puff action period (y) is defined. In the following description, the puff action interval (v) is represented by t_{int} .

[0087] Specifically, the function $C_{30}(x, t_{int})$ of the time correction model MD based on the atomization characteristics 1a and 2a is represented by the following two linear functions (Formula 3) based on the puff action periods:

- The case of $0 < x \leq T_{10}$

$$y = 0$$

- The case of $T_{10} < x \leq 2.4$

$$y = n (x - T_{10})$$

[0088] In this regard, since $y=2.4+b$ when $X=2.4$, the slope n is represented by the following formula (Formula 4) based on Formula 2 and Formula 3:

$$\begin{aligned} n &= (2.4 + b) / (2.4 - T_{10}) \\ &= (2.4 + p (t_{int} - 10)) / (2.4 - T_{10}) \end{aligned}$$

[0089] Thereafter, by substituting Formula 4 in Formula 3, the function $C_{30}(x, t_{int})$ of the time correction model MD is represented by the following formulas (Formula 5):

- The case of $0 < x \leq T_{10}$

$$y = 0$$

- The case of $T_{10} < x \leq 2.4$

$$y = ((2.4 + p (t_{int} - 10)) / (2.4 - T_{10})) * (x - T_{10})$$

As explained above, "p" and " T_{10} " are constants that have been set in advance; thus, finally, the function $C_{30}(x, t_{int})$ of the time correction model MD can be represented as a function of the puff action periods x and the puff action intervals T_{int} .

[0090] As explained above, the time correction model MD is defined based on the atomization characteristics 1a and 2a of the aerosol source. By using the model, finally, as shown by Formula 5, the corrected puff action period (y) can be calculated from the puff action period x and the puff action intervals T_{int} , and the respective values of the constants p and T_{10} . That is, in response to detection, by a sensor 212, of puff action performed by a user by using the inhaler 100, detected-time, that is a puff action period during that the detected puff action is continued, is measured, and a time interval between two successive puff actions is measured to obtain a puff action interval. Thereafter, by substituting the above values in the puff action period x and the puff action interval T_{int} in Formula 5, the corrected puff action period can be obtained. In this regard, it is preferable that the constants p and T_{10} be set appropriately in accordance with a device characteristic and/or the design of the inhaler 100, at the time of designing, for example.

(4) Functional Block Diagram Relating to Estimation of Level of Remaining Quantity of Inhaled Component Source by Inhaler

[0091] Fig. 10 relates to the inhaler 100 (especially, the electric power source unit 202 which is a component thereof) according to the present embodiment, and shows examples of main functional blocks implemented by a controller 106 (206) and a sensor 212, and examples of main pieces of information stored in the memory 114 (214).

[0092] The controller 206 controls, in cooperation with the sensor 212 and the memory 214, various kinds of operation relating to estimation of the remaining quantity levels/level of the flavor source and/or the aerosol source. Examples of functional blocks of the controller 206 comprise a puff-detection-time measuring unit 206a, a puff-action-interval measuring unit 206b, a detected-time corrector 206c, a detected-time accumulator 206d, an inhaled-component-source remaining-quantity-level estimator 206e, and a notification instructing unit 206f. Examples of functional blocks of the sensor 212 comprise a puff detector 212a and an output unit 212b. An example of information stored in the memory 214 comprises time information such as cartridge's maximum consumption time information 214a, capsule's maximum consumption time information 214b, time correction model information 214c, and accumulated detected-time information 214d, and so on.

[0093] The puff-detection-time measuring unit 206a measures detected-time (a time period) of puff action detected by the puff detector 212a. Specifically, the puff-detection-time measuring unit 206a may measure, by use of a timer, a period from the time of a start to the time of an end of puff action detected by the puff detector 212a. The value of the puff action period is obtained based on the measured detected-time. Especially, in the present embodiment, the detected-time is further corrected.

[0094] The puff-action-interval measuring unit 206b measures a time interval between two successive puff actions. Specifically, the puff-action-interval measuring unit 206b may continuously measure, with respect to two successive puff actions detected by the puff detector 212a, time between the time of an end of a first puff action and the time of a start

of a next, i.e., a second puff action, by using a timer. A puff action interval is obtained based on the measured time interval.

[0095] The detected-time corrector 206c corrects detected-time of a puff action, in accordance with the time correction model MD that is defined based on the atomization characteristics 1a and 2a of the aerosol source in puff action. As explained above, the time correction model MD is related to puff action intervals and puff action periods.

[0096] The detected-time accumulator 206d calculates accumulated detected-time by accumulating corrected detected-time of puff action.

[0097] The inhaled-component-source remaining-quantity-level estimator 206e estimates the remaining quantity levels/level of the flavor source and/or the aerosol source, based on the accumulated detected-time. Further, it is judged that shortage in the remaining quantities (quantity) of the flavor source and/or the aerosol source has occurred, in the case that the accumulated lengths (length) of detected-time have (has) reached predetermined threshold lengths (length) of time.

[0098] The notification instructing unit 206f instructs the notifier 108 to perform notification operation, in response to a result of estimation of the remaining quantity levels/level of the flavor source and/or the aerosol source. Especially, in the case that it is judged in the inhaled-component-source remaining-quantity-level estimator 206e that shortage in the remaining quantity has occurred, the notifier 108 is operated in response thereto to output notification representing shortage in the remaining quantity.

[0099] Further, the puff detector 112a detects a series of puff actions performed by a user and/or non-puff action, by using a suction sensor such as a microphone condenser, for example. Further, the output unit 112b outputs various kinds of pieces of information detected by the sensor 112 to the controller 106, or stores them in the memory 214.

[0100] Regarding the information stored in the memory 214, the cartridge's maximum consumption time information 214a represents time information (for example 1000 seconds) corresponding to the maximum consumption quantities/quantity of the aerosol source and/or the flavor source held in the reservoir 116 of the cartridge.

[0101] The capsule's maximum consumption time information 214b represents time information (for example 100 seconds) corresponding to the maximum consumption quantity of the flavor source 128 held in the capsule of the inhaler 100B. It is preferable that they be set, in advance, at the time of designing of the cartridge and the capsule, for example. Further, regarding the flavor source 128 held in the capsule, it is preferable that the values be set in such a manner that different values are set to correspond to respective kinds of flavor sources.

[0102] The time correction model information 214c comprises information relating to the above-explained atomization characteristics 1a and 2a of the aerosol source, and information relating to the time correction model MD that is based on the atomization characteristics 1a and 2a of the aerosol source. For example, the time correction model information 214c comprises the function $C_{30}(x, t_{int})$ of the time correction model 2A shown in relation to above Formula 5, and information of the constants p and T_{10} used in the calculation.

[0103] The accumulated detected-time information 214d is information representing the accumulated detected-time accumulated by the detected-time accumulator 106d, and is updated every time when puff action is performed by a user.

[0104] In this regard, the respective values of puff action periods measured during a series of puff actions and puff action intervals between two successive puff actions may be associated with respective puff actions, and sequentially stored.

(5) Processing Flow for Controlling Operation of Controller

[0105] Each of Fig. 11 to Fig. 14 is an example of a process flow of control, performed by the controller 206, of operation of the inhaler 100 according to the present embodiment. Fig. 11 is an example of an overall process flow relating to control operation performed by the controller 206. Fig. 12 is an example of a process flow relating to a process for estimating, based on accumulated detected-time of puff action, a remaining quantity level. Fig. 13 is an example of a process flow relating to a process for correcting the detected-time of puff action. Fig. 14 is an example of a process flow relating to a process of initial setting of values of the puff action interval.

[0106] It should be reminded that the respective process steps shown herein are mere examples, and, without limiting steps thereto, it may be possible to include any other step(s) and/or omit a part(s) of the process steps. Further, the order of the respective process steps shown herein is also a mere example, and, without limiting the order of steps thereto, it may be possible to adopt any other order, and/or there may be a case wherein the steps may be allowed to be performed in a parallel manner.

[0107] When the process flow in Fig. 11 is started, the electric power source of the inhaler 100 is turned on, and a user performs a series of puff actions by using the inhaler 100. In a different case, the inhaler 100 returns from its sleep state, and a user performs a series of puff actions by using the inhaler 100. First, in step S10, the puff-action-interval measuring unit 206b measures time until a "first-time" puff action is performed by the user. The term "first-time" puff action means a puff action that is performed first after turning on of the electric power source of the inhaler 100 or after returning of the inhaler 100 from its sleep state.

[0108] In step S11, the controller 206 makes the puff detector 212a in the sensor detect a series of puff actions

(including the first-time puff action) performed by the user. Specifically, in the present case, it is judged whether a puff action is detected by the puff detector 212a.

[0109] If a puff action is detected in step S11 (step S11: Yes), the puff-action-interval measuring unit 206b stops measurement, that is being performed, of the time interval between puff actions in step S12. That is, the time interval between the detected puff action and a puff action just before the detected puff action (i.e., two successive puff actions) is measured, and, consequently, the value of the puff action interval is obtained. In this regard, in an example, the value of the puff action interval associated with the first-time puff action may be set to the value of the measurement time between the above-explained step S10 and step S12 (this will be explained later in relation to Fig. 14).

[0110] Subsequent to the above process, the puff-detection-time measuring unit 206a measures detected-time of the detected puff action. Specifically, in step S13, the puff-detection-time measuring unit 206a starts measurement of the detected-time of the puff action. Thereafter, in response to detection of an end of the puff action by the puff detector 212a in step S14, the puff-detection-time measuring unit 206a stops measurement of the detected-time of the puff action in step S15. That is, the detected-time is measured, and, consequently, the value of the puff action period during that the puff action was being continued is obtained.

[0111] In this regard, in the present embodiment, it is preferable that the controller 200 makes a heater perform heating operation during the time when the puff action performed by the user is being detected. That is, controlling of the heating operation is related to measuring of detected-time of the puff action. Specifically, when a start of a puff action is detected, heating operation by the heater is started, and, at the same time, measurement of detected-time of the puff action is started (step S13). Thereafter, after detection of an end of the puff action, the heating operation by the heater is stopped, and, at the same time, measuring of the detected-time of the puff action is stopped (step S15).

[0112] Next, in step S16, the controller 206 performs a process for estimating the remaining quantity level based on accumulating of the detected-time (this will be explained later in relation to Fig. 12 and Fig. 13).

[0113] Further, in step S17, for a puff action that will be detected next time, processes for adjusting timers in the puff-detection-time measuring unit 206a and the puff-action-interval measuring unit 206b are performed. For example, it may be preferable that both the value of the detected-time counted by the puff-detection-time measuring unit 206a and the value of the puff action interval counted by the puff-action-interval measuring unit 206b be reset to 0.

[0114] Subsequent to the above process, in step S18, the puff-action-interval measuring unit 206b starts measurement, and the process returns to step S11. In the above step, the time interval between puff actions, until a next puff action is detected, is measured. In more detail, it is preferable that measurement of the time interval between puff actions be started in step S18 by using, as a trigger thereof, detection of an end of a puff action in step S14. Thereafter, it is preferable that it be stopped in step S12 by using, as a trigger thereof, detection of a start of a puff action in step S11. That is, it can be regarded that a time interval between puff actions is a non-puff action period.

[0115] It should be noted that the cycle from step S11 to step S18 is repeated at least during the period of a series of puff actions performed by a user. In a different case, the above cycle may be repeated until the electric power source of the inhaler 100 is turned off, or until the state of the inhaler 100 is changed to a sleep state.

[0116] Regarding above-explained step S16, the process flow relating to estimating of the remaining quantity level based on accumulating of the detected-time will be explained further with reference to Fig. 12 and Fig. 13. Regarding step S16, first, in step S161, the puff-action-interval measuring unit 206b obtains the value of a puff action interval. The value of the puff action interval is obtained via above-explained step S18 (or step S10) and step S12. Further, in step S162, the puff-detection-time measuring unit 206a obtains the value of a puff action period. The value of the puff action period is the detected-time of the puff action measured via above-explained step S13 to step S15.

[0117] Next, in step S163, the detected-time corrector 206c corrects the detected-time of the puff action, by using the above-explained time correction model MD (Fig. 9) that is related to the puff action period and the puff action interval. The time correction model MD is defined based on the atomization characteristics 1a and 2a of the aerosol source in the inhaler 100, and stored as the time correction model information 214c in the memory 214.

[0118] In more detail, as shown in the process flow in Fig. 13, in correcting of the detected-time of the puff action, first, in step S163a, it is judged whether the puff action interval t_{int} obtained in step S161 in Fig. 12 is shorter than 10 seconds. The above judgment process is related to the atomization characteristics 2 and 2a of the aerosol source shown in Figs. 4 and 7, and also related to the time correction model 2A that is based on the atomization characteristic 2a shown in Fig. 8.

[0119] In the present embodiment, it is supposed that the corrected detected-time relating to actual detected-time " t " of a puff action is t_{10_crt} . In the case that the puff action interval t_{int} is shorter than 10 seconds (S163a: Yes), the corrected detected-time is calculated as shown below in step S163c, based on above Formula 5 that has been defined as the time correction model MD;

$$t_{10_crt} = C_{30}(t, t_{int}) \\ = ((2.4 + p(t_{int} - 10)) / (2.4 - T_{10})) * (t - T_{10})$$

and outputted for use in next step S164.

[0120] On the other hand, in the case that the puff action interval t_{int} is equal to or longer than 10 seconds (S163a: No), the puff action interval t_{int} is set based on Formula 2 in such a manner that $t_{int}=10$, in step S163b. Thereafter, in next step S163c, the corrected detected-time is calculated as shown below by setting $t_{int}=10$ in Formula 5;

$$\begin{aligned} t_{10_crt} &= C_{30}(t, 10) \\ &= (2.4 / (2.4 - T_{10})) * (t - T_{10}) \end{aligned}$$

and outputted for use in next step S164.

[0121] Fig. 12 is referred to here again; and, subsequent to step S163, in step S164, the detected-time accumulator 206d calculates the accumulated detected-time by accumulating the detected-time corrected in step S163. The accumulated detected-time is stored in the memory 214d every time when it is updated, as a part of accumulated detected-time information 214d relating to the flavor source and/or the aerosol source.

[0122] Subsequent to the above process, in step S165, the inhaled-component-source remaining-quantity-level estimator 106e estimates, based on the accumulated detected-time calculated in step S164, the remaining quantity levels/level of the flavor source and/or the aerosol source. The remaining quantity level may be represented as that having any form, specifically, it may be calculated as puff time (in seconds) that is allowed to spend for future puff action, or may be calculated as a percentage (%) of the puff time. Further, it is possible to perform judgment to judge that shortage in the remaining quantities (quantity) of the flavor source and/or the aerosol source has occurred, in the case that the accumulated lengths (length) of detected-time have (has) reached predetermined lengths of threshold time (a predetermined length of threshold time). The predetermined lengths (length) of threshold time are (is) stored in the memory 214 in advance as a part of capsule's maximum consumption time information 114b (for example, 100 seconds) and/or a part of the cartridge's maximum consumption time information 114a (for example, 1000 seconds).

[0123] Finally, in step S166, the notification instructing unit 206f instructs the notifier 108 to perform operation for notifying the remaining quantity levels/level estimated in step S165. For example, it is preferable to provide a user with notification in various forms, for example, lighting by an LED, displaying by a display, vocalization by a speaker, vibration by a vibrator, or the like, or an arbitrarily selected combination thereof. Especially, in the case that it is judged in step S165 that shortage in the remaining quantities/quantity of the flavor source and/or the aerosol source has occurred, it is preferable that the notifier 108 be operated to output notification representing shortage in the remaining quantities/quantity.

[0124] In the present embodiment, the object of estimation of the remaining quantity level can be set flexibly, according to the structures of the inhalers 100A and 100B. Specifically, in the cases/case of the capsule 126 and/or the cartridge 104, processing required to be performed is, merely, converting the quantities/quantity of the inhaled component sources/source to time information, and storing the time information as the capsule's maximum consumption time information 214b and/or the cartridge's maximum consumption time information 214a. Since such time information only is used in the controller 206 when operation for estimating the remaining quantity level is performed, the processing is efficient.

[0125] As explained above, according to the present embodiment, the value of the detected-time of the puff action is appropriately corrected through the time correction model MD. That is, detected-time, that is more closely related to an actual state, i.e., an actual consumption quantity of an aerosol source, and a quantity of aerosol that has actually passed through a flavor source (in other words, an actual flavor quantity given by the flavor source), can be calculated. As a result, accuracy at the time of estimating of the remaining quantity level can be improved further.

[0126] Regarding the example of the process flow according to the present embodiment, supplementary explanation relating thereto will be provided further with reference to Fig. 14. Fig. 14 shows an example of a process flow relating to initial setting of the value of a puff-action interval.

[0127] In the above explanation, it has been explained that the value of the puff action interval related to the first-time puff action may be set to the value of the time period from the time when measurement operation in step S10, that starts when the process flow in Fig. 11 is started, for measuring time until a start of the first-time puff action is started to the time when the measurement operation is stopped in step S12.

[0128] As explained above, examples of the first-time puff action may include a puff action that is performed right after turning on of the electric power source in the inhaler 100, and a puff action that is performed right after returning of the inhaler 100 from its sleep state. In this regard, a sleep state is a state that the operation process enters when no puff action by a user is detected for a predetermined period of time, even in the case that the electric power source is being turned on. In such a case, for allowing a user to perform puff action, it is required to make the inhaler 100 return from its sleep state.

[0129] Regarding the value of the puff action interval related to the first-time puff action, in addition to the above or in place of the above, initial setting thereof may be performed by using a predetermined initial value. As an example thereof, Fig. 14 shows a process flow wherein the case that the electric power source is turned on is considered, and an example

of initial setting that is performed right after turning on of the electric power source is explained. The initial setting is performed by the puff-action-interval measuring unit 206b.

[0130] First, in step S101, the controller 206 performs judgment as to whether the state of the electric power source in the inhaler 100 is transitioned from an off state to an on state. If it is judged that the electric power source in the inhaler 100 has been turned on, a process for confirming the state that the value of the puff action interval has not yet been existed in the memory may be performed optionally. Next, in step S102, the value of a puff action interval, that is to be related to a puff action that will be performed soon by a user (step S11), is set to a predetermined initial value, and the predetermined initial value is related to the first-time puff action.

[0131] After setting the value of the first puff action interval to the initial value in step S102, the process may proceed to above-explained step S10 next, and measuring of the puff action interval may be started. In such a case, in the memory, the initial value that has been set in step S102 may be updated by using the measured value obtained via steps S10-12. In a different construction, the initial value may not be updated by using the measured value, or either one of the initial value and the measured value may be selected (for example, a larger value is selected). Further, in the case that the value of the first puff action interval is set to the initial value in step S102, above-explained step 10 may be skipped to avoid starting it.

[0132] In the present case, it is preferable that the initial value be set to 10 seconds. As explained in relation to Fig. 8, in the case that the value of the puff action interval is set to 10 seconds, the corrected difference puff action period (adjustment time) becomes 0 (Formula 2). That is, by performing initial setting to set the value of the puff action interval to 10 seconds for conforming the value to the value explained in relation to Fig. 8, the adjustment time calculated in relation to the part of the time correction model 2A, that is based on the atomization characteristic 2a, in the time correction model MD can be made to be 0, with respect to the first puff action interval.

« 3. Modification Examples »

(1) First Modification Example

[0133] It has been explained in the above explanation of the above embodiment that the puff-action-interval measuring unit 206b measures a time interval between one puff action and the other puff action just before the one puff action (the two successive puff actions), and sets the value of a puff action interval to the value of the time interval (as it stands), in step S18 and steps S10-S12 in Fig. 11 and step S161 in Fig. 12. The above embodiment is advantageous in the case that the puff action is precisely detected by the puff detector 212a. In addition to the above or in place of the above, in the present modification example, it becomes possible to perform appropriate correction of the detected time, that is based on the time correction model MD, by appropriately adjusting the time interval measured in relation to puff actions to thereby flexibly set the value of the puff action interval. Especially, the value of the puff action interval set in relation to puff actions is obtained by adjusting measurement of the time interval in relation to the value of the puff action period that has been obtained with respect to the last puff action.

[0134] For example, when a user performs a series of puff actions, there may be a case that the suction force of a user tends to become weak due to preference, a habit, or the like of the user when puff action is performed. In the above case, the puff detector 212a is required to detect a puff action performed by applying weak suction force; and, on the other hand, the puff detector 212a may not be able to detect such a weak puff action if the ability of detection is insufficient. Further, even in the case that the puff detector 212a is able to detect a puff action performed by applying weak suction force, there may be a case that the puff detector 212a merely detects some parts of the weak puff action and detects the weak puff action as intermittent puff actions. As a result, a single puff action may be divided into extremely short puff actions having extremely short periods of time, and detected as plural puff actions. That is, in the case of a puff action that is performed by applying weak suction force, although a single puff action was performed originally, the puff action may be divided into plural puff actions having extremely short puff action periods of time when detection operation is performed, and detected as the plural puff actions.

[0135] Accordingly, the present modification example is constructed to consider a solution that is applicable in the case that the puff detector 212a is not able to appropriately detect a puff action for the reason that the suction force of a user is weak or for the other reason(s). In the following description, a tangible example thereof will be shown. In this regard, in the following explanation, with respect to one puff action, a pair of "the time interval" between the one puff action and the other puff action just before the one puff action and "the detected-time of the one puff action" is denoted as [Time interval from just-before puff action, Detected-time of puff action] .

[0136] Fig. 15 is an example conceptual diagram which shows a puff action performed by applying weak suction force by a user, together with the time intervals and the detected-time relating thereto. Fig. 15 shows a case wherein a puff action #n-1 is detected, and, thereafter, a puff action #n having related values [5.42, 0.16] is detected, and, immediately after the puff action #n, a puff action #n+1 having related values [0.21, 1.18] is detected by the puff detector 212a.

[0137] As shown in the figure, the detected-time of the puff action #n is 0.16 seconds, and the time 0.16 seconds can

be regarded as a value of a period of time of an extremely short puff action. In this regard, a usual time length of a puff action performed by a user is longer than 1 second, so that the value of 0.16 seconds is assumed as that smaller than T_{10} used in Formula 5. In the above case, if the process is based on the time correction model MD in the above embodiment, the corrected puff action period of the puff action #n will be set to 0 ($y=0$). That is, as a result of the correction process based on the time correction model MD, the puff action #n is regarded as a puff action that was not substantially performed, and the detected-time relating thereto is not added to the accumulated detected-time of puff action.

[0138] On the other hand, the detected-time of the next puff action #n+1 that follows the puff action #n is 1.18 seconds, and the time interval between the puff action #n and the puff action #n+1 is 0.21 seconds. Thus, according to the above embodiment, the corrected puff action period (y) of the puff action #n+1, that is based on the time correction model MD, is calculated as shown below by using Formula 5:

$$\begin{aligned} y &= ((2.4 + p * (t_{int} - 10)) / (2.4 - T_{10})) * (x - T_{10}) \\ &= ((2.4 + (-0.1) * (0.21 - 10)) / (2.4 - 0.2)) * (1.18 - 0.2) \\ &= 1.57 \end{aligned}$$

(In this regard, it will be understood that, although it has been set in above calculation that the constant $p=-0.1$ and the constant $T_{10}=0.2$, the values of the constant p and the constant T_{10} are mere example values, and the values are not limited thereto.)

[0139] According to the above calculation, it can be understood that time of 1.18 seconds, that is the detected-time of the puff action #n+1 is corrected to 1.57 seconds, in accordance with the time correction model MD.

[0140] In the above calculation, the time 0.21 seconds, that is the time interval between the present puff action #n+1 and the last puff action #n, is adopted as it stands as the value of the puff action interval, according to the explanation of the above-explained embodiment. On the other hand, in the present example, since the detected-time of the puff action #n is 0.16 seconds that is considered as an extremely short period of time, it is regarded that the puff detector 212a has divided a single puff action, that was performed originally, into two puff actions #n and #n+1 and has detected them.

[0141] Thus, in the present modification example, the measured value of the time interval between the puff action #n+1 and the puff action #n just before the puff action #n+1, i.e., 0.21 seconds, is not used as it stands as the value of the above time interval; and the value is obtained by adding the above value, i.e., the time 0.21 seconds, to the time 5.42 seconds that is the time interval between the puff action #n and the puff action #n-1. That is, in the present modification example, the total value, i.e., the time 5.63 seconds (0.21+5.42 seconds), is adopted as the value of the puff action interval relating to the puff action #n+1, and the total value is used in Formula 5.

[0142] Specifically, in the present modification example, the corrected puff action period (y) of the puff action #n+1, that is based on the time correction model MD, is calculated as shown below:

$$\begin{aligned} y &= ((2.4 + p * (t_{int} - 10)) / (2.4 - T_{10})) * (x - T_{10}) \\ &= ((2.4 + (-0.1) * (5.63 - 10)) / (2.4 - 0.2)) * (1.18 - 0.2) \\ &= 1.32 \end{aligned}$$

[0143] According to the above calculation, as a result that the modified value of the puff action interval, i.e., the time 5.63 seconds, is obtained, the time 1.18 seconds, that is the detected-time of the puff action #n+1, is corrected to 1.32 seconds in accordance with the time correction model MD.

[0144] As shown in Fig. 8, the time correction model 2A, which is a component of the time correction model MD, is defined in such a manner that the corrected puff action period becomes shorter as the value of the puff action interval becomes larger. That is, regarding the above value, i.e., 1.32 seconds, it can be observed that the degree of correction applied to the value of the puff action period is mitigated, compared with the case of 1.57 seconds that is obtained when the value of the puff action interval is 0.21 seconds. Such mitigation of correction can be regarded as appropriate treatment, in view of the situation wherein an originally single puff action is divided into the puff action #n and the puff action #n+1 and they are detected as separate puff actions by the puff detector 212a.

[0145] That is, by applying the present modification example, even in the case that a puff action performed by applying weak suction force is not detected correctly, the detected-time of the puff action can be further and appropriately corrected, and, as a result, a more precise corrected puff action period can be calculated. That is, according to the present modification example, appropriate estimation of the remaining quantity levels/level of the flavor source and/or the aerosol source can be realized.

[0146] The process for obtaining the value of a puff action interval according to the present modification example will be explained in detail based on a process flow. Fig. 16 shows an example of a process flow for adjusting measurement

of a time interval, in relation to a puff action period that has been obtained with respect to the last puff action.

[0147] In the present modification example, a time interval between the puff action #n+1 and the puff action #n just before the puff action #n+1 is measured, and the value of the puff action interval relating to the puff action #n+1 is obtained based at least on the above time interval. Especially, as explained in relation to the tangible example in Fig. 15, the value of the puff action interval relating to the puff action #n+1 is obtained by adjusting, in relation to the value of the puff action period obtained with respect to the last puff action #n (0.16 seconds in the example in Fig. 13), measurement of the time interval.

[0148] The process flow in Fig. 16 is applied to the process for adjusting the timer in step S17 in Fig. 11, for realizing adjustment of measurement of the time interval. In the present case, it is supposed that, before the process proceeds to step S17 in Fig. 11, the end of the puff action #n has been detected in step S14, and measuring of the detected-time of the puff action #n has been stopped in step S15. As a result, similar to the case of the example in Fig. 15, in step S16, especially, in step S161 in Fig. 12, the value of the puff action interval, specifically, the time 5.42 seconds, is obtained, and, in step S162, the value of the puff action period, specifically, the time 0.16 seconds, is obtained (the value of the detected-time of the puff action is also 0.16 seconds).

[0149] First, in step S21, the puff-detection-time measuring unit 206a resets the count of the timer. That is, the puff-detection-time measuring unit 206a resets the value of the detected-time of the puff action, to prepare itself for next counting operation that will be performed when a next puff action is performed.

[0150] Next, in step S22, judgment as to whether the value of the puff action period, that has been obtained with respect to the puff action #n, is smaller than 0.5 seconds is performed. In this regard, a person skilled in the art will understand that the value 0.5 seconds is a mere example, and the value is not limited to the above value. In the case that the value of the puff action period of the puff action #n is smaller than 0.5 seconds (steps S22: Yes), measurement of the time interval between the puff action #n and the next puff action #n+1 is resumed from the point when the value of the puff action interval was obtained in relation to the puff action #n. That is, the count of the timer, that has been activated for measurement relating to the puff action #n, is not reset, and measurement of the time interval, that has been interrupted, is resumed and counting is continued.

[0151] On the other hand, in the case that the value of the puff action period of the puff action #n is equal to or larger than 0.5 seconds (steps S22: No), the count of the timer, that has been activated for measurement relating to the puff action #n, is reset in step S23. Thereafter, measurement of the time interval between the puff action #n and the next puff action #n+1 is started from the point where the time is 0 second (step S18).

[0152] In the example of Fig. 15, the value of the puff action period of the puff action #n is 0.16 seconds; thus, the value is smaller than 0.5 seconds (step S22: Yes). Thus, regarding measurement of the time interval between the puff action #n and the next puff action #n+1, the value of the time interval between the puff action #n-1 and the puff action #n, i.e., the time 5.42 seconds that is the value of the last time interval, is not reset (to 0 second), and the above measurement is resumed from the point of 5.42 seconds without any change (step S18). Consequently, if a start of the next puff action #n+1 is detected (step S11) and measurement of the time interval is stopped (S12), the time interval to be measured will be 5.63 seconds, that is 0.21 seconds ahead of the above 5.42 seconds, wherein 0.21 seconds is the actual time interval. That is, the time interval t_{int} between the puff action #n and the next puff action #n+1 is obtained as the time 5.63 seconds (=5.42 seconds + 0.21 seconds).

[0153] That is, by applying the present modification example, even in the case that a puff action performed by applying weak suction force may not be detected precisely by the puff action detector 212a, a value that is appropriate as that of a puff action interval can be obtained by adjusting measurement of a time interval. Consequently, it becomes possible to correct detected-time of a puff action more appropriately, that is, it becomes possible to calculate a corrected puff action period more precisely. That is, the present modification example is especially useful in the case when a puff action is performed by applying weak suction force.

[0154] Further, in the case that a puff action performed by applying weak suction force is divided into plural puff actions including a puff action having extremely short detected-time and the other puff action when detection operation is performed, it becomes possible to judge, by using the present modification example, that the measured time interval between a puff action #n+1 and a puff action #n is inappropriate as the time interval. Then, i.e., in the case that result of judgment is that explained above, a value that is appropriate as that of the puff action interval may be obtained, by adjusting measurement of the time interval in such a manner that counting in the timer is not to be reset. On the other hand, if it is not judged that the measured time interval between the puff action #n+1 and the puff action #n is inappropriate as the time interval, the count of the timer is reset to 0 and time is measured thereafter, simply. That is, control required to be performed for obtaining the puff action interval is merely control of operation relating to resetting of the count of the timer, so that additional load in terms of processing is not required; thus, the processing is efficient.

(2) Second Modification Example

[0155] In the above explanation of the above embodiment, in the time correction model MD based on the atomization

characteristics 1a and 2a of the aerosol source, the constant T_{10} is introduced, and the corrected puff action period (y) is set to 0 if the value of the puff action period (x) is equal to or less than T_{10} (Formula 3 and Fig. 9). The constant T_{10} may be set to any value smaller than approximately 1.0 second, for example. The above matter is based on inventors' consideration such that it may be satisfactory even if time correction is not applied to a puff action period shorter than 1.0 second, since a puff action period shorter than 1.0 second is rarely observed and occurrence of such a puff action period is rarely anticipated. The following description explains tangible reasons relating thereto.

[0156] If it is constructed in such a manner that a calculation process for time correction is performed every time when a puff action period shorter than 1.0 second is observed, such a construction may not match an expected reasonable cost required for calculation processing in the controller 206. In more detail, for implementing a process for such time correction, it is required to preparer, for storing an algorithm for such time correction, a corresponding storage capacity in the memory 214. On the other hand, since occurrence of a puff action period shorter than 1.0 second is rarely expected, it is considered that implementation of a process such as that explained above is not reasonable since the cost for calculation processing thereof is too high. Further, regarding a puff action such as that having a period shorter than 1.0 second, since the quantity of consumption of the inhaled components is sufficiently small, it may be considered that such sufficiently small quantity may not be required to be taken into consideration, originally.

[0157] In the above embodiment, the corrected puff action period (y) is set to 0 if T_{10} is a value less than 1.0; on the other hand, in the present modification example, the corrected puff action period (y) is set to a predetermined constant that is somewhat larger than 0, instead of uniformly setting the every corrected puff action period (y) to 0. By adopting the above construction, values of accumulated detected-time calculated by the detected-time accumulator 206d can be accumulated, even in the case that a device defect has occurred and a puff action period having a value less than 1.0 second only could be accepted due thereto. That is, the value of the accumulated detected-time such as that explained above can be used appropriately for detecting a device defect, and the life of the device can be extended thereby.

[0158] Thus, further, in the present modification example, it is preferable that, with respect to the puff action period (detected-time) corrected by the time correction model MD in the above embodiment, if the value thereof is equal to or less than a predetermined constant, the value of corrected detected-time be updated in a uniform manner to the value of the constant.

[0159] Fig. 17 shows an example of an additional time correction model MD' based on the atomization characteristics 1a and 2a of the aerosol source. In the graph in Fig. 17, similar to Fig. 9, the horizontal axis (x axis) represents a puff action period (in seconds) and the vertical axis (y axis) represents a corrected puff action period (in seconds) relating to the puff action period. The time correction model MD' further defines, in the time correction model MD shown in Fig. 9, a function to update, in a uniform manner, the value of the corrected puff action period to q in the case that the corrected puff action period is $0 < y \leq q$. In this regard, it is preferable that the constant q be obtained by experiment and also by taking device characteristics of the inhaler 100 into consideration, and be set in the memory 214.

[0160] Fig. 18 shows an example of a detailed process flow relating to a process S163' for correcting detected-time of a puff action, and the above process is applied to step S 16 in Fig. 11 relating to the above embodiment. The present process flow is performed by the detected-time corrector 206c. In this regard, in the process S163' for correcting detected-time of a puff action, contents of processing in steps S163a, 163b, and S163c are similar to that of processing performed in the steps having the same reference symbols, so that explanation of the processing will be omitted herein.

[0161] Further, in the present modification example, regarding the output, $t_{10_crt} = C_{30}(t, t_{int})$, obtained in step S163c, judgment as to whether the value of t_{10_crt} is equal to or smaller than the constant q is further performed in step S163d. In the case that the value of t_{10_crt} is equal to or smaller than the constant q (S163d: Yes), the value of t_{10_crt} is updated to q, and outputted for the next process for calculating the accumulated detected-time (step S164), in step S163e. On the other hand, In the case that the value of t_{10_crt} is larger than the constant q (S163d: No), the value of t_{10_crt} as it stands is set as the corrected puff action period, and outputted for the next process for calculating the accumulated detected-time (step S164).

[0162] As explained above, according to the present modification example, by updating a calculated corrected puff action period in a uniform manner to q in the case that the corrected puff action period is equal to or smaller than a predetermined constant, it becomes possible to reduce loads applied to calculation processing in the controller, and, further, detect a device defect.

<<4. Supplement>>

[0163] In the above explanation, preferred embodiments, and some modification examples, of the present disclosure have been explained in detail with reference to attached figures. The inhaler 100 according to the present disclosure is constructed to precisely estimate the remaining quantity level, through dynamic correction of detected-time that is a period of time during that a detected puff action is continued. That is, it becomes possible to estimate a puff action period and an accumulated puff action period more precisely, compared with the case using actually detected detected-time of a puff action, and, accordingly, appropriate estimation of the remaining quantities/quantity of the flavor source and/or

the aerosol source can be realized. Thus, appropriate consumption-level estimation, judgment with respect to replacement, and notification relating to the cartridge and/or the capsule can be realized.

[0164] Especially, even in the case that a puff action performed by applying weak suction force is not correctly detected by a sensor, the detected-time of the puff action is corrected appropriately, and the corrected puff action period can be calculated more precisely. Consequently, further appropriate estimation of the remaining quantity levels/level with respect to the flavor source and/or the aerosol source can be realized.

[0165] In the above description, embodiments of the present disclosure have been explained; and, in this regard, it should be understood that they are mere examples, and they are not those limiting the scope of the present disclosure. It should be understood that change, addition, and modification with respect to the embodiments can be performed appropriately, without departing from the gist and the scope of the present disclosure. The scope of the present disclosure should not be limited by any of the above-explained embodiments, and should be defined by the claims and equivalents thereof only.

[0166] It should be reminded that the series of processes performed by the respective devices explained in the present specification may be realized by using any one of software, hardware, and a combination of software and hardware. Programs, that are components of the software, are stored in advance in a computer-readable storage medium/media (a non-transitory medium: a non-transitory media) implemented in the inside or the outside of the respective devices, for example. Further, for example, each program is read into a RAM when a computer, which controls each inhaler explained in the present specification, is operated, and is executed by a processor such as a CPU. The above storage medium is, for example, a magnetic disk, an optical disk, a magneto-optical disk, a flash memory, or the like. Further, the computer program may be delivered via a network without using a storage medium, for example.

[0167] It should be reminded that the constructions such as those shown below are also constructions within the scope of the techniques of the present invention.

(1) A method for operating an inhaler, including:

making a sensor detect a series of puff actions performed by a user;
measuring a time interval between a first puff action and a second puff action just before the first puff action to obtain a value of a puff action interval relating to the first puff action (S10, S18-S22, S 161);
measuring detected-time of the first puff action to obtain a value of a puff action period during that the first puff action continues (s13-s15, s162);
correcting the detected-time by using a time correction model relating to the puff action interval and the puff action period (S16, S163);
calculating accumulated detected-time by accumulating the corrected detected-time (S16, S164); and
estimating a remaining quantity level of an inhaled component source, based on the accumulated detected-time (S16, S165); wherein
the value of the puff action interval relating to the first puff action is obtained by adjusting, according to the value of the puff action period that has been obtained with respect to the second puff action, measurement of the time interval.

(2) The method explained in above item (1), wherein, in the case that the value of the puff action period relating to the second puff action is shorter than predetermined first time (S22; Yes), measurement of the time interval is adjusted in such a manner that the measurement resumes from a point corresponding to the value of the puff action interval that has been obtained with respect to the second puff action.

(3) The method explained in above item (2), wherein the first time is 0.5 seconds (S22).

(4) The method explained in any one of above items (1)-(3), wherein said estimating the remaining quantity level of the inhaled component source includes judging that the remaining quantity of the inhaled component source is insufficient, in the case that the accumulated detected-time has reached predetermined second time.

(5) The method explained in above item (4) further including making the inhaler output notification for informing insufficiency of the remaining quantity, in response to the judgment representing the matter that the remaining quantity of the inhaled component source is insufficient.

(6) The method explained in any one of above items (1)-(5), wherein the time correction model is defined to include a characteristic that the detected-time to be corrected is maintained to be predetermined third time, in the case that the value of the detected-time is the third time.

(7) The method explained in item (6), wherein the time correction model is defined to include a characteristic that the detected-time is shortened, in the case that the value of the detected-time is smaller than the third time.

(8) The method explained in item (6) or (7), wherein the third time is 2.4 seconds.

(9) The method explained in any one of above items (1)-(8), wherein the time correction model is defined to include a characteristic that the measured detected-time is increased by adding adjustment time, that is calculated based

on the puff action interval, to the value of the measured detected-time, in the case that the value of the puff action interval is smaller than fourth time.

(10) The method explained in item (9) further including performing initial setting to set the value of the puff action interval, that relates to the second puff action, to the fourth time in the case that the second puff action is a first puff action (S101, S102).

(11) The method explained in item (9) or (10), wherein the fourth time is 10 seconds.

(12) A program which makes the inhaler perform the method explained in any one of items (1)-(11).

(13) An inhaler comprising:

a sensor for detecting a series of puff actions performed by a user; and
a controller (206) for making the inhaler perform operation for

measuring a time interval between a first puff action and a second puff action just before the first puff action to obtain a value of a puff action interval relating to the first puff action detected by the sensor (206b);
measuring detected-time of the first puff action to obtain a value of a puff action period during that the first puff action continues (206a);
correcting the detected-time by using a time correction model relating to the puff action interval and the puff action period (206c);
calculating accumulated detected-time by accumulating the corrected detected-time (206d); and
estimating a remaining quantity level of an inhaled component source, based on the accumulated detected-time (206e); wherein

the value of the puff action interval relating to the first puff action is obtained by adjusting, according to the value of the puff action period that has been obtained with respect to the second puff action, measurement of the time interval (S17, S161, S21-S23).

(14) The inhaler explained in above item (13), wherein, in the case that the value of the puff action period relating to the second puff action is shorter than predetermined first time (S22; Yes), measurement of the time interval is adjusted in such a manner that the measurement resumes from a point corresponding to the value of the puff action interval that has been obtained with respect to the second puff action.

(15) The inhaler explained in above item (14), wherein the first time is 0.5 seconds (S22).

(16) The inhaler explained in any one of above items (13)-(15), wherein the operation for estimating the remaining quantity level of the inhaled component source comprises operation for judging that the remaining quantity of the inhaled component source is insufficient, in the case that the accumulated detected-time has reached predetermined second time.

(17) The inhaler explained in above items (16) further comprising a notifier, wherein the controller makes the notifier output notification for informing insufficiency of the remaining quantity, in response to the judgment representing the matter that the remaining quantity of the inhaled component source is insufficient (2061).

(18) The inhaler explained in any one of above items (13)-(17), wherein the measured detected-time is increased by adding adjustment time, that is calculated based on the puff action interval, to the value of the measured detected-time, in the case that the value of the puff action interval is smaller than third time.

(19) The inhaler explained in above item (18), wherein the controller is further constructed to set the value of the puff action interval, that relates to the second puff action, to the third time in the case that the second puff action is a first puff action (S101, S102).

(20) The inhaler explained in above item (18) or (19), wherein the third time is 10 seconds.

REFERENCE SIGNS LIST

[0168] 100A, 100B, 100 ... Inhaler: 102 ... First member (Electric power source unit): 104 ... Second member (Cartridge): 106, 206 ... Controller: 108 ... Notifier: 110 ... Battery: 112, 212 ... Sensor: 114, 214 ... Memory: 116 ... Reservoir: 118 ... Atomizer: 120 ... Air taking-in flow path: 121 ... Aerosol flow path: 122 ... Suction opening part: 126 ... Third member (Capsule): 128 ... Flavor source:
206a ... Puff-detection-time measuring unit: 206b ... Puff-action-interval measuring unit: 206c ... Detected-time corrector;
206d ... Detected-time accumulator: 206e ... Inhaled-component-source remaining-quantity-level estimator: 206f... Notification instructing unit: 212a ... Puff detector: 212b ... Output unit:
214a ... Cartridge's maximum consumption time information: 214b ... Capsule's maximum consumption time information: 214c ... Time correction model information: 214d ... Accumulated detected-time information

Claims

1. A method for operating an inhaler, including:

5 making a sensor detect a series of puff actions performed by a user;
 measuring a time interval between a first puff action and a second puff action just before the first puff action to
 obtain a value of a puff action interval relating to the first puff action;
 measuring detected-time of the first puff action to obtain a value of a puff action period during that the first puff
 action continues;
 10 correcting the detected-time by using a time correction model relating to the puff action interval and the puff
 action period;
 calculating accumulated detected-time by accumulating the corrected detected-time; and
 estimating a remaining quantity level of an inhaled component source, based on the accumulated detected-
 time; wherein
 15 the value of the puff action interval relating to the first puff action is obtained by adjusting, according to the value
 of the puff action period that has been obtained with respect to the second puff action, measurement of the time
 interval.

2. The method according to Claim 1, wherein, in the case that the value of the puff action period relating to the second
 20 puff action is shorter than predetermined first time, measurement of the time interval is adjusted in such a manner
 that the measurement resumes from a point corresponding to the value of the puff action interval that has been
 obtained with respect to the second puff action.

3. The method according to Claim 2, wherein the first time is 0.5 seconds.

4. The method according to any one of Claims 1-3, wherein said estimating the remaining quantity level of the inhaled
 component source includes judging that the remaining quantity of the inhaled component source is insufficient, in
 the case that the accumulated detected-time has reached predetermined second time.

5. The method according to Claim 4 further including making the inhaler output notification for informing insufficiency
 of the remaining quantity, in response to the judgment representing the matter that the remaining quantity of the
 inhaled component source is insufficient.

6. The method according to any one of Claims 1-5, wherein the time correction model is defined to include a characteristic
 35 that the detected-time to be corrected is maintained to be predetermined third time, in the case that the value of the
 detected-time is the third time.

7. The method according to Claim 6, wherein the time correction model is defined to include a characteristic that the
 detected-time is shortened, in the case that the value of the detected-time is smaller than the third time.

8. The method according to Claim 6 or 7, wherein the third time is 2.4 seconds.

9. The method according to any one of Claims 1-8, wherein the time correction model is defined to include a characteristic
 45 that the measured detected-time is increased by adding adjustment time, that is calculated based on the puff action
 interval, to the value of the measured detected-time, in the case that the value of the puff action interval is smaller
 than fourth time.

10. The method according to Claim 9 further including performing initial setting to set the value of the puff action interval,
 that relates to the second puff action, to the fourth time in the case that the second puff action is a first puff action.

11. The method according to Claim 9 or 10, wherein the fourth time is 10 seconds.

12. A program which makes the inhaler perform the method according to any one of Claims 1-11.

13. An inhaler comprising:

a sensor for detecting a series of puff actions performed by a user; and
 a controller for making the inhaler perform operation for

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measuring a time interval between a first puff action and a second puff action just before the first puff action to obtain a value of a puff action interval relating to the first puff action detected by the sensor;
measuring detected-time of the first puff action to obtain a value of a puff action period during that the first puff action continues;
5 correcting the detected-time by using a time correction model relating to the puff action interval and the puff action period;
calculating accumulated detected-time by accumulating the corrected detected-time; and
estimating a remaining quantity level of an inhaled component source, based on the accumulated detected-time; wherein

10 the value of the puff action interval relating to the first puff action is obtained by adjusting, according to the value of the puff action period that has been obtained with respect to the second puff action, measurement of the time interval.

Fig. 1A

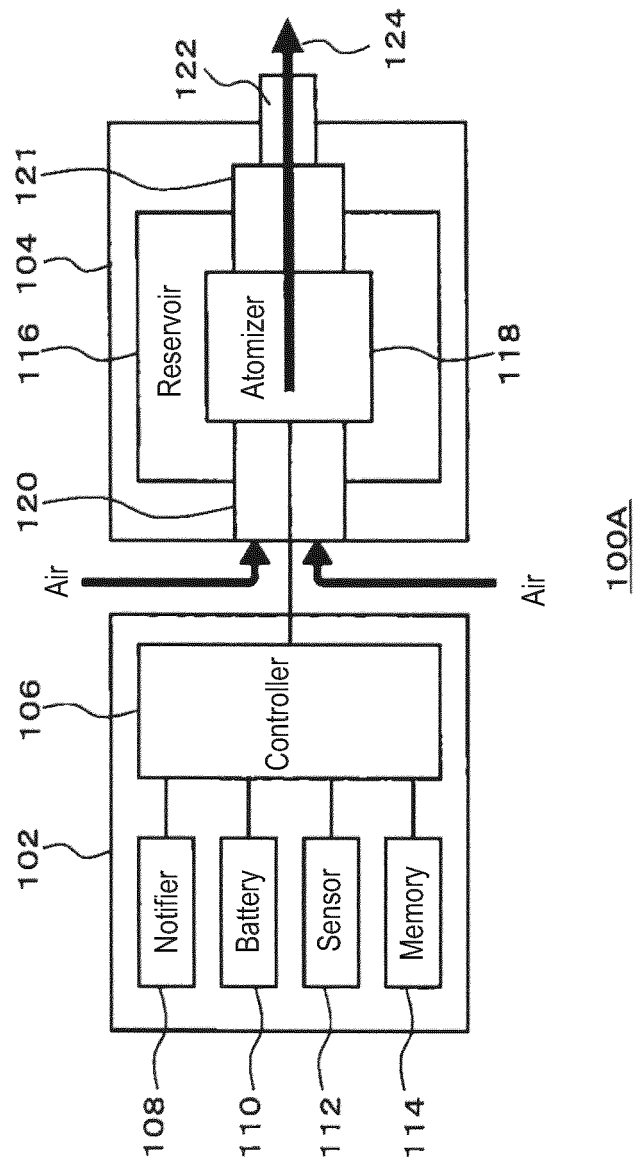


Fig. 1B

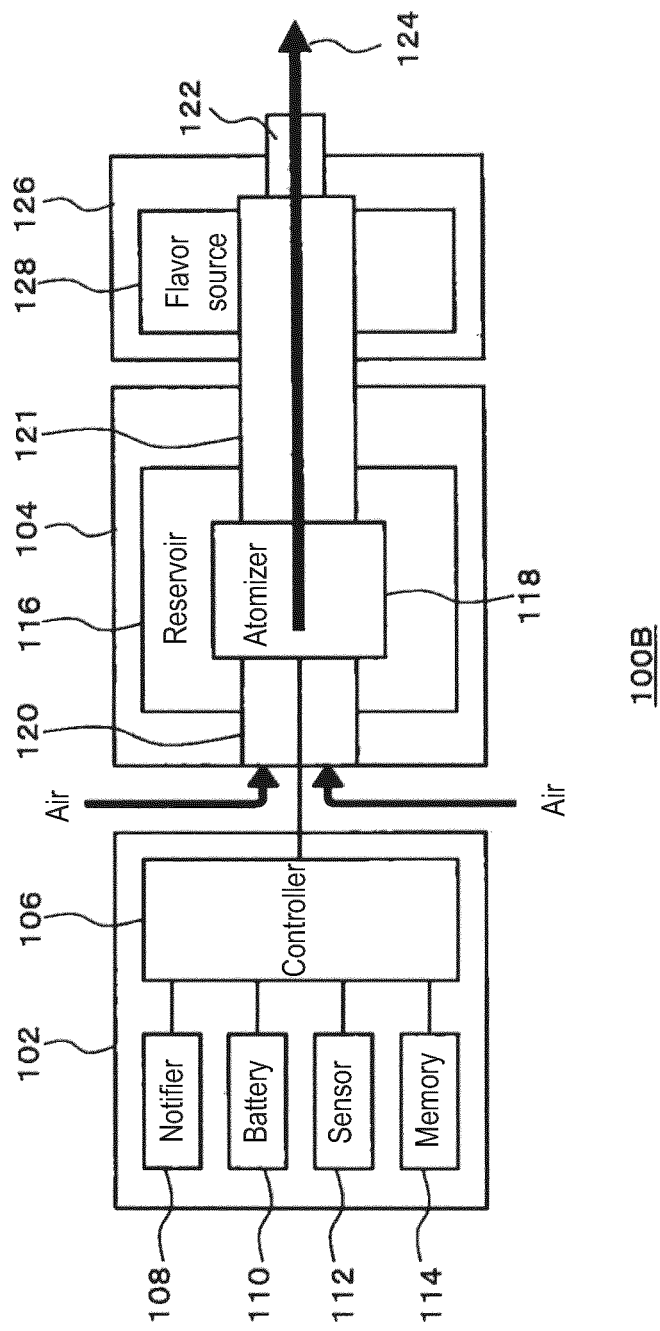


Fig. 2

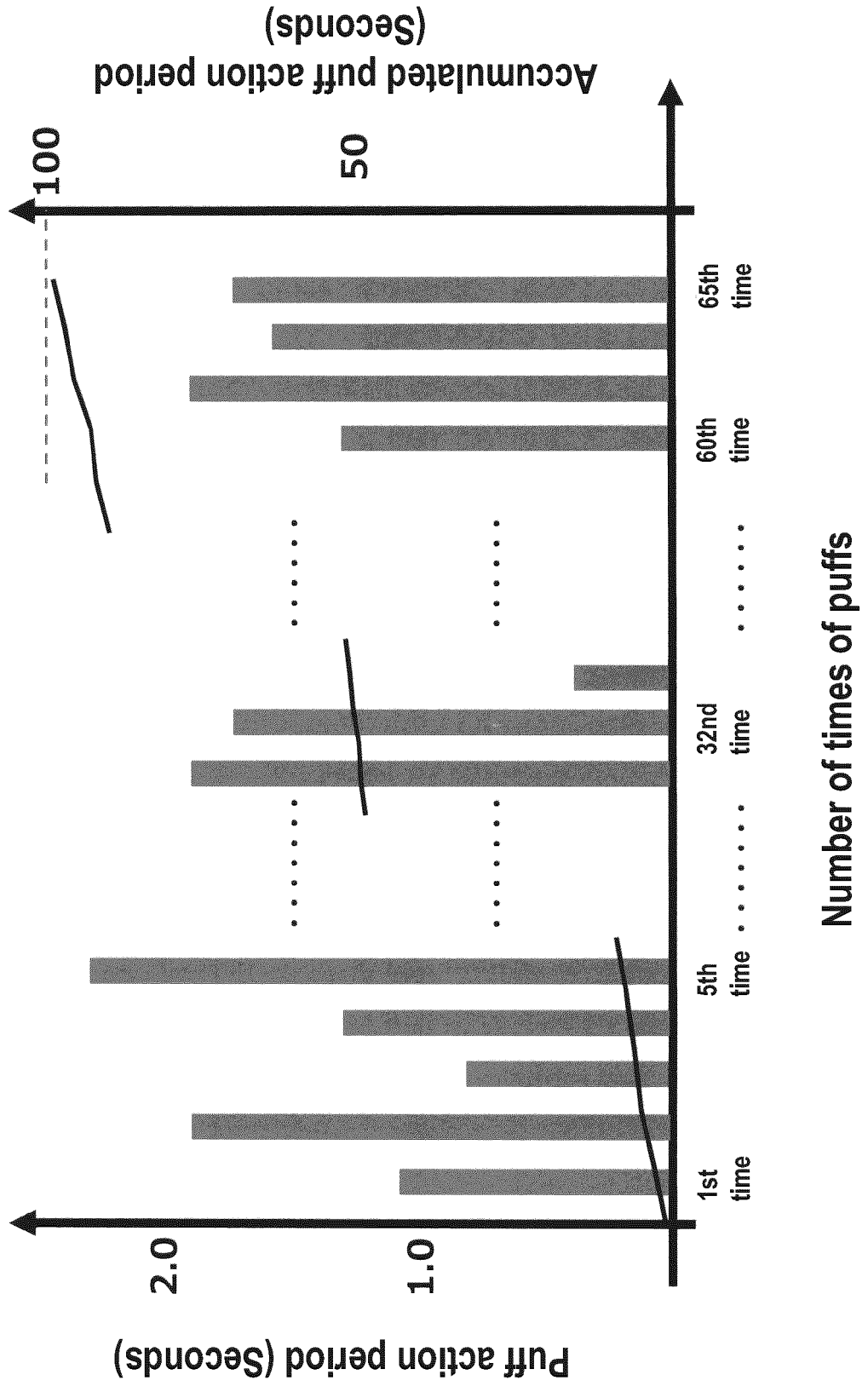


Fig. 3

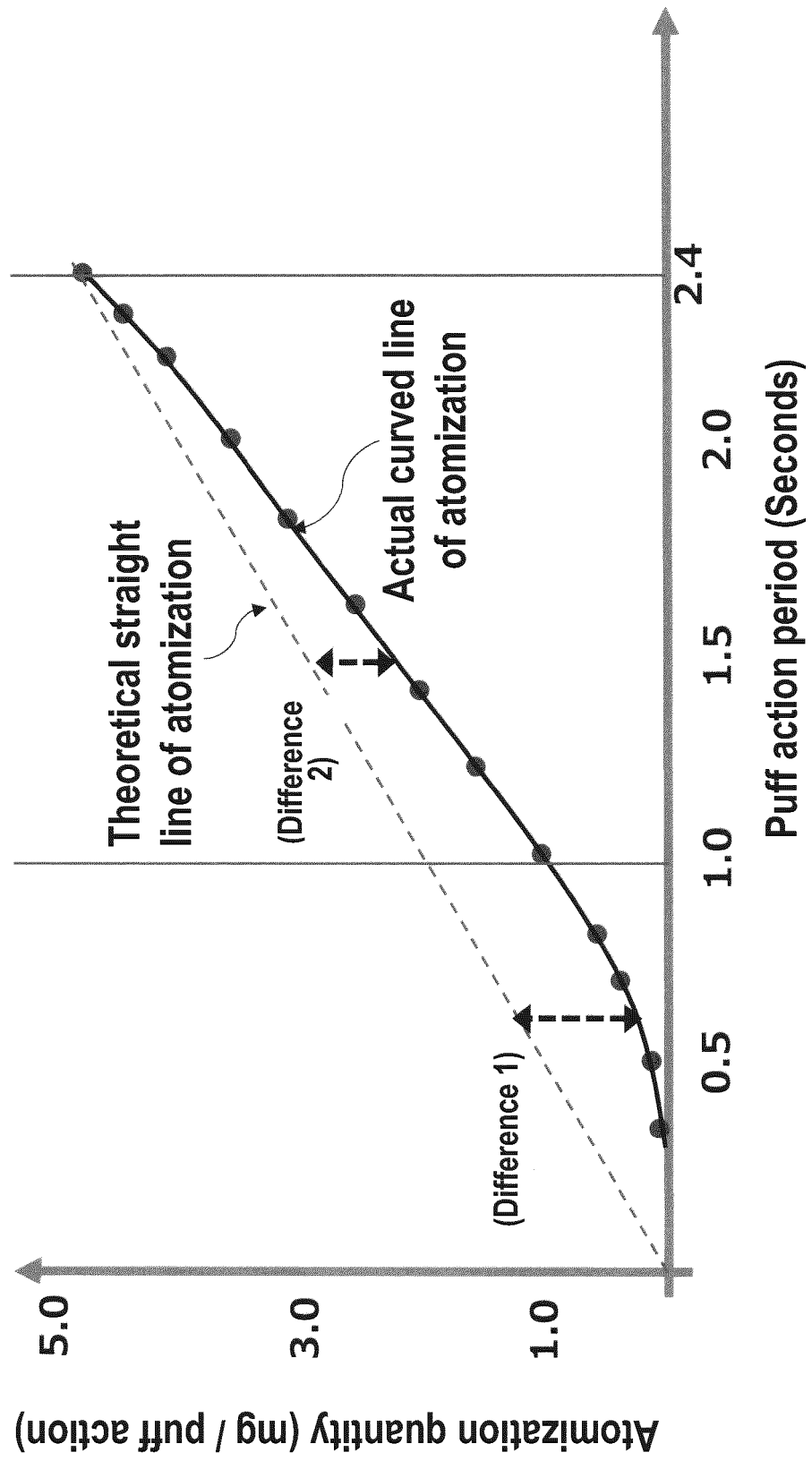
Atomization Characteristic 1 of Aerosol Source

Fig. 4

Atomization Characteristic 2 of Aerosol Source

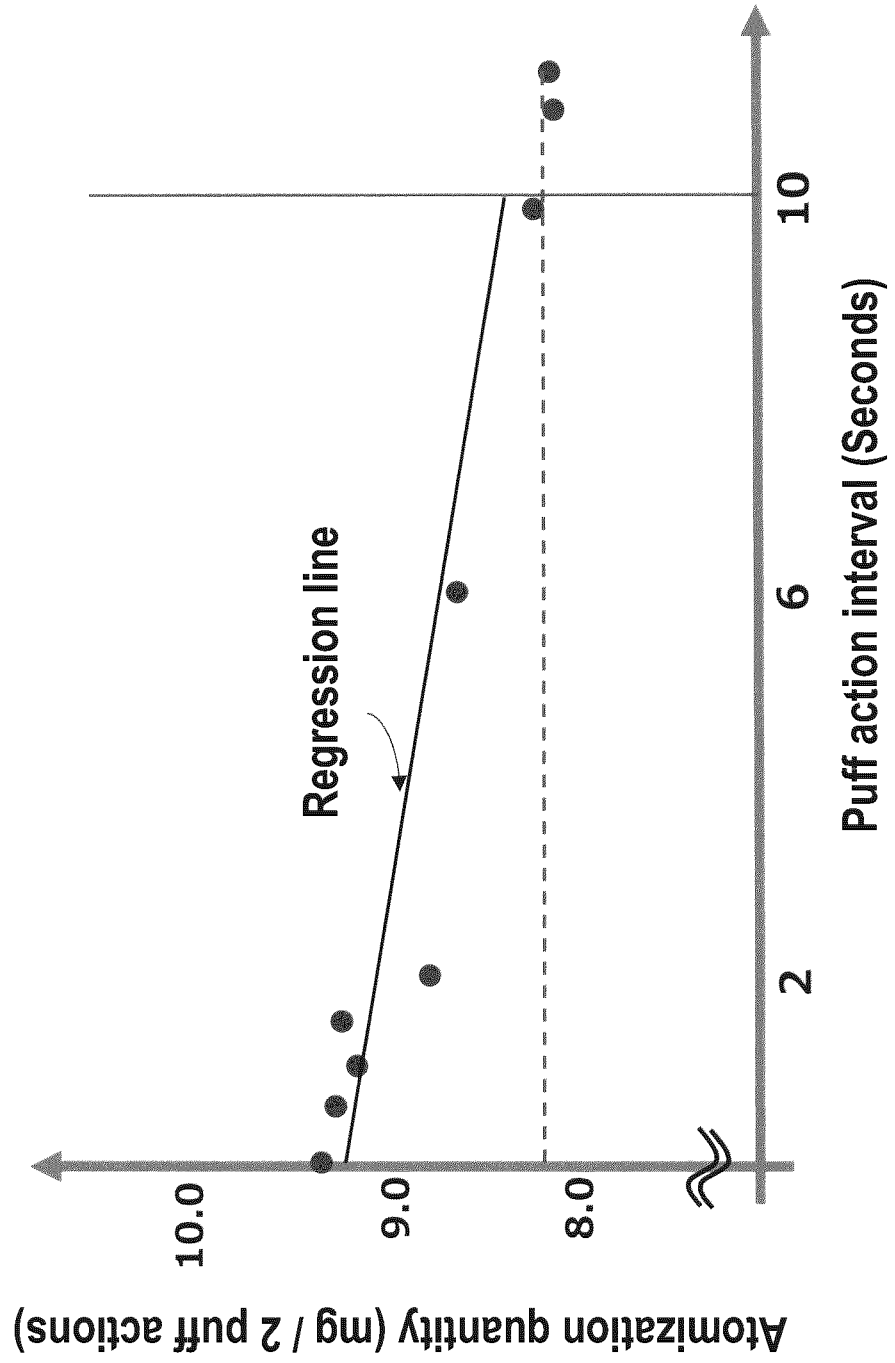


Fig. 5

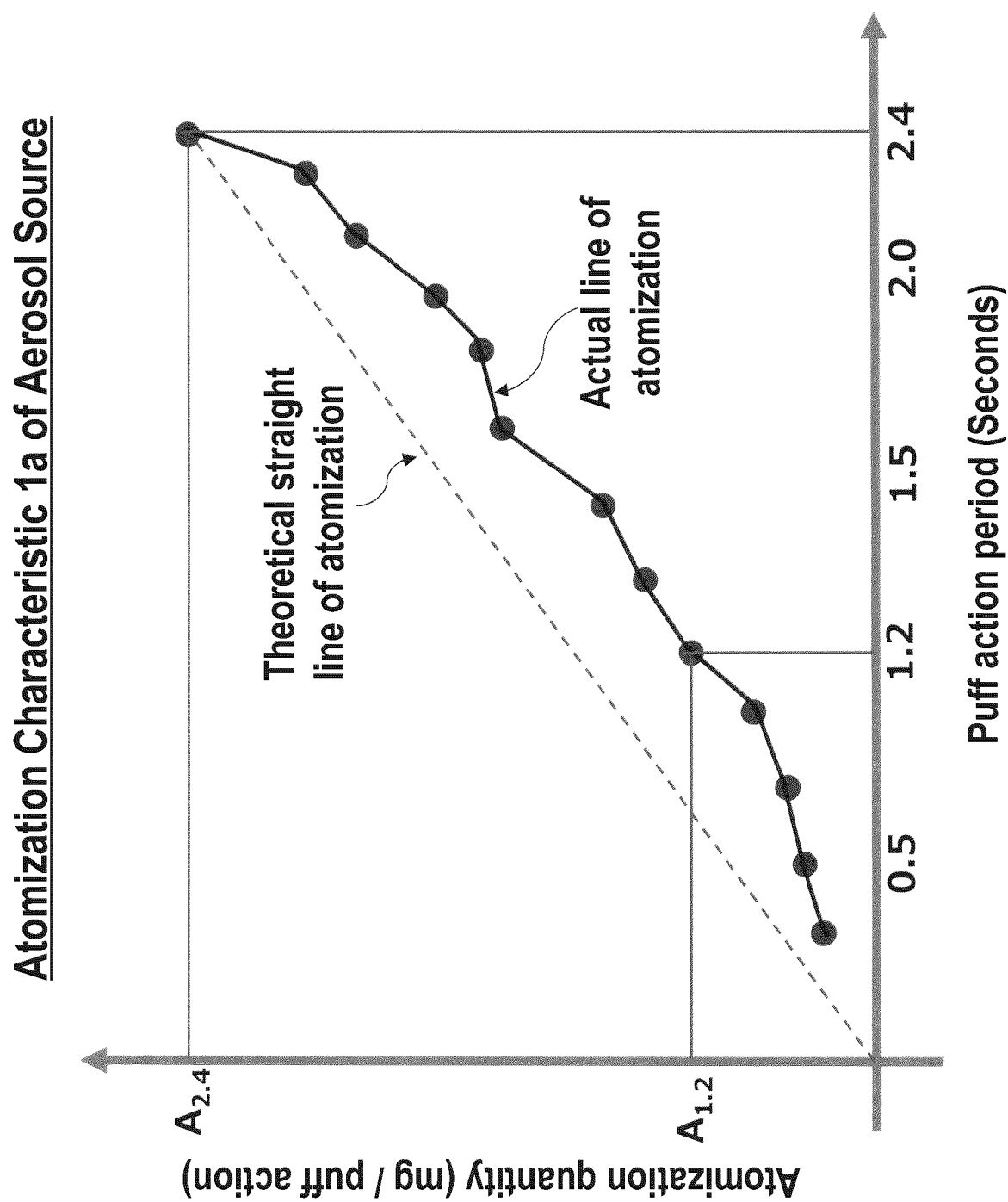


Fig. 6A

Time Correction Model 1A_{1D} Corresponding to
Atomization Characteristic 1a of Aerosol Source

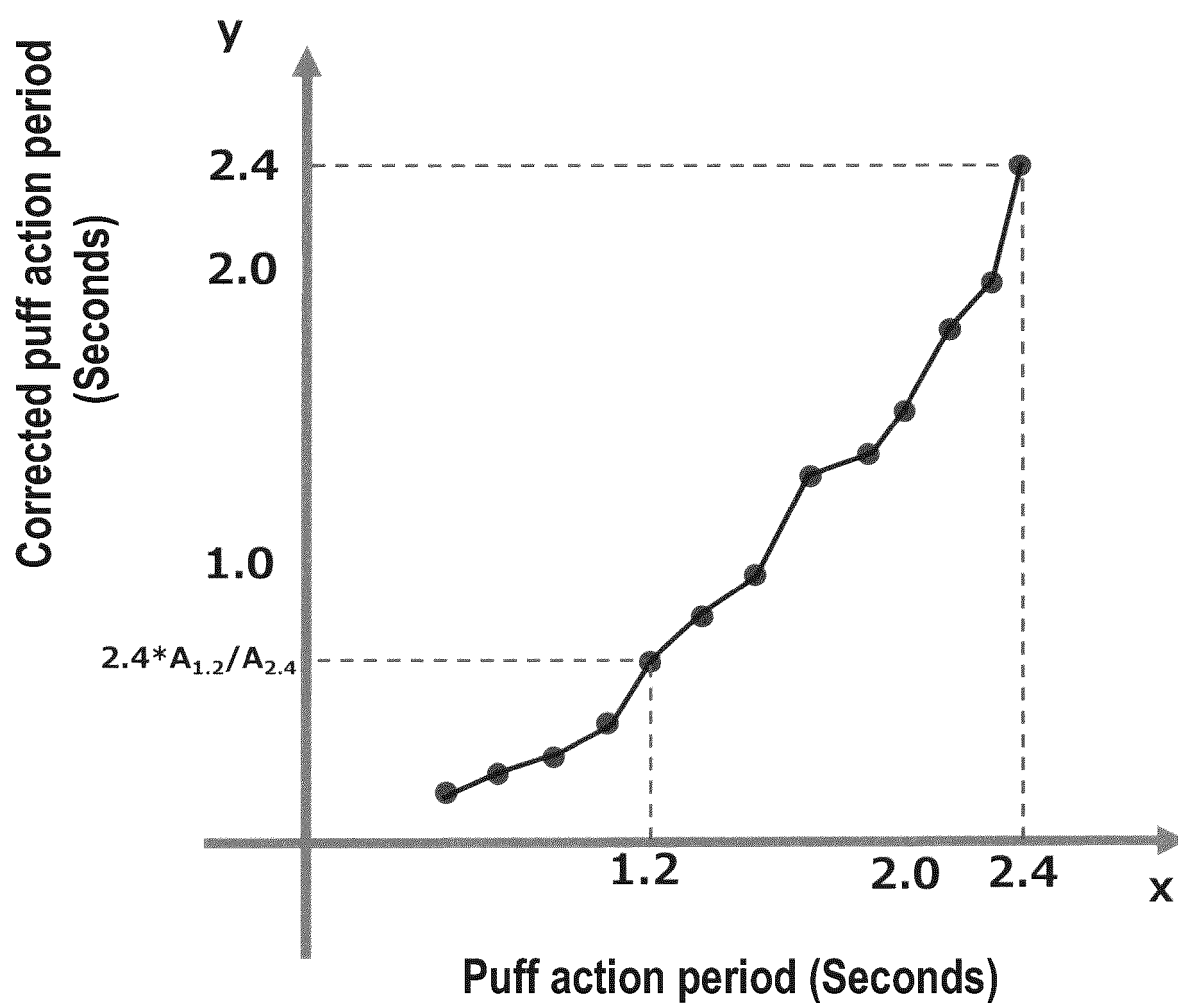


Fig. 6B

Time Correction Model 1A Based on Atomization
Characteristic 1a of Aerosol Source

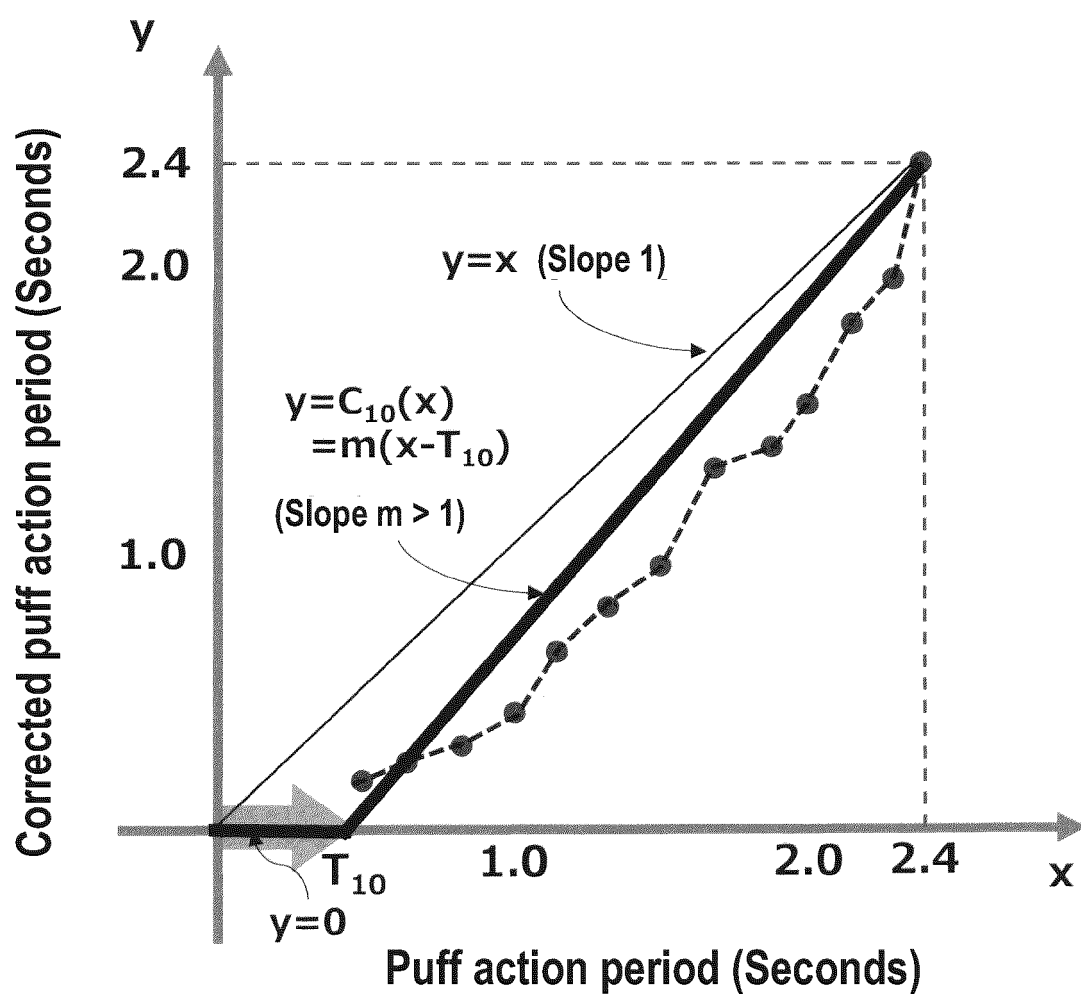


Fig. 7

Atomization Characteristic 2a of Aerosol Source

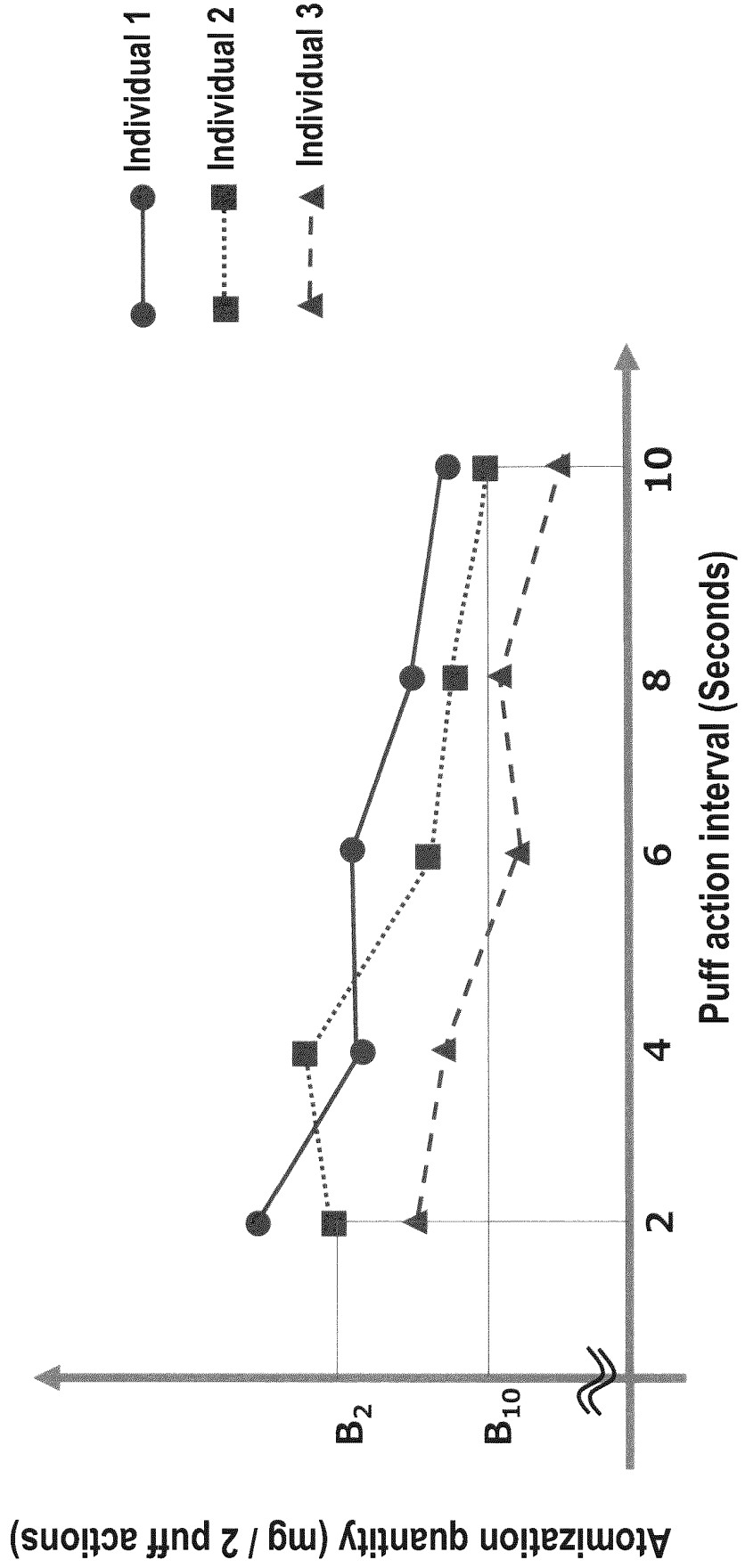


Fig. 8

Time Correction Model 2A Based on Atomization
Characteristic 2a of Aerosol Source

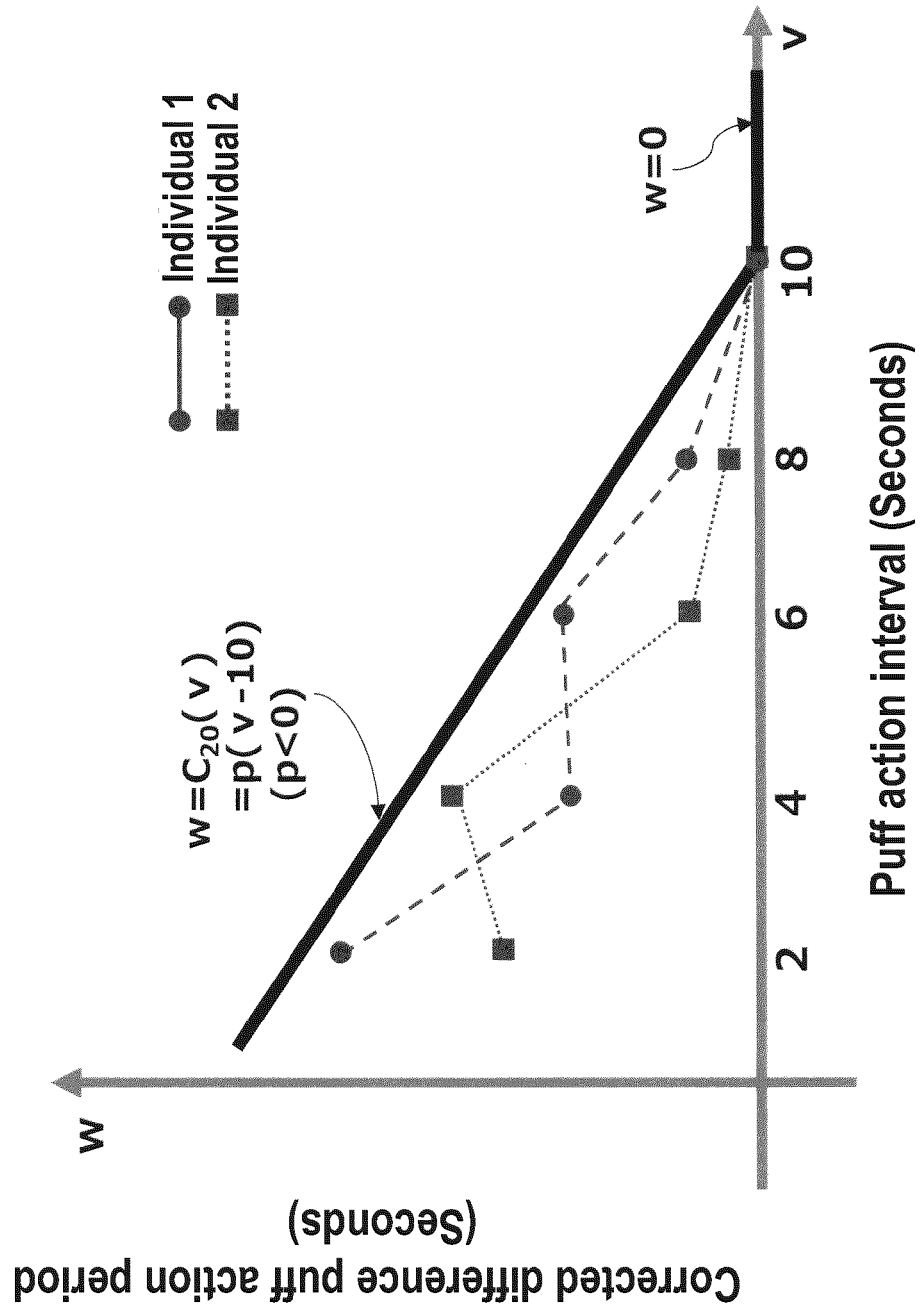


Fig. 9

Time Correction Model MD Based on
Atomization Characteristics 1a and 2a of
Aerosol Source

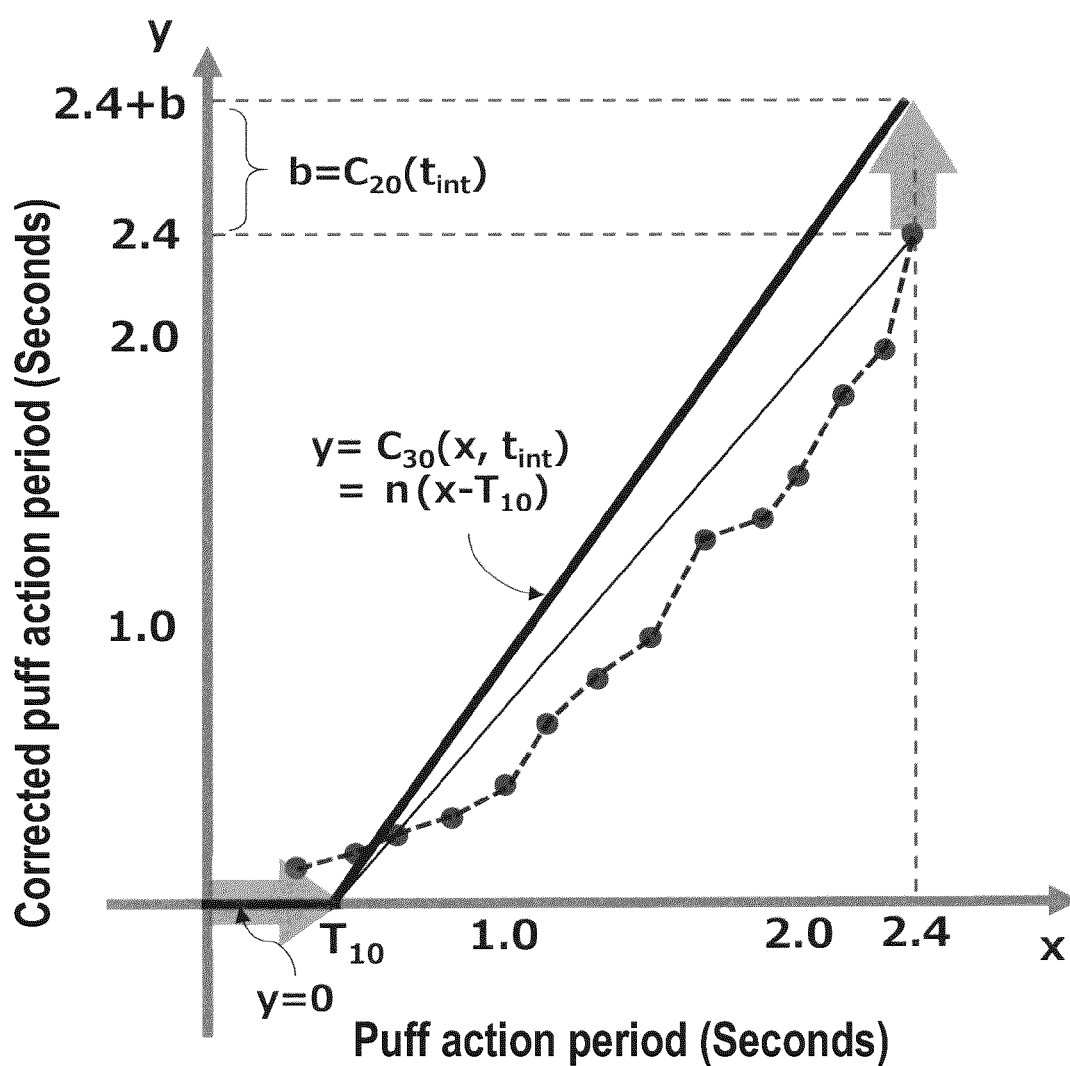


Fig. 10

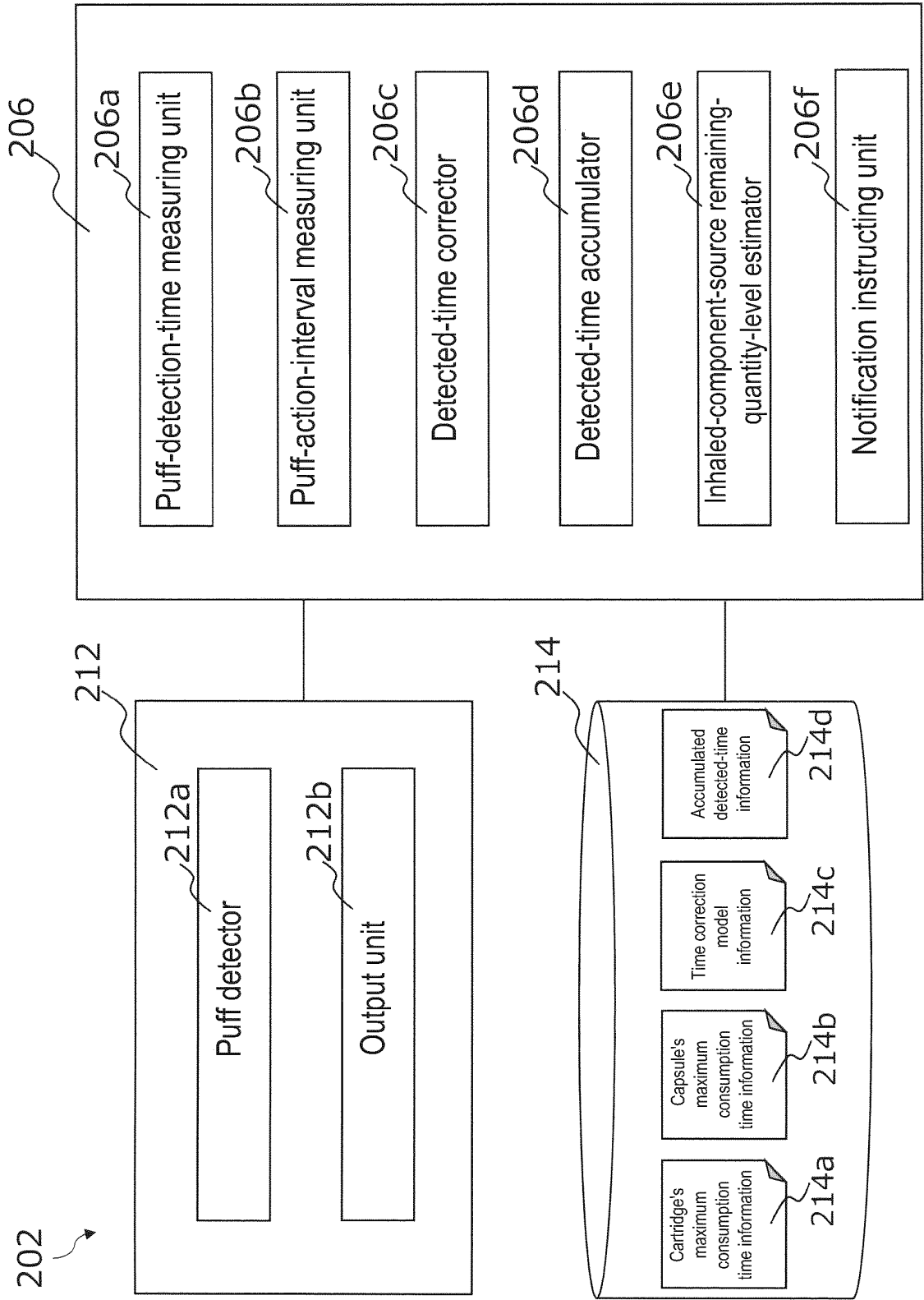


Fig. 11

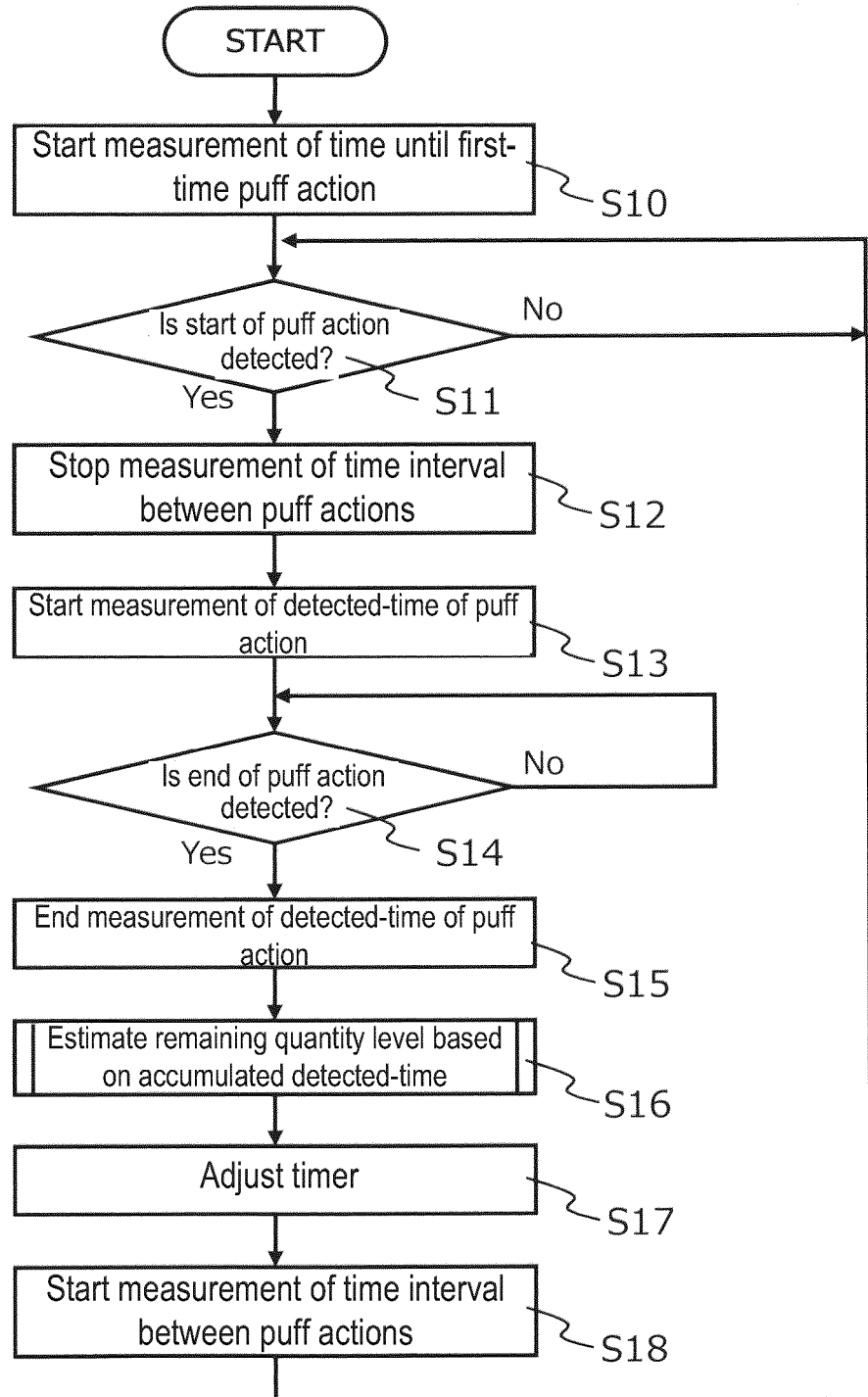


Fig. 12

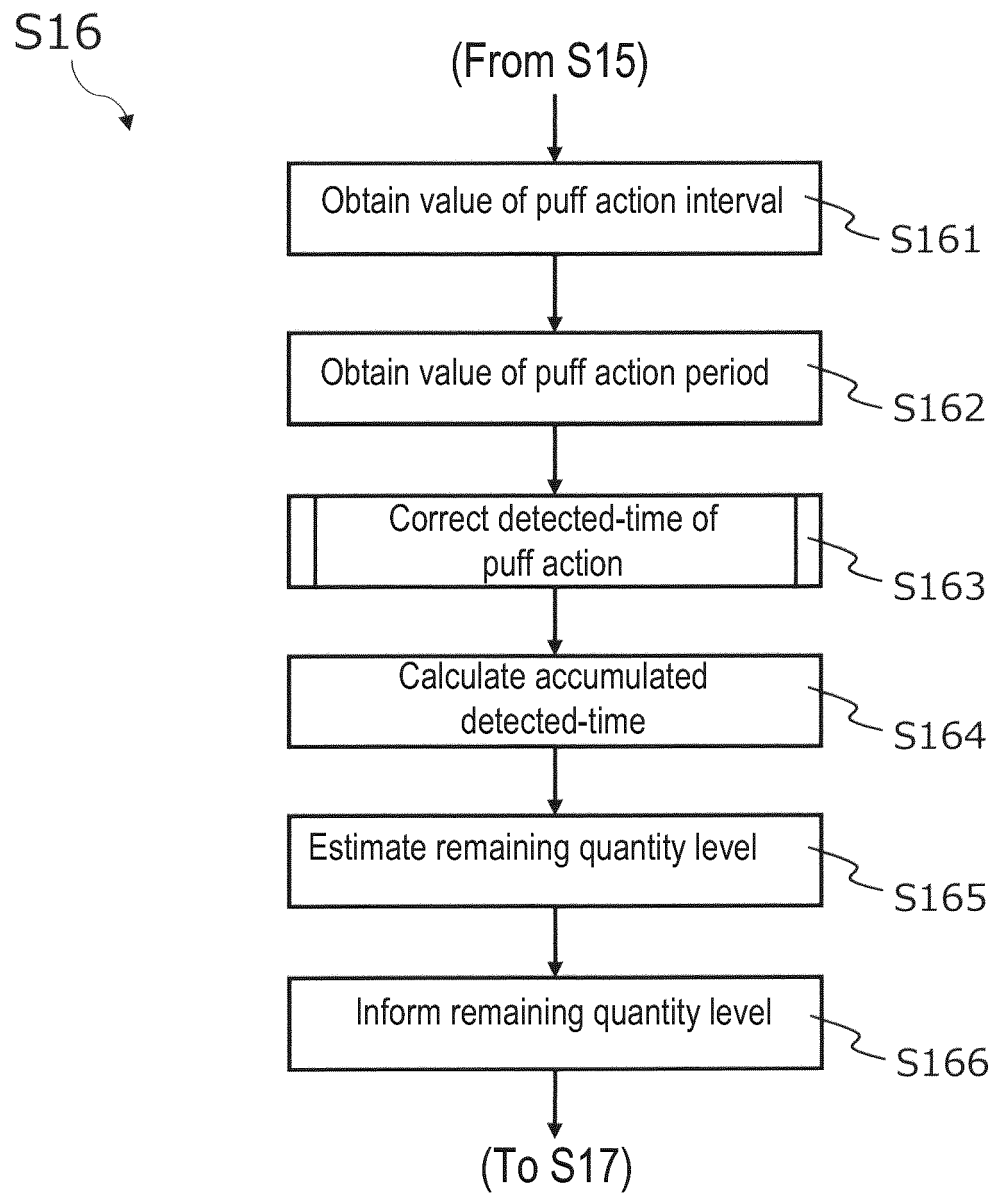


Fig. 13

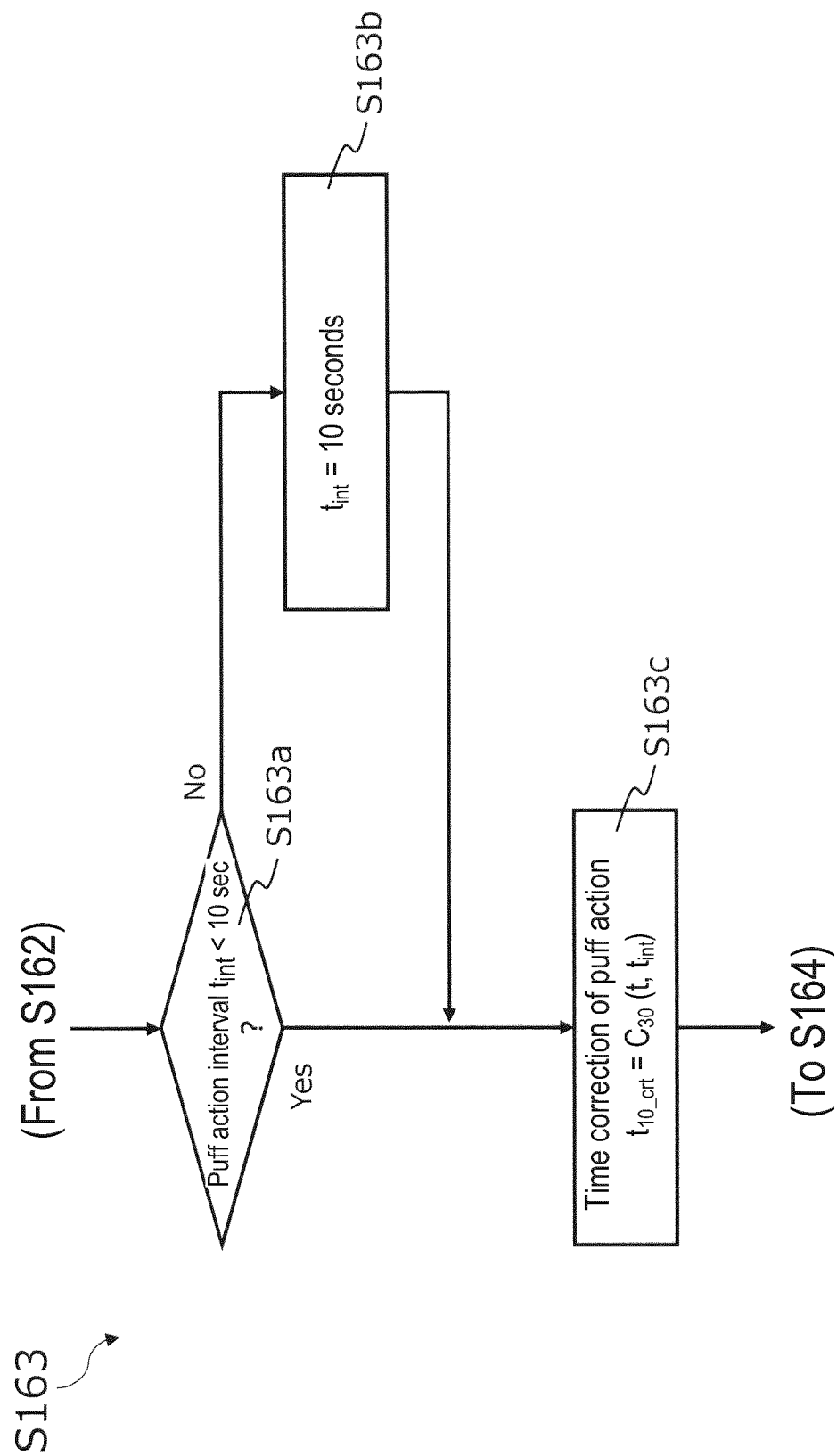


Fig. 14

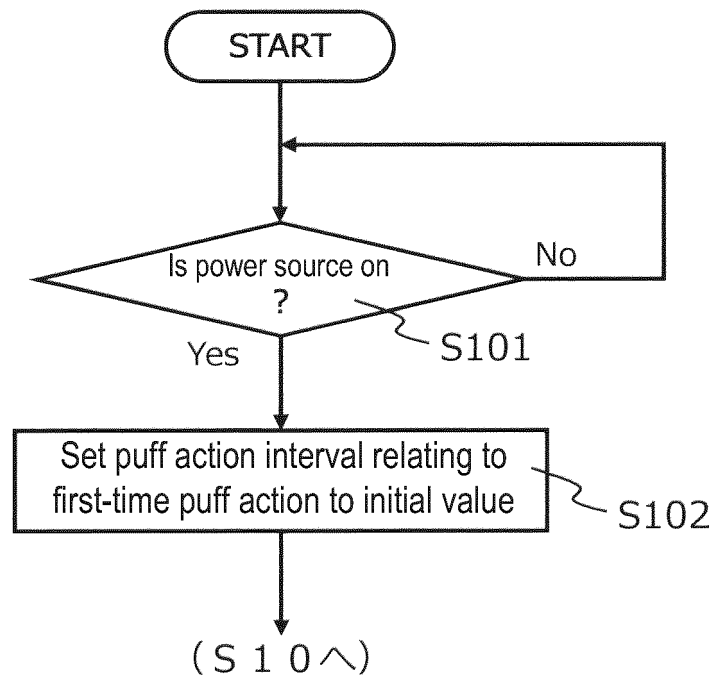


Fig. 15

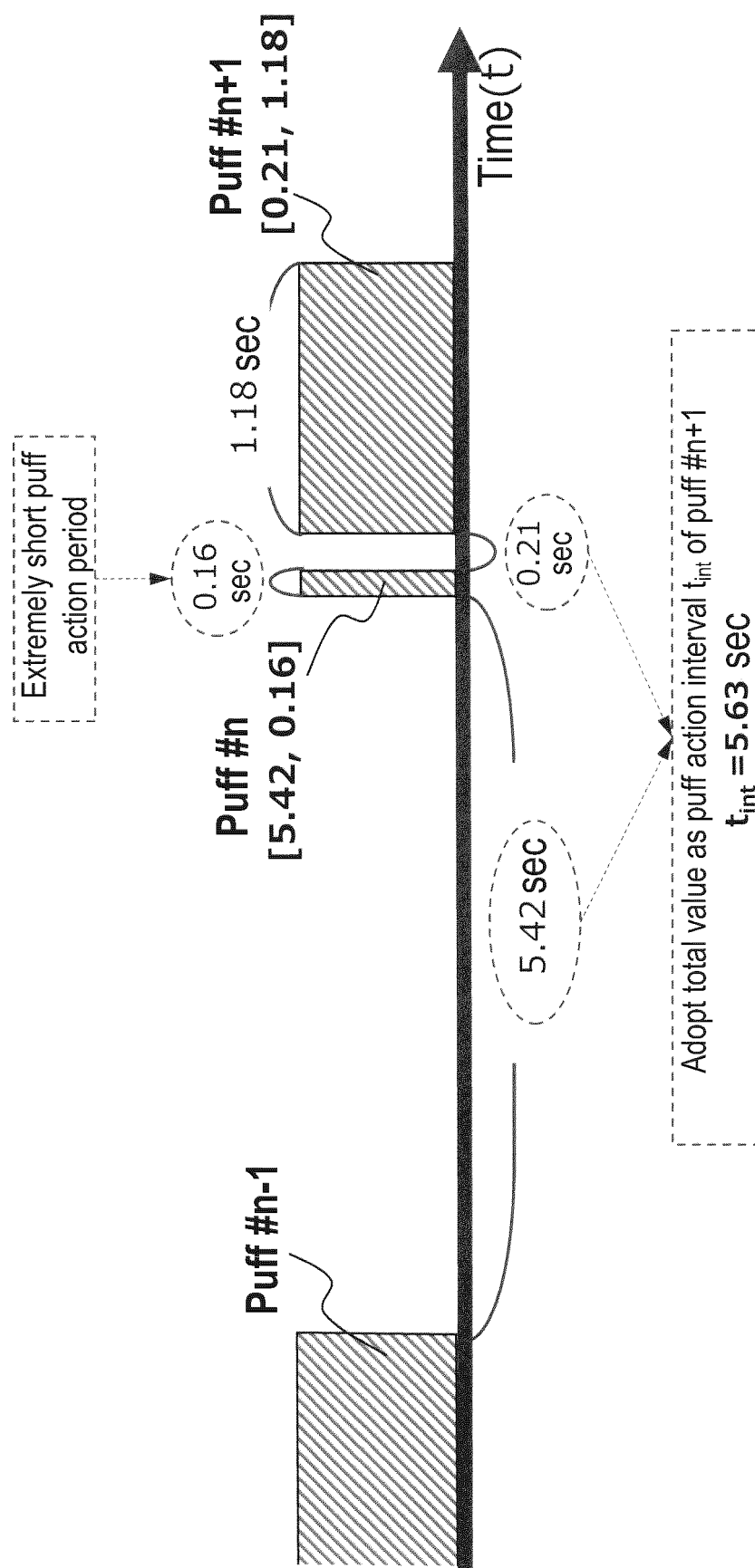


Fig. 16

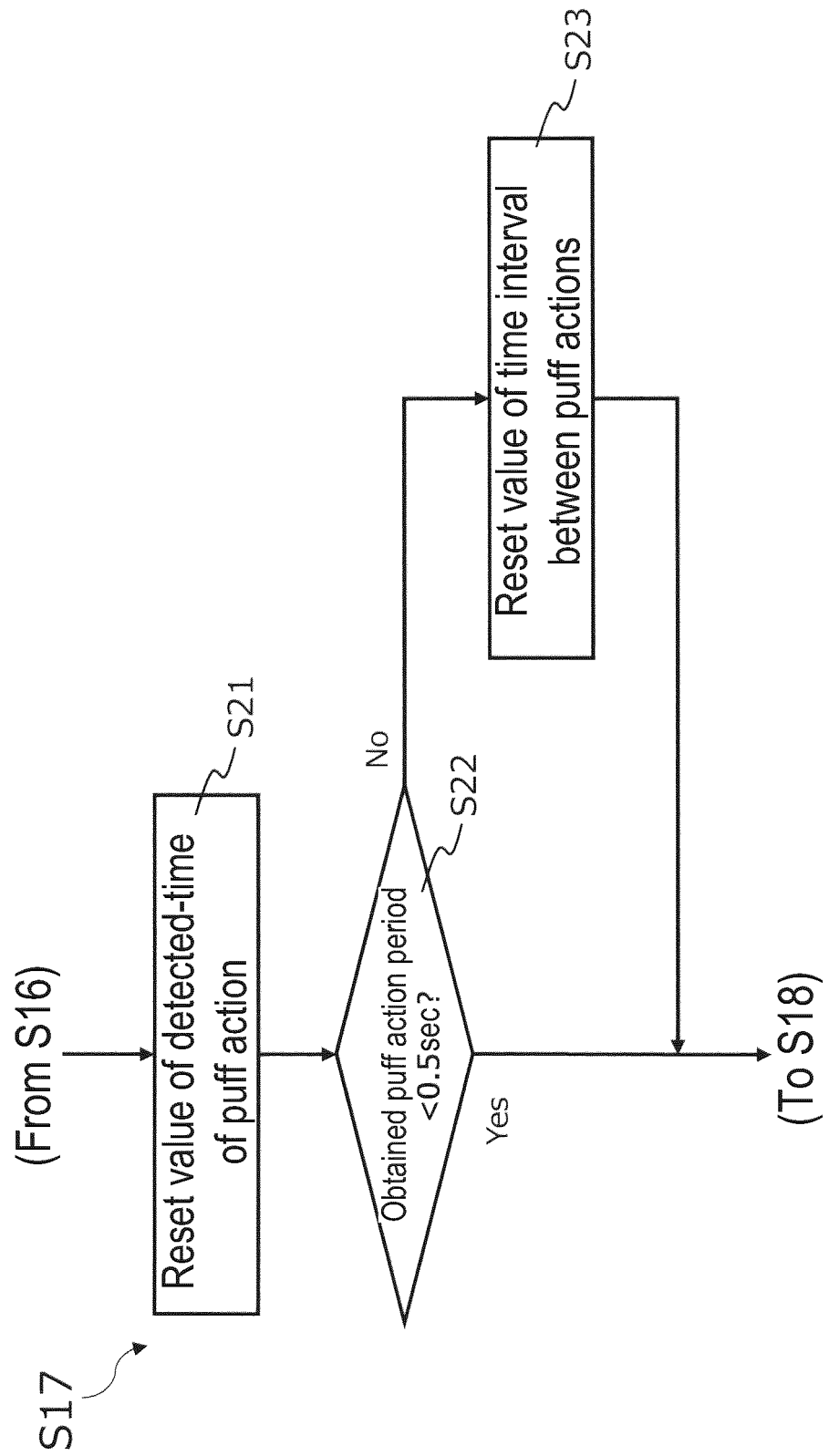


Fig. 17

Time Correction Model MD' Based on
Atomization Characteristics 1a and 2a of
Aerosol Source

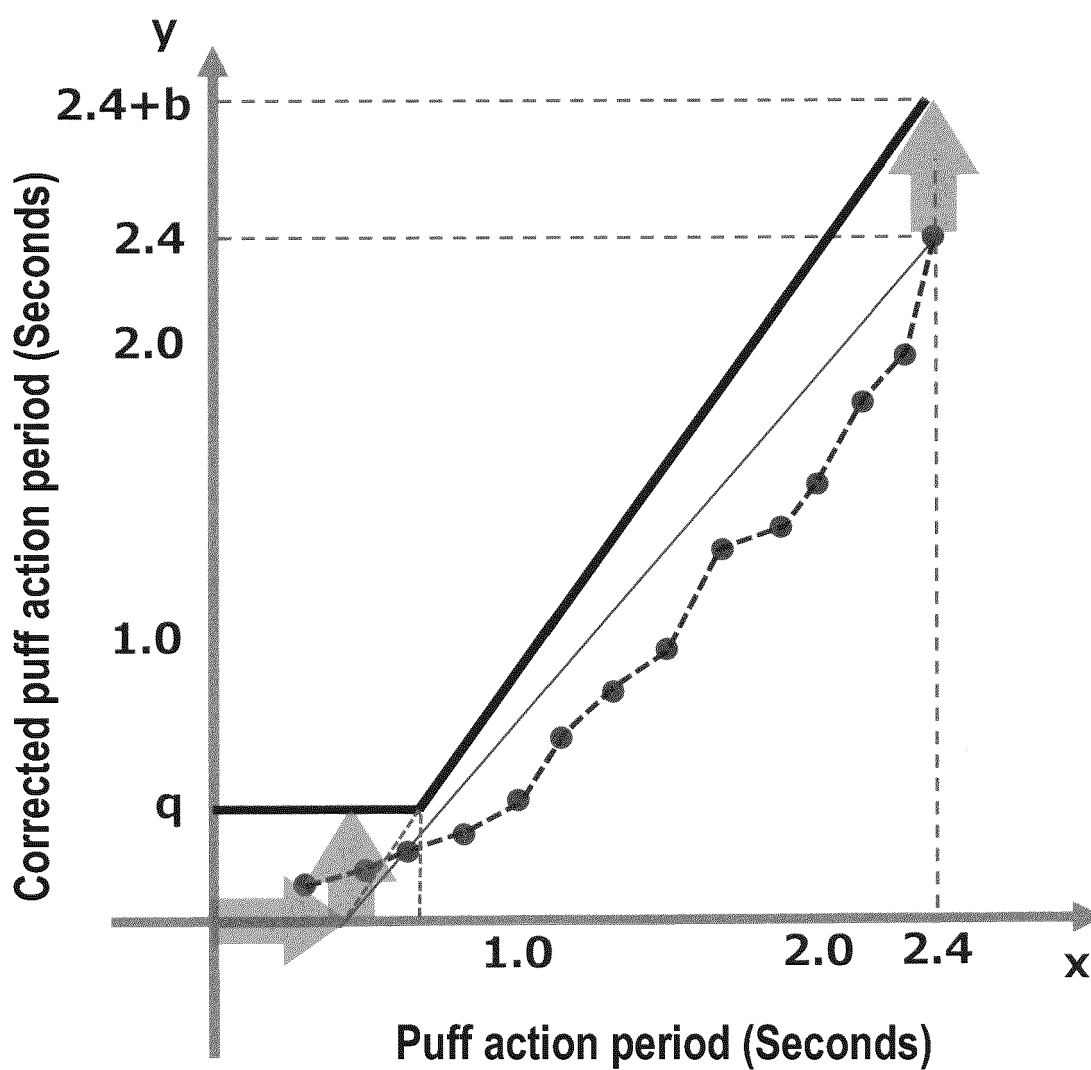
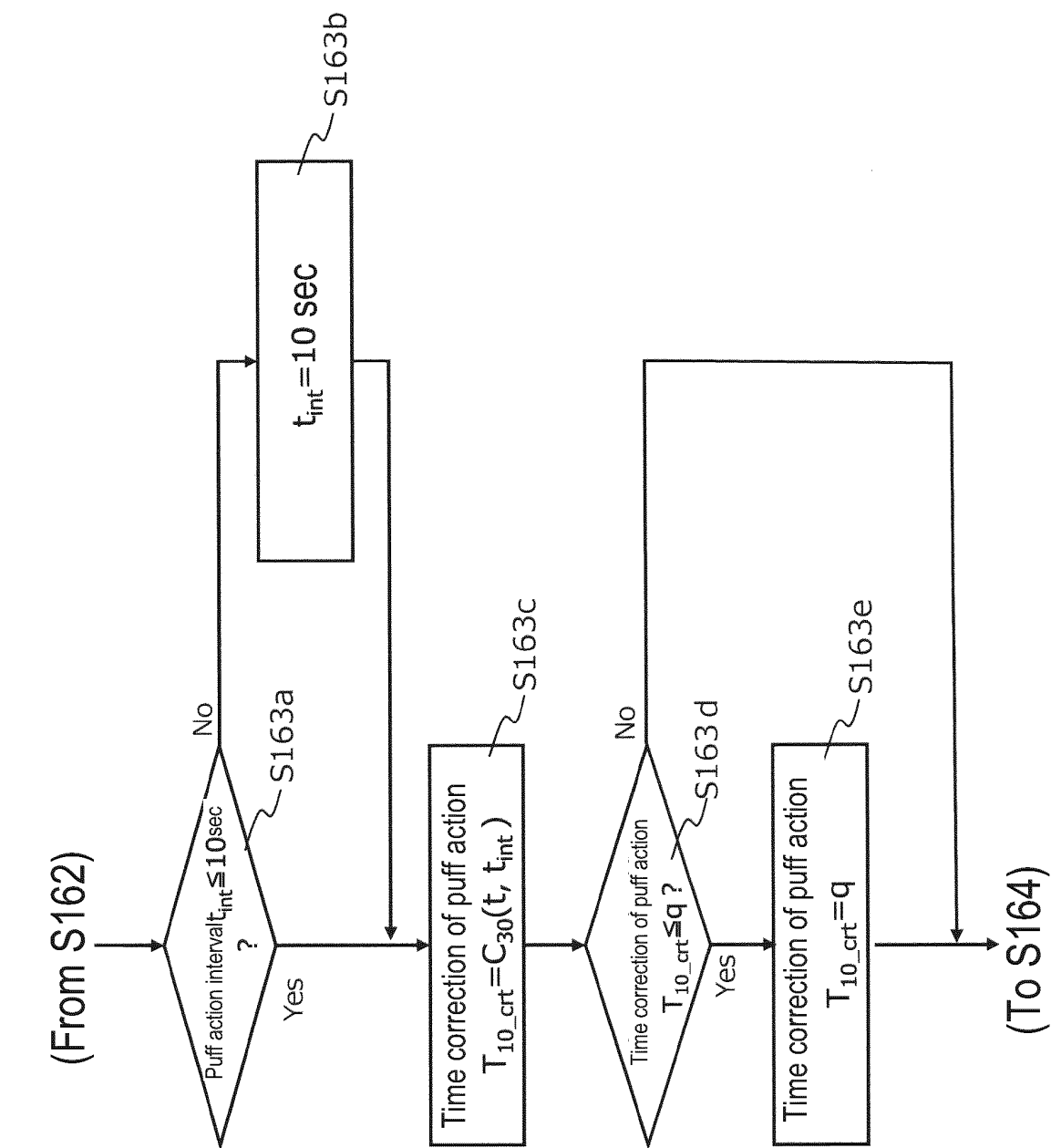


Fig. 18



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/035595

A. CLASSIFICATION OF SUBJECT MATTER

A24F 40/50(2020.01)i; *A24F 40/53*(2020.01)i
 FI: A24F40/53; A24F40/50

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)

A24F40/00-47/00

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	WO 2021/002392 A1 (JAPAN TOBACCO INCORPORATED) 07 January 2021 (2021-01-07) entire text, all drawings	1-13
A	JP 2017-192393 A (JAPAN TOBACCO INCORPORATED) 26 October 2017 (2017-10-26) entire text, all drawings	1-13
A	WO 2018/224823 A1 (NICOVENTURES HOLDINGS LIMITED) 13 December 2018 (2018-12-13) entire text, all drawings	1-13
A	KR 10-2018-0070443 A (KT&G CORPORATION) 26 June 2018 (2018-06-26) entire text, all drawings	1-13
A	JP 2021-509276 A (KT&G CORPORATION) 25 March 2021 (2021-03-25) entire text, all drawings	1-13
A	JP 2021-509259 A (KT&G CORPORATION) 25 March 2021 (2021-03-25) entire text, all drawings	1-13

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

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search

10 November 2021

Date of mailing of the international search report

30 November 2021

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2021/035595

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