US 20250256289A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0256289 A1**

UDA et al. (43) **Pub. Date: Aug. 14, 2025**

(54) **DUST COLLECTION SYSTEM AND DUST COLLECTION METHOD**

(71) Applicant: **MITSUBISHI HEAVY INDUSTRIES, LTD.**, Tokyo (JP)

(72) Inventors: **Nobuki UDA**, Tokyo (JP); **Yasutoshi UEDA**, Tokyo (JP)

(73) Assignee: **MITSUBISHI HEAVY INDUSTRIES, LTD.**, Tokyo (JP)

(21) Appl. No.: **18/724,358**

(22) PCT Filed: **Mar. 9, 2023**

(86) PCT No.: **PCT/JP2023/009088**

§ 371 (c)(1),
(2) Date: **Jun. 26, 2024**

(30) **Foreign Application Priority Data**

Apr. 15, 2022 (JP) 2022-067895

Publication Classification

(51) **Int. Cl.**

B03C 3/41	(2006.01)
B03C 3/014	(2006.01)
B03C 3/017	(2006.01)
B03C 3/16	(2006.01)

(52) **U.S. Cl.**

CPC ***B03C 3/41*** (2013.01); ***B03C 3/014*** (2013.01); ***B03C 3/0175*** (2013.01); ***B03C 3/16*** (2013.01)

(57) **ABSTRACT**

Provided are a dust collection system and a dust collection method that make it possible to efficiently collect fine particles included in a gas. The dust collection system includes: a flow path route through which a gas flows; a droplet supply section for supplying droplets to the flow path route; an electrostatic agglomeration unit that is arranged in the flow path route downstream from the position at which droplets are supplied, forms an electric field in the flow path of the gas, electrostatically charges the droplets and fine particles included in the gas, and causes the fine particles and the droplets to collide (agglomerate); and a dust collection section t is arranged in the flow path route downstream from the electrostatic agglomeration unit and collects the droplets and fine particles.

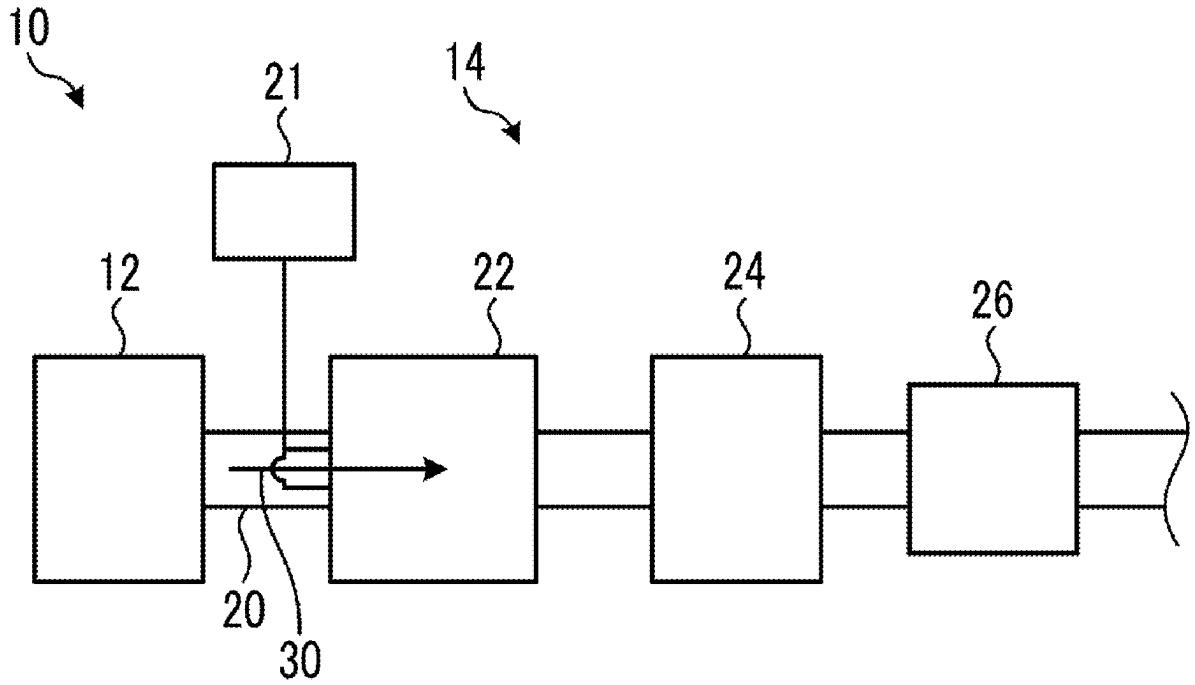


FIG. 1

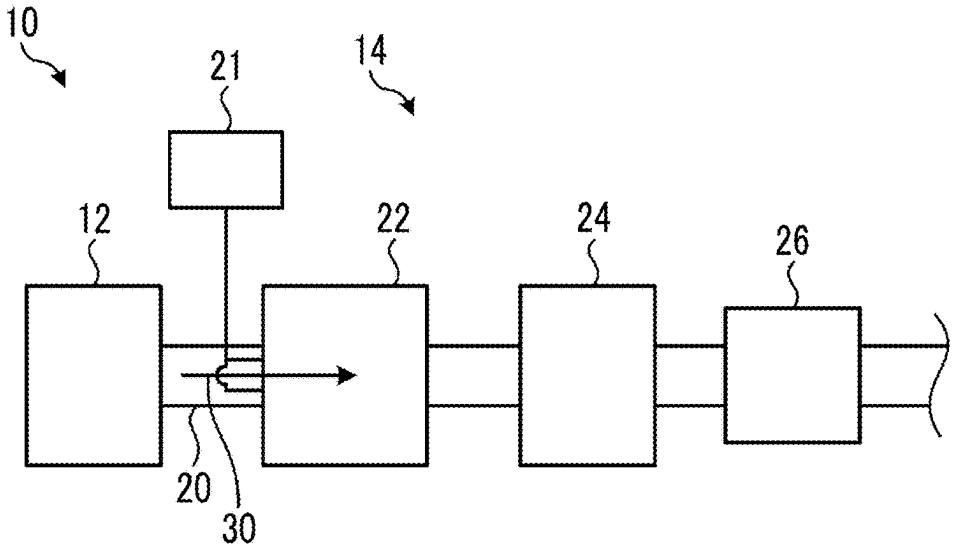


FIG. 2

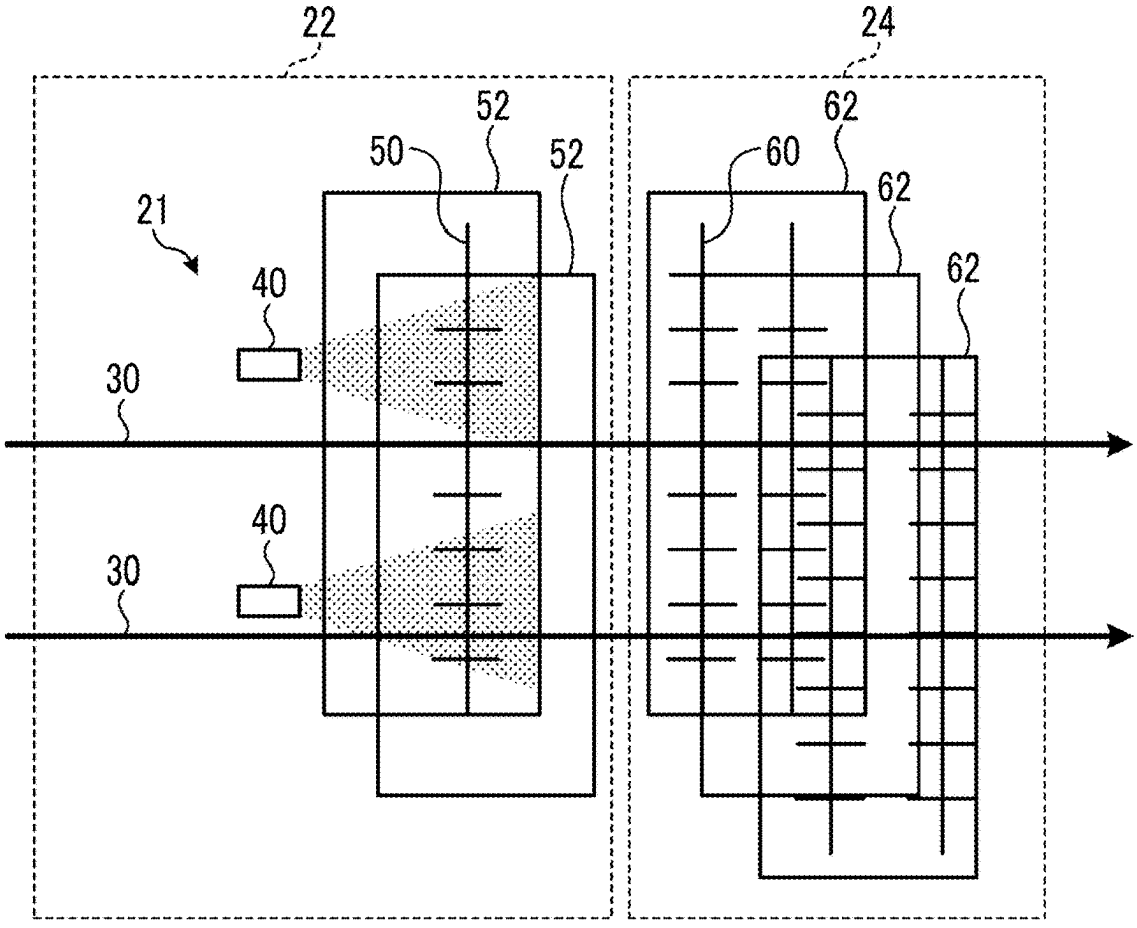


FIG. 3

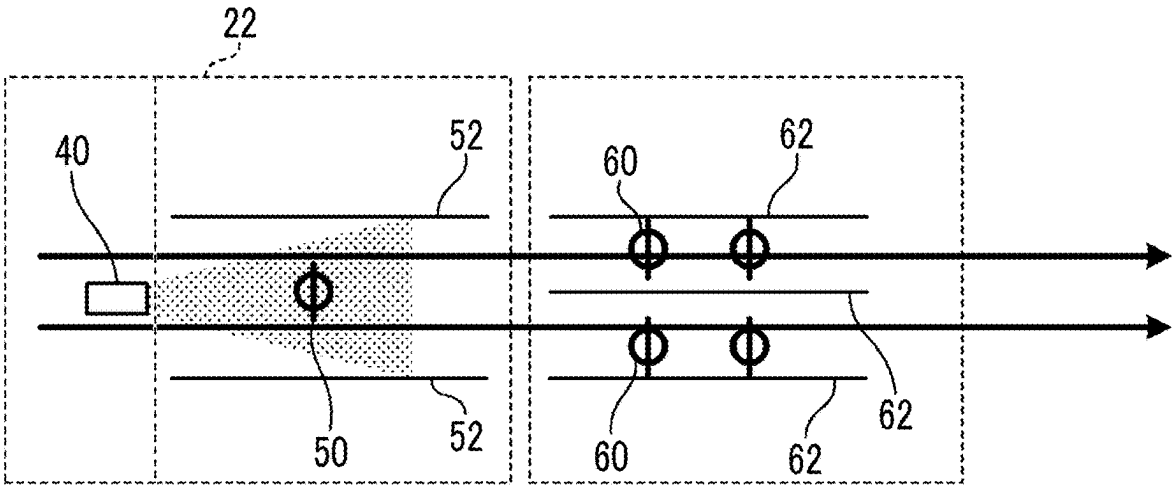


FIG. 4

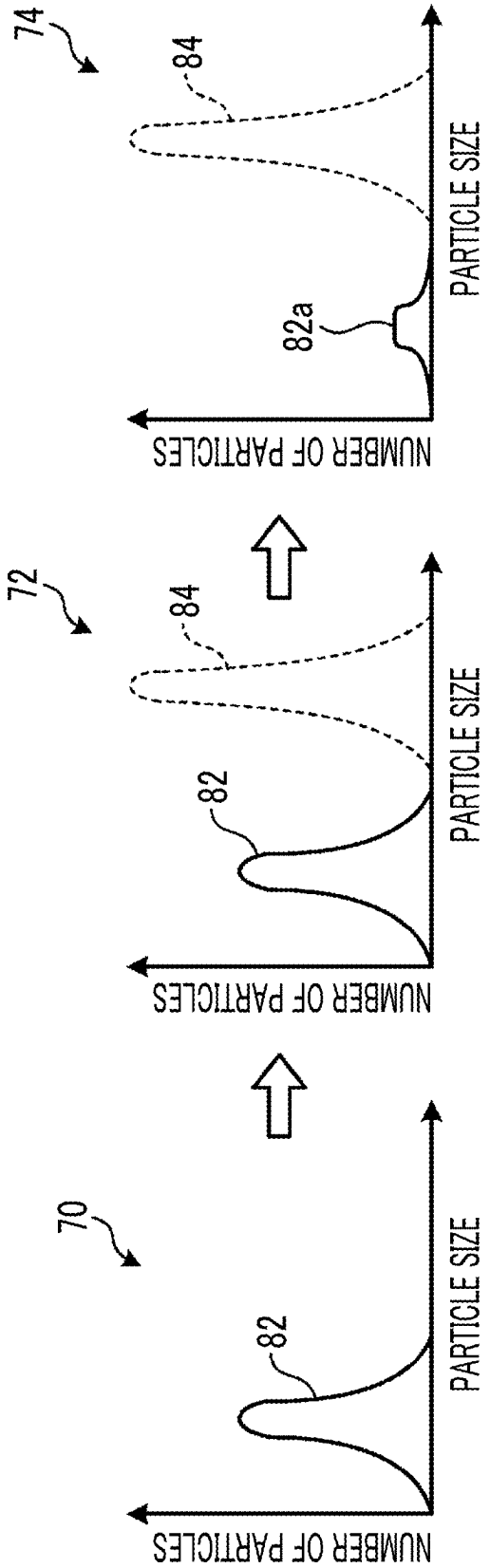

70
82
PARTICLE SIZE
NUMBER OF PARTICLES
72
82
84
PARTICLE SIZE
NUMBER OF PARTICLES
74
82a
84
PARTICLE SIZE
NUMBER OF PARTICLES

FIG. 5

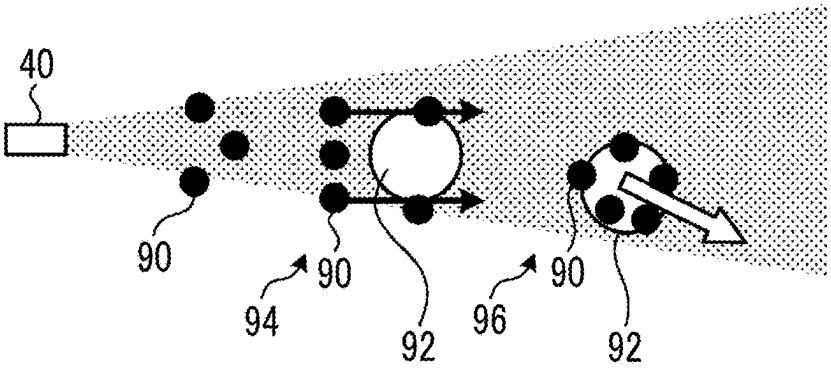


FIG. 6

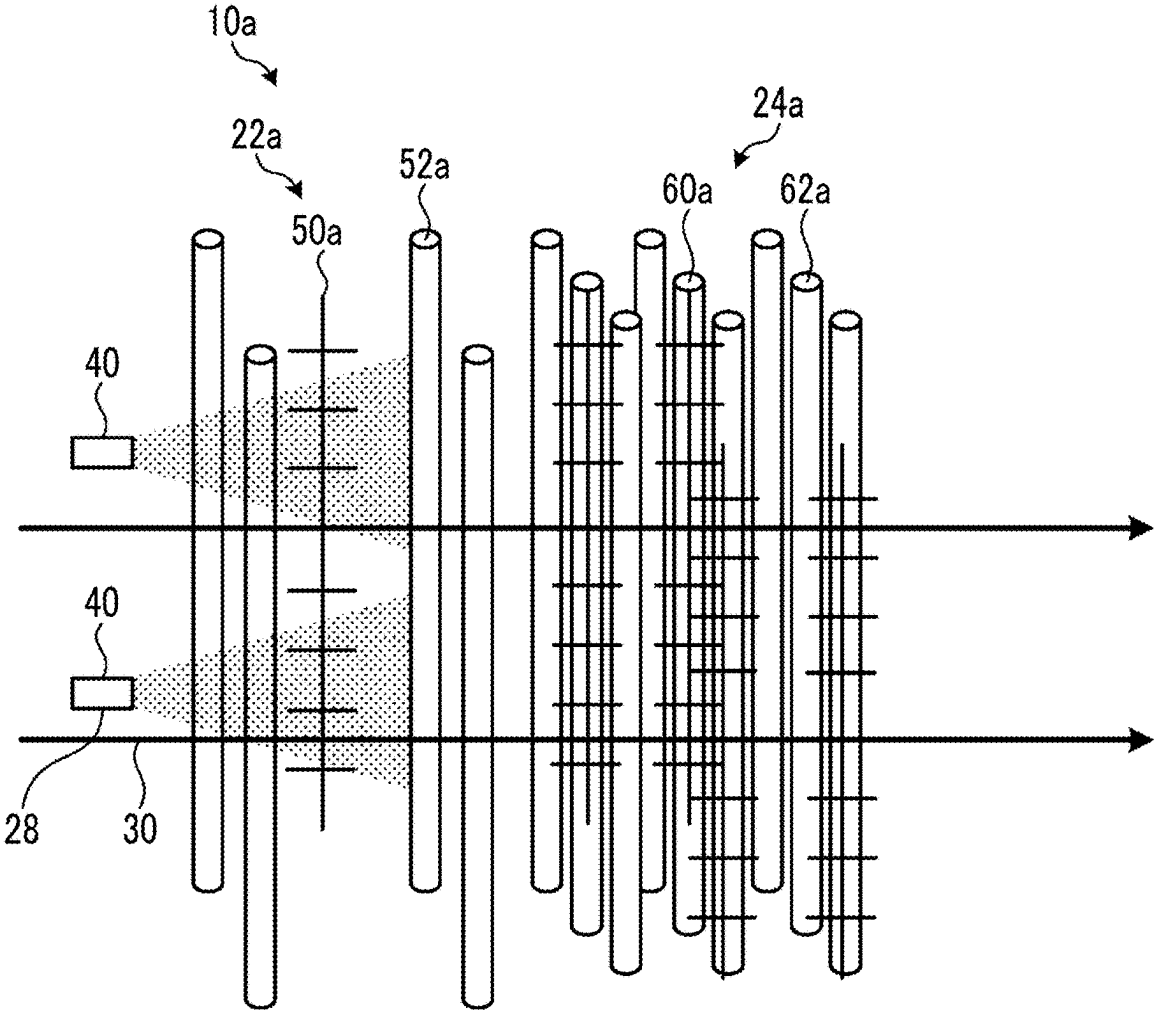


FIG. 7

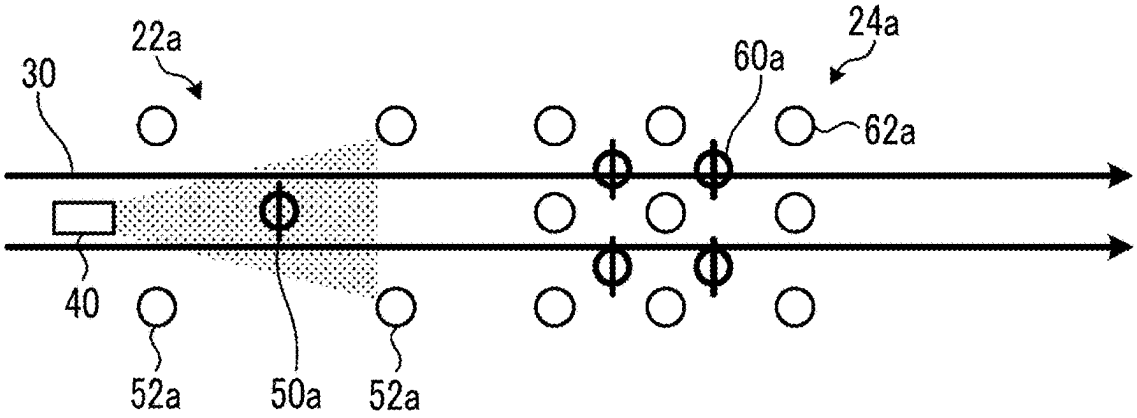


FIG. 8

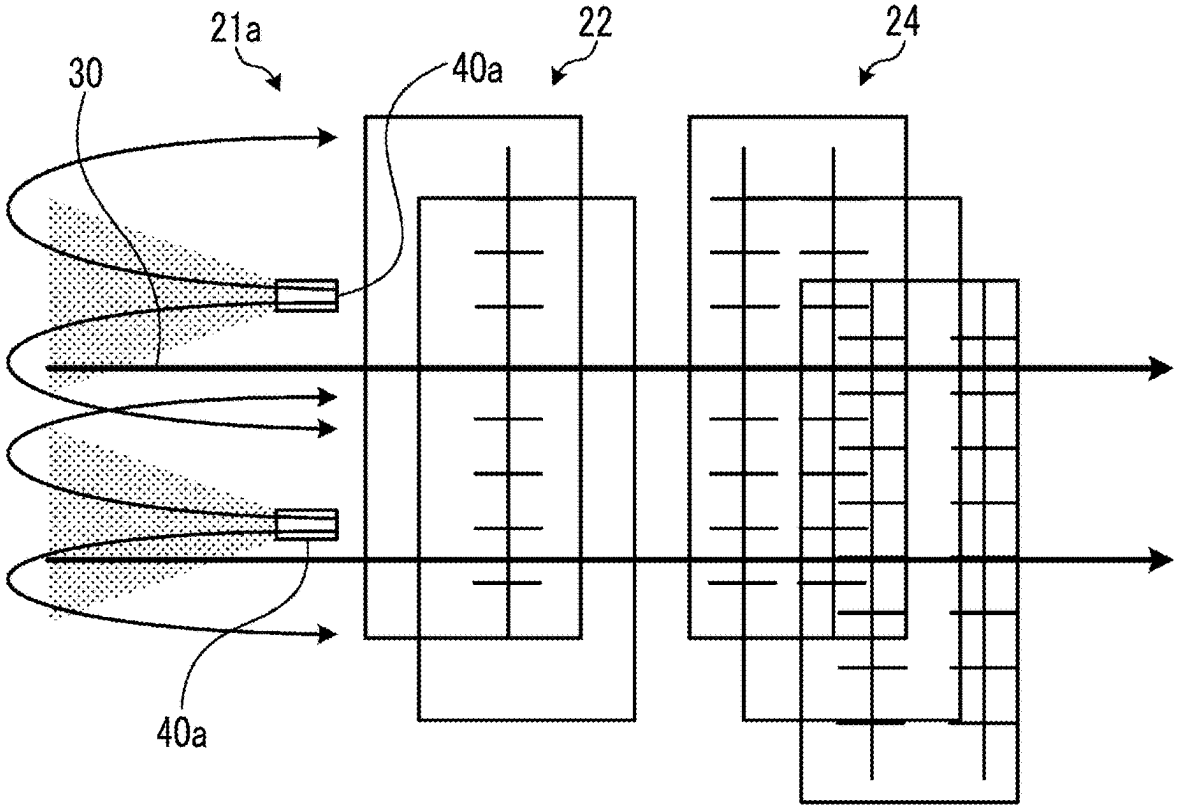


FIG. 9

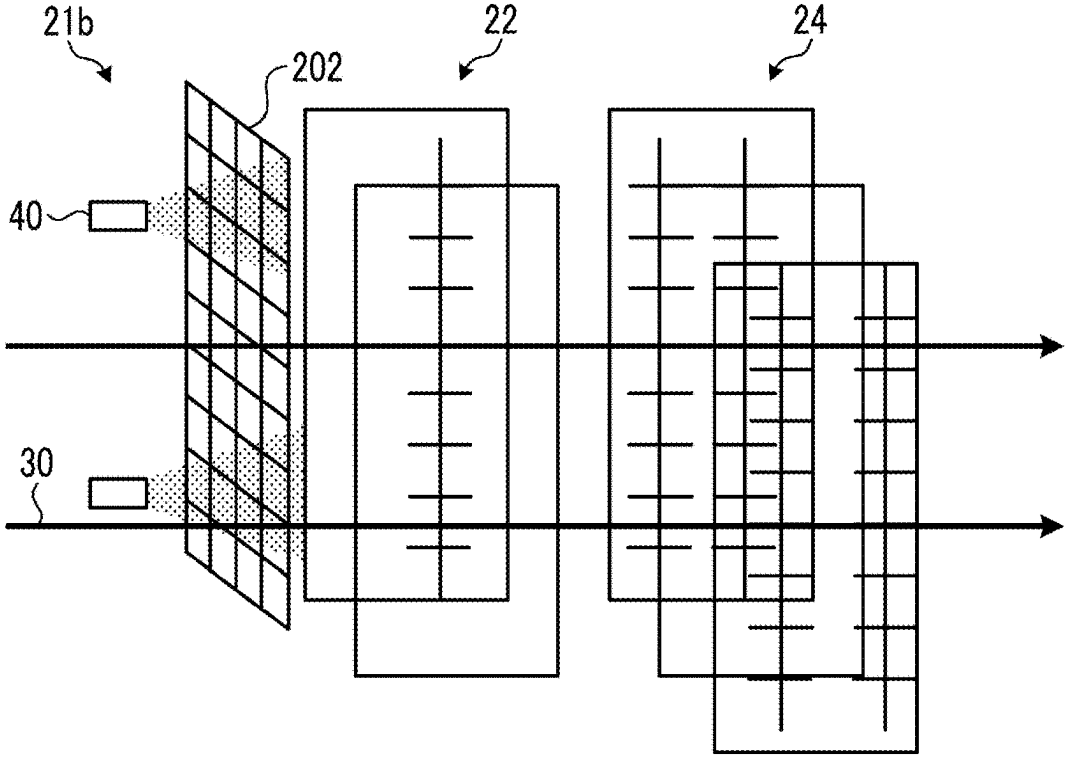
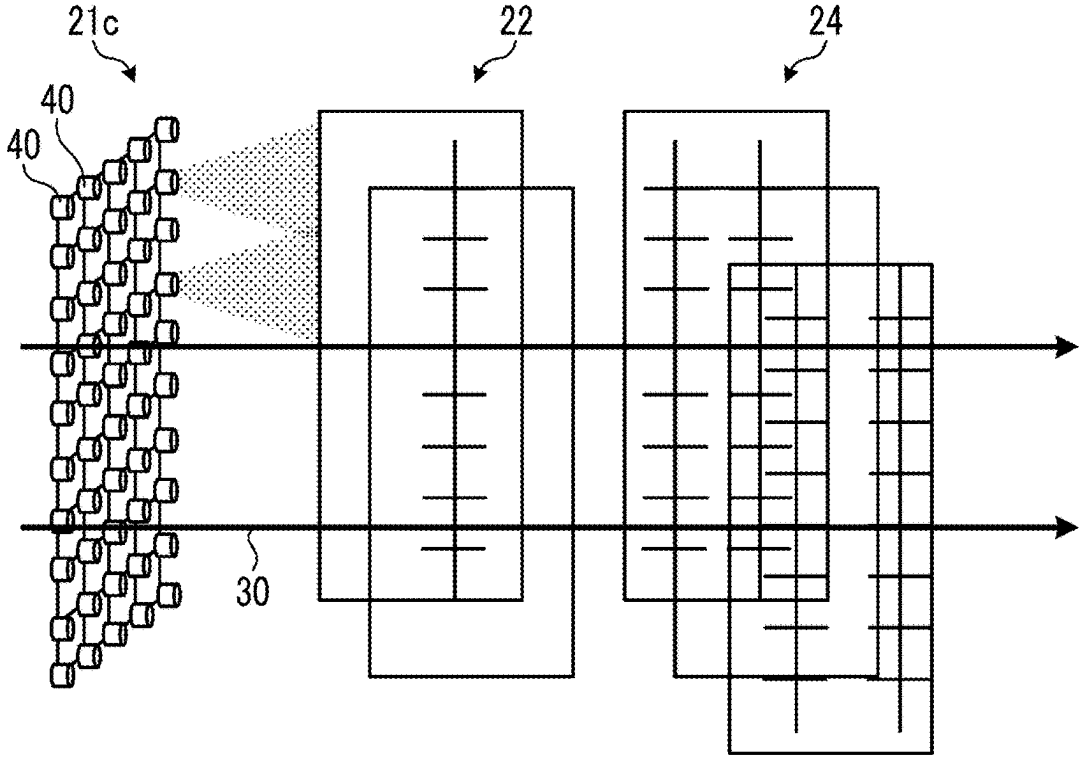


FIG. 10



DUST COLLECTION SYSTEM AND DUST COLLECTION METHOD

TECHNICAL FIELD

[0001] The present disclosure relates to a dust collection system and a dust collection method.

BACKGROUND ART

[0002] In a power plant that combusts fossil fuel or a waste treatment plant that combusts waste, a dust collection system that collects fine particles contained in exhaust gas is disposed as an exhaust gas treatment device. Examples of the dust collection system include an electric dust collector that forms an electric field in a passage of exhaust gas to collect charged fine particles by causing the fine particles to adhere to an electrode, a wet type dust collector that sprays droplets into the exhaust gas to collect the fine particles with the droplets, and a cyclone type dust collector that rotates the exhaust gas to perform centrifugal separation of the fine particles. For example, PTL 1 and PTL 2 describe a system in which droplets are sprayed by a spray on an upstream side of an electric dust collector.

CITATION LIST

Patent Literature

[0003] [PTL 1] International Publication No. WO2011/108324

[0004] [PTL 2] International Publication No. WO2016/153046

SUMMARY OF INVENTION

Technical Problem

[0005] As in PTL 1 and PTL 2, the water can be caused to adhere to the fine particles by spraying the water into the exhaust gas, and the fine particles can be collected by electric dust collector on the downstream. However, more efficient collection is required.

[0006] The present disclosure has been made in view of such problems, and an object of the present disclosure is to provide a dust collection system and a dust collection method capable of efficiently collecting fine particles contained in a gas.

Solution to Problem

[0007] A dust collection system of the present disclosure for solving the above problems includes a circulation passage through which a gas circulates; a droplet supply unit that supplies circulation passage; an droplets to the electrostatic flocculation unit that is disposed in the circulation passage on a downstream side from a supply position of the droplets, forms an electric field in a flow path of the gas, and charges fine particles contained in the gas and the droplets to collide (flocculate) with each other; and a dust collection unit that is disposed in the circulation passage on a downstream side from the electrostatic flocculation unit and collects the droplets and the fine particles.

[0008] A dust collection method of the present disclosure for solving the above problems includes a step of supplying droplets to a circulation passage through which a gas circulates; a step of forming an electric field in the circulation passage on a downstream side from a supply position of the droplets, and charging fine particles contained in the gas and the droplets to collide (flocculate) with each other; and a step of collecting the droplets and the fine particles in the circulation passage on a downstream side from a position where the fine particles and the droplets are charged.

Advantageous Effects of Invention

[0009] According to the present disclosure, the fine particles contained in the gas can be efficiently collected.

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. **1** is a schematic diagram showing a schematic configuration of a combustion plant having a dust collection system according to the present embodiment.

[0011] FIG. **2** is a perspective view showing a schematic configuration of the dust collection system.

[0012] FIG. **3** is a cross-sectional view showing a schematic configuration of the dust collection system shown in FIG. **2**.

[0013] FIG. **4** is a view for describing a process of the dust collection system.

[0014] FIG. **5** is a view for describing a process of the dust collection system.

[0015] FIG. **6** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment.

[0016] FIG. **7** is a cross-sectional view showing a schematic configuration of the dust collection system shown in FIG. **6**.

[0017] FIG. **8** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment.

[0018] FIG. **9** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment.

[0019] FIG. **10** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment.

DESCRIPTION OF EMBODIMENTS

[0020] Hereinafter, a dust collection system and a dust collection method according to the present disclosure will be described with reference to the drawings. It should be noted that the present disclosure describes an embodiment of the present invention, and the present invention is not limited thereto. The present embodiment will describe the dust collection system as a case of processing the exhaust gas combusted by the combustion device. However, the present embodiment is not limited thereto. The dust collection system can be used to collect various fine particles contained in a gas. For example, the dust collection system can be used as a system for recovering fine particles contained in air in a manufacturing plant or a system for recovering fine particles, for example, dust in a work site such as a demolition work site. In addition, the fine particles are not limited to the solid, and may be a liquid such as a droplet or tar.

[0021] FIG. **1** is a schematic diagram showing a schematic configuration of a combustion plant having a dust collection system according to the present embodiment. A combustion plant **10** shown in FIG. **1** includes a combustion device **12** and a dust collection system **14**.

[0022] The combustion device **12** is a device that combusts fossil fuel, incineration object, or the like. The combustion device **12** discharges the exhaust gas generated during combustion. The heat generated by combusting the target contained in the exhaust gas can be used as a power generation or a heat source. In the combustion plant **10**, an exhaust heat recovery device that recovers heat of the exhaust gas or an exhaust gas treatment device that treats a harmful component other than fine particles may be disposed in the passage of the exhaust gas.

[0023] Next, the dust collection system **14** will be described with reference to FIGS. **1**, **2**, and **3**. FIG. **2** is a perspective view showing a schematic configuration of the dust collection system. FIG. **3** is a cross-sectional view showing a schematic configuration of the dust collection system shown in FIG. **2**. The dust collection system **14** collects fine particles contained in the exhaust gas discharged from the combustion device **12**. The dust collection system **14** includes a circulation passage **20**, a droplet supply unit **21**, an electrostatic flocculation unit **22**, an electric dust collector **24**, and a blower **26**. The circulation flow path **20** is a pipeline through which the exhaust gas generated by the combustion device **12** flows in the circulation direction **30**. The circulation flow path **20** is disposed in the droplet supply unit **21**, the electrostatic flocculation unit **22**, the electric dust collector **24**, and the blower **26** in this order from the upstream side in the circulation direction **30**.

[0024] The droplet supply unit **21** sprays a liquid into the circulation flow path **20** to form a large number of droplets. The droplet supply unit **21** includes a plurality of nozzles **40**. The nozzle **40** sprays a liquid to form droplets having a particle size in a predetermined range.

[0025] The electrostatic flocculation unit **22** is disposed on a downstream side from the nozzle **40** of the droplet supply unit **21** of the circulation flow path **20**. The electrostatic flocculation unit **22** forms an electric field in a region through which the fine particles and the droplets pass, and charges the fine particles and the droplets. The charged fine particles and the droplets move in the electric field by diffusion and electrophoresis to collide (flocculate) with each other. When the fine particles collide with the droplets, the fine particles are taken into the droplets. The electrostatic flocculation unit **22** has a discharge electrode **50** and a ground electrode **52**. A predetermined voltage is applied to the discharge electrode **50**. The ground electrode **52** is a plate-shaped electrode disposed to face the discharge electrode **50**. The ground electrode **52** is disposed such that a direction along the circulation direction **30** is a surface. Accordingly, the ground electrode **52** can be suppressed from becoming a resistance to the flow of the exhaust gas. The ground electrode **52** is grounded. The electrostatic flocculation unit **22** applies a predetermined voltage to the discharge electrode **50** to form an electric field between the discharge electrode **50** and the ground electrode **52**. The electrostatic flocculation unit **22** may form an electric field between the discharge electrode **50** and the ground electrode **52**, and a predetermined voltage may be applied without grounding the ground electrode **52**.

[0026] In the present embodiment, the electrostatic flocculation unit **22** is disposed on the downstream side of the nozzle **40**. However, the present disclosure is not limited thereto. A part of the electrostatic flocculation unit **22** may be disposed on the upstream side of the nozzle **40**. That is, the nozzle **40** may be disposed in the electrostatic flocculation unit **22**.

[0027] The electric dust collector **24** is disposed on a downstream side from the electrostatic flocculation unit **22** of the circulation flow path **20**. The electric dust collector **24** forms an electric field in a region through which the fine particles and the droplets pass, and collects the fine particles and the droplets. The electric dust collector **24** has a discharge electrode **60** and a ground electrode (collection electrode) **62**. A predetermined voltage is applied to the discharge electrode **60**. The ground electrode **62** is a plate-shaped electrode disposed to face the discharge electrode **60**. The ground electrode **62** is disposed such that a direction along the circulation direction **30** is a surface. Accordingly, the ground electrode **62** can be suppressed from becoming a resistance to the flow of the exhaust gas. The ground electrode **62** is grounded. In the electric dust collector **24** of the present embodiment, the discharge electrode **60** and the ground electrode (collection electrode) **62** are disposed at an interval shorter than the interval between the discharge electrode **50** and the ground electrode **52** of the electrostatic flocculation unit **22**. The electric dust collector **24** applies a predetermined voltage to the discharge electrode **60** to form an electric field between the discharge electrode **60** and the ground electrode **62**. The electric dust collector **24** forms an electric field to move the fine particles contained in the exhaust gas and the droplets toward the ground electrode **62** and collects the fine particles and the droplets by adhering the fine particles and the droplets to the ground electrode **62**.

[0028] The electric dust collector **24** may form an electric field between the discharge electrode **60** and the ground electrode **62**, and may apply a predetermined voltage without grounding the ground electrode **62**. The electric dust collector **24** may include a washing device that removes fine particles adhering to the ground electrode **62** or a recovery device that drops the fine particles in a vertical direction and recovers the fine particles.

[0029] The blower **26** is disposed in the circulation flow path **20** on a downstream side from the electric dust collector **24**. The blower **26** forms a flow directed from the combustion device **12** toward the electric dust collector **24** and sends the exhaust gas in the circulation direction **30**. In a case where the exhaust gas from the combustion device **12** or the like is discharged at a predetermined flow velocity, the dust collection system **14** may not be provided with the blower **26**. That is, the combustion device **12** may satisfy the blowing function.

[0030] Next, a dust collection method of the dust collection system **14** will be described with reference to FIGS. **4** and **5** in addition to FIGS. **2** and **3**. Each of FIGS. **4** and **5** is a view for describing a process of the dust collection system. The exhaust gas containing fine particles is supplied to the dust collection system **14**. As shown in a particle distribution **70** in FIG. **4**, the distribution of the particles contained in the gas flowing into the dust collection system **14** is only a fine particle distribution **82** corresponding to the fine particles.

[0031] The exhaust gas flowing into the dust collection system **14** moves along the circulation direction **30**, and the droplets are supplied in a region where the nozzle **40** is disposed. As shown in a particle distribution **72** in FIG. **4**, the distribution of the particles contained in the gas to which the droplets are supplied includes a fine particle distribution

82 corresponding to the fine particles and a droplet distribution 84 corresponding to the droplets. That is, a state where the droplets and the fine particles are mixed is formed.

[0032] In the dust collection system 14, when the gas in which the droplets and the fine particles are mixed passes through the electrostatic flocculation unit 22, the fine particles 90 and the droplets 92 pass through the first region 94 in which an electric field is formed, as shown in FIG. 5. The fine particles 90 and the droplets 92 are charged when passing through the first region 94 where the electrostatic flocculation unit 22 is disposed. When the fine particles 90 approach a vicinity of the droplets 92 in a charged state, the fine particles 90 adhere to the droplets 92 or are absorbed into the droplets. Accordingly, as shown in FIG. 4, in the dust collection system 14, the particle distribution 74 of the gas that has passed through the electrostatic flocculation unit 22 becomes the fine particle distribution 82*a* and the droplet distribution 84. Here, the fine particle distribution 82*a* is decreased from the fine particle distribution 82 for fine particles to integrate with the droplets.

[0033] In the dust collection system 14, the gas in the state of the particle distribution 74 passes through a second region 96 where the electric dust collector 24 is disposed. The droplets 92 to which the fine particles 90 passing through the second region 96 is adhered is subjected to a force which moves toward the ground electrode 62 in an electric field formed in the electric dust collector 24, moves toward the ground electrode 62, and adheres to the ground electrode 62.

[0034] As described above, the dust collection system 14 is provided with the droplet supply unit 21 and the electrostatic flocculation unit 22 on the upstream side of the electric dust collector 24. The droplet supply unit 21 supplies the droplets to the exhaust gas, and the electrostatic flocculation unit 22 charges the droplets and the fine particles. In this manner, the droplets and the fine particles are easily brought into collision with each other, and the fine particles can be collected by the droplets. The droplets that collect fine particles can be collected by the electric dust collector 24, so that the fine particles in the exhaust gas can be collected.

[0035] In a case where the droplets and the fine particles are not charged, the fine particles are not brought close to the droplets due to the influence of a gas flow around the droplets generated by moving along the flow of the exhaust gas, and the fine particles are less likely to come into contact with the droplets. When the droplets and the fine particles reach the electric dust collector 24 in this state, the droplets and the fine particles are in separate states, and the electric dust collector 24 collects the droplets to which the fine particles are not adhered. In contrast, the droplets and the fine particles are charged by the electrostatic flocculation unit 22, as described above, whereby the fine particles can be easily caused to collide with the droplets, and the fine particles can adhere to the droplets before reaching the electric dust collector 24. Accordingly, the droplets in which the fine particles are collected can be collected by the electric dust collector 24.

[0036] In the dust collection system 14, the droplets that are easier to move than the fine particles in the same electric field can be collected by collecting the droplets to which the fine particles adhere by the electric dust collector 24, and can be collected the droplets more efficiently than collecting the fine particles alone. In addition, since the droplets can be collected at a distance shorter than that of the fine particles, the size of the electric dust collector 24 can be reduced.

[0037] Here, it is preferable that the electrostatic flocculation unit 22 forms an electric field having a lower electric field strength than that of the electric dust collector 24. Accordingly, in the electrostatic flocculation unit 22, the fine particles and the droplets can be brought into contact with each other while the collection of the droplets is suppressed, and the droplets can be collected by the electric dust collector 24.

[0038] It is preferable that the electrostatic flocculation unit 22 has a distance between the ground electrode and the discharge electrode larger than that of the electric dust collector 24. It is preferable that the electrostatic flocculation unit 22 has a distance between the ground electrode and the discharge electrode equal to or more than 2 times and equal to or less than 3 times with respect to the electric dust collector 24.

[0039] It is preferable that the electrostatic flocculation unit 22 has a potential difference between the ground electrode and the discharge electrode smaller than that of the electric dust collector 24. It is preferable that the electrostatic flocculation unit 22 has a potential difference between the ground electrode and the discharge electrode equal to or larger than ⅓ and equal to or smaller than 1 with respect to the electric dust collector 24. The electrostatic flocculation unit 22 can charge the droplets and the fine particles while suppressing the occurrence of discharge via the droplets between the ground electrode and the discharge electrode by making the potential difference between the ground electrode and the discharge electrode smaller than that of the electric dust collector 24.

[0040] It is preferable that the electrode interval (the interval in the gas flow direction or the distance in the direction perpendicular thereto) between the discharge electrode and the ground electrode of the electrostatic flocculation unit 22 is 100 mm or more and 500 mm or less. It is preferable that the potential difference between the discharge electrode and the ground electrode of the electrostatic flocculation unit 22 is 10 kV or more and 50 kV or less. By increasing the electrode interval in the gas flow direction, it is possible to secure a collision time between the fine particles and the droplets.

[0041] It is preferable that the droplet supply unit 21 supplies, to the circulation flow path 30, the droplets in which a relationship between a flow rate α (L/min) of the droplets to be supplied and a gas flow rate β (m^3/min) of the circulation flow path 30 satisfies $0.1 \leq (\alpha/\beta) \leq 1.0$. Accordingly, the droplets and the fine particles can be charged while suppressing the occurrence of abnormal discharge (spark) via the droplets between the ground electrode and the discharge electrode.

[0042] The electrostatic flocculation unit 22 and the electric dust collector 24 may be disposed inside one housing. For example, the electrostatic flocculation unit 22 and the electric dust collector 24 may be configured such that an electrode for forming an electric field is disposed in the circulation flow path 20. In addition, the dust collection system 14 may be provided with a predetermined distance between the electrostatic flocculation unit 22 and the electric dust collector 24. In this manner, the fine particles charged by the electrostatic flocculation unit 22 can enter the electric dust collector 24 in a state of being adhered to the droplets, and thus the efficiency of collecting the fine particles can be further improved.

[0043] In the dust collection system **14** of the present embodiment, the dust is collected by the electric dust collector **24**, so that the charged droplets and the fine particles can be efficiently moved, and the fine particles can be efficiently collected. Here, since the dust collection system **14** of the present embodiment can obtain the above-described effect, the droplets and the fine particles are collected by the electric dust collector **24**. However, the dust collection unit is not limited thereto. In dust collection system **14**, as the dust collection unit, a cyclone type dust collector that collects that rotates a gas in a centrifugal direction to collect the droplets by using a centrifugal force may be used, a mist trap that collects the droplets may be provided, or a wet type dust collector that supplies droplets, combines the droplets with the adhered fine particles, and drops the droplets is provided may be used.

[0044] FIG. **6** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment. FIG. **7** is a cross-sectional view showing a schematic configuration of the dust collection system shown in FIG. **6**. The dust collection system shown in FIGS. **6** and **7** is the same as the dust collection system **14** except for the structure of the electrostatic flocculation unit **22***a* and the electric dust collector **24***a*.

[0045] The electrostatic flocculation unit **22***a* has a discharge electrode **50***a* and a ground electrode **52***a*. The discharge electrode **50***a* is a rod-shaped electrode. The ground electrode **52** is a rod-shaped electrode and is disposed around the discharge electrode **50***a*. The electric dust collector **24***a* has a discharge electrode **60***a* and a ground electrode **62***a*. The discharge electrode **60***a* is a rod-shaped electrode. The ground electrode **62** is a rod-shaped electrode and is disposed around the discharge electrode **60***a*. In a case where a plurality of the discharge electrodes **60***a* are disposed around the ground electrode **62**, the ground electrode **62** is disposed to be at an equal distance from each of the plurality of discharge electrodes **60***a*.

[0046] As described above, the ground electrodes **52***a* and **62***a* may have a rod-like shape. Also in this case, by setting the electric field of the electrostatic flocculation unit **22***a* to a lower electric field strength than the electric field of the electric dust collector **24***a*, the droplets and the fine particles are charged in the electrostatic flocculation unit **22***a*, and the droplets containing the fine particles can be easily collected by the electric dust collector **24***a* by colliding (flocculating) the droplets and fine particles.

[0047] FIG. **8** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment. In the dust collection system shown in FIG. **8**, the droplet supply unit **21***a* is different from the dust collection system **14**. Hereinafter, specific points of the dust collection system shown in FIG. **8** will be described. In the droplet supply unit **21***a* of the dust collection system shown in FIG. **8**, the spraying direction of the nozzle **40***a* is opposite to the circulation direction **30**. That is, the nozzle **40***a* sprays the droplets toward the upstream side in the circulation direction **30**. Accordingly, after the sprayed droplets move to the upstream side in the circulation direction **30**, the advancing direction of the droplets is reversed by the force of the exhaust gas flowing along the circulation direction **30**, and the droplets move along the circulation direction **30**.

[0048] In the dust collection system shown in FIG. **8**, the spray port of the nozzle **40***a* is disposed on the upstream side in the circulation direction **30**, and the droplets are sprayed toward the upstream side in the circulation direction **30**. In this manner, the distance that the droplets sprayed from the nozzle **40***a* move until the droplets enter the electrostatic flocculation unit **22** can be made longer. Accordingly, the droplets supplied from the droplet supply unit **21***a* can be caused to enter the electrostatic flocculation unit **22** in a more dispersed state. The dispersed droplets enter the electrostatic flocculation unit **22**, so that the fine particles and the droplets can be brought into close contact with each other. In addition, even when the distance between the nozzle **40***a* and the electrostatic flocculation unit **22** shortened, the droplets can move by a distance necessary for the droplets to be dispersed. Therefore, the performance of collecting the fine particles can be improved while the size of the dust collection system in the circulation direction **30** is shortened.

[0049] FIG. **9** is a perspective view showing a schematic configuration of a dust collection system according to another embodiment. In the dust collection system shown in FIG. **9**, the droplet supply unit **21***b* is different from the dust collection system **14**. Hereinafter, specific points of the dust collection system shown in FIG. **9** will be described. The droplet supply unit **21***b* of the dust collection system shown in FIG. **9** includes the rectification mechanism **202** in addition to each portion of the droplet supply unit **21**.

[0050] The rectification mechanism **202** is disposed between the nozzle **40** and the electrostatic flocculation unit **22**. The rectification mechanism **202** is a mesh disposed in a plate like, so-called plate shape, in which an opening through which the droplets and the fine particles pass is regularly formed. For example, the rectification mechanism **202** can use a mesh having an opening ratio of 0.5. It is preferable that the rectification mechanism **202** has an opening ratio of the mesh of 0.2 or more and 0.6 or less.

[0051] The droplet supply unit **21***b* disposes the rectification mechanism **202** in which the openings are regularly formed between the nozzle **40** and the electrostatic flocculation unit **22**, so that the flow of the droplets sprayed from the nozzle **40** and the fine particles contained in the exhaust gas is rectified, and the fine particles are easily caused to collide with the droplets. Specifically, in the rectification mechanism **202**, a region through which the droplets and the fine particles can pass can be constrained to the opening of the rectification mechanism **202**. Accordingly, at the time of passing through the opening, the droplets can be in a state of being in the vicinity of the fine particles, and the fine particles can be easily caused to collide with the droplets. In addition, the droplets can be dispersed over a wide range of the rectification mechanism **202** by uniformly spreading the droplets on the mesh surface. As a result, the droplets and the fine particles can be brought into contact with each other over a wider range.

[0052] The rectification mechanism **202** is not limited to the mesh-shaped plate, and may have various shapes that are capable of restricting the movement of the droplets and the fine particles sprayed from the nozzle **40** and promoting the adhesion of the fine particles to the droplets. The rectification mechanism **202** may have a structure in which tubular flow paths are two-dimensionally arranged, that is, a structure in which a thick mesh is disposed. In addition, a plurality of stages of the rectification mechanism **202** may be installed.

[0053] FIG. **10** is a perspective view showing a schematic configuration of a dust collection system according to

another embodiment. In the dust collection system shown in FIG. **10**, the droplet supply unit **21***c* is different from the dust collection system **14**. Hereinafter, specific points of the dust collection system shown in FIG. **10** will be described. In the droplet supply unit **21***c* of the dust collection system shown in FIG. **10**, the nozzles **40** are disposed in a lattice pattern. For example, the droplet supply unit **21***c* disposes 60 nozzles **40** per 1 m^2.

[0054] The droplet supply unit **21***c* disposes the nozzles **40** in a lattice pattern. Accordingly, a region where the droplets are sprayed by one nozzle **40** can be reduced, and a distance (a distance in the circulation direction **30**) required for the sprayed droplets to diffuse to a predetermined range can be shortened. In addition, the droplets are sprayed from the plurality of nozzles disposed in a lattice pattern, so that the droplets to be sprayed can be easily decelerated, and the droplets can be decelerated to the same flow velocity as the fine particles over a short distance. Accordingly, the fine particles and the droplets can be easily brought into contact with each other, and the fine particles can be more reliably collected by the droplets.

[0055] In the present embodiment, the nozzle **40** is disposed in a row-and-column arrangement in the two-dimensional direction. However, the nozzle **40** may be disposed in a zig-zag lattice pattern. Additionally, the droplet supply units **21***c* may be two-dimensionally arranged when viewed from the circulation direction **30**, and may be disposed such that the positions thereof in the circulation direction **30** are shifted.

[0056] The present disclosure discloses the following invention. The following is not limited to the following.

[0057] (1) A dust collection system includes a circulation passage through which a gas circulates, a droplet supply unit that supplies droplets to the circulation passage, an electrostatic flocculation unit that is disposed in the circulation passage on a downstream side from a supply position of the droplets, forms an electric field in a flow path of the gas, charges fine particles contained in the gas and the droplets, and causes the fine particles and the droplets to collide with each other, and a dust collection unit that is disposed in the circulation passage on a downstream side from the electrostatic flocculation unit and collects the droplets and the fine particles.

[0058] (2) The dust collection system according to (1), in which the dust collection unit is an electric dust collector that has a discharge electrode and a ground electrode, forms an electric field between the discharge electrode and the ground electrode, and causes the droplets and the fine particles to adhere to the ground electrode.

[0059] (3) The dust collection system according to (2), in which the electrostatic flocculation unit forms an electric field having an electric field strength lower than that of the dust collection unit.

[0060] (4) The dust collection system according to (3), in which the electrostatic flocculation unit has an applied voltage smaller than that of the dust collection unit.

[0061] (5) The dust collection system according to (3) or (4), in which the electrostatic flocculation unit has a discharge electrode and a ground electrode, and a distance between the discharge electrode and the ground electrode is larger than that of the dust collection unit.

[0062] (6) The dust collection system according to any one of (2) to (5), in which the ground electrode is a plate-shaped electrode.

[0063] (7) The dust collection system according to any one of (2) to (5), in which the ground electrode is a rod-shaped electrode.

[0064] (8) The dust collection system according to any one of (1) to (7), in which the droplet supply unit supplies, to the circulation flow path, droplets in which a relationship between a flow rate α (L/min) of the droplets to be supplied and a gas flow rate β (m^3/min) of the circulation flow path satisfies $0.1 \leq (\alpha/\beta) \leq 1.0$.

[0065] (9) The dust collection system according to any one of (1) to (8), in which the droplet supply unit sprays the droplets to an upstream side.

[0066] (10) The dust collection system according to any one of (1) to (9), in which the droplet supply unit has spray ports that spray the droplets, the spray ports being arranged in a lattice pattern on a surface orthogonal to a flow direction of the gas.

[0067] (11) The dust collection system according to any one of (1) to (10), in which the droplet supply unit includes a mesh-shaped rectification mechanism on a downstream side of a spraying position where the droplets are sprayed.

[0068] (12) A dust collection method includes a step of supplying droplets to a circulation passage through which a gas circulates, a step of forming an electric field in the circulation passage on a downstream side from a supply position of the droplets, and charging fine particles contained in the gas and the droplets, a step of causing the fine particles and the droplets to collide with each other, and a step of collecting the droplets and the fine particles in the circulation passage on a downstream side from a position where the fine particles and the droplets are charged.

REFERENCE SIGNS LIST

[0069] **10**: Combustion plant
[0070] **12**: Combustion device
[0071] **14**: Dust collection system
[0072] **20**: Circulation passage
[0073] **21**: Droplet supply unit
[0074] **22**: Electrostatic flocculation unit
[0075] **24**: Electric dust collector (Dust collection unit)
[0076] **26**: Blower
[0077] **30**: Circulation direction
[0078] **40**: Nozzle
[0079] **50**, **60**: Discharge electrode
[0080] **52**, **62**: Ground electrode
[0081] **70**, **72**, **74**: Particle distribution
[0082] **82**, **82***a*: Fine particle distribution
[0083] **84**: Droplet distribution
[0084] **90**: Fine particle
[0085] **92**: Droplet
[0086] **94**: First region
[0087] **96**: Second region

1. A dust collection system comprising:

a circulation passage through which a gas circulates;

a droplet supply unit that supplies droplets to the circulation passage;

an electrostatic flocculation unit that is disposed in the circulation passage on a downstream side from a supply position of the droplets, forms an electric field in a flow path of the gas, charges fine particles contained in the gas and the droplets, and causes the fine particles and the droplets to collide with each other; and

a dust collection unit that is disposed in the circulation passage on a downstream side from the electrostatic flocculation unit and collects the droplets and the fine particles,

wherein the dust collection unit is an electric dust collector that has a discharge electrode and a ground electrode, forms an electric field between the discharge electrode and the ground electrode, and causes the droplets and the fine particles to adhere to the ground electrode.

2. (canceled)

3. The dust collection system according to claim **1**, wherein

the electrostatic flocculation unit forms an electric field having an electric field strength lower than that of the dust collection unit.

4. The dust collection system according to claim **3**, wherein

the electrostatic flocculation unit has an applied voltage smaller than that of the dust collection unit.

5. The dust collection system according to claim **3**, wherein

the electrostatic flocculation unit has a discharge electrode and a ground electrode, and a distance between the discharge electrode and the ground electrode is larger than that of the dust collection unit.

6. The dust collection system according to claim **1**, wherein

the ground electrode is a plate-shaped electrode.

7. The dust collection system according to claim **1**, wherein

the ground electrode is a rod-shaped electrode.

8. The dust collection system according to claim **1**, wherein

the droplet supply unit supplies, to the circulation flow path, droplets in which a relationship between a flow rate α (L/min) of the droplets to be supplied and a gas flow rate β (m^3/min) of the circulation flow path satisfies $0.1 \leq (\alpha/\beta) \leq 1.0$.

9. The dust collection system according to claim **1**, wherein

the droplet supply unit sprays the droplets to an upstream side.

10. The dust collection system according to claim **1**, wherein

the droplet supply unit has spray ports that spray the droplets, the spray ports being arranged in a lattice pattern on a surface orthogonal to a flow direction of the gas.

11. The dust collection system according to claim **1**, wherein

the droplet supply unit includes a mesh-shaped rectification mechanism on a downstream side of a spraying position where the droplets are sprayed.

12. A dust collection method comprising:

supplying droplets to a circulation passage through which a gas circulates;

forming an electric field in the circulation passage on a downstream side from a supply position of the droplets, and charging fine particles contained in the gas and the droplets;

causing the fine particles and the droplets to collide with each other; and

collecting the droplets and the fine particles in the circulation passage on a downstream side from a position where the fine particles and the droplets are charged.

* * * * *