Claims

Claim 1

A device, which is installed in an open space, for managing fine particle concentration of a target region in the open space by supplying charges to the target region, the device comprising:

a container configured to store liquid;

at least one nozzle exposed to the open space and configured to output the liquid to the open space;

a pump configured to supply the liquid from the container to the at least one nozzle;

a power supply configured to supply power to the device; and

a controller configured to apply a negative voltage to the at least one nozzle by using the power supply such that:

a) electrical field between the at least one nozzle and surrounding terrain feature where the device is installed can be formed wherein the surrounding terrain feature is not a part of the device and the surrounding terrain feature is functioned as a counter electrode of the at least one nozzle, and

b) electrons can be supplied to the target region in the open space through the at least one nozzle,

wherein the electrons are supplied by providing negatively charged droplets through the at least one nozzle,

wherein the negatively charged droplets are provided by:

a) applying the negative voltage equal to or greater than a first reference value to the at least one nozzle, and

b) supplying the stored liquid from the container to the at least one nozzle,

wherein the electrons supplied to the target region induce, the fine particles in the target region to be negatively charged,

wherein the negatively charged fine particles, the electrons and the negatively charged droplets form a spatial electric field having a non-uniform charge density between the at least one nozzle and the surrounding terrain feature where the device is installed, and

whereby the negatively charged fine particles in the target region in the open space are forced by:

a) the electrical field formed by the at least one nozzle, and

b) the spatial electric field formed by the electrons, the negatively charged droplets and the negatively charged fine particles such that the negatively charged fine particles are pushed outwards from the device.

Claim 2

The device of claim 1,

wherein the controller is configured to, by supplying the electrons to the target region in the open space for more than a predetermined time period, maintain the spatial electric field formed by the electrons, the negatively charged droplets and the negatively charged fine particles for more than the predetermined time period.

Claim 3

The device of claim 1,

wherein the controller is configured to determine the first reference value by considering a predetermined effective radius to the at least one nozzle by using the power supply, and

wherein the predetermined effective radius is a distance to a point at which the fine particles concentration decreases to a reference ratio within a reference time period.

Claim 4

The device of claim 1,

wherein the controller is configured to determine the first reference value to output a current from 10μA to 10mA through the at least one nozzle.

Claim 5

The device of claim 1,

wherein the controller is further configured to control the negative voltage applied to the at least one nozzle to be equal to or less than the second reference value, wherein the second reference value is determined to prevent direct discharge of a charge from the nozzle.

Claim 6

A device, which is installed in an open space, for managing fine particle concentration of a target region in the open space by supplying charges to the target region, the device comprising:

a container configured to store liquid;

at least one nozzle exposed to the open space and configured to output the liquid to the open space;

a pump configured to supply the liquid from the container to the at least one nozzle;

a power supply configured to supply power to the device; and

a controller configured to apply a negative voltage to the at least one nozzle by using the power supply such that:

a) electrical field between the at least one nozzle and surrounding terrain feature where the device is installed can be formed, wherein the surrounding terrain feature is not a part of the device and the surrounding terrain feature is functioned as a counter

electrode of the at least one nozzle, and

b) electrons can be supplied to the target region in the open space through the at least one nozzle; and

a particle dispersion unit configured to provide non-electric force to near the at least one nozzle,

wherein the electrons are supplied by providing negatively charged droplets through the at least one nozzle,

wherein the negatively charged droplets are provided by

a) applying the negative voltage equal to or greater than a first reference value to the at least one nozzle, and

b) supplying the stored liquid from the container to the at least one nozzle,

wherein the electrons supplied to the target region induce the fine particles in the target region to be negatively charged,

wherein the negatively charged fine particles, the electrons and the negatively charged droplets form a spatial electric field having a non-uniform charge density between the at least one nozzle and the surrounding terrain feature where the device is installed, and

whereby the negatively charged fine particles in the target region in the open space are forced by:

a) the electrical field formed by the at least one nozzle,

b) the spatial electric field formed by the electrons, the negatively charged droplets and the negatively charged fine particles, and

c) the non-electric force provided by the particle dispersion unit

such that the negatively charged fine particles are pushed outwards from the device.

Claim 7

The device of claim 6,

wherein the particle dispersion unit is configured to provide the non-electric force by spraying an electrically neutral substance near the at least one nozzle.

Claim 8

The device of claim 6,

wherein the particle dispersion unit includes at least one air nozzle configured to spray a gas, and is configured to spray the gas in a direction away from the at least one nozzle.

Claim 9

A method for managing fine particle concentration in a target region in an open space by using a device, which is installed in the open space, being located at a predetermined distance from a ground and supplying electrons to the target region,

wherein the device comprises a container configured to store liquid, at least one nozzle exposed to the open space and configured to output the liquid to the open space, a pump configured to supply the liquid from the container to the at least one nozzle, a power supply configured to supply power and a controller configured to apply a negative voltage to the at least one nozzle by using the power supply,

the method comprising:

applying, by the controller, the negative voltage equal to or greater than a first reference value to the at least one nozzle;

supplying, by the controller, the liquid to the at least one nozzle by using the pump;

outputting, by the controller, negatively charged droplets through the at least one nozzle by using the power supply and the pump, such that the electrons are supplied to the target region in the open space; and

inducing the fine particles in the target region to br negatively charged by the supplied electrons,

wherein the negatively charged fine particles the electrons and the negatively charged droplets form a spatial electric field having a non-uniform charge density between the at least one nozzle and surrounding terrain feature where the device is installed, and

whereby the negatively charged fine particles in the target region in the open space are forced by:

a) electrical field formed, by the at least one nozzle, between the at least one nozzle and the surrounding terrain feature where the device is installed,

wherein the surrounding terrain feature is not a part of the device and the surrounding terrain feature is functioned as a counter electrode of the at least one nozzle, and

b) the spatial electric field formed by the electrons, the negatively charged droplets and the negatively charged fine particles

such that the negatively charged fine particles are pushed outwards from the device.

Claim 10

The method of claim 9, wherein the method further comprises:

maintaining to output the negatively charged droplets to the target region for more than a predetermined time period.

Claim 11

The method of claim 9,

wherein the device further comprises a particle dispersion unit configured to provide non-electric force to near the at least one nozzle, and

wherein the method further comprises providing, by the controller, non-electric force to near the at least one nozzle such that negatively charged fine particles in the target region are also forced by the provided non-electric force.

Claim 12

The method of claim 9,

wherein the first reference value is determined by considering a predetermined effective radius, and

wherein the predetermined effective radius is a distance to a point at which the fine particles concentration decreases to a reference ratio within a reference time period.

Claim 13

The method of claim 9,

wherein the first reference value is determined to output a current from 10μA to 10mA through the at least one nozzle.

Claim 14

The method of claim 9, further comprising:

controlling the negative voltage applied to the at least one nozzle to be equal to or less than the second reference value, wherein the second reference value is determined to prevent direct discharge of a charge from the nozzle.