DESCRIPTION

SPRAY DEVICE, SPRAY METHOD, AND MIST SPACE STAGING SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to a spray device and a spray method for spraying mist, obtained by mixing liquid and gas and atomizing the liquid, into an indoor space with two-fluid nozzles, and a mist space staging system which mainly includes the spray device. Specifically, the mist space staging system is a mist space staging system capable of adjusting the mist concentration in the mist space in multiple levels by an operation made by a console externally connected to the spray device.

BACKGROUND ART

[0002] In recent years, a video projection method which uses mist has been developed, and the availability of such a method in art or entertainment is expanding.

[0003] As illustrated in FIG. 8, Patent Literature (PTL) 1 discloses projection device 1 which includes projection unit 2 and screen forming device 3 electrically connected to projection unit 2.

[0004] As illustrated in FIG. 9, screen forming device 3 includes generator 301 and ejection portion 303 which communicates with generator 301 via duct 302. Generator 301 includes tank 307 which has one end surface with opening 305 and another end surface that communicates with duct 302. For example, water 308 is stored in tank 307, and ultrasonic transducer 309 is provided in water 308. In order to manage the mist concentration measurement, light emitter 401 and light receiver 402 are provided in each of generator 301 and ejection portion 303. Screen forming device 3 is capable of forming a uniform mist screen and appropriately projecting an image onto the mist screen.

Citation List

Patent Literature

[0005] [PTL 1] Japanese Unexamined Patent Application Publication No. 2015-179130

[PTL 2] International Application Publication No. WO2018/179474

SUMMARY

[0006] In order to spray mist, which is atomized liquid, into the indoor space and stage a mist space in various forms, it is necessary to adjust the mist concentration in the indoor

space to a desired state each time through multilevel adjustment of the spray volume of the mist and in combination with mist and another staging device.

[0007] With the configuration disclosed in PTL 1, a mist screen can be formed which has a locally increased mist concentration. However, no consideration has been given to an idea of adjusting the mist concentration in the indoor space in multiple levels, and such a multilevel adjustment is not possible in terms of the structural aspect.

[0008] Accordingly, as in PTL 2, a configuration of a spray system which uses two-fluid spray nozzles that mix liquid and gas to produce mist has been proposed. In the configuration, the spray volume is adjusted with a liquid flow control valve capable of adjusting the valve opening degree by pulse control and controlling the supply volume in multiple levels.

[0009] However, in the configuration of PTL 2, it may be that the pressure difference between the gas and the liquid supplied to the nozzles exceeds the allowable pressure difference of the liquid flow control valve, and the pressure greater than or equal to the driving torque of the liquid flow control valve is applied to the liquid flow control valve. As a result, the liquid flow control valve may have a malfunction such as opening and closing failure.

[0010] To solve the above-mentioned conventional problems, the present disclosure provides a spray device, a spray method, and a mist space staging system capable of adjusting the mist concentration in a mist staging space in multiple levels by spraying mist, which is atomized liquid, into an indoor space with two-fluid nozzles.

[0011] In one aspect, this present disclosure includes a spray device which comprises: a two-fluid nozzle which sprays mist obtained by mixing liquid and gas and atomizing the liquid; a spray-device-side gas flow path for supplying the gas to the two-fluid nozzle; a gas valve which opens and closes the spray-device-side gas flow path; a gas supply source which supplies the gas to the spray-device-side gas flow path; a spray-device-side liquid flow path for supplying the liquid to the two-fluid nozzle; a liquid valve which opens and closes the spray-device-side liquid flow path; and a liquid supply source which supplies the liquid to the spray-device-side liquid flow path. The spray device according to the present disclosure also includes: a liquid flow control valve which is provided in the spray-device-side liquid flow path between the two-fluid nozzle and the liquid valve, is driven by a pulse, and has a valve opening degree that is adjusted according to a pulse signal to control a flow rate of the liquid in the spray-device-side liquid flow path; and a

controller which adjusts the valve opening degree of the liquid flow control valve according to the pulse signal from a console externally provided to the spray device. The controller adjusts, in multiple levels, the concentration of the mist sprayed from the two-fluid nozzle by adjusting the valve opening degree of the liquid flow control valve.

[0012] In one example, a mist space staging system according to the present disclosure includes a spray device and a staging device. The controller adjusts the mist concentration in multiple levels in accordance with an output from the staging device.

[0013] In another aspect, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path which is opened and closed by a gas valve; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path which is opened and closed by a liquid valve; spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid; receiving, by a controller, a pulse signal from a console when the mist is sprayed from the two-fluid nozzle; and adjusting, in multiple levels, a concentration of the mist sprayed from the two-fluid nozzle by adjusting, by the controller, a valve opening degree control pulse of a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path between the two-fluid nozzle and the liquid valve to control a flow rate of the liquid in the spray-device-side liquid flow path.

[0014] In another example, the controller adjusts the valve opening degree of the liquid flow control valve to spray mist, which is atomized liquid, into the indoor space with the two-fluid nozzles. Accordingly, the mist concentration in the indoor space can be adjusted in multiple levels. As a result, the mist space can be staged in various forms by adjusting the mist concentration in accordance with the intensity of an output, such as the sound or light flux, from another staging device to be combined with the mist.

[0015] In another aspect, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path; and spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid. The spray method according to the present disclosure also includes, when the mist is sprayed from the two-fluid nozzle, (i) closing an on-off valve provided in the spray-device-side liquid

flow path between the liquid flow control valve and the liquid pressure gauge when the pressure of liquid detected by a liquid pressure gauge provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source is greater than the pressure of gas detected by a gas pressure gauge provided in the spray-device-side gas flow path between the two-fluid nozzle and the gas supply source and a pressure difference between the pressure of the liquid and the pressure of the gas is greater than or equal to an allowable pressure difference preset to the liquid flow control valve, and (ii) opening the on-off valve when the pressure difference is less than the allowable pressure difference.

[0016] In another aspect, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path; and spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid. The spray method according to the present disclosure includes, when the mist is sprayed from the two-fluid nozzle, (i) discharging the gas from the gas supply source at a pressure less than an allowable pressure, and (ii) causing a pressure reducing valve to reduce a pressure of the liquid discharged from the liquid supply source such that a pressure difference between a pressure of the gas discharged from the gas supply source and the pressure of the liquid discharged from the liquid supply source is less than an allowable pressure difference. The pressure reducing valve is provided in the spray-device-side liquid flow path between the liquid flow control valve and the liquid supply source to reduce the pressure of the liquid discharged from the liquid supply source.

[0017] In another aspect, this present disclosure includes a spray method which comprises: supplying gas from a gas supply source to a two-fluid nozzle via a spray-device-side gas flow path; supplying liquid from a liquid supply source to the two-fluid nozzle via a spray-device-side liquid flow path and a pulse-driven liquid flow control valve provided in the spray-device-side liquid flow path; and spraying, from the two-fluid nozzle, mist obtained by mixing the liquid and the gas supplied to the two-fluid nozzle and atomizing the liquid. The spray method according to the present disclosure also includes, when the mist is sprayed from the two-fluid nozzle, causing a check valve provided in the spray-device-side liquid flow path between the liquid flow control valve and the two-fluid nozzle (i) to allow the liquid to flow from a liquid flow

control valve side to a two-fluid nozzle side and (ii) to prevent

the liquid to flow from the two-fluid nozzle side to the liquid flow control valve side.

[0018] In another example, the controller causes the on-off valve to open or close the spray-device-side liquid flow path, or the pressure reducing valve reduces the pressure of the liquid such that the pressure difference between the pressure of the gas discharged from the gas supply source and the pressure of the liquid discharged from the liquid supply source is less than the allowable pressure difference, or the check valve is included which prevents liquid from flowing from a two-fluid nozzle side to a liquid flow control valve side. With such a configuration, the pressure difference between the pressure of the liquid and the pressure of the gas does not become greater than or equal to the allowable pressure difference preset to the liquid flow control valve, and thus, it is possible to reduce the occurrence of malfunctions of the liquid flow control valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 is a configuration diagram of a mist space staging system which includes spray devices according to the present disclosure.

FIG. 2A is a cross-sectional view of a two-fluid nozzle of a spray device according to the present disclosure.

FIG. 2B is a cross-sectional view of the two-fluid nozzle according to the present disclosure taken along line 2B-2B in FIG. 2A .

FIG. 2C is a cross-sectional view of the two-fluid nozzle according to the present disclosure taken along line 2C-2C in FIG. 2A.

FIG. 3 is a flowchart of a pulse determination operation in a mist space staging system according to a variation of the present disclosure.

FIG. 4 is a configuration diagram of a mist space staging system which includes spray devices according to the present disclosure.

FIG. 5A is a configuration diagram of a spray device according to the present disclosure.

FIG. 5B is a configuration diagram of a spray device according to the present disclosure.

FIG. 6A is a configuration diagram of a spray device according to the present disclosure.

FIG. 6B is a configuration diagram of a spray device according to the present disclosure.

FIG. 7 is a configuration diagram of a spray device according to the present