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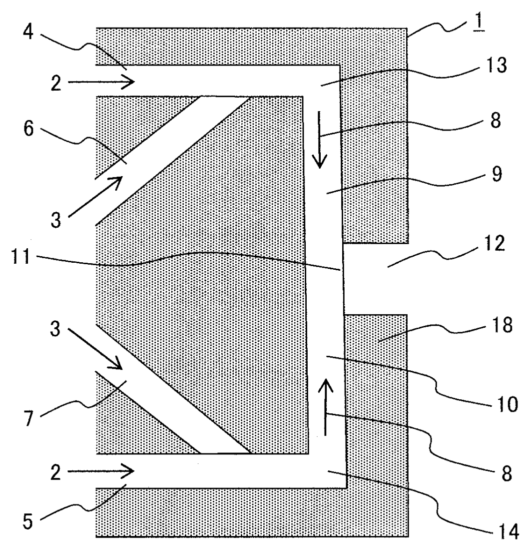
(54) **SPRAY NOZZLE, AND BURNER AND COMBUSTION DEVICE EQUIPPED WITH SAME**

(57) An object of the present invention is to provide a spray nozzle that can facilitate atomization of spray fluid and can also reduce the amount of spray medium to be used and a force with which the spray medium is pressurized.

To achieve the above object, a spray nozzle in the present invention, comprising: at least two spray fluid flow paths for flowing a spray fluid flows; at least two spray medium flow paths for flowing a spray medium, in each of which joins a relevant spray fluid flow path at a first joining part; at least two mixed fluid flow paths, in each of which a mixed fluid of the spray fluid and the spray medium that have joined together at the first joining part for flowing the mixed fluid and which are formed so as to face each other and allow mixed fluids to flow oppositely and have a second joining part at which the mixed fluids flowing oppositely collide with each other and join together; and an outlet hole from which the mixed fluids that have joined at the second joining part are jetted; wherein in each mixed fluid flow path, a bent part at which a direction of a flow of the mixed fluid is changed is formed between the first joining part and the second joining part.

FIG. 3



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Description

{Technical Field}

[0001] The present invention relates to a spray nozzle and a burner and a combustion device that are equipped the spray nozzle, and more particularly to a spray nozzle that is suitable for atomizing a spray fluid (liquid) by using a spray medium (gas) and a burner and a combustion device that are equipped with the spray nozzle.

{Background Art}

[0002] In general, many high-output, large-load combustion devices such as power generation boilers use a floating combustion method in which a fuel is burned horizontally. If a liquid fuel is used as a fuel, the fuel is atomized with a spray nozzle, is made to float in the furnace of the combustion device, and is burned.

[0003] Not only in a combustion device that uses a liquid fuel as the main fuel but also in a combustion device that uses a solid fuel such as powdered coal as the main fuel, a spray nozzle as described above is often used to burn an auxiliary fuel that is used for activation and flame stabilization.

[0004] In the combustion of a liquid fuel, if sprayed particle diameters are large, the combustion reaction is slowed, lowering the combustion efficiency and making soot dust, carbon monoxide, and nitrogen oxides likely to be generated. The liquid fuel is not easily mixed with combustion air, so if combustion air around sprayed particles is insufficient, soot dust and carbon monoxide are easily generated.

[0005] In liquid fuel combustion, therefore, it is necessary to take care in atomization and mixing with combustion air.

[0006] There is also a demand for a so-called large capacity, that is, for the high-output, large-load combustion devices in which the amount of liquid fuel to be jetted per spray nozzle is increased.

[0007] As a spray nozzle type, there is a two-fluid spray method in which atomization is performed by supplying air or steam as a spray medium used for atomization besides a spray fluid and then mixing it with the spray fluid.

[0008] In this two-fluid spray method, atomization is superior even in the spray of a large volume when compared with atomization of only a spray fluid. Therefore, this method is generally used by large-load combustion devices such as power generation boilers. However, the problem with this method is to reduce the amount of spray medium to be used and an amount by which the spray fluid and spray medium are pressurized to jet them.

[0009] When steam is used as the spray medium, for example, the steam supplied into the combustion device becomes moisture in an exhaust combustion gas. If the amount of exhaust combustion gas is increased, the thermal coefficient of the combustion device is lowered due to this moisture.

[0010] Therefore, it is desirable to reduce the amount of steam in a range in which the atomization of a liquid fluid is not impaired. If an amount by which a spray fluid and spray medium are pressurized to spray them is reduced, energy consumption can be reduced.

[0011] To solve the above problem, in the two-fluid spray method, spray medium mixing methods and the like have been studied.

[0012] Of these, an example is described in Patent Literature 1. In the example, mixed fluids of a spray fluid and a spray medium are supplied so that they face each other in the vicinity of an outlet hole formed at the front end of a spray nozzle and the opposing flows of the mixed fluids collide with each other to facilitate atomization.

[0013] In Patent Literature 1 above, the spray medium is mixed with the spray fluid in a flow path disposed upstream of the outlet hole in the spray nozzle and the mixed fluid collides with the other mixed fluid in the vicinity of the outlet hole. Since a mixed fluid of a spray fluid and a spray medium is used, atomization is performed with a stronger collision force of the spray fluid than when the spray fluid is used alone.

[0014] As a method of achieving both a larger capacity by which the amount of liquid fuel to be jetted per spray nozzle is increased and atomization of the liquid fluid, a method in which more outlet holes are formed at the front end of the spray nozzle is used in general. When more outlet holes are formed in the spray nozzle, a large capacity is achieved without having to increase the size of each outlet hole.

[0015] An example of a spray nozzle having a plurality of outlet holes is described in Patent Literature 2. Patent Literature 2 describes an example of a so-called intermediate mixing type of spray nozzle in which a spray fluid and a spray medium are mixed at intermediate point of a flow path.

[0016] Furthermore, Patent Literature 3 describes an example of a so-called internal mixing type of spray nozzle in which a spray fluid and a spray medium are mixed in a space provided upstream of the outlet hole in the spray nozzle.

{Citation List}

{Patent Literature}

[0017]

{Patent Literature 1} Japanese Unexamined Patent Application Publication No. Hei 9(1997)-239299
{Patent Literature 2} Japanese Unexamined Patent Application Publication No. Sho 62(1987)-112905
{Patent Literature 3} Japanese Unexamined Patent Application Publication No. Sho 62(1987)-186112

{Summary of Invention}

{Technical Problem}

[0018] The two-fluid spray nozzle described in Patent Literature 1 above internally includes a flow path of a spray fluid (liquid) and a flow path of a spray medium (gas), which is disposed at the outer peripheral position of the flow path of the spray fluid. Directions of flows in the flow paths of the spray fluid and spray medium are changed by partition walls that enclose the outlet hole formed at the front end of the spray nozzle. Since both flow paths cross each other, the spray fluid and spray medium are mixed together. Flow paths of the mixed fluid are provided in the vicinity of the outlet hole in the spray nozzle so as to face each other.

[0019] In this case, the atomization of the spray fluid proceeds due to three effects described below.

[0020]

(1) Atomization due to a collision of the spray fluid and spray medium with the partition wall at a joining part at which the flow path of the spray fluid crosses the flow path of the spray medium and the spray fluid and spray medium join together.

(2) Atomization due to the mixing of the spray fluid and spray medium.

(3) Atomization due to collision of the mixed fluids that flow so as to face each other in the vicinity of the outlet hole in the spray nozzle.

[0021] However, effects (1) and (2) are mutually contradictory items: if one of them is strengthened, the other is weakened. That is, if the amount of motion of the spray fluid is increased to strength the effect (1), the amount of motion of the spray medium is relatively reduced in comparison with the spray fluid and mixing is thereby slowed, so the effect (2) is weakened. Conversely, if the amount of flow of the spray medium and its flow rate are increased to increase the effect (2), the spray medium become hard to collide with the partition wall, so the effect (1) is weakened.

[0022] Another problem is that since a distance traveled after the spray fluid and spray medium are mixed until the resulting mixed fluid is jetted from the outlet hole in the spray nozzle is short, it is difficult to uniformly mix the spray fluid and spray medium. If the spray fluid and spray medium are not uniformly mixed, atomization is worsened at a portion at which the ratio of the spray medium is small. In this case, to facilitate atomization, it is necessary to increase the amount of spray medium to be used or increase a force with which the spray medium is pressurized.

[0023] A problem with a larger capacity to increase the amount of liquid fuel to be jetted per spray nozzle by increasing the number of holes is that when part of outlet holes in the spray nozzle is blocked, atomization performance is lowered and the flow path is blocked.

[0024] This problem will be described below by taking Patent Literatures 2 and 3 described above as examples.

[0025] For the intermediate mixing type described in Patent Literature 2, if one of the outlet holes in the spray nozzle is blocked or partially blocked due to impurities or deposits in the spray fluid and spray medium, the flows in the flow paths of the spray fluid and spray medium, the paths being connected to the blocked outlet hole, are stopped or slowed.

[0026] If the flows in the flow paths of the spray fluid and spray medium are stopped or slowed, the liquid fuel flowing as the spray fluid is heated due to radiant heat from the interior of the combustion device and the solid content in the liquid fluid may be deposited. If the solid content in the liquid fluid is deposited, the flow path is blocked and the blocked range expands to the upstream side of the flow path, making it hard to perform maintenance.

[0027] For the internal mixing type described in Patent Literature 3, even if one outlet hole in the spray nozzle is blocked, the spray fluid and spray medium are jetted from other outlet holes, so the blocked range is less likely to expand to the flow path on the upstream side.

[0028] However, a space in which the spray fluid and spray medium are mixed together (mixing chamber) in Patent Literature 3 is large, so if part of outlet holes in the spray nozzle is blocked, the flowing state in the mixing chamber is changed, making it difficult to maintain a constant ratio between the spray fluid and the spray medium.

[0029] For this reason, there is the problem that, depending on outlet holes in the spray nozzle, not only the ratio of the spray medium to the mixed fluid varies but also atomization characteristics vary.

[0030] The present invention addresses the above problems, with the object of providing a spray nozzle that can facilitate atomization of spray fluid and can also reduce the amount of spray medium to be used and a force with which the spray medium is pressurized and providing a burner and a combustion device that are equipped with the spray nozzle.

{Solution to Problem}

[0031] To achieve the above object, a spray nozzle in the present invention, comprising: at least two spray fluid flow paths for flowing a spray fluid flows; at least two spray medium flow paths for flowing a spray medium, in each of which joins a relevant spray fluid flow path at a first joining part; at least two mixed fluid flow paths, in each of which a mixed fluid of the spray fluid and the spray medium that have joined together at the first joining part for flowing the mixed fluid and which are formed so as to face each other and allow mixed fluids to flow oppositely and have a second joining part at which the mixed fluids flowing oppositely collide with each other and join together; and an outlet hole from which the mixed fluids that have joined at the second joining part are jetted; wherein in each mixed fluid flow path, a bent part at which a direction of a flow of the mixed fluid is changed is formed between the first joining part and the second joining part.

[0032] To achieve the above object, a burner in the present invention, the burner that uses a liquid fuel as a fuel and the burner uses a spray nozzle having the structure described above to supply the liquid fluid to a front end of the spray nozzle as the spray fluid and also supply steam or compressed air to the front end of the spray nozzle as the spray medium.

[0033] Alternatively, the burner has a fuel nozzle from which a solid fuel and a carrier gas of the solid fuel are jetted, a spray nozzle from which a liquid fuel is jetted, and a combustion gas nozzle from which a combustion gas used to burn the solid fuel and liquid fuel are jetted, wherein the burner uses a spray nozzle having the structure described above as the spray nozzle to supply the liquid fluid to the front end of the spray nozzle as the spray fluid and also supply steam or compressed air to the front end of the spray nozzle as the spray medium.

[0034] To achieve the above object, a combustion device in the present invention that burns a solid fuel and a liquid fuel, the combustion device comprising: a combustion furnace that burns a fuel; a solid fuel supply system through which a solid fuel is supplied to the combustion furnace; a liquid fuel supply system through which a liquid fuel is supplied to the combustion furnace; a combustion gas supply system through which a combustion gas is supplied to the combustion furnace; a plurality of burners to which the fuel supply paths and the combustion gas supply system are connected, the plurality of burners being disposed on a furnace wall of the combustion furnace and being configured to burn the solid fuel and the liquid fuel; a heat exchanger that collects heat from an exhaust combustion gas generated in the combustion furnace; and a flue through which the collected exhaust combustion gas is supplied to an outside of the combustion furnace; wherein the burner having the structure described above is used as one of the burners.

{Advantageous Effects of Invention}

[0035] The present invention has an advantage in that it is possible to facilitate atomization of spray fluid and to reduce the amount of spray medium to be used and a force with which the spray medium is pressurized.

{Brief Description of Drawings}

[0036]

{Fig. 1} FIG. 1 is a cross sectional view substantially illustrating the structure of a burner that uses the spray nozzle in the present invention.

{Fig. 2} FIG. 2 substantially illustrates the structure of a combustion device including the spray nozzle in the present invention.

{Fig. 3} FIG. 3 illustrates a first embodiment of the spray nozzle in the present invention; the drawing is a cross sectional view illustrating the front end of the spray nozzle.

{Fig. 4} FIG. 4 is a vertical cross sectional view of FIG. 3.

{Fig. 5} FIG. 5 illustrates an example of atomization performance in the first embodiment of the spray nozzle in the present invention; the drawing is a characteristic chart indicating a relationship among the changing angle of the bent part in the mixed fluid flow path, the mean particle diameter in a spray, and a pressure loss ratio.

{Fig. 6} FIG. 6 illustrates a second embodiment of the spray nozzle in the present invention; the drawing is a cross sectional view illustrating the front end of the spray nozzle.

{Fig. 7} FIG. 7 is a vertical cross sectional view of FIG. 6.

{Fig. 8} FIG. 8 illustrates a third embodiment of the spray nozzle in the present invention; the drawing is a plan view illustrating the front end of the spray nozzle.

{Fig. 9} FIG. 9 is a cross sectional view taken along line A-A in FIG. 8.

{Fig. 10} FIG. 10 is a cross sectional view taken along line B-B in FIG. 8.

{Description of Embodiments}

[0037] The spray nozzle in the present invention and the burner and combustion device that have the spray nozzle will be described below according to the illustrated embodiments. In these embodiments, like parts are denoted by like reference characters.

{Embodiment 1}

[0038] FIG. 1 illustrates an embodiment of a burner that has the spray nozzle in the present invention, and FIG. 2 illustrates an embodiment of a combustion device that has the burner.

[0039] As illustrated in FIG. 1, the burner 20 in this embodiment has a spray nozzle 1 at its center and a central axis 21 through which a spray fluid (liquid fuel) and a spray medium (steam, compressed air, or the like) flow. An obstacle 22 used to stabilize a flame is provided in the vicinity of the front end of the central axis 21. A fuel is jetted from the spray nozzle 1 and a spray 23 with a fan shape is formed. The obstacle 22 is generally a swirling flow generator or a disturbing plate having slits.

[0040] Combustion air is supplied from a window box 24 in three flow paths. The three flow paths are a primary flow path 25, a secondary flow path 26, and a tertiary flow path 27, which are closer to the spray nozzle 1 at the center of the burner 20 in that order. Primary air 28, secondary air 29, and tertiary air 30 are respectively jetted from the primary flow path 25, secondary flow path 26, and tertiary flow path 27 into a furnace interior 31 as combustion air.

[0041] Directions of the combustion air flow are changed by swirling flow generators 32 and 33 and guide plates 34 to suppress the generation of soot dust and NOx. The flow rate of the combustion air is controlled by a damper (not illustrated) provided in each flow path.

[0042] Furthermore, the burner 20 is connected to a furnace wall 35. Heat transfer pipes 36 are provided on the furnace wall 35 to collect heat. As illustrated in FIG. 2, a plurality of burners 20 (two in FIG. 2) are provided on the furnace wall 35. A combustion air supply system 41, liquid fuel supply systems 42, and spray medium supply systems 43 are connected to each burner 20.

[0043] In this embodiment, the combustion air supply system 41 branches to pipes 45 connected to the burners 20 and to a pipe 46 connected to an air supply port 44, the pipe 46 being disposed downstream of the pipes 45. A flow rate adjustment valve (not illustrated) is connected to each of the pipes 45 and pipe 46. A supply unit (not illustrated), which adjusts pressure and the amount of flow, is connected on the upstream side of each of the liquid fuel supply systems 42 and spray medium supply systems 43. The spray nozzle 1 is attached to the downstream end of each liquid fuel supply system 42 and spray medium supply system 43.

[0044] This embodiment is characterized in that the spray nozzle 1 has a bent part, which changes a flow direction, in a mixed fluid flow path between a mixing part, at which the spray fluid and spray medium are mixed together, and an outlet hole.

[0045] The spray nozzle 1 in this embodiment will be described with reference to FIGs. 3 and 4.

[0046] As illustrated in FIG. 3, spray fluids 2 and spray medium 3 in this embodiment pass through independent spray fluid flow paths 4 and 5 and spray medium flow paths 6 and 7, which constitute the spray nozzle 1, and are mixed at intermediate points in the spray fluid paths 4 and 5. Mixed fluids 8 of the spray fluid 2 and spray medium 3 pass through mixed fluid flow paths 9 and 10 and collide with each other in the vicinity of an outlet hole 11 in the spray nozzle 1 and are jetted from the outlet hole 11.

[0047] The mixed fluid 8 jetted from the outlet hole 11 forms a fan-shaped spray in a direction orthogonal to the flow directions of the mixed fluid flow paths 9 and 10 (directions in which the mixed fluid flow paths extends) due to the collision in the vicinity of the outlet hole 11. In the outlet hole 11 in the spray nozzle 1, a groove 12 is formed in the same direction as the direction in which the fan-shaped spray is formed. The outlet hole 11 is a part which the groove 12 and mixed fluid flow paths 9 and 10 cross each other.

[0048] The spray fluid 2 is atomized due to mixing with the spray medium 3 and also becomes a thin liquid film due to a collision of the mixed fluids 8 in the outlet hole 11. After being jetted from the outlet hole 11, the liquid film is broken due to a shear force by an ambient gas and is atomized.

[0049] A spray method of atomizing a liquid film with a collision force of fluids in this way is generally called a fan spray method.

[0050] In the fan spray method, since the mixed fluids 8 passing through the mixed fluid flow paths 9 and 10, which are oppositely disposed, collide with each other in the vicinity of the outlet hole 11, the mixed fluids 8 spread in an orthogonal direction, so the amount of motion of the spray is reduced. Particularly, in the outer peripheral portion of the spray, the spray easily spreads and a thin liquid film is thereby formed, so many fine particles (with diameters of less than 100 μm) are formed. Since the amount of motion is small, fine particles are likely to stay in the vicinity of the spray nozzle. Particles that have been atomized to diameters of less than 100 μm, if possible, 50 μm or less (these particles will be referred to below as fine particles), have a large surface area for their volumes, so the temperatures of these particles are easily raised and they are easily burned.

[0051] Therefore, when these fine particles are made to stay in the vicinity of the spray nozzle 1, the spray is ignited at an early time, contributing to flame stabilization and the facilitation of a combustion reaction.

[0052] The degree of atomization can be adjusted by adjusting the pressure of the mixed fluid and the amount of spray medium (the ratio of the spray medium to the spray fluid).

[0053] At the central portion of a fan spray, the amount of flow is larger than in the outer peripheral portion, so the spray is less likely to spread, forming a thicker liquid film than in the outer peripheral portion. Therefore, the central portion of the fan spray includes many large particles (with diameters of 100 to 300 μm). The amount of motion of a large particle is larger than that of a fine particle, so the large particle is likely to be mixed with combustion air flowing at a distant location, but its combustion reaction is slower than that of the fine particle.

[0054] Therefore, atomization needs to be facilitated by not only the collision of the mixed fluids but also mixing with the spray medium.

[0055] However, the spray fluid 2 and spray medium 3 have different densities and viscosities, so they may not be easily mixed together. Particularly, if the mixed fluid flow paths 9 and 10 are short or linear, it can be considered that the spray fluid and spray medium flow to the outlet hole 11 without being mixed together.

[0056] In this case, of the mixed fluid 8, a portion in which the ratio of the spray medium 3 is high is easily atomized, but a portion in which the ratio of the spray medium 3 is low is not easily atomized, causing large particles to be easily formed.

[0057] Thus, in the flow path structure described above in the spray nozzle 1 in this embodiment, bent parts 13 and 14 are formed in the mixed fluid flow paths 9 and 10 between a part (first joining part) at which the spray fluid 2 and spray medium 3 join together and the outlet hole 11 in a part (second joining part) at which the mixed fluids 8 flowing in the oppositely formed mixed fluid flow paths 9 and 10 join together.

[0058] Since the bent parts 13 and 14 are formed in the mixed fluid flow paths 9 and 10, the flow directions of the mixed fluids 8 are changed. Therefore, the flows in the mixed fluid flow paths 9 and 10 are disturbed, facilitating the mixing of the spray fluid 2 and spray medium 3 constituting the mixed fluid 8.

[0059] When the spray fluid 2 and spray medium 3 are uniformly mixed together, the ratio of the spray medium 3 in the mixed fluid 8 becomes uniform, uniform atomization proceeds, so the amount of spray medium 3 needed to facilitate atomization can be suppressed and, even if a pressure to be applied to the spray fluid 2 and spray medium 3 is reduced, atomization can be maintained.

[0060] To cause a turbulence, an angle by which the flow directions are changed at the bent parts 13 and 14 is preferably 30 degrees or more but up to about 120 degrees. This is because if the changing angle is 30 degree or less, the change in the flow direction is small, so turbulence is less and mixing is likely not to be facilitated, and because if the changing angle is 120 degrees or more, a pressure loss due to the change of the flow is large.

[0061] FIG. 5 illustrates an example of atomization performance in the first embodiment of the spray nozzle 1 in the present invention. The vertical axis on the left side in the drawing indicates mean particle diameters in a spray, the vertical axis on the right side indicates pressure loss ratios, and the horizontal axis indicates direction changing angles at the bent parts 13 and 14. The pressure loss is based on a changing angle of 90 degrees.

[0062] The mean particle diameter was obtained for a fan-shaped spay jetted from the outlet hole 11; particle diameters in the spray were optically measured for the long axis and short axis that pass the central axis of the fan-shaped spray at a position 300 mm downstream of the spray and the mean of the measured particle diameters was indicated as the volume-surface mean diameter.

[0063] As illustrated in FIG. 5, when the direction changing angle at the bent parts 13 and 14 is as small as 20 degrees, the mean particle diameter is about 10 μm larger than when the direction changing angle is 30 degrees. This is because if the direction changing angle of the bent parts 13 and bent part 14 is small, the change in the flow direction is small and the turbulence is thereby small, making it difficult to facilitate mixing. However, if the changing angle is 120 degrees or more, a pressure loss due to the change in the flow direction becomes large.

[0064] Therefore, it is found that the changing angle to cause a turbulence in the flow direction at the bent parts 13 and 14 is preferably 30 degrees or more but up to 120 degrees.

[0065] To facilitate the mixing of the spray fluid 2 and spray medium 3, it is preferable for the spray fluid flow paths 4 and 5 for the spray fluid 2 and the spray medium flow paths 6 and 7 for the spray medium 3 to join together at a crossing angle of 30 to 90 degrees. This is because if the crossing angle is less than 30 degrees, the change in the flow direction is small and the spray fluid 2 and spray medium 3 thereby flow in parallel, making it difficult to facilitate mixing; if the crossing angle is 90 degrees or more, the spray fluid 2 and spray medium 3 are mixed while flowing oppositely, increasing the pressure loss.

[0066] With the spray nozzle 1 in this embodiment, the surface area per unit weight of a liquid fuel is increased due to atomization, and the combustion reaction is hastened. Accordingly, non-burned content, soot dust, and carbon monoxide at the outlet of the combustion device are reduced, so the combustion efficient can be increased. Since the combustion reaction is hastened, consumption of oxygen proceeds, so generation of nitrogen oxides can be suppressed. Furthermore, since non-burned content, soot dust, and carbon monoxide are reduced, extra air supplied into the combustion device can be reduced. When extra air is reduced, the amount of exhaust combustion gas is also reduced, so it is possible to reduce sensible heat released to the outside of the combustion device together with the exhaust combustion gas and thereby to increase the thermal efficiency.

[0067] Due to the suppression of the amount of spray medium to be used and the reduction of pressure, the amount of energy consumption required for supplies and pressurizing forces can be reduced. If steam is used as the spray medium, the thermal efficiency in the combustion device is lowered due to the steam supplied into the combustion device. When the spray nozzle 1 in this embodiment is used, however, even if the amount of steam to be used is reduced, atomization can be maintained as before, so it is possible to prevent thermal efficiency from being lowered.

[0068] Although, in this embodiment, a case in which the combustion device uses a liquid fuel has been indicated, the embodiment can also be applied to a case in which a solid fuel such as powdered coal is used as the main fuel and a liquid fuel is used as an auxiliary fuel. In this case, when the liquid fuel is jetted from the spray nozzle 1 into the furnace 31, the effect described above can be obtained.

[0069] In this embodiment, as illustrated in FIG. 2, the combustion air branches to the pipes 45 and pipe 46 and is jetted from the burners 20 and air supply ports 44 into the furnace 31. When the combustion air is supplied in parts in this way, the temperature of a flame formed by each burner 20 can be reduced.

[0070] If air is insufficient during combustion in the vicinity of the burner 20, a reducing agent is created from part of nitrogen included in the fuel and a reaction to reduce NOx generated in the combustion to nitrogen occurs.

[0071] Therefore, the NOx density at the outlet of the furnace 31 is lower than when all combustion air is supplied from the burner 20. Since the remaining combustion air is supplied from the air supply ports 44 to completely burn the fuel, non-burned content can be reduced.

[0072] A combustion gas 47 in which combustion air from the air supply ports 44 is mixed passes through a heat exchanger 48 at the top in the furnace 31, also passes through a flue 49, and is released from a chimney 50 to the atmosphere.

[0073] Although an embodiment in which the combustion air branches to the pipes 45 and pipe 46 has been illustrated in FIG. 2 as the embodiment of the combustion device, the spray nozzle 1 in this embodiment can also be applied to a case in which the combustion air is supplied only from the burners 20 without branching the combustion air. Although FIGs. 1 and 2 illustrate a case in which the burners 20 are attached to one wall surface of the furnace 31, the spray nozzle 1 in this embodiment can also be applied to a case in which the burners 20 are attached to a plurality of wall surfaces and to a case in which they are attached to corners of wall surfaces.

[0074] When a bent part is provided behind the outlet port of the flow path of a mixed fluid in which a spray fluid and a spray medium have been mixed together as with the spray nozzle in this embodiment described above, the flow direction of the mixed fluid is changed, causing a turbulence in the flow of the mixed fluid flowing in the flow path and thereby advancing the mixing of the spray fluid and spray medium. In addition, since the spray fluid and spray medium are uniformly mixed, the ratio of the spray medium in the mixed fluid becomes uniform, uniformly advancing atomization.

[0075] Therefore, the amount of spray medium to be used to facilitate atomization can be suppressed and even if a pressure to be applied to the spray fluid and spray medium is reduced, an effect of maintaining atomization is obtained.

{Embodiment 2}

[0076] FIGs. 6 and 7 illustrate a second embodiment of the spray nozzle in the present invention. The embodiment illustrated in these drawings is characterized in that the spray nozzle 1 has a plurality of outlet holes, a plurality of second joining parts, at each of which mixed fluids flowing through mixed fluid flow paths formed so as to face each other join together, and a communication flow path that mutually connect the plurality of second joining parts, the communication path being disposed between the first joining parts, at each of which a flow path of a spray fluid and a flow path of a spray medium join together, and the second joining parts.

[0077] That is, this embodiment differs from the first embodiment in that the spray nozzle 1 has a plurality of outlet holes 11A and 11B and in flow path structures formed upstream of the outlet holes 11A and 11B. Here, descriptions will focus on the flow path structures.

[0078] FIG. 6 illustrates a case in which the spray nozzle 1 vertically has two outlet holes, which are identified by subscripts A and B. However, even if the spray nozzle 1 has more outlet holes, the structure is the same.

[0079] At the front end of the spray nozzle 1 in this embodiment illustrated in FIGs. 6 and 7, the spray fluids 2 and spray medium 3 pass through independent spray fluid flow paths 4A, 4B, 5A and 5B and spray medium flow paths 6A, 6B, 7A, and 7B, pass through bent parts 13A, 13B, 14A and 14B, and are mixed at first joining parts. The mixed fluids 8 of the spray fluid 2 and spray medium 3 pass through mixed fluid flow paths 9A, 9B, 10A and 10B and collide with each other in the vicinity of the outlet holes 11A and 11B, which are second joining parts, and are jetted from their respective outlet holes 11A and 11B.

[0080] The mixed fluids 8 jetted from the outlet holes 11A and 11B each form a fan-shaped spray in a direction orthogonal to the flow direction of the mixed fluid flow path 9A, 9B, 10A or 10B (direction in which the mixed fluid flow path extends) due to a collision. In the outlet holes 11A and 11B in the spray nozzle 1, grooves 12A and 12B are formed in the same direction as the direction in which the fan-shaped spray is formed. The outlet holes 11A and 11B are crossing parts of the grooves 12A and 12B and mixed fluid flow paths 9A, 9B, 10A and 10B.

[0081] In this embodiment, at intermediate points of the mixed fluid flow paths 10A and 10B at the central portion before reaching the outlet ports 11A and 11B, the mixed fluid flow paths 10A and 10B are mutually connected with a communication pipe (communication flow path) 60. At intermediate points of the mixed fluid flow paths 9A and 9B on the outer peripheral side before reaching the outlet ports 11A and 11B, the mixed fluid flow paths 9A and 9B are mutually connected with a branching pipe (communication path) 61 (see FIG. 7).

[0082] The spray fluid 2 is atomized due to the mixing with the spray medium 3 and also becomes a thin liquid film due to the collision with the mixed fluid 8 in the outlet holes 11A and 11B. After being jetted from the outlet holes 11A and 11B, the liquid film is broken due to a shear force by an ambient gas and is atomized. Since the thin film is atomized due to the force generated by the fluid collision and the mixed fluid flow paths 9 and 10 have the bent parts 13 and 14 as in the first embodiment, the mixing of the spray fluid 2 and spray medium 3 is facilitated and atomization is advanced.

[0083] When the number of outlet holes is increased, that is, a so-called porous structure is used, the amount of jet from the spray nozzle 1 can be increased without increasing the amount of jet from one outlet hole. A problem with a large capacity due to which the amount of jet from the spray nozzle 1 is increased is that when part of outlet holes in the spray nozzle is blocked, atomization performance is lowered and the flow path is blocked.

[0084] With the spray nozzle 1 in this embodiment, if part of the outlet holes 11A and 11B is blocked or partially blocked due to impurities or deposits in the spray fluid 2 or spray medium 3, then in the flow path of the mixed fluid 8, which is connected to the relevant outlet hole, fluids in the flow paths of the mixed fluid 8, spray fluid 2, and spray medium 3 flow toward the other open outlet hole through the branching pipe 61, so the temperature of each flow path is maintained by the fluid.

[0085] If, for example, the outlet hole 11A is blocked for some reason, flows stop at a portion of the mixed fluid flow path 9A connected to the outlet hole 11A, the portion being close to the outlet hole 11A, and in the branching mixed fluid flow path 10A.

[0086] However, on the upstream side of the mixed fluid flow path 9A and in the spray fluid flow path 4A and spray medium flow path 6A, the mixed fluid 8 flows through the branching pipe 61 to the outlet hole 11B. In the mixed fluid flow path 10A as well as the spray fluid flow path 5A and spray medium flow path 7A disposed upstream of the mixed fluid flow path 10A, the fluid flows through the communication pipe 60 to the outlet hole 11B.

[0087] Therefore, since the mixed fluid 8 flows through many flow paths to the outlet hole 11B, resistances in the flow paths are reduced and the amount of flow is increased, so it is possible to suppress the amount of flow of the spray fluid 2 from being reduced by the blockage of the outlet hole 11A.

[0088] When a liquid fuel flowing as the spray fluid 2 is heated, solid content is deposited and the deposited solid content may block the flow path. With the spray nozzle 1 in this embodiment, however, flows through the branching pipe 61 to the open outlet hole can be maintained, so blocking does not easily proceed.

[0089] That is, even if part of outlet holes is blocked, the blocked portion is restricted to a portion from the blocked outlet hole to the branching pipe 61, so the blockage can be easily eliminated. If, for example, the outlet hole 11A described above is blocked, the blocked portion is restricted to portions, in the mixed fluid flow paths 9A and 10A, close to the outlet hole 11A.

[0090] Furthermore, with the spray nozzle 1 in this embodiment, the spray fluid 2 and spray medium 3 are individually mixed together at intermediate points in flow paths, so the ratio of the spray medium 3 to the mixed fluid 8 can be maintained. Therefore, the atomization characteristics of the mixed fluid 8 jetted from each outlet hole can be kept constant.

[0091] As described above, in this embodiment, even if part of outlet holes is blocked, the atomization characteristics of the mixed fluid 8 jetted from the normal outlet hole can be kept constant. Blockage in the flow path is restricted to only part of the flow path, so it is possible to suppress the amount of spray fluid 2 jetted from the spray nozzle 1 from being reduced.

[0092] Therefore, the atomization characteristics of the mixed fluid 8 can be maintained, so the amount of spray medium 3 to be used can be suppressed. In a case as well in which a force with which the spray fluid 2 and spray medium 3 are pressurized is increased to increase the amount of jet, it is possible to suppress the pressurization force from being increased.

[0093] As described above, the surface area per unit weight of the liquid fuel is increased due to the atomization of the mixed fluid 8, hastening the combustion reaction. Accordingly, non-burned content, soot dust, and carbon monoxide at the outlet of the combustion device are reduced, so the combustion efficient can be increased. Since the combustion reaction is hastened, consumption of oxygen proceeds, so generation of nitrogen oxides can be suppressed.

[0094] Furthermore, since non-burned content, soot dust, and carbon monoxide are reduced, extra air supplied into the combustion device can be reduced. When extra air is reduced, the amount of exhaust combustion gas is also reduced, so it is possible to reduce sensible heat to be released to the outside of the combustion device along with the exhaust combustion gas, thereby increasing the thermal efficiency.

[0095] Due to the suppression of the amount of spray medium 2 to be used and the reduction of pressure, the amount of energy consumption required for supplies and pressurizing forces can be reduced. If steam is used as the spray medium 2, the thermal efficiency in the combustion device is lowered due to the steam supplied into the combustion device; however, when the spray nozzle 1 in this embodiment is used, even if the amount of steam to be used is reduced, the atomization of the mixed fluid 8 can be maintained as before, preventing the thermal efficiency from being lowered.

{Embodiment 3}

[0096] FIGs. 8 to 10 illustrate a third embodiment of the spray nozzle in the present invention. The embodiment illustrated in these drawings is characterized in that the spray nozzle 1 has a plurality of outlet holes and that the mixed fluid flow path branches to a plurality of paths downstream of the first joining part at which the spray fluid and spray medium joins together and the branching mixed fluid flow paths form flow paths connected to different outlet holes.

[0097] That is, this embodiment differs from the second embodiment in flow path structures formed upstream of the outlet holes 11A and 11B. Here, descriptions will focus on the flow path structures. FIGs. 8 to 10 illustrate a case in which the spray nozzle 1 vertically has two outlet holes, outlet holes 11A and 11B. However, even if the spray nozzle 1 has more outlet holes, the structure is the same.

[0098] At the front end of the spray nozzle 1 in this embodiment illustrated in FIG. 9, the spray fluids 2 and spray medium 3 pass through independent spray fluid flow paths 4A and 4B and spray medium flow paths 6A and 6B and are mixed at first joining parts. Mixed fluids 8 of the spray fluid 2 and spray medium 3 pass through mixed fluid flow paths 9A and 9B.

[0099] The mixed fluid flow paths 9A and 9B branch in the middle and further branch to circular mixed fluid flow paths 9C, 9D, 9E, and 9F, indicated by the dotted lines in FIG. 8, through which the mixed fluids 8 flow toward the outlet holes 11A and 11B.

[0100] The outlet holes 11A and 11B in the spray nozzle 1 in this embodiment are concentrically formed with respect to the central axis of the spray nozzle 1, and the flow paths from the branching mixed fluid flow paths 9C, 9D, 9E, and 9F to the second joining parts are circumferentially formed with respect to the central axis of the spray nozzle 1.

[0101] The mixed fluids 8 collide with each other in the vicinity of the outlet holes 11A and 11B, which are the second joining parts, and are jetted from the outlet holes 11A and 11B. The mixed fluids 8 jetted from the outlet hole 11A and 11B each form a fan-shaped spray in a direction orthogonal to the flow direction of the mixed fluid flow path 9C, 9D, 9E, or 9F (circumferential direction in FIG. 8) due to the collision.

[0102] In this embodiment, therefore, sprays are formed radially with respect to the central axis of the spray nozzle 1.

[0103] In the outlet holes 11A and 11B in the spray nozzle 1, grooves 12A and 12B are formed in the same direction as the direction in which the fan-shaped sprays are formed (radial direction). The outlet holes 11A and 11B are parts at which the grooves 12A and 12B and the mixed fuel paths cross each other.

[0104] The spray fluid 2 is atomized due to the mixing with the spray medium 3 and also becomes a thin liquid film due to the collision with the mixed fluid 8 in the outlet holes 11A and 11B. After being jetted from the outlet holes 11A and 11B, the liquid film is broken due to a shear force by an ambient gas and is atomized.

[0105] Since the liquid film is atomized by the collision force of the fluids in this way and the mixed fluid flow paths have the bent parts 13 and 14 as in the first and second embodiments, the mixing of the spray fluid 2 and spray medium 3 is facilitated and atomization advances.

[0106] With the spray nozzle 1 in this embodiment, as illustrated in the second embodiment, if part of the outlet holes is blocked or partially blocked due to impurities or deposits in the spray fluid 2 or spray medium 3, then in the flow path of the mixed fluid 8, which is connected to the relevant outlet hole, fluids in the flow paths of the mixed fluid 8, spray fluid 2, and spray medium 3 flow toward the other open outlet hole through the branching pipe 61, so the temperature of each flow path is maintained by the fluid.

[0107] When a liquid fuel flowing as the spray fluid 2 is heated, solid content is deposited and the deposited solid content may block the flow path. With the spray nozzle 1 in this embodiment, however, flows through the branching pipe 61 to the open outlet hole can be maintained, so blocking does not easily proceed.

[0108] That is, even if part of outlet holes is blocked, the blocked portion is restricted to a portion from the blocked outlet hole to the branching pipe 61, so the blockage can be easily eliminated. If, for example, the outlet hole 11A described above is blocked, the blocked portion is restricted to the mixed fluid flow paths 9C and 9E in the mixed fluid flow path 9A, which are close to the outlet hole 11A.

[0109] Furthermore, with the spray nozzle 1 in this embodiment, the spray fluid 2 and spray medium 3 are individually mixed together at intermediate points in flow paths, so the ratio of the spray medium 3 to the mixed fluid 8 can be maintained. Therefore, the atomization characteristics of the mixed fluid 8 jetted from each outlet hole can be kept constant.

[0110] Thus, in the same way as the second embodiment, in this embodiment as well, even if part of outlet holes is blocked, the atomization characteristics of the mixed fluid jetted from the normal outlet hole can be kept constant. Also, blockage in the flow path is restricted to only part of the flow path, so it is possible to suppress the amount of spray fluid 2 jetted from the spray nozzle 1 from being reduced.

[0111] Therefore, the atomization characteristics of the mixed fluid 8 can be maintained, so the amount of spray medium 3 to be used can be suppressed. In a case as well in which a force with which the spray fluid 2 and spray medium 3 are pressurized is increased to increase the amount of jet, it is possible to suppress the pressurization force from being increased.

[0112] In the second and third embodiments described above, examples in which the number of outlet holes is 2 have been described, but an effect obtained when more outlet holes are formed is the same as described above. Furthermore, when the spray nozzle 1 is built into a combustion device, effects of facilitating atomization, reducing the spray medium, and reducing pressurization force are obtained as in the first embodiment.

[0113] A combustion device that burns a solid fuel and a liquid fuel has been described as the combustion device in the embodiments described above, but the embodiments can also be, of course, applied to a combustion device that burn fossil fuels instead of a solid fuel and a liquid fuel.

[0114] The present invention is not limited to the embodiments described above. The present invention includes various variations. For example, as an aid to comprehension of the present invention, the above embodiments have been described in detail. The present invention is not always limited to embodiments in which all structures described above are provided. It is possible to replace part of a structure in an embodiment with a structure in another embodiment. It is also possible to add a structure in another structure to a structure in an embodiment. For part of a structure in each embodiment, it is also possible to add, delete, or replace another structure.

{Reference Signs List}

[0115] 1 spray nozzle, 2 spray fluid, 3 spray medium, 4, 4A, 4B, 5, 5A, 5B spray fluid flow path, 6, 6A, 6B, 7, 7A, 7B spray medium flow path, 8 mixed fluid, 9, 9A, 9B, 9C, 9D, 9E, 9F, 10, 10A, 10B mixed fluid flow path, 11, 11A, 11B outlet hole, 12, 12A, 12B groove, 13, 13A, 13B, 14, 14A, 14B bent part, 20 burner, 21 central axis, 22 obstacle, 23 spray, 24 window box, 25 primary flow path, 26 secondary flow path, 27 tertiary flow path, 28 primary air, 29 secondary air, 30 tertiary air, 31 furnace, 32, 33 swirling flow generator 34 guide plate, 35 furnace wall, 36 transfer pipe, 41 combustion air supply system, 42 liquid fuel supply system, 43 spray medium supply system, 44 air supply port, 45, 46 pipe, 47 combustion gas, 48 heat exchanger, 49 flue, 50 chimney, 60 communication pipe, 61 branching pipe

Claims

1. A spray nozzle, comprising: at least two spray fluid flow paths for flowing a spray fluid; at least two spray medium flow paths for flowing a spray medium, in each of which joins a relevant spray fluid flow path at a first joining part;
at least two mixed fluid flow paths, in each of which a mixed fluid of the spray fluid and the spray medium that have joined together at the first joining part for flowing the mixed fluid and which are formed so as to face each other and allow mixed fluids to flow oppositely and have a second joining part at which the mixed fluids flowing oppositely collide with each other and join together; and
an outlet hole from which the mixed fluids that have joined at the second joining part are jetted; wherein in each mixed fluid flow path, a bent part at which a direction of a flow of the mixed fluid is changed is formed between the first joining part and the second joining part.

2. A spray nozzle to mix a spray fluid with a spray medium for atomization, comprising: a spray fluid flow path and a spray medium flow path at an inlet of the spray nozzle;
the spray fluid flow path and the spray medium flow path having a first joining part at which the spray fluid flow path and the spray medium flow path join together in the spray nozzle and also having a plurality of mixed fluid flow paths, in which the spray fluid and the spray medium join together, in the spray nozzle, the mixed fluids flowing so as to face each other in part of the mixed fluid flow paths; a second joining part at which opposite flows collide with each other and join together at an outlet of the spray nozzle; and an outlet hole formed immediately at downstream side of the second joining part;
wherein in each mixed fluid flow path, a bent part at which a direction of a flow of the mixed fluid is changed is formed between the first joining part and the second joining part.

3. The spray nozzle according to claim 1 or 2, wherein an angle by which the bent part formed in the mixed fluid flow path between the first joining part and the second joining part changes a direction of the mixed fluid is 30 degrees to 120 degrees.

4. The spray nozzle according to any one of claims 1 to 3, wherein: a plurality of the outlet holes are formed in the spray nozzle; a plurality of the second joining parts are formed; and a communication flow path that mutually connects the plurality of the second joining parts is provided between the first joining part and the second joining part.

5. The spray nozzle according to claim 4, wherein the communication flow path includes a communication pipe and a branching pipe, the communication pipe being configured so that two mixed fluid flow paths positioned at a central position of the spray nozzle communicate with each other at an intermediate point before reaching the outlet hole, and the branching pipe being configured so that two mixed fluid flow paths positioned on an outer peripheral side of the spray nozzle communicate with each other at an intermediate point before reaching the outlet hole.

6. The spray nozzle according to any one of claims 1 to 3, wherein a plurality of the outlet holes are formed in the spray nozzle, and the mixed fluid flow path branches to a plurality of paths downstream of the first part and each of the branching mixed fluid flow paths is formed a flow paths which is connected to the different outlet holes.

7. The spray nozzle according to claim 6, wherein the outlet holes in the spray nozzle are concentrically formed with respect to a central axis of the spray nozzle, and flow paths from the branching mixed fluid flow paths to the second joining parts are circumferentially formed with respect to the central axis of the spray nozzle.

8. The spray nozzle according to any one of claims 1 to 7, wherein in the outlet hole in the spray nozzle, a groove is formed in the same direction as a direction in which a spray is formed from the spray nozzle.

9. The spray nozzle according to claim 8, wherein the outlet hole is a part at which the groove and the mixed fuel path cross each other.

10. A burner that uses a liquid fuel as a fuel, wherein the spray nozzle according to any one of claims 1 to 9 is used to supply the liquid fluid to a front end of the spray nozzle as the spray fluid and also supply steam or compressed air to the front end of the spray nozzle as the spray medium.

11. A burner equipped with a fuel nozzle from which a solid fuel and a carrier gas of the solid fuel are jetted, a spray nozzle from which a liquid fuel is jetted, and a combustion gas nozzle from which a combustion gas used to burn the solid fuel and liquid fuel are jetted, wherein
the spray nozzle according to any one of claims 1 to

9 is used as the spray nozzle to supply the liquid fluid to a front end of the spray nozzle as the spray fluid and also supply steam or compressed air to the front end of the spray nozzle as the spray medium.

12. A combustion device that burns a solid fuel and a liquid fuel, the combustion device comprising: a combustion furnace that burns a fuel; a solid fuel supply system through which a solid fuel is supplied to the combustion furnace; a liquid fuel supply system through which a liquid fuel is supplied to the combustion furnace; a combustion gas supply system through which a combustion gas is supplied to the combustion furnace; a plurality of burners to which the fuel supply paths and the combustion gas supply system are connected, the plurality of burners being disposed on a furnace wall of the combustion furnace and being configured to burn the solid fuel and the liquid fuel; a heat exchanger that collects heat from an exhaust combustion gas generated in the combustion furnace; and a flue through which the collected exhaust combustion gas is supplied to an outside of the combustion furnace; wherein
the burner according to claim 10 or 11 is used as one of burners.

13. A combustion device that burns a fossil fuel, the combustion device comprising: a combustion furnace that burns a fossil fuel; a fuel supply system through which a fossil fuel is supplied to the combustion furnace; a combustion gas supply system through which a combustion gas is supplied to the combustion furnace; a burner to which the fuel supply system and the combustion gas supply system are connected, the burner being disposed on a furnace wall of the combustion furnace and being configured to burn the fossil fuel; a heat exchanger that collects heat from an exhaust combustion gas generated in the combustion furnace; and a flue through which the collected exhaust combustion gas is supplied to an outside of the combustion furnace; wherein
the burner according to claim 10 uses a liquid fuel as the fossil fuel is used as a burner.

FIG. 1

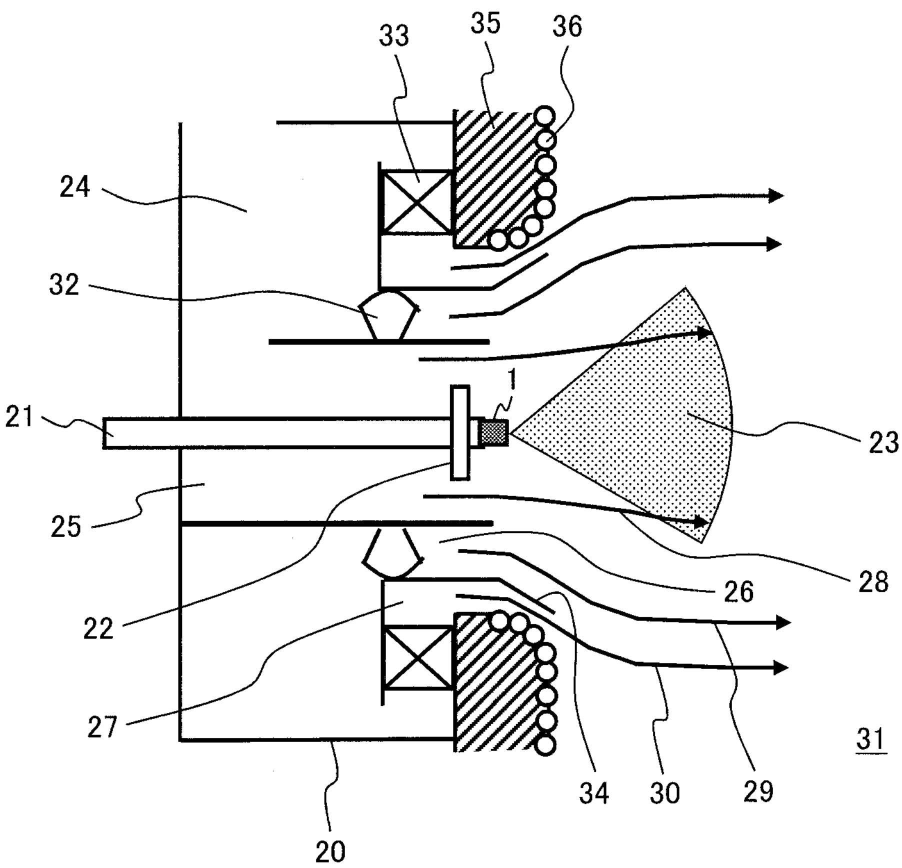


FIG. 2

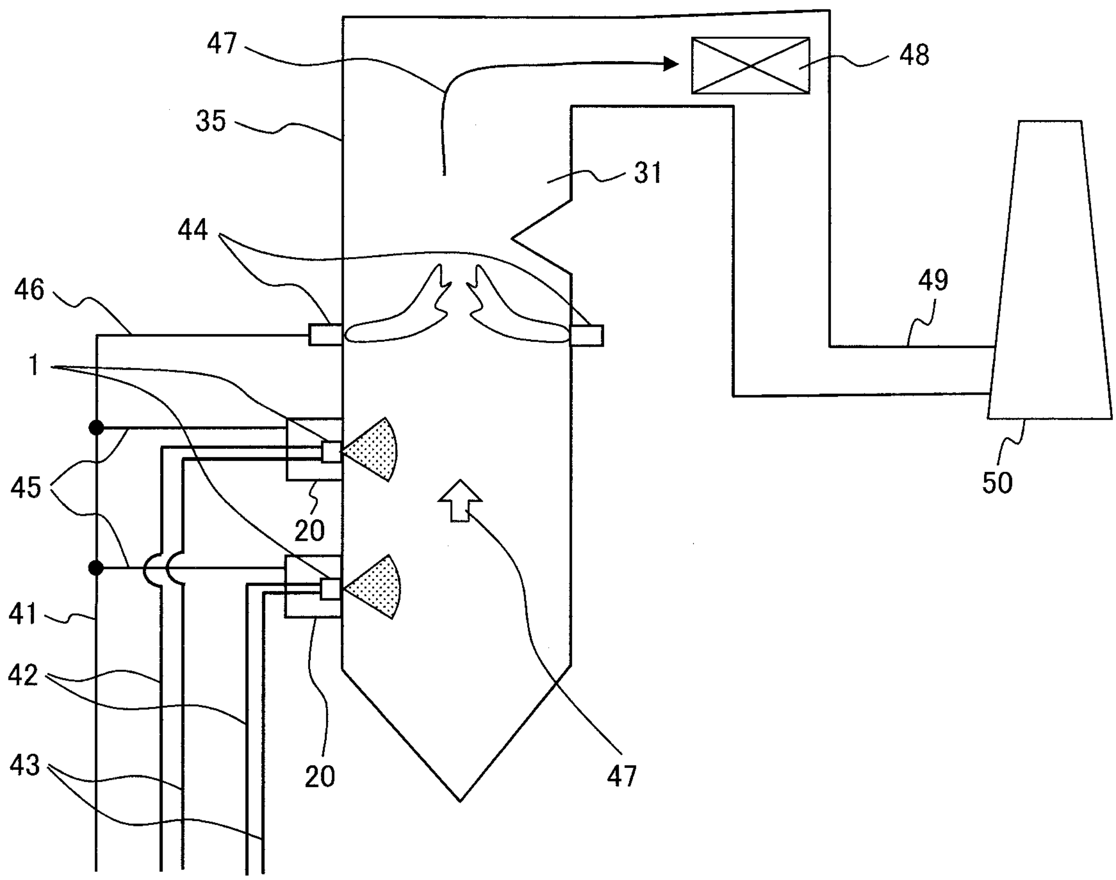


FIG. 3

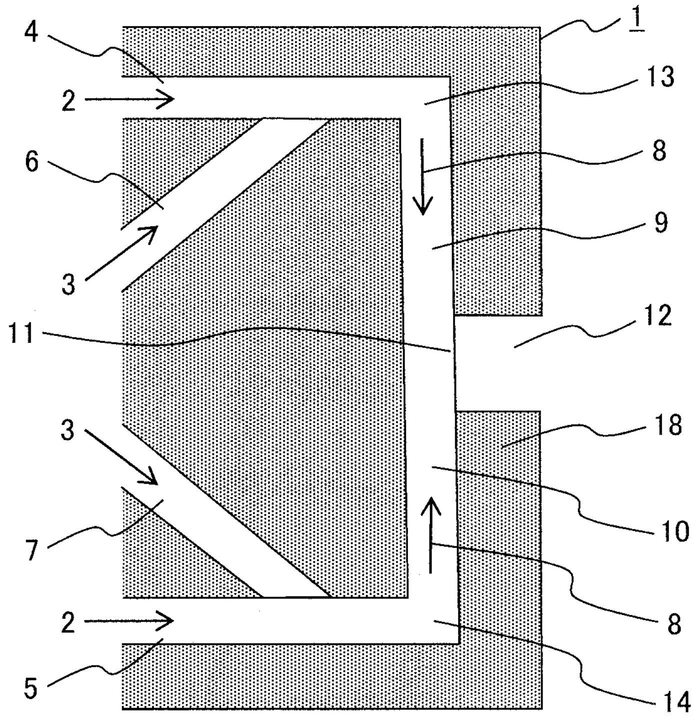


FIG. 4

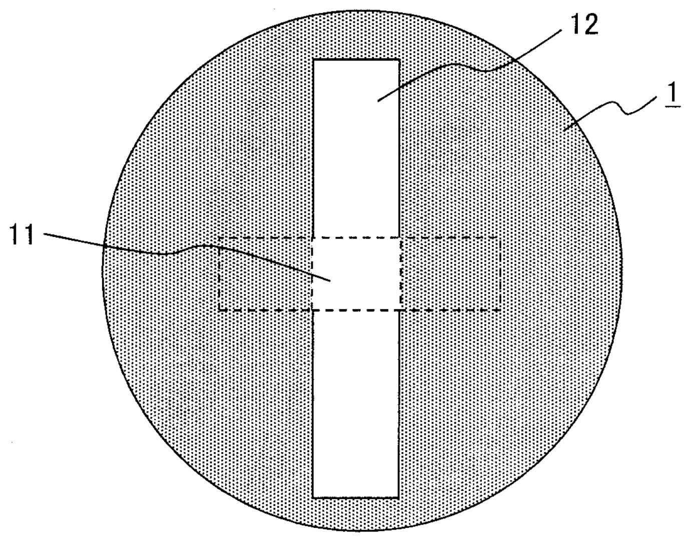


FIG. 5

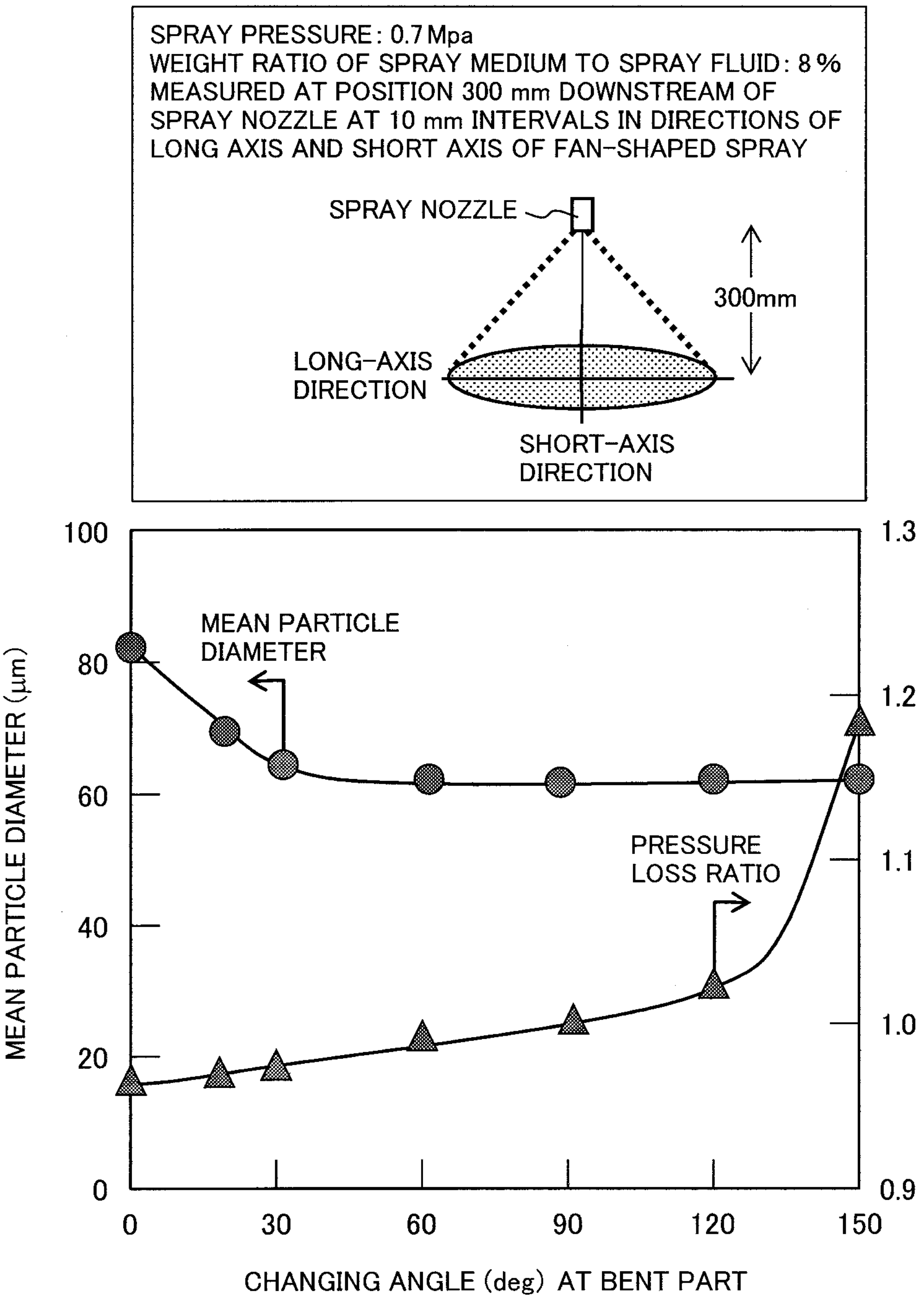

SPRAY PRESSURE: 0.7 Mpa
WEIGHT RATIO OF SPRAY MEDIUM TO SPRAY FLUID: 8 %
MEASURED AT POSITION 300 mm DOWNSTREAM OF SPRAY NOZZLE AT 10 mm INTERVALS IN DIRECTIONS OF LONG AXIS AND SHORT AXIS OF FAN-SHAPED SPRAY
SPRAY NOZZLE
300mm
LONG-AXIS DIRECTION
SHORT-AXIS DIRECTION
MEAN PARTICLE DIAMETER
PRESSURE LOSS RATIO
MEAN PARTICLE DIAMETER (μm)
PRESSURE LOSS RATIO (-)
100
80
60
40
20
0
1.3
1.2
1.1
1.0
0.9
0
30
60
90
120
150
CHANGING ANGLE (deg) AT BENT PART

FIG. 6

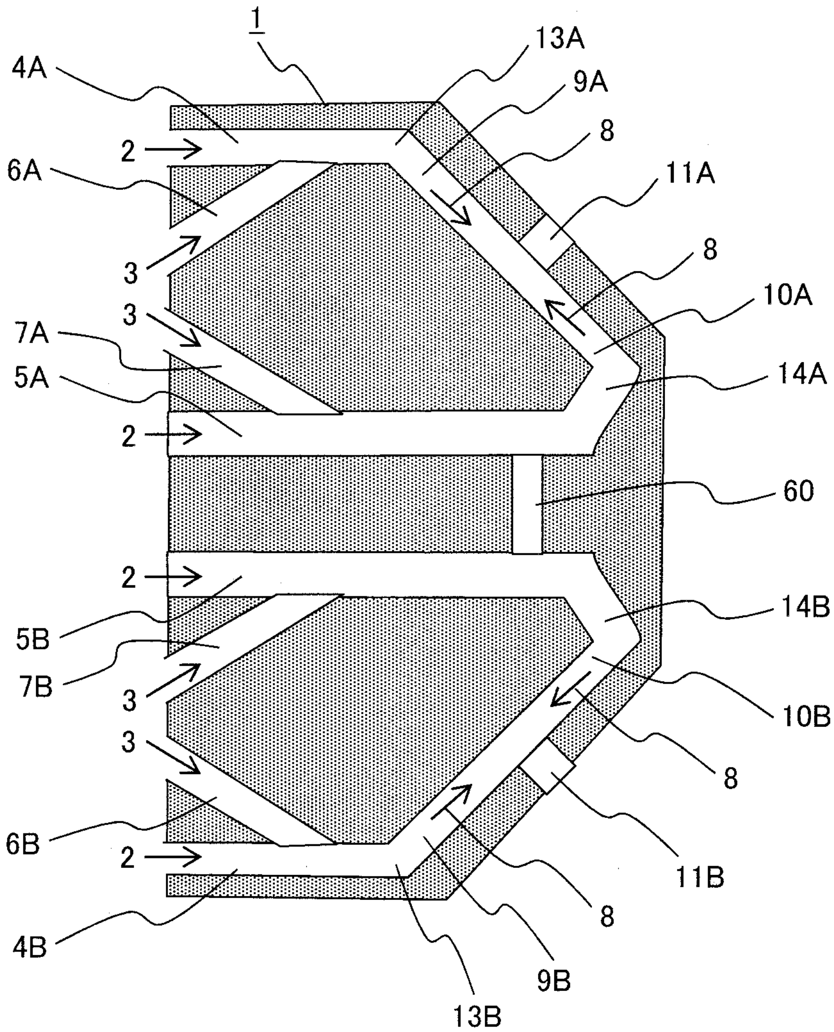

1
4A
13A
9A
8
2
6A
11A
3
8
3
10A
7A
5A
14A
2
60
2
14B
5B
7B
3
10B
3
8
6B
11B
2
4B
8
9B
13B

FIG. 7

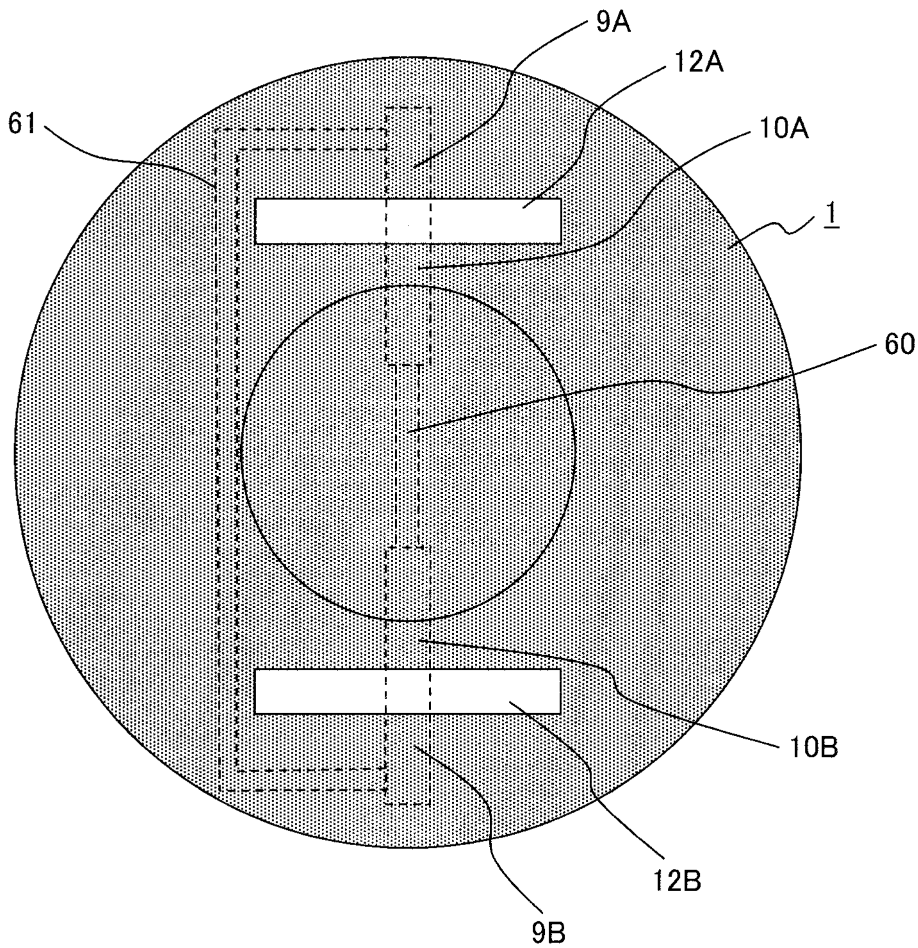


FIG. 8

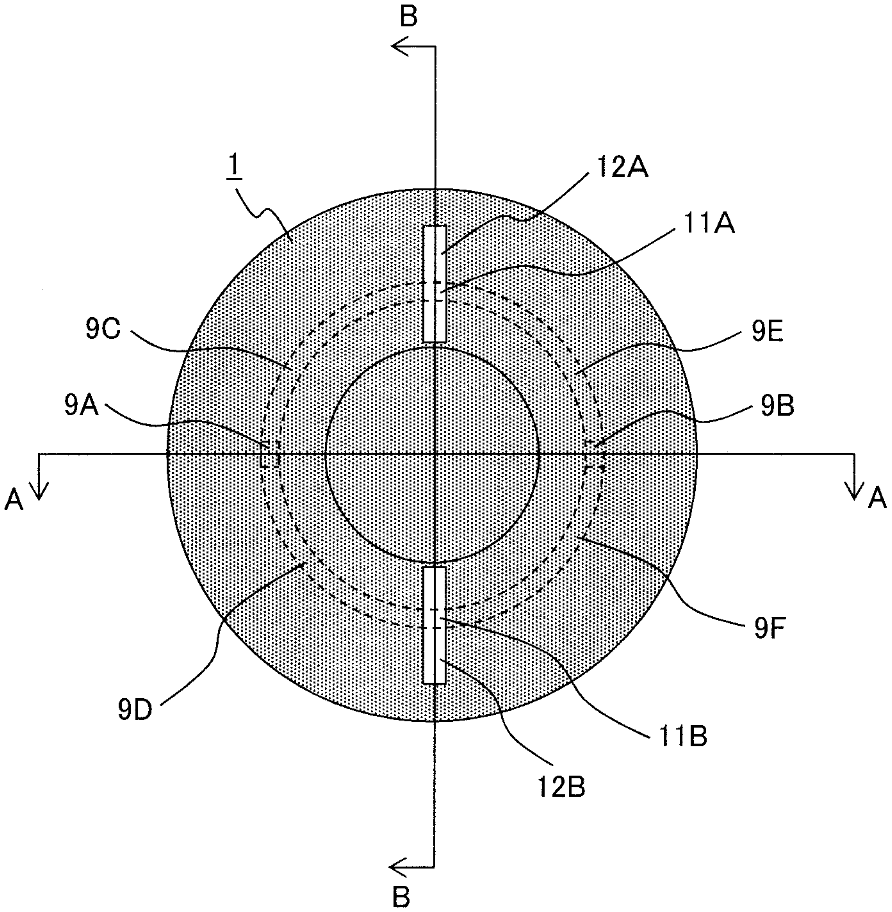


FIG. 9

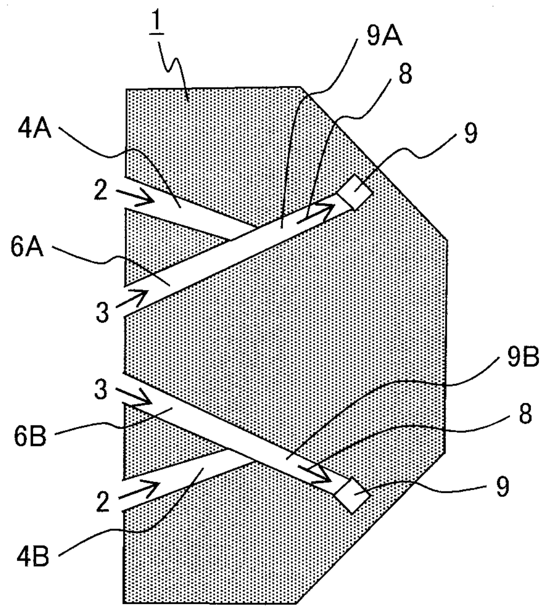
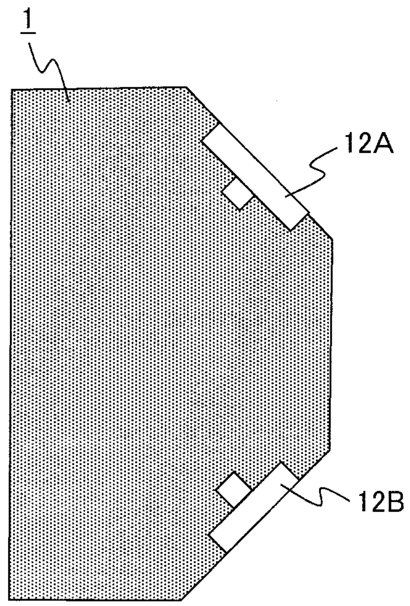


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/071102

A. CLASSIFICATION OF SUBJECT MATTER
F23D11/38(2006.01)i, *B05B1/26*(2006.01)i, *B05B7/04*(2006.01)i, *F23D11/10*(2006.01)i, *F23D11/12*(2006.01)i

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)
F23D11/38, B05B1/26, B05B7/04, F23D11/10, F23D11/12

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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.
Y A	JP 9-159113 A (Kawasaki Heavy Industries, Ltd.), 20 June 1997 (20.06.1997), paragraphs [0018] to [0020]; fig. 3 (Family: none)	1-3,6-13 4,5
Y	JP 10-5633 A (Mitsubishi Electric Corp.), 13 January 1998 (13.01.1998), paragraphs [0015] to [0022]; fig. 1 (Family: none)	1-3,6-13
Y	WO 2012/096318 A1 (Babcock-Hitachi Kabushiki Kaisha), 19 July 2012 (19.07.2012), paragraphs [0024] to [0044]; fig. 1 to 9B & JP 2012-145026 A & TW 201238664 A	1-3,6-13

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

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"&" document member of the same patent family

Date of the actual completion of the international search 22 August, 2013 (22.08.13)	Date of mailing of the international search report 03 September, 2013 (03.09.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/071102

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-299932 A (Nippondenso Co., Ltd., Toyota Central Research and Development Laboratories, Inc.), 25 October 1994 (25.10.1994), paragraph [0036]; fig. 14 & US 5492277 A & EP 611886 A1 & DE 69415362 T2 & CA 2115819 A1	6-13
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 137342/1984(Laid-open No. 53639/1986) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 11 April 1986 (11.04.1986), entire text; all drawings (Family: none)	1-13

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REFERENCES CITED IN THE DESCRIPTION

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- JP SHO621987112905 B **[0017]**
- JP SHO621987186112 B **[0017]**