

SPECIFICATION

Apparatus for the treatment of combustion gas used as an inert gas in an anti-explosion system

5 The present invention relates to an apparatus for the treatment of combustion gas in order to remove soot and sulfur dioxide gas therefrom, and more particularly to an apparatus for the treatment of combustion gas used as an inert gas in an anti-explosion system, particularly but not exclusively for use in an oil storage tank, any space above the oil being filled with the inert gas in order to prevent an explosion.

15 In order to protect such an oil storage tank as an oil container of an oil carrier, an oil storage tank on sea, an oil storage tank on land, etc., from a dangerous explosion, it has been proposed already to fill the empty space above the oil in the tank with an inert gas such as carbon dioxide gas.

20 However, it is considered that the use of combustion gas as said inert gas, after cooling and eliminating dust and sulfur dioxide from it, may be more beneficial because combustion gas can be easily obtained. For example, in case of an oil combustion gas from a boiler provided in an engine room or from an engine can be easily introduced and utilized if proper purification is carried out. This is an especially advantageous example of utilizing combustion gas, but in the case of ordinary storage tanks, also the utilization of combustion gas may be conveniently possible. Here, it can be pointed out that any conventional apparatus for the purification of combustion gas in order to prepare said inert gas, which hitherto has been tried, has never brought such a benefit as anticipated above because the conventional apparatus had only an ordinary simple structure, such as only being provided with a spray nozzle for water within a passage of combustion gas.

40 Accordingly, the apparatus was inevitably large, expensive, and moreover inefficient. In order to improve the efficiency of the conventional apparatus, further devices may be added, but as a result the pressure loss becomes large and the necessary power to drive those devices and to compensate the pressure loss becomes large, bringing a large cost penalty.

The object of the present invention is mainly to provide an apparatus for the treatment of combustion gas used as an inert gas in an anti-explosion system, which is compact so that it is possible to fit it within a small space in a ship, but which nevertheless has a sufficient capacity to adequately treat a sufficient quantity of combustion gas, gives no anxiety on the corrosion of relating machines and tools, does not require an excess amount of power in operation and whose costs, for the apparatus itself, installation and operation are very low.

60 According to the present invention there is provided an apparatus for the treatment of combustion gas for use as an inert gas in an anti-explosion system comprising:
a cylindrical outer casing,

65 a venturi tube arranged vertically through the top of the casing with its upper end projecting above said top to serve as an inlet for admitting combustion gas, said upper end being provided with a spray nozzle for spraying a scrubbing liquid toward the lower end of the venturi,

70 a liquid receptacle provided on the bottom of the casing under the venturi for receiving said scrubbing liquid, said lower end of the venturi projecting into the receptacle so that the combustion gas comes into contact with the liquid in the receptacle,

75 at least one volute passage surrounding the venturi above the receptacle and provided with scrubbing liquid spraying means for further washing of the combustion gas, said volute passage having an inlet adjacent the outer casing for introducing the combustion gas from the receptacle and an outlet adjacent the venturi,

80 a gas-liquid separating chamber disposed around the venturi above the volute passage for receiving the gas from the outlet of the volute in whirling motion, said chamber being provided with a plurality of circumferentially spaced slits for allowing the gas to pass from the separating chamber outlet provided in the outer casing.

90 That is, the invention offers an apparatus for the treatment of combustion gas, which acts to purify a combustion gas in such a way that, at first, during passing through said venturi the gas is cooled down and dust contained in it is removed, by the co-operative action of the liquid receptacle, the remainder of the dust component and, at the same time, a portion of sulfur dioxide gas contained in the combustion gas are removed as the result of an intimate contact of the combustion gas with misted particles of liquid consequent upon the collision of the combustion gas with the liquid in the receptacle and finally, an effective removal of the remainder of the sulfur dioxide component is carried out, again, by intimately contacting the gas with fine particles of liquid and falling liquid film layers along the wall surfaces of the volute passage while the gas passes therethrough.

100 According to a practical embodiment of the present invention, the action to eliminate the dust and sulfur dioxide contained in the combustion gas is reinforced by providing a conical projection at the centre of the bottom plate of said liquid receptacle substantially coaxial with the venturi.

115 Moreover, in a preferred embodiment by providing a liquid spraying system situated at an intermediate position of said volute passage using pairs of spray nozzles arranged so that each pair of nozzles spray horizontally against each other in order to form a thick and uniform layer of fine liquid particles and thin liquid layers, the functional ability to remove sulfur is very much enhanced.

125 Embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, wherein:

Figure 1 shows a flow sheet of an anti-explosion system having an inert gas incorporated

in an oil tanker, i.e. a bulk oil carrier,

Figure 2 is a vertical sectional front view of an example of a gas scrubber of the apparatus shown in Figure 1,

5 Figure 3 is a cross-sectional view of the apparatus shown in Figure 2, along the cross-section III—III,

10 Figure 4 is a vertical sectional front view of another example of a gas scrubber, having a modified structure, and

Figure 5 is a cross-sectional view of the apparatus shown in Figure 4, along the cross-section V—V.

15 Referring those figures, the anti-explosion system containing an inert gas of the present invention will be explained in detail.

In Figure 1 (1) is a flue to a boiler (not shown) provided in an engine room of an oil carrier having a plurality of oil tanks or containers 2, from which
20 flue 1 a flue gas can be obtained as the source of the inert gas. The flue 1 is connected with a main gas pipe 3 leading to each oil container 2 in order to introduce the combustion gas in the flue 1 to the containers 2 to reduce the risk of explosions in
25 the latter. On the halfway of the main gas pipe 3, a treating apparatus 4 for the combustion gas (hereafter, this treating apparatus will be referred to as a scrubber for short), two blowing fans 5a and 5b which are arranged in parallel as shown in
30 Figure 1 and a sealing apparatus 6 for preventing the reverse flow of the gas from the containers 2 are provided in succession in the normal flow direction of the combustion gas. If necessary, a demister (not shown) can be arranged between
35 the scrubber 4 and the blowing fans 5a and 5b. An automatic valve 7 is provided in the main gas pipe 3 between the flue 1 and the scrubber 4. The scrubber 4 is connected with a feeding pipe 8 provided with a pump 9 and two valves 10a and 10b for the feeding of sea water. The water,
40 exhausted from the scrubber 4 is received in a drain sealer 11 and then sent to a neutralizing vessel 12 for neutralization and at last, exhausted to the outside of the ship. At branch pipes 3b of the main gas pipe which connect said two
45 blowing fans 5a and 5b with the scrubber 4, two closable inlet valves 13a and 13b, are provided respectively for the fans and also a fresh gas introducing pipe 14 is connected to each of said
50 branch pipes 3b through a corresponding valve 15a or 15b. Each blowing fan 5a or 5b has an inlet vane 16a or 16b for the regulation of the inner pressure and an electric heater 18a and 18b
55 for the prevention of corrosion of the fan by preventing the condensation of water vapour contained in the gas.

At a further part 3c of the main gas pipe 3, which connects said blowing fans 5a and 5b with the sealing apparatus 6, two outlet valves of
60 opening and closing types, 19a and 19b, are respectively fitted and at the non-branching portion of the main pipe 3c, an automatic valve 20 is fitted. The inside of the sealing apparatus 6 is separated into two chambers, an upper one 22
65 and a lower one 23, by a partition plate 21,

wherein on the one side, a gas inlet pipe 24 which is connected with said main gas pipe 3c goes
downwards through the upper chamber 22 and enters into the lower chamber 23 with its mouth

70 open downwards above the bottom of the lower chamber 23. The end of the main gas pipe 3d, provided for connecting the sealing apparatus 6 to the containers 2 is connected to the lower
chamber 23. Between the upper chamber 22 and the lower chamber 23, a water up-flow pipe 25
75 and a water down-flow pipe 26 are fitted, wherein the former pipe 25 is arranged so as its lower open end is situated lower than the opening end of the gas inlet pipe 24, nearer to the bottom
80 of the lower chamber 23 and the latter pipe 26 is arranged to connect the upper chamber 22 and the lower chamber 23 in order to allow the water accumulated in the upper chamber 22 to flow into the lower chamber 23. At the same time, the
85 latter pipe 26 is provided with an automatic valve 27. Furthermore, the upper chamber 22 has a supply pipe 30 for sea water provided with a pump 28 and an automatic valve 29 and a suction pipe 31 which serves to connect the
90 upper portion of the upper chamber 22 and vacuum passage connected between both sets of said inlet vanes 16a, 16b and the blowing fans 5a, 5b, the suction pipe 31 being provided with an automatic valve 32. Furthermore, the lower
95 chamber 23 has an overflow pipe 33 to exhaust the accumulated water, and a heating coil 34. The main gas pipe 3d, which connects the sealing apparatus 6 and each container tank 2 is provided with a pressure transmitter 35 and valves 36,
100 each associated with a respective one of the containers 2. By the way, a return pipe 37 having an automatic valve 38 is provided in order to connect said main gas pipe 3c and the scrubber 4. Said pressure transmitter 35 detects the inner
105 pressure of each container tank 2 and converts it into an electric signal and by such an electric signal, the automatic valves 7, 20, 27, 32 and 38 and the inlet vanes 16a and 16b are controlled.

Upon the start-up of an anti-explosion system
110 to be protected with an inert gas, at first, an appreciable amount of sea water is fed into the upper chamber 22 of the sealing apparatus 6 through the water supplying pipe 30 until the level of the water reaches a predetermined height
115 and next, by opening the automatic valve 27 of the water going-down pipe 26 the sea water received in the upper chamber 22 is introduced into the lower chamber 23 until the height of the water in the chamber becomes sufficient to seal
120 both the gas inlet pipe 24 and the main gas pipe 3d. When those pipes are sealed, the inlet vanes 16a and 16b, the valves 36 of the main gas pipe 3d, the automatic valve 27 of the water down-flow pipe 26 and the automatic valve 38 of the
125 return pipe 37 are closed, and the automatic valves 7 and 20 and the automatic valve 32 of the suction pipe 31 are opened and the drive of the blowing fans 5a and 5b is begun. By the drive of those fans 5a and 5b since the upper zone of the
130 upper chamber 22 of the sealing apparatus 6 is

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sucked through the suction pipe 31, the sea water received in the lower chamber 23 is sucked up into the upper chamber 22 through the water up-flow pipe 25 and the water sealing of the gas inlet pipe 24 and the main gas pipe 3d in the lower chamber 23 is retracted. Here, the inlet vanes 16a and 16b of the blowing fans 5a and 5b and the valve 36 of the main gas pipe 3b are opened and the automatic valve 32 of the suction pipe 31 is closed, then, the combustion gas in the flue 1, which comes from the boiler, enters into the scrubber 4 through the main gas pipe 3a and the combustion gas is treated in the scrubber 4 to cool it down and to remove its dust and sulfur contents. Then the combustion gas is forced into the sealing apparatus 6 by the blowing fans 5a and 5b and then, passing through the lower chamber 23 which is not yet in a water-sealing state for the prevention of reverse flow of gas (that is, yet in a dry state) and the main gas pipe 3d, the combustion gas is sent into the container tanks 2. With the progress of filling of the gas within the container tanks 2, when the inner pressure of those tanks attains a desired level, the pressure transmitter 35 detects the pressure and instantly, the automatic valve 7 and 20 are closed and the automatic valve 38 of the return pipe 37 is opened. In this stage the combustion gas is only circulated between the scrubber 4 and the blowing fans 5a and 5b. When the inner pressure of the container tanks decreases due to the exhaustion of oil or any other reasons, the pressure transmitter 35 detects it and instantly, the automatic valves 7 and 20 are opened and the automatic valve 38 is closed and here again, the feeding of the combustion gas into the container tanks 2 begins. In the normal state of operation, the action as mentioned above is repeated for many many times. The main gas pipe 3d is provided with a proper P/V breaker in order to prevent the danger of too high a pressure or a too low vacuum prevailing in the containers.

During such a normal operation as mentioned above, when an accident happened in any upper stream line of the system, such as for example, when the condition of a blowing fan 5a or 5b became bad, the automatic valve 27 of the water down flow pipe 26 instantly opens ordered by a signal informing a bad condition and here, instantly, the sea water trapped within the upper chamber 22 of the sealing apparatus 6 flows into the lower chamber 23 through the pipe 26 and the connection between the gas inlet pipe 24 and the main gas pipe 3d is shut up by sealing them with the sea water in the lower chamber 23. Thus, the reverse flow of gas from the container 2 to the main gas pipe 3c situated at the upper stream line of the system is surely prevented.

Next, an example of the gas scrubber for the treatment of combustion gas will be explained in detail referring to Figure 2 and Figure 3.

The scrubber 4 shown in Figures 2 and 3 is composed of a cylindrical body 41 whose ends are closed, and a venturi tube 44 situated concentrically inside the former. The cylindrical

body 41 is separated into three chambers by two partition plates 42 and 43. The upper portion of the venturi tube 44 projects to the outside of the cylindrical body 41 penetrating the lid 41a and is formed into a combustion gas inlet 45. At the middle position of the peripheral wall of the projecting portion, a hole is provided to insert a spray nozzle 47. Said spray nozzle has an outlet facing downwards, situated on the axis of the venturi tube. In the lower chamber 48 of the cylindrical body 41, a liquid receiving vessel 49 of cylindrical shape is arranged, wherein the outlet end 50 of the venturi tube is inserted within the receiving vessel 49 so that the outlet end 50 is close to the bottom of the receiving vessel 49. The middle chamber 51 of the cylindrical body 41 is further separated into two chambers, an upper chamber 53 and a lower chamber 54, by a partition wall 52 and again, each of these chambers 53 and 54 is formed into a passage of volute structure, 57 or 58 using a partition plate 55 or 56. At each peripheral portion of the middle partition plate 52 and the lower partition plate 43 a hole 59 or 60 is provided in order to connect the initial portions 57a and 58a of said volute passages with the lower chamber 48 through those holes 59 and 60. And again, in the gas passage composed of the lower chamber 48 and the volute passages 57 and 58 a multiple number of spray nozzles 61 of circular type, whose outlets are directing downwards and expanding into a broad angle, are provided at the upper position of the holes 59 and 60. Furthermore, in the outermost passages 57b and 58b which follow the initial portions 57a and 58a of the volute passage, a multiple number of spray nozzles of collision type, 62 and 63 are provided wherein the spray nozzle of collision type means that, for example, each spray nozzle of collision type 62 consists of a pair of spray nozzles 62a and 62b which are arranged horizontally and facing each other and by such an arrangement it becomes possible to spray mist-like fine particles of liquid (of course, this is also true in the case of the spray nozzle 63 which belongs to the collision type, also.) In the upper chamber 64 of the cylindrical body 41 a gas-liquid separating chamber 65 surrounds the venturi tube 44 concentrically, that is, the gas-liquid separating chamber 65 is composed of a cylindrical wall 67 which has many slits 66 arranged circumferentially and is situated between the lid 41a of the cylindrical body 41 and the upper portion plate 42 and thus, the separating chamber 65 is connected to the final portions 57c and 58c of the volute passages 57 and 58, through those holes 68 provided at the central portions of the upper partition plate 42 and the middle partition plate 52. The outside space of the gas-liquid separating chamber 65 in the upper chamber 64 is nothing but a ring-formed passage 69 of gas, which is provided with an exhaust outlet 70 for the treated combustion gas. At the bottom side of the lower chamber 48 and of said ring-formed passage 69 an exhaust outlet pipe 71 for the treated liquor and an

exhaust outlet 72 for the separated liquid are respectively fitted.

The operation of the apparatus mentioned above will be explained in detail.

5 A combustion gas is supplied into the gas inlet
45 of the venturi tube 44. The supplied
combustion gas is cooled down by a spray of a
liquid body such as water, sea water or a solution
10 of caustic soda from the nozzle 47 and at the
same time, the dust contained in the gas is
removed. The flow of the combustion gas is
accelerated as it flows down in the venturi tube
44. Thus, the gas blows out from the gas exhaust
outlet 50 where it is directed on to the bottom
15 wall 49a. Since there exists a liquid body in the
liquid receiving vessel 49 which came from the
liquid sprayed by the spray nozzle 47, the gas
blown out from the outlet 50 with an appreciable
high speed collides violently with the liquid in the
20 receiving vessel 49 and changes its state into
mist-like fine particles or evaporates. Here, the
combustion gas reverses its flow direction just
after the collision and again intimately contacts
the mist-like liquid spray or its vapour to provide
25 an almost complete elimination of any dust or
soot remaining in the gas and, of course, the
removal of sulfur dioxide contained in the gas
dose also occur by said intimate contact, at the
same time. Next, the combustion gas enters into
30 the volute passages 57 and 58 through the holes
59, 60. In the section belonging to the connecting
portion between the lower chamber 48 and the
volute passages 57 and 58, that is, in the section
belonging to the initial portions 57a and 58a of
35 the volute passages, spraying is carried out by the
spray nozzles 61 of broad angle and circular type
and in the following range belonging the volute
passages 57b and 58b, the spraying is carried out
by the spray nozzles of collision type, 62 and 63.
40 That is, a combustion gas introduced into the
volute passages 57 and 58, does contact, at first
in each initial portion of those passages, rapidly
with misted liquid particles given by the spray
nozzles of broad angle and circular type, 61 and
45 then, successively with misted fine liquid particles
given by the spray nozzles of collision type, 62
and 63. By such a treatment sulfur dioxide gas
contained in the combustion gas is effectively
removed. The rate of flow of the combustion gas
50 in the volute passages 57 and 58, is very high and
accordingly, the efficiency of the misted liquid
particles in absorbing sulfur dioxide is high.
Moreover, it can be pointed out that since those
fine liquid particles move in the volute passages
55 57 and 58, accompanying with the combustion
gas, those particles collide with the surface of the
volute passage forced by the centrifugal force
obtained from the kinetic energy of gaseous
molecules; thus, thin liquid film layers are formed
60 on the surfaces of the band-like plates 55 and 56
of the volute passages 57 and 58 and
accordingly, an effective absorption of sulfur
dioxide does also occur by a rapid contact of the
combustion gas with the liquid layers. As
65 explained in above, the combustion gas is

effectively desulphurized during its passage
through the volute passages 57 and 58. The
liquid which absorbs sulfur dioxide gas is allowed
to fall down into the lower chamber 48 from the
70 holes 59 and 60 at any time and then is
exhausted to the outside through the waste liquid
exhaust outlet pipe 71 from the lower chamber
48. The combustion gas which has passed
through the volute passages 57 and 58, enters
75 into the gas-liquid separating chamber 65 passing
through the holes 68. Here, the flow direction of
the gas upon entering into the separating
chamber 65 is tangential to the chamber wall
because the gas has been rising, circulating along
80 the volute structure, and the entered gas is
released from the slits 66, again in the direction
tangential to each slit. Thus, the combustion gas
is separated from the liquid component and after
passing through the ring-formed passage 69 it is
85 sent to the outside of the treating apparatus 4
from the treated gas exhaust pipe 70. On the
other side, the separated liquid component is
exhausted to the outside of the treating apparatus
through the separated liquid exhaust pipe 72 from
90 the ring-formed passage 69.

In the above example, the volute passage was
separated into two steps, the upper one 57 and
the lower one 58, however, only one step of
volute passage will do in the present invention.
95 Furthermore, on the type of spray nozzles 47, 61,
62 and 63 and the structure of gas-liquid
separator, various modifications or changes are,
of course, possible in the apparatus of the present
invention.

100 Figures 4 and 5 show another example of the
gas scrubber which is somewhat different from
the example shown in Figures 2 and 3, wherein to
any part in Figures 4 and 5, which is the same to
the corresponding part of the previous example in
105 Figures 2 and 3, the same part number is given as
before in order to make it easy to understand the
difference between two examples. In the
following, the difference between the two
examples will be explained in detail.

110 The lower chamber 48 and the initial portion
57a of the volute passage 57 are connected to
each other through holes 81 and 82 and the
lower chamber 48 and the initial portion 58a of
the passage of volute structure 58 are connected
115 to each other through a hole 83. In order to
provide a passage for the combustion gas
released into the lower chamber 48 from the
outlet of the venturi tube 44 through the liquid
receiving vessel 49 a partition plate 84 of arc-like
shape is provided at the outside of the liquid
120 receiving vessel 49, to provide two passages 85
and 86 for the gas formed between the partition
plate 84 and the cylindrical body 41 and
moreover, a plural number of spray nozzles of
horizontal type 87 are provided within the
125 passages 85 and 86 facing against the flow
direction of gas.

In place of the spray nozzle 61 in the previous
example, by providing the passages 85 and 86
130 between the holes 81, 82 and 83 and the outlet

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end 50 of the venturi tube 44 and arranging the spray nozzles of horizontal type, 87 within those passages, it becomes possible to make the contact between the combustion gas and fine liquid particles very effective. Moreover, on the lid 41a of the cylindrical body 41 of the apparatus, a plural number of spray nozzle 88, which are directing downwards, are equi-distantly arranged concentrically with the cylindrical body 41 forming a smaller diameter than the cylindrical body 41. After passing through the volute passages 57 and 58, the combustion gas again contacts fine liquid particles sprayed from those spray nozzles 88 provided on the lid 41a. Thus, it becomes possible to completely remove sulfur dioxide gas from the combustion gas. Furthermore, a drain pipe 89, which has its open end at the bottom of the lower chamber 48, penetrates the middle partition plate 52 and the lower partition plate 43 to pass in the region of the final portion of the volute passage 58, perpendicularly from the corresponding position of the final portion of the volute passage 57, its top end being open at the bottom of the passage 57. A drain pipe 90, which has its open end at the bottom of the lower chamber 48 penetrates the lower partition plate 43. By providing these two drain pipes 89 and 90, it becomes always possible to equalize the drain level. If those drain pipes 89 and 90 are not provided, sprayed liquid particles fall onto the bottom of the volute passages 57 and 58 and accumulate within them. Such a condition brings sometimes an increase of pressure loss for the flow of gas and also an instability of the flow of gas, because the accumulated liquid moves with the flow of gas and is prevented from flowing towards the hole passages 81, 82, 83 resulting in an irregular liquid level and an excess pressure loss. For example, the liquid level may become higher the nearer to the finish point of the volute passage. The arrangement of those drain pipes 89 and 90 dissolves such a disadvantageous problem. Furthermore, each of said spray nozzles 61, 62, 87 and 88 is supplied from a header 91. A spraying body 92 which projects within the cylindrical body 41, penetrating said header 91 and the cylindrical body 41 itself, has a passage for liquid within itself, connected to the inside of said header 91 and a plurality of nozzles 93 fitted on the spraying body 92. Since a liquid body is sprayed from such nozzles 93 fitted on the body 92 as explained above, it becomes possible to get a spray forming a stable layer of very fine particles of liquid in a broad range and accordingly, to enhance the efficiency of contact between gas and liquid. Thus, said constitution of each spray nozzle having a header serves to stabilize the layer of sprays. Furthermore, 94 is a drain exhaust pipe, which serves to exhaust the liquid received in the upper chamber 64 into the lower chamber 48, provided in place of the exhaust outlet 72 for the separated liquid.

Claims

- 65 1. An apparatus for the treatment of combustion gas for use as an inert gas in an anti-explosion system comprising:
 - a cylindrical outer casing,
 - a venturi tube arranged vertically through the top of the casing with its upper end projecting above said top to serve as an inlet for admitting combustion gas, said upper end being provided with a spray nozzle for spraying a scrubbing liquid toward the lower end of the venturi,
 - a liquid receptacle provided on the bottom of the casing under the venturi for receiving said scrubbing liquid, said lower end of the venturi projecting into the receptacle so that the combustion gas comes into contact with the liquid in the receptacle,
 - at least one volute passage surrounding the venturi above the receptacle and provided with scrubbing liquid spraying means for further washing of the combustion gas, said volute passage having an inlet adjacent the outer casing for introducing the combustion gas from the receptacle and an outlet adjacent the venturi,
 - a gas-liquid separating chamber disposed around the venturi above the volute passage for receiving the gas from the outlet of the volute in whirling motion, said chamber being provided with a plurality of circumferentially space slits for allowing the gas to pass from the separating chamber outlet provided in the outer casing.
- 95 2. An apparatus as defined in Claim 1, wherein the bottom of the receptacle has a conical surface projecting toward the lower end of the venturi coaxially therewith.
- 100 3. An apparatus as defined in Claim 1 or 2 wherein said spraying means comprises a plurality of sprayers, each comprising a pair of spray nozzles capable of spraying a scrubbing liquid substantially horizontally towards each other.
- 105 4. An apparatus as defined in Claim 1, 2 or 3 further comprising scrubbing liquid spray nozzles at said inlet of the volute passage.
- 110 5. An apparatus as defined in any one of Claims 1 to 4 wherein said gas-liquid separating chamber is circumferentially defined by a cylindrical plate provided with said slits and has one end closed by the top of the outer casing and the other end opening into said outlet of the volute passage and an annular passage communicating said outlet of the outer casing is formed around the cylindrical plate.
- 115 6. An apparatus as defined in any one of Claims 2 to 5 wherein the space in the outer casing is vertically divided by a pair of spaced partition plates into a lower section in which the lower end portion of the venturi and the liquid receptacle are located, an intermediate section in which a spiral plate between the outer casing and the venturi defines said volute passage, and an upper section in which a cylindrical plate arranged between the outer casing and the venturi and
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end 50 of the venturi tube 44 and arranging the spray nozzles of horizontal type, 87 within those passages, it becomes possible to make the contact between the combustion gas and fine liquid particles very effective. Moreover, on the lid 41a of the cylindrical body 41 of the apparatus, a plural number of spray nozzle 88, which are directing downwards, are equi-distantly arranged concentrically with the cylindrical body 41 forming a smaller diameter than the cylindrical body 41. After passing through the volute passages 57 and 58, the combustion gas again contacts fine liquid particles sprayed from those spray nozzles 88 provided on the lid 41a. Thus, it becomes possible to completely remove sulfur dioxide gas from the combustion gas. Furthermore, a drain pipe 89, which has its open end at the bottom of the lower chamber 48, penetrates the middle partition plate 52 and the lower partition plate 43 to pass in the region of the final portion of the volute passage 58, perpendicularly from the corresponding position of the final portion of the volute passage 57, its top end being open at the bottom of the passage 57. A drain pipe 90, which has its open end at the bottom of the lower chamber 48 penetrates the lower partition plate 43. By providing these two drain pipes 89 and 90, it becomes always possible to equalize the drain level. If those drain pipes 89 and 90 are not provided, sprayed liquid particles fall onto the bottom of the volute passages 57 and 58 and accumulate within them. Such a condition brings sometimes an increase of pressure loss for the flow of gas and also an instability of the flow of gas, because the accumulated liquid moves with the flow of gas and is prevented from flowing towards the hole passages 81, 82, 83 resulting in an irregular liquid level and an excess pressure loss. For example, the liquid level may become higher the nearer to the finish point of the volute passage. The arrangement of those drain pipes 89 and 90 dissolves such a disadvantageous problem. Furthermore, each of said spray nozzles 61, 62, 87 and 88 is supplied from a header 91. A spraying body 92, which projects within the cylindrical body 41, penetrating said header 91 and the cylindrical body 41 itself, has a passage for liquid within itself, connected to the inside of said header 91 and a plurality of nozzles 93 fitted on the spraying body 92. Since a liquid body is sprayed from such nozzles 93 fitted on the body 92 as explained above, it becomes possible to get a spray forming a stable layer of very fine particles of liquid in a broad range and accordingly, to enhance the efficiency of contact between gas and liquid. Thus, said constitution of each spray nozzle having a header serves to stabilize the layer of sprays. Furthermore, 94 is a drain exhaust pipe, which serves to exhaust the liquid received in the upper chamber 64 into the lower chamber 48, provided in place of the exhaust outlet 72 for the separated liquid.

Claims

- 65 1. An apparatus for the treatment of combustion gas for use as an inert gas in an anti-explosion system comprising:
 - a cylindrical outer casing,
 - a venturi tube arranged vertically through the top of the casing with its upper end projecting above said top to serve as an inlet for admitting combustion gas, said upper end being provided with a spray nozzle for spraying a scrubbing liquid toward the lower end of the venturi,
 - a liquid receptacle provided on the bottom of the casing under the venturi for receiving said scrubbing liquid, said lower end of the venturi projecting into the receptacle so that the combustion gas comes into contact with the liquid in the receptacle,
 - at least one volute passage surrounding the venturi above the receptacle and provided with scrubbing liquid spraying means for further washing of the combustion gas, said volute passage having an inlet adjacent the outer casing for introducing the combustion gas from the receptacle and an outlet adjacent the venturi,
 - a gas-liquid separating chamber disposed around the venturi above the volute passage for receiving the gas from the outlet of the volute in whirling motion, said chamber being provided with a plurality of circumferentially space slits for allowing the gas to pass from the separating chamber outlet provided in the outer casing.
- 95 2. An apparatus as defined in Claim 1, wherein the bottom of the receptacle has a conical surface projecting toward the lower end of the venturi coaxially therewith.
3. An apparatus as defined in Claim 1 or 2 wherein said spraying means comprises a plurality of sprayers, each comprising a pair of spray nozzles capable of spraying a scrubbing liquid substantially horizontally towards each other.
- 105 4. An apparatus as defined in Claim 1, 2 or 3 further comprising scrubbing liquid spray nozzles at said inlet of the volute passage.
5. An apparatus as defined in any one of Claims 1 to 4 wherein said gas-liquid separating chamber is circumferentially defined by a cylindrical plate provided with said slits and has one end closed by the top of the outer casing and the other end opening into said outlet of the volute passage and an annular passage communicating said outlet of the outer casing is formed around the cylindrical plate.
6. An apparatus as defined in any one of Claims 2 to 5 wherein the space in the outer casing is vertically divided by a pair of spaced partition plates into a lower section in which the lower end portion of the venturi and the liquid receptacle are located, an intermediate section in which a spiral plate between the outer casing and the venturi defines said volute passage, and an upper section in which a cylindrical plate arranged between the outer casing and the venturi and

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provided circumferentially with said slits defines said gas-liquid separating chamber.

7. An apparatus as defined in Claim 6, wherein the lower section is provided along its periphery with at least one arcuate passage having one end open to receive the gas from the lower end of the venturi and the other end communicating with the intermediate section for transferring the gas into the volute passage, said arcuate passage being provided along its path with scrubbing liquid spraying nozzles.

8. An apparatus as defined in Claim 6 or 7 wherein the gas-liquid separating chamber is provided with spray nozzles for spraying a scrubbing liquid against the inflowing swirling gas.

9. An apparatus as defined in Claim 6, 7 or 8

- wherein at least one drain pipe extends through the partition plate between the lower and intermediate sections for discharging slurry formed in the volute passage into the lower section.

10. An apparatus as defined in any of the preceding claims wherein each of the spray nozzles and the spraying means comprises a liquid header, a liquid passage communicating with the header, and a plurality of spray tips communicating with the liquid passage.

11. An apparatus for the treatment of combustion gas used as an inert gas in an anti-explosion system, substantially as described herein with reference to and as illustrated in Figures 1 to 3 or Figures 1 to 3 as modified by Figures 4 and 5 of the accompanying drawings.