

| REPLACED SHEETS                                 |                             | SG |
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## EXHAUST GAS TREATMENT APPARATUS AND EXHAUST GAS TREATMENT EQUIPMENT

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### BACK GROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to an exhaust gas treatment apparatus for treating exhaust gas containing a mixture of fine-powder type solid contaminants and gaseous atmospheric contaminants, and an exhaust gas treatment system having the apparatus.

#### 2. Description of Related Art

In general, high-temperature exhaust gas contains not only air contaminants (pollutants) such as  $\text{No}_x$ , dioxin group, etc. which exist in a gaseous state, but also materials such as fine particulate, etc. which exist in a solid state.

A cyclone using a centrifugal force system, a bag filter using a filtration system, etc. have been hitherto known as means of removing fine-powder type solid materials from exhaust gas. These apparatuses can separate and collect only the fine-powder type solid materials in the exhaust gas, but they cannot remove gaseous air contaminants. Therefore, most of the air contaminants are discharged into the air.

Therefore, in order to remove such gaseous air contaminants, chemical equipment using water solution for absorbing the air contaminants is separately needed. Such chemical equipment is provided with a reaction tank in which gaseous air contaminants and



water solution are reacted with each other, an apparatus for circulating the water solution in the equipment, an apparatus for newly supplying water solution, an apparatus for treating the water solution, etc.

Accordingly, an apparatus having an assembly of a dust  
5 collector such as a cyclone or the like and chemical equipment has been generally used to process exhaust gas containing a mixture of polluting materials existing in a solid state and air contaminants existing in a gaseous state.

In such an exhaust gas treatment apparatus as described above,  
10 however, the chemical equipment must be designed on an extremely large scale, and the manufacturing cost of the apparatus is increased. In addition, the water solution must be supplied and processed, resulting in increase of the running cost. Therefore, the chemical industry, the iron industry, etc. which produce a large amount of exhaust gas in the  
15 manufacturing process of products, etc. have increasingly required such an apparatus which can remove gaseous air contaminants with no chemical equipment.

Therefore, in order to satisfy this requirement, the applicant of this application has proposed an exhaust gas treatment apparatus as  
20 described in International Laid-open Application WO 92/02292.

The exhaust gas treatment apparatus includes a conical cylinder which is tapered (i.e., reduced in diameter) toward the lower side thereof, and a jetting nozzle for jetting compressed gas along the inner peripheral surface of the upper portion of the conical cylinder. An  
25 upper open portion for sucking exhaust gas is formed at the upper



portion of the conical cylinder, and an exhaust port is formed at the lower portion of the conical cylinder.

The following is a mechanism of treating exhaust gas containing a mixture of solid pollutants and gaseous air contaminants  
5 in the exhaust gas treatment apparatus.

Inside the conical cylinder, the pressure is increased due to introduction of compressed gas, and the temperature is reduced due to adiabatic expansion of the compressed gas, etc. Therefore, some of the gaseous contaminants in the exhaust gas which is introduced into the  
10 conical cylinder is changed from the gas phase to the liquid phase due to the pressure increase and the temperature reduction in the conical cylinder. The air contaminants thus liquefied impinge against the fine-powder type solid pollutants in eddy flow in the conical cylinder, so that the air contaminants are adsorbed by the fine-powder type solid  
15 pollutants. The fine-powder type solid pollutants are removed by action of centrifugal force. That is, the gaseous air contaminants are removed together with the fine-powder type solid pollutants from the exhaust gas while adsorbed by the solid pollutants, and discharged from the exhaust port.

20 According to the exhaust gas treatment apparatus described in the above International Laid-open Application No. WO 92/02292, exhaust gas containing a mixture of pollutants existing in a solid state and air contaminants existing in a gaseous state can be highly efficiently processed with a relatively simple construction, and thus the  
25 increase in the manufacturing cost and the running cost can be



suppressed, which makes this apparatus extremely useful.

However, more and more attention is being paid to pollution problems at present, and an apparatus which can process exhaust gas with higher efficiency is now required.

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### SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide an exhaust gas treatment apparatus which can efficiently process exhaust gas containing a mixture of pollutants existing in a solid state (i.e., solid  
10 pollutants) and air contaminants existing in a gaseous state (i.e., gaseous air contaminants) with a relatively simple construction, and exhaust gas treatment equipment having the exhaust gas treatment apparatus.

In order to attain the above object, a first exhaust gas  
15 treatment apparatus includes: a hollow conical cylinder having an upper open portion which is formed at the upper portion thereof and adapted to take in the exhaust gas, and a lower open portion which is formed at the lower portion and adapted to exhaust constituent  
20 materials of the exhaust gas passing through the inside of the cylinder; a jetting nozzle for jetting compressed gas so as to swirl around the center axis of the conical cylinder along the inner peripheral surface of the upper portion of the conical cylinder; compressed gas supply means for supplying the compressed gas to the jetting nozzle; a casing for receiving materials discharged from said lower open portion of said  
25 conical cylinder, the casing having an exhaust port which is formed at



the upper portion thereof and adapted to exhaust gas components of the exhaust gas and an exhaust port which is formed at the lower portion thereof and adapted to exhaust fine-powder type solid materials of the exhaust gas; and a sheet which is disposed in a gas flow path inside the casing and has minute holes through which the gas can be passed.

In order to attain the above object, according to a second exhaust gas treatment apparatus, the first exhaust gas treatment apparatus is provided with cooling means for cooling the exhaust gas during a period from the time when the exhaust gas is supplied from an exhaust gas generating source for generating the exhaust gas until the time when the exhaust gas is introduced into the conical cylinder.

In order to attain the above object, according to a third exhaust gas treatment apparatus, in the second exhaust gas treatment apparatus, the cooling means has a cooling jacket which covers the outer peripheral surface of the conical cylinder so that refrigerant is supplied into the gap between the outer peripheral surface of the conical cylinder and the cooling jacket, refrigerant supply means for supplying the refrigerant into the cooling jacket, and refrigerant discharging means for discharging the refrigerant from the cooling jacket.

In order to attain the above object, according to a fourth exhaust gas treatment apparatus, any one of the first to third exhaust gas treatment apparatuses is further provided with swirling flow forming means for swirling the exhaust gas around the center axis of the conical cylinder to feed the exhaust gas from the upper open portion of the conical cylinder into the conical cylinder,



In order to attain the above object, according to a fifth exhaust gas treatment apparatus, in the fourth exhaust gas treatment apparatus, the swirling flow forming means has an exhaust gas swirling cylinder which is designed in a hollow cylindrical shape and disposed at the upper end of the conical cylinder, the exhaust gas swirling cylinder having an opening which is formed on the side periphery thereof and adapted to take the exhaust gas into the hollow cylinder, and swirling vanes which are provided at the edge of the opening and adapted to swirl the exhaust gas flowing from the opening into the hollow cylinder.

10 In order to attain the above object, according to a sixth exhaust gas treatment apparatus, in the fourth exhaust gas treatment apparatus, the swirl flow forming means has an exhaust gas swirling pan-shaped plate which is disposed at the upper end of the conical cylinder and designed in a pan shape which is gradually downwardly projected as it approaches the center axis of the conical cylinder, the exhaust gas swirling pan-shaped plate having plural through holes which are formed therein so as to extend from the upper surface of the plate to the lower surface of the plate in the swirling direction of the exhaust gas.

20 In order to attain the above object, according to a seventh exhaust gas treatment apparatus, any one of the first to sixth exhaust gas treatment apparatuses is further provided with plural jetting nozzles.

In order to attain the above object, according to an eighth exhaust gas treatment apparatus, in any one of the first to seventh

exhaust gas treatment apparatus, the sheet is a belt-shaped screen filter and there are further provided a supply roll shaft around which the screen filter is wound, a take-up roll shaft for taking up the screen filter and a take-up mechanism for rotating the take-up roll shaft, the  
5 supply roll shaft and the take-up roll shaft being disposed so that the screen filter which is supplied from the supply roll shaft, but is not yet taken up by the take-up roll shaft, is located in the gas flow path in the casing.

In order to attain the above object, according to a ninth exhaust  
10 gas treatment apparatus, in the eighth exhaust gas treatment apparatus, at least one of adsorption material which adsorbs specific components in the exhaust gas, and promoting material for promoting the reaction between the specific components and reactive material which reacts with the specific components, is attached to the screen  
15 filter.

In order to attain the above object, according to a tenth exhaust gas treatment apparatus, any one of the eighth and ninth exhaust gas treatment apparatuses is further provided with reactive material supply means for supplying the screen filter with the reactive material  
20 which reacts with the specific components in the exhaust gas.

In order to attain the above object, according to an eleventh exhaust gas treatment apparatus, in any one of the eighth to tenth exhaust gas treatment apparatuses, a liquid discharge port for discharging liquid which is formed due to condensation of the exhaust  
25 gas and water in the compressed gas is formed at the lower portion of



the casing, and a liquid circulating system for re-swirling the liquid discharged from the liquid discharge port of the casing into the conical cylinder.

5 In order to attain the above object, according to a twelfth gas treatment apparatus, in any one of the first to seventh exhaust gas treatment apparatus, the sheet is composed of filter cloth for a bag filter which is designed in a bag shape having an opening.

10 In order to attain the above object, first exhaust gas equipment includes any one of the first to twelfth exhaust gas treatment apparatuses, cooling means for cooling the exhaust gas from an exhaust gas generating source, and gas feeding means for feeding the exhaust gas cooled by the cooling means to the exhaust gas treatment apparatus.

15 In order to attain the above object, second exhaust gas equipment includes any one of the eighth to eleventh exhaust gas treatment apparatuses (hereinafter referred to as "upstream-side exhaust gas treatment apparatus"), and the twelfth exhaust gas treatment apparatus (hereinafter referred to as "downstream-side exhaust gas treatment apparatus"), the exhaust port of the upstream-  
20 side exhaust gas treatment apparatus and the upper open portion of the conical cylinder of the downstream-side exhaust gas treatment apparatus being connected to each other through a gas line.

In order to attain the above object, according to a third exhaust gas treatment apparatus, the second exhaust gas treatment equipment  
25 includes cooling means for cooling the exhaust gas from an exhaust gas



generating source, and gas feeding means for feeding the exhaust gas cooled by the cooling means to the upstream-side exhaust gas treatment apparatus.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partially-notched perspective view of an exhaust gas treatment apparatus according to an embodiment of the present invention;

10 Fig. 2 is a partially-notched perspective view showing an upstream-side exhaust gas treatment apparatus according to an embodiment of the present invention;

Fig. 3 is a partially-notched perspective view showing a downstream-side exhaust gas treatment apparatus according to an embodiment of the present invention;

15 Fig. 4 is a cross-sectional view showing a cyclone type treatment apparatus according to an embodiment of the present invention;

Fig. 5 is a perspective view showing an exhaust gas swirling cylinder according to an embodiment of the present invention;

20 Fig. 6 is a cross-sectional view which is taken along a line VI-VI of Fig. 5;

Fig. 7 is a plan view showing an exhaust gas swirling pan-shaped plate according to an embodiment of the present invention;

25 Fig. 8 is a cross-sectional view which is taken along a line VIII-VIII of Fig. 4; and



Fig. 9 is a perspective view showing adsorption paper, a take-up device for the paper and a liquid-chemicals supply device according to an embodiment of the present invention.

## 5     DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Exhaust gas treatment equipment according to an embodiment of the present invention will be described with reference to the accompanying drawings.

As shown in Fig. 1, exhaust gas treatment equipment according to this embodiment is connected to a boiler (exhaust gas generating source) for burning heavy oil, flammable materials, etc. High-temperature exhaust gas which is exhausted from the boiler 1 contains not only air contaminants existing in a gaseous state such as dioxin group, NO<sub>x</sub>, SO<sub>x</sub>, etc., but also materials existing in a solid state such as fine particulate, etc.

The exhaust gas treatment apparatus according to this embodiment includes a cooler (cooling means) for cooling exhaust gas generated in the boiler 1, an upstream-side exhaust gas treatment apparatus A and a downstream-side exhaust gas treatment apparatus B for treating the exhaust gas cooled by the cooler 2, and an air blowing fan 3 for blowing the exhaust gas cooled by the cooler 2 to the upstream-side gas treatment apparatus A.

As shown in Fig. 2, the upstream-side exhaust gas treatment apparatus A includes a cyclone type treatment apparatus 10A, a screen filter type treatment apparatus 30, and a liquid circulating apparatus



60 for feeding a part of liquid discharged from the screen filter type treatment apparatus 30 to the cyclone type treatment apparatus 10A.

As shown in Figs 2 and 4, the cyclone type treatment apparatus 10A includes a conical inner cylinder 11 which is tapered in section toward the lower side thereof (i.e., the diameter thereof is gradually reduced from the upper portion thereof to the lower portion thereof), plural jetting nozzles 19, 19... for jetting compressed air to the upper portion of the conical inner cylinder 11, a compressor (compressed gas supply means) 4 for supplying the compressed air to the plural jetting nozzles 19, 19... a pan-shaped exhaust gas swirling plate 13 which is disposed at the upper end of the conical inner cylinder 11 and downwardly gradually projected toward the center axis C of the conical inner cylinder 11 and has plural through holes 14 extending from the upper surface to the lower surface thereof, an exhaust gas swirling cylinder 16 which is disposed at the upper end of the conical inner cylinder 11 and designed in a hollow cylindrical shape and has on the side periphery thereof plural openings 17, 17... for taking the exhaust gas into the hollow cylinder, a cooling jacket (cooling means) 20 which covers the outer peripheral surface of the conical inner cylinder 11 and is supplied with water into the gap between the cooling jacket 20 and the outer peripheral surface of the conical inner cylinder 11, an outer cylinder which covers the outer peripheries of the exhaust gas swirling cylinder 16 and the conical inner cylinder 11 to which the cooling jacket 20 is secured, an outer cylinder lid 26 for closing the upper end of the outer cylinder 25, a compressed air divider 27 for dividing the



compressed air from the compressor 4 to the plural jetting nozzles 19, and a rectangular cylindrical casing 28 for covering the above elements.

The conical inner cylinder 11 is opened at the upper end thereof, that is, at the portion corresponding to the bottom surface of the cone (i.e., it has an upper open portion), and also it is opened at the lower end thereof, that is, at the portion corresponding to the apex of the cone (i.e., it has a lower open portion). The lower open portion constitutes the discharge port 12. As shown in Fig. 2, the discharge port 12 is connected to a fine-powder discharge pipe 59 which extends to the lower portion of the side surface of the screen filter type treatment apparatus 30. The upper open portion of the conical inner cylinder is closed by the exhaust gas swirling pan-shaped plate 13.

As described above, the plural through holes 14, 14... are formed in the exhaust gas swirling pan-shaped plate 13 so as to extend from the upper surface of the plate 13 to the lower surface thereof. As shown in Fig. 7, all of the through holes 14, 14... are formed on a line segment which is drawn in a spiral form with the center axis C of the conical inner cylinder 11 located at the center of the segment line. Further, the through holes 14 are formed so as to extend obliquely from the upper surface to the lower surface of the exhaust gas swirling pan-shaped plate 13 in a clockwise direction around the center axis C of the conical inner cylinder 11 so that the exhaust gas passing through the through holes 14 forms a swirling flow in the clockwise direction (viewed from the upper surface).

As shown in Fig. 4, the cooling jacket 20 covering the outer



peripheral surface of the conical inner cylinder 11 is connected to a cooling water supply pipe 21a at the lower portion thereof, and also to a cooling water drain pipe 21b at the upper portion thereof. The cooling water supply pipe 21a and the cooling water drain pipe 21b are provided  
5 with flow-amount adjusting valves 22a, 22b and thermometers 23a, 23b for detecting the temperature of the cooling water, respectively.

As shown in Fig. 5, the exhaust gas swirling cylinder 16 is designed in a hollow cylindrical shape, and opened at the upper and lower surfaces thereof. At the side periphery of the gas swirling cylinder  
10 16, plural rectangular openings 17, 17... for taking the exhaust gas into the hollow cylinder are formed. A swirling vane 18 for swirling the exhaust gas flowing from the opening 17 into the hollow cylinder 11 in the clockwise direction (viewed from the upper side) with the center axis C of the conical inner cylinder 11 at the center is provided at the edge  
15 of each opening 17, 17... . The exhaust gas swirling cylinder 16 is provided just above the exhaust gas swirling pan-shaped plate 13.

As shown in Fig. 4, an opening 25a is formed at the lower portion of the outer cylinder 25 which covers the peripheral surfaces of the conical inner cylinder 11 and the exhaust gas swirling cylinder 16 to  
20 which the cooling jacket 20 is secured. The opening 25a is connected to an exhaust-gas induction chamber 29 which is formed at the lower portion of the casing 28. An induction port 29a is formed in the side wall of the casing which forms the exhaust gas induction chamber 29. The induction port 29a is connected through the cooler 2 and the air blow fan  
25 3 to a gas duct 5 extending from the boiler 1 (Fig. 2). The upper portion



of the outer cylinder 25 is closed by a ceiling plate 26. The ceiling plate 26 serves to close the upper opening of the outer cylinder 25, and also to close the upper opening of the exhaust gas swirling cylinder 16.

The compressed air divider 27 provided around the outer  
5 cylinder 25 is connected to the compressed air supply pipe 58 extending from the compressor 44. Further, as shown in Fig. 8, the compressed air divider 27 is provided with seven jetting nozzles 19, 19... . The tip portions of the jetting nozzles 19 are bent so that the compressed air jetting from the tip portions swirls around the center axis C of the  
10 conical inner cylinder 11 in the clockwise direction (viewed from the upper side) along the inner peripheral surface of the upper portion of the conical inner cylinder 11. In Fig. 8, the exhaust gas swirling pan-shaped plate 13 is omitted in order to make it easy to understand the jetting direction of the compressed air in the conical inner cylinder 11.

15 As shown in Fig. 2, the screen filter type treatment apparatus 30 includes adsorption paper (sheet) 31 which forms a screen filter, a supply roll shaft 32 around which the adsorption paper 31 is wound, a take-up roll shaft 33 for taking up the adsorption paper 31, a screw 49 for feeding fine-powder type solid materials in the exhaust gas to a  
20 desired direction, a casing 40 for covering the above elements, a take-up mechanism 35 for rotating the take-up roll shaft 33, and a liquid-chemicals supply apparatus 50 for supplying liquid chemicals to the adsorption paper 31. Each of the adsorption paper 31, the supply roll shaft 32, the take-up roll shaft 33 and the take-up mechanism 35 is  
25 provided in pairs.



The casing 40 has an upper portion in a square-pillar shape and a lower portion in a quadrangular pyramid shape. As described above, the fine-powder type discharge pipe 59 which extend from the cyclone type treatment apparatus 10A is connected to the side surface of the quadrangular-pyramid shaped portion of the casing 40. The screw 49 described above is provided at the lower portion of the square-pillar-shaped portion of the casing 40. A liquid discharge port 42 and a fine-powder discharge port 41 are formed at the lower portion of the screw 49 and in the wall surface which forms the casing 40. A partition plate 44 for partitioning the inside of the casing 40 is provided at the boundary between the square-pillar shaped portion and the quadrangular pyramid shaped portion of the casing 40. The partition plate 44 is provided with many through holes which penetrate in the vertical direction. The side wall of the square-pillar portion of the casing 40 is projected to the side direction at four places, and these projecting portions constitute adsorption roll stock chambers 45 and 46. Every two of the four adsorption roll stock chambers 45, 46 are confronted to each other, and the adsorption roll chamber 45 of the two confronting adsorption roll chambers is provided with the supply roll shaft 32, and the other adsorption roll chamber 46 is provided with the take-up roll shaft 33. The belt-shaped adsorption paper 31 is wound around the supply roll shaft 32 at one end thereof, it extends therefrom in the horizontal direction traversing the casing 40, and is wound around the take-up roll shaft 33 at the other end thereof. Further, an exhaust port 43 is formed at the upper portion of the side wall which



forms the square pillar portion of the casing 40. Powdery activated charcoal is previously attached to the adsorption paper 31 disposed at the upper stage side.

As shown in Fig. 9, the take-up mechanism 35 includes a gear motor 39, a driving pulley 38 which is fixed to the output shaft of the gear motor 39, a driven pulley 36 which is fixed to the take-up roll shaft 33, and a belt 37 which is suspended over both the pulleys 36, 38.

As shown in Fig. 9, the liquid chemical supply apparatus 50 includes a liquid chemical tank 51 in which chemicals such as ammonium water are stocked, and a liquid chemical pipe 52 for supplying ammonium water in the liquid chemical tank 51 to the adsorption paper 31 which is wound around the supply roll shaft 32.

As shown in Fig. 2, the liquid circulating apparatus 60 includes a lower cone type tank 61 for temporarily stocking liquid discharged from the screen filter type treatment apparatus 30, a liquid circulating pump 69 for feeding liquid in the tank 61 into the exhaust gas swirling cylinder 16 of the cyclone type treatment apparatus 10A, a strainer 68 for removing solid materials in the liquid which is discharged from the tank 61, and a spraying apparatus 70 for spraying the liquid fed from the liquid circulating pump 69.

The upper portion of the lower cone type tank 61 is connected to a liquid pipe 62 extending from the liquid discharge port 42 which is formed at the lower portion of the casing 40 of the screen filter type treatment apparatus 30, and a chemical pipe 63. At the lower portion of the tank 61 there is provided a sludge discharge port 66 through which



sludge stocked in the tank 61 is discharged. The tank 61 is provided with a pH meter 65 for measuring pH of the liquid in the tank 61. The chemical pipe 63 is provided with a chemical flow-amount adjusting valve 64 for changing the valve opening degree in accordance with the pH value measured by the pH meter 65. Ammonium water flows into the liquid chemical pipe 63. A liquid pipe 67 is connected to the upper portion of the cone portion of the tank 61. The liquid pipe 67 is connected to the induction port of the liquid circulating pump 69 through the strainer 68.

As shown in Fig. 4, the spraying apparatus 70 includes a spraying container 71 for receiving the liquid which is fed from the liquid circulating pump 69, plural jetting nozzles 72, 72... for jetting the compressed air into the spraying container 71, and a casing 73 which covers the above elements and serves to feed the gas sprayed in the spraying container 71 into the exhaust gas swirling cylinder 16 of the cyclone type treatment apparatus 10A.

The spraying container 71 is designed substantially in a cylindrical shape, and it is opened at the upper portion and has a bottom at the lower portion. The plural jetting nozzles 72, 72... are fixed to the spraying container 71 so that the compressed air is jetted to the bottom of the spraying container 71. The liquid which is fed from the liquid circulating pump 69 is sprayed by the compressed air which is jetted from the jetting nozzles 72 and collides against the bottom of the spraying container 71 and changes the moving direction thereof to the upward direction. The sprayed liquid goes out of the spraying container

71 through the upper opening 71a of the spraying container, together with the compressed air, so that the sprayed liquid is discharged from the circulated liquid discharge port 74 of the casing 73 into the exhaust gas whirling cylinder 16 of the cyclone type treatment apparatus 10A.

5           As shown in Fig. 3, the downstream-side exhaust gas treatment apparatus B includes a cyclone type treatment apparatus 10B, and a bag filter type treatment apparatus 80. The cyclone type treatment apparatus 10B is substantially the same as the cyclone type treatment apparatus 10A of the upstream-side exhaust gas treatment apparatus A.

10   However, the cyclone type treatment apparatus 10B of the downstream-side exhaust gas treatment apparatus B is different from the cyclone type treatment apparatus 10A of the upstream-side exhaust gas treatment apparatus A in that the spraying apparatus 70 of the liquid circulating apparatus 60 is not provided at the upper portion, and

15   also the fine-powder discharge pipe 59B provided at the lower portion of the conical inner cylinder 11 extends vertically downwards. The induction port 29a of the cyclone type treatment apparatus 10B of the downstream-side exhaust gas treatment apparatus B is connected to the exhaust port 43 of the screen filter type treatment apparatus 80 of the

20   upstream-side exhaust gas treatment apparatus A.

          The bag filter type treatment apparatus 80 includes bag type Teflon filter cloths (sheets) 81, 81..., a screw 89 for feeding the fine-powder type solid materials in the exhaust gas in a desired direction, a casing 85 for covering these elements, and an inverse cleaning

25   apparatus 90 for avoiding clogging of the filter cloths 81.



Each filter cloth 81 has a cylindrical shape, and it is opened at the upper portion and has a bottom at the lower portion. The filter cloth 81 is supported at the edge of the upper opening thereof by a partition plate 87.

5           The casing 85 has an upper portion in a square-pillar shape, and a lower portion in a quadrangular pyramid shape. The inside of the quadrangular pyramid portion of the casing 85 is partitioned into upper and lower spaces by the partition plate 87, and the lower space thereof forms a induction chamber 82 while the upper space thereof forms an exhaust chamber 83. Further, an exhaust port 88 is formed in the side wall of the casing 40 which forms the exhaust chamber 83. In the induction chamber 82 there are disposed the plural cloths 81, 81... which are supported by the partition plate 87, and are also located the lower end opening 59Ba of the fine-powder discharge pipe 59B which extends from the cyclone type treatment apparatus 10B. Further, the quadrangular pyramid portion of the casing 85 is provided with the screw 89 at the lower portion thereof, and a fine-powder discharge port 86 is formed at the lower portion of the screw 89 and on the wall surface which forms the casing 85.

20           The inverse cleaning apparatus 90 includes a header 91 for temporarily stocking the compressed air and pipes 92, 92... for guiding the compressed air in the header 91 into the filter clothes 81, 81... .

Next, the operation of the exhaust gas treatment apparatus according to this embodiment will be described hereunder.

25           The exhaust gas from the boiler 1 is cooled by the cooler 2,

pressurized to about 700 mmAq in the air blow fan 3, and then flows into the cyclone type treatment apparatus 10A of the upstream-side exhaust gas treatment apparatus A.

The exhaust gas flowing into the cyclone type treatment apparatus 10A passes through the exhaust gas induction chamber 29, and then passes from the opening 25a of the outer cylinder 25 through the gap between the inner peripheral surface of the outer cylinder 25 and the outer peripheral surface of the cooling jacket 20. In this process, the exhaust gas is heat-exchanged with the cooling water to be cooled in the cooling jacket 20. When arriving at the gap between the inner peripheral surface of the outer cylinder 25 and the exhaust gas whirling cylinder 16, the exhaust gas flows from the plural openings 17, 17... of the exhaust gas swirling cylinder 16 into the exhaust gas swirling cylinder 16. During this process, the exhaust gas is forced to swirl in the clockwise direction by the swirling vanes 18, 18... which are provided to the respective openings 17, 17... of the exhaust gas swirling cylinder 16. The exhaust gas in the exhaust gas swirling cylinder 16 flows downwardly while swirling in the clockwise direction, passes through the through holes 14 of the exhaust gas swirling pad-shaped plate 13 and then flows into the conical inner cylinder 11. In this process, the swirling performance of the exhaust gas is enhanced because the through holes 14 of the exhaust gas swirling pan-shaped plate 13 extend in the swirling direction of the exhaust gas.

Not only the exhaust gas, but also the compressed air from the compressor 4 is supplied into the conical inner cylinder 11 of the cyclone



type treatment apparatus 10A. In this embodiment, the compressed air is adjusted to about 4.5 to 7.0kg/cm<sup>2</sup>, and it is jetted from the jetting nozzles 19 into the conical inner cylinder 11 in the swirling direction of the exhaust gas. Accordingly, the inner pressure of the conical inner  
5 cylinder 11 is increased, and the swirling force of the exhaust gas in the conical inner cylinder 11 is also increased. On the assumption that the amount of the exhaust gas flowing into one cyclone type treatment apparatus 10A is equal to about 22Nm<sup>3</sup>/min., the amount of compressed air to be supplied to one cyclone type treatment apparatus 10A is equal  
10 to 0.25Nm<sup>3</sup>/min. which is a very slight value.

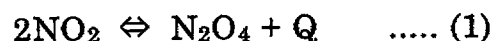
In the conical inner cylinder 11, the pressure is increased to a specific pressure and the temperature is reduced to a specific temperature due to the flow-in of the compressed air. The reduction in temperature occurs due to the adiabatic effect of the compressed air and  
15 the inherent effect of the cyclone. Further, the gas in the conical inner cylinder 11 is cooled by the cooling water in the cooling jacket 20. Due to the pressure increase and the temperature decrease in the conical inner cylinder 11, the gas contaminants in the exhaust gas are liquefied, and adsorbed by the fine-powder type solid materials in the exhaust gas.  
20 Further, the gas contaminants in the exhaust gas are dissolved into liquid water which is produced due to condensation of water in the compressed air, and this water is adsorbed by the fine-powder type solid materials in the exhaust gas. As described above, the fine-powder type solid materials adsorb the water in the compressed air and the liquefied  
25 gaseous contaminants, and they are mutually attached to one another

to be relatively large and heavy lumps. Accordingly, the fine-powder type solid materials swirl and move downwardly together with the exhaust gas from which almost all of the gaseous contaminants and the fine-powder type solid materials are removed, and they are subjected to centrifugal force during the above swirling process, and are separated from the exhaust gas.

Here, the mechanism for removing the gaseous contaminants from the exhaust gas will be described in the case of nitride oxide and dioxin groups.

10 Nitride oxide and dioxin groups are the most critical pollutants in the present air pollution problem.

Nitrogen dioxide  $\text{NO}_2$  is a nitrogen oxide that has recently been most problematic because it optically induces the "smog phenomenon" and emits a particularly offensive odor. The nitrogen oxides are produced during the burning process of fossil fuel such as coal, petroleum, etc., or in a chemical process of producing nitric acid or the like. Among the nitrogen oxides, nitrogen monoxide is produced by the direct reaction between oxygen and nitrogen in the burning process of fossil fuels, and nitrogen dioxide is produced by the oxidation reaction of nitrogen monoxide again. When  $\text{NO}_2$  molecules are cooled, a bimolecular coupling reaction occurs between them, and  $\text{NO}_2$  is changed to colorless liquid nitrogen tetroxide ( $\text{N}_2\text{O}_4$ ). This reaction is as follows:



This reaction is a reversible reaction and an exothermic reaction. Accordingly, even when the temperature is reduced or the



pressure increases, the equilibrium reaction formula (1) progresses to the right and thus  $\text{NO}_2$  is changed to liquid nitrogen tetroxide ( $\text{N}_2\text{O}_4$ ).

When fine-powder type solid materials exist in the atmosphere where  $\text{NO}_2$  is changed to liquid  $\text{N}_2\text{O}_4$  as described above, even a slight  
5 amount of  $\text{N}_2\text{O}_4$  is adsorbed by the fine-powder type solid materials, and it is removed together with the fine-powder type solid materials. Accordingly, when the pressure of the exhaust gas atmosphere is increased and the exhaust gas is cooled, most of the gaseous contaminants in the exhaust gas are liquefied, and adsorbed by the  
10 fine-powder type solid materials. The details of the liquefaction of gaseous contaminants in exhaust gas are described in a chapter entitled "The Atmosphere" of *Kogai Bunseki Shishin* (A Guide to Pollution Analysis) issued by the Kanto branch of the Japan Society for Analytical Chemistry.

15 The dioxin group is a general term for chlorinated dioxin in which two benzene rings are coupled to each other by two oxygen atoms and chlorinated dibenzofuran in which two benzene rings are coupled to each other by one oxygen atom. The dioxin group became known from the fact that a large amount of dioxin group was contained in defoliants  
20 which had been used in The Vietnam war and produced many deformed children. Recently, the dioxin group has produced a significant problem because it has been detected in exhaust gas from urban incinerators and it has also been detected in the milk of mothers who live in the vicinity of these incinerators.

25 The generation of the dioxin group in the incineration process



of dust, etc. is divided into two ways. One way is that the dioxin group is generated in the incinerator, and the other way is that the dioxin group is generated in a cooling process of exhaust gas discharged from the incinerator.

5           In the incinerator, a large amount of hydrocarbon ( $C_nH_m$ ) is generated in the initial incineration stage of refuse, etc., and it comes into contact with air, so that it is normally decomposed into carbon dioxide and water. However, if the contact between hydrocarbon and air is bad, dioxin group or materials (precursors) having a similar structure  
10 to that of dioxin group would be generated. Further, even when no dioxin group is generated in the incinerator, but if the precursors of the dioxin group are generated, dioxin group may be synthesized from these precursors in the cooling process of exhaust gas by using copper chloride, iron chloride, carbon or the like as a catalyst. Particularly when the  
15 temperature of the exhaust gas is near to  $300^{\circ}\text{C}$ , this synthesizing reaction is liable to occur. About  $300^{\circ}\text{C}$  is equal to the melting point of the dioxin group.

          Therefore, according to this embodiment, before the exhaust gas is discharged to the air, the temperature of the exhaust gas is  
20 reduced to be less than  $300^{\circ}\text{C}$  to synthesize dioxin group from the precursors. In addition, the synthesized dioxin group and dioxin group which is contained beforehand in the exhaust gas are substantially finely powdered and then collected.

          Specifically, according to this embodiment, the temperature of  
25 the exhaust gas ( $800^{\circ}\text{C}$  or more) which is generated in the boiler 1 is



reduced to about 120°C by the cooler 2, and further the temperature of the exhaust gas in the cylindrical inner cylinder 11 is reduced to about 70°C by the cooling jacket 20 in the cyclone type treatment apparatus 10A, the adiabatic expansion in the cylindrical inner cylinder 11, etc. As  
5 a result, in the cylindrical inner cylinder 11, most of the dioxin group contained in the exhaust gas is finely powdered. As described above, the finely powdered dioxin group is adsorbed by the water in the compressed air and the liquefied gas contaminants, and these elements are mutually attached to the fine-powder type solid materials and  
10 finally become relatively large lumps. These lumps are swirled and moved downwardly together with the exhaust gas from which the gas contaminants and the fine-powder type solid material are substantially completely removed, and in this process centrifugal force is applied to the lumps, so that these lumps are separated from the exhaust gas.

15 The important elements in the process of removing the gas contaminants in the exhaust gas are the exhaust gas swirling cylinder 16 and the exhaust gas swirling pan-shaped plate 13 which serve as swirl flow forming means, and the cooling jacket 20.

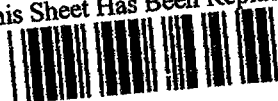
The exhaust gas swirling cylinder 16 and the exhaust gas  
20 swirling pan-shaped plate 13 enhance the swirling performance of the exhaust gas in the conical inner cylinder 11 to enhance the effect of separating the fine-powder type solid materials in the exhaust gas by the centrifugal force and also enhance the cooling effect of the exhaust gas. The enhancement of the cooling effect of the exhaust gas is gained  
25 by the following mechanism.



When the swirl stream (flow) is formed in the conical inner cylinder 11, the pressure around the center axis of the conical inner cylinder 11 is reduced, and the pressure at the outer peripheral side of the conical inner cylinder 11 is increased. Accordingly, when the swirling performance of the exhaust gas in the conical inner cylinder 11 is enhanced, the difference between the pressure around the center axis of the conical inner cylinder 11 and the pressure at the outer peripheral side of the conical inner cylinder 11 is further increased. Therefore, when the swirling performance of the exhaust gas in the conical inner cylinder 11 is enhanced by the exhaust gas swirling cylinder 16 and the exhaust gas swirling pan-shaped plate 13, the adiabatic expansion coefficient of the compressed air is increased in the process where the compressed air approaches the center axis of the conical inner cylinder 11 while swirling, so that the cooling effect of the exhaust gas is also enhanced. The exhaust gas swirling cylinder 16 and the exhaust gas swirling pan-shaped plate 13 serve not only to enhance the swirling performance of the exhaust gas in the conical inner cylinder 11, but also to prevent the counter flow of the exhaust gas when the pressure at the downstream side of each of the exhaust gas swirling cylinder 16 and the exhaust gas swirling pan-shaped plate 13 is increased for some reason.

Further, the cooling jacket 20 also cools the exhaust gas. The cooling jacket 20 cools not only the exhaust gas passing through the gap between the outer cylinder 25 and the jacket 20, but also the exhaust gas flowing in the conical inner cylinder 11. In other words, it cools both the exhaust gas just after it flows into the cyclone type treatment

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apparatus 10A, and the exhaust gas just before it flows out of the cyclone type treatment apparatus 10A, and thus it cools the exhaust gas efficiently. The temperature of the exhaust gas in the conical inner cylinder 11 is adjusted by adjusting the valve opening degree of the flow  
5 amount adjustment valves 22a, 22b provided in the cooling water supply pipe 21a and the cooling water drain pipe 21b to control the amount of the cooling water to be supplied to the cooling jacket 20.

As described above, the fine-powder type solid materials containing dioxin group adsorb the water in the compressed air and the  
10 liquefied gas contaminants, and mutually attached to one another to form relatively large lumps. Thereafter, these lumps of the fine-powder type solid materials are passed from the discharge port 12 of the conical inner cylinder 11 through the fine-powder discharge pipe 59 and then fed into the casing 40 of the screen filter type treatment apparatus  
15 together with the exhaust gas from which most of the gas contaminants and the fine-powder type solid materials have been removed.

Out of the gas and solid materials fed from the cyclone type treatment apparatus 10, the solid materials which are wet and thus composed of relatively-large particles are fed to the fine-powder  
20 discharge port 41 by the screw 49 provided at the lower portion of the casing 40, and then discharged to the outside. As described above, the water which is formed by the condensation of water in the compressed air and the liquid containing the liquefied gas contaminants, etc. are formed in the cyclone type treatment apparatus 10. This liquid is fed  
25 from the liquid discharge port 42 formed at the lower portion of the

casing 40 to the cone type tank 61 at the lower portion of the liquid circulating apparatus 60. Further, a part of the liquid is also discharged from the fine-powder discharge port 41 together with the solid as described above. Since the pressure in the casing 40 is higher than the atmospheric pressure, the gas, etc. which are fed into the casing 40 are not passed through the adsorption filter 31, but may leak from the fine-powder type discharge port 41. In this embodiment, the fine-powder discharge port 41 is somewhat sealed by the wet fine powder which is trapped between the vanes of the screw 49 to prevent the leakage of the gas, etc. from the fine-powder discharge port 41. When the sealing by the wet fine powder, etc. is insufficient, a rotary valve or the like may be provided to the fine-powder discharge port 41. Further, for the same reason, a rotary valve or the like may be provided to the fine-powder discharge port 86 of the bag filter type treatment apparatus 80 of the downstream-side exhaust gas treatment apparatus B.

The gas, etc. which are fed from the cyclone type treatment apparatus 10 passes through the through holes of the partition plate 44, ascend and then arrive at the adsorption paper 31 at the lower stage. The partition plate 44 has such a function that some of the solid materials which are fed into the casing 40, but do not fall down immediately, that is, most of suspension in the gas, are prevented from directly reaching the adsorption paper 31. While the gas, etc. arriving at the adsorption paper 31 at the lower stage pass through the adsorption paper 31, slightly fine powder (containing dioxin group) contained in the gas is captured by the adsorption paper 31. Further, ammonium



which is supplied from the chemical supply apparatus 50 is attached to the adsorption paper, and thus  $\text{NO}_x$  which is not liquefied in the cyclone type treatment apparatus 10 is decomposed into nitrogen and water while passing through the adsorption paper 31.

5           In order to enhance the denitration efficiency, a catalyst for promoting the reaction between  $\text{NO}_x$  and ammonium may be attached beforehand to the adsorption paper 31. The gas, etc. which pass through the adsorption paper 31 at the lower stage further pass through the adsorption paper 31 at the upper stage. During this process, the fine  
10 powder in the gas is captured, and also  $\text{NO}_x$  is decomposed into nitrogen and oxygen. Since powdery activated charcoal is attached to the adsorption paper 31 at the upper stage, the capturing effect of the fine powder containing dioxin group is enhanced, and also a deodorizing effect is can also be expected. The take-up roll shafts 33, 33... around  
15 which the adsorption papers 31, 31 at the lower and upper stages are wound is rotated at all times by the driving of the take-up mechanisms 35, 35 respectively, although the rotation is slow. Accordingly, the adsorption papers 31, 31 at the lower and upper stages are wound around the take-up roll shafts 33, 33 little by little at all times.  
20 Therefore, even when the fine powder, etc. is attached to the adsorption paper 31, a new adsorption paper 31 is supplied from the supply roll shaft 32 to the gas flow path before the new adsorption paper 31 becomes clogged.

          According to this embodiment, the adsorption paper 31 is  
25 moved at all times. In place of this method, the following method may be



used. That is, the pressure difference between the upper stream side and the lower stream side of the adsorption paper 31 is detected at all times, and if the pressure difference is equal to or larger than a predetermined value, in other words, if the adsorption paper 31 is  
5 almost clogged, the take-up mechanisms 35 are driven to take up the clogged adsorption papers 31.

The gas, etc. which pass through the adsorption papers 31 at the lower and upper stages are fed from the discharge port 43 of the casing 40 through the bag filter type treatment apparatus 30 and the  
10 gas duct 6 into the cyclone type treatment apparatus 10B of the downstream-side discharge gas treatment apparatus B.

In this embodiment, the adsorption papers 31, 31 are provided at the upper and lower stages, however, the adsorption papers 31 may be provided at multiple stages or at only one stage. The stage number of  
15 the adsorption papers 31 should be suitably determined in accordance with the amount of fine powder contained in the exhaust gas, the presence or absence of the downstream-side exhaust gas treatment apparatus, etc. Further, in this embodiment, paper is used as the screen filter. This is because it is considered that it is wasted after it is taken  
20 up by the take-up roller shaft 33. However, when recycling is considered, Belt-shaped Teflon cloth having high resistance to abrasion may be used. In this case, the Teflon cloth may be circulated between the take-up roll shaft 33 and the supply roll shaft 32, and the compressed air or water may be sprayed on to the Teflon cloth to remove the fine  
25 powder, etc. attached to the Teflon cloth during the process of returning



it from the take-up roll shaft 33 to the supply roll shaft 32. Still further, in this embodiment, ammonium is supplied to the adsorption papers 31, 31 at the upper and lower stages. However, ammonium may be supplied to any one of the adsorption papers 31, 31 to decompose  $\text{NO}_x$  while raw  
5 lime solution is supplied to the other adsorption paper 31 to decompose  $\text{SO}_x$ .

On the other hand, the liquid which is discharged from the screen filter type treatment apparatus 30 and then reaches the lower cone type tank 61 of the liquid circulating apparatus 60 is passed  
10 through a strainer 68 and fed to the liquid circulating pump 69. Materials discharged from the liquid discharge port 42 of the screen filter type treatment apparatus 30 contain not only the liquid, but also a lot of solid materials of fine particle diameter. Therefore, the solid materials of fine particle diameter are precipitated at the bottom  
15 portion of the tank 61, and thus these solid materials, etc. are discharged periodically from the sludge discharge port 66 of the tank 61. Further, as much as possible of the solid materials floating in the liquid are captured by the strainer 68 before they reach the liquid circulating pump 69. The pH of the liquid in the tank 61 is measured by the pH  
20 meter 65. The valve opening degree of the chemical flow amount adjusting valve 64 is varied in accordance with the pH degree which is measured by the pH meter 65. When the pH degree is small, the valve opening degree is set to a large value, and ammonium water is fed into the tank 61.

25 The liquid is fed from the liquid circulating pump 69 into the



spraying container 71 of the spraying apparatus 70. Not only this liquid is sprayed from the spraying container 71, but also the compressed air is jetted from the jetting nozzles 72. The compressed air sprays the liquid fed into the spraying container 71 in the process where the compressed  
5 air impinges against the bottom of the spraying container 71 and then ascends, and it then goes out of the spraying container 71 through the upper open portion 71a of the spraying container 71, and is then discharged from the circulated liquid discharge port 74 of the casing 73 into the exhaust gas swirling cylinder 16 of the cyclone type treatment  
10 apparatus 10A. The liquid which is discharged into the exhaust gas swirling cylinder 16 is fed to the cylindrical inner cylinder 11, in which the fine-powder type solid materials in the exhaust gas are wetted to promote the mutual attachment of the fine-powder type solid materials. Further, the liquid is mixed with ammonium in the process where it  
15 passes through the liquid circulating apparatus 60, and thus  $\text{NO}_x$  in the exhaust gas is partially decomposed into nitrogen and water.

In this embodiment, ammonium is supplied to the liquid which is returned to the adsorption paper 31 and the cyclone type treatment apparatus 10A. Therefore, when it is required to effectively remove  $\text{SO}_x$   
20 in place of  $\text{NO}_x$ , raw lime water solution which reacts with  $\text{SO}_x$  may be supplied in place of ammonium. Further, it may be adopted that the liquid which occurs in the cyclone type treatment apparatus 10A is not returned, and ammonium, raw lime water solution, powdery activated charcoal, etc. are directly supplied into the cyclone type treatment  
25 apparatus 10A. That is, any material may be supplied to the adsorbing



paper 31 and the cyclone type treatment apparatus 10A insofar as the material can adsorb specific components in the exhaust gas, react with specific components, or serve as a catalyst for promoting the reaction of the specific components.

5           The gas contaminants in the gas, etc. which are fed to the downstream-side exhaust gas treatment apparatus B are liquefied and also the fine powder is classified in the cyclone type treatment apparatus 10B of the downstream-side exhaust gas treatment apparatus. These gas contaminants are passed through the fine powder  
10 discharge pipe 59B from the cyclone type treatment apparatus 10B, and then fed into the induction chamber 82 of the bag filter type treatment apparatus 80.

          The relatively large fine powder in the gas, etc. arriving at the induction chamber 82 directly falls down, and it is discharged from the  
15 fine-powder discharge port 86 by a screw 89 provided at the lower portion of the casing 85.

          Further, the relatively small fine powder floated in the gas is captured by the Teflon cloth 81 in the process that the gas passes from the outer peripheral side of the cloth to the inner peripheral side. The  
20 gas passing through the Teflon cloth 81 passes from the upper opening of the Teflon cloth 81 to the exhaust chamber 83, and is then discharged from the discharge chamber 83 through the discharge port 88 to the outside air.

          When the fine powder is attached to the outer periphery of the  
25 Teflon cloth 81 and the difference in pressure between the outer

peripheral side and the inner peripheral side of the Teflon cloth 81 is increased, the compressed air is fed from the inverse cleaning device 90 to the inner peripheral side of the Teflon cloth 81, and the fine powder attached to the outer periphery of the cloth 81 is blown off by the  
5 compressed air. This fine powder is discharged from the fine-powder discharge port 86 which is provided at the lower portion of the casing 85. In this embodiment, the fine powder attached to the cloth is blown off with the compressed air from the inverse cleaning device 90. However, in place of the inverse cleaning device 90, a vibrator for vibrating the  
10 cloth 81 may be provided.

As described above, in the exhaust gas treatment equipment of this embodiment, the gas contaminants and the fine-powder type solid pollutants of the exhaust gas can be removed without separately providing any large chemical equipment, so that the running cost and  
15 the manufacturing cost can be reduced.

Further, in the exhaust gas treatment equipment, the fine-powder solid materials contained in the exhaust gas in the conical inner cylinder 11 adsorb the liquefied gas contaminants and the water in the compressed air, and are gradually wetted. Therefore, these fine-powder  
20 type solid materials become mutually attached to one another. Accordingly, these fine-powder type solid materials gradually become large particles although the particle diameter of the fine-powder type solid materials is small. Therefore, the fine-powder type solid materials having a smaller particle diameter can be more easily separated  
25 compared with the fine-powder type solid-material separation process



using the cyclone. Further, the fine powder which is not removed after passing through the cyclone type treatment apparatuses 10A and 10B is captured by the adsorption paper 31 or the Teflon cloth 81. The point to which attention should be paid is the fact that the fine powder which  
5 has not been removed in the cyclone type treatment apparatuses 10A and 10B is slightly wetted, and thus it is liable to be attached to the adsorption paper 31 or the Teflon cloth 81, so that the capturing efficiency for the fine powder is somewhat higher than that for dry fine powder having the same diameter. Accordingly, the removal efficiency  
10 of the fine powder, etc. can be enhanced by providing a sheet such as the adsorption paper 31, the Teflon cloth 81 or the like at the downstream side as well as both the cyclone type treatment apparatuses 10A, 10B.

Further, in this embodiment, the ammonium water solution is sprayed into the cyclone type treatment apparatus 10A, and also  
15 ammonium and activated charcoal are attached beforehand to the adsorption paper 31, so that the removal efficiency of  $\text{NO}_x$  and fine powder in the exhaust gas can be further enhanced.

In the above embodiment, the boiler 1 is used as the exhaust gas generating source. However, the present invention is not limited to  
20 the boiler, but it is applicable to a diesel engine for a ship, a vehicle or the like, a reactor of a chemical plant, an incinerator, etc.

Further, in the above embodiment, two exhaust gas treatment apparatuses A and B are arranged in series with the exhaust gas generating source, but in order to enhance the capability of removing  
25 harmful objects in the exhaust gas, many exhaust gas treatment



apparatuses may be provided in series. In order to increase the amount of the exhaust gas to be processed, plural exhaust gas treatment apparatuses may be provided in parallel to the exhaust gas generating source.

5           According to the present invention, the pressure of the exhaust gas in the conical cylinder is increased and also the exhaust gas is cooled to liquefy the gas contaminants in the exhaust gas and adsorb the liquefied gas contaminants to the fine-powder type solid materials in the exhaust gas, and then the fine-powder type solid materials are  
10 removed by the cyclone effect. Accordingly, the gas contaminants and the fine-powder type solid materials in the exhaust gas can be removed without separately providing any chemical equipment, so that the running cost and the manufacturing cost can be reduced.

          Further, the fine-powder type solid materials in the exhaust  
15 gas which are not separated in the conical cylinder can be captured by the sheet which is provided at the downstream side of the conical cylinder, and the fine-powder type solid materials can be removed with high efficiency. Particularly, according to the present invention, the fine powder contained in the exhaust gas in the conical cylinder is  
20 wetted, so that the capturing efficiency of the fine-powder type solid materials can be enhanced by providing the sheet at the downstream side of the conical cylinder.

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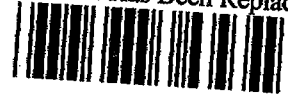




What is claimed is:

- 1           1. An exhaust gas treatment apparatus for treating exhaust gas
- 2     containing a mixture of fine-powder type solid contaminants and
- 3     gaseous air contaminants includes:
- 4           a hollow conical cylinder reduced downwardly in diameter
- 5     thereof having an upper open portion which is formed at an upper
- 6     portion thereof and adapted to take in the exhaust gas, and a lower open
- 7     portion which is formed at a lower portion and adapted to exhaust
- 8     constituent materials of the exhaust gas passing through the inside of
- 9     said cylinder;
- 10          a jetting nozzle for jetting compressed gas so as to swirl around
- 11     a center axis of said conical cylinder along an inner peripheral surface
- 12     of the upper portion of said conical cylinder;
- 13          compressed gas supply means for supplying the compressed gas
- 14     to said jetting nozzle;
- 15          a casing for receiving materials discharged from said lower open
- 16     portion of said conical cylinder, said casing having a first exhaust port
- 17     which is formed at an upper portion thereof and adapted to exhaust gas
- 18     components of the exhaust gas and a second exhaust port which is
- 19     formed at a lower portion thereof and adapted to exhaust fine-powder
- 20     type solid numerous materials of the exhaust gas; and
- 21          a sheet which is disposed in a gas flow path inside said casing
- 22     and has minute holes through which the gas can be passed.





1           2. The exhaust gas treatment apparatus as claimed in claim 1,  
2 further including cooling means for cooling the exhaust gas during a  
3 period from the time when the exhaust gas is supplied from an exhaust  
4 gas generating source for generating the exhaust gas until the time  
5 when the exhaust gas is introduced into said conical cylinder.

1           3. The exhaust gas treatment apparatus as claimed in claim 2,  
2 wherein said cooling means has a cooling jacket which covers an outer  
3 peripheral surface of said conical cylinder so that refrigerant is supplied  
4 into a gap between the outer peripheral surface of said conical cylinder  
5 and said cooling jacket, refrigerant supply means for supplying the  
6 refrigerant into said cooling jacket, and refrigerant discharging means  
7 for discharging the refrigerant from said cooling jacket.

1           4. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 1 to 3, further including swirling flow forming means for  
3 swirling the exhaust gas around the center axis of said conical cylinder  
4 to feed the exhaust gas from the upper open portion of said conical  
5 cylinder into said conical cylinder.

1           5. The exhaust gas treatment apparatus as claimed in claim 4,  
2 wherein said swirling flow forming means has an exhaust gas swirling  
3 cylinder which is designed in a hollow cylindrical shape and is disposed  
4 at the upper end of said conical cylinder, said exhaust gas swirling  
5 cylinder having an opening which is formed on the side periphery





6 thereof and adapted to take the exhaust gas into said hollow cylinder,  
7 and swirling vanes which are provided at the edge of said opening and  
8 adapted to swirl the exhaust gas flowing from said opening into said  
9 hollow cylinder.

1           6. The exhaust gas treatment apparatus as claimed in claim 4,  
2 wherein said swirling flow forming means has an exhaust gas swirling  
3 pan-shaped plate which is disposed at the upper end of said conical  
4 cylinder and designed in a pan shape which is gradually downwardly  
5 projected toward the center axis of the conical cylinder, said exhaust  
6 gas swirling pan-shaped plate having plural through holes which are  
7 formed therein so as to extend from the upper surface of said plate to the  
8 lower surface of said plate in the swirling direction of the exhaust gas.

1           7. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 1 to 6, further including plural jetting nozzles.

1           8. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 1 to 7, wherein said sheet is a belt-shaped screen filter, and  
3 said apparatus further includes a supply roll shaft around which said  
4 screen filter is wound, a take-up roll shaft for taking up said screen  
5 filter and a take-up mechanism for rotating the take-up roll shaft, the  
6 supply roll shaft and the take-up roll shaft being disposed so that said  
7 screen filter which is supplied from said supply roll shaft, but is not yet  
8 taken up by said take-up roll shaft, is located in the gas flow path in





9 said casing.

1           9. The exhaust gas treatment apparatus as claimed in claim 8,  
2 wherein at least one of adsorption material which adsorbs specific  
3 components in the exhaust gas, and promoting material for promoting  
4 the reaction between the specific components and reactive material  
5 which reacts with the specific components, is attached to said screen  
6 filter.

1           10. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 8 and 9, further including reactive material supply means for  
3 supplying said screen filter with the reactive material which reacts with  
4 the specific components in the exhaust gas.

1           11. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 8 to 10, wherein a liquid discharge port for discharging liquid  
3 which is formed due to condensation of the exhaust gas and water in the  
4 compressed gas is formed at the lower portion of said casing, and a  
5 liquid circulating system for re-swirling the liquid discharged from said  
6 liquid discharge port of said casing into said conical cylinder.

1           12. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 1 to 7, wherein said sheet is filter cloth for a bag filter which is  
3 designed in a bag shape having an opening.





1           13. The exhaust gas treatment apparatus as claimed in any one  
2 of claims 1 to 12, further including:  
3           cooling means for cooling the exhaust gas from an exhaust gas  
4 generating source; and  
5           gas feed-in means for feeding the exhaust gas cooled by said  
6 cooling means to said exhaust gas treatment apparatus.

1           14. An exhaust gas treatment equipment including:  
2           said exhaust gas treatment apparatuses as claimed in any one  
3 of claims 8 to 11 (hereinafter referred to as "upstream-side exhaust gas  
4 treatment apparatus"); and  
5           said exhaust gas treatment apparatus as claimed in claim 12  
6 (hereinafter referred to as "downstream-side exhaust gas treatment  
7 apparatus"), wherein the exhaust port of said upstream-side exhaust  
8 gas treatment apparatus and the upper open portion of said conical  
9 cylinder of said downstream-side exhaust gas treatment apparatus are  
10 connected to each other through a gas line.

1           15. The exhaust gas treatment apparatus as claimed in claim 14,  
2 further including:  
3           cooling means for cooling the exhaust gas from an exhaust gas  
4 generating source; and  
5           gas feeding means for feeding the exhaust gas cooled by said  
6 cooling means to said upstream-side exhaust gas treatment apparatus.

