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(54) **Cyclone apparatus with preliminary swirling unit and powder dust remover or automobile including the apparatus**

(57) An object of the present invention is to provide a new cyclone apparatus capable to realize high processing efficiency and miniaturization, a preliminary swirling unit used in the apparatus, and a powder dust remover or an automobile having the apparatus. A cyclone apparatus, comprising includes a cyclone body for providing swirling movement to fluid including an object in powder or granular state and processing the object and the fluid,

a preliminary swirling unit with an approximate cylindrical shape for providing swirling movement in same direction of swirling flow in the cyclone body to the fluid containing the object in advance, and a connecting path for discharging the fluid previously swirled in the preliminary swirling unit from the preliminary swirling unit in tangential direction and introducing the fluid to the cyclone body in tangential direction.

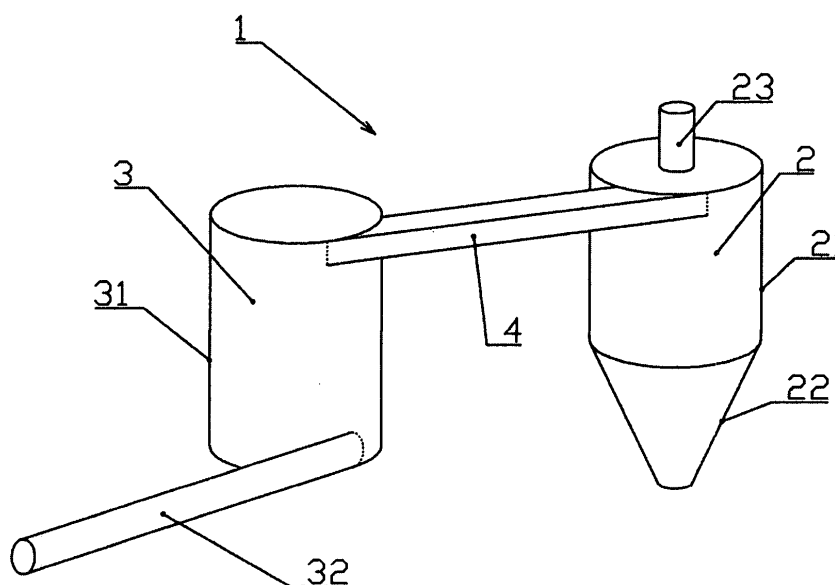


FIGURE 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a cyclone apparatus configured to provide swirling movement to fluid containing object in powder or granular state and process the object and the fluid, a preliminary swirling unit used in the apparatus, and a powder dust remover or an automobile including the apparatus.

2. Description of the Related Art

[0002] A cyclone apparatus (centrifugal dust collector) for providing centrifugal force generated by swirling movement to fluid containing objects in powder or granular state and processing the object in the fluid is widely used in many fields.

[0003] The principle of the cyclone apparatus itself was invented in the 19th century. In a general structure, a pipe line is connected to an inlet of a case body (cyclone body) which is formed an approximate cylindrical shape and stands straight. Through the pipe line, fluid containing objects in powder or granular state is introduced in a direction tangential to an interior wall of the case body so that component of swirling velocity is generated. In use of centrifugal force generated by swirling movement, objects which have higher specific gravity than fluid fall to a lower portion of the case body as being pressed to the interior wall of the case body. In addition, fluid from which object is removed is discharged from an outlet pipe standing near the center of the case body.

[0004] However, according to a conventional method in which fluid is introduced simply through a pipe line, objects introduced to an inlet of a case body are in condition that distribution density is even because the objects which pass through the pipe line are uniformly distributed in fluid.

[0005] The turning radius of particles introduced into the central side of the case body from the inlet is smaller than that of particles introduced into the outer side. As a result, it becomes a problem that efficient centrifugal force is not provided to the particles introduced in the central side of the case body, and the particles contacts and disturbs swirling flow in the case body so that the processing efficiency becomes down.

[0006] This problem is solved by maintaining time to provide efficient centrifugal force to the particles introduced in the central side of the case body. However, a cyclone apparatus having such a vertically long case body may be long in longitudinal direction so that it is physically impossible to be employed in an industry in which installation space is not assured. For example, such apparatus cannot be employed as an exhaust gas processing device in an automobile.

[0007] On the other hand, focusing on such introducing

condition of object contained in fluid, a centrifugal dust collector including a pipe line having a curvature in lower part as seen in direction of fluid flow is invented (Japanese Patent Application Laid-Open No. 6-320055, for example).

[0008] Similarly, focusing on such introducing condition of object contained in fluid, a cyclone apparatus including a bent pipe for providing horizontal swirling movement, in the same direction to swirling flow in the cyclone apparatus, to fluid in advance, a horizontal straight rectifier pipe connected to the bent pipe, a pipe for being connected to the horizontal straight pipe and introducing the fluid into an external pipe vorticosely from outside of the external pipe of the cyclone apparatus is invented (Japanese Patent Application Laid-Open No. 10-34022, for example).

[0009] However, according to the centrifugal dust collector described in Japanese Patent Application Laid-Open No. 6-320055, powder and granular materials are gathered to the lower part of a gas inlet, so that the height of the cyclone cannot be used effectively and the number of swirling reduces. As a result, in addition to the reduction of collecting efficiency, disturbance of gas at the inlet of the cyclone increases and its capability is not improved.

[0010] On the other hand, according to the centrifugal dust collector described in Japanese Patent Application Laid-Open No. 10-34022, by providing centrifugal force to powder and granular materials in advance of introduction into a cyclone, the powder and granular materials are gathered and introduced to a part distant from the central part of a gas inlet pipe of the cyclone. However, when the introducing speed (initial speed) of the powder and granular materials cannot be ensured, efficient centrifugal force is not provided to the powder and granular materials by simply leading them through the bent pipe. Further, when the objects contained in the powder and granular materials are fine powder dust whose gravity is small, efficient centrifugal force cannot be provided to the fine powder dust. Therefore, the introducing condition of objects contained in the powder and granular materials cannot be improved.

[0011] After keen examinations for solution of the problem, the present inventor achieved a cyclone apparatus (hereinafter referred to as "the cyclone apparatus of the present invention"). The cyclone apparatus includes a "cyclone body" for providing swirling movement to fluid containing objects in powder or granular state and processing the objects and the fluid, a "preliminary swirling unit" for being formed an approximate cylindrical shape and providing swirling movement to in the same direction of the swirling flow in the cyclone body to the fluid containing object in advance, a "connecting path" for discharging the fluid previously swirled in the preliminary swirling unit from the preliminary swirling unit in tangential direction and introducing the fluid to the cyclone body in tangential direction.

SUMMARY OF THE INVENTION

[0012] In other words, according to the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to the fluid. The objects in the fluid is pressed to an interior wall of the preliminary swirling unit, that is, the distribution condition of the objects in the fluid is gathered to the side of the interior wall of the preliminary swirling unit. Fluid which is made in such condition is sequentially introduced into the cyclone body via the connecting path. With such structure, it is found that the disadvantage of the conventional cyclone apparatus, which is the processing inefficiency caused by the introducing condition of the objects in fluid, can be solved.

[0013] According to the cyclone apparatus of the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to the fluid and the objects in the fluid is gathered to the side of the interior wall of the preliminary swirling unit. The objects introduced into the cyclone body are in an efficient condition to be processed in a short amount of time. As a result, the cyclone body can be downsized so that it may be employed in an industry in which space for installation is not assured. For example, it may be employed as an exhaust gas processing device in an automobile.

[0014] According to the cyclone apparatus of the present invention, the fluid is swirled in both of the preliminary swirling unit and the cyclone body. It is found that phase of noise generated in the preliminary swirling unit and phase of noise generated in the cyclone body are inverted so as to cancel each other, and the noise can be kept turned down.

[0015] The present invention has been completed based on the above findings and an object of the invention is to provide a new cyclone apparatus capable to realize high processing efficiency and miniaturization, a preliminary swirling unit used in the apparatus, and a powder dust remover or an automobile having the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

FIG 1 is a diagram showing a cyclone apparatus of the present invention;

FIGS. 2A and 2B are diagrams showing an object distribution condition in fluid in a connecting path of the cyclone apparatus of the present invention;

FIG 3 is a diagram showing another cyclone apparatus of the present invention;

FIG 4 is a diagram showing another cyclone apparatus of the present invention;

FIG 5 is a diagram showing another cyclone apparatus of the present invention; and

FIG 6 is a cross-sectional diagram showing a cyclone

body employed in another cyclone apparatus.

DETAILED DESCRIPTION OF THE INVENTION

[0017] As a means to solve the problem, a cyclone apparatus of the present invention includes a "cyclone body" for providing swirling movement to fluid containing objects in powder or granular state and processing the objects and fluid, a "preliminary swirling unit" with an approximate cylindrical shape for providing swirling movement in the same direction as that of the swirling flow in the cyclone body to the fluid containing objects in advance, and a "connecting path" for discharging the fluid previously swirled in the preliminary swirling units from the preliminary swirling unit in tangential direction and introducing the fluid to the cyclone body in tangential direction.

[0018] A cyclone apparatus of the present invention, a preliminary swirling unit used in the apparatus, and a powder dust remover or an automobile having the apparatus will be described in detail.

[0019] "Fluid containing objects in powder or granular state", as an object to be processed by the cyclone apparatus of the present invention, is a material that flows promptly in the cyclone apparatus without accumulating and should not be limited. It may be in liquid or gas state.

[0020] Concretely, it may be, for example, exhaust gases or the like exhausted in various industries such as manufacturing industry, electricity generating industry, construction industry, waste disposal industry, and agricultural industry, or exhaust gases or the like exhausted from various means of transportation such as bikes, automobiles, trucks, busses, locomotives and ships.

[0021] The cyclone apparatus of the present invention is to process such fluid containing objects in powder or granular state, and includes a "cyclone body", a "preliminary swirling unit" and a "connecting path".

[0022] The "cyclone body" included in the cyclone apparatus of the present invention should not be limited and a conventional cyclone using a principle of processing objects such as powder dust in use of centrifugal force generated by swirling fluid can be employed. Generally, a cyclone is employed, which has an approximate cylindrical body for fluid slewing, an approximate conical lower body portion for being provided continuously to the bottom part of the body, a fluid outlet pipe, and a connecting unit which is explained below.

[0023] According to the cyclone apparatus of the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to the fluid, and the object in the fluid is gathered to the side of the interior wall of the preliminary swirling unit. The object introduced into the cyclone body is in an efficient condition to be processed in a short amount of time. With such structure, the cyclone body can be downsized.

[0024] Therefore, the cyclone body used in the cyclone apparatus of the present invention may be shorter than

the conventional cyclone. That is, the cyclone body which is short in the vertical length may be used preferably. By applying such shorter cyclone body, the cyclone apparatus of the present invention may be employed in an industry in which installation space is not assured and in which a conventional cyclone can not be applied. For example, it may be used as an exhaust gas processing device in automobiles.

[0025] The vertical length of the cyclone body can be determined according to the applying field or the acceptable installing space, and it should not be limited. Generally, it is preferable that the length is set 1 to 5 times longer than the average diameter of the approximate cylindrical body for slewing fluid. Further, it is more preferable that the length is set 1.5 to 3 times longer than the average diameter of the body.

[0026] It is not preferable that the vertical length of the cyclone body is set shorter than the average diameter of the approximate cylindrical body for swirling fluid because efficient swirling movement cannot be provided to fluid. Also, it is not preferable that the vertical length of the cyclone body is set more than 5 times longer than the average diameter of the approximate cylindrical body for swirling fluid because the cyclone body becomes very long in vertical direction and the applying field may be limited.

[0027] The "approximate cylindrical" means not only a literally called cylindrical shape (circular cylinder) in which the top diameter and the bottom diameter are the same but also a shape such as circular cone which is cut in a horizontal face (campanulate shape or inverted campanulate shape), for example. In short, the "approximate cylindrical" used for the cyclone apparatus of the present invention represents any kind of hollow shapes in which fluid is swirled promptly without accumulating. In other words, it represents all hollow shapes having a circular horizontal cross section.

[0028] Therefore, the "average diameter" represents an average value of diameters of the body from the upper part to the bottom part.

[0029] The "approximate conical" means not only a literally called circular cone shape but also a hemispheric shape, a cone-shaped hollow, a centroclinal shape or the like. In short, "approximate conical (bottom portion of the body)" is continuously provided to the approximate cylindrical body for swirling fluid and includes any kinds of hollow shapes in which its diameter changes smaller gradually as in lower part of the cyclone body.

[0030] According to the cyclone apparatus of the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to the fluid and the objects in the fluid is gathered to the side of the interior wall of the preliminary swirling unit. The objects in fluid is pressed to the interior wall of the preliminary swirling unit, that is, the distribution condition of the objects in fluid is gathered to the side of the interior wall of the preliminary swirling unit. Fluid which is made in such condition is

introduced into the cyclone body via the connecting path. This is the greatest feature of the present invention.

[0031] According to the cyclone apparatus of the present invention, swirling movement is provided to fluid in the preliminary swirling unit and the objects in the fluid are gathered to the side of the interior wall of the preliminary swirling unit. Fluid which is made in such condition is sequentially introduced into the cyclone body so that the objects in fluid introduced to the cyclone body are in an efficient condition to be processed in a small amount of time.

[0032] The "preliminary swirling unit" used in the cyclone apparatus of the present invention has an approximate cylindrical body, a fluid inlet for introducing the fluid into the body in tangential direction, and a connecting path which is described later. The "preliminary swirling unit" is a unit to swirl fluid promptly without accumulating and it should not be limited.

[0033] The "approximate cylindrical" means not only a literally called cylindrical shape (circular cylinder) in which the above diameter and the bottom diameter are the same but also a shape such as circular cone which is cut in a horizontal face (campanulate shape or inverted campanulate shape), for example. In short, the "approximate cylindrical" used for the cyclone apparatus of the present invention represents any kinds of hollow shapes in which fluid is swirled promptly without accumulating. In other words, it represents all hollow shapes having a circular horizontal cross section.

[0034] It is preferable that the interior wall of the preliminary swirling unit is smooth with few concavities and convexities because extreme concavities and convexities on the interior wall of the preliminary swirling unit may disturb the swirling flow.

[0035] However, according to the present invention, it is preferable that the diameter of the preliminary swirling unit is made to change gradually smaller from the portion where an inlet is formed to the portion where the connecting path, explained later, is formed. With such structure, the swirling speed of the fluid introduced into the preliminary swirling unit can be accelerated until it reaches to the connecting path. As a result, efficient centrifugal force can be provided to the objects contained in the fluid.

[0036] The vertical length of the preliminary swirling unit can be determined according to the applying field or the acceptable installing space, and it should not be limited. Generally, it is preferable that the length is set 1 to 5 times longer than the average diameter of the approximate cylindrical body for slewing fluid. Further, it is more preferable that the length is set 1.5 to 3 times longer than the average diameter of the body.

[0037] It is not preferable that the vertical length of the preliminary swirling unit is set shorter than the average diameter of the approximate cylindrical body for swirling fluid because efficient swirling movement cannot be provided to fluid. Also, it is not preferable that the vertical length of the preliminary swirling unit is set more than 5 times longer than the average diameter of the approxi-

mate cylindrical body for swirling fluid because the preliminary swirling unit becomes very long in vertical direction and the applying field is limited.

[0038] The "average diameter" represents an average value of diameters of the body from the upper part to the bottom part.

[0039] According to the cyclone apparatus of the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to the fluid and the objects in fluid is gathered to the side of the interior wall of the preliminary swirling unit. The objects in fluid is pressed to an interior wall of the preliminary swirling unit, that is, the distribution condition of the objects in fluid is gathered to the side of the interior wall of the preliminary swirling unit. Fluid which is made in such condition is introduced into the cyclone body via the connecting path.

[0040] In other words, in the cyclone apparatus of the present invention, swirling movement is provided to fluid in the preliminary swirling unit in advance. Fluid in condition that objects in the fluid is gathered to the side of the interior wall of the preliminary swirling unit is introduced into the cyclone body. As a result, an efficient swirling movement can be provided to fluid even when introducing speed (initial speed) for introducing fluid is not ensured. Further, efficient centrifugal force can be provided to objects even when the objects in fluid is fine powder dust, and the introducing condition of objects in fluid to the cyclone body can be improved.

[0041] The "connecting path" for connecting the cyclone body and the preliminary swirling unit is a path for discharging fluid previously swirled in the preliminary swirling unit from the preliminary swirling unit in tangential direction and introducing the fluid into the cyclone body in tangential direction, and it should not be limited. However, it is preferable that the connecting path linearly connects the cyclone body and the preliminary swirling unit to maintain the distribution condition of the objects in fluid, which is gathered in the preliminary swirling unit, and to prevent resistance (impact) given to the fluid drained from the preliminary swirling unit.

[0042] According to the cyclone apparatus of the present invention, it is preferable that the connecting path has a flat interior wall at least in outer side of the apparatus, that is, a greater density side of the object distribution in fluid when the fluid passes through the connecting path. With such structure, diffusion of object in the connecting path can be prevented and the distribution of the objects in fluid, which is gathered in the preliminary swirling unit, can be maintained.

[0043] As described above, the cyclone apparatus of the present invention includes a "cyclone body", a "preliminary swirling unit", and a "connecting path". However, each element is not limited and more than one unit may be provided for each element. In some situations, another cyclone body (sub-cyclone), another preliminary swirling unit, or another connecting path for connecting those elements may be provided.

[0044] In other words, there may be situations that the amount of fluid flow from the preliminary swirling unit to the cyclone body is excess so that it cannot pass through the connecting path promptly, or that the amount of fluid flow exceed the processing amount of the cyclone body so that some excess fluid which cannot be introduced into the cyclone body overflows. Those situations are caused in condition that a large amount of fluid is to be processed, or that the amount of introduced fluid is not constant. However, according to the cyclone apparatus of the present invention, it is preferable that a sub-cyclone is provided for processing fluid which cannot be introduced to the cyclone body (overflowed fluid) in addition to the cyclone body to avoid overflow situations

[0045] The sub-cyclone is connected to the preliminary swirling unit via a different connecting path from what connects the cyclone body. However, the same as the cyclone body is connected to the preliminary swirling unit via the same as the connecting path. Therefore, to avoid repetition, those explanations are omitted here.

[0046] According to the cyclone apparatus of the present invention, a further sub-cyclone may be provided if required. By providing a plurality of sub-cyclones, overflow situations may be prevented and processing amount in the apparatus can be increased.

[0047] On the other hand, when introducing speed (initial speed) for introducing fluid is extremely slow, or the height of the preliminary swirling unit is not enough because of the installing space is limited in the cyclone apparatus, it is difficult to provide efficient swirling movement to fluid introduced into the preliminary swirling unit from a fluid inlet pipe.

[0048] In such situation, according to the present invention, a plurality of preliminary swirling units are serially connected so that time can be maintained to provide efficient swirling movement to the fluid introduced into the preliminary swirling units from a fluid inlet pipe.

[0049] Especially, for the plurality of preliminary swirling units used in this case, it is preferable that the diameter of the preliminary swirling unit is made to change gradually smaller from the portion where the inlet is formed to the portion where the connecting path, explained later, is formed. In use of preliminary swirling units having such structure, efficient centrifugal force can be provided to the objects in fluid while the fluid is passing through the plurality of preliminary swirling units even when introducing speed (initial speed) for introducing fluid is extremely slow.

[0050] The plurality of preliminary swirling units are serially connected via connecting paths. However, they are connected via the same as the above connecting path for connecting the cyclone body and the preliminary swirling unit. Therefore, to avoid repetition, those explanations are omitted here.

[0051] According to the cyclone apparatus of the present invention, the average diameters for each of the approximate cylindrical body for swirling fluid in the cyclone body and the approximate cylindrical body of the

preliminary swirling unit may be determined according to the applying field or the acceptable installing space, and they should not be limited.

[0052] However, according to the cyclone apparatus of the present invention, fluid is swirled in both of the preliminary swirling unit and the cyclone body. It is found that the noise generated in the preliminary swirling unit and the noise generated in the cyclone body cancel each other and the noise can be kept turned down. Especially, it is found that generated noise becomes smallest in the condition that the phase of noise generated in the preliminary swirling unit and phase of noise generated in the cyclone body are inverted.

[0053] The condition that phase of noise generated in the preliminary swirling unit and phase of noise generated in the cyclone body are inverted can be achieved when the average internal diameters of the approximate cylindrical body for slewing fluid in the cyclone body and the approximate cylindrical body in the preliminary swirling unit are set almost the same. Therefore, it is preferable that, when the average internal diameter of the approximate cylindrical body for slewing fluid in the cyclone body is set "1", the average internal diameter of the approximate cylindrical body in the preliminary swirling unit is set to " 1 ± 0.2 " (proportion). It is more preferable that it is adjusted to " 1 ± 0.1 " (proportion).

[0054] Further, in case where a plurality of preliminary swirling units are serially connected, the same noise reduction effects as mentioned above can also be achieved when the average internal diameters of the approximate cylindrical body for slewing fluid in the cyclone body and the approximate cylindrical body in the preliminary swirling unit are set almost the same. Therefore, in this case, it is preferable that, when the average internal diameter of the approximate cylindrical body for slewing fluid in the cyclone body is set "1", the average internal diameter of the approximate cylindrical body in the preliminary swirling unit is set to " 1 ± 0.2 " (proportion), more preferably " 1 ± 0.1 " (proportion).

[0055] On the other hand, it is found that, in the case that a sub-cyclone is provided and the average internal diameters of the approximate cylindrical body for slewing fluid in the cyclone body and the approximate cylindrical body for slewing fluid in the sub-cyclone apparatus are set almost the same, noise generated in the cyclone body and noise generated in the sub-cyclone emphasize each other. As a result, it is found that the noise becomes larger.

[0056] Therefore, according to the cyclone apparatus of the present invention, when one or more sub-cyclones are provided, the average internal diameters of the approximate cylindrical body for slewing fluid in the cyclone body and the approximate cylindrical body in the sub-cyclone are set differently. In detail, when the average internal diameter of the cyclone body is set to "1", the average internal diameter of the sub-cyclone is set to " 1 ± 0.2 " (proportion) so that the phases of noise generated in each becomes different so that each noise does not

accentuate each other.

[0057] As described above, the cyclone apparatus of the present invention is for providing swirling movement to the fluid in the preliminary swirling unit and the objects in fluid are gathered to the side of the interior wall of the preliminary swirling unit and processing the fluid and the objects in the cyclone body.

[0058] Here, among objects, especially, powder dust is rubbed on the interior walls and burned off during the swirling movement in the preliminary swirling unit and the cyclone body. It finally changes into gas such as carbon dioxide.

[0059] Accordingly, when the cyclone apparatus of the present invention processes objects contained in fluid, which is mostly fine powder dust such as exhaust gas of an automobile, most of the fine powder dust contained in the exhaust gas is burned out during swirling movement in the preliminary swirling unit and the cyclone body. Then, they turn into gas so as to be drained with fluid.

[0060] However, some fine powder dust which remains without being burned out is gathered to the bottom portion of the cyclone body or the like (the cyclone body and/or the sub-cyclone). Here, when a predetermined amount of the fine powder dust is accumulated, they have to be removed.

[0061] According to the cyclone apparatus of the present invention, it is preferable that the objects gathered in the cyclone body and/or the sub-cyclone may be reintroduced to the preliminary swirling unit as required. With such structure, the collected objects which are remained without being burned off can be swirled again in the preliminary swirling unit and the cyclone body to be changed into gas. As a result, an operation of removing the collected fine powder dust can be omitted. It realizes what is called maintenance-free.

[0062] It should not be limited as a means for reintroducing the collected objects to the preliminary swirling unit. Concretely, for example, the powder dust may be collected by means for collecting such as a rocker valve at the bottom part of the cyclone body. With the operation of the rocker valve or the like, the collected powder dust may be led to a reintroducing pipe which is connected to the preliminary swirling unit. The powder dust may be reintroduced to the preliminary swirling unit via the reintroducing pipe.

[0063] A preliminary swirling unit of the present invention has the above structure and employed in the cyclone apparatus of the present invention. The processing efficiency of a conventional cyclone body can be remarkably improved by connecting the preliminary swirling unit with the conventional cyclone body.

[0064] A powder dust remover of the present invention is a new powder dust remover including the cyclone apparatus of the present invention. The powder dust remover is distinguished so that processing efficiency is increased, the cyclone apparatus of the present invention can be downsized, and the noise is kept turned down.

[0065] An automobile of the present invention includes

the cyclone apparatus of the present invention. Its exhaust gas is processed with the cyclone system although it had been impossible because the installation space could not be ensured. Because of the sound deadening effect of the cyclone apparatus of the present invention, a muffling device such as a muffler is not required to be installed and a maintenance-free mechanism is achieved.

[0066] The cyclone apparatus of the present invention includes a "cyclone body" for providing swirling movement to fluid containing objects in powder or granular state and processing the object and the fluid, a "preliminary swirling unit" for being formed an approximate cylindrical shape and providing swirling movement in the same direction of the swirling flow in the cyclone body to fluid containing objects in advance, a "connecting path" for discharging fluid previously swirled in the preliminary swirling unit from the preliminary swirling unit in tangential direction and introducing the fluid to the cyclone body in tangential direction.

[0067] In other words, according to the cyclone apparatus of the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to the fluid and the objects in the fluid are gathered to the side of the interior wall of the preliminary swirling unit. Fluid which is made in such condition is introduced sequentially into the cyclone body. With such structure, the disadvantage of the conventional cyclone apparatus, which is a processing inefficiency caused by the introducing condition of the objects in fluid, can be solved.

[0068] According to the cyclone apparatus of the present invention, before fluid containing objects in powder or granular state is introduced into the cyclone body, swirling movement is provided to fluid and the objects in the fluid is gathered to the side of the interior wall of the preliminary swirling unit. The objects in fluid introduced into the cyclone body can be in an efficient condition to be processed in a short amount of time. As a result, the cyclone body can be downsized and may be employed in an industry in which space for installation is not assured. For example, it may be employed as an exhaust gas processing device in an automobile.

[0069] According to the cyclone apparatus of the present invention, the fluid is swirled in both of the preliminary swirling unit and the cyclone body. It is found that the phase of noise generated in the preliminary swirling unit and phase of noise generated in the cyclone body are inverted so as to cancel each other and the noise can be kept turned down.

[0070] A powder dust remover of the present invention is a new powder dust remover including the cyclone apparatus of the present invention. The powder dust remover is distinguished so that processing efficiency is increased, the cyclone apparatus of the present invention can be downsized, and the noise is kept turned down.

[0071] An automobile of the present invention includes the cyclone apparatus of the present invention. Its ex-

haust gas is processed with a cyclone system although it had been impossible because the installation space could not be ensured. Because of the sound deadening effect of the cyclone apparatus of the present invention, a muffling device such as a muffler is not required to be installed and a maintenance-free mechanism is achieved.

[0072] Examples of the present invention will be described. It is noted that the present invention should not be limited thereto.

Example 1

[0073] FIG 1 is a diagram showing a cyclone apparatus 1 of the present invention. The apparatus 1 includes a cyclone body 2, a preliminary swirling unit 3 and a connecting path 4.

[0074] The cyclone body 2 includes an approximate cylindrical body 21 for slewing fluid, an approximate conical lower body portion 22, and a fluid outlet pipe 23. The cyclone body 2 employs a principle of processing objects, such as powder dust, in use of centrifugal force which is generated by swirling fluid tangentially introduced from the connecting path 4.

[0075] The preliminary swirling unit 3 includes an approximate cylindrical body 31, a fluid inlet pipe 32 for tangentially introducing fluid from the body 31. The preliminary swirling unit 3 is configured to introduce fluid to the cyclone body 2 via the connecting path 4. The fluid is tangentially introduced from the fluid inlet pipe 32 to be swirled. In use of the centrifugal force, distribution of objects in the fluid is gathered in side of an interior wall of the preliminary swirling unit 3. Fluid which is made in such condition is introduced sequentially.

[0076] As a connecting path 4 connecting the cyclone body 2 and the preliminary swirling unit 3, a square pipe, which is straight and whose section is square, is used to prevent a diffusion of the gathered objects in the preliminary swirling unit 3, in other words, to maintain the object distribution condition.

[0077] FIG 2A is a diagram showing an object condition in fluid passing through the connecting path 4 of the cyclone apparatus 1 of the present invention. FIG 2B is an overhead transparent diagram showing a part of the connecting path 4 in the condition of FIG 2A.

[0078] As shown in FIG 2A, objects in fluid which is gathered in the side of the interior wall of the preliminary swirling unit 3 by swirling movement are introduced to the connecting path 4 from the preliminary swirling unit 3.

[0079] When the objects in fluid is introduced to the connecting path 4, the condition that the objects is gathered in outer side in the connecting path 4 is maintained as shown in FIG 2B even though its vector is changed to a vertical direction.

[0080] Fluid is introduced into the cyclone body 2 while maintaining the condition that the objects are gathered in outer side in the connecting path 4.

[0081] In other words, in the cyclone apparatus 1 of

the present invention, swirling movement is provided to fluid in advance in the preliminary swirling unit 3. Fluid in condition that objects in the fluid are gathered in outer side of the preliminary swirling unit 3 is introduced into the cyclone body 2. The distribution condition of the objects in fluid introduced into the cyclone body 2 is efficient to be processed in a short amount of time. As a result, the cyclone body 2 can be downsized, and an efficient swirling movement can be provided to fluid even when introducing speed (initial speed) for introducing fluid is not ensured. Further, efficient centrifugal force can be provided to objects even when the objects in fluid are fine powder dust, and the introducing condition of the objects in fluid to the cyclone body 2 can be improved.

[0082] In this Example, when the average internal diameters of the approximate cylindrical body 21 for slewing fluid in the cyclone body 2 and an approximate cylindrical body 31 in the preliminary swirling unit 3 are set about the same, phase of noise generated in the preliminary swirling unit 3 and phase of noise generated in the cyclone body 2 are inverted so as to cancel each other and the noise can be kept turned down.

Example 2

[0083] FIG 3 is a diagram showing a cyclone apparatus 1 of another embodiment of the present invention. The apparatus 1 includes a cyclone body 2, a sub-cyclone 5, a preliminary swirling unit 3 and connecting paths 4 (41, 42).

[0084] The cyclone apparatus 1 shown in FIG 3 has the same structure as Example 1 except that it includes the sub-cyclone 5 in addition to the cyclone body 2. It prevents situations such as that the amount of fluid flow from the preliminary swirling unit 3 to the cyclone body 2 is excess so that it cannot pass through the connecting path 41 promptly, and that the amount of fluid flow exceeds the processing amount of the cyclone body 2 so that some excess fluid which cannot be introduced into the cyclone body 2 overflows. Those situations are caused in condition that a large amount of fluid is to be processed, or that the introducing amount of fluid is not constant.

[0085] The cyclone body 2, the preliminary swirling unit 3 and the connecting paths 4 employed in this Example can be the same as those explained in Example 1. Therefore, to avoid repetition, those explanations are omitted here.

[0086] The sub-cyclone 5 of this Example is connected to the preliminary swirling unit 3 via the connecting path 42 similar to the connecting path 41. Thus, to avoid repetition, its explanation is omitted here.

[0087] The sub-cyclone 5 includes an approximate cylindrical body 51 for slewing fluid, an approximate conical lower body portion 52, and a fluid outlet pipe 53. The sub-cyclone 5 employs a principle of processing objects, such as powder dust, in use of centrifugal force which is generated by swirling fluid tangentially introduced from the

connecting path 42. A device similar to the cyclone body 2 may be applied as the sub-cyclone 5. However, in this Example, the average internal diameters of the approximate cylindrical body 21 for slewing fluid in the cyclone body 2 and the approximate cylindrical body 51 in the sub-cyclone 5 are set differently. As a result, phases of noises generated in each of them become different to prevent that the noises accentuate each other.

Example 3

[0088] FIG 4 is a diagram showing a cyclone apparatus 1 of another embodiment of the present invention. The apparatus 1 includes a cyclone body 2, a first preliminary swirling unit 3a, a second preliminary swirling unit 3b, and connecting paths 4 (41, 43).

[0089] The cyclone apparatus 1 shown in FIG 4 has the same structure as Example 1 except that it includes a couple of (a plurality of) preliminary swirling units, the first preliminary swirling unit 3a and the second preliminary swirling unit 3b, which are serially connected. With this structure, efficient time for providing efficient swirling movement to fluid introduced into the preliminary swirling units from a fluid inlet pipe 32 can be ensured in case that introducing speed (initial speed) for introducing fluid is extremely slow, or in case that the height of the preliminary swirling units is not enough.

[0090] The cyclone body 2, the preliminary swirling units (the first preliminary swirling unit 3a and the second preliminary swirling unit 3b), and the connecting paths 4 employed in this Example can be the same as those explained in Example 1. Therefore, to avoid repetition, those explanations are omitted here.

[0091] The first preliminary swirling unit 3a and the second preliminary swirling unit 3b are serially connected via the connecting path 43. Here, the connecting paths 43 can be the same as a connecting path 41 which connects the second preliminary swirling unit 3b and the cyclone body 2. Therefore, to avoid repetition, its explanation is omitted here.

Example 4

[0092] FIG 5 is a diagram showing a cyclone apparatus 1 of another embodiment of the present invention. The apparatus 1 includes a cyclone body 2, a sub-cyclone 5, a preliminary swirling unit 3, connecting paths 4, and a reintroducing pipe 6.

[0093] The cyclone body 2 (and the sub-cyclone 5), as shown in a sectional diagram of FIG 6, includes an approximate cylindrical body 21 (51) for slewing fluid, an approximate conical lower body portion 22 (52), a fluid outlet pipe 23 (53), and a rocker valve 24(54). The cyclone body 2 employs a principle of processing objects, such as powder dust, in use of centrifugal force which is generated by swirling fluid tangentially introduced from the connecting path 41(42). Particularly, collected objects are collected in the rocker valve 24(54), and, by the

operation of the rocker valve 24(54), the collected objects are brought to the reintroducing pipe 6 which is connected with the preliminary swirling unit 3. The collected objects are reintroduced to the preliminary swirling unit 3 via the reintroducing pipe 6.

[0094] In other words, the cyclone apparatus 1 shown in FIG 5 has the same structure as Example 1, except for that it employs the cyclone body 2 (and sub-cyclone 5) having the rocker valve 24(54) in its bottom portion and includes the reintroducing pipe 6 for reintroducing the collected objects in the rocker valve 24(54) into the preliminary swirling unit 3. Particularly, when most of the objects in fluid are fine powder dust, such as exhaust gas from an automobile, the objects can be completely burned off to gasify by slewing in the preliminary swirling unit 3, the cyclone body 2 or the like. As a result, an operation for removing the collected fine powder dust can be omitted, and a maintenance-free mechanism is achieved.

[0095] The preliminary swirling unit 3 and the connecting paths 4 can be the same as those explained in Example 1. Therefore, to avoid repetition, those explanations are omitted here.

[0096] Further, the reintroducing pipe 6 is connected to a fluid inlet pipe 32 so as to make the inside of the reintroducing pipe 6 to be in pressure-reduced condition when new fluid is introduced into the fluid inlet pipe 32. As a result, the objects brought to the reintroducing pipe 6 from the rocker valve 24(54) can be promptly introduced into the fluid inlet pipe 32.

[0097] A cyclone apparatus of the present invention includes a cyclone body for providing swirling movement to fluid containing objects in powder or granular state and processing the objects and fluid, a preliminary swirling unit for being an approximate cylindrical shape and providing swirling movement in the same direction of the swirling flow in the cyclone body to the fluid containing objects in advance, and a connecting path for discharging fluid previously swirled in the preliminary swirling unit from the preliminary swirling unit in tangential direction and introducing the fluid to the cyclone body in tangential direction. The cyclone apparatus of the present invention can preferably process exhaust gases or the like exhausted in various industries such as manufacturing industry, electricity generating industry, construction industry, waste disposal industry, and agricultural industry, or exhaust gases or the like exhausted from various means of transportation such as bikes, automobiles, trucks, busses, locomotives, and ships. Therefore, the cyclone apparatus of the present invention can be applied not only to powder dust removers or automobiles but also kitchen instruments, smokeless roasters, ash collectors, air purification systems, clean room equipments, exhaust gas treatment devices for ships, construction machines, agricultural instruments, steam locomotives, diesel locomotives, garbage disposals, spin-dryers, sawdust separators for lumber sawing, or leather waste segregators.

Claims

1. A cyclone apparatus, comprising:

- 5 a cyclone body for providing swirling movement to fluid containing an object in powder or granular state and processing the object and the fluid;
10 a preliminary swirling unit with an approximate cylindrical shape for providing swirling movement in the same direction as that of swirling flow in the cyclone body to the fluid containing the object in advance; and
15 a connecting path for discharging the fluid previously swirled in the preliminary swirling unit from the preliminary swirling unit in tangential direction and introducing the fluid to the cyclone body in tangential direction.
- 20 2. The cyclone apparatus of claim 1, wherein the preliminary swirling unit and the cyclone body are linearly connected through the connecting path.
- 25 3. The cyclone apparatus of claim 1 or 2, wherein the connecting path includes a flat interior wall at least in an outer side thereof.
- 30 4. The cyclone apparatus of any one of claims 1 to 3, further comprising a sub-cyclone.
- 35 5. The cyclone apparatus of any one of claims 1 to 4, wherein a plurality of preliminary swirling units are serially connected.
- 40 6. The cyclone apparatus of any one of claims 1 to 5, wherein, when an average internal diameter of an approximate cylindrical body for slewing fluid in the cyclone body is set "1", an average internal diameter of an approximate cylindrical body in the preliminary swirling unit is set " 1 ± 0.2 ".
- 45 7. The cyclone apparatus of any one of claims 1 to 6, wherein average internal diameters of an approximate cylindrical body for slewing fluid in the cyclone body and an approximate cylindrical body in a sub-cyclone are set differently.
- 50 8. The cyclone apparatus of any one of claims 1 to 7, wherein an object collected in the cyclone body and a sub-cyclone is reintroduced to the preliminary swirling unit.
- 55 9. A preliminary swirling unit, included in the cyclone apparatus of any one of claims 1 to 8.
10. A powder dust remover, including the cyclone apparatus of any one of claims 1 to 8.

- 11.** An automobile, including the cyclone apparatus of one of claims 1, 2, 3, 4, 5, 6, 7 and 8.

Amended claims in accordance with Rule 86(2) EPC. 5

- 1.** A cyclone apparatus (1), comprising:

a cyclone body (2) for providing swirling movement to fluid containing an object in powder or granular state and processing the object and the fluid; 10
 a preliminary swirling unit (3) with an approximate cylindrical shape for providing swirling movement in the same direction as that of swirling flow in the cyclone body to the fluid containing the object in advance; 15
 a fluid inlet (32) for introducing fluid into the preliminary swirling unit 3 in a tangential direction; and 20
 a connecting path (4) for discharging the fluid previously swirled in the preliminary swirling unit (3) from the preliminary swirling unit (3) in tangential direction and introducing the fluid to the cyclone body (2) in tangential direction. 25
 wherein the fluid discharged into the connecting path (4) has been tangentially introduced to the preliminary swirling unit (3) via the fluid inlet (32).

- 2.** The cyclone apparatus of claim 1, wherein the preliminary swirling unit (3) and the cyclone body (2) are linearly connected through the connecting path. 30

- 3.** The cyclone apparatus of claim 1 or 2, wherein the connecting path (4) includes a flat interior wall at least in an outer side thereof. 35

- 4.** The cyclone apparatus of any one of claims 1 to 3, further comprising a sub-cyclone (5). 40

- 5.** The cyclone apparatus of any one of claims 1 to 4, wherein a plurality of preliminary swirling units (3a, 3b) are serially connected.

- 6.** The cyclone apparatus of any one of claims 1 to 5, wherein, when an average internal diameter of an approximate cylindrical body for slewing fluid in the cyclone body (2) is set "1", an average internal diameter of an approximate cylindrical body in the preliminary swirling unit (3) is set " 1 ± 0.2 ". 50

- 7.** The cyclone apparatus of any one of claims 1 to 6, wherein average internal diameters of an approximate cylindrical body for slewing fluid in the cyclone body (2) and an approximate cylindrical body in a sub-cyclone (5) are set differently. 55

- 8.** The cyclone apparatus of any one of claims 1 to

7, wherein an object collected in the cyclone body (2) and a sub-cyclone (5) is reintroduced to the preliminary swirling unit (3).

- 9.** A preliminary swirling unit (3), included in the cyclone apparatus (1) of any one of claims 1 to 8.

- 10.** A powder dust remover, including the cyclone apparatus (1) of any one of claims 1 to 8.

- 11.** An automobile, including the cyclone apparatus (1) of one of claims 1, 2, 3, 4, 5, 6, 7 and 8.

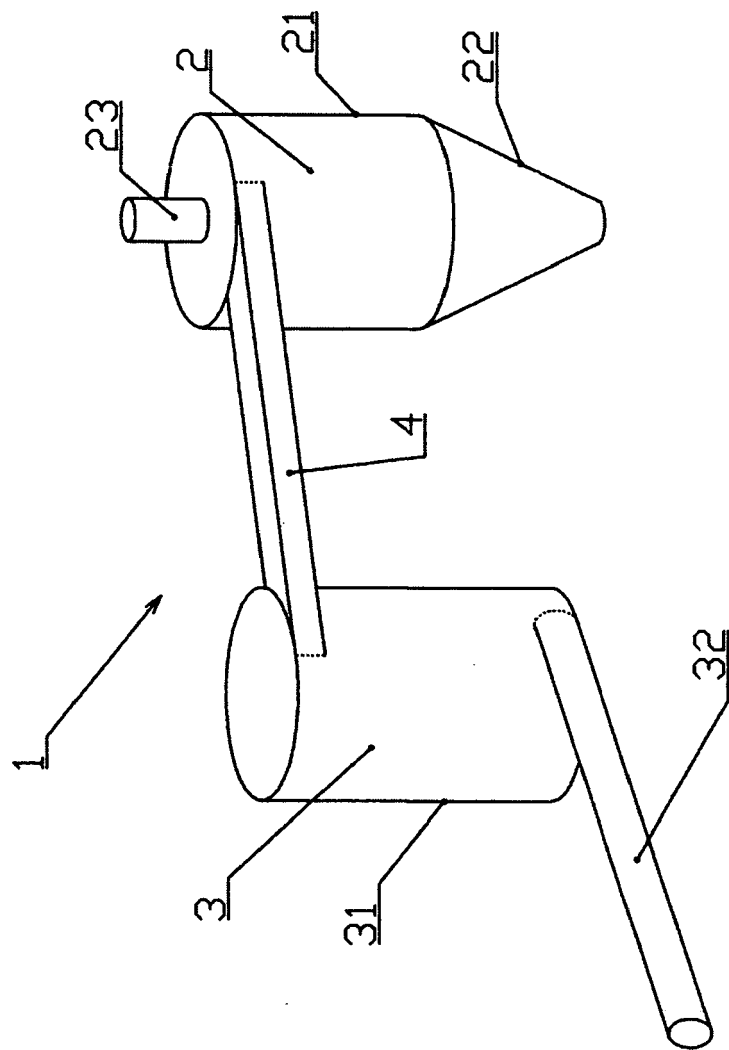


FIGURE 1

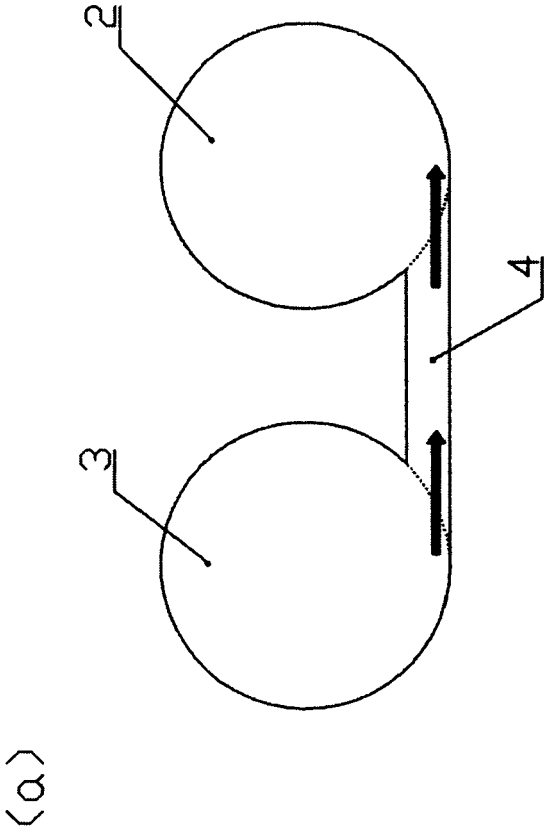


FIGURE 2A

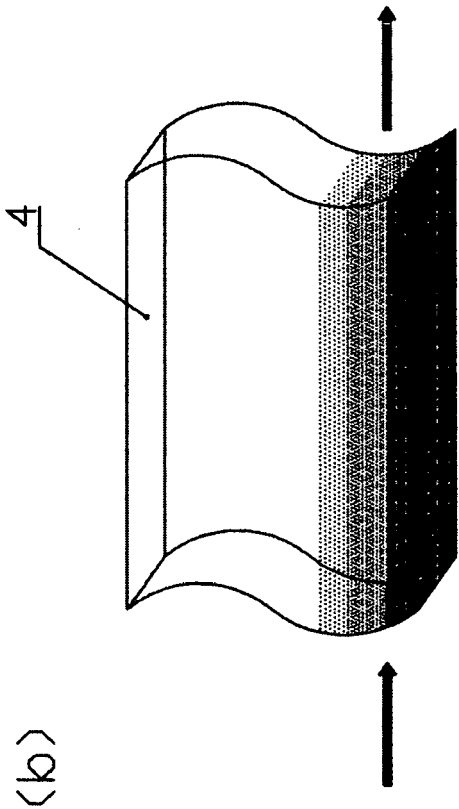


FIGURE 2B

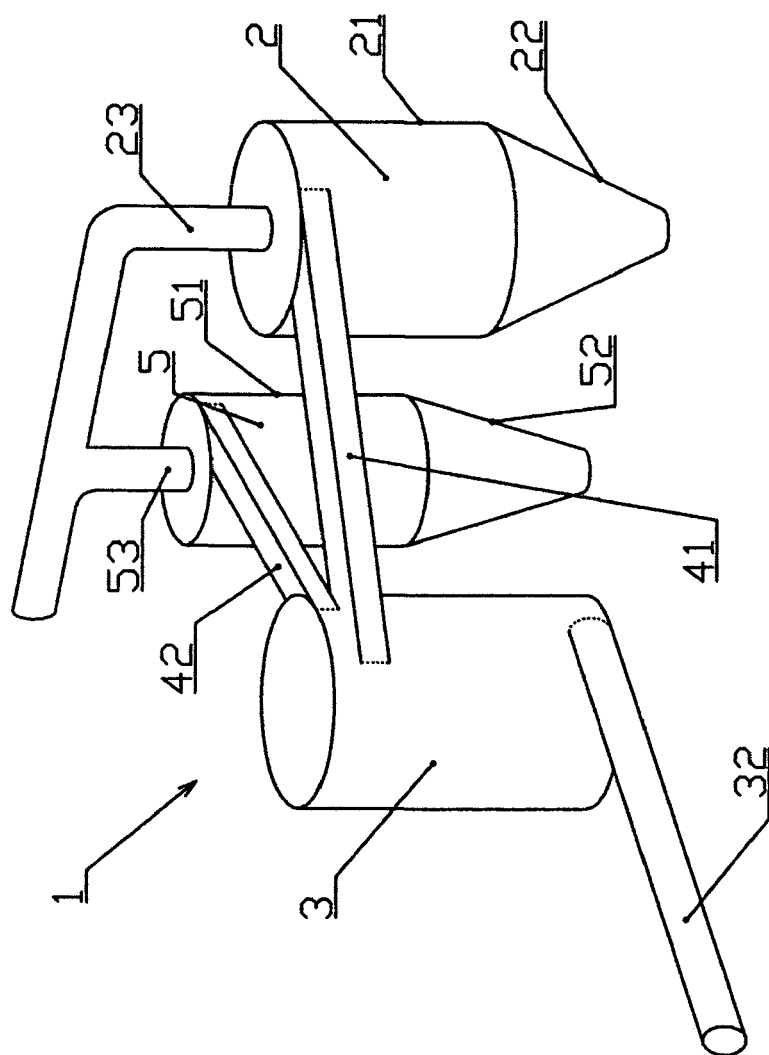


FIGURE 3

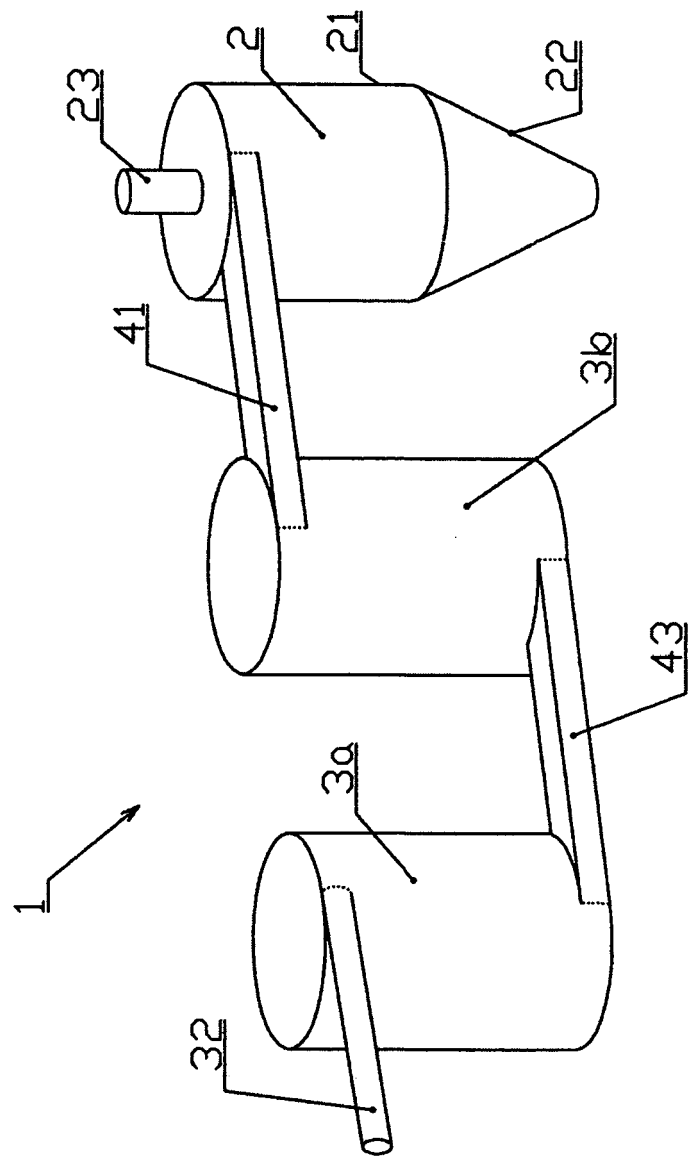


FIGURE 4

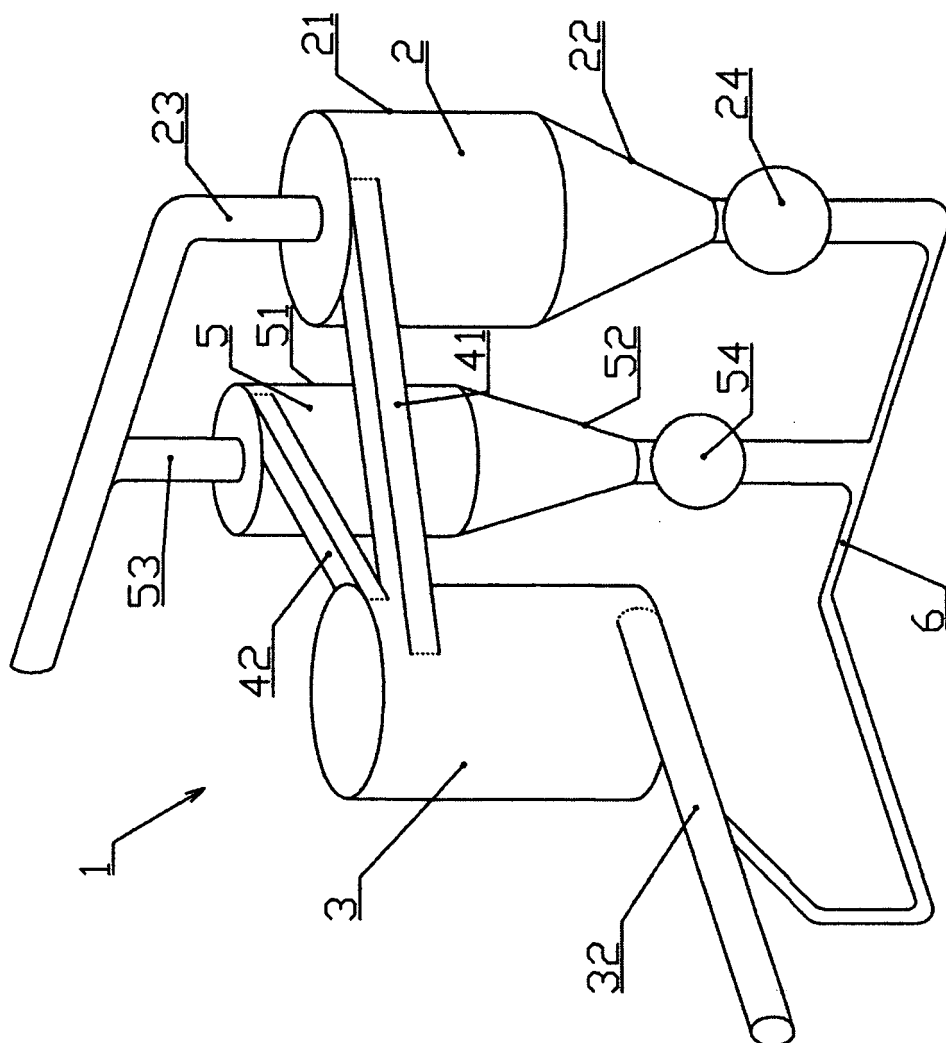


FIGURE 5

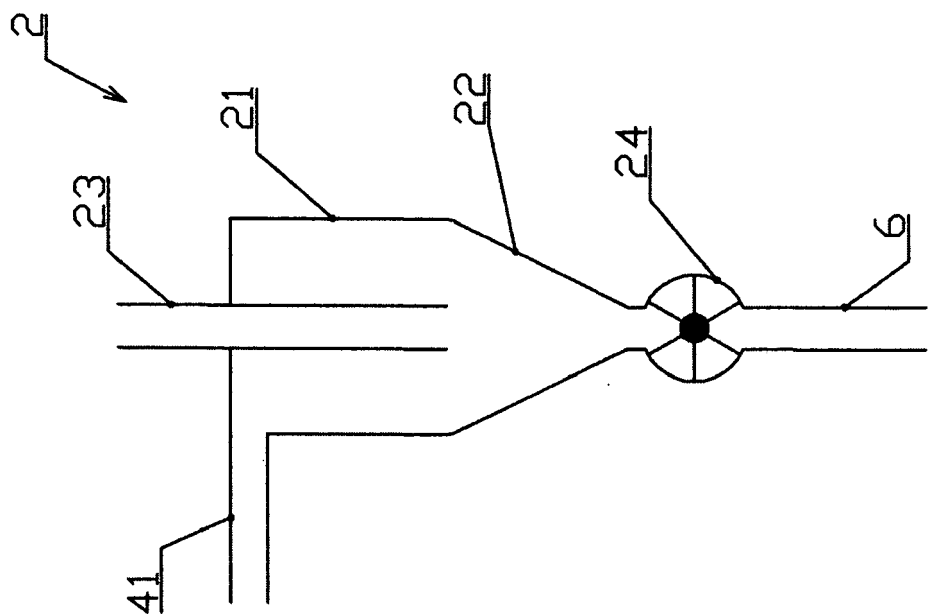


FIGURE 6



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EUROPEAN SEARCH REPORT

Application Number
EP 05 25 5892

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 430 647 A (SMOLENSKY, LEO ALEXANDER; WYSK, STANLEY RONALD) 5 June 1991 (1991-06-05)	1-5,8-10	B04C5/02
Y	* column 1, line 1 - line 4 * * column 2, line 32 - line 43 * * column 5, line 3 - column 10, line 23 * * figures 1-11 *	11	
X	DE 37 41 753 A1 (COAL INDUSTRY LTD) 14 July 1988 (1988-07-14) * page 2, line 48 - line 50 * * page 3, line 41 - page 4, line 7 * * figures 1,2 *	1,2,9,10	
Y	US 3 466 853 A (KURT BUICK ET AL) 16 September 1969 (1969-09-16) * abstract * * figures 1-3 *	11	
Y	US 5 679 074 A (SIEGEL ET AL) 21 October 1997 (1997-10-21) * abstract * * figures 1-4 *	11	TECHNICAL FIELDS SEARCHED (IPC)
X	US 2005/115273 A1 (BAKKER HILLEGONDA ET AL) 2 June 2005 (2005-06-02) * page 1, paragraph 1 * * page 3, paragraph 39 - paragraph 41 * * figure 1 *	1,2,4,7	B04C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 15 February 2006	Examiner Redelsperger, C
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 25 5892

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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15-02-2006

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0430647	A	05-06-1991	AT	121643 T	15-05-1995
			CA	2030102 A1	29-05-1991
			DE	69018942 D1	01-06-1995
			DE	69018942 T2	23-11-1995
			JP	3224649 A	03-10-1991
			US	5180486 A	19-01-1993

DE 3741753	A1	14-07-1988	AU	595970 B2	12-04-1990
			AU	8312387 A	30-06-1988
			BE	1002909 A3	30-07-1991
			CA	1308693 C	13-10-1992
			GB	2199518 A	13-07-1988
			ZA	8709222 A	09-06-1988

US 3466853	A	16-09-1969	AT	280700 B	27-04-1970
			BE	708985 A	16-05-1968
			DE	1576610 A1	27-05-1970
			FR	1554021 A	17-01-1969
			GB	1173394 A	10-12-1969
			NL	6716657 A	08-07-1968
			SE	339772 B	18-10-1971

US 5679074	A	21-10-1997	DE	19505213 C1	22-02-1996
			JP	3090418 B2	18-09-2000
			JP	8244445 A	24-09-1996

US 2005115273	A1	02-06-2005	AU	2002364401 A1	15-07-2003
			BR	0215333 A	16-11-2004
			CA	2470689 A1	10-07-2003
			CN	1610574 A	27-04-2005
			EA	5727 B1	30-06-2005
			WO	03055575 A1	10-07-2003
			ZA	200404613 A	29-08-2005

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 6320055 A [0007] [0009]
- JP 10034022 A [0008] [0010]