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(54) **Cyclone separator with an inlet container and separating method using this separator2**

(57) The present invention aims to provide a method of introducing into a cyclone body fluid containing new to be treated materials, a cyclone system, and a dust removal device and an incinerator comprising the system, and an exhaust gas treatment method that are simple and have high physical strength, and yet can improve treatment efficiency. A method of introducing into a cyclone body fluid containing to be treated materials in a cyclone comprising the cyclone body for swirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for

evacuating the fluid, characterized in that by not only enclosing at least a part or all of said cyclone body with an introduction container but also exposing said fluid inlet in the said introduction container, and by introducing the fluid containing the to be treated material into said introduction container, the method introduces into the cyclone body the fluid introduced into the said introduction container without continuous piping.

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## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

**[0001]** The present invention relates to a method of introducing into a cyclone body of fluid containing to be treated materials, in the cyclone that treats said to be treated material and fluid, by providing fluid containing the to be treated materials with whirling motion, a cyclone system, and a dust removal device and an incinerator comprising the system, and an exhaust gas treatment method.

#### 2. Description of the Related Art

**[0002]** In general, so-called a cyclone (centrifugal dust collector) that provides fluid containing to be treated materials with centrifugal force from whirling motion and treats the to be treated materials in the fluid has pipe line connected to a fluid inlet in almost tubular cyclone body, applies centrifugal force by introducing through the pipe line fluid containing to be treated materials toward an inner wall of a container body from tangential direction and generating a whirling speed component, and lets the to be treated materials having a greater specific gravity than fluid drop to the lower part of the container while pressing them against the inner wall of the container body, and also has the fluid from which the to be treated materials have been removed discharged from an outlet duct for evacuation that is raised near the center of the container body.

**[0003]** This cyclone principle itself was already invented in the 19<sup>th</sup> century, and at present, many kinds of technologies applying this cyclone principle have been developed in different fields (refer to Japanese Patent Application Laid Open No. H6-320055 and Japanese Patent Application Laid Open No.: H10-34022, for instance).

### SUMMARY OF THE INVENTION

**[0004]** There is the problem with a conventional method of introducing fluid through pipe line, however, that as physical load due to strain or vibration generated during operation of a cyclone concentrates on a junction between the said pipe line and a cyclone body, the said junction is susceptible to crack or breakdown.

**[0005]** In addition, generally as pipe line for introducing fluid into a cyclone, it is preferable to use a relatively thin pipe line in order to improve treatment efficiency or not to disturb whirling currents to be generated in the cyclone body. Thus, the junction area between the pipe line and the cyclone body is smaller, thereby becoming more susceptible to cracks or breakdown.

**[0006]** In addition, there is another problem that in the case in which diameter cross section (inside diameter,

size) or a shape, etc. is different between a so-called transfer tube transferring fluid containing to be treated materials from various industries, etc. to neighborhood of the cyclone and a pipe line for introducing the said fluid into the cyclone body, a junction between the transfer tube and the pipe line becomes complicated and requires special welding techniques or connectors of a special shape, which thus increases cost for joining.

**[0007]** In particular, although in recent days, a so-called multi-cyclone system comprising a plurality of cyclones has been developed (for instance, Japanese Patent Application Laid-Open No. H10-263439), and increased number of cyclones will require pipe lines of the same number for introducing fluid into respective cyclones, thus increasing junctions between the pipe line and the cyclones, which leads to the problem that the number of parts that may suffer from cracks or damages will increase by the increased number of cyclones.

**[0008]** In addition, such the multi-cyclone system also has the difficulty of securing a space for installing piping, which is attributable to increased pipes for introducing fluid to the cyclone system. In a field that cannot secure a space for installation, for example, to installation of the system in a car body as an exhaust gas treatment device of automobiles, etc. becomes physically impossible.

**[0009]** Hence, as a result of keen examination to solve such the problems, the inventor has completed a method of introducing into a cyclone body fluid containing to be treated materials in a cyclone comprising the cyclone body for whirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for fluid evacuation, characterized in that since the method of introducing into the cyclone body of the fluid containing to be treated materials (hereinafter referred to as the inventive method) is not only encloses at least a part or all of said cyclone body with an introduction container, but also exposes said fluid inlet within the said introduction container, and thereby introduces the fluid containing the to be treated materials into said introduction container, the method introduces into the cyclone body the fluid introduced into the said introduction container, without using continuous piping.

**[0010]** At the same time, the inventor has completed a cyclone system (hereinafter referred to as the inventive system) characterized in that it comprises a cyclone comprising a cyclone body for swirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid; an introduction container enclosing at least a part or all of said cyclone body and exposing said fluid inlet within the said container; and an introduction pipe for introducing fluid containing to be treated materials into the introduction container.

**[0011]** More specifically, by not only enclosing the introducing at least a part or all of cyclone body, but also exposing said fluid inlet within the said introduction container and introducing fluid containing to be treated materials into said introduction container, in other words, by introducing into the cyclone body the fluid containing the to be treated materials through the introduction container

without directly joining a transfer tube that transfers fluid containing the to be treated materials discharged from various industries, etc. to the neighborhood of the cyclone with the fluid inlet in the cyclone body, the inventor has eliminated a junction between the introduction pipe and fluid introduction pipe, and thus has solved the problem of crack or breakdown occurrence attributable to physical load due to strain or vibration generated during operation of the cyclone concentrated on the junction between the said pipe line and the cyclone body.

**[0012]** In addition, by introducing the fluid containing the to be treated materials into said cyclone body through the introduction container, rather than directly joining the transfer tube with the fluid inlet in the cyclone body, the inventor has gained knowledge that an introduction system that is extremely inexpensive yet does not require a special welding technique or a connector, etc. can be constructed even in the case in which the diameter cross section (inside diameter, size) or a shape of the transfer tube and the fluid inlet differs.

**[0013]** The inventor has also gained knowledge that in a so-called multi-cyclone system that concurrently uses a plurality of cyclones, by not only enclosing at least a part or all of respective cyclone bodies in the plurality of cyclones by one introduction container, but also exposing the leading end of each fluid inlet in said plurality of cyclones in the said introduction container, the need for complicated piping facilities can be eliminated and a multi-cyclone system of a very simple configuration can be constructed.

**[0014]** In addition, the inventor has gained knowledge that with such the configuration, that is to say, by introducing fluid containing to be treated materials into the cyclone body through the introduction container, rather than introducing it directly into the cyclone body, the to be treated materials in the fluid can be roughly filtered out to some degree in the introduction container, enabling introduction of relatively clean fluid into the cyclone body, thereby improving the treatment efficiency of the fluid as a result.

**[0015]** In particular, the inventor has gained knowledge that the efficiency of rough filtering of the to be treated materials in the fluid in the introduction container can be improved by enclosing periphery of the cyclone body by the introduction container and further introducing the fluid containing the to be treated materials from tangential direction of the said introduction container.

**[0016]** The present invention has been completed based on the above knowledge, and aims to provide a method of introducing fluid containing to be treated materials into a cyclone body, a cyclone system, and a dust removal device and an incinerator comprising the system, and an exhaust gas treatment method that are simple and have high physical strength, yet are novel and can improve the treatment efficiency.

**[0017]** The present invention being the means of solving the above problems is a method of introducing into a cyclone body fluid containing to be treated materials in

a cyclone comprising the cyclone body for whirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for fluid evacuation, wherein the method is characterized in that by not only enclosing at least a part or all of said cyclone body by an introduction container, but also exposing said fluid inlet within the said introduction container, it introduces the fluid introduced into the said introduction container into the cyclone body without continuous piping.

**[0018]** The present invention is also a cyclone system for treating to be treated materials in fluid by providing the fluid containing the to be treated materials with whirling motion, wherein the cyclone system is characterized in that it comprises a cyclone comprising a cyclone body for swirling fluid, a fluid inlet for introducing the fluid and an outlet duct for fluid evacuation, an introduction container being a container enclosing at least a part or all of said cyclone body and exposing said fluid inlet within the said container, and an introduction pipe for introducing the fluid containing the to be treated materials.

**[0019]** In addition, a dust removal device and an incinerator of the present invention are characterized in that they comprise said inventive system, and an exhaust gas treatment method of the present invention is characterized in that it treats exhaust gas discharged from an internal combustion engine by using the said inventive system.

In the following, we describe in detail the inventive system, and the dust removal device and the incinerator comprising the inventive system, and the exhaust gas treatment method.

**[0020]** "Fluid containing to be treated materials" that is an object to be treated according to the invention may not be specifically limited as far as it has a measure of fluidity to be able to flow promptly without staying in a cyclone to be used in the inventive method, and its state may be liquid or gas.

**[0021]** Specifically, exhaust gas discharged in various industries such as manufacturing, power generation, construction, waste-disposal, and agriculture, or gas emissions from various transport facilities such as bikes, automobiles, trucks, buses, locomotives and marine vessels, etc. can be listed. In short, the inventive method applies to every type of fluid containing to be treated materials to be generated by some kind of production activities.

**[0022]** In addition, in the inventive method, a cyclone into which fluid containing said to be treated materials may not be specifically limited, and a publicly known cyclone comprising a cyclone body for swirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid may be used as appropriate.

**[0023]** Then, the inventive method is a method for introducing the fluid containing said to be treated materials into said cyclone body, the method having a major characteristic that by not only enclosing at least a part or all of said cyclone body by an introduction container but also exposing said fluid inlet within the said introduction con-

tainer, it introduces the fluid introduced into the said introduction container into the cyclone body without continuous piping.

**[0024]** In other words, in the inventive method, first not only a part or all of the cyclone body is enclosed (sealed) with the introduction container, but also the fluid inlet for introducing the fluid into the cyclone body is exposed within the said introduction container.

**[0025]** Then, in this state, if the fluid containing the to be treated materials was introduced into said introduction container, the introduced fluid would be sequentially fed into the cyclone body, since in the introduction container, there is no other route than said fluid inlet for the introduced fluid to escape.

**[0026]** In fact, by introducing into the cyclone body the fluid containing the to be treated materials through the introduction container, rather than directly connecting the piping for transferring the fluid containing to be treated materials discharged from various industries to the neighborhood of the cyclone with the fluid inlet for introducing the fluid into the cyclone body, the inventive method can eliminate a junction between the piping for transferring the fluid and the fluid inlet, thereby solving the problem of cracks or breakdown resulting from concentration on the junction between the said pipe line and the cyclone body of physical load due to strain or vibration to be generated during operation of the cyclone.

**[0027]** In addition, since the inventive method introduces the fluid containing the to be treated materials through the introduction container rather than directly joining said transfer tube with the fluid inlet in the cyclone body, even in the case diameter cross section (inside diameter, size) or a shape of the transfer tube and the fluid inlet differs, no special welding technique or a connector of special shape is required, thus enabling construction of extremely inexpensive introduction system.

**[0028]** In addition, in a so-called multi-cyclone system that concurrently uses a plurality of cyclones, by not only enclosing at least a part or all of respective cyclone bodies in the plurality of cyclones by one introduction container, but also exposing each fluid inlet in said plurality of cyclones in the said introduction container, the need for complicated piping facilities can be eliminated and a multi-cyclone system of a very simple configuration can be constructed.

**[0029]** In addition, with such the configuration, that is to say, by introducing fluid containing to be treated materials into the cyclone body through the introduction container, rather than introducing it directly into the cyclone body, the to be treated materials in the fluid can be roughly filtered out to some degree in the introduction container, enabling introduction of relatively clean fluid into the cyclone body compared with the case in which the fluid is directly introduced into the cyclone through the piping, thereby improving the treatment efficiency of the fluid as a result.

**[0030]** In addition, for the rough filtering in the introduction container, in the inventive method, it is preferable

to protrude the leading end of the fluid inlet in the introduction container, and with such configuration, constant motion energy or directionality, etc., is needed for the treated material in the fluid to enter the cyclone body from the said fluid inlet. This would significantly increase the rough filtering efficiency of the to be treated materials in the fluid in the introduction container.

**[0031]** Furthermore, in the inventive method, if the leading end of the fluid inlet was protruded in the introduction container, it would be possible to direct the fluid passing through the said fluid inlet to be introduced from tangential direction toward the inner wall of the cyclone body. This allows the fluid passing through the fluid inlet to promptly start whirling motion in the cyclone body, thereby improving the treatment efficiency in the cyclone.

**[0032]** In particular, in the inventive method, it is preferable to enclose the cyclone body with said introduction container by using an almost cylindrical hollow body as said introduction container, and further to introduce the fluid containing to be treated materials from the tangential direction toward the inner wall of the said introduction container and let said fluid whirl in said introduction container.

**[0033]** In other words, by providing whirling motion in the introduction container before introducing the fluid containing the to be treated materials into the cyclone body, a part or all of the to be treated materials in the fluid cannot move to the upper part of the introduction container, i.e., cannot reach the fluid inlet in the cyclone, and thus repeatedly whirls in the lower or middle part of the introduction container. Consequently, relatively clean fluid from which the to be treated materials have been further roughly filtered out can be introduced into the cyclone body.

**[0034]** In addition, the meaning of said "almost cylindrical" includes not only literal cylinder (tubular body) that is a rectangular solid when viewed from the front wherein inside diameter of the basal plane and that of the ceiling plane are identical, but also anything having different inside diameters of the basal and ceiling planes, such as those having a shape like a circular cone that is broken away at a level surface (bell shape or inverted bell shape) or those having the inside diameter that varies in continuity or in incremental steps. In short, in the inventive method, "almost cylindrical" means all hollow bodies in which fluid can whirl, in other words, all hollow bodies whose transverse section is almost circular.

**[0035]** In the following, we describe the inventive system.

**[0036]** The inventive system is a cyclone system for providing fluid containing to be treated materials with centrifugal force resulting from whirling motion and treating the to be treated materials in the fluid, wherein the cyclone system is characterized in that it is comprised of a "cyclone" comprising a cyclone body for swirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid, an "introduction container" being a container enclosing at least a part or all of said cyclone

body and exposing said fluid inlet in the said container, and an "introduction pipe" for introducing the fluid containing the to be treated materials.

**[0037]** A "cyclone" to be used in the inventive system may not be specifically limited, and, in fact, a publicly known cyclone that swirls the introduced fluid and employs the principle of treating such to be treated materials as dust, etc. by using its centrifugal force, i.e., a general cyclone comprising a cyclone body for whirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid may be suitably used.

**[0038]** In addition, an "introduction container" to be used in the inventive system is a container enclosing (sealing) at least a part or all of the cyclone body in said cyclone and exposes said fluid inlet in the said container.

**[0039]** Furthermore, an "introduction pipe" to be used in the inventive system is for introducing the fluid containing to be treated materials into said introduction container, and, in general, a transfer tube for transferring fluid containing to be treated materials discharged from various industries, etc. to the neighborhood of the cyclone is used as the introduction pipe.

**[0040]** In the inventive system, the fluid containing the to be treated materials is introduced from said introduction pipe into said introduction container.

**[0041]** The fluid introduced into the introduction container is sequentially fed into the cyclone body because in the said introduction container, there is no other route than said fluid inlet for the introduced fluid to escape.

**[0042]** Then, the fluid containing the to be treated materials fed into the cyclone body is provided whirling motion in the cyclone body, drops the to be treated materials having greater specific gravity than the fluid to the lower part of the cyclone body while pressing them against the inner wall of the cyclone body, and concurrently lets treated fluid evacuate from the outlet for evacuation that is raised near the center of the container body.

**[0043]** In fact, in the inventive system, by introducing into a cyclone body fluid containing to be treated materials through an introduction container rather than directly connecting a transfer tube (introduction pipe) for transferring the fluid containing the to be treated materials discharged from various industries, etc. with a fluid inlet for introducing the fluid into the cyclone body, a junction between the transfer tube (introduction pipe) and the fluid inlet can be eliminated, thereby solving the problem of cracks or breakdown, etc. resulting from concentration on the said junction of physical load due to strain or vibration to be generated during operation of the cyclone.

**[0044]** In addition, in the inventive system, by introducing into a cyclone body fluid containing to be treated materials through an introduction container, rather than directly joining a transfer tube (introduction pipe) for transferring the fluid containing the to be treated materials discharged from various industries, etc. to the neighborhood of the cyclone, with a fluid inlet in the cyclone body, even in the case diameter cross section (inside diameter, size) or a shape of the transfer tube (introduction pipe)

and the fluid inlet differs, no special welding technique or a connector of special shape is required, thus enabling construction of extremely inexpensive introduction system.

**[0045]** Therefore, in the inventive system, diameter cross section of a fluid inlet can be freely selected, and, for instance, diameter cross section of the fluid inlet can be configured to be smaller than that of the transfer tube (introduction pipe) or vice versa. In fact, if the diameter cross section of the fluid inlet is configured to be smaller than that of the transfer tube (introduction pipe), the speed of introducing the fluid into the cyclone body can be accelerated, while if the diameter cross section of the fluid inlet is configured to be larger than that of the transfer tube (introduction pipe), the speed of introducing the fluid into the cyclone body can be decelerated. In fact, provision of a difference between the diameter cross section of the fluid inlet and that of the inlet could enable control of the speed of introducing the fluid into the cyclone body.

**[0046]** It is no surprise, however, that in general, it is preferable to accelerate the speed of introducing the fluid into the cyclone body to improve the treatment efficiency in the cyclone. Thus, in the present invention, it is preferable to configure the diameter cross section of the fluid inlet to be smaller than that of the transfer tube (introduction pipe).

**[0047]** In addition, in the inventive system, by introducing the fluid containing the to be treated materials into the cyclone body through the introduction container, the to be treated materials in the fluid can be roughly filtered out to some degree in the introduction container, and relatively clean fluid can thus be introduced into the cyclone body compared with the case in which the fluid is directly introduced into the cyclone through continuous piping, thereby improving the treatment efficiency of the fluid as a result.

**[0048]** In particular, when a so-called multi-cyclone system that concurrently uses a plurality of cyclones is constructed, by not only enclosing together at least part or all of respective cyclone bodies in the plurality of cyclones with one introduction container, but also exposing respective fluid inlets in said plurality of cyclones in the said introduction container, complicated piping facilities become unnecessary, thereby enabling construction of a multi-cyclone system of a very simple configuration.

**[0049]** Now, in the inventive system, when a so-called multi-cyclone system that concurrently uses a plurality of cyclones is constructed, it is preferable to set the total number of the said plurality of cyclones to an even number, and to make a swirling current of half the said plurality of cyclones opposite to direction of a swirling current of the remaining half of the cyclones. With such the configuration, noise phases occurring in the respective cyclones are reversed between the cyclones having the different directions of the swirling currents and mutual noise is cancelled, thus making noise to occur very small. Thus, this could make it possible to use the inventive system as a silencer (muffling device) such as a muffler

that reduces engine sound from an internal combustion engine of an automobile, etc.

**[0050]** In the inventive system, it is preferable to protrude the leading end of the fluid inlet in the introduction container, and with such configuration, constant motion energy or directionality, etc., is needed for the treated material in the fluid to enter the cyclone body from the said fluid inlet. This would significantly increase the rough filtering efficiency of the to be treated materials in the fluid in the introduction container.

**[0051]** Furthermore, in the inventive method, if the leading end of the fluid inlet for introducing the fluid into the cyclone body was protruded in the introduction container, and connection was made so that the fluid passes through the said fluid inlet and is introduced from tangential direction toward the inner wall of the cyclone body, the direction of introducing the fluid into the cyclone body could be determined while it was passing through the said fluid inlet. This allows the fluid passing through the fluid inlet to promptly start whirling motion in the cyclone body.

**[0052]** The degree of protrusion of the leading end of the fluid inlet may not be specifically limited. However, extremely long protrusion may lead to breakdown or cracks due to physical resistance, etc., such as vibrations during operation of the cyclone or wind pressure to be received from the fluid, etc.

**[0053]** Thus, the degree (length) of the protrusion of the leading end of the fluid inlet in the inventive system may generally have a ratio of approximately 0.05 to 1.0 time when it is compared with inside diameter of the ceiling plane in the cyclone body, and preferably of approximately 0.1 to 0.5 time.

**[0054]** If the degree of the protrusion of the leading end of the fluid inlet is set to less than 0.05 time compared with the inside diameter of the ceiling plane in the cyclone body, the efficiency of rough filtering in the introduction container, etc., may decrease, because the degree of the protrusion is too low, while if it is set to 1.0 time or more, breakdown or cracks may occur due to vibrations during operation of the cyclone or physical resistance to be received from fluid, etc., both of which are not preferable.

**[0055]** In the inventive system, it is preferable to enclose the cyclone body with the introduction container.

**[0056]** In fact, if the cyclone body is enclosed with the introduction container, junction area of the cyclone body and the introduction container expands, which can thus improve durability of the cyclone system of the present invention.

**[0057]** Then, it is preferable to join the ceiling plane of the cyclone body and that of the introduction container by surface contact, or configure the ceiling plane of the cyclone body and that of the introduction container with a common member, and such the configuration can further improve durability of the inventive system.

**[0058]** In addition, if the introduction container enclosed the cyclone body, the fluid containing the intro-

duced to be treated materials could be given such a degree of freedom that it can go around the cyclone till it reaches the fluid inlet, which could further increase the efficiency of rough filtering of the to be treated materials in the fluid in the introduction container.

**[0059]** Therefore, in the inventive system, it is preferable to use an almost cylindrical hollow body as said introduction container and to enclose the cyclone body with the introduction container. Use of the almost cylindrical hollow body as the introduction container makes it easier for the fluid containing the introduced to be treated materials to go around the cyclone body.

**[0060]** In particular, in the inventive system, it is preferable to actively swirl in the said introduction container the fluid containing the to be treated materials to be introduced into the said introduction container, by not only using the almost cylindrical hollow body as the introduction container and enclosing the cyclone body with the introduction container, but also using, as the introduction pipe in the said introduction container, a means of introducing the fluid from the tangential direction toward the inner wall of the said introduction container.

**[0061]** In other words, by swirling the fluid containing the to be treated materials in the introduction container before introducing it into the cyclone body, a part or all of the to be treated materials in the fluid cannot move to the upper part of the introduction container, i.e., cannot reach the fluid inlet in the cyclone, and thus repeatedly whirls in the lower or middle part of the introduction container. Consequently, relatively clean fluid from which the to be treated materials have been further roughly filtered out can be introduced into the cyclone body.

**[0062]** In addition, the meaning of said "almost cylindrical" includes not only literal cylinder (tubular body) that is a rectangular solid when viewed from the front wherein inside diameter of the ceiling plane and that of the basal plane are identical, but also anything having different inside diameters of the ceiling and basal planes, such as those having a shape like a circular cone that is broken away at a level surface (bell shape or inverted bell shape) or those having the inside diameter that varies in continuity or in incremental steps. In short, in the inventive system, "almost cylindrical" means all hollow bodies in which fluid can whirl, in other words, all hollow bodies whose transverse section is almost circular.

**[0063]** Now, in the inventive system, if the liquid containing to be treated materials is swirled in the introduction container, it is preferable to arrange the fluid inlet in the cyclone in a position opposed to the swirling current occurring in said introduction container. This is because of the following:

In fact, when fluid is introduced from a fluid inlet in a general cyclone, the to be treated materials of uniform distribution density, irrespective of their positions on the section, will flow in, because to be treated materials in the fluid that passes through said fluid inlet are distributed almost uniformly in the cross sec-

tion of the fluid inlet.

**[0064]** Thus, the to be treated materials entering the cyclone body from a position closer to the cyclone body at the fluid inlet will have a smaller gyration radius than that of particles entering from a position farther from the cyclone body at the fluid inlet, thus not only being unable to gain necessary centrifugal force, but also contacting the swirling current of the cyclone body and disturbing the swirling current, which leads to the problem of reduced treatment efficiency.

**[0065]** In this respect, if whirling motion is given to the fluid containing to be treated materials in the introduction container, the to be treated materials in the fluid are pressed against the inner wall of the introduction container, i.e., distribution of the to be treated materials in the fluid is biased to the inner wall direction of the introduction container. Then, if the fluid in such distribution state was directly introduced into the cyclone body, introduction of the fluid in such distribution state directly into the cyclone body could remove the defect of the conventional cyclone system, namely, reduction of the treatment efficiency attributable to the distribution state of the to be treated materials in the fluid.

**[0066]** Thus, in the inventive system, it is preferable to locate the fluid inlet in the cyclone opposed to the swirling current in the introduction container, and such the configuration could enable direct introduction into the cyclone body of the fluid with the to be treated materials therein distributed biasedly toward the inner wall of the introduction container, thereby improving the treatment efficiency attributed to how the to be treated materials in the fluid are introduced.

**[0067]** In addition, with such the configuration, since the to be treated materials in the fluid introduced into the cyclone body are well distributed to be treated in extremely short time, length of the cyclone body (and the introduction container) can be shortened. Thus, the inventive system can be applied even in the field in which installation space for a long cyclone system cannot be secured, and, for instance, can be installed in the car body, as an emission treatment device, etc., for automobiles.

**[0068]** Now, as the to be treated materials are pressed against the inner wall of the introduction container when the fluid containing to be treated materials is swirled in the introduction container, the distribution density of the to be treated materials is highest in or near the inner wall side of the introduction container, and (the distribution density of the to be treated materials) gradually decreases toward the center of the introduction container.

**[0069]** Thus, in this state, if the leading end of the fluid inlet in the cyclone body is arranged by the inner wall of the introduction container, fluid with relatively high content of to be treated materials will be introduced into the cyclone body.

**[0070]** On the one hand, in this state, if the fluid inlet in the cyclone body is arranged closer to the center than to the inner wall of the introduction container, relatively

clean fluid will be introduced into the cyclone body.

**[0071]** In fact, when the fluid having the less content of to be treated materials is treated or when a cyclone with higher treatment capacity is used, more to be treated materials can be treated in the said cyclone if the fluid inlet in the cyclone body is arranged by the inner wall of the introducing wall and more to be treated materials are introduced into the cyclone. On the contrary, when the fluid having more content of to be treated materials is treated or when a cyclone with lower treatment capacity is used, more to be treated materials can be treated in the introduction container by positioning the fluid inlet in the cyclone body closer to the center side than to the inner wall of the introduction container.

**[0072]** In addition, in the inventive system, it is preferable to change a position of the fluid inlet in the introduction container arbitrarily or according to quantity of the to be treated materials in the fluid, as appropriate.

**[0073]** For instance, usually, emission gas emitted from an internal combustion engine, such as a car engine has a higher content of to be treated materials such as PM, etc. when the inventive system runs at low speed, while it has a lower content of to be treated materials such as PM, etc., when the inventive system runs at high speed.

**[0074]** Hence, in the inventive system, it is preferable to change, as appropriate, the position of the fluid inlet in the introduction container arbitrarily or according to quantity of to be treated materials in the fluid, and with such the configuration, it also becomes possible to handle those in which the content of the to be treated materials varies depending on such the operating states, etc.

**[0075]** Then, in the inventive system, if fluid containing to be treated materials is whirled in the introduction container, said introduction container gets smaller from a position where the introduction pipe is provided in the said introduction container to a position where the fluid inlet is provided in the cyclone body. In other words, it is preferable to make the inside diameter of the ceiling plane in the almost cylindrical introduction container smaller than that of the basal plane in the said introduction container. With such the configuration, the swirling speed of the fluid introduced from the introduction pipe into the introduction container can be accelerated to the level that the speed reaches the fluid inlet in the cyclone, thus not only being able to apply stronger centrifugal force to the to be treated materials in the fluid, but also accelerating the speed of introducing the fluid into the cyclone body.

**[0076]** In this case, although it is also acceptable to continuously (gradually) reduce the inside diameter of the introduction container from the basal plane to the ceiling plane, in the inventive system, it is preferable to reduce the inside diameter of the introduction container in phases from the basal plane to the ceiling plane. With such the configuration, each stage in the introduction container becomes a barrier and makes it difficult for the to be treated materials in the fluid to go beyond the each stage in the introduction container, thus further improving

the efficiency of rough filtering in the introduction container.

**[0077]** As described above, the inventive system is comprised by enclosing a part of all of the cyclone body with the introduction container. In addition, it is also acceptable to sequentially enclose a part or all of the said introduction container with one or more separate introduction containers, and thus to be treated materials in the fluid can be roughly filter out in the respective introduction containers by providing more than one introduction container, thereby being able to improve the treatment efficiency of the whole cyclone system of the present invention.

**[0078]** In addition, one or more introduction containers that enclose the introduction container may be same as the introduction container that encloses the cyclone body as described above. Although we omit the description herein to avoid repetitions, naturally, the inlets (fluid inlets) for each fluid introduction are provided in different introduction containers, and these inlets are arranged not to be exposed in the different introduction container that encloses the said introduction container.

**[0079]** In the inventive system, to be treated materials roughly filtered out in the introduction container are collected in the said introduction container, while to be treated materials treated in the cyclone are respectively collected in the said cyclone.

**[0080]** Then, the collected to be treated materials should be removed in due course or regularly.

**[0081]** Then, if the to be treated materials are safe to human bodies, there is no problem except that the removal procedure is complicated. However, in the case of PM (particulate pollutants) or graphite or other fine particles, it is possible that workers who breathes them may suffer from health hazard such as pneumoconiosis, etc., and it is also reported that in particular, PM or graphite contains more carcinogen.

**[0082]** Thus, in the inventive system, it is preferable to provide in the introduction container and/or cyclone body a catalyst and/or absorbent for detoxifying or absorbing to be treated materials, and it is preferable to have the to be treated materials contact the said catalyst in the introduction container or the cyclone body and treat them.

**[0083]** In the inventive system, as a part or all of to be treated materials is repeatedly subject to swirling motion in the introduction container or the cyclone body, it has been confirmed that they are rubbed on the inner wall during swirling motion, become so-called burn-out, and are finally gasified into a gas such as carbon dioxide, etc.

**[0084]** Therefore, in the case of treatment when most of to be treated materials in fluid are fine particles, such as emissions of automobiles, the most fine particles in the emission gas can be gasified by repeatedly subjecting the fluid containing the to be treated materials to swirling motion in the inventive system. Thus, intervals needed for removing collected to be treated materials can be significantly extended, thereby realizing so-called free maintenance.

**[0085]** In addition to subjecting the fluid containing to be treated materials in the introduction container to swirling motion in the inventive system, if a catalyst and/or absorbent that absorbs or detoxifies to be treated materials are/is provided in the introduction container and/or cyclone body, the intervals needed for removal of collected to be treated materials can be significantly extended, thereby realizing so-called maintenance-free.

**[0086]** In addition, in the inventive system, the to be treated materials in the fluid repeatedly make contact with the catalyst or absorbent while whirling and have many contacts with the catalyst or absorbent, which can further improve the efficiency of detoxification or absorption by the catalyst or absorbent.

**[0087]** In addition, although said catalyst to be used in the inventive system may not be specifically limited, as far as by making contact with the to be treated materials in the fluid or gasified to be treated materials, it treats the said to be treated materials or gasified to be treated materials into almost same condition, to be more precise, a publicly known inorganic catalyst or urea crystal such as platinum or alumina catalyst, etc., for instance, may be suitably used.

**[0088]** On the one hand, said absorbent to be used in the inventive system may not be specifically limited as far as by making contact with the to be treated materials in the fluid or gasified to be treated materials, it absorbs the said to be treated materials or gasified to be treated materials, and a publicly known absorbent such as activated charcoal or silica gel, zeolite or powder or granulation of porous ceramics in concrete terms.

**[0089]** A dust removal device of the present invention is a novel dust removal device characterized in that it comprises said inventive system. In fact, it introduces into a cyclone body and treats, without continuous piping, fluid containing dust discharged from various industries, and that it is an exceptional dust removal device in that it has excellent durability, high treatment efficiency and yet can significantly extend intervals needed for removal of collected to be treated materials or realize so-called free maintenance.

**[0090]** In addition, an incinerator of the present invention is a novel incinerator characterized in that it comprises said inventive system. In fact, it introduces into a cyclone body and treats, without continuous piping, smoke containing incineration ash that includes toxic substances such as dioxin, etc., discharged from incinerators, and is an exceptional incinerator in that it has excellent durability, high treatment efficiency, and, in particular, can gasify such toxic substances as dioxin, etc. into a gas such as carbon dioxide, etc., by repeatedly providing swirling motion in an introduction container, and yet can significantly extend intervals needed for removal of collected to be treated materials or realize so-called free maintenance.

**[0091]** In addition, an exhaust gas treatment method of the present invention is characterized in that it treats emission gas emitted from internal combustion engines

by using said inventive system. In fact, it introduces into a cyclone body and treats, without continuous piping, emission gas to be emitted from internal combustion engines as typified by engines of automobiles or marine vessels, etc., and is an exceptional exhaust gas treatment method in that it has excellent durability, high treatment efficiency, and yet can significantly extend intervals needed for removal of collected to be treated materials, or realize so-called free maintenance, and can eliminate the need for installation of such a muffing device as a muffler by noise reduction through the use of a plurality of cyclones.

**[0092]** The present invention is a method of introducing fluid containing new to be treated materials into a cyclone body, a cyclone system, a dust removal device and an incinerator comprising the system, and an exhaust gas treatment method that have the configurations described above, are simple, have high physical strength, and yet can improve treatment efficiency.

**[0093]** The inventive method is a method of introducing fluid containing to be treated materials into a cyclone body in a cyclone comprising the cyclone body for swirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid, and characterized in that by not only enclosing at least a part or all of said cyclone body with an introduction container, but also exposing said fluid inlet in the said introduction container, and introducing the fluid containing the to be treated materials into said introduction container, it introduces into the cyclone body the fluid introduced into the said introduction container without continuous piping.

**[0094]** In addition, the inventive system is a cyclone comprising a cyclone body for swirling fluid, a fluid inlet for introducing the fluid and an outlet duct for evacuating the fluid, and a container for enclosing at least a part or all of said cyclone body, and is characterized in that it comprises an introduction container for exposing said fluid inlet in the said container and an introduction pipe for introducing fluid containing to be treated materials into the introduction container.

**[0095]** In fact, by not only enclosing at least a part or all of a cyclone body with an introduction container, but also exposing said fluid inlet in the said introduction container, and introducing fluid containing to be treated materials into said introduction container, in other words, by introducing into said cyclone body the fluid containing the to be treated materials through the introduction container rather than directly joining a transfer tube for transferring the fluid containing the to be treated materials discharged from various industries, etc., to the neighborhood of the cyclone, and the fluid inlet in the cyclone body, the present invention can eliminate a junction between the introduction pipe and the fluid introduction pipe, and thus solve the problem of cracks or breakdown attributable to concentration on the junction between the said pipe line and the cyclone body of physical load due to strain or vibrations during operation of the cyclone.

**[0096]** In addition, by introducing into said cyclone

body the fluid containing to be treated materials through the introduction container, rather than directly connecting the transfer tube for transferring the fluid containing the to be treated materials discharged from various industries, and the fluid inlet in the cyclone body, the present invention can construct an extremely inexpensive introduction system without the need of a special welding technique or a connector, etc., even in the case in which the diameter cross section (inside diameter, size) or a shape of the transfer tube and the fluid inlet differs.

**[0097]** Furthermore, in a so-called multi-cyclone system that concurrently uses a plurality of cyclones, by not only enclosing at least a part or all of respective cyclone bodies in the plurality of cyclones by one introduction container, but also exposing the leading end of each fluid inlet in said plurality of cyclones in the said introduction container, the need for complicated piping facilities can be eliminated and a multi-cyclone system of a very simple configuration can be constructed.

**[0098]** In addition, by introducing fluid containing to be treated materials into a cyclone body through an introduction container, rather than introducing it directly into the cyclone body, the to be treated materials in the fluid can be roughly filtered out to some degree in the introduction container, and relatively clean fluid can be introduced into the cyclone body, thereby improving the treatment efficiency of the fluid as a result.

**[0099]** In particular, by making an introduction container almost cylindrical, enclosing the cyclone body with the introduction container, introducing fluid containing to be treated materials from tangential direction of the said introduction container, and subjecting the fluid to swirling motion in said introduction container, the rough filtering efficiency of the to be treated materials in the fluid in the introduction container can be improved.

**[0100]** A dust removal device of the present invention is a novel dust removal device characterized in that it comprises said inventive system, and is an exceptional dust removal device in that it has excellent durability, high treatment efficiency, and yet can significantly extend intervals needed for removal of collected to be treated materials, or realize so-called free maintenance.

**[0101]** In addition, an incinerator of the present invention is a novel incinerator characterized in that it comprises said inventive system, and is an exceptional incinerator in that it has excellent durability, high treatment efficiency, and by repeatedly providing swirling motion in an introduction container, in particular, can gasify such toxic substances as dioxin, etc., into gas such as carbon dioxide, and yet can significantly extend intervals needed for removal of collected to be treated materials or realize so-called free maintenance.

**[0102]** Furthermore, an exhaust gas treatment method of the present invention is characterized in that it treats exhaust gas discharged from internal combustion engines by using said inventive system, and is an exceptional exhaust gas treatment method in that it has excellent durability, high treatment efficiency, and yet can sig-

nificantly extend intervals needed for removal of collected to be treated materials or realize so-called free maintenance, or can eliminate the need for installation of such a muffing device as a muffler by noise reduction through the use of a plurality of cyclones.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0103]

FIG. 1 is a schematic view showing a cyclone system according to Embodiment 1 of the present invention. FIG. 2 is a schematic view showing how to be treated materials in fluid has moved in the cyclone system of the invention according to Embodiment 1.

FIG. 3 is a schematic view showing the cyclone system of the present invention according to Embodiment 2.

FIG. 4 is a schematic view showing the cyclone system of the present invention according to Embodiment 3.

FIG. 5 is a schematic view showing distribution of to be treated materials in fluid in an introduction container of the cyclone system of the present invention according to Embodiment 3.

FIGS. 6A and 6B are schematic views showing a difference in introduction state of fluid depending on changes in positions of fluid inlet in the cyclone system of the present invention according to Embodiment 3.

FIGS. 7A and 7B are schematic views showing a different example of the fluid inlet in the cyclone system of the present invention according to Embodiment 3.

FIG. 8 is a schematic view showing the cyclone system of the present invention according to Embodiment 4.

FIG. 9 is a schematic view showing the cyclone system of the present invention according to Embodiment 5.

FIG. 10 is a schematic view showing the cyclone system of the present invention according to Embodiment 6.

FIG. 11 is a schematic view showing the cyclone system of the present invention according to Embodiment 7.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0104] In the following, we describe embodiments of the invention. However, the invention shall not be limited to the embodiments.

### Embodiment 1

[0105] FIG. 1 is a schematic view showing the inventive system 1 according to Embodiment 1, wherein by showing an introduction container 3 in see-through state,

inside of the said introduction container 3 is made visible.

[0106] Then, the inventive system 1 according to the embodiment comprises a cyclone 2, an introduction container 3, and an introduction pipe 4.

5 [0107] The cyclone 2 is a publicly known cyclone that utilizes the principle of swirling introduced fluid and treating to be treated materials such as dust, etc. by using centrifugal force thereof, and is a general cyclone that comprises a cyclone body 21 comprising an almost cylindrical body 211 for swirling fluid and an almost conical lower body 212 provided following the lower part of the body, a fluid inlet 22 for introducing the fluid, and an outlet duct 23 for evacuating the fluid.

10 [0108] In addition, the introduction container 3 is a container enclosing at least a part or all of the cyclone body in said cyclone, and exposes said fluid inlet 22 in the said container.

15 [0109] In addition, the introduction pipe 4 is for introducing fluid containing to be treated materials into said introduction container 3, and in general, a transfer tube for transferring to be treated materials discharged from various industries to the neighborhood of the cyclone is used as the introduction pipe.

20 [0110] In the embodiment, fluid containing to be treated materials is introduced from said introduction pipe 4 into said introduction container 3.

25 [0111] As the fluid introduced into the introduction container 3 has no other route to escape than said fluid inlet 22 in the said introduction container 3, the introduced fluid is sequentially fed into the cyclone body 21.

30 [0112] Then, the fluid containing the to be treated materials that was fed into the cyclone body 21 is provided with swirling motion in the cyclone body 21, drops the to be treated materials having a greater gravity than the fluid into the lower part of the cyclone 21, while pressing them against the inner wall of the cyclone body 21, and has treated fluid discharged from the outlet duct 23 for evacuation that is raised near the center of the cyclone body 21.

35 [0113] In fact, in the embodiment, by introducing into the cyclone body 2 the fluid containing to be treated materials through the introduction container 3, rather than directly connecting the introduction pipe 4 and the fluid inlet 22, a junction between the introduction pipe and the fluid inlet is eliminated, and thus the problem of cracks or breakdown resulting from concentration on the said junction of physical load due to strain or vibrations during operation of the cyclone 2 can be solved.

40 [0114] In addition, in the embodiment, by introducing into the cyclone body 21 the fluid containing to be treated materials through the introduction container, rather than directly joining the introduction pipe 4 and the fluid inlet 22, a special welding technique or a connector, etc. is not required, thereby enabling construction of an extremely inexpensive introduction system even in the case in which the diameter cross section (inside diameter, size) or a shape of the introduction pipe 4 and the fluid inlet 22 differs.

**[0115]** Furthermore, provision of a difference between the diameter cross section of the introduction pipe 4 and that of the fluid inlet 22 could control the speed of introducing the fluid into the cyclone body 21. In particular, by making the diameter cross section of the introduction pipe 4 smaller than that of the fluid inlet 22, the speed of introducing the fluid into the cyclone body 21 can be accelerated, thereby considerably improving the treatment efficiency as a result.

**[0116]** In addition, with such the configuration, i.e., by introducing into the cyclone body the fluid containing the to be treated materials through the introduction container 3 rather than directly introducing it into the cyclone body 21, the to be treated materials in the fluid are roughly filtered out to some degree in the introduction container 3, and relatively clean fluid can be introduced into the cyclone body 21 compared with the case in which the fluid is introduced directly into the cyclone through the piping, resulting in the improved treatment efficiency of the fluid.

**[0117]** In addition, in the embodiment, not only the leading end of the fluid inlet 22 is protruded in the introduction container 3, but also the said fluid inlet 22 is such connected that the fluid is introduced from tangential direction toward the inner wall of the cyclone body 21.

**[0118]** This is because, as shown in FIG. 2, if the leading end of the fluid inlet 22 is protruded in the introduction container 3, constant motion energy and directionality, etc. are required for the to be treated materials in the fluid introduced into the introduction container 3 from the inlet 4 to enter the cyclone body 21 from the fluid inlet 22, which thus considerably enhances the rough filtering effect of the to be treated materials in the fluid in the introduction container 3.

**[0119]** In addition, with the said fluid inlet 22 connected so that the fluid is introduced from the tangential direction toward the inner wall of the cyclone body 21, a direction of introducing the fluid into the cyclone 21 can be determined, while passing through said fluid inlet 22, which allows the fluid passing through the fluid inlet 22 to promptly start whirling motion in the cyclone body 21.

#### Embodiment 2

**[0120]** FIG. 3 is a schematic view showing the inventive system 1 according to Embodiment 2, wherein by showing an introduction container 3 in see-through state, inside of the said introduction container 3 is made visible.

**[0121]** Then, the inventive system 1 according to the embodiment comprises a cyclone 2a, a cyclone 2b, an introduction container 3, and an introduction pipe 4.

**[0122]** In fact, the inventive system 1 according to the embodiment is a so-called multi-cyclone system that concurrently uses the plurality of (two) cyclones 2a, 2b, wherein not only one introduction container 3 encloses at least a part or all of respective cyclone bodies 21a, 21b in a plurality of (two) cyclones 2a, 2b, but also respective fluid inlets 22a, 22b in said plurality of (two) cy-

clones 2a, 2b are protruded in the said introduction container 3, which is a multi-cyclone system of a very simple configuration in which the need for complicated piping facilities is eliminated.

**[0123]** In addition, in the embodiment, the configuration is such that a direction of swirling current of one cyclone 2a of the plurality of (two) cyclones 2a, 2b is opposite to a direction of swirling current of the other cyclone 2b, and with such the configuration, noise phases occurring in the respective cyclones are reversed between the cyclones having the different directions of the swirling currents and mutual noise is cancelled, thus making noise to occur very small.

#### Embodiment 3

**[0124]** FIG. 4 is a schematic view showing the inventive system 1 according to Embodiment 3, wherein by showing an introduction container 3 in see-through state, inside of the said introduction container 3 is made visible.

**[0125]** Then, the inventive system 1 according to the embodiment comprises a cyclone 2, an introduction container 3 and an introduction pipe 4, wherein the cylindrical introduction container 3 encloses a cyclone body 21.

**[0126]** In fact, the inventive system 1 according to the embodiment is comprised of a cyclone body 2 enclosed by an almost cylindrical introduction 3, wherein a junction area between the cyclone body 21 and the introduction container 3 expands, thereby further improving durability.

**[0127]** In addition, in the embodiment, the ceiling plane of the cyclone body 21 and the basal plane of the introduction container 3 are formed of common members, i.e., a part of the ceiling plane of the cyclone body 21 and that of the introduction container 3 is commonly used, thus improving durability even further.

**[0128]** Then, in the inventive system 1 according to the embodiment, an almost cylindrical hollow body is used as the introduction container 3, and not only the introduction container 3 encloses the cyclone body 21 but also as the introduction pipe 4 in the said introduction container 3, an introduction pipe that lets fluid introduced from tangential direction toward the inner wall of the said introduction container 3, which provides the fluid containing to be treated materials to be introduced to the said introduction container 3 with swirling motion in the said introduction container 3.

**[0129]** In fact, the inventive system 1 according to the embodiment actively subjects fluid containing to be treated materials to swirling motion in the introduction container 3 before introducing it into the cyclone body 21. With such the configuration, a part or all of the to be treated materials in said fluid cannot move to the upper part in the introduction container 3, i.e., it cannot reach the fluid inlet 22 in the cyclone 2 and repeatedly whirls in the lower or middle part of the introduction container 3. This consequently enables introduction into the cyclone body 21 of relatively clean fluid from which further to be treated materials have been roughly filtered out.

**[0130]** In addition, in the inventive system 1 according to the embodiment, the fluid inlet 22 in the cyclone 2 is opposed to swirling current in the introduction container 3.

**[0131]** In fact, as shown in FIG. 5, in the embodiment, since fluid containing to be treated materials is given swirling motion in the introduction container 3, the to be treated materials in the fluid are pressed against the inner wall of the introduction container, i.e., distribution of the to be treated materials in the fluid is biased to the direction to the inner wall of the introduction container.

**[0132]** Then, in the embodiment, as the fluid inlet in the cyclone is opposed to the swirling direction of the fluid in the introduction container, the fluid can be introduced into the cyclone body 21 with the distribution of the to be treated materials in the fluid biased to the inner wall direction of the introduction container 3 unchanged, thus solving reduction of the treatment efficiency attributable to the introduction state of the to be treated materials in the fluid.

**[0133]** In addition, with such the configuration, since the to be treated materials in the fluid introduced into the cyclone body 21 are well distributed to be treated in extremely short time, length of the cyclone body 21 (and the introduction container 3) can be shortened. Thus, the inventive system can be applied even in the field in which installation space for a long cyclone system cannot be secured, and, for instance, can be installed in the car body, as an emission treatment device, etc., for automobiles.

**[0134]** Now, as shown in FIG. 6A, in the embodiment, if the leading end of the fluid inlet 22 in the cyclone body 21 is arranged by the inner wall of the introduction container 3, fluid with relatively high content of to be treated materials will be introduced into the cyclone body 21.

**[0135]** On the one hand, as shown in FIG. 6B, in the embodiment, if the fluid inlet 22 in the cyclone body 21 is arranged closer to the center than to the inner wall of the introduction container 3, relatively clean fluid will be introduced into the cyclone body.

**[0136]** In fact, when the fluid having the less content of to be treated materials is treated or when a cyclone 2 with higher treatment capacity is used, more to be treated materials may be treated in the cyclone 2 by making the fluid inlet 22 in the cyclone body 21 be by the inner wall of the introduction container 3 and introducing more to be treated materials into the cyclone body 21. On the contrary, when the fluid having more content of to be treated materials is treated or when a cyclone 2 with lower treatment capacity is used, more to be treated materials may be treated in the introduction container 3 by positioning the fluid inlet 22 in the cyclone body 21 closer to the center side than to the inner wall of the introduction container 3.

**[0137]** In addition, in the embodiment as shown in FIG. 7, the configuration may be such that, without fixing the position of the fluid inlet 22, the fluid inlet 22 in the introduction container 3 can be positioned arbitrarily or

changed, as appropriate, depending on the amount of to be treated materials in the fluid. With such the configuration, it becomes possible to handle, as needed, even the case in which the content of to be treated materials in fluid varies.

#### Embodiment 4

**[0138]** FIG. 8 is a schematic view showing the inventive system 1 according to Embodiment 4, wherein by showing an introduction container 3 in see-through state, inside of the said introduction container 3 is made visible.

**[0139]** Then, the inventive system 1 according to the embodiment comprises a cyclone 2, an introduction container 3 and an introduction pipe 4, wherein the cylindrical introduction container 3 encloses a cyclone body 21.

**[0140]** In fact, the almost cylindrical introduction container 3 to be used in the embodiment is such configured that the inside diameter of the said introduction container 3 decreases in phases from the basal plane to the ceiling plane. With such the configuration, the swirling speed of the fluid introduced into the introduction container 3 from the introduction pipe 4 can be accelerated till the fluid reaches the fluid inlet 22 in the cyclone, which can not only provide to be treated materials in the fluid with adequate centrifugal force but also accelerate the introduction speed of the fluid into the cyclone body 21.

**[0141]** In addition, in the embodiment, since the configuration is such that the inside diameter of the said introduction container 3 decreases in phases from the basal plane to the ceiling plane, each stage in the introduction container 3 becomes a barrier, making it difficult for the to be treated materials in the fluid to go beyond the each stage in the introduction container 3, which thus further improves the efficiency of rough filtering in the introduction container 3.

#### Embodiment 5

**[0142]** FIG. 9 is a schematic view showing the inventive system 1 according to Embodiment 5, wherein by showing an introduction container 3 (3a, 3b) in see-through state, inside of the said introduction container 3 (3a, 3b) is made visible.

**[0143]** Then, the inventive system 1 according to the embodiment comprises a cyclone 2, an almost cylindrical introduction container 3 (3a, 3b) and an introduction pipe 4 (4a, 4b).

**[0144]** In fact, since the inventive system 1 according to the embodiment comprises a plurality of (two) introduction containers, wherein to be treated materials in fluid are roughly filtered in the respective introduction containers 3a, 3b, the treatment efficiency as a whole cyclone system can be improved.

**[0145]** In addition, introduction of fluid from the introduction container 3a to the introduction container 3b takes place through the introduction pipe 4b. In the embodiment, the said introduction pipe 4b is such configured

that liquid that is given swirling motion in the introduction container 3a is not only run off from the tangential direction but also is flowed to the inner wall of the introduction container 3b from the tangential direction.

**[0146]** Thus, in the embodiment, the fluid can be introduced into the introduction container 3b with the distribution of the to be treated materials in the fluid biased to the inner wall direction of the introduction container 3a unchanged, and furthermore, the fluid can be introduced into the cyclone body 21 with the distribution of the to be treated materials in the fluid further biased to the inner wall direction of the introduction container 3b.

**[0147]** In addition, in the embodiment, provision of a difference the diameter cross section of in the introduction pipe 4a, introduction pipe 4b, and the fluid inlet 22, respectively could enable control of the introduction speed of the fluid.

#### Embodiment 6

**[0148]** FIG. 10 is a schematic view showing the inventive system 1 according to Embodiment 5, wherein by showing an introduction containers 3 (3a, 3b, 3c) with a part thereof broken away, inside of the said introduction containers 3 (3a, 3b, 3c) is made visible.

**[0149]** Then, the inventive system 1 according to the embodiment comprises a cyclone 2, an almost cylindrical introduction container 3 (3a) and an introduction pipe 4 (4a), and furthermore, said introduction container 3 (3a) is sequentially enclosed by a plurality of (two) different introduction containers 3b, 3c.

**[0150]** In fact, the inventive system 1 according to the embodiment comprises introduction containers that are concentrically provided in layers, wherein as to be treated materials in fluid are roughly filtered out in respective introduction containers 3a, 3b, 3c, the treatment efficiency as a whole cyclone system can be improved.

**[0151]** In addition, those same as the introduction containers 3a can be used as the separate introduction containers 3b, 3c surrounding the introduction container 3a, except that the inside diameters are different. Also in the separate introduction containers 3b, 3c are provided inlets 4b, 4c for introducing fluid, respectively, wherein the inlet 4a in the introduction container 3a is such arranged that it is exposed or protruded within the separate introduction container 3b that surrounds outer side of the innermost layer, and the fluid inlet 4b in the separate introduction container 3b is arranged that it is exposed or protruded within the separate container 3c that surrounds outer side of the second innermost layer, and the fluid containing to be treated materials will be introduced from the introduction pipe 4c provided in the introduction container 3c.

**[0152]** Thus, in the embodiment, the fluid can be introduced into the introduction container 3b with the distribution of the to be treated materials in the fluid biased to the inner wall direction of the introduction container 3c unchanged, then it can be introduced into the introduction

container 3a with the distribution of the to be treated materials in the fluid further biased by one layer to the inner wall direction of the introduction container 3b, and furthermore the fluid can be introduced into the cyclone body 21 with the distribution of the to be treated materials in the fluid biased by one layer to the inner wall direction of the introduction container 3a.

**[0153]** In addition, in the embodiment, provision of a difference in the diameter cross section of the inlet 4a, inlet 4b, inlet 4c, and the fluid inlet 22 could enable control of the introduction speed of the fluid.

#### Embodiment 7

**[0154]** FIG. 11 is a schematic view showing the inventive system 1 according to Embodiment 6, wherein by showing a part of an introduction container 3 in see-through state, inside of the said introduction container 3 is made visible.

**[0155]** Then, the inventive system 1 comprises a cyclone 2, an introduction container 3 and an introduction pipe 4, wherein the almost cylindrical introduction container 3 encloses a cyclone body 21, and furthermore, a catalyst 5 and absorbent 6 are provided in the cyclone body 21 and the introduction container 3.

**[0156]** In fact, the inventive system 1 according to the embodiment gasify a part or all of to be treated materials by subjecting fluid containing to be treated materials to swirling motion in the introduction container 3, and treats remaining to be treated materials that are collected without being gasified and gasified to be treated materials with a catalyst or absorbent provided in the introduction container 3 and the cyclone body. This could significantly extend intervals needed for removal of collected to be treated materials or realize so-called free maintenance.

**[0157]** In addition, as the cyclone 2 to be used in the embodiment does not have to actively collect to be treated materials, a cyclone having no lower part of an almost conical body provided following the lower part of an almost cylindrical body 211 for swirling fluid is used, and the basal plane of the cyclone body 21 and that of the introduction container 3 are formed of common material, i.e., a part of the basal plane of the cyclone body 21 and that of the introduction container 3 are used partly in common, thus further improving durability.

#### INDUSTRIAL APPLICABILITY

**[0158]** The inventive method and the inventive system can suitably treat exhaust gas emitted from various industries such as manufacturing, power generation, construction, waste-disposal, and agriculture, or gas emissions from various transport facilities such as bikes, automobiles, trucks, buses, locomotives and marine vessels, etc. can be listed. In short, the inventive method applies to every type of fluid containing to be treated materials to be generated by some kind of production activities. Therefore, they are not limited to a dust removal

device or an incinerator, but can be applied to kitchen instruments, smokeless roasters, dust collection equipment, air purification system equipment for clean room, an exhaust gas treatment device for marine vessels, construction machinery, agricultural instruments, steam locomotives, diesel locomotives, food scrap treatment device, dehydrator, sawdust separator or leather waste sorter, etc.

## Claims

1. In a cyclone comprising a cyclone body for swirling fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid, a method of introducing into the cyclone body fluid containing to be treated materials, **characterized in that** by not only enclosing at least a part or all of said cyclone body with an introduction container, but also exposing said fluid inlet in the said introduction container, and by introducing the fluid containing the to be treated materials into said introduction container, the method can introduce into the cyclone body the fluid introduced into said introduction unit without continuous piping.
2. The method of introducing into the cyclone body the fluid containing the to be treated materials according to Claim 1, being comprised by protruding the leading end of the fluid inlet in the introduction container.
3. The method of introducing into the cyclone body the fluid containing to be treated materials according to Claim 1 or 2, wherein the introduction container is almost cylindrical, the introduction container encloses the cyclone body, and yet the fluid containing the to be treated materials is introduced from tangential direction of the inner wall of the said introduction container, and the fluid is subjected to swirling motion in said introduction container.
4. A cyclone system for providing fluid containing to be treated materials with swirling motion and treating the to be treated materials in the fluid, the cyclone system **characterized in that** it comprises:
  - a cyclone comprising a cyclone body for swirling the fluid, a fluid inlet for introducing the fluid, and an outlet duct for evacuating the fluid,
  - an introduction container being an container enclosing at least a part or all of said cyclone body, and exposing said fluid inlet in the said container, and
  - an introduction pipe for introducing into the introduction container the fluid containing the to be treated materials.
5. The cyclone system according to Claim 4, wherein it controls the speed of introducing the fluid into the

cyclone body by providing a difference between diameter cross section of the fluid inlet and that of the inlet.

6. The cyclone system according to Claim 4 or 5, wherein not only at least a part of all of the respective cyclone bodies in a plurality of cyclones is enclosed with one introduction container, but also in the said introduction container the leading end of the respective fluid inlets in said plurality of cyclones is exposed in the said introduction container.
7. The cyclone system according to Claim 6, wherein among a plurality of cyclones, a direction of swirling current in half the cyclones are opposite to a direction of swirling current in the remaining half of the cyclones.
8. The cyclone system according to any one of Claim 4 or Claim 7, being comprised by protruding the leading end of the fluid inlet in the introduction container.
9. The cyclone system according to any one of Claim 4 or Claim 8, wherein the cyclone body is enclosed with the introduction container.
10. The cyclone system according to Claim 9, wherein the cyclone body is enclosed with the introduction container.
11. The cyclone system according to Claim 10, wherein the introduction container has the introduction pipe for introducing the fluid from tangential direction toward the inner wall of the said introduction container connected thereto.
12. The cyclone system according to Claim 11, wherein the fluid inlet in the cyclone is opposed to the swirling current in the introduction container.
13. The cyclone system according to Claim 11 or Claim 12, wherein the leading end of the fluid inlet is arranged by the inner wall of the introduction container.
14. The cyclone system according to Claim 11 or Claim 12 wherein the leading end of the fluid inlet is arranged close to the center side than to the inner wall of the introduction container.
15. The cyclone system according to Claim 11 or Claim 12, wherein a position of the leading end of the fluid inlet varies arbitrarily or depending on current speed of the fluid.
16. The cyclone system according to any one of Claim 11 or Claim 15, wherein the inside diameter of a ceiling plane in the introduction container is smaller than that of a basal plane in the said introduction contain-

er.

17. The cyclone system according to Claim 16, wherein the inside diameter of the introduction container decreases in phases from the basal plane to the ceiling plane. 5
18. The cyclone system according to any one of Claim 4 or 17, wherein one or more separate introduction containers sequentially enclose at least a part or all of the introduction containers. 10
19. The cyclone system according to any one of Claim 4 or Claim 18, wherein a catalyst and/or absorbent is present in the introduction container and/or in the cyclone body. 15
20. A dust removal device **characterized in that** it comprises the cyclone system according to any one of Claim 4 or Claim 19. 20
21. An incinerator **characterized in that** it comprises the cyclone system according to any one of Claim 4 or Claim 19. 25
22. An exhaust gas treatment method **characterized in that** it treats exhaust gas discharged from internal combustion engines by using the cyclone system according to any one of Claim 4 or Claim 19. 30

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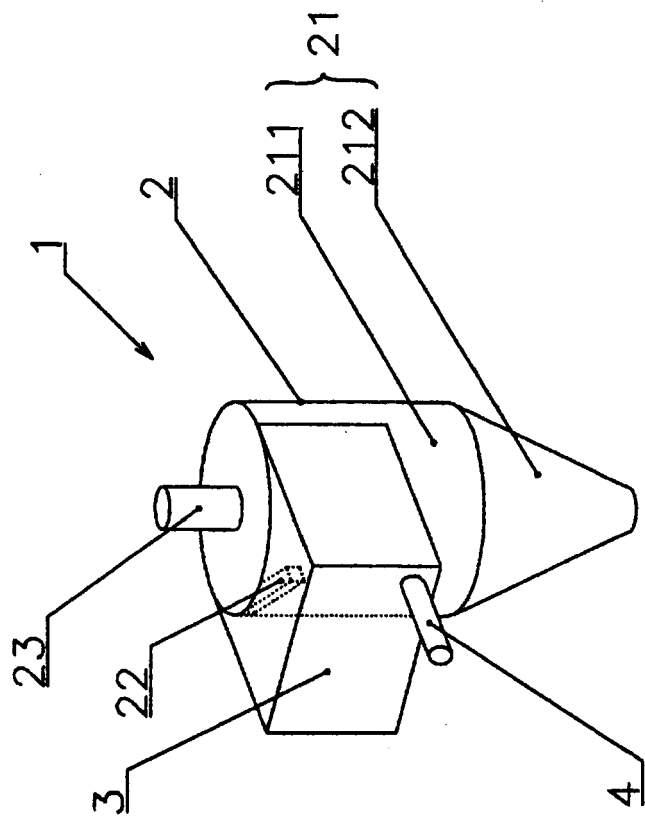


FIGURE 1

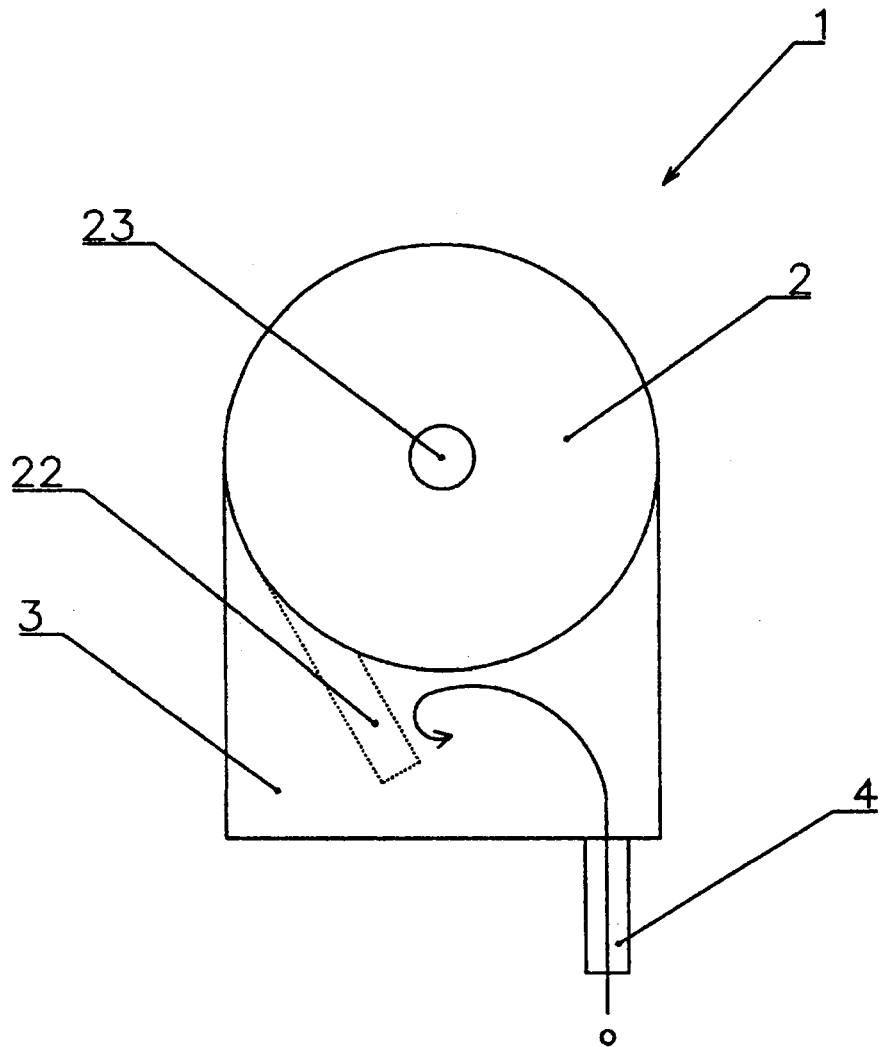


FIGURE 2

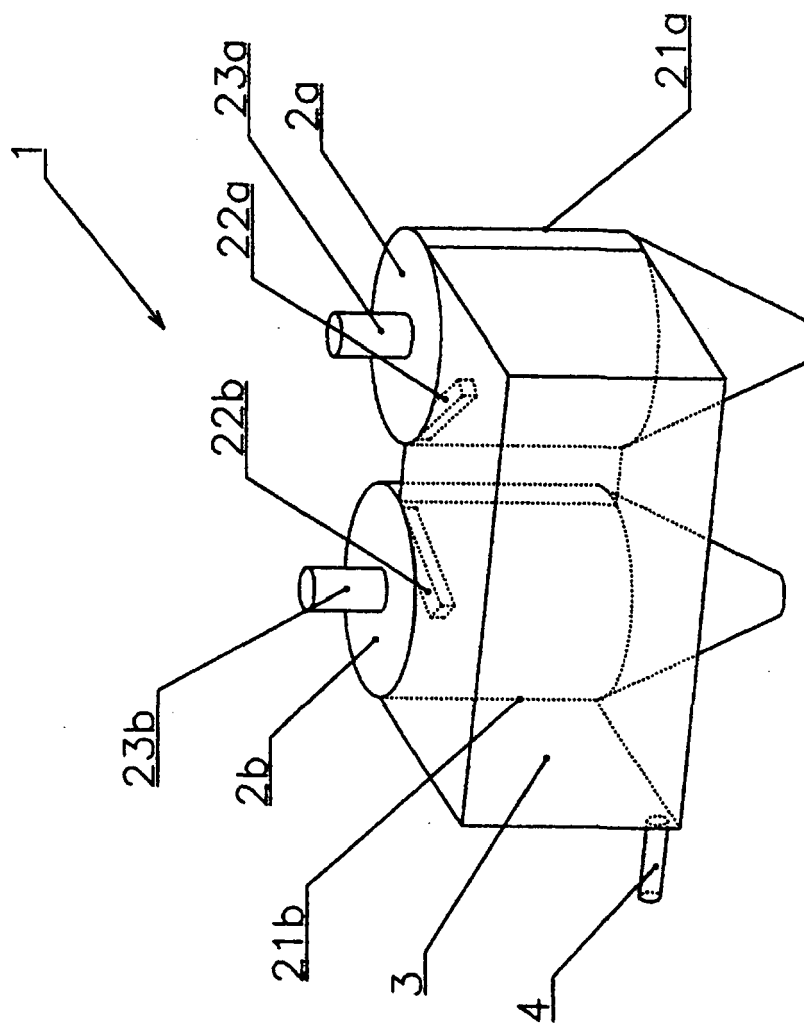


FIGURE 3

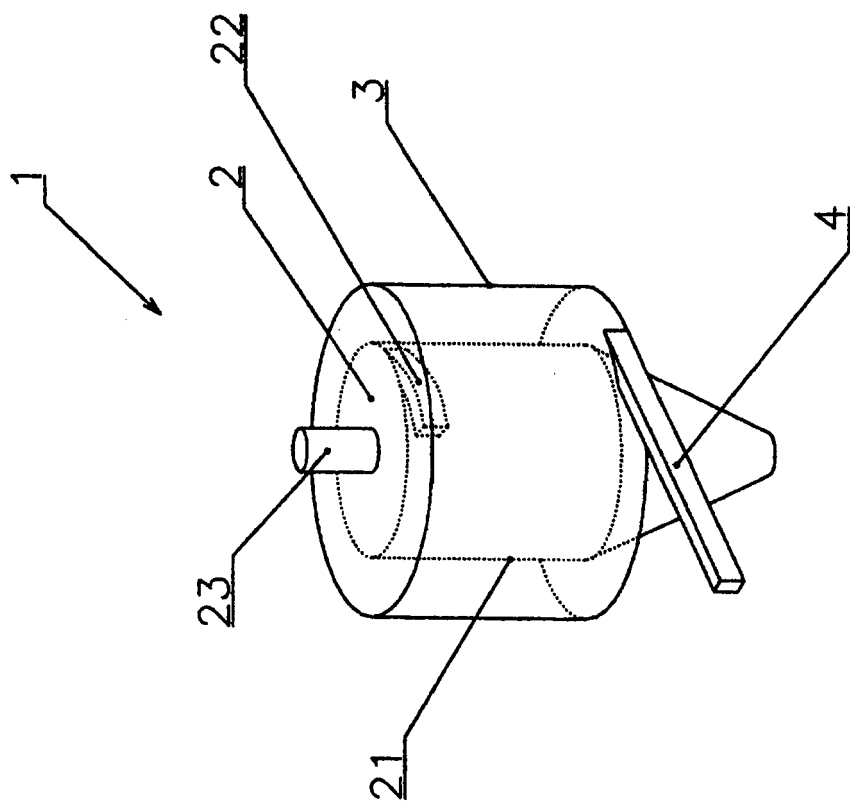


FIGURE 4

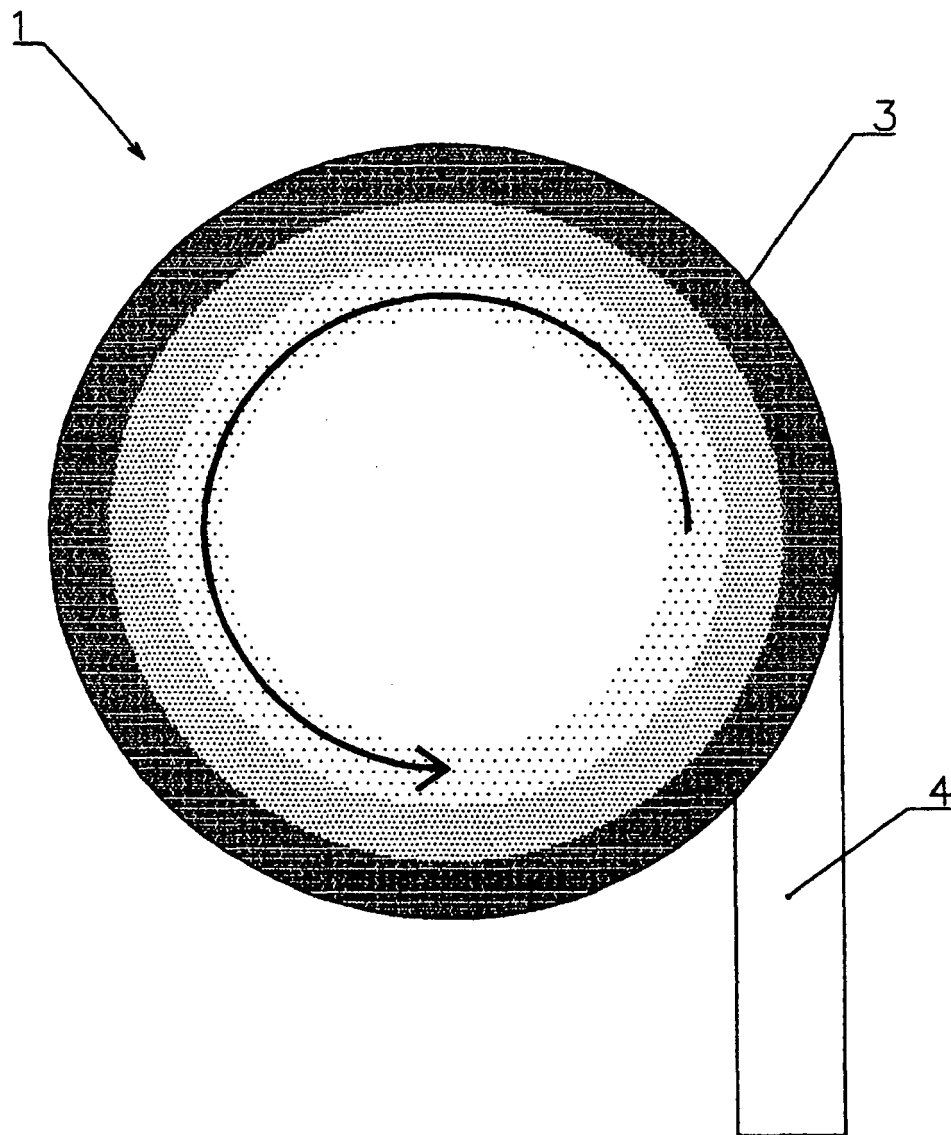


FIGURE 5

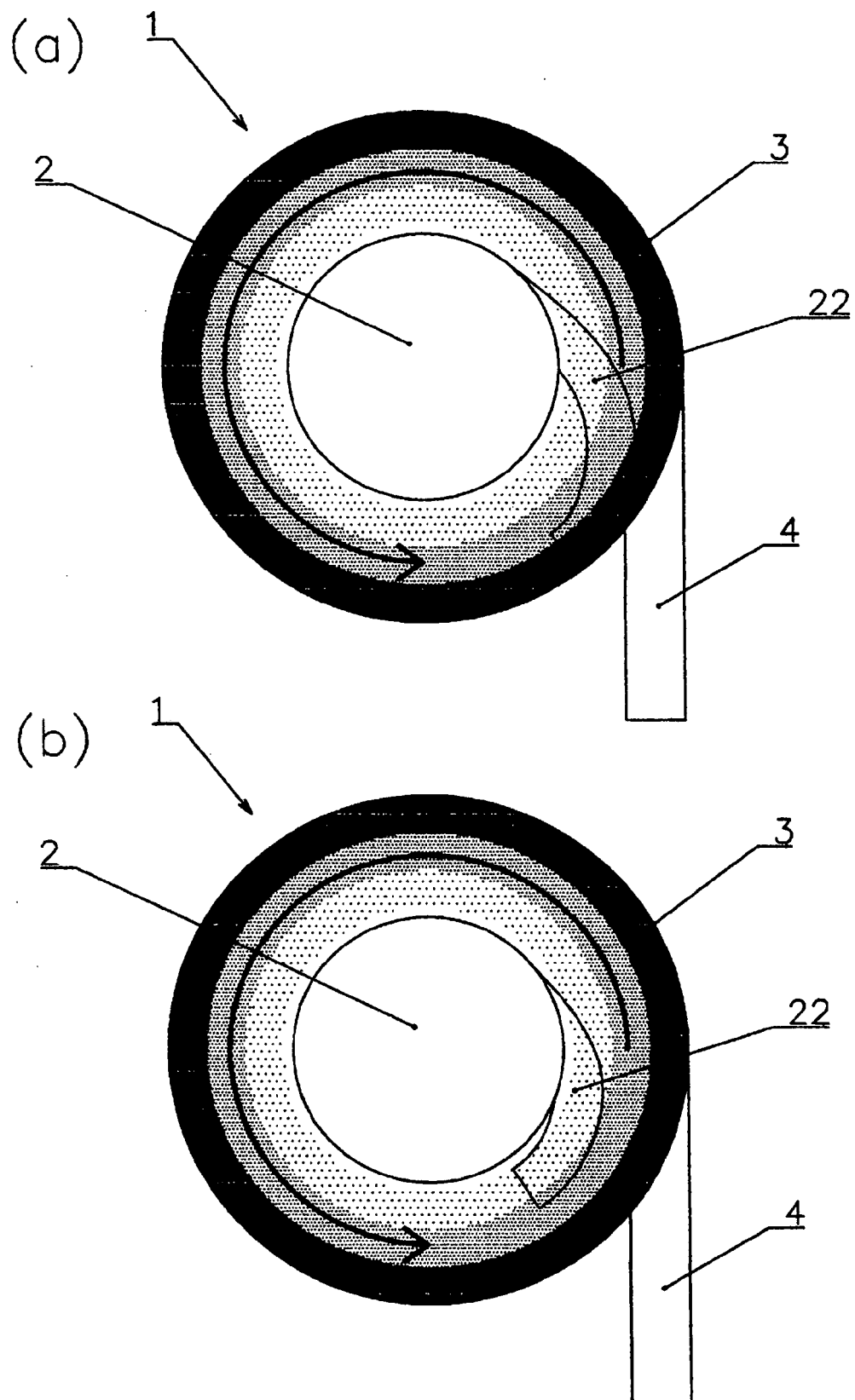


FIGURE 6

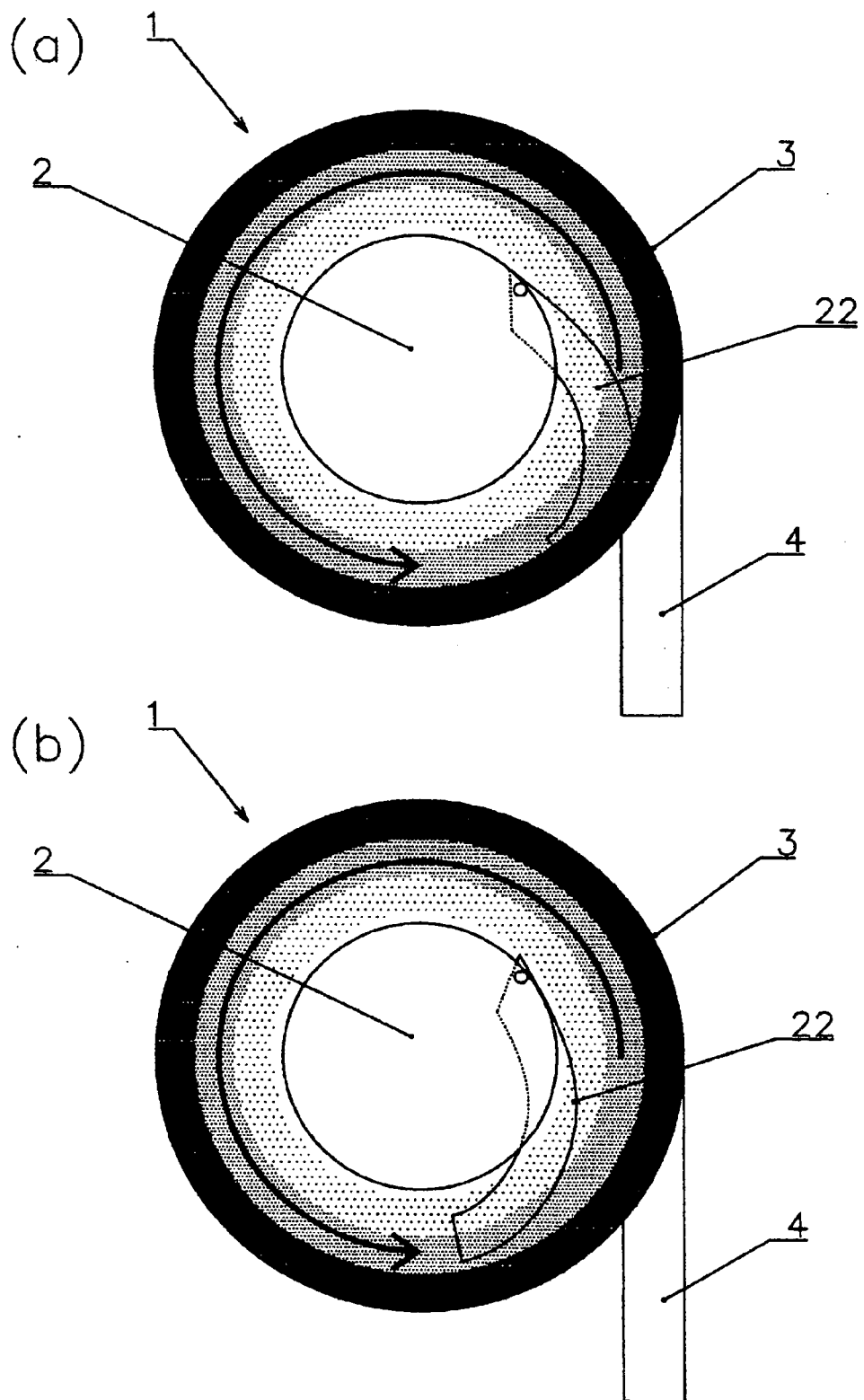


FIGURE 7

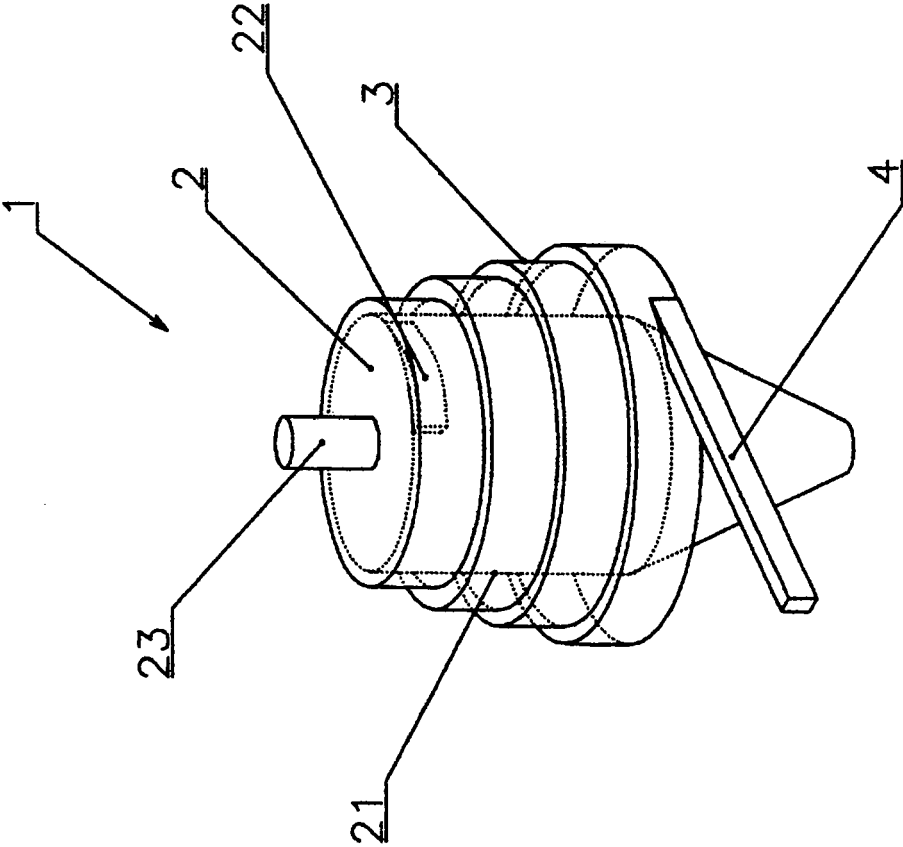


FIGURE 8

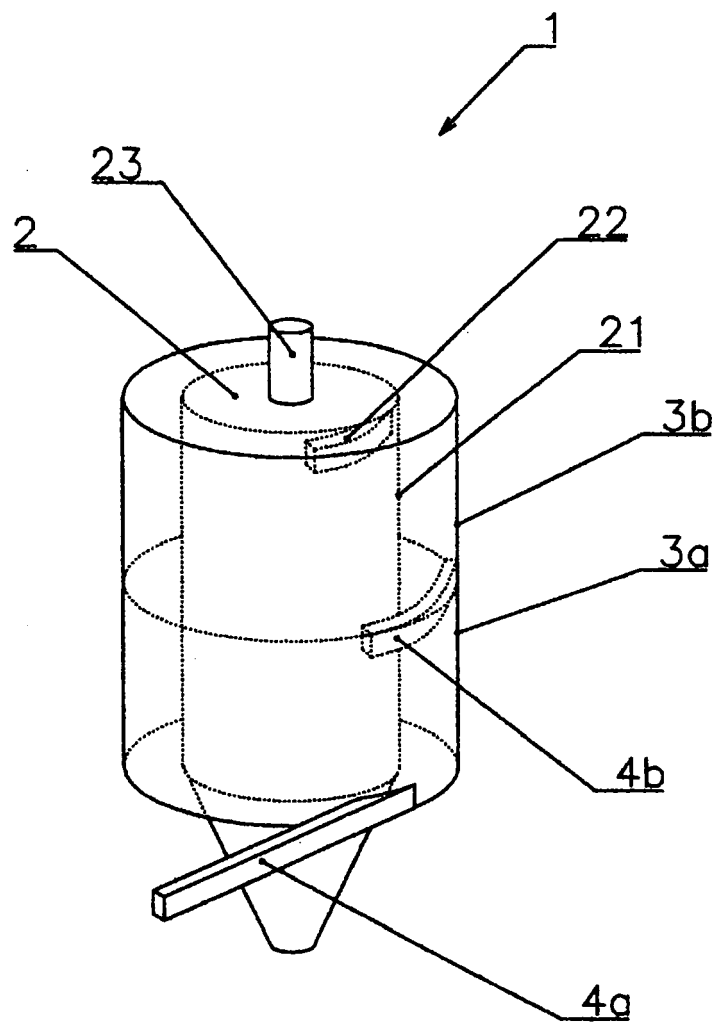


FIGURE 9

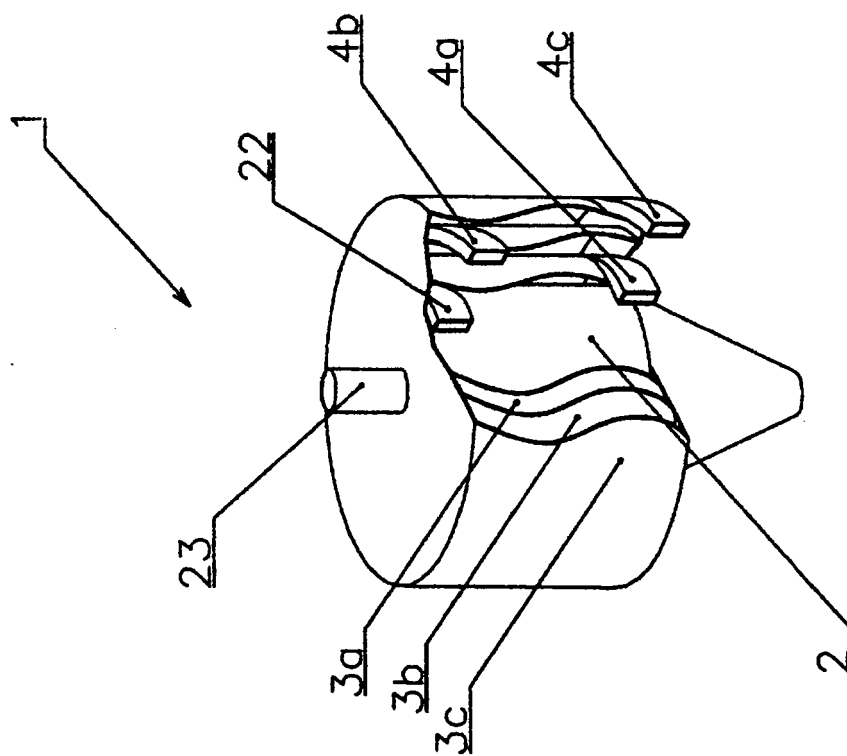


FIGURE 10

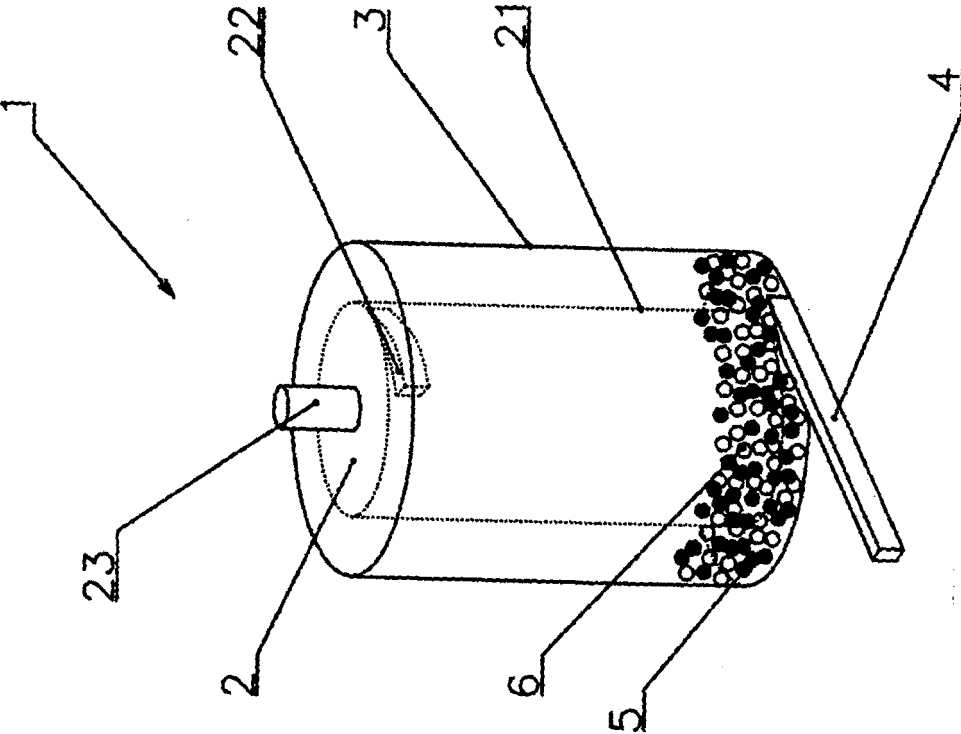


FIGURE 11



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Y	* column 1, line 3 - line 27 *  * column 3, line 34 - column 5, line 26 * * column 5, line 52 - column 6, line 28 * * figures 1,2 *	6,11,13, 20-22	
X	----- US 2005/242007 A1 (SIMPSON PETER) 3 November 2005 (2005-11-03)	1	
Y	* page 3, paragraph 46 * * figures 1-4 *	11,13	
X	----- US 3 720 314 A (PHILLIPPI H,US) 13 March 1973 (1973-03-13)	4	TECHNICAL FIELDS SEARCHED (IPC)  B04C
Y	* column 1, line 2 - line 5 * * column 2, line 9 - line 24 * * figures 1,2 *	20	
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Y	* column 3, line 8 - line 53 * * figures 1-4 *	21	
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-/--			
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>22 May 2006</b>	Examiner <b>Redelsperger, C</b>
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			

EPO FORM 1503 03.82 (P04C01)



European Patent  
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# EUROPEAN SEARCH REPORT

Application Number  
EP 05 25 7883

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The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>22 May 2006</b>	Examiner <b>Redelsperger, C</b>
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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