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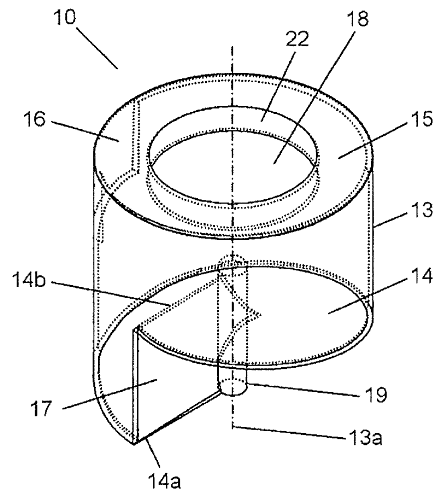
(54) **DUST-CATCHING DEVICE AND AIR CLEANING DEVICE USING SAME**

(57) The dust-catching device is provided with a swirl generation unit (10) placed within an air passage, and a dust-catching chamber, which collects and stores dirt and dust that has been separated at the swirl generation unit (10). The swirl generation unit (10) has a cylindrical casing (13) having an air flow inlet (17) disposed at the upstream side of the air passage, an air flow outlet (18) disposed at the downstream side within the air passage, and an ejection outlet (16) for dirt and dust which is disposed on the outer periphery portion which is connected to an aperture of the dust-catching chamber. In addition, the swirl generation unit (10) is provided with a spiral gyration promoting surface (14), which promotes gyration of air, disposed at the upstream side of the air passage of the cylindrical casing (13). Furthermore, the air flow inlet (17) is formed from two sides including the gyration promoting surface (14), and a portion of the sidewall of the cylindrical casing (13) as another side.

Fig.3



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Description

FIELD

[0001] The present invention relates to a dust collecting device that swirls dust-contained air to separate and collect dust and an air purifier using the dust collecting device.

BACKGROUND

[0002] Such type of a dust collecting device, which is generally referred to as a cyclonic type, separates dust from air using centrifugal force to obtain purified air. Here, purified air refers to air having a decreased dust concentration after flowing through a dust collecting device compared to before flowing through the dust collecting device.

[0003] A conventional type of a known dust collecting device will be described below (e.g., refer to patent document 1).

[0004] The conventional dust collecting device will now be described with reference to Fig. 9.

[0005] As illustrated in Fig. 9, a conventional dust collecting device includes a tubular casing 101. The tubular casing 101 includes a tubular airflow inlet 102 in one end and a tubular airflow outlet 103 in the other end. The casing 101 also accommodates a spiral vane 104 used for swirling air. The outer circumferential surface of the casing 101 includes a dust exit 105, which discharges dust separated from dust-contained air. Additionally, the conventional dust collecting device includes a dust container 106, which is connected to the dust exit 105 and stores dust.

[0006] A conventional type of another known dust collecting device will be described below (e.g., refer to patent document 2).

[0007] The conventional dust collecting device will now be described with reference to Fig. 10.

[0008] As illustrated in Fig. 10, the conventional dust collecting device includes a tubular casing 107. The tubular casing 107 includes an airflow inlet 108 arranged on the upstream side surface and extending in a tangential direction and an airflow outlet 109 arranged at the downstream side and discharging air in the axial direction of the casing 107. Additionally, a dust exit 110, which discharges dust separated from dust-contained air out of the casing 107, is arranged on the outer circumferential surface of the casing 107 located toward the airflow outlet 109. Further, the conventional dust collecting device includes a dust container 111, which is connected to the dust exit 110 and stores the dust.

[0009] In the dust collecting device illustrated in Fig. 9, dust-contained air flows from the tubular airflow inlet 102 into the casing 101 in the same direction as the axial direction of the casing 101. The spiral vane 104 deflects the current of the dust-contained air by approximately 90° in the casing 101. Thus, the dust-contained air is swirled when flowing in the axial direction of the casing 101 along the spiral vane 104 and the side surface of the casing 101.

[0010] In this structure, the direction of the air current changes at the inlet portion. This increases the pressure loss.

[0011] Additionally, when the dust collecting device is used in an upright position (airflow inlet located in a lower position and airflow outlet located in an upper position), the airflow inlet 102 is oriented downward. When installed in this manner, the airflow inlet 102 is blocked. Thus, an L-shaped joint or the like needs to be used to provide the airflow inlet 102 with an inlet surface that lies sideward. Thus, an additional component needs to be connected. This increases the size of the dust collecting device.

[0012] Further, a location between the tubular airflow inlet 102 and the spiral vane 104, that is, a location where the air current is deflected by approximately 90°, is narrower than the airflow inlet 102. This also increases the pressure loss.

[0013] In the dust collecting device illustrated in Fig. 10, dust-contained air flows in the tangential direction of the tubular casing 107 and then along the circumference of the casing 107. Thus, the dust-contained air is swirled when flowing in the axial direction of the casing 107 to the airflow outlet 109.

[0014] To obtain a sufficient swirling current in the casing 107, an air passage (i.e., airflow inlet 108) extending from the tubular casing 107 in the tangential direction is necessary. Thus, a component and space for the air passage are necessary when forming a dust collecting device. Additionally, when widening the opening of the airflow inlet 108 toward the axis of the tubular casing 107 to decrease the inflow speed in the airflow inlet 108 and reduce the pressure loss, interference increases between the entering air current and the swirling current. This may result in a failure to obtain a sufficient swirling current in the tubular casing 107 or form an unnecessary whirl. Thus, the pressure loss would be increased.

PRIOR ART DOCUMENTS

[0015]

Patent Document 1: Japanese Laid-Open Patent Publication No. 2004-129783

Patent Document 2: Japanese Laid-Open Patent Publication No. 2000-157463

SUMMARY

[0016] As described above, a component is necessary for a conventional dust collecting device so that the airflow inlet is not closed, and the entire size is increased.

[0017] Also, the conventional dust collecting device has a structure in which the direction of an air current changes in the inlet portion. This increases the pressure loss.

[0018] Additionally, in the other conventional dust collecting device, there is a large interference of the entering flow with the swirling flow due to the location of the opening of the airflow inlet. This increases the pressure loss.

[0019] In this regard, the present invention provides a dust collecting device that reduces pressure loss and is miniaturized and an air purifier using the dust collecting device.

[0020] A dust collecting device of the present invention includes a whirl formation unit and a dust collection chamber. The whirl formation unit is arranged in a blow passage for air containing dust and forms a whirl. The dust collection chamber collects and stores dust separated by the whirl generation unit. The whirl formation unit includes a tubular casing including an air inflow port arranged at an upstream side of air flowing through the blow passage, an air outflow port arranged at a downstream side of the air flowing through the blow passage, and a dust discharge port arranged in a circumferential portion connected to an opening of the dust collection chamber. The whirl formation unit also includes a spiral swirl enhancement surface formed around a center axis extending through a center of the tubular casing and arranged at an upstream side of the air flowing through the blow passage in the tubular casing. The inflow port includes two sides lying along the swirl enhancement surface and another side lying along a portion of a side wall of the tubular casing. Planes of the inflow port and the discharge port each have a parallel relationship with an axial direction of the center axis.

[0021] In the dust collecting device of the present invention, the planes of the inflow port and the discharge port each have a parallel relationship with the axial direction of the center axis. Thus, the inflow port does not project from the tubular casing. This reduces the size of the device.

[0022] Additionally, the dust collecting device of the present invention allows the inflow port to be largely widened to the proximity of the axis of the tubular casing without interference of an incoming air current entering the inflow port with a swirling current in the tubular casing. This limits the inflow speed of the air current and thus reduces the pressure loss.

[0023] Further, in the dust collecting device of the present invention, air is not suddenly deflected in the dust collecting device and smoothly moves from the inflow port to the swirl enhancement surface. This reduces the pressure loss.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Fig. 1 is a diagram of a first embodiment of an air purifier according to the present invention.

Fig. 2A is a perspective view of a dust collecting device of the first embodiment according to the present invention.

Fig. 2B is a side view of the dust collecting device of the first embodiment according to the present invention.

Fig. 3 is a perspective view of a whirl formation unit of the first embodiment according to the present invention.

Fig. 4 is a diagram of a second embodiment of an air purifier according to the present invention.

Fig. 5 is a perspective view of a dust collecting device of the second embodiment according to the present invention.

Fig. 6 is a perspective view of the dust collecting device of the second embodiment according to the present invention.

Fig. 7 is a diagram of the air purifier of the second embodiment according to the present invention.

Fig. 8 is a perspective view of a main portion of the dust collecting device of the second embodiment according to the present invention.

Fig. 9 is a cross-sectional view illustrating a conventional dust collecting device.

Fig. 10 is a cross-sectional view illustrating another conventional dust collecting device.

EMBODIMENTS OF THE INVENTION

[0025] Embodiments of the present invention will be described below with reference to the drawings.

[First Embodiment]

[0026] A first embodiment of a dust collecting device and an air purifier using the dust collecting device according to the present invention will now be described with reference to the drawings.

[0027] Fig. 1 is a diagram of the first embodiment of an air purifier according to the present invention.

[0028] As illustrated in Fig. 1, an air purifier 30 includes a body 1, an air inlet 2 located in a lower portion of the body 1, an air outlet 3 located in an upper portion of the body 1, a dust collecting device 4, an air filter 5, a deodorization filter 6, and an air blower 7, which are located inside the air purifier 30.

[0029] The body 1 includes a case 1a, which is vertically elongated and has the form of a tetragonal post, a base 1b hooding the air purifier 30 upright, and poles 1c connecting the case 1 a and the base 1 b.

[0030] Although not illustrated in the drawings, the air inlet 2 is surrounded by a grille, which is arranged around the dust collecting device 4 and includes gaps.

[0031] When the air blower 7 is driven, dust-contained air is drawn from the air inlet 2, which is located at the lower portion, and dust is removed by the dust collecting device 4. Further fine dust, which is not removed by the dust collecting device 4, is captured by the air filter 5 arranged at the downstream side of the dust collecting device 4. Thus, the air is further purified. Such purified air flows through the air blower 7 and is discharged from the air outlet 3.

[0032] In the present embodiment, the case of the air purifier 30 has the form of a tetragonal post. However, the case of the air purifier 30 may have a different form, such as the form of a tube or a polygonal post other than a tetragonal post.

[0033] The air filter 5 includes two pleated filtering members, which are box-shaped. The filtering members are arranged to be V-shaped. Thus, a large area of the filtering member may be obtained using little space. In this structure, the large area of the filtering member decreases the speed of air passing through the filtering member. This reduces the pressure loss. Additionally, this structure allows the pressure loss to rise gradually as the deposition of dust increases. Thus, the air filter 5 may be used over a long time.

[0034] The air filter 5 is not limited to the V-shaped arrangement and may be arranged to be reversed-V-shaped, horizontal, parallel, or the like. Alternatively, the shape of the air filter 5 may be tubular. When the shape is tubular, air may flow from the outside of the tube to the inside or from the inside of the tube to the outside. Either structure may be used in the present embodiment.

[0035] The deodorization filter 6 is arranged at the downstream side of the air filter 5. In the deodorization filter 6, a frame, which functions to maintain the form of a filter, is thoroughly covered by granular activated carbon. Molecules that would produce an odor are adsorbed by the adsorption effect of activated carbon. This results in deodorization. Also, the use of granular activated carbon increases the surface area and further improves the deodorization effect.

[0036] Instead of activated carbon, the deodorization filter 6 may have a different structure such as that using a catalyst. Alternatively, activated carbon may have a honeycomb structure.

[0037] The air blower 7 uses a turbo fan that produces a flow of air in the circumferential direction. Thus, a guide 8, which is arranged around the air blower 7, changes the direction of the air flow upward so that the air is discharged from the air outlet 3. The air blower 7 may include a sirocco fan, a diagonal flow fan, or the like.

[0038] The structure of the dust collecting device 4 will now be described.

[0039] As illustrated in Figs. 2A, 2B, the dust collecting device 4 includes a whirl formation unit 10, a dust collection chamber 11, and a connector 12 connecting the two.

[0040] Although not illustrated in Fig. 1, one dust collection chamber 11 is arranged in a lower central portion of the air purifier 30 and surrounded by eight whirl formation units 10.

[0041] As illustrated in Figs. 2A, 2B, eight dust inflow ports 20, arranged in a tubular outer portion of the dust collection chamber 11, are respectively in communication with the whirl formation units 10. The dust inflow ports 20 are connected to the whirl formation units 10 by the connectors 12, respectively. Each of Figs. 2A, 2B illustrates a single representative whirl formation unit 10.

[0042] In this manner, any number of the whirl formation units 10 may be connected to a single dust collection chamber 11. However, it is desirable that the number of the whirl formation units 10 be determined by considering the dust capturing performance, pressure loss, power of the air blower 7, noise, and the like in a comprehensive manner. Additionally, a lower portion of the dust collection chamber 11 includes a removable dust collection tray 9. The lower portion of the dust collection chamber 11 has a separable structure allowing the dust collection tray 9 to slide sideward for removal to facilitate disposal of the collected dust.

[0043] As illustrated in Fig. 3, the whirl formation unit 10 includes a tubular casing 13, a spiral swirl enhancement surface 14, an outflow surface 15, and a rib 22. In Fig. 3, the single-dashed line indicates a center axis 13a extending through the center of the tubular casing 13.

[0044] The tubular casing 13 includes a discharge port 16 in the circumferential surface at the downstream side (upper portion in Fig. 3). The discharge port 16 functions as an opening for discharging dust. The discharge port 16 is connected to one of the dust inflow ports 20 of the dust collection chamber 11 by the connector 12, which is illustrated in Figs. 2A, 2B.

[0045] At the upstream side (lower portion in Fig. 3) of the tubular casing 13, the tubular casing 13 is cut and shaped along the swirl enhancement surface 14. Thus, an upstream end plane of the tubular casing 13 and the circumference of the swirl enhancement surface 14 are connected. This is as if the upstream side of the tubular casing 13 is covered by the swirl enhancement surface 14. Such a structure forms an opening, that is, the opening between an initial end 14a and a terminal end 14b of the swirl enhancement surface 14. This opening serves as an inflow port 17 of the whirl formation unit 10.

[0046] In the present embodiment, the swirl enhancement surface 14 is a surface continuous for 360 degrees from the initial end 14a to the terminal end 14b. Thus, a vertical plane lying where the initial end 14a and the terminal end 14b overlap in a plan view defines the inflow port 17. However, the swirl enhancement surface 14 may be a surface continuous for 360 degrees or more from the initial end 14a to the terminal end 14b. In this case, the inflow port 17 is defined by an opening formed between the initial end 14a and the swirl enhancement surface 14. Further, the swirl enhancement surface 14 may be less than 360 degrees, and a gap of approximately a few millimeters may be formed between the initial end 14a and the terminal end 14b when the swirl enhancement surface 14 is viewed from the downstream side (upper side in Fig. 3) of the tubular casing 13. In this case, when the swirl enhancement surface 14 is manufactured using molds, a draft angle may be set so that the molds contact each other at where the inflow port 17 is located. This simplifies manufacturing.

[0047] The outflow surface 15 includes an opening that is smaller than the inner diameter of the tubular casing

13. The opening defines an outflow port 18 of the whirl formation unit 10. In the present embodiment, the outflow surface 15 is formed to be perpendicular to the axis of the tubular casing 13. However, for example, the outflow surface 15 may be gradually inclined toward the central portion and the upstream side (lower side in Fig. 3).

[0048] The rib 22 is shaped to project from the open end of the outflow port 18 toward the upstream side. It is desirable that the projection length R of the rib 22 be 0.01 to 0.2 times longer than the diameter ϕ of the tubular casing 13. In the present embodiment, the projection length is 0.1 times longer than the diameter ϕ of the tubular casing 13.

[0049] The rib 22 serves as a resistance when a swirling current flows through the outflow port 18 toward the downstream side. The resistance prevents dust contained in the swirling current from flowing toward the downstream side. This further improves the dust capturing performance. When the projection length R is set to be greater than 0.2 times longer than the diameter ϕ of the tubular casing 13, the resistance directly acts on the air flow. This increases the pressure loss. However, dust may be captured without the rib 22.

[0050] A center rod 19 is arranged in the center of the swirl enhancement surface 14 and coupled to the spiral surface. In this structure, the center rod 19 supports the swirl enhancement surface 14. This increases the strength of the swirl enhancement surface 14.

[0051] The inflow port 17 includes four sides. Two sides lie along the swirl enhancement surface 14, another side lies along a portion of the side wall of the tubular casing 13, and the remaining side lies along the center rod 19 arranged along the center axis 13a extending through the center of the tubular casing 13.

[0052] In the present embodiment, the center rod 19 has a length from the initial end 14a to the terminal end 14b of the swirl enhancement surface 14. However, the center rod 19 may be extended from the initial end 14a of the swirl enhancement surface 14 to the outflow surface 15. In this structure, from the terminal end 14b of the swirl enhancement surface 14 to the outflow surface 15, the center rod 19 may be formed to have a diameter that gradually increases toward the outflow surface 15. In this case, the void in which the air flows in the tubular casing 13 gradually narrows toward the downstream side of the air flow. This increases the swirl speed of the air. Consequently, centrifugal force received by dust is increased, and the dust capturing performance is improved.

[0053] The dust collection chamber 11, which is tubular, includes the dust inflow ports 20 in an upper portion of the circumferential surface. The dust collection chamber 11 also includes the connectors 12 each projecting from around one of the dust inflow ports 20 toward an outer side of the dust collection chamber 11. The discharge port 16 of each whirl formation unit 10 is connected to the dust collection chamber 11 by a connector 12. The dust separated by the whirl formation unit 10 flows through the dust inflow port 20 and is captured in the dust collection chamber 11. The shape of the dust collection chamber 11 is not limited to a tube and may be a tetragonal post, a polygonal post, or the like.

[0054] The connector 12 is a member connecting the dust discharge port 16 of the whirl formation unit 10 and the dust inflow port 20 of the corresponding dust collection chamber 11. Gaps are eliminated from portions connected to the connector 12 so that there is no air leakage.

[0055] The dust collection principle of the dust collecting device 4 in the present embodiment will now be described.

[0056] In Fig. 2A, the current of air is indicated by the arrows. The air enters the inflow port 17, forms a swirling current in the whirl formation unit 10, and exits the outflow port 18.

[0057] In this case, in the swirling current, dust (grains or fibers having weight) suspended in the air receives centrifugal force acting from the center of the tubular casing 13 toward the circumference. The dust, which receives the centrifugal force, moves toward the circumference and swirls near the circumference (near the inner wall surface of the tubular casing 13). When moving past the discharge port 16 arranged in the circumferential surface of the tubular casing 13, the dust, to which the centrifugal force is applied, is forced out the tubular casing 13 through the discharge port 16.

[0058] Then, the dust moves through the connector 12 and enters the dust collection chamber 11. Here, the inertial force produced during the swirling is retained. Thus, the dust continues to somewhat fly in the dust collection chamber 11 but falls into the dust collection chamber 11 due to gravity.

[0059] Other than the dust inflow ports 20, the dust collection chamber 11 includes no openings. Thus, not much air flows from the whirl formation units 10 to the dust collection chamber 11 and vice-versa. Still, a certain amount of air moves in and out.

[0060] In this case, in Fig. 2B, a lower surface of the connector 12 is inclined downward toward the dust collection chamber 11. The dust that collects on the inclined surface receives force directed toward the dust collection chamber 11 and produced by the inclination and the gravity. This limits the return of dust from the dust collection chamber 11 to the whirl formation units 10 even when a certain amount of air moves in and out.

[0061] In the whirl formation unit 10, dust is swirled and directed toward the downstream side (upper portion in Fig. 3). Dust swirled near the center rather than near the inner wall surface of the tubular casing 13 may not be discharged from the discharge port 16. However, when providing the outflow surface 15, the dust strikes the outflow surface 15 and cannot move further toward the downstream side. The dust, on which the centrifugal force resulting from the swirling continues to act, moves along the outflow surface 15 toward the inner wall surface of the tubular casing 13 and then moves from the discharge port 16 to the dust collection chamber 11. For this reason, the outflow surface 15 improves the dust capturing performance.

[0062] It is assumed that dust strikes the outflow surface 15. Thus, the outflow port 18 formed in the outflow surface 15 needs to be smaller than the inner diameter of the tubular casing 13. Additionally, the outflow port 18 is arranged so that the center of the outflow port 18 of the outflow surface 15 lies along the center axis 13a of the tubular casing 13. This structure hinders dust, which continues to swirl even when striking the outflow surface 15, from exiting the outflow port 18. When the center of the outflow port 18 lies along the center axis 13a of the tubular casing 13, the distance from the inner wall surface of the tubular casing 13 to the outflow port 18 may be uniform throughout the entire circumference of the outflow port 18. Thus, it is difficult for continuously swirling dust to move to the outflow port 18 against the centrifugal force. This minimizes the amount of dust exiting the outflow port 18. Thus, the dust capturing performance may be improved.

[0063] It is preferred that the discharge port 16 be arranged at the downstream side of the air inflow port 17 (in Fig. 3, upper side from the inflow port 17) so that dust is discharged as much as possible. This is because time is necessary for centrifugal force to move dust toward the inner wall surface of the tubular casing 13. If the discharge port 16 is located near the air inflow port 17, dust would move toward the downstream side of the discharge port 16 before moving to the inner wall surface of the tubular casing 13. Thus, much dust would not be discharged.

[0064] To discharge more dust, in the present embodiment, the discharge port 16 is arranged at the most downstream side of the tubular casing 13, that is, a portion that is in contact with the outflow surface 15. This maximizes the time for dust to receive the centrifugal force and move toward the inner wall surface of the tubular casing 13. Consequently, the amount of dust exiting the discharge port 16 may be increased. Additionally, dust, which strikes the outflow surface 15 and moves toward the inner wall surface of the tubular casing 13, may be smoothly discharged from the discharge port 16. This improves the dust capturing performance. Although the shape of the discharge port 16 is tetragonal, there is no limit to such a configuration.

[0065] As illustrated in Fig. 2B, distance D of the tubular casing 13 in the axial direction is the sum of distance Ds of the inflow port 17 in the axial direction and distance Du from a downstream end of the inflow port 17 to the outflow surface 15. In the present embodiment, the ratio of distance Ds to distance Du is Ds:Du=1:0.9 to 2. When distance Ds is 1 and distance Du is less than 0.9, the void between the swirl enhancement surface 14 and the outflow surface 15 becomes narrow. This increases pressure loss. When distance Du is greater than 2 relative to distance Ds, the time in which a swirling current contacts the wall surface of the tubular casing 13 becomes long. This weakens the swirling current due to contact friction with the wall surface and decreases the dust capturing performance. Therefore, when distance Ds is 1 and distance Du is 0.9 to 2, more desirably, 1 to 1.5, the dust capturing performance may be improved without any increases in the pressure loss.

[0066] The inflow port 17 will now be described.

[0067] The inflow port 17 is located at the inner side of the circumference of the tubular casing 13 at the upstream side (lower portion in Fig. 3) of the tubular casing 13. The current of air entering the inflow port 17 is directed orthogonal to the inflow port 17, which is defined by the initial end 14a and the terminal end 14b of the swirl enhancement surface 14. The swirl enhancement surface 14 includes a spiral surface extending toward the downstream side (upper portion in Fig. 3). The swirl enhancement surface 14 smoothly changes the direction of the current of air entering the inflow port 17 toward the downstream side (upper portion in Fig. 3). At the same time, the inner wall of the tubular casing 13 transforms the air to a smoothly swirling current. That is, the current of the air entering the inflow port 17 forms a swirling current smoothly directed toward the downstream side.

[0068] Thus, the current of air is not suddenly changed, for example, deflected by 90°. In the present embodiment, the whirl formation unit 10 of the dust collecting device 4 reduces the pressure loss. Additionally, in the structure, the inflow port 17 is integrally formed by the swirl enhancement surface 14 and the tubular casing 13 instead of projecting from the tubular casing 13. Thus, there is no need for an additional space for inflow and a component to provide such space. This reduces the size of the whirl formation unit 10.

[0069] Further, in the present embodiment, the width of the inflow port 17 may be freely set and thus may be increased toward the center rod 19. More specifically, the width of the inflow port 17 may be freely set in accordance with the diameter of the center rod 19. When the diameter of the center rod 19 is reduced or the center rod 19 is not used, the width of the inflow port 17 may be increased. This widens the area of the inflow port 17 and decreases the air speed. Thus, pressure loss caused by the entrance of air may be decreased.

[0070] In a conventional dust collecting device such as that illustrated in Fig 10, it is difficult to increase the width of the inflow port 17 toward the center of a swirling current as described above.

[0071] As illustrated in Fig. 10, a swirling current is formed in the tubular casing 107. The swirling current is formed caused by the airflow inlet 108 extending in the tangential direction connected to the upstream side surface of the casing 107. Air enters the casing 107 through the airflow inlet 108 in the tangential direction and then swirls along the inner wall of the casing 107. In this structure, the air swirling in the casing 107 joins and somewhat interferes with the fresh air entering the airflow inlet 108.

[0072] In such a structure, when the width of the airflow inlet 108 is increased toward the center of the swirling current as much as possible, the area of the airflow inlet

108 is widened. This decreases the speed of inflow air. However, this also increases interference of the swirling current in the casing 107 with the air entering the airflow inlet 108. Thus, the entering air interferes with the swirl. Consequently, an unnecessary whirl is formed. This increases the pressure loss and the weakened swirling current would decrease the dust capturing performance. Therefore, in a conventional dust collecting device such as that illustrated in Fig. 10, the width of the airflow inlet 108 cannot be increased toward the center of the swirling current.

[0073] In the present embodiment, the width of the inflow port 17 may be increased toward the center of the swirling current without the need for space. This allows the whirl formation unit 10 to be miniaturized and reduces the pressure loss. Additionally, the planes of the inflow port 17 and the discharge port 16 each have a parallel relationship with the axial direction of the center axis 13a extending through the center of the tubular casing 13. Thus, the current of air, which enters the inflow port 17 and forms a swirling current constantly flowing parallel to the center axis 13a, moves in the axial direction of the tubular casing 13. Then, dust is smoothly discharged from the discharge port 16 located at the downstream side.

[0074] As illustrated in Fig. 1, in the dust collecting device 4 of the present embodiment, a plurality of whirl formation units 10 may be arranged for one dust collection chamber 11. In this case, in correspondence with each whirl formation unit 10, a dust inflow port 20 is arranged in the dust collection chamber 11 and connected to the whirl formation unit 10 by a connector 12.

[0075] When one wishes to increase the processed air amount, the number of whirl formation units 10 that are used may be increased. This increases the processed air amount without any increases in the pressure loss.

[0076] As illustrated in Fig. 1, in the air purifier 30 using eight whirl formation units 10, when the air is the rated maximum air amount, all of the eight whirl formation units 10 are used to process the air. Thus, the pressure loss is limited. Additionally, when one wishes to decrease the air amount of the air purifier 30, for example, when one wishes to operate at one eighth of the rated maximum air amount, seven whirl formation units 10 may be closed so that air does not flow. In this case, the amount of air flowing to the single whirl formation unit 10 is the same as the air amount when using eight whirl formation units 10 in the rated maximum air amount. Thus, the flow speed of the swirling current in the whirl formation unit 10 is not decreased, and centrifugal force received by dust is unchanged. This allows the air amount to be decreased while maintaining the dust capturing performance. In this manner, the present embodiment provides the air purifier 30 that allows the capturing performance of the dust collecting device 4 to be maintained over a wide range of the air amount.

[0077] Additionally, the layout of the whirl formation units 10 with respect to the single dust collection chamber 11 is not limited to a tetragonal arrangement along the inner wall of the case 1a illustrated in Fig. 1 and may be a circular arrangement around the dust collection chamber 11. Alternatively, for example, when eight whirl formation units 10 are arranged in 4 units × 2 rows, a dust collection chamber 11 having an elongated shape may be arranged between the rows. In this manner, the dust collecting device 4 may have any shape in accordance with the shape of the air purifier 30.

[0078] The dust collecting device 4 of the present embodiment is not limited to that in which the forward direction of the swirling current is an upward direction as described above. For example, in Figs. 2A, 2B, the dust collecting device 4 may be used when reversed upside down. In this case, there is the need for a sufficient space for storing dust from the dust inflow ports 20 in a direction of gravity. Alternatively, the dust collecting device 4 illustrated in Figs. 2A, 2B, may be used sideward by rotating the dust collecting device 4 90 degrees. Also, in this case, sufficient space is needed to collect dust from the dust inflow ports 20 in the gravitational direction. In this manner, the dust collecting device 4 of the present embodiment may be changed to any direction.

[Second Embodiment]

[0079] A second embodiment of a dust collecting device and an air purifier using the dust collecting device according to the present embodiment will now be described with reference to the drawings.

[0080] As illustrated in Fig. 4, the dust collecting device 4 and the air blower 7, which is located below the dust collecting device 4, are arranged in a blow passage 23 of the air purifier 30. The air blower 7 forms an air current in the blow passage 23. The air current passes through the dust collecting device 4.

[0081] As illustrated in Figs. 5 and 6, the dust collecting device 4 includes whirl formation units 10, which swirls passing air and centrifugally separates dust, and a dust collection chamber 11, which collects and stores the separated dust. Each whirl formation unit 10 includes a tubular casing 13, a swirl enhancement surface 14, an inflow port 17, an outflow port 18, a discharge port 16, and an outflow surface 15. In detail, the spiral swirl enhancement surface 14 used for swirling an air current is arranged in the tubular casing 13, and the inflow port 17 for drawing in air is arranged in one end of the tubular casing 13. Additionally, the outflow surface 15, in which the outflow port 18 is formed, is arranged on the other end of the tubular casing 13, and the discharge port 16 for discharging dust to the dust collection chamber 11 is arranged in a side surface of the tubular casing 13.

[0082] In the dust collection chamber 11, at least two voids are formed by a partition 24. Each void is connected to the discharge port 16 of a whirl formation unit 10. Each void and the whirl formation unit 10, which is connected to the void, are treated as a set. Each set includes an opening-closing unit 25 that opens and closes the outflow port 18 of the whirl formation unit 10.

[0083] Figs. 5, 6, 7 each illustrate a mode in which the dust collection chamber 11 is separated by a single partition 24 to form two sets.

[0084] Fig. 6 illustrates that the opening-closing unit 25 is open in each set. In this situation, for example, when the rated air amount is 200 m^3/h, the amount of air flowing in the whirl formation unit 10 of each set is 100 m^3/h.

[0085] When the output of the air blower 7 is decreased and the entire air amount is decreased to 100 m^3/h, which is half of the rated value, the air amount of each whirl formation unit 10 is 50 m^3/h. Thus, the speed of the air current is decreased to one-half. When the speed of the air current is decreased, centrifugal force received by dust in the air current is also decreased. This decreases the dust capturing efficiency.

[0086] In this case, when the opening-closing unit 25 is closed in one of the two sets, air current is not formed in the whirl formation unit 10 of the closed set.

[0087] A case in which an air current is not formed in the whirl formation unit 10 of one of the two sets will now be described with reference to Fig. 7. In Fig. 7, to distinguish the two sets, different reference characters are given to components having the same function.

[0088] As illustrated in Fig. 7, in a left set 26a, a case in which a left opening-closing unit 25a is closed to block a left outflow port 18a will now be described. In this case, air is drawn from a right inflow port 17b of a right set 26b by the suction force of the air blower 7. Then, as indicated by the arrow in the drawing, the air forms an air current and swirls in a right whirl formation unit 10b. Dust in the swirling air current receives centrifugal force and moves to the inner wall of the right whirl formation unit 10b. The dust passes through a right discharge port 16b and enters the dust collection chamber 11. The air current, which swirls in the right whirl formation unit 10b, passes through a right outflow port 18b and moves toward the air blower 7.

[0089] In the left set 26a, the left opening-closing unit 25a closes the left outflow port 18a. Thus, an air current from the left outflow port 18a toward the air blower 7 is not formed. Further, in the dust collection chamber 11, the partition 24 prevents the air current from being joined between the left set 26a and the right set 26b. Thus, a passage through which air flows from the left inflow port 17a via the left discharge port 16a, the dust collection chamber 11, the right discharge port 16b, and the right whirl formation unit 10b to the right outflow port 18b is not formed.

[0090] When one of the left opening-closing unit 25a and a right opening-closing unit 25b is closed, the corresponding one of the left outflow port 18a and a right outflow port 18b is blocked. Consequently, an air current is only formed in one of a left whirl formation unit 10a of the left set 26a and the right whirl formation unit 10b of the right set 26b. When the entire air amount is decreased from 200 m^3/h to 100 m^3/h, one of the left opening-closing unit 25a and the right opening-closing unit 25b is accordingly closed. This maintains the air speed of the air current passing through one of the left whirl formation unit 10a and the right whirl formation unit 10b and prevents a decrease in the efficiency of dust collection.

[0091] In the present embodiment, the air blower 7 is a blowing fan or the like. In Fig. 4, the air blower 7 and the dust collecting device 4 are illustrated separately in the blow passage 23. However, the air blower 7 only needs to form an air current in the whirl formation units 10 of the dust collecting device 4 illustrated in Fig. 5. Thus, the dust collecting device 4 and the air blower 7 may be formed integrally.

[0092] As illustrated in Fig. 5, an outflow surface 15 is arranged on the upper end surface of each tubular casing 13 so that the outflow port 18 of the whirl formation unit 10 has a smaller diameter than the tubular casing 13. That is, the opening of the outflow surface 15 at an inner side functions as the outflow port 18.

[0093] When receiving centrifugal force, dust in an air current is discharged from the discharge port 16 to the dust collection chamber 11 as the dust swirls near the inner wall surface of the tubular casing 13. However, some of the dust flows out of the outflow port 18 due to induction force of the air current. Here, the upper end surface of the tubular casing 13 includes the outflow surface 15 having the opening that is smaller than the diameter of the tubular casing 13. In such a structure, dust does not flow out of the outflow port 18 together with the air current and repeats the swirling under the outflow surface 15 as compared to a structure in which the upper end surface of the tubular casing 13 is entirely open. This increases the opportunities in which dust, which is repetitively swirled, is discharged from the discharge port 16 to the dust collection chamber 11. Thus, the dust capturing efficiency will be improved in the dust collecting device of the present embodiment.

[0094] The shape of the outflow port 18 is determined in correspondence with the shape of the outflow surface 15. Taking into consideration the pressure loss of an air current, it is preferred that the shape of the outflow port 18 be circular. Although a smaller diameter of the outflow port 18 improves the efficiency of dust collection, a smaller diameter increases the pressure loss. Thus, a designer determines the optimal diameter in accordance with the capacity of the air blower 7 and design parameters, such as the dimensions of the device to obtain the set air amount, the set air speed in the whirl formation unit 10, and the like.

[0095] The opening-closing unit 25 only needs to be shaped to completely close the outflow port 18. For example, as illustrated in Fig. 8, a stem 27 may project from a portion of the circumference of a discoid block plate 28, which is coupled to a hinge 29, so that the block plate 28 functions as a lid of the outflow port 18 to open and close when an end of the stem 27 functions as a shaft.

[0096] Although the dust collection chamber 11 is box-shaped in the drawings, the dust collection chamber 11 may be shaped to be circular or the like.

[0097] As described above, a dust collecting device of the present invention is located in a blow passage of dust-contained air and includes a whirl formation unit forming a whirl and a dust collection chamber storing dust separated by the whirl formation unit. The whirl formation unit includes an inflow port arranged in one end located at the upstream side of air flowing through the blow passage, an outflow port arranged in the other end located at the downstream side of the air flowing through the blow passage, and a tubular casing including a discharge port, which is arranged in a peripheral portion and connected to an opening of the dust collection chamber. The whirl formation unit also includes a spiral swirl enhancement surface, which is arranged at the upstream side of the air flowing through the blow passage of the tubular casing and formed around a center axis extending through the center of the tubular casing. Additionally, the inflow port is defined by two sides of the swirl enhancement surface and a portion of the side wall of the tubular casing, which serves as another side. The planes of the inflow port and the discharge port each have a parallel relationship with the axial direction of the center axis. In this structure, the inflow port exists in an inner side of the circumference of the tubular casing 13. Thus, the inflow port does not project from the tubular casing. This eliminates the need for space for the inflow port and reduces the size of the entire device.

[0098] Additionally, even when the air inflow port is largely widened to the proximity of the axis of the center axis of the tubular casing, an incoming air current, which enters the air inflow port, does not interfere with a swirling current in the tubular casing. This limits the inflow speed of the air current and reduces the pressure loss.

[0099] Further, the air entering the air inflow port smoothly moves from the inflow port to the swirl enhancement surface without a sudden deflection. This allows the formation of a swirling current, which is a whirl, while reducing the pressure loss. Additionally, due to the swirling current, centrifugal force acts on dust, and the dust may be smoothly discharged from the discharge port.

[0100] Additionally, the dust collecting device of the present invention may include an outflow surface arranged on the downstream end and including an opening that is smaller than the inner diameter of the tubular casing.

[0101] Due to the swirl enhancement surface, dust-contained air moves and swirls toward the downstream side. While the air is discharged from the opening arranged in the outflow surface, centrifugal force acts on swirling dust due to its weight. Thus, the swirling dust acts to move close to the circumferential surface of the tubular casing. Here, the outflow surface blocks dust that has not completely moved close to the circumference of the tubular casing. Such dust moves along the outflow surface and close to the circumference caused by the centrifugal force. This enhances separation of the dust from the air exiting the opening of the outflow surface and improves the dust capturing performance.

[0102] In the dust collecting device of the present invention, distance D of the tubular casing in the axial direction is the sum of distance Ds of the inflow port in the axial direction and distance Du from the downstream end of the inflow port to the outflow surface. Preferably, the relationship of distance Ds and distance Du is Ds:Du=1:0.9 to 2.

[0103] This allows a swirling current, which is formed by the swirl enhancement surface, to continue a sufficient swirl from the downstream end of the inflow port to the outflow surface. Thus, the dust capturing performance may be improved.

[0104] The dust collecting device of the present invention may have a structure in which the center of the opening of the outflow surface is aligned with a portion of the center axis of the tubular casing. This reduces the opportunities in which dust, swirled close to the circumference of the tubular casing, encounters the opening the outflow surface throughout the circumferential direction. Thus, the separation of dust from the air may be increased, and the dust capturing performance may be further improved.

[0105] In the dust collecting device of the present invention, a dust discharge port may be arranged toward the air outflow port from the air inflow port. This ensures an increase in the time during which dust is swirled. Thus, a larger amount of dust moves close to the circumference of the tubular casing. This increases the amount of dust exiting the discharge port and further improves the dust capturing performance.

[0106] In the dust collecting device of the present invention, the dust discharge port may be arranged adjacent to the outflow surface. Consequently, dust may easily enter the dust discharge port when striking the outflow surface and then moving along the outflow surface close to the circumference of the tubular casing. This further improves the capturing performance.

[0107] In the dust collecting device of the present invention, the open end of the outflow surface may include a rib projecting toward the inside of the tubular casing. The relationship of the diameter ϕ of the tubular casing and the projection length R of the rib may be $R=(0.01 \text{ to } 0.2)\times\phi$.

[0108] When a swirling current in the tubular casing moves toward the outflow port, the rib functions as a resistance and prevents dust from flowing together with the swirling current. This further improves the dust capturing performance.

[0109] Additionally, an air purifier of the present invention includes a body including an air inlet and an air outlet, an air blower accommodated in the body, and the dust collecting device of the present invention arranged in the blow passage, through which air flows with the air blower. Further, the air purifier of the present invention may have a structure in which dust-contained air is drawn from the air inflow port of the dust collecting device and the air, from which dust is removed by the whirl formation unit of the dust collecting device, is blown out from the air outlet.

[0110] This allows for use as the air purifier. When located and used in a place where dust-contained air exists, dust is removed from the air. Thus, ambient air may be purified.

INDUSTRIAL APPLICABILITY

[0111] The dust collecting device of the present invention may be miniaturized and reduces the pressure loss. Thus, the dust collecting device of the present invention is applicable to a dust collecting device and an air purifier that separate and collect dust in various processed air amounts.

DESCRIPTION OF REFERENCE CHARACTERS

[0112]

1	body
1a	case
1b	base
1c	pole
2	air inlet
3	air outlet
4	dust collecting device
5	air filter
6	deodorization filter
7	air blower
8	guide
9	dust collection tray
10	whirl formation unit
10a	left whirl formation unit
10b	right whirl formation unit
11	dust collection chamber
12	connector
13	tubular casing
13a	center axis
14	swirl enhancement surface
14a	initial end
14b	terminal end
15	outflow surface
16	discharge port
16a	left discharge port
16b	right discharge port
17	inflow port
18	outflow port
18a	left outflow port
18b	right outflow port
19	center rod
20	dust inflow port
22	rib
23	blow passage
24	partition
25	opening-closing unit
25a	left opening-closing unit
25b	right opening-closing unit
26a	left set
26b	right set
27	stem
28	block plate
29	hinge
30	air purifier

Claims

1. A dust collecting device comprising:

a whirl formation unit arranged in a blow passage for air containing dust and configured to form a whirl; and
a dust collection chamber configured to collect and store dust separated by the whirl generation unit,
the dust correcting device **characterized in that**:

the whirl formation unit includes
a tubular casing including an air inflow port arranged at an upstream side of air flowing through the blow passage, an air outflow port arranged at a downstream side of the air flowing through the blow passage, and a dust discharge port arranged in a circumferential portion connected to an opening of the dust collection chamber, and
a spiral swirl enhancement surface formed around a center axis extending through a center of the tubular casing and arranged at an upstream side of the air flowing through the blow passage in the tubular casing;
the inflow port includes two sides lying along the swirl enhancement surface and another side lying along a portion of a side wall of the tubular casing; and
planes of the inflow port and the discharge port each have a parallel relationship with an axial direction of the center axis.

2. The dust collecting device according to claim 1, wherein:

an outflow surface is arranged at a downstream side of the air flowing through the blow passage in the tubular casing; and
the outflow surface includes the outflow port, which is smaller than an inner diameter of the tubular casing.

3. The dust collecting device according to claim 2, wherein a relationship between a distance Ds of the inflow port in the axial direction of the center axis and a distance Du from a downstream end of the inflow port to the outflow surface is set to Ds:Du=1:0.9 to 2.

4. The dust collecting device according to claim 2, wherein a center of the outflow port of the outflow surface is aligned with an axial line of the center axis of the tubular casing.

5. The dust collecting device according to claim 1, wherein the discharge port is arranged between a downstream end of the swirl enhancement surface and the outflow port.

6. The dust collecting device according to claim 4, wherein the discharge port is arranged adjacent to the outflow surface.

7. The dust collecting device according to claim 2, wherein
an end of the outflow port includes a rib projecting into the tubular casing, and
a relationship between a diameter ϕ of the tubular casing and a projection length R of

8. An air purifier comprising:

a body including an air inlet and an air outlet;
an air blower arranged in the body; and
a dust collecting device according to any one of claims 1 to 7, the dust collecting device being arranged in the blow passage through which air delivered by the air blower flows,
wherein the air purifier is configured to draw in dust-contained air from the inflow port of the dust collecting device and blow out air, from which dust is removed by the whirl formation unit of the dust collecting device, from the discharge port.

Fig.1

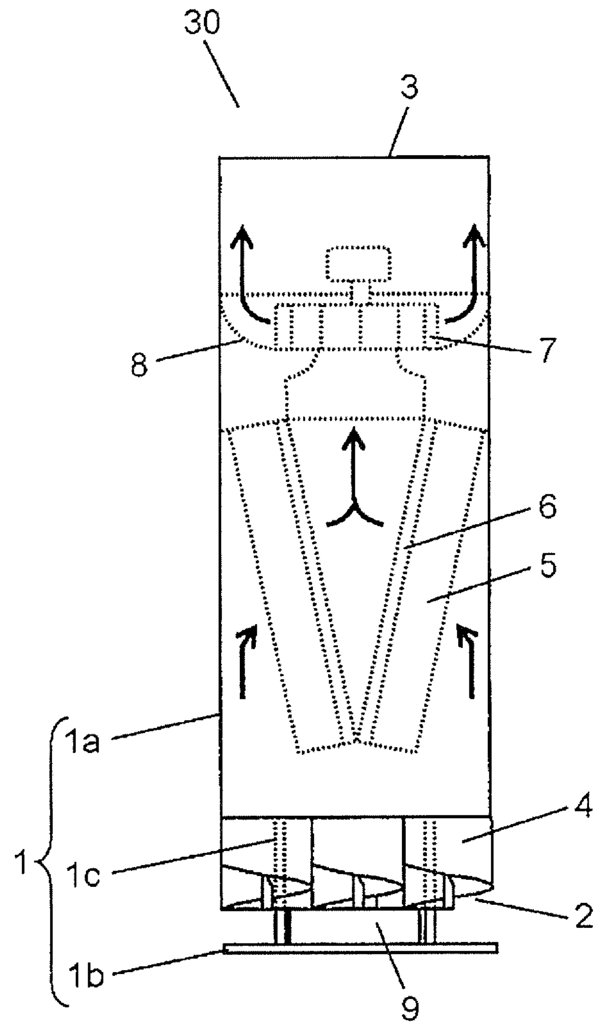


Fig.2A

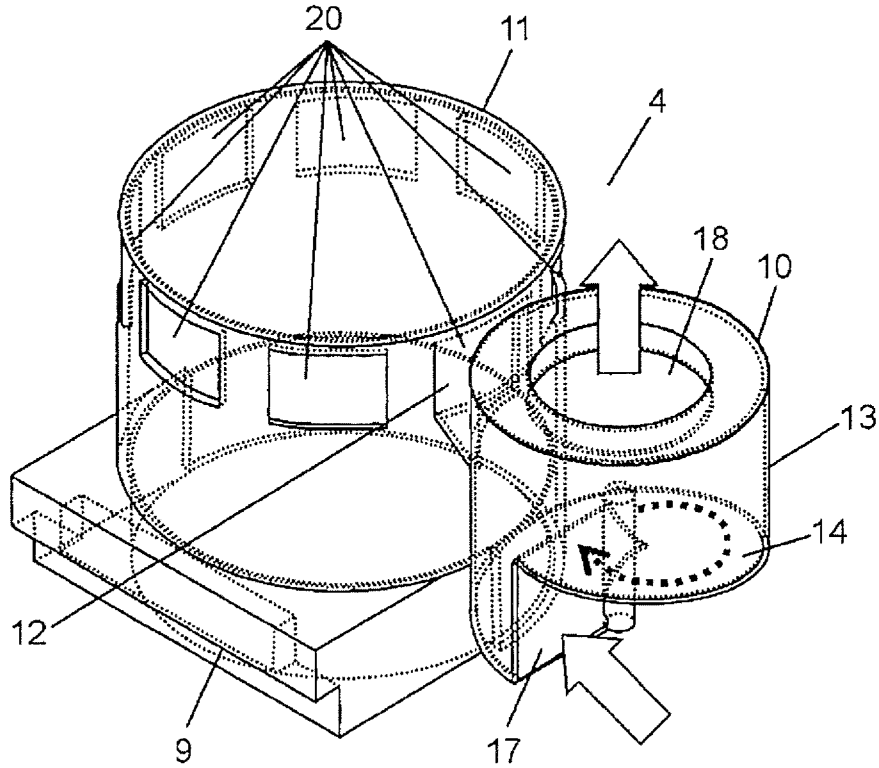


Fig.2B

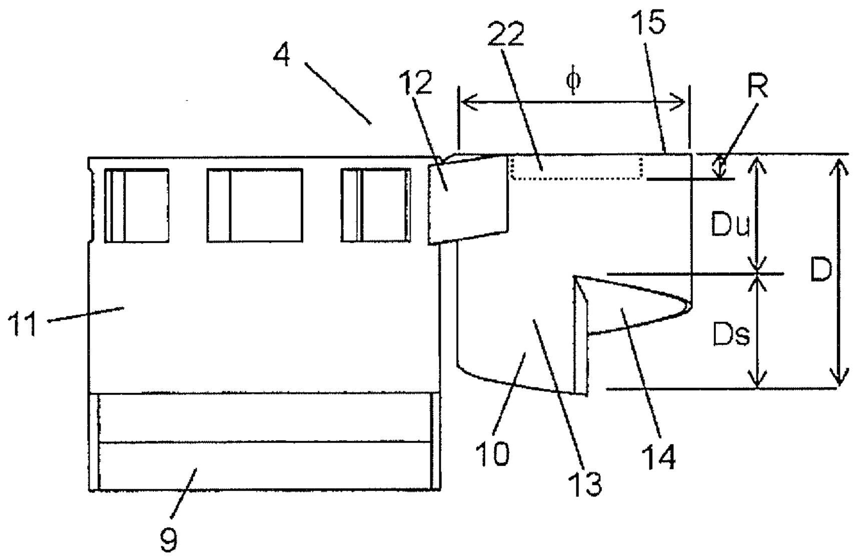


Fig.3

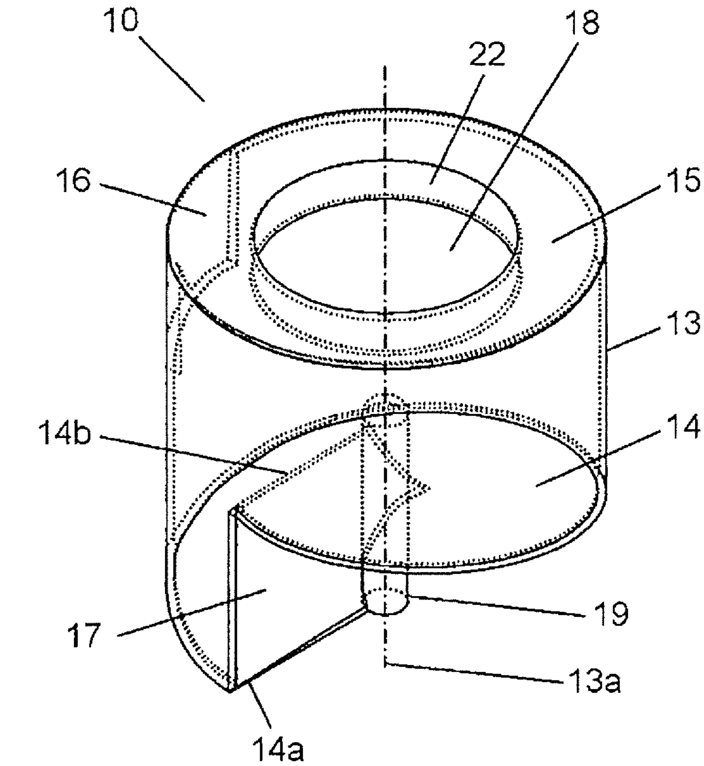


Fig.4

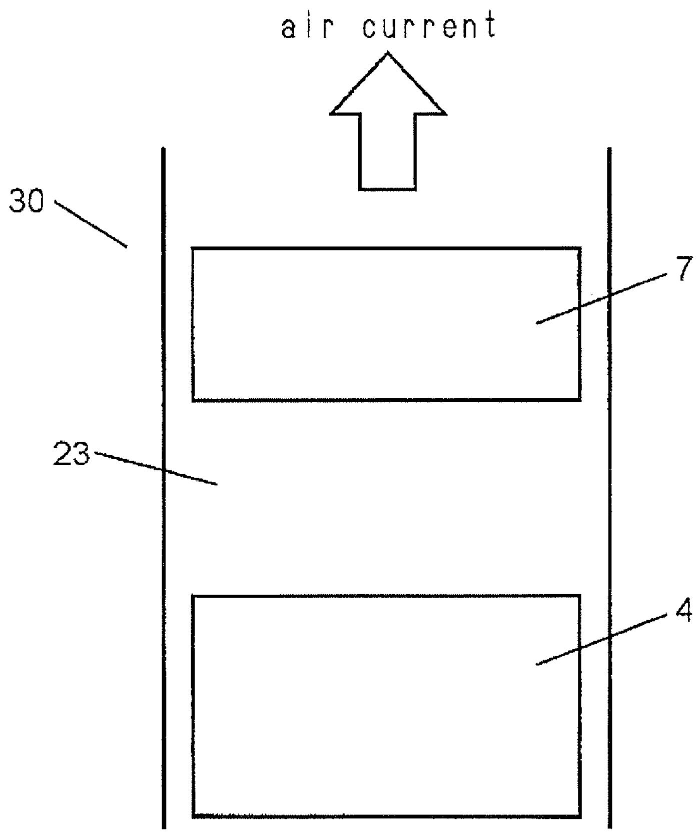


Fig.5

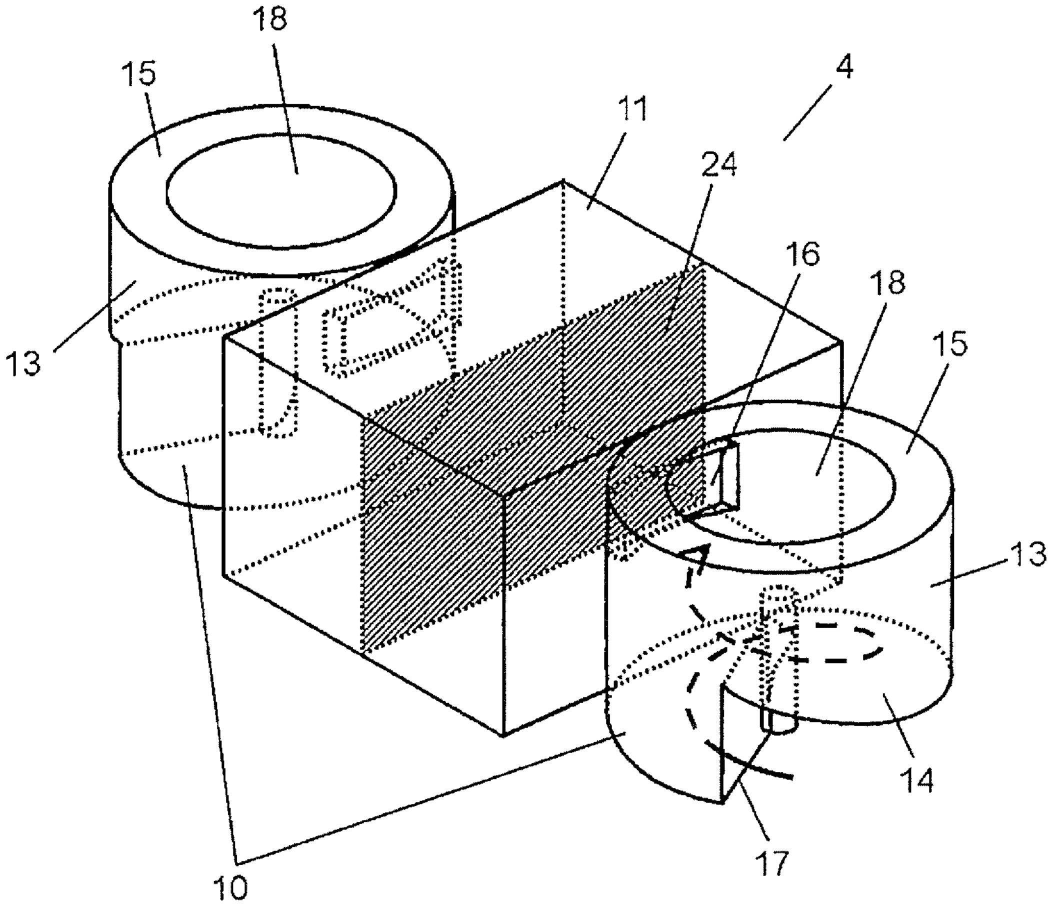


Fig.6

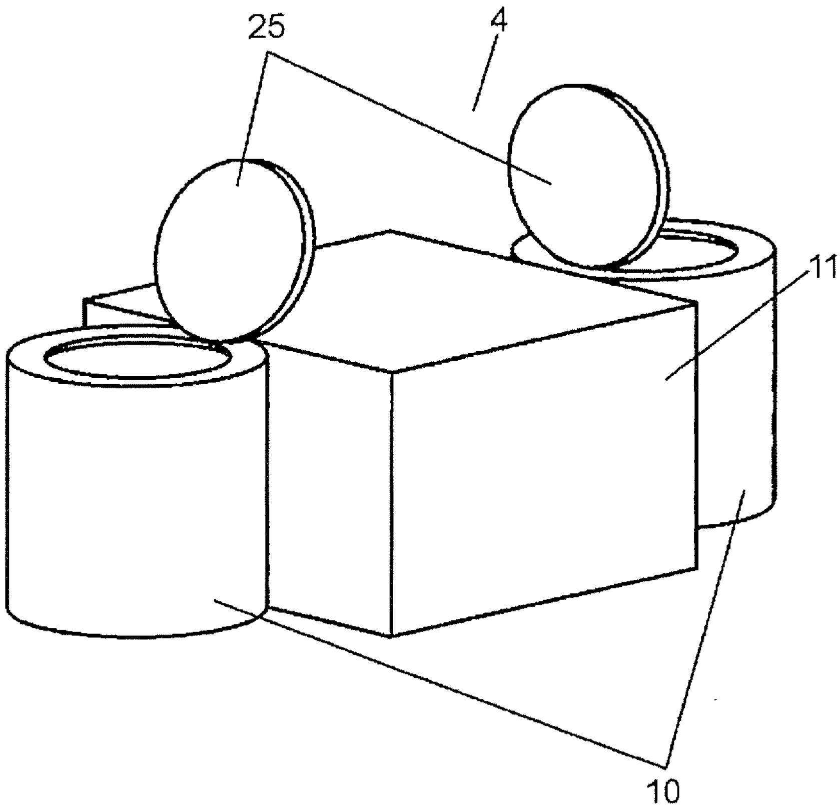


Fig.7

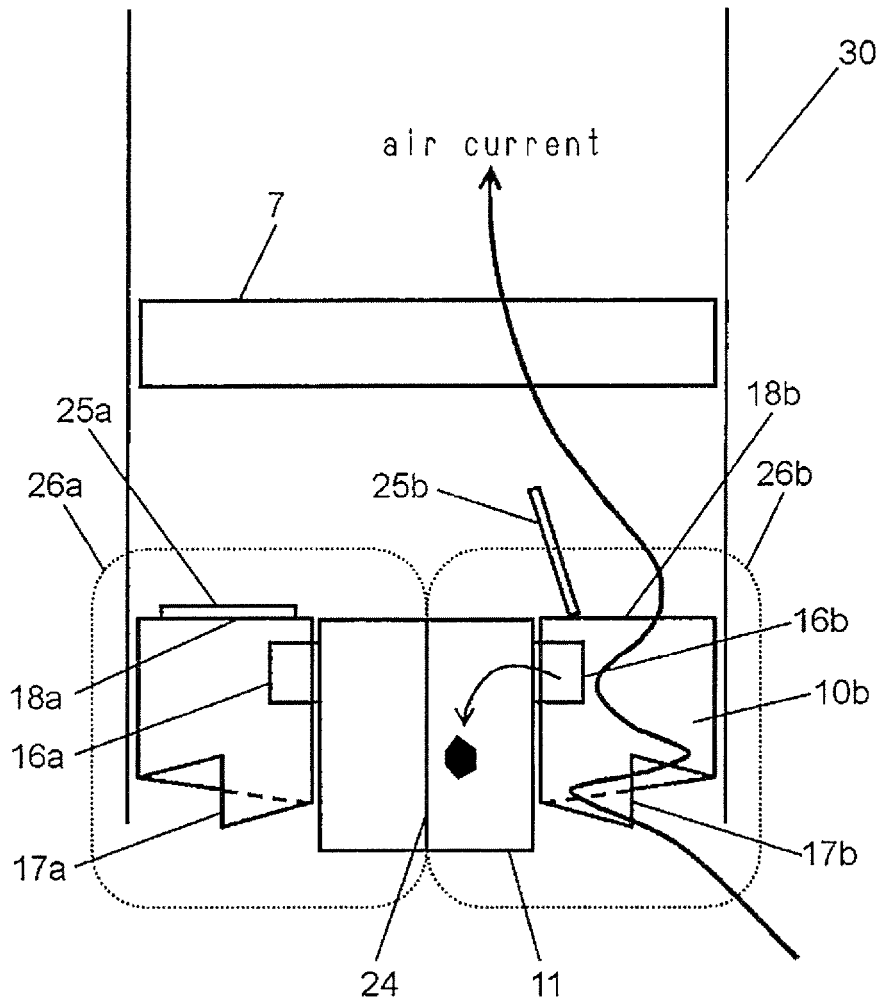

30
air current
7
25a
18b
26a
25b
26b
16b
18a
10b
16a
17a
17b
24
11

Fig.8

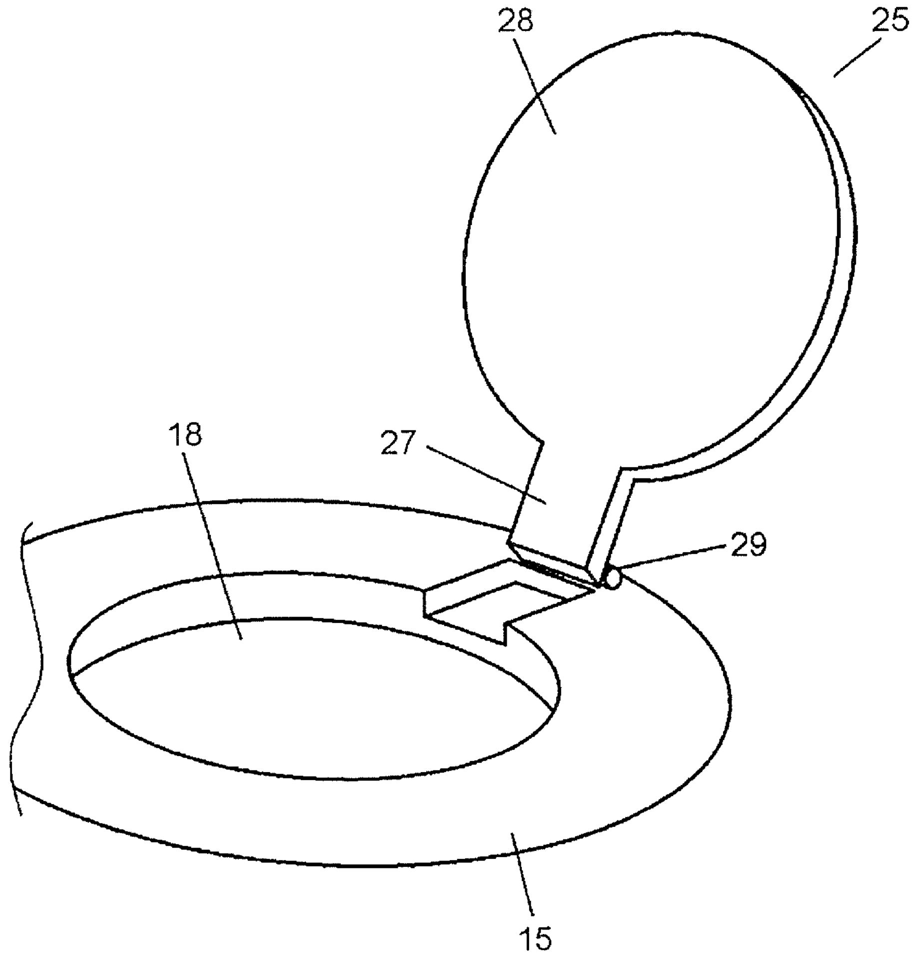


Fig.9

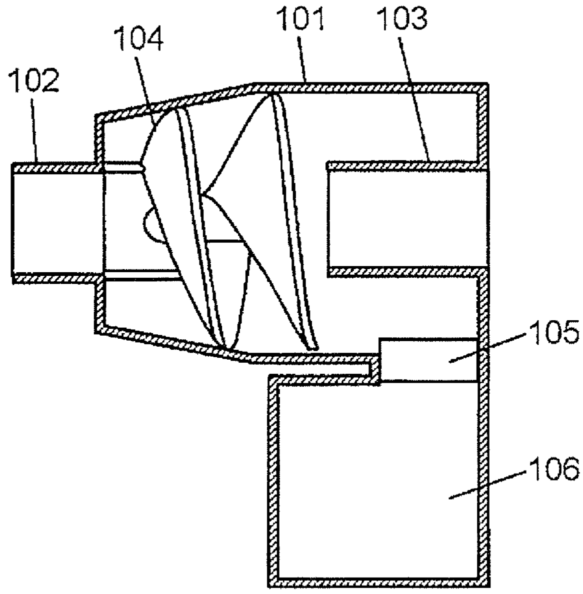
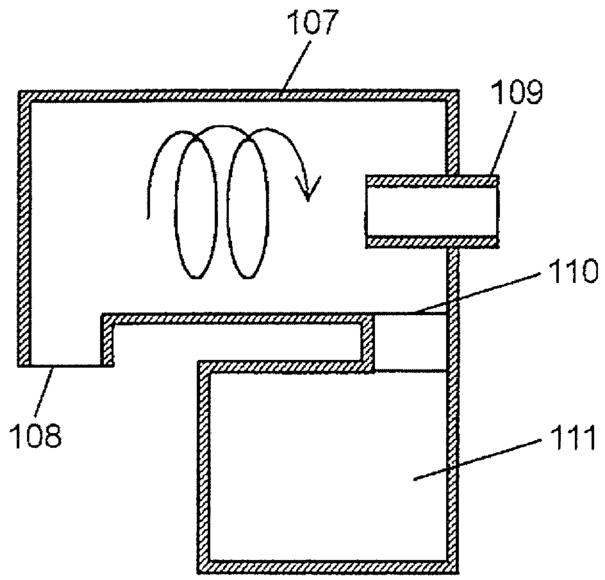


Fig.10



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/001087

A. CLASSIFICATION OF SUBJECT MATTER

A47L9/16(2006.01)i, *B04C3/06*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A47L9/16, B04C3/06

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-173493 A (Sanyo Electric Co., Ltd.), 31 July 2008 (31.07.2008), entire text; all drawings (Family: none)	1-8
A	JP 2007-275867 A (Samsung Electronics Co., Ltd.), 25 October 2007 (25.10.2007), entire text; all drawings & US 2007/0234691 A1 & KR 10-2007-0101056 A & CN 101053858 A	1-8
A	JP 2012-29705 A (Toshiba Corp.), 16 February 2012 (16.02.2012), entire text; all drawings & CN 102342800 A & KR 10-2012-0011828 A & RU 2484756 C	1-8

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

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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 May, 2014 (14.05.14)	27 May, 2014 (27.05.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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