

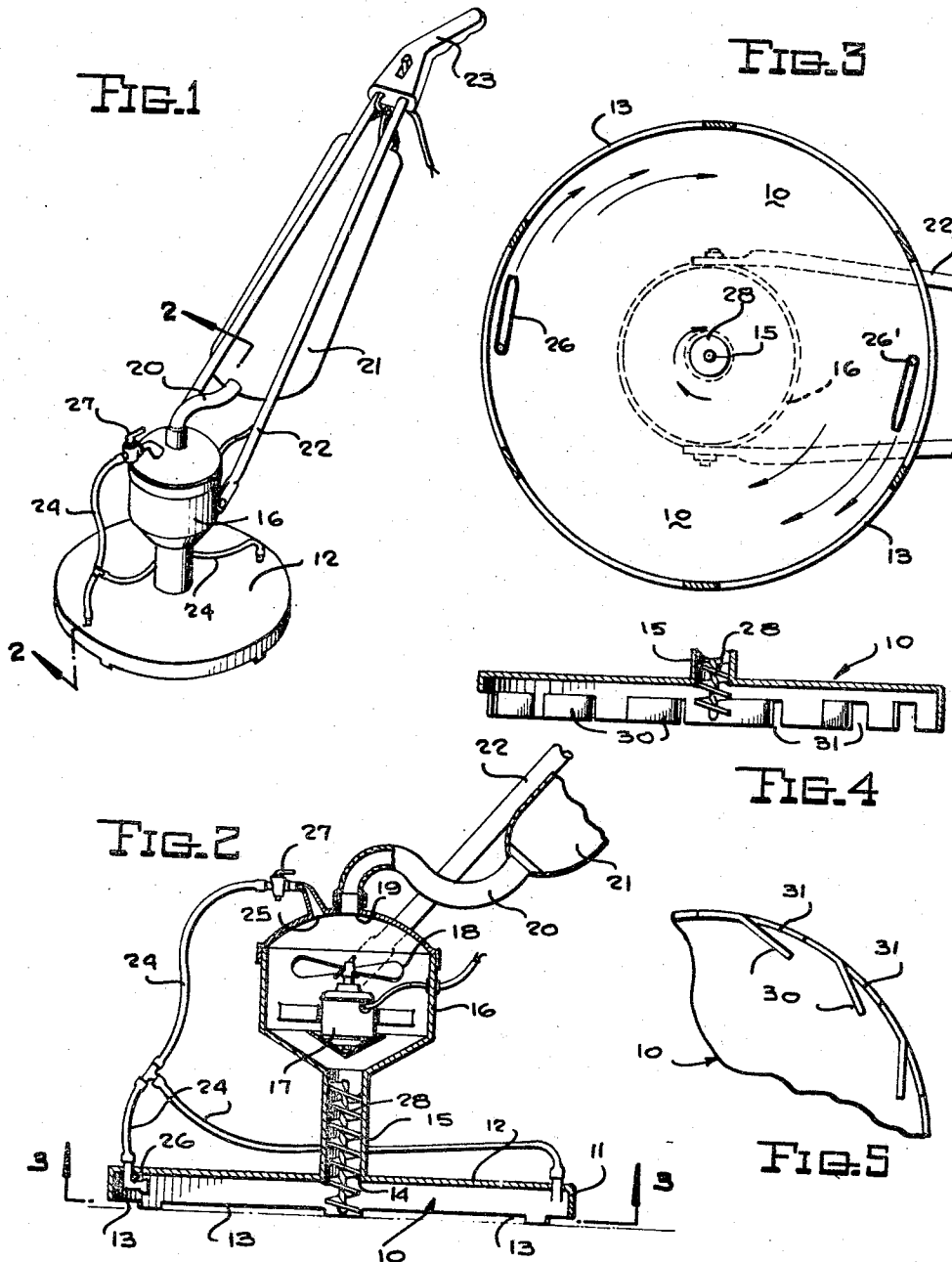
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VACUUM CLEANER

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VACUUM CLEANER

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The present invention relates generally to fluid operated devices, and more particularly to devices for generating and controlling fluid vortices and for applying the vortices so generated and controlled generally to the art of cleaning by inducing fluid flow over the article to be cleaned, and more particularly to the air flow cleaning of floors, fabrics, rugs and the like, or to water-flow cleaning of underwater surfaces, such as the bottoms or walls of swimming pools, or the like.

So-called "vacuum cleaners" have heretofore generally operated by generating rapid air flow over or through fabrics, rugs or the like, thereby generating differential pressures across dirt particles in the path of the flow, thus constraining such particles to move in a predetermined path leading ultimately into a suitable container. Where dirt particles have been deeply embedded, mechanical action has been introduced, as by beater action provided by rotary mechanical brushes, to loosen the dirt particles and thereby to render them more readily susceptible to the flow of air. Such mechanical action tends to cause damage to fabrics, rugs and the like, and therefore has been dispensed with in many types of vacuum cleaners, but with a corresponding reduction in cleaning effectiveness. The problem of providing more effective vacuum cleaner action is ultimately one of applying to the dirt an air flow of sufficiently great volume and flow velocity, consistent with avoiding damage to the object being cleaned, and the latter problem has been met, in the prior art, by increasing the size of blower motors and the efficiency of blower fans.

According to the present invention, vacuum cleaner action is effected by increasing the speed of movement of air utilized to move dirt particles over the speeds presently available from a given fan and motor design, by utilizing a novel principle of vacuum cleaner action. This novel principle is the vortex principle.

In general terms, according to the present invention, a vortical air flow is generated at a surface to be cleaned, in a manner analogous to generation of a cyclone in nature, by applying relatively slight circumferential or tangential air flow to a column of air flowing radially at a relatively great mass flow rate. An amplifying effect is produced, in that the tangential or circumferential velocity of fluid flow adjacent the center of the column of air is far greater than the velocity of tangential fluid flow at a large radius. To a first approximation fluid velocity is inversely proportional to radius at which it is measured, so that introduction of a tangential component of air flow at a large radius, but at relatively low velocity can generate extremely high velocity vortical flow of air at small radii. The latter flow of air superimposed upon the new radial velocity component is utilized as the primary dirt motive element of a vacuum cleaner, according to the present invention, and is found to provide more effective cleaning action for a given expenditure of power and size of cleaner, than has been the case in hitherto known devices for the same purpose, because the rapid rate of flow of air, applied to the pile of a rug or the interstices of a fabric, provides a far greater differential air pressure across dirt particles in the path of the flow than is otherwise available.

Considered in a broad sense, the device described is a velocity amplifier, since by utilization of the vortex principle a high speed rotary flow of air is derived from a high power fluid flow source, under the control of a relatively

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small and low speed air flow applied tangentially at a considerable radius. It can be shown that the rotary speed of the fluid vortex, at any selected small radius, can not only be produced, but can be controlled in respect to magnitude by properly valving the tangential input flow or by properly selecting the radius at which it is applied.

Control of fluid flow velocities by simple control devices, e.g., valves, in systems generally of the types above described, leads to increased utility in effecting controlled vacuum cleaner action, since obviously the fluid flow rates appropriate to different situations are different. In cleaning a rug having a heavy pile, for example, maximum vortex velocities may be desired, but such high velocities may be destructive of delicate drapes, curtains, or the like.

The required tangential flow of air may be produced by diverting air from an output vent of the system to an input nozzle or nozzles. The diversion may be of a selected portion of the entire output flow regardless of its rotary velocity. In such case the total flow of air to the input nozzle is relatively constant, but control of rotary velocity at or adjacent to the center of the vortex can be controlled by valving or otherwise manipulating the fed back or control flow of air which is applied tangentially. The required tangential flow of air may also be produced by means of vanes in a wall of the vortex chamber.

The description of the present invention has proceeded on the basis that the fluid vortex employs air as the fluid. However, water operated cleaners have found utility, for example in cleaning swimming pools. The principles of the invention are applicable to any fluid, air and water being examples only. In cleaning the walls and bottom of a swimming pool, or the bottom of a ship or boat, the high velocity vortex provided by the present invention serves not only to remove loose material but also provides a scrubbing action which can loosen and remove vegetation, fungus, small animals, such as barnacles, and the like.

I may employ, as a scoop for assisting in removal of fluid from the vortex, an Archimedes screw, located in the fluid outlet passage and extending well into the vortex chamber adjacent to the surface to be cleaned. Such a screw performs the function of assisting in fluid removal when the sense of rotation of the vortex corresponds with the sense of advance of the screw. The screw thus reduces the impedance of the fluid circuit, and permits attainment of greater flow velocities than are otherwise feasible.

It is not totally unknown to provide vacuum cleaners employing vortex action. However, known devices of which I am aware fail of effectiveness because they are designed according to erroneous principles. To obtain effective cleaner action high speed flow must be induced at the surface to be cleaned. The entire vortical flow must therefore be constrained to occur at this surface. The vortex chamber itself should therefore be cylindrical, with its base formed by the surface to be cleaned and its top spaced very closely from the surface to be cleaned. The path of air in the vortex is then a flat spiral and constrained throughout to flow and act on the surface to be cleaned. Where vortex chambers are employed which have considerable height the vortical flow of fluid follows a spiral path of constantly tightening turns approaching the fluid outlet, but the higher speed portion of the vortex, i.e., the center, is then not necessarily in contact with the surface to be cleaned. It is thought that in such devices reliance is placed on the low pressure area which is produced at the center of a vortex, as in a cyclone, rather than on the direct application of high speed flow of fluid against the foreign particles which it is desired to remove. In cases where chamber height is increased as radius decreases the

radial velocity component is not used to maximum advantage. In the case of irrotational radial flow in a chamber of constant height the radial velocity component is inversely proportional to radius. If height increases as radius decreases, the radial velocity component is less than the corresponding constant height case. If height decreases as radius decreases then the radial velocity component will be larger than the corresponding constant height case. This invention makes use of pressure distribution of both the radial and tangential flow velocity components.

It is, accordingly, a broad object of the present invention to provide a novel vortex device for cleaning a surface by virtue of the direct application of high speed fluid flow at the surface, where the high speed fluid flow is enhanced by vortical action and occurs in increasing strength as flow approaches the center of the vortex.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a view in perspective of a vacuum cleaner according to the present invention;

FIGURE 2 is a view in section taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a view in section taken on the line 3—3 of FIGURE 2;

FIGURE 4 is a view in vertical section of a modified vortex chamber, employing circumferential vanes extending to produce vortical flow; and

FIGURE 5 is a broken away view, taken in plan to show the vanes of FIGURE 4.

Referring now to the accompanying drawings, the reference numeral 10 denotes the vortex chamber of a vacuum cleaner, selected as exemplary of the present invention. The chamber 10 is generally cylindrical having a cylindrical wall 11, and a top wall 12, the bottom of the cylinder being preferably wholly open, although partial closure, i.e., closure at large radii will not radically reduce the effectiveness of the device. The radius of the cylinder may preferably be great, since rotary velocity of fluid at the center of the vortex is directly proportional to the radius of the cylinder. Slots or other openings 13 may be provided in the arcuate wall 11, to permit adequate ingress of fluid, although for air cleaning of rugs, for example, these are unnecessary.

A small passage 14 is provided axially of the top wall 12, from which extends an elongated cylindrical channel 15. The latter terminates in an enlarged chamber 16, containing an electric motor 17 and fan 18, suitably supported. The chamber 16 is provided with an outlet opening 19, which may be co-axial with the channel 15. The outlet opening 19 communicates with a short hose 20, which leads to an opening in a porous receptacle or bag 21 fabricated of material having a mesh which is sufficiently small to entrap dust, while permitting escape of air.

Pusher rods 22 are pivotally secured at one end to chamber 16, and at their other end terminate in a suitable handle 23.

Fluid feed-back paths are provided, in the form of conduits 24 extending from an opening 25 adjacent to main outlet opening 19 and terminating within vortex chamber 10, in nozzles 26 and 26'. The latter are located immediately adjacent to the cylindrical wall 11, and project fluid circumferentially; in this case in a clockwise direction about passage 14. A valve 27 is provided in the conduit 24, and serves to permit adjustment of fluid flow to the nozzles 26 and 26', and thereby the circumferential velocity of the vortex generated in the chamber 10.

It is the function of the nozzles 26 and 26' to direct air flow tangentially or circumferentially, at a large radius, in superposition of the radial flow which is induced by the fan 18. Even a slight tangential flow, at a large radius, can give rise to a very rapid rotation at slight radii, and to

theoretically infinitely rapid rotation at the center of the vortex. In any real viscous fluid vortex there is a core of small diameter which rotates as a unit rather than with increasing speed as one approaches the center of rotation.

The removal of rapidly rotating air from the chamber 10 via channel 15 is facilitated by inclusion of an Archimedes screw 28 within the chamber 10 and channel 15, the screw having a sense of advance which coincides with the direction of rotation of fluid in the vortex, so that the rapidly rotating fluid in the vortex is deflected toward passage 14 and continues its rotation as it passes along the screw into channel 15. The screw, in facilitating egress of rotating fluid, permits a lower impedance to flow of fluid than does the channel 15 alone, whereby the vortical velocity is effectively used to increase flow through channel 15 and the dirt removing efficiency of the system is increased.

Suitable dimensions for a vacuum cleaner, according to the present invention, and designed primarily for cleaning rugs, may involve an outer diameter of chamber 10 equal to 12", an inner diameter of channel 15 of 1", a height of cylindrical wall 11 of about 1/2". The dimensions suggested are intended to be exemplary only, and not limiting.

In the embodiment of my invention illustrated in FIGURES 4 and 5 of the accompanying drawings, the conduits 24, and the nozzles 26, 26' are dispensed with and tangential flow of fluid induced by vanes 30, suitably oriented adjacent openings 31 in the circumferential wall of the vortex chamber 10. Preferably the vanes 30 extend at an acute angle to the circumference, although 45° angles or greater are operative.

It is clear that the jets 26, 26' may be used in combination with the vanes 30, if desired, each device then supplementing the other.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A vortex device, comprising means for establishing a fluid flow subsisting in a direction perpendicular to a predetermined plane, and means for imparting vortical flow to said fluid while maintaining said vortical flow substantially entirely in said plane, said last means including a hollow cylinder having a relatively large diameter and a height not greater than one-fifth said diameter, said predetermined plane subsisting within said cylinder and perpendicular to the axis thereof.

2. The combination according to claim 1 wherein is provided means for diverting a portion of said vortical flow and applying the diverted flow internally of said cylinder and vortically.

3. A vortex device comprising an egress orifice having an axis extending generally perpendicular to a predetermined plane, means for establishing a fluid flow of relatively great mass flow rate into and through said egress orifice, means for imparting a controlled vortical component of flow to said fluid parallel to said predetermined plane, said last-mentioned means comprising a fluid input device for adding to said fluid flow, at a relatively large radius with respect to the axis of said orifice, a quantity of fluid which is small compared with the quantity of fluid flowing through said egress orifice and which has a component of flow directed at an angle to said relatively great fluid flow and lying in a plane substantially perpendicular to the axis of said egress orifice, and a fluid flow control device independent of said means for establishing fluid flow for controlling the rate of mass flow from said fluid input device.

4. The combination according to claim 3 wherein said means for imparting a controlled vortical component further includes means for deriving the fluid supplied

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to said fluid input device from said relatively great mass flow.

5. A fluid vortex device comprising a cylindrical chamber having an axial orifice, said chamber having a relatively large diameter and a maximum height not more than one-tenth said diameter, means for admitting fluid to said chamber adjacent the periphery thereof and for establishing egress of said fluid through said orifice, and means for establishing variable vortical flow through said chamber to said orifice.

6. A fluid vortex device comprising a generally cylindrical chamber having an axial orifice, means for establishing a flow of fluid to said chamber adjacent the periphery thereof with the flow through said chamber being parallel to a predetermined surface generally perpendicular to said orifice, means for inducing vortical flow through said chamber and means for maintaining said vortical flow at said surface over the region between the outer periphery of said chamber and said axial orifice, said last-mentioned means comprising the dimensions of said chamber being such that the ratio of the difference between the diameters of said chamber and said axial orifice to the height of said chamber is at least five-to-one.

7. A fluid vortex device according to claim 6 wherein is provided at least one nozzle located in said chamber, said nozzle being arranged to provide fluid flow in said chamber having a tangential component.

8. The combination according to claim 7 wherein is provided a conduit extending between said axial orifice and said at least one nozzle, and fluid flow control means in said conduit.

9. The combination according to claim 8 wherein a fluid scoop is located in said axial orifice.

10. The combination according to claim 9 wherein said fluid scoop is a screw.

11. The combination according to claim 10 wherein said screw extends into said chamber along the axis thereof.

12. The combination according to claim 6 wherein said means for inducing vortical flow includes a pair of nozzles located in said chamber, said nozzles being located on a common diameter and being arranged to provide similarly directed fluid flow in said chamber, said last mentioned fluid flow including a tangential component of flow.

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13. A fluid vortex device including a cylindrical chamber having an axial opening for egress of fluid, first means establishing fluid flow through said chamber into said axial opening, second means establishing vortical flow of said fluid in said cylindrical chamber, and third means located in said axial opening having an impedance to fluid flow therethrough which is relatively low for fluid rotating in the direction established by said second means and which is relatively high to fluid rotating in a direction opposite to the direction of rotation established by said second means, said second and third means being independent of said first means.

14. A fluid vortex device including a cylindrical chamber having a central fluid egress orifice, means to supply a mass of fluid to said chamber and means for supplying to said chamber a quantity of fluid small relative to said mass of fluid and having a tangential component of flow for controlling the rate of rotation of said mass of fluid, said last means including a fluid path extending between said first means and said chamber and a variable flow rate device independent of said first means located in said fluid path.

15. A vortex cleaning device comprising a generally cylindrical chamber having an axial orifice, means for establishing a flow of fluid to said chamber adjacent the periphery thereof with the flow through said chamber being parallel to a predetermined surface generally perpendicular to said orifice, means for inducing vortical flow through said chamber and means for maintaining said vortical flow at said surface over the region between the outer periphery of said chamber and said axial orifice, said last-mentioned means comprising the dimensions of said chamber being such that the ratio of the difference between the diameters of said chamber and said axial orifice to the height of said chamber is at least five-to-one.

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