

APPLICATION DATA SHEET

Electronic Version v14

Stylesheet Version v14.0

Title of Invention	VACUUM CLEANER WITH MULTIPLE CYCLONIC DIRT SEPARATORS AND BOTTOM DISCHARGE DIRT CUP		
Application Type : provisional, utility Attorney Docket Number : 71189-1693			
Correspondence address: Customer Number: 20915 			
Inventor Information: <u>Inventor 1:</u> Applicant Authority Type: Inventor Citizenship: US Given Name: Joseph Middle Name: A. Family Name: Fester Residence: City of Residence: Ada State of Residence: MI Country of Residence: US Address-1 of Mailing Address: 61 Honey Creek, N.E. Address-2 of Mailing Address: City of Mailing Address: Ada State of Mailing Address: MI Postal Code of Mailing Address: 49301 Country of Mailing Address: US Phone: Fax: E-mail:			
Attorney Information: practitioner(s) at Customer Number: 20915  as my attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.			

FEE TRANSMITTAL

Electronic Version v09

Stylesheet Version v08.0

Title of Invention	VACUUM CLEANER WITH MULTIPLE CYCLONIC DIRT SEPARATORS AND BOTTOM DISCHARGE DIRT CUP														
Application Number :															
Date :															
First Named Applicant:		Joseph A. Fester													
Attorney Docket Number:		71189-1693													
TOTAL FEE AUTHORIZED \$ 160															
Patent fees are subject to annual revisions on or about October 1st of each year.															
Filing as large entity															
BASIC FILING FEE															
<table border="1"><thead><tr><th>Fee Description</th><th>Fee Code</th><th>Amount \$</th><th>Fee Paid \$</th></tr></thead><tbody><tr><td>Provisional Filing Fee</td><td>1005</td><td>160</td><td>160</td></tr><tr><td colspan="4">Subtotal For Basic Filing Fee: \$160</td></tr></tbody></table>				Fee Description	Fee Code	Amount \$	Fee Paid \$	Provisional Filing Fee	1005	160	160	Subtotal For Basic Filing Fee: \$160			
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Provisional Filing Fee	1005	160	160												
Subtotal For Basic Filing Fee: \$160															
AUTHORIZED BILLING INFORMATION															
The commissioner is hereby authorized to charge indicated fees and credit any overpayments to:															
Deposit account number:		502003													
Deposit name:		McGarry Bair PC													
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TRANSMITTAL

Electronic Version v1.1

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Title of Invention	VACUUM CLEANER WITH MULTIPLE CYCLONIC DIRT SEPARATORS AND BOTTOM DISCHARGE DIRT CUP							
Application Number :								
Date :								
First Named Applicant:	Joseph A. Fester							
Confirmation Number:								
Attorney Docket Number:	71189-1693							
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<table border="1"><tr><td>Submitted By:</td><td>Elec. Sign.</td><td>Sign. Capacity</td></tr><tr><td>John E. McGarry Registered Number: 22,360</td><td>/John E McGarry/</td><td>Attorney</td></tr></table>			Submitted By:	Elec. Sign.	Sign. Capacity	John E. McGarry Registered Number: 22,360	/John E McGarry/	Attorney
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John E. McGarry Registered Number: 22,360	/John E McGarry/	Attorney						

Documents being submitted:	Files
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Comments	

ACKNOWLEDGEMENT RECEIPT

Electronic Version 1.1

Stylesheet Version v1.1.1

Title of Invention	VACUUM CLEANER WITH MULTIPLE CYCLONIC DIRT SEPARATORS AND BOTTOM DISCHARGE DIRT CUP												
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Application Number:	60/593125												
EFS ID:	74130												
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First Named Applicant:	Joseph Fester												

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VACUUM CLEANER WITH MULTIPLE CYCLONIC DIRT SEPARATORS AND BOTTOM DISCHARGE DIRT CUP

DESCRIPTION

FIELD OF THE INVENTION

[Para 1] The invention relates to suction cleaners, and in particular to a separator for a suction cleaner. In one of its aspects, the invention relates to a separator with a cyclonic airflow path to separate dirt and debris from air drawn into the cleaner. In another of its aspects, the invention relates to a separator that deposits the dirt and debris in a collection receptacle. In another of its aspects, the invention relates to a bottom discharge dirt cup with an integrated filter chamber. In another of its aspects, the invention relates to a separator including structure for inhibiting the re-entrainment of debris that vacillates with upward airflows in the collection receptacle. In another of its aspects, the invention relates to multiple cyclone separators including a single primary cyclone in series with a plurality of secondary cyclones arranged in parallel.

DESCRIPTION OF THE RELATED ART

[Para 2] Cyclone separators are well known. Some follow the textbook examples using frusto-conical shape separators and others use high-speed rotational motion of the air/dirt to separate the dirt by centrifugal force. Typically, working air enters and exits at an upper portion of the cyclone separator and the bottom portion of the cyclone separator is used to collect debris. Furthermore, in an effort to reduce weight, the suction source that

creates the working air flow is typically placed at the bottom of the handle, below the cyclone separator. This arrangement therefore, requires a tortuous air path from the top of the cyclone assembly, down the handle to the inlet of the motor/fan assembly. This creates a long air path with multiple parts which may allow for air leaks and generally negatively impacting airflow and, necessarily, cleaning performance.

[Para 3] U.S. Patent No. 6,238,451 to Conrad discloses a cyclonic separator in a vacuum cleaner comprising a single first stage cyclone and a plurality of vertically aligned secondary downstream cyclones arranged in parallel relative to one another. The secondary cyclones are located within the same footprint of and directly above the upstream cyclone. This arrangement of cyclones necessarily creates a tall unit because the downstream cyclones are located above the upstream cyclone.

[Para 4] U.S. Patent No. 6,607,572 to Dyson discloses a cyclonic separating apparatus with upstream and downstream cyclonic units, wherein the downstream units comprise a plurality of downstream cyclones located above the upstream cyclone and inverted relative to the upstream cyclone.

[Para 5] U.S. Patent No. 6,070,291 to Bair et al. and its progeny shortens the air path from the cyclone exhaust to the motor inlet. These patents disclose a pleated cylindrical filter in a cyclonic chamber whereby the working air is drawn through the cylindrical filter and then through the bottom of the cyclonic chamber, through another filter and directly into the suction source inlet. The suction source is in a vertical position below the cyclonic chamber which is undesirable due to the amount of space needed at the bottom of the handle.

[Para 6] U.S. Patent No. 6,341,404 to Salo et al. discloses a bottom discharge cyclone chamber with the suction source mounted horizontally below the cyclone chamber. However, motor exhaust air is redirected back up towards the bottom of the cyclone chamber where it exits the unit in a radial fashion. This path introduces a number of turns which tends to create backpressure and therefore reduce efficiency.

[Para 7] U.S. Patent No. 6,129,775 to Conrad discloses a cyclone separator with a number of different forms of flow inhibitors to inhibit airflow within the cyclone separator. As shown in FIG. 14(d), the terminal insert may comprise a plurality of longitudinally extending members (such as rods), which extend upwardly into the cyclone separator cavity from the bottom surface of the cyclone separator. The rods are said to interact with circulating fluid 48 to disrupt its rotational motion. The rods may be positioned symmetrically non-symmetrically around longitudinal axis of the separator. The rods may be a variety of shapes such as, in transverse section, squares, ellipses or other closed convex or abode shapes. Further, the transverse section of rods may vary longitudinally.

SUMMARY OF THE INVENTION

[Para 8] According to the invention, a vacuum cleaner comprises a housing defining a first cyclonic airflow chamber for separating contaminants from a dirt-containing air stream and a first cyclonic chamber inlet and an air stream outlet in fluid communication with the cyclonic airflow chamber, a nozzle housing including a suction opening fluidly connected with the cyclonic chamber inlet, an airstream suction source fluidly connected to the suction opening and to the first cyclonic airflow chamber for transporting dirt-containing air from the suction opening to the cyclonic airflow chamber, whereby the suction source is adapted to establish and maintain a dirt-containing airstream from the suction opening through the first cyclonic airflow chamber inlet and to a first cyclonic airflow chamber outlet to remove debris from the working airflow.

[Para 9] A dirt cup assembly is mounted to the housing beneath the first cyclonic airflow chamber and comprises a bottom wall with an opening therein, a sidewall, and a centrally located hollow standpipe in fluid communication with the bottom wall opening.

[Para 10] At least one secondary cyclone, preferably between one and sixteen cyclones, each of which is in fluid communication with the air stream outlet of the first cyclonic airflow chamber and is positioned adjacent to the first cyclonic chamber. The at least one secondary cyclone has an outlet that is in fluid communication with the hollow standpipe.

[Para 11] In one embodiment, the each secondary cyclone has a cyclonic axis that is oriented parallel to a cyclonic axis of the first cyclonic airflow chamber.

[Para 12] In a preferred embodiment, each secondary cyclone is located outside of the first cyclonic chamber and arranged to maintain an unobstructed view of at least a portion of the first cyclonic airflow chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 13] FIG. 1 is a perspective view of an upright vacuum cleaner with cyclone separator according to the invention.

[Para 14] FIG. 2 is a cut-away perspective view of the cyclonic separator of FIG. 1.

[Para 15] FIG. 3 is an exploded perspective view of the cyclonic separator of FIGS. 1–2.

[Para 16] FIG. 4 is a front cross-sectional view taken through line 4–4 of FIGS. 1.

[Para 17] FIG. 5 is an exploded perspective view of the dirt cup assembly of FIGS. 1–2.

[Para 18] FIG. 6 is a cross-sectional view taken through line 6–6 of FIG. 4.

[Para 19] FIG. 7 is a cross-sectional view taken through line 7–7 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[Para 20] Referring now to the drawings and to FIG. 1 in particular, an upright vacuum cleaner 10 comprises an upright handle 14 with a handle grip 13 formed on a rearward portion at a top end and pivotally mounted to a nozzle base 16 at the other end thereof. , The nozzle base 16 further comprises a suction nozzle opening 11 on a forward portion thereof. The upright handle 14 mounts a cyclonic dirt separator and dirt cup assembly 12 that comprises a cyclone separator assembly 18 and a dirt cup assembly 54. A grip 23 to facilitate insertion and removal of the dirt cup assembly 54 can be separately formed and attached to the dirt cup assembly 54 in a commonly known manner, preferably with screws. However, the grip 23 can also be integrally formed with the dirt cup assembly 54 or can be fastened in other commonly known ways such as adhesives or ultrasonic welding.

[Para 21] Referring to FIGS. 2 and 3, the cyclone separator assembly 18 further comprises a primary separation region containing a primary cyclone 19 and a secondary separation region 21 containing a plurality of secondary cyclones 102. The exterior of the cyclone separator assembly 18 is defined by a cyclone cap 20, and a cyclone sidewall 22, the sidewall 22 terminating in a lower offset lip 24. The cyclone side wall 22 further supports a secondary air manifold 29 at an upper portion thereof. An annular collar 26 depends from the secondary air manifold 29, the collar 26 being centered in the primary cyclone 19. A bottom wall 25 is formed at a lower portion of the secondary separation region 21 extending in a perpendicular manner from an inside surface of the cyclone side wall 22 to an outside surface of the primary cyclone 19. The primary cyclone 19 is further defined by a generally circular primary separator side wall 17 about its perimeter and a bottom surface of the secondary air manifold 29 at the top, as described more fully below. A portion of the sidewall 22 further includes a tangential air inlet 28 aligned proximate the cyclone cap 20 for generating a tangential airflow in the primary separation region parallel to the cyclone cap 20.

[Para 22] The primary cyclone 19 further comprises an exhaust assembly 30 that includes a hollow cylindrical cage 32 mounted on a separator plate 34.

The cage 32 further comprises a plurality of apertures 36 cylindrically arranged between a top portion of the cage 32 and the separator plate 34. A working air path is defined through the cage 32 and through a centrally located aperture on the separator plate 34. The cage 32 and separator plate 34 are removably mounted on the annular collar 26 on the cyclone cap 20 of the primary cyclone 19 via a bayonet on the annular collar 26 that engages with a slot 31 to provide a twist and lock connection. However, other mechanical fastening means can be used to removably mount the exhaust assembly 30 to the annular collar. For example, friction fit, ramped threads, detents, or any other commonly known fastening method can be used according to the invention.

[Para 23] Also, in this manner a primary toroidal chamber 48 is defined between an outer surface of the cage 32 and an inner surface of the primary separator side wall 17, and between a bottom surface of the secondary air manifold 29 and the separator plate 34, respectively. In the preferred embodiment, the air inlet 28 is vertically aligned between the cyclone cap 20 and the separator plate 34 such that the tangential airflow generated from the tangential air inlet 28 is directed in a slightly downward direction tangentially into the primary toroidal chamber 48.

[Para 24] With further reference to FIGS. 2–4, the tangential airflow, containing particulate matter, passes through the tangential air inlet 28 and into the primary toroidal chamber 48 to travel around the exhaust assembly 30. As the airflow travels about the primary toroidal chamber 48, heavier dirt particles are forced toward the primary separator sidewall 17. These particles fall under the force of gravity through a gap 50 defined between an edge 52 of the separator plate 34 and the primary separator sidewall 17. Referring particularly to FIG. 4, dirt particles falling through the gap 50 drop through an opening at a bottom of the primary separation side wall 17 and are collected in a primary dirt collection region 56 of the dirt cup assembly 54. The upper end of the dirt cup assembly 54 is received in a nesting relationship in the lower offset lip 24 of the cyclone sidewall 22 to seal the cyclone separator assembly 18 to the dirt cup assembly 54. The primary dirt collecting region 56 thereby

performs the function of collecting the dirt separated from the airflow within the primary cyclone 19.

[Para 25] As the inlet air traverses through toroidal chamber 48, casting dirt particles toward sidewall 22, the inlet air is drawn inwardly through the apertures 36. In the preferred embodiment, the apertures 36 are in a flattened circular shape, however any geometry can be used to effectively prevent larger debris and dirt particles from exiting the primary toroidal chamber 48, the limiting factor being the size of the debris to be filtered. The dirt particles are urged toward the gap 50 by the circulating air flow in the primary toroidal chamber 48.

[Para 26] Since the primary cyclone region 19 is not 100% efficient, some fine debris may remain in the working air. As shown in FIGS. 4 and 6, the working air that exits the exhaust assembly 30 continues through a secondary cyclone toroidal path 90 formed between an inner surface of the exhaust assembly 30 and an outer solid surface of a hollow air outlet duct 92 depending from the secondary air manifold 29. The secondary air manifold 29 further comprises a plurality of vertically oriented secondary cyclone separators 102 mounted outside the perimeter of the primary cyclone 19 and arranged on opposite sides of the primary separation region relative to the front of the upright vacuum cleaner 10 on a perpendicular axis A with respect to the suction nozzle 11. In the preferred embodiment, four secondary cyclone separators 102 are located on the side of the cyclone separator assembly 18 where the tangential air inlet 28 is located and five secondary cyclone separators 102 are located on the other side of the cyclone separator assembly. In an alternate embodiment, all of the secondary cyclone separators 102 are located on only one side of the perpendicular axis A, the preferred number of secondary cyclone separators 102 ranging from between one and 10, preferably between three and seven, with five being the preferred number. The cyclone sidewall 22 is preferably made of a transparent material to allow a view of the features contained therein. No secondary cyclones 102 are located in a forward location to allow an unobstructed view of the primary cyclone 19.

[Para 27] The secondary cyclones 102 are comprised of a frusto-conical housing 104 with a larger end 106 comprising an air inlet 118 and centrally located air outlet 122 and a smaller end 110 forming a secondary debris outlet 120 through which separated debris passes to a secondary dirt collecting region 58. The housings 104 are associated via a housing support 105 that may either be a separate piece or integrally molded with the desired number of housings 104. The vertical axes of the secondary cyclones are parallel with the vertical axis of the primary separation region drawn through the center of the exhaust assembly 30.

[Para 28] The size and shape of the secondary cyclones 102 are important for maximizing separation efficiency. In the preferred embodiment, the larger end 106 of the housing 104 has an opening that is 10 times the surface area of the smaller end 110. However, acceptable performance is obtained within a range of ratios of the larger end to the smaller end of about 2 to 1 to about 20 to 1, preferably between about 3.5 to 1 to about 8.5 to 1.

[Para 29] Other arrangements of secondary cyclones 102 have been found to perform in an acceptable manner. Configurations of between one and fifteen secondary cyclones 102 arranged in split fashion as previously described or completely encircling the primary cyclone 19 have been tried. It has been found that the smaller the secondary cyclones 102 become, the less efficiently they perform. As can be appreciated, the overall size of the cyclonic dirt separator and dirt cup assembly 12 is limited by the maximum useful size of the portable upright vacuum cleaner 12. Therefore, given a fixed maximum design envelope, as the number of secondary cyclones 102 increases, the individual size of each secondary cyclone must be reduced to fit within the fixed envelope. It has been found that secondary cyclones with a larger end that is smaller than 1 inch in diameter tend to clog with debris and are, therefore undesirable. Therefore, groupings of between five and eleven secondary cyclones are preferred.

[Para 30] The cyclone side wall 22 is shaped to correspond with the secondary cyclones 102 located within, that being a generally tapered outer wall. The

outer dimension is largest at the top where it abuts the cyclone cap 20 and generally decreases at the offset lip 24.

[Para 31] Referring to FIGS. 2, 3 and 7, the secondary air manifold 29 further comprises a lower surface 115 and an upper surface 117. A plurality of working air inlets 119 are formed in the bottom surface 115 and is in fluid communication with a corresponding secondary cyclone 102 air inlet 118 via an inlet passage 121. A working air exhaust chamber 123 is formed between the upper surface 117 of the secondary air manifold 29 and an inner surface of the cyclone cap 20 and is in fluid communication with an open upper end 125 of the hollow air outlet duct 92. An air manifold gasket 125 is positioned between the bottom surface 115 of the secondary air manifold 20 and an upper surface of the housing support 105 to thereby form an airtight seal and to prevent air leaks in the working air path.

[Para 32] Referring now to the dirt cup assembly 54 shown in FIGS. 2, 4 and 5, the dirt cup assembly 54 comprises a primary dirt collecting region 56, the secondary dirt collecting region 58, a working air standpipe 68, and a post-cyclone filter assembly 76. The primary dirt collecting region 56 is formed by a generally planar dirt cup bottom wall 62 and an upstanding dirt cup sidewall 64 to form an open-topped receptacle. The dirt cup sidewalls 64 are slightly tapered, meaning that the top surface adjacent the lip 24 has a larger footprint than that of the bottom wall 62. The taper tends to create an air flow pattern within the dirt cup assembly 54 that minimizes debris reentrainment. Additionally, the taper creates a narrower dirt cup assembly 54 that is sized to facilitate manipulation the dirt cup assembly with only one hand by a user.

[Para 33] To further inhibit reentrainment of debris, a plurality of upstanding prongs or fingers 66 project upwardly from the bottom wall 62. The fingers 66 can function in varying arrangements, but in the preferred embodiment the fingers 66 are arranged generally symmetrically about the hollow standpipe 68 centrally located within the dirt cup assembly 54. The hollow standpipe 68 is in fluid communication at a top end thereof with a bottom portion of the air outlet duct 92 and at a bottom end thereof with a centrally located aperture in the dirt cup bottom wall 62. The mating surfaces between the air outlet duct

92 and the hollow standpipe 68 are effectively sealed with a commonly known gasket 33 to prevent air leaks. The fingers 66 are found to function best when displaced at least some distance from an outer wall of the standpipe 68. The dirt cup assembly 54 further includes a pair of fins 70, 72 affixed to and contiguous with the sidewall 64. The fins 70, 72 are generally rectangular in cross-section, in plan view, projecting inwardly from the sidewall 64 toward a center of the dirt cup assembly 54. Details of acceptable sizing and spacing of the fingers 66 and fins 70, 72 are found in U.S. Patent 6,810,557 to Hansen et. al. which is incorporated herein by reference in its entirety.

[Para 34] The secondary dirt collecting region 58 further comprises at least one secondary dirt cup 75 integrally formed with or assembled to a cup support 77. Like the primary dirt collecting region 56, the secondary dirt cup 75 is defined by a bottom wall 79 and a pair of generally perpendicular side walls 81 to form an open top receptacle. The secondary dirt collecting region 58 is assembled to the primary dirt collecting region 56 so that the open top of the secondary dirt cup 75 is positioned directly below the secondary debris outlets 120. In the preferred embodiment, one secondary dirt cup 75 is used to collect secondary debris from more than one secondary cyclone 102. However, a series of individual secondary dirt cups 75 can be used to collect debris from each corresponding secondary cyclone 102. The cup support 77 is fixedly attached to an upper surface of the dirt cup side wall so that the secondary dirt cups 75 lie within the perimeter thereof. A dirt cup gasket 83 is positioned between the top of the dirt cup assembly 54 and the lower offset lip 24 to seal the cyclone separator assembly from air leaks.

[Para 35] The filter assembly 76 further comprises a filter cage 84 and a filter element 86. The filter assembly 76 is in fluid communication with a bottom portion of the standpipe 68 on a top side and a suction source 87 inlet on a bottom. The filter cage 84 further comprises an open tray 85 to removably receive the filter 86 element. Preferably, the filter element 86 is an open cell foam filter, however, paper pleated filters and other common filter element types can also be used. The filter cage 84 mates with the bottom wall

62 of the primary dirt collection region via a ¼ turn bayonet fastener or any other suitable mechanical fastening means as previously described.

[Para 36] The dirt cup assembly 54 is removably connected to the housing 12. The dirt cup assembly 54 is generally vertically adjustable relative to the cyclone separator 18, such as by a cam mechanism, so that it can be raised into an engaged and operative position underneath the cyclone separator 18. The upper edge of the sidewall 64 is received within the offset lip 24 and sealed by the gasket 83, which prevents the dirt cup assembly 54 from being dislodged from the cyclone separator 18. To remove the dirt cup assembly 54 from the cyclone separator 18, such as to discard accumulated dirt, the dirt cup assembly 54 is displaced downwardly from the cyclone separator 18. Once disengaged from the offset lip 24, the dirt cup assembly 54 can be slid forward and removed from the separator 18.

[Para 37] Referring to FIG. 4, in operation, a suction source located in either the upright handle 14 or the nozzle base 16 generates a working airflow through the upright vacuum cleaner 10. Dirty working air enters the cleaner 10 at the suction nozzle 11 and flows through a suitable conduit (not shown) to the tangential air inlet 28 to the cyclonic dirt separator and dirt cup assembly 12. The working air traverses around the toroidal chamber 48 casting dirt particles toward the primary separator sidewall 17 thereby separating larger primary debris from the air stream and depositing the primary debris, by force of gravity, through the gap 50 between the separator plate edge 52 and an inner surface of the cup support 77. Working air passes through the apertures 36 and into the secondary cyclone toroidal path 90. Since the plurality of secondary cyclone separators 102 are arranged in parallel, working air is evenly divided to each working air inlet 119. Working air then tangentially enters the housing 104 near the larger end 106 to create a swirling action within in the housing 104. As the swirling air approaches the smaller end 110 of the housing 104, the velocity of the air speeds up and throws the fine secondary debris remaining in the air stream toward an inner wall of the housing 104 in a fashion similar to the primary cyclone 19. The fine secondary debris exits the interior of the housing 104 at the secondary debris outlet 120

where it falls, under force of gravity, into the secondary dirt collector 58 located in the dirt cup assembly 54.

[Para 38] The working air is then forced to change direction and exits the secondary cyclone separators 102 through the air outlet 122 at the larger end 106 of the housing 104. Working air passes through the working air exhaust chamber 123 and enters the open upper end 125 of the air outlet duct 92. The working air then passes through the dirt cup standpipe 68 and into the filter assembly 76 where the foam filter 86 can capture additional particulate material before the working air is drawn into the suction source. Optionally, a pre-motor filter (not shown) can be located immediately upstream of the suction source to prevent any remaining debris from entering the suction source which can damage internal components and shorten the useful life of the suction source. Working air continues through a fan assembly associated with the suction source 87 and passes through an optional HEPA filter 89 and eventually passing through the vacuum unit 10 through an exhaust aperture 91.

[Para 39] While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation. Reasonable variation and modification are possible within the foregoing disclosure and drawings without departing from the spirit of the invention which is defined in the appended claims.

What is claimed is:

[Claim 1] A vacuum cleaner comprising:

a housing defining a first cyclonic airflow chamber for separating contaminants from a dirt-containing airstream as it travels about a cyclonic axis in the first cyclonic airflow chamber, said housing further comprising a cyclonic chamber inlet and an airstream outlet in fluid communication with said cyclonic airflow chamber;

a nozzle housing including a suction opening, said suction opening being fluidly connected with said cyclonic chamber inlet;

an airstream suction source fluidly connected to said main suction opening and to the first cyclonic airflow chamber for transporting dirt-containing air from the main suction opening to the cyclonic airflow chamber, said suction source is adapted to establish and maintain a dirt-containing airstream from said main suction opening through said first cyclonic airflow chamber inlet and to a first cyclonic airflow chamber outlet;

a dirt cup assembly mounted to the housing beneath said first cyclonic airflow chamber, the dirt cup assembly comprising a bottom wall, a sidewall, and a centrally located hollow standpipe;

a plurality of secondary cyclones, each of which is in fluid communication with the first cyclonic airflow chamber outlet wherein the secondary cyclones have cyclonic axes that are oriented parallel to the cyclonic axis of the first cyclonic airflow chamber;

the improvement comprising the plurality of secondary cyclones are located outside of the first cyclonic airflow chamber and arranged to maintain an unobstructed view of at least a portion of the first cyclonic airflow chamber.

[Claim 2] A vacuum cleaner according to claim 1 wherein the plurality of secondary cyclones is between one and 16 secondary cyclones.

[Claim 3] A vacuum cleaner comprising:

a housing defining a first cyclonic airflow chamber for separating contaminants from a dirt-containing air stream, a first cyclonic chamber inlet

and an air stream outlet in fluid communication with the cyclonic airflow chamber;

a nozzle housing including a suction opening fluidly connected with the cyclonic chamber inlet;

an airstream suction source fluidly connected to the suction opening and to the first cyclonic airflow chamber for transporting dirt-containing air from the suction opening to the cyclonic airflow chamber, whereby the suction source is adapted to establish and maintain a dirt-containing airstream from the suction opening through the first cyclonic airflow chamber inlet and to a first cyclonic airflow chamber outlet to remove debris from the working airflow;

a dirt cup assembly is mounted to the housing beneath the first cyclonic airflow chamber and comprises a bottom wall with an opening therein, a sidewall, and a centrally located hollow standpipe in fluid communication with the bottom wall opening;

at least one secondary cyclone in fluid communication with the air stream outlet of the first cyclonic airflow chamber and positioned adjacent to the first cyclonic chamber, the at least one secondary cyclone has an outlet that is in fluid communication with the hollow standpipe.

[Claim 4] A vacuum cleaner according to claim 3 wherein the or each secondary cyclone has a cyclonic axis that is oriented parallel to a cyclonic axis of the first cyclonic airflow chamber.

[Claim 5] A vacuum cleaner according to claims 3 or 4 wherein the or each secondary cyclone is located outside of the first cyclonic chamber and arranged to maintain an unobstructed view of at least a portion of the first cyclonic airflow chamber.

ABSTRACT

A vacuum cleaner with cyclonic dirt separation and a bottom discharge dirt cup beneath the cyclone separator and a filter beneath the dirt cup and between the dirt cup and a suction motor inlet. A separator plate separates the cyclone separator from the dirt cup. Fins project from a sidewall of the dirt tank, and fingers projecting from a bottom wall of the dirt tank. A hollow standpipe in the dirt cup transports working air from the cyclone separator outlet to the filter. A cyclone separator further comprising a plurality of secondary cyclones oriented generally parallel to and outside the outer perimeter of a primary cyclone separator.

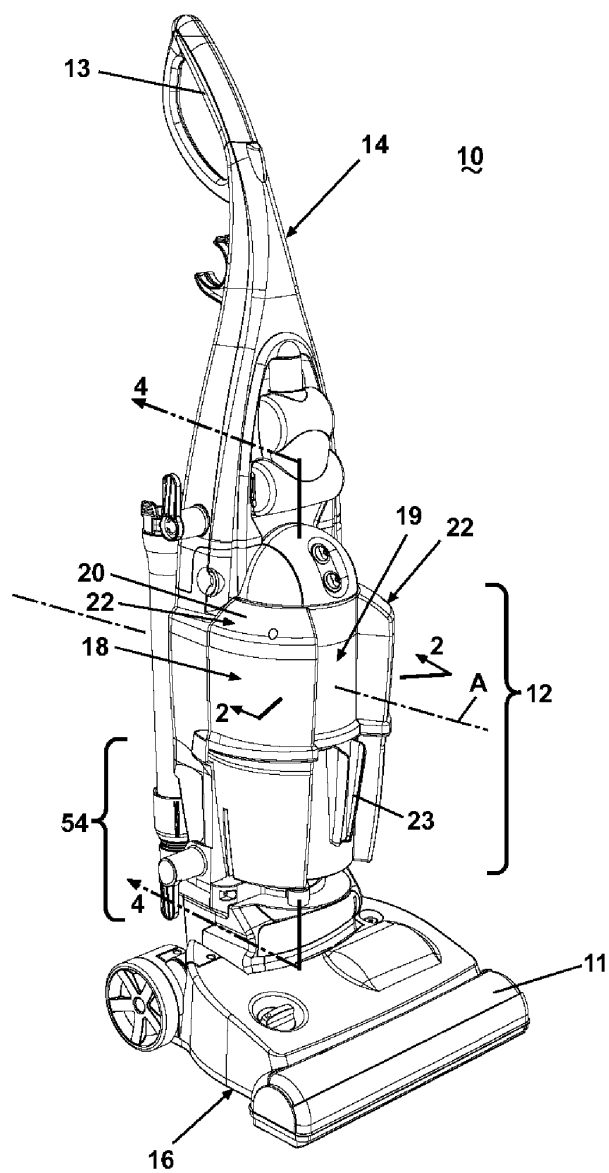


Fig. 1

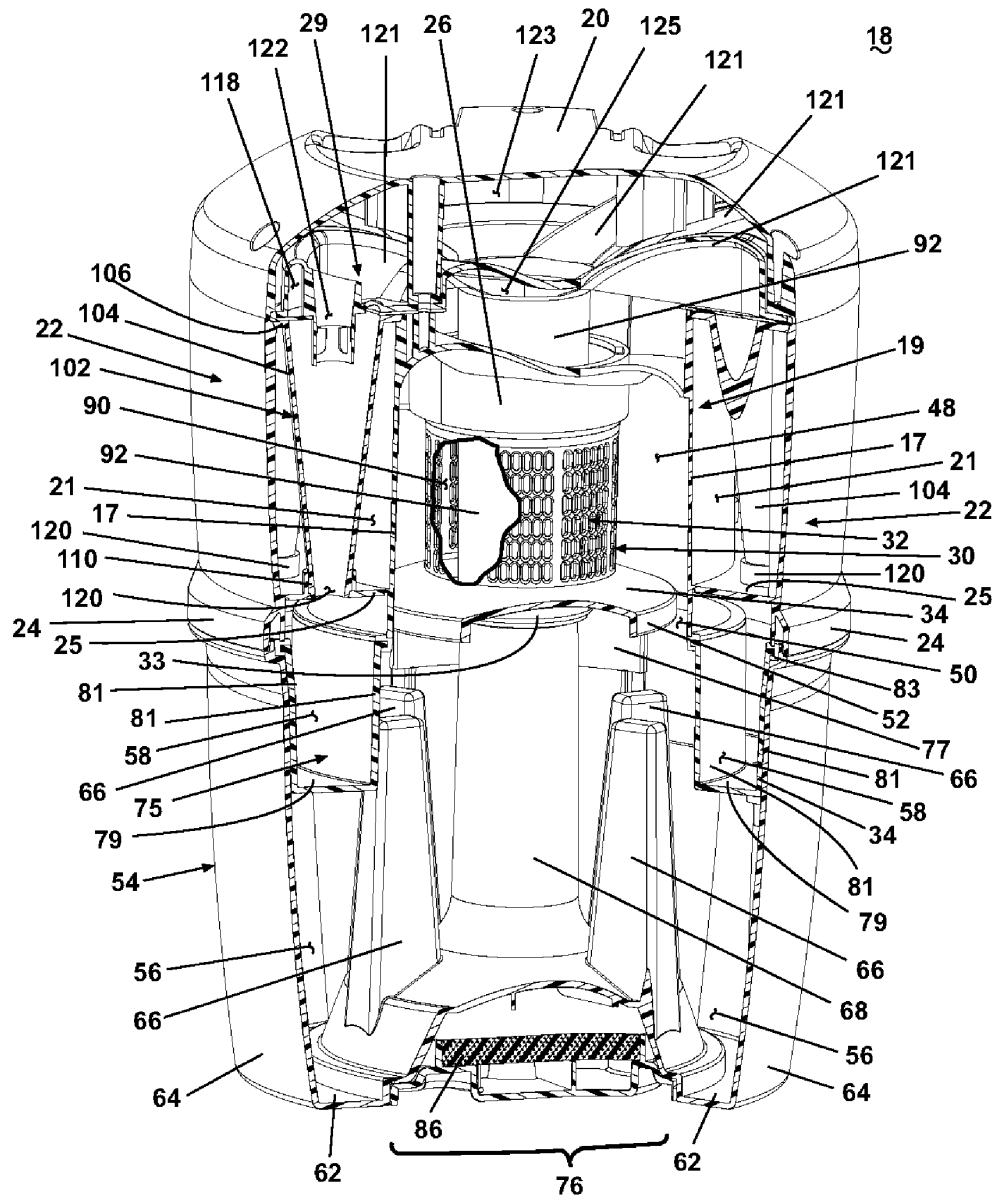
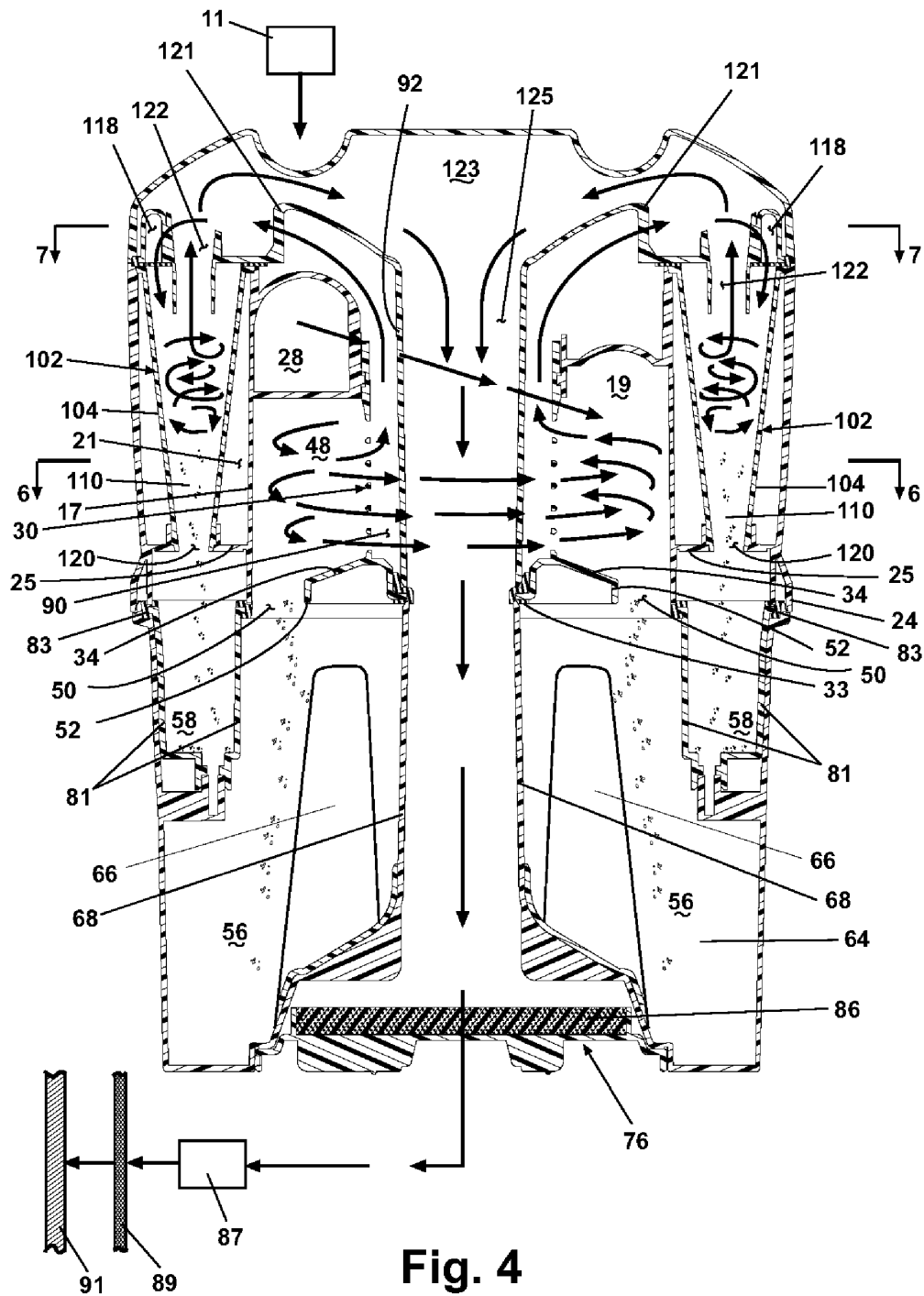


Fig. 2



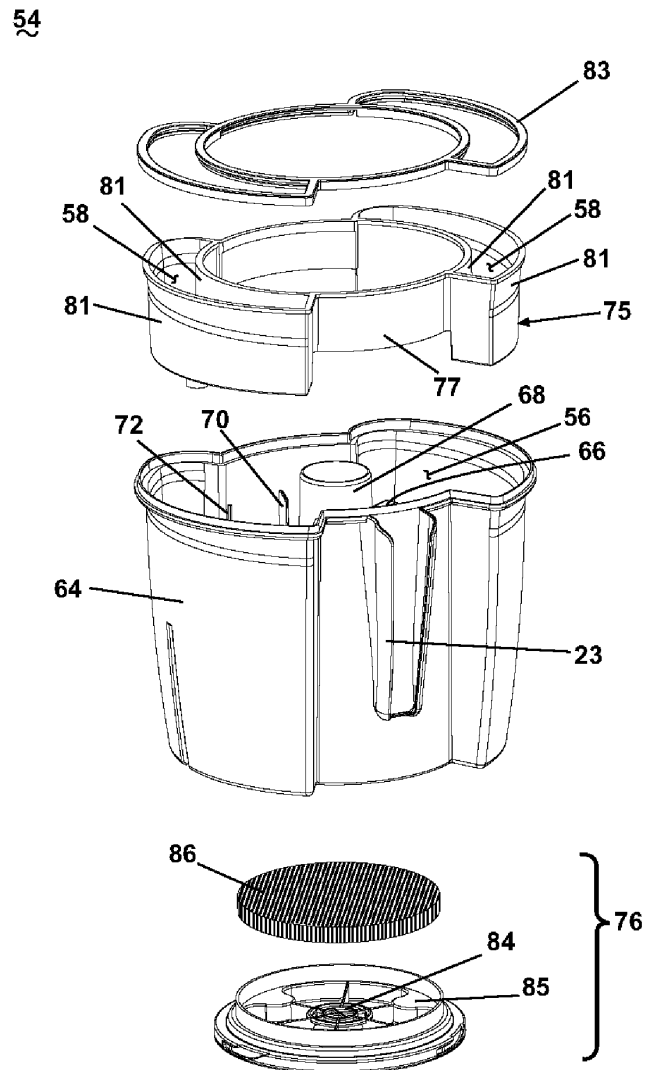


Fig. 5

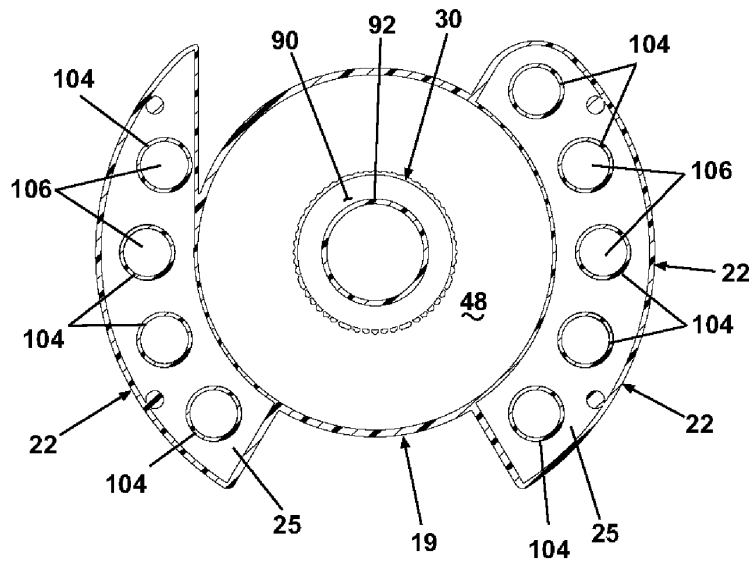


Fig. 6

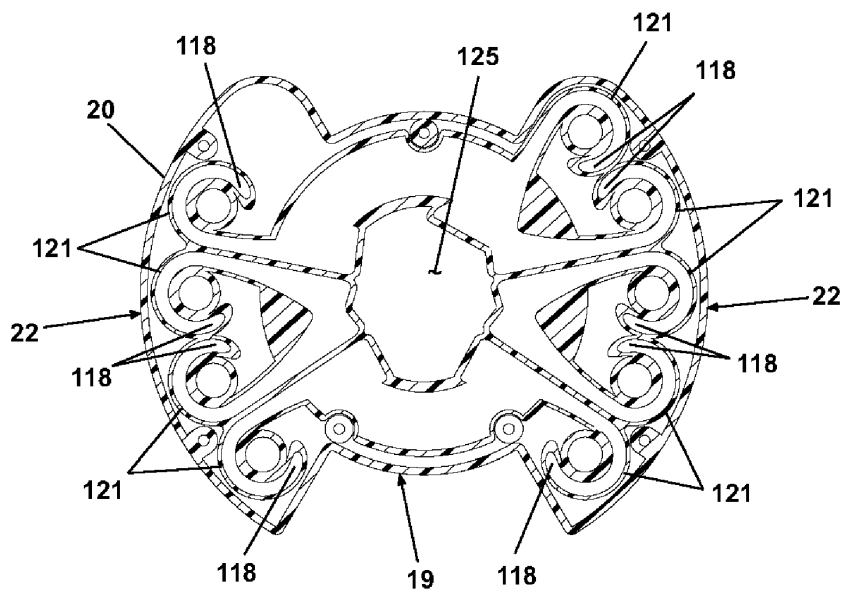


Fig. 7

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SEPARATORS AND BOTTOM
DISCHARGE DIRT CUP

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