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(54) **HAND-HELD CORDLESS VACUUM CLEANER**

(52) **U.S. Cl. 15/344**

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(57) **ABSTRACT**

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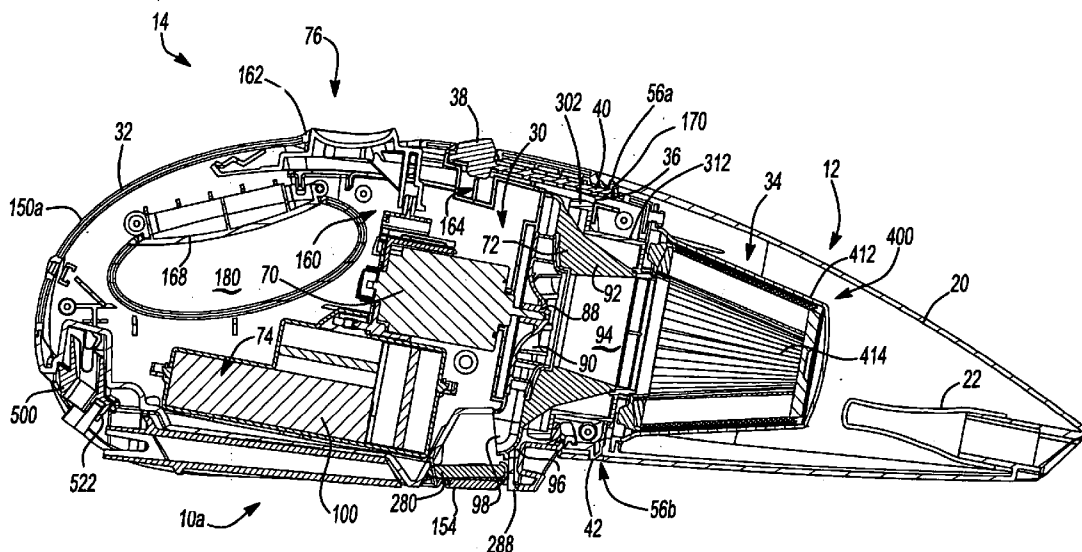
A hand-held vacuum cleaner with a container for the storage of dirt and debris therein. To provide improved efficiency and performance, the hand-held vacuum may employ a primary HEPA filter, a device for swirling a dirt and debris laden air flow and/or a mechanized filter cleaning device. Swirling may be employed to direct entrained dirt and debris in a desired direction relative to the container to slow the rate with which dirt and debris accumulates on the primary filter and/or to centrifugally remove dirt and debris from the air flow. Mechanized cleaning is employed to shake, scrape or otherwise remove accumulated dirt and debris from the primary filter.

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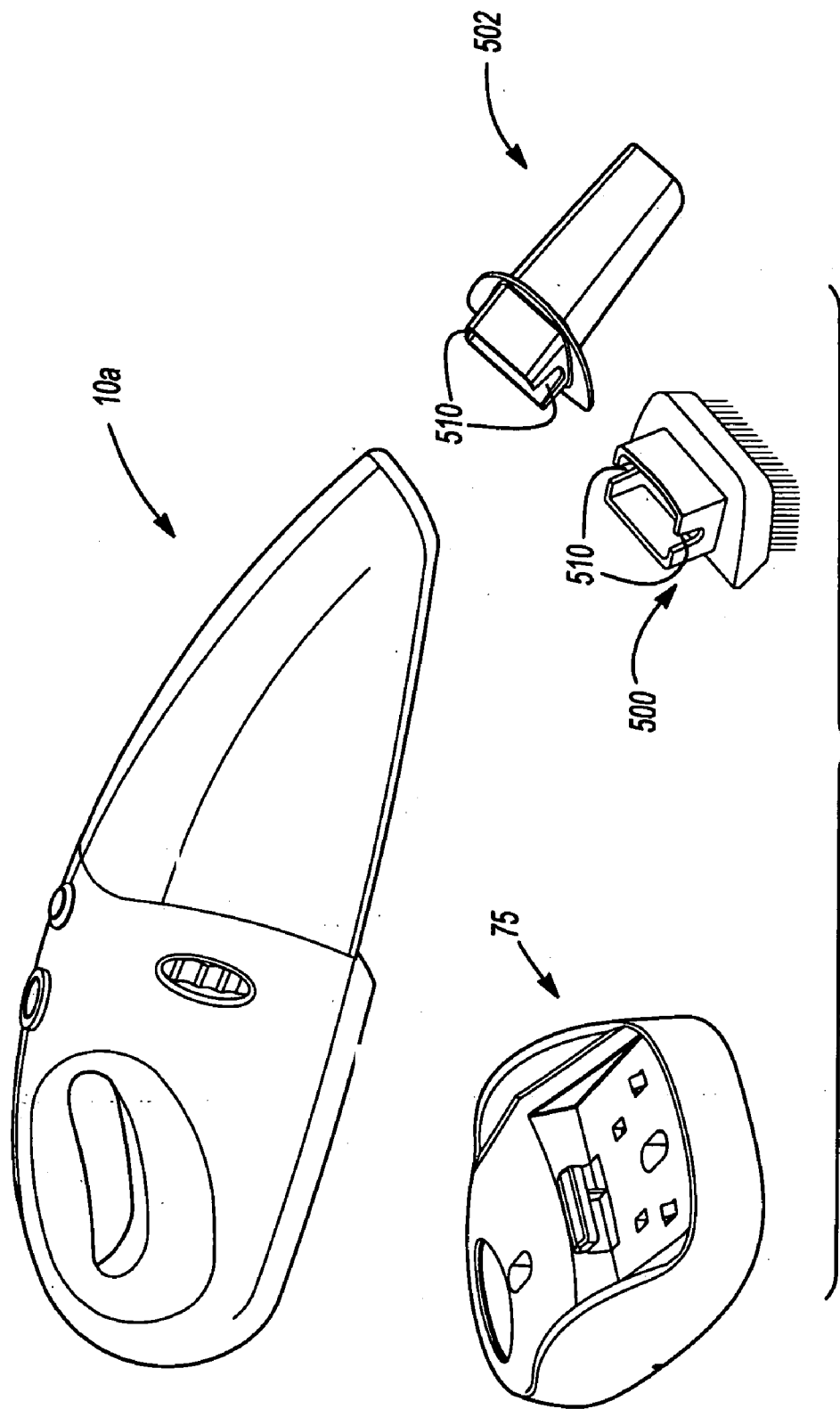


Fig-1

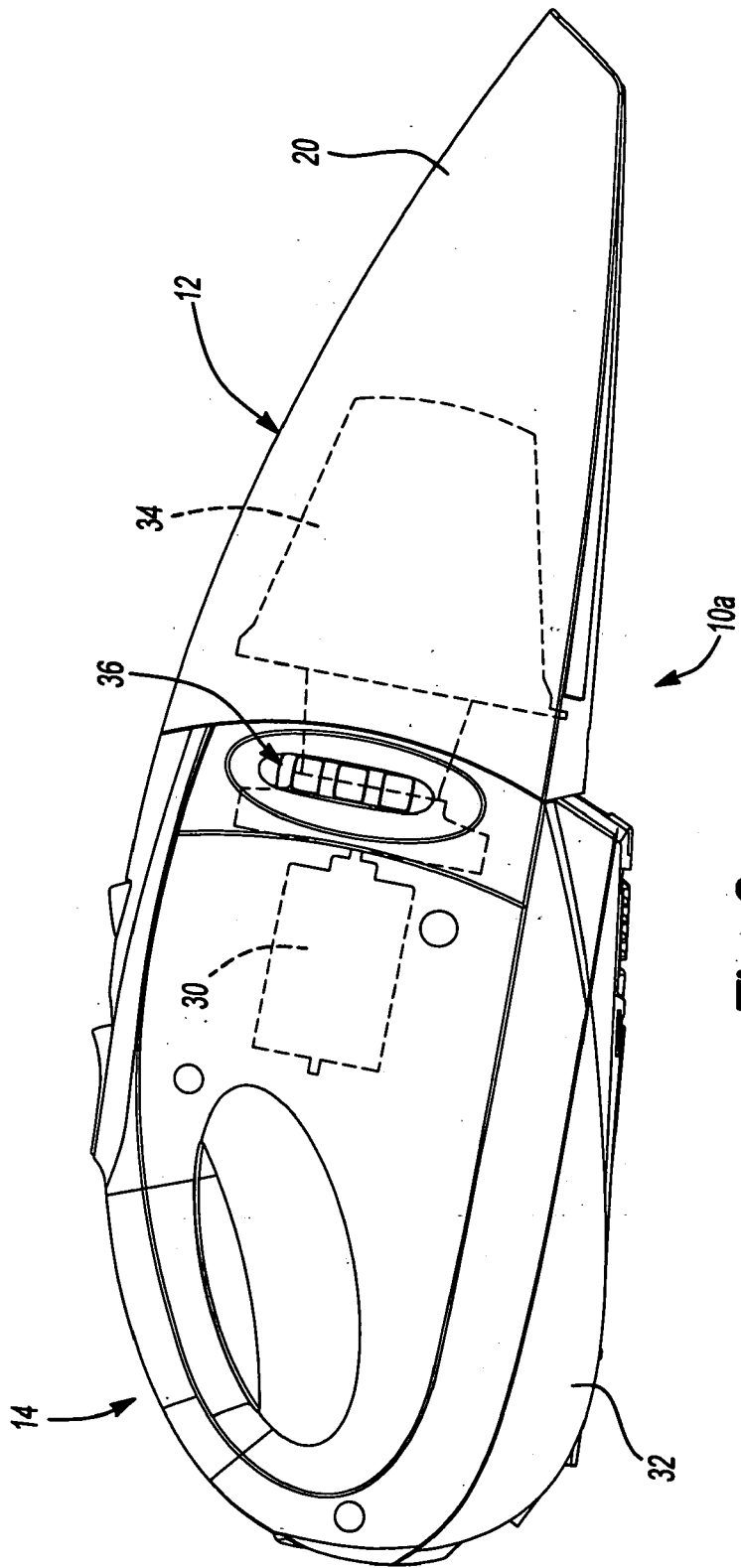


Fig-2

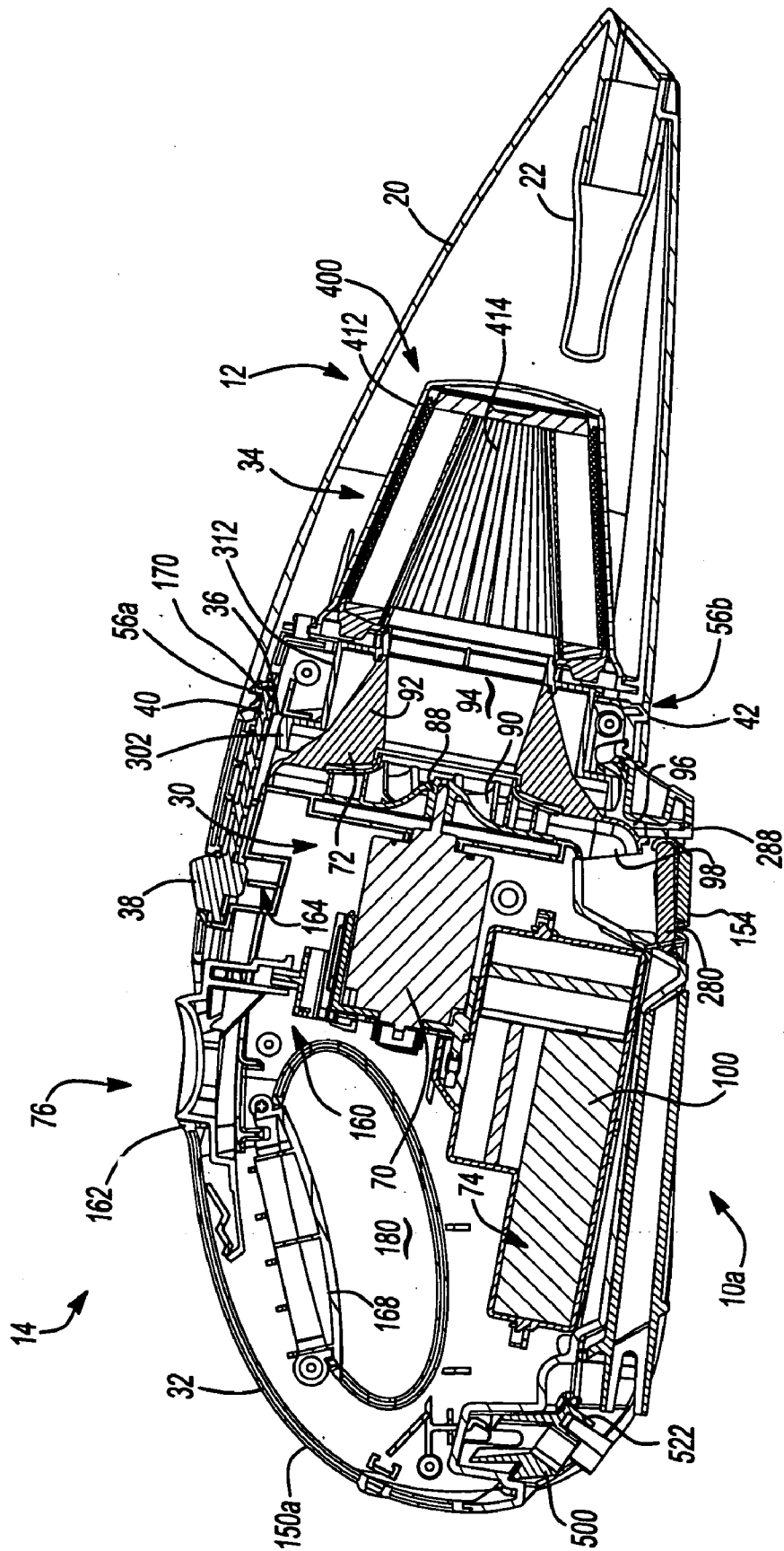


Fig-3

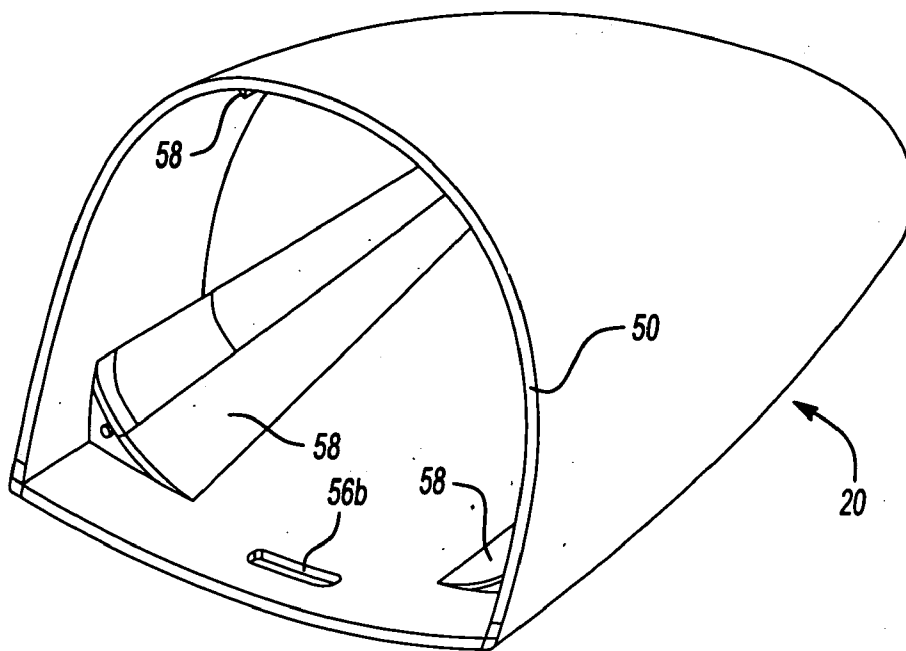


Fig-4

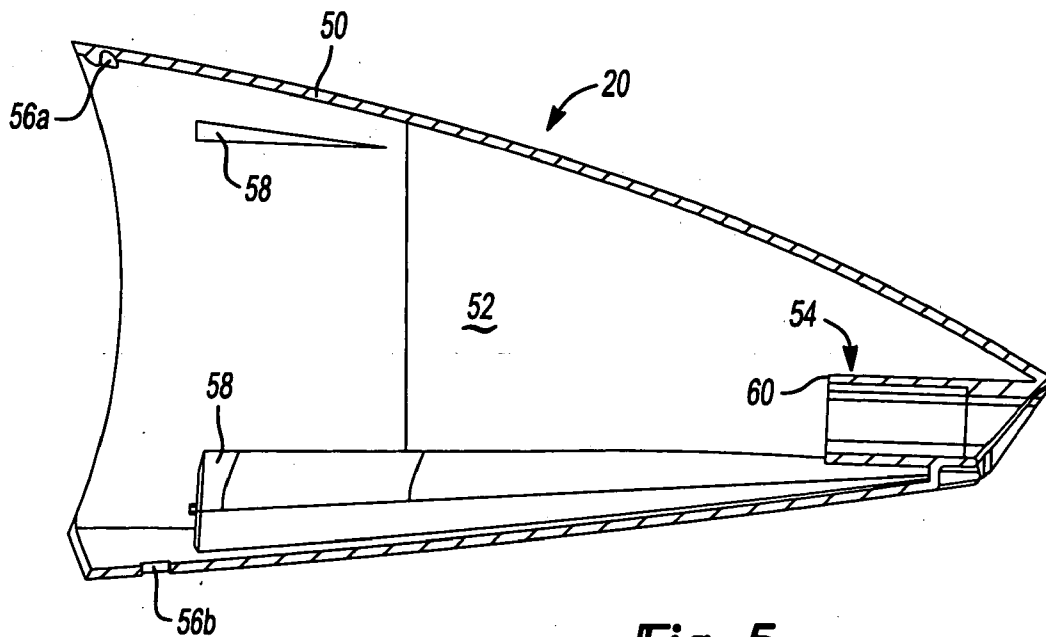
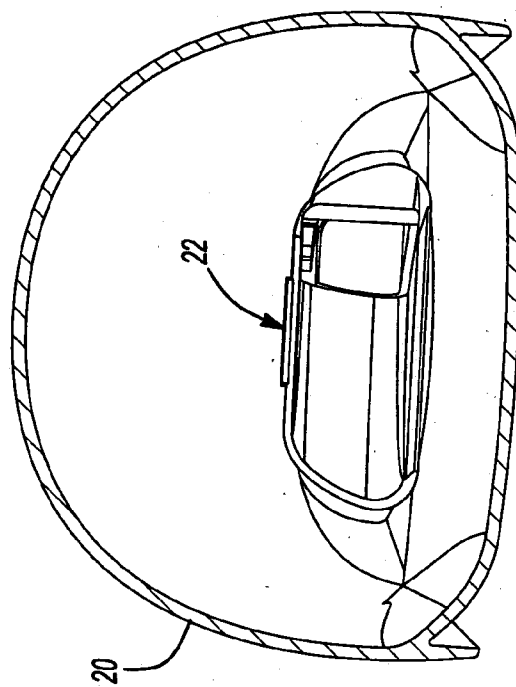
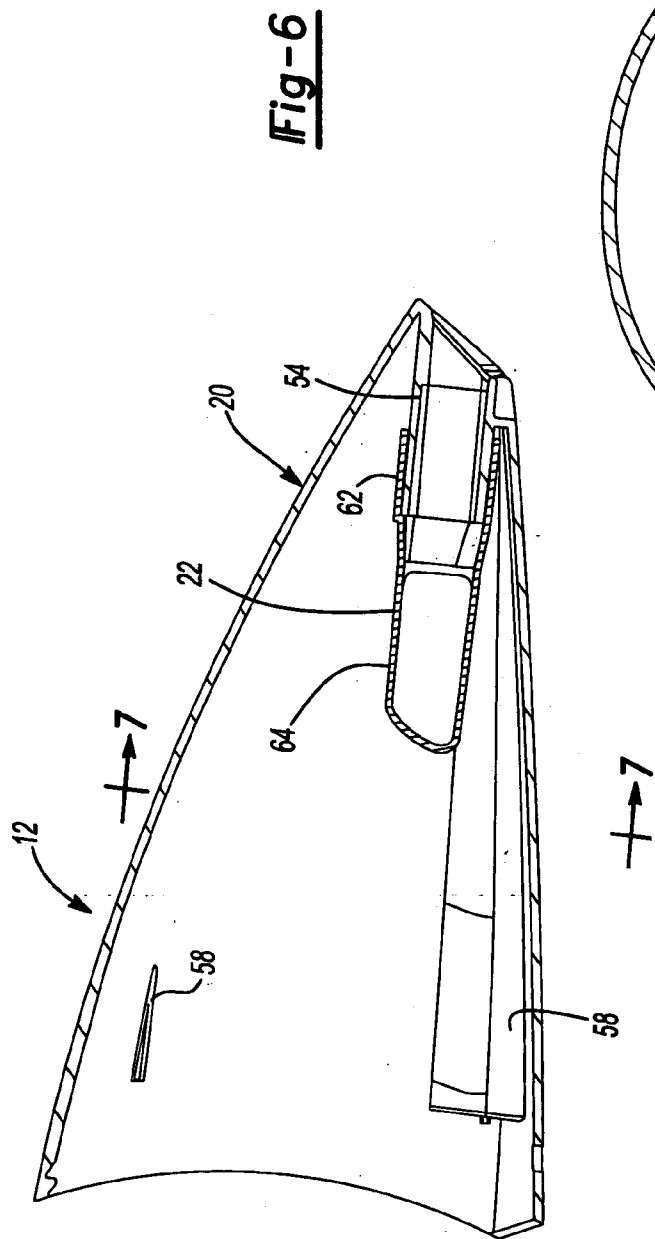


Fig-5



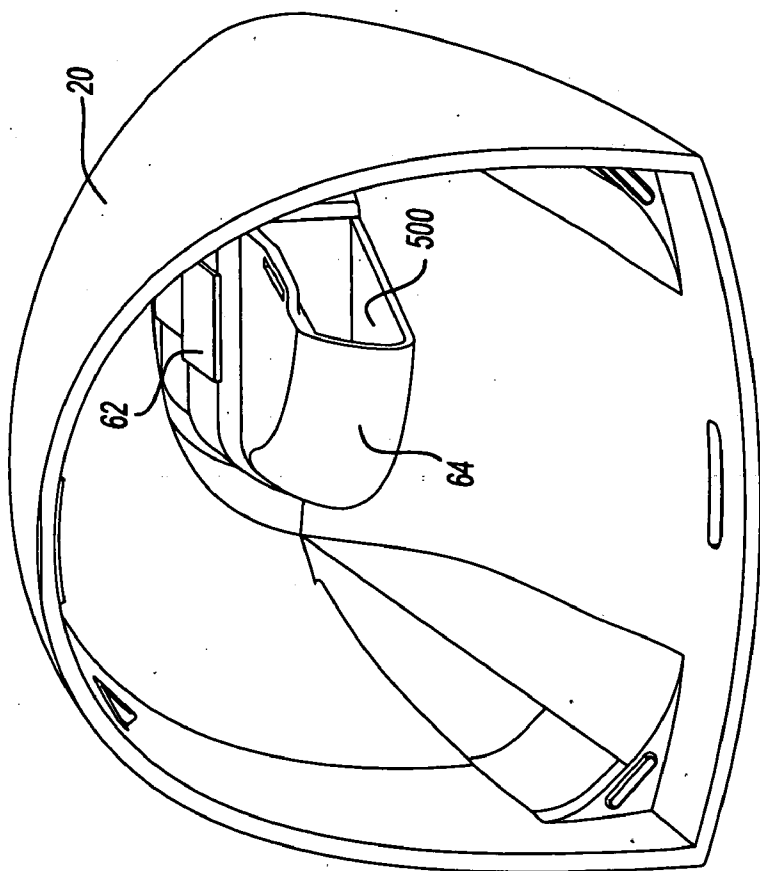


Fig-8

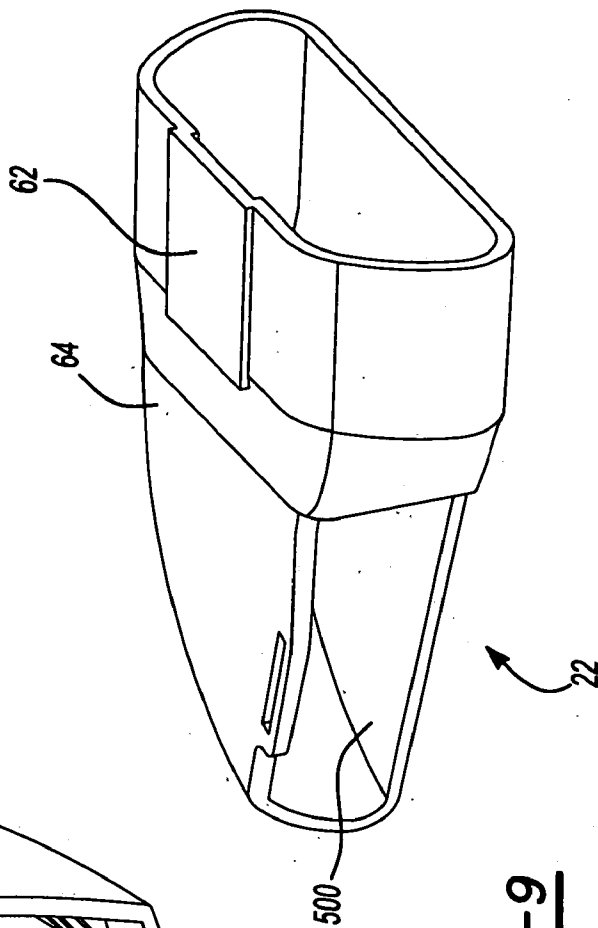
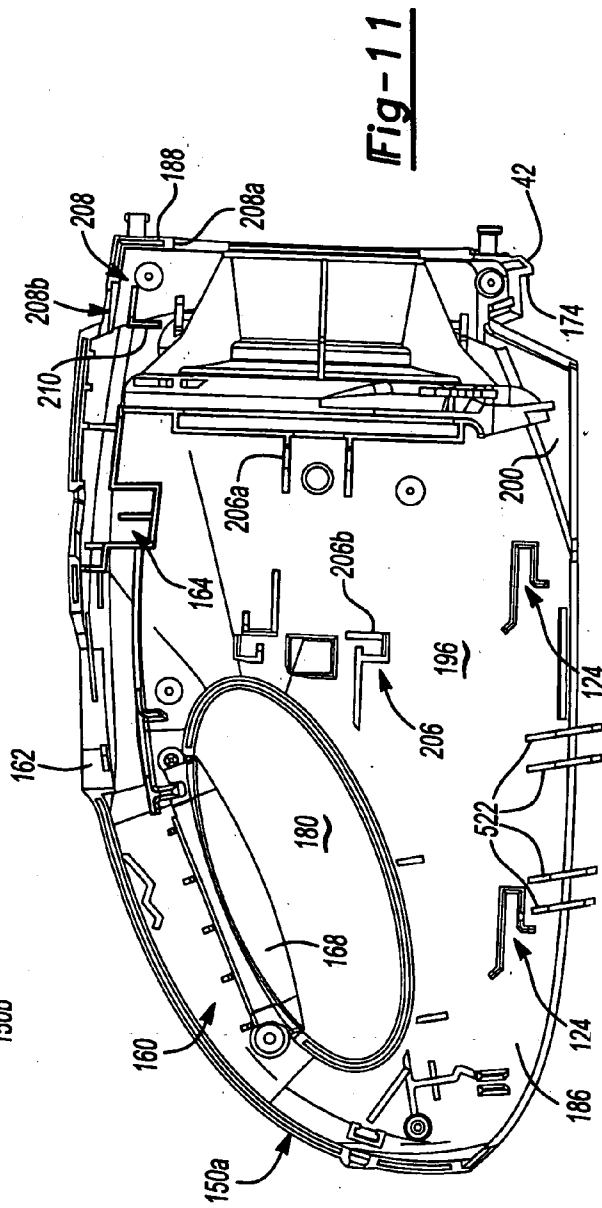
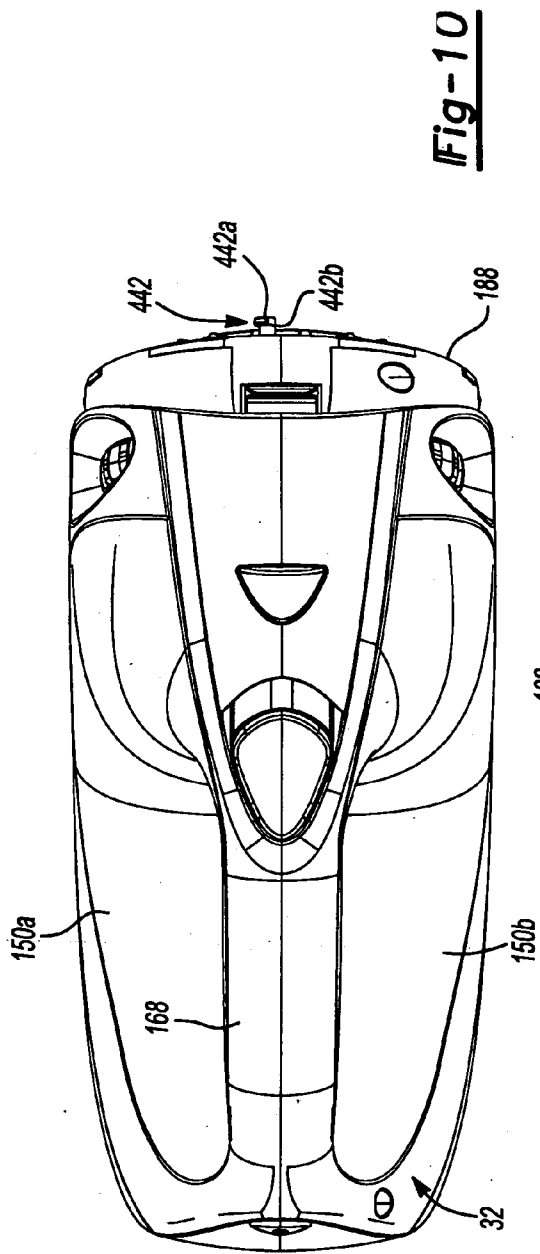


Fig-9



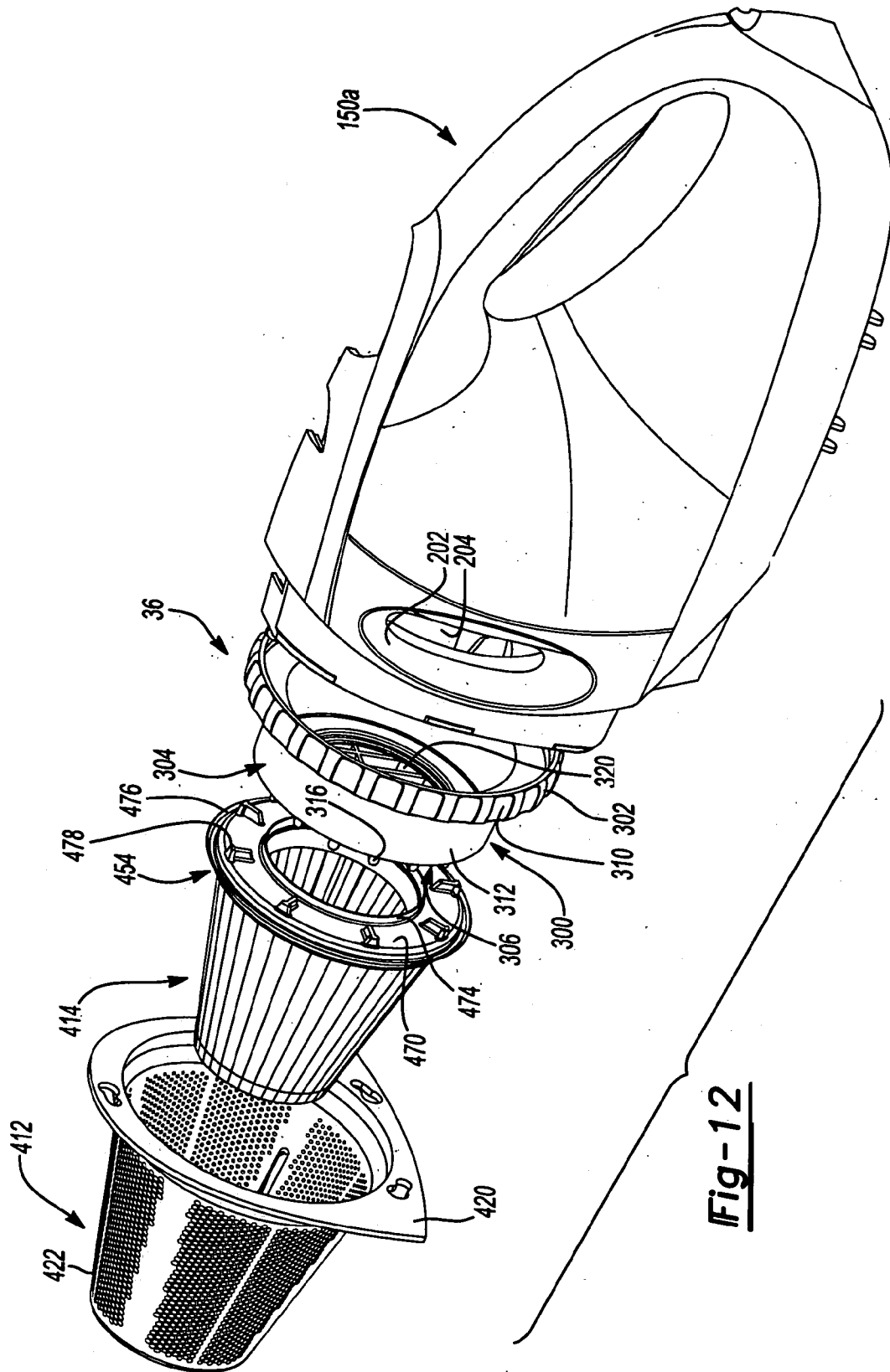


Fig-12

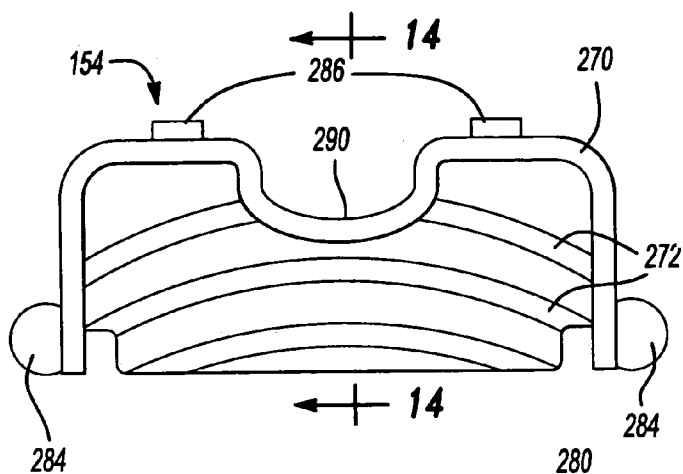
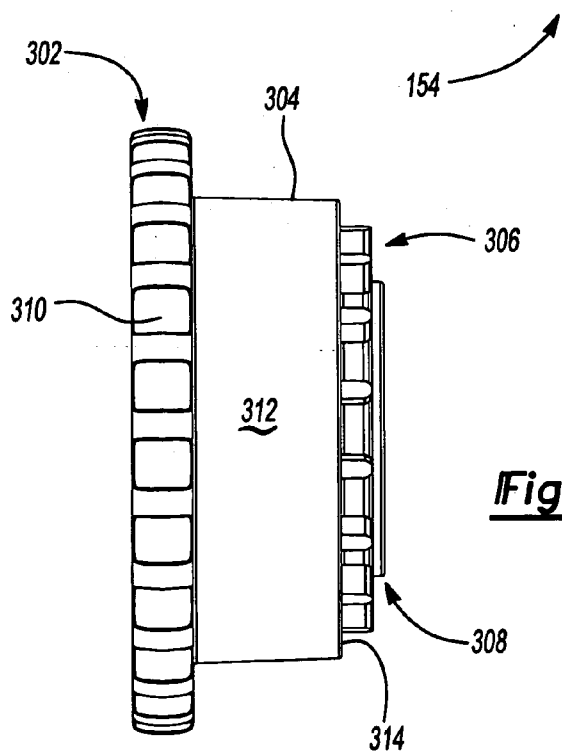
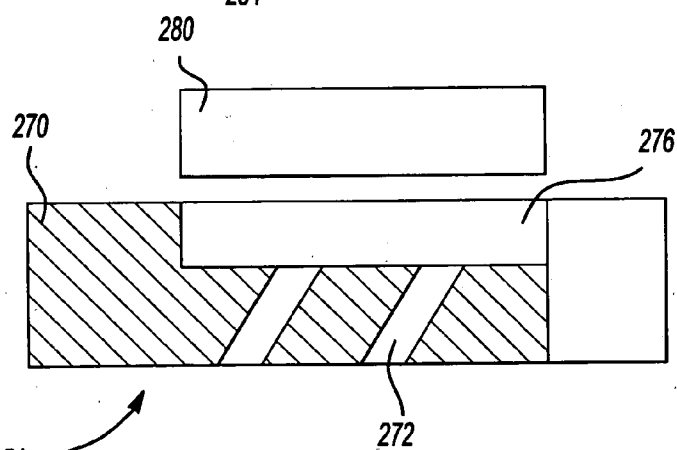


Fig-14



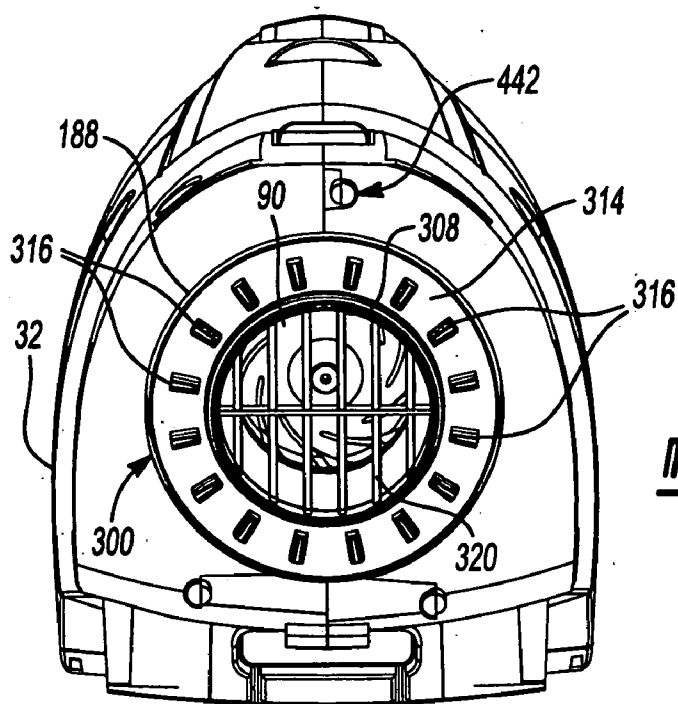


Fig-16

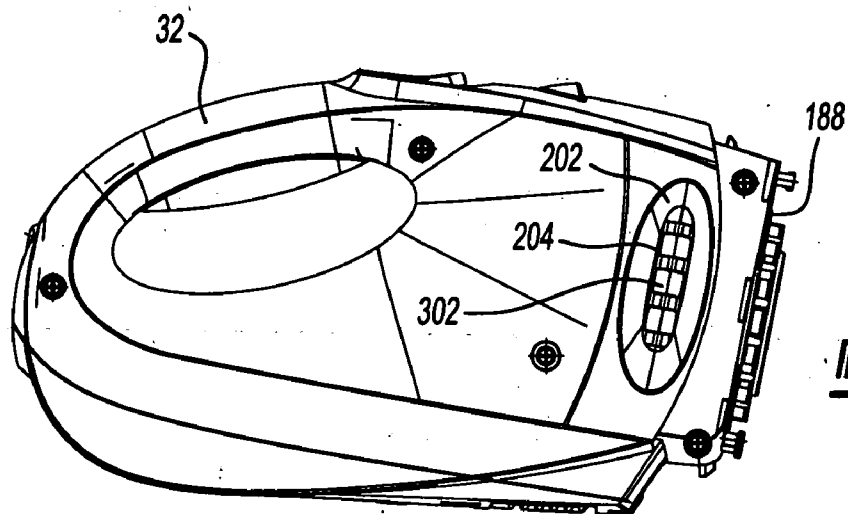


Fig-17

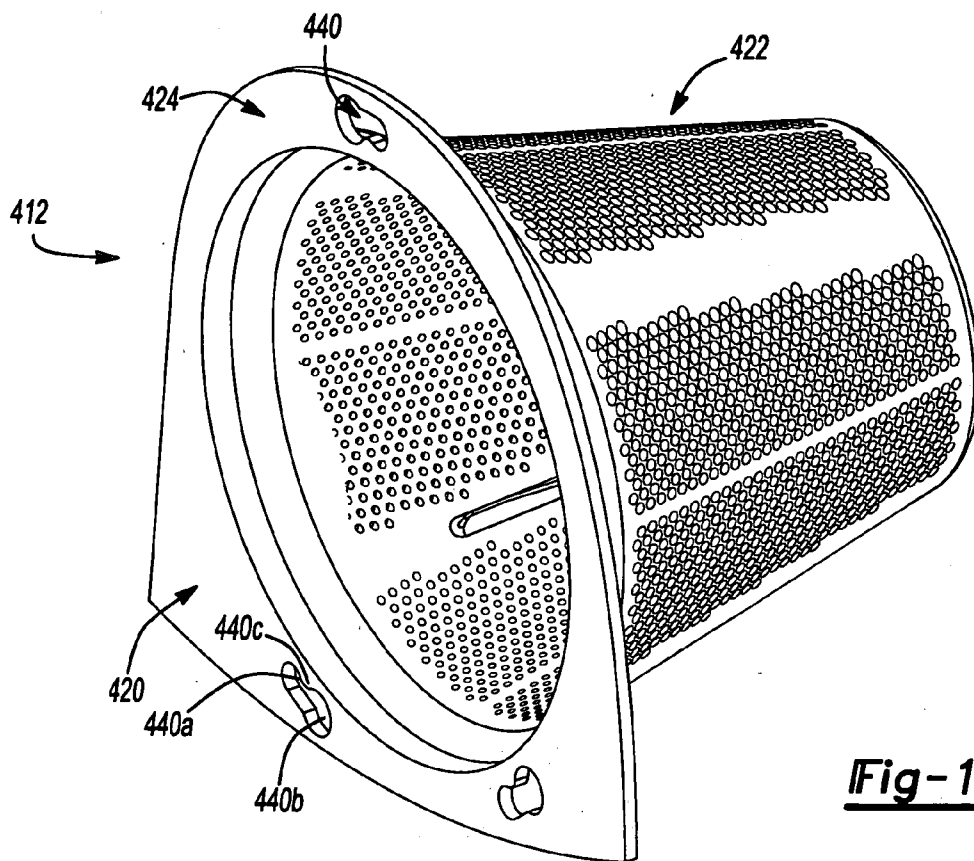


Fig-18

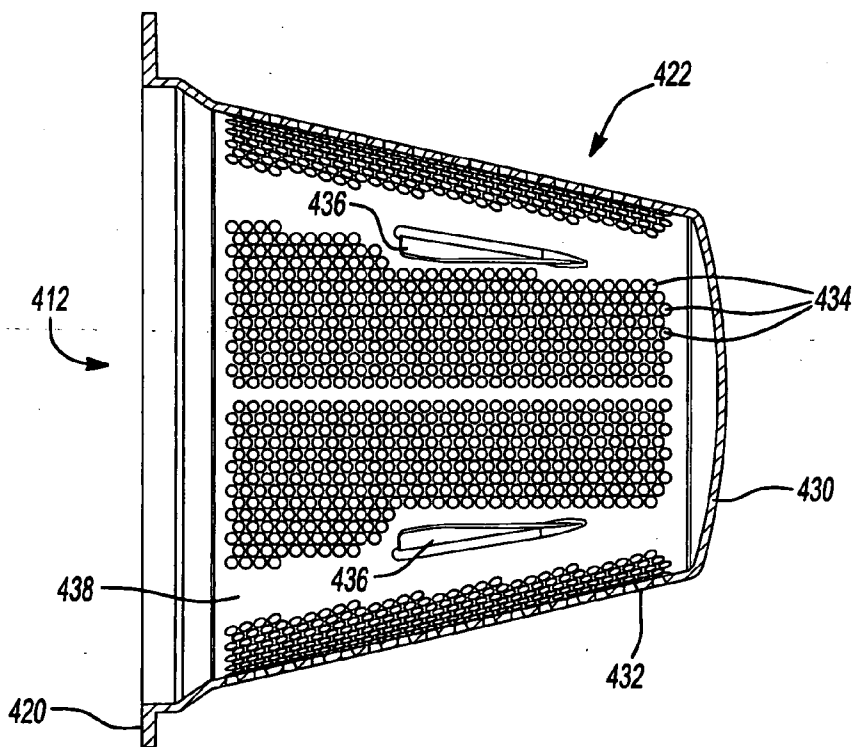


Fig-19

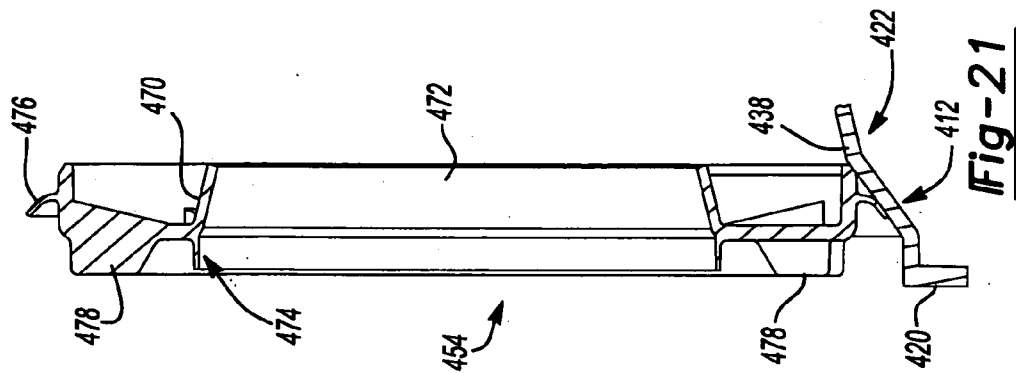


Fig-21

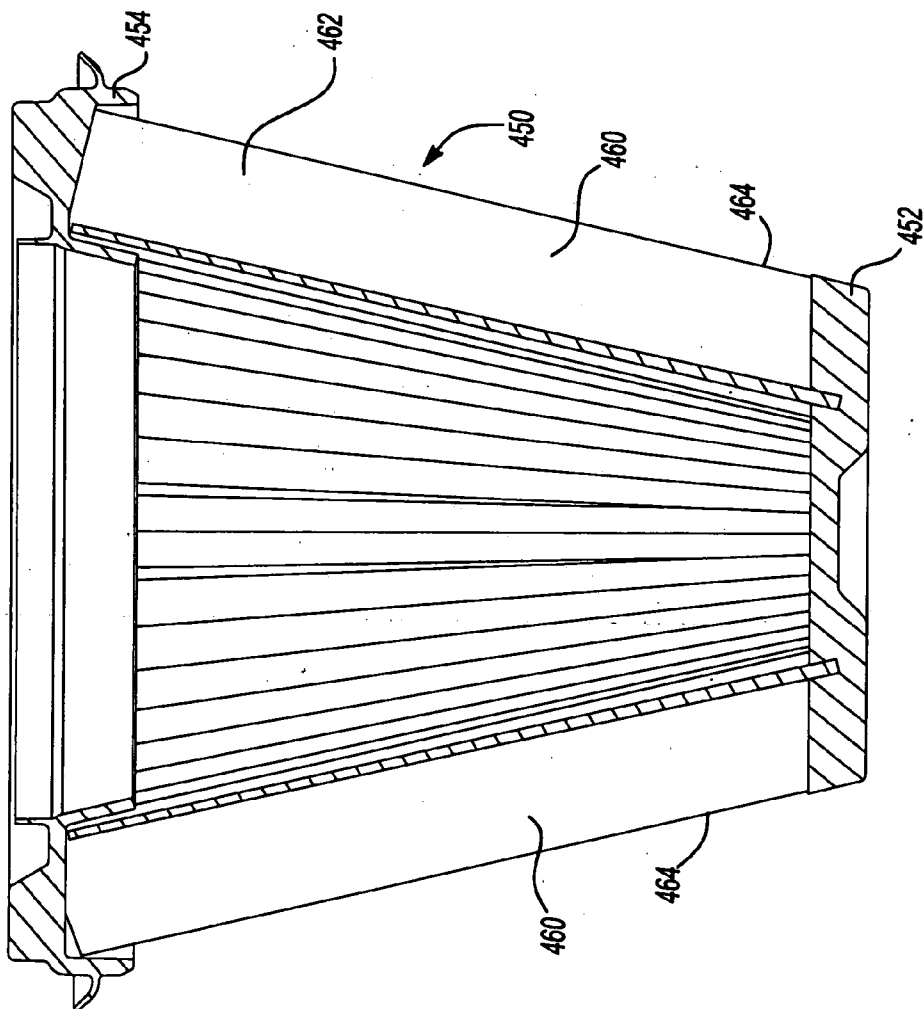
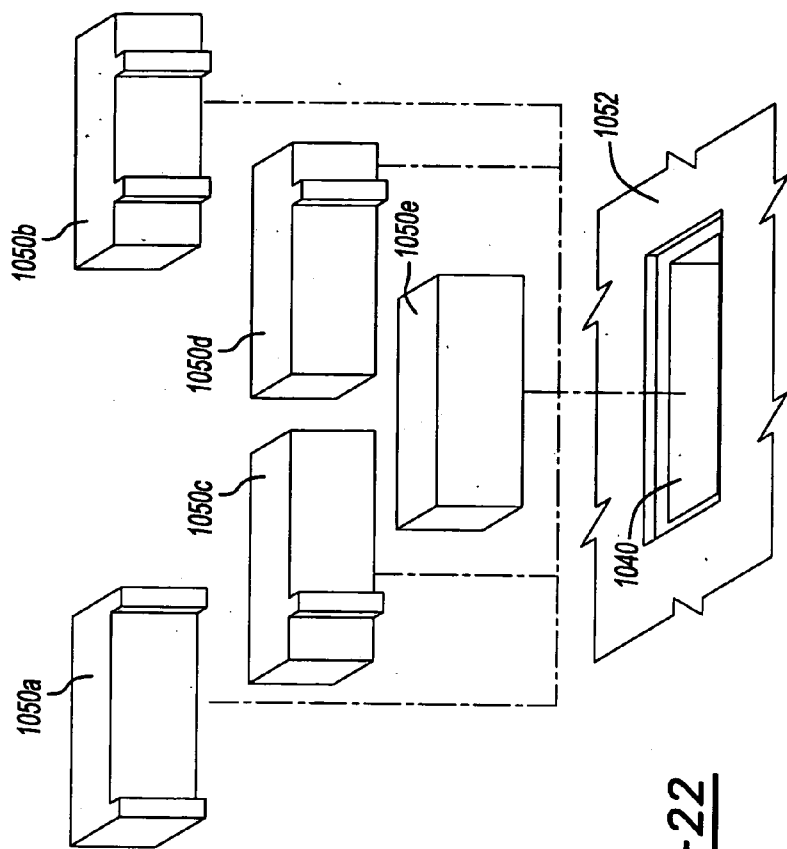
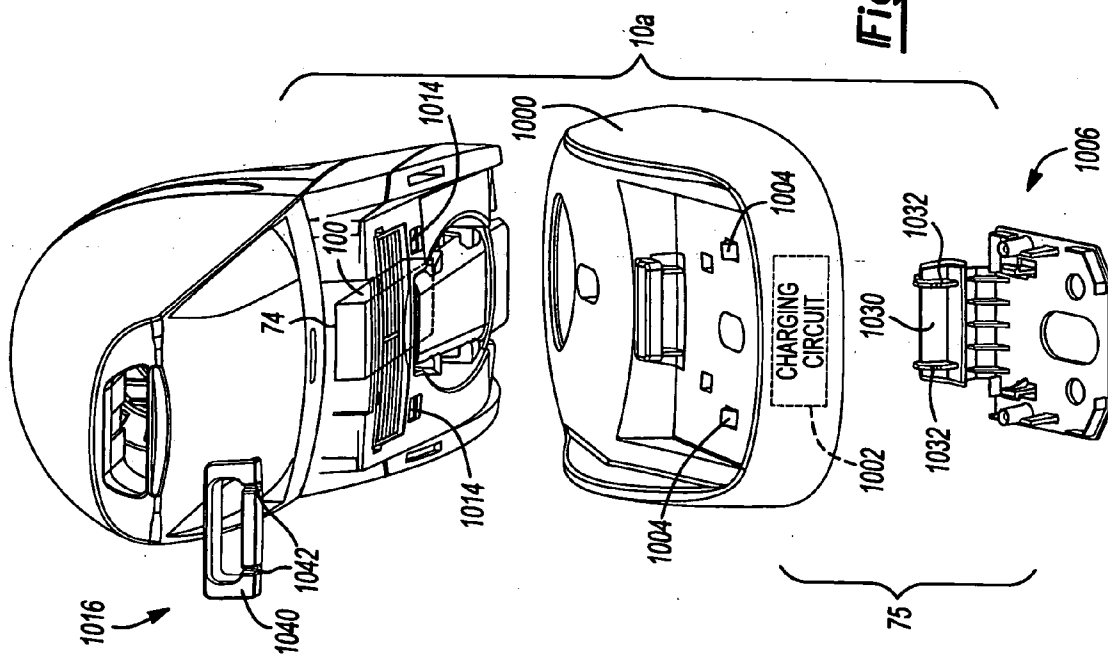


Fig-20



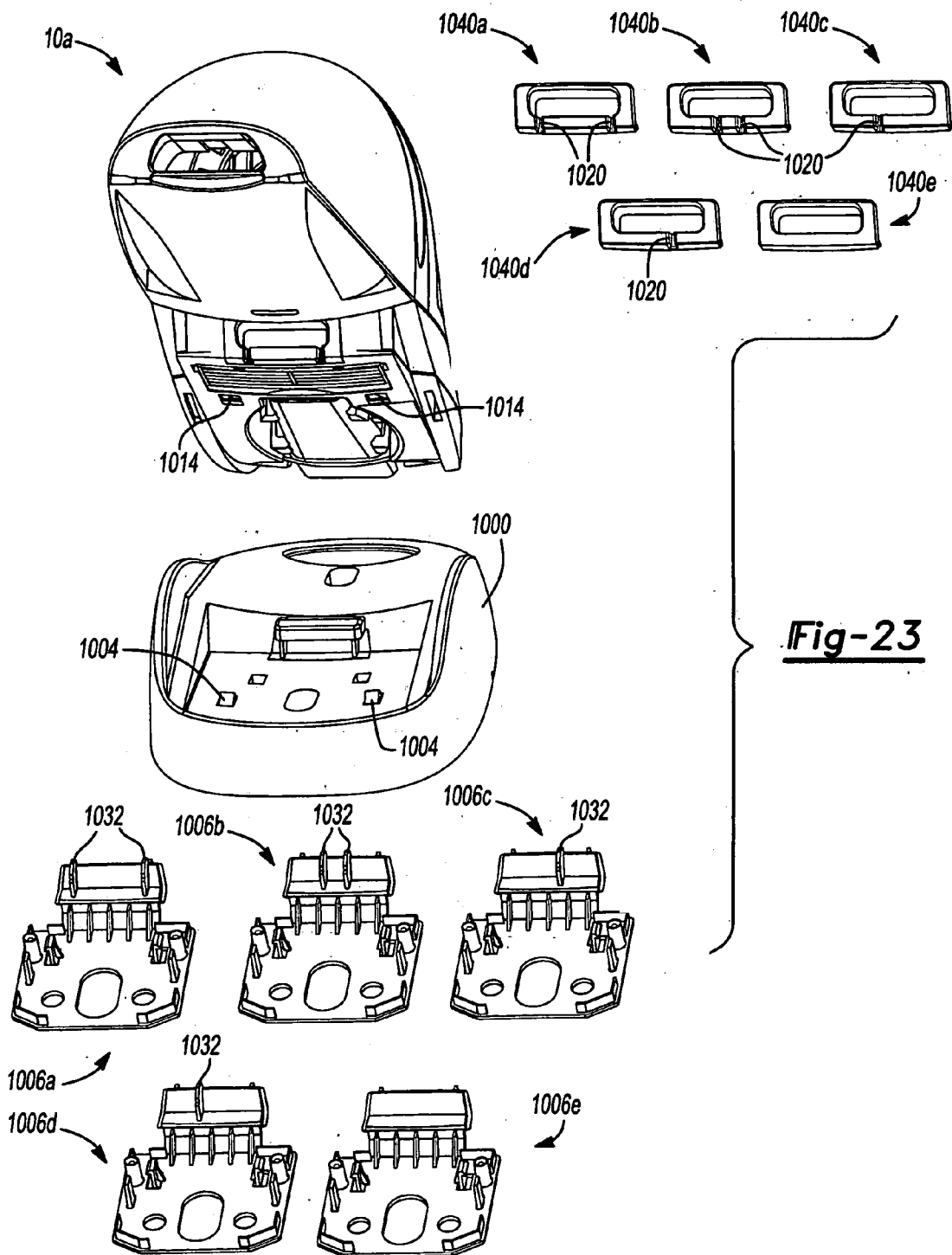
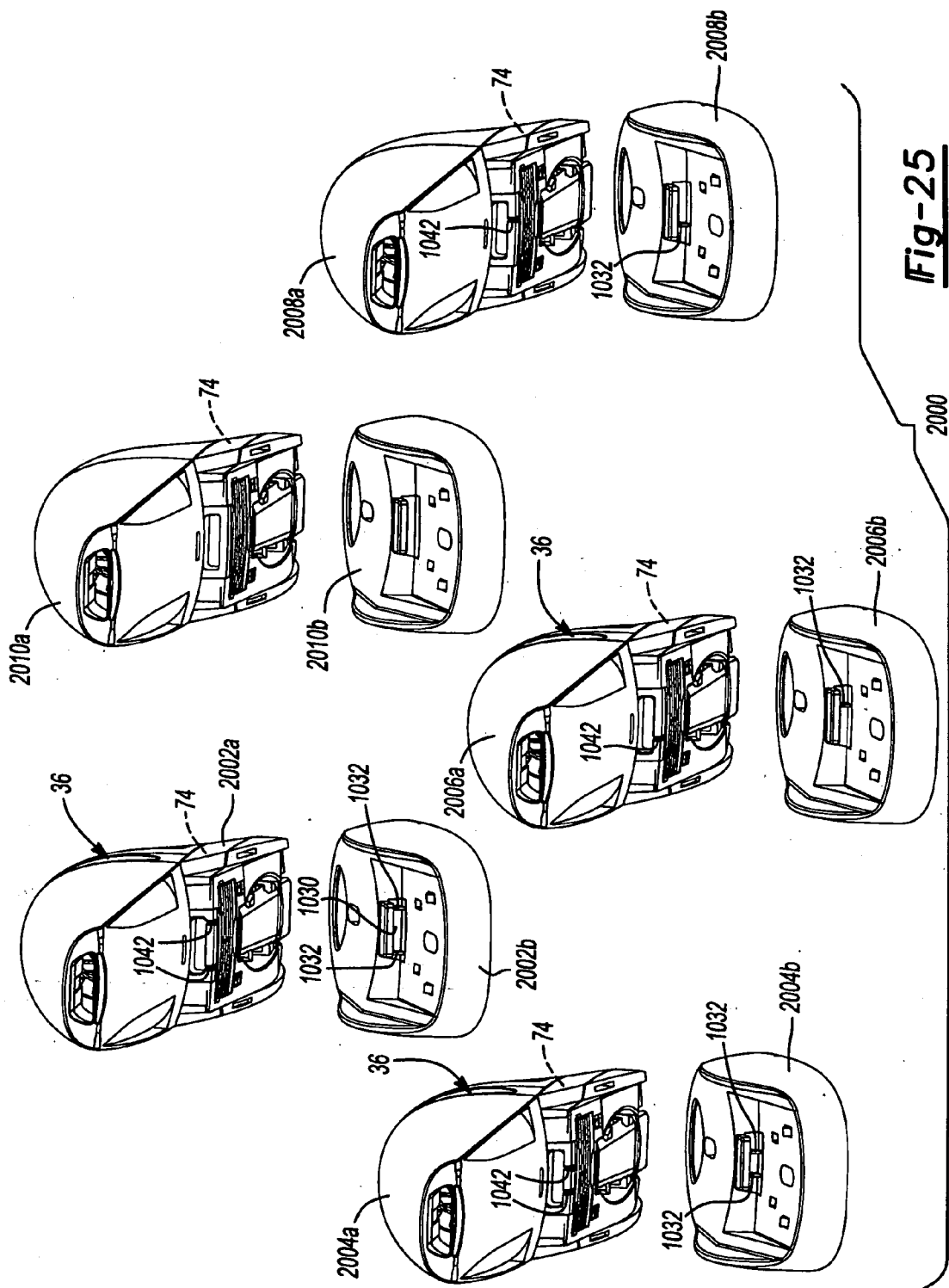


Fig-23



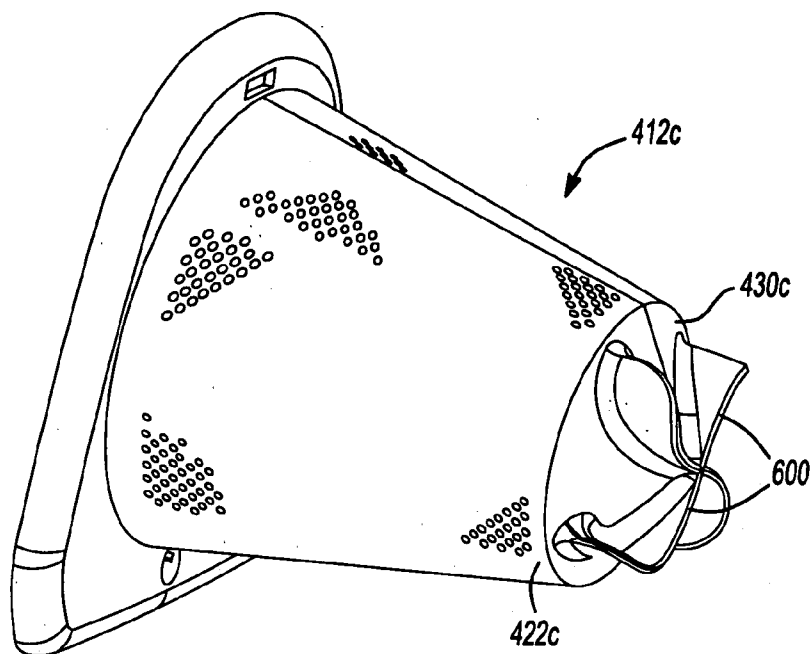


Fig-26

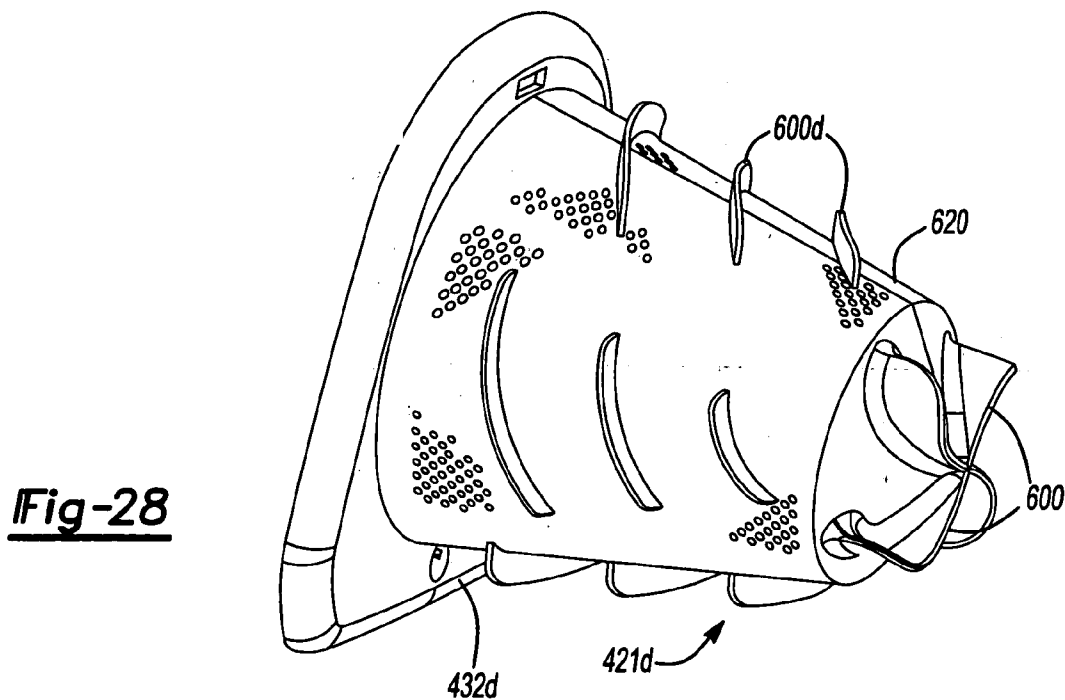


Fig-28

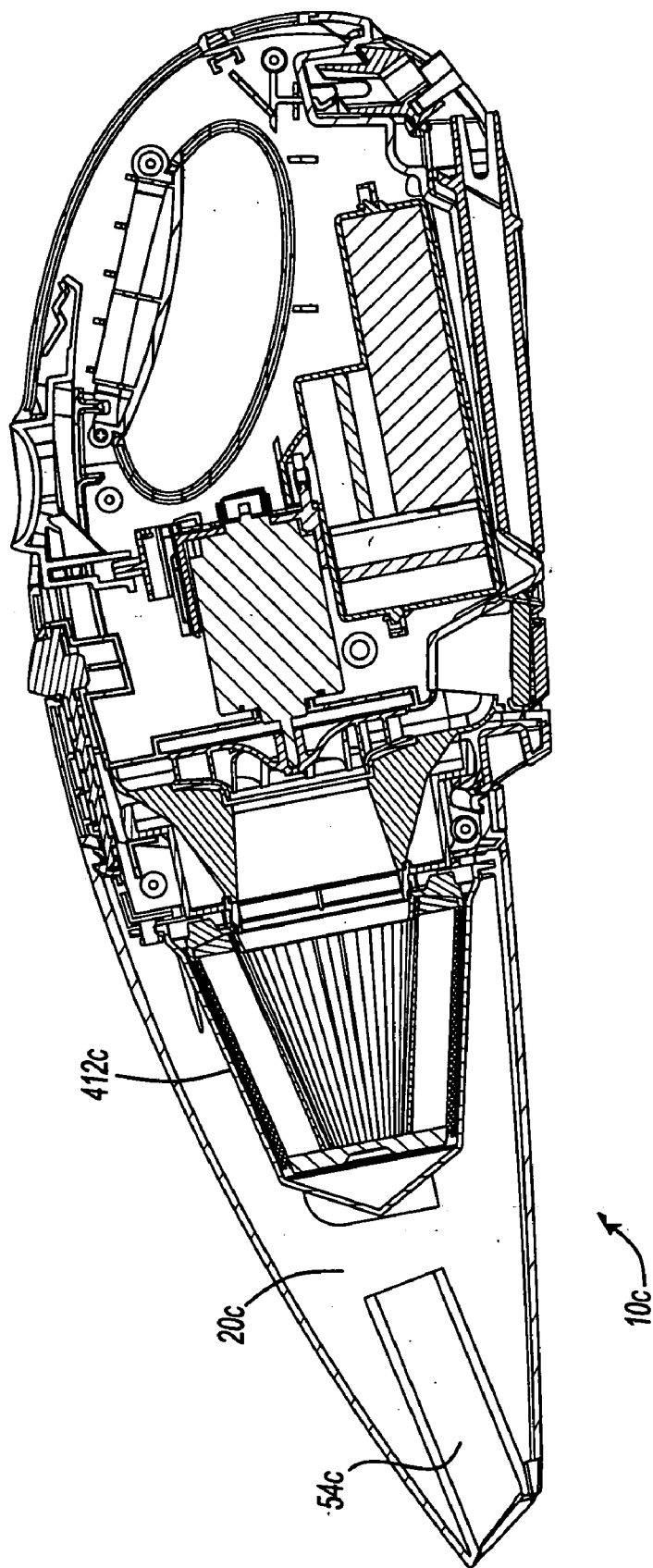
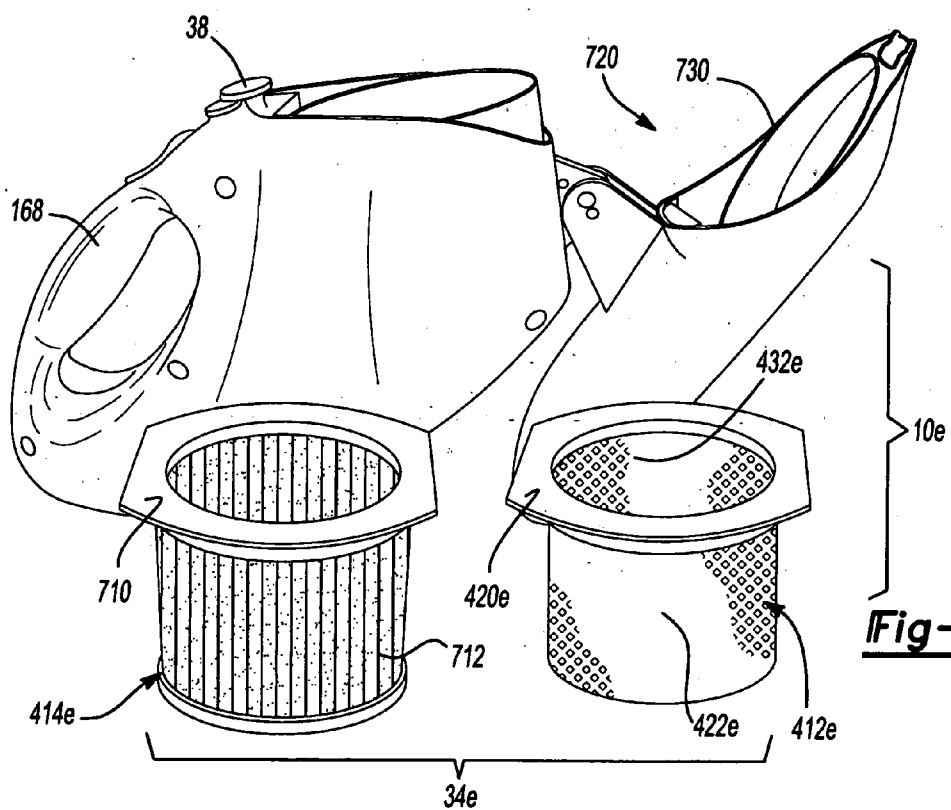
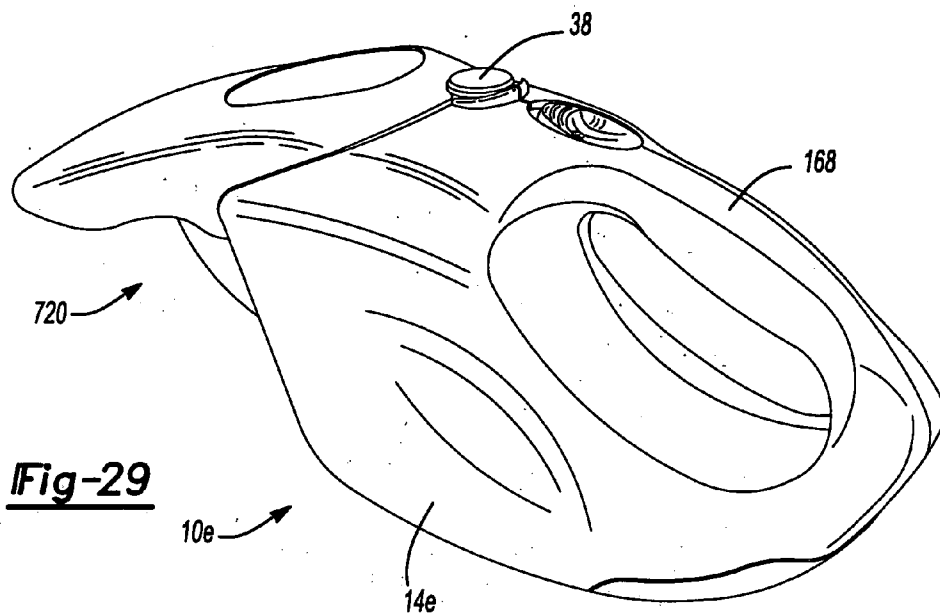


Fig-27



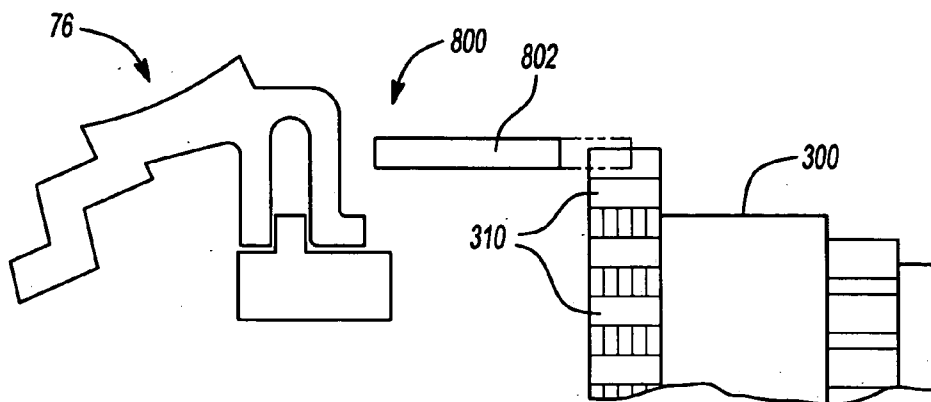


Fig-31

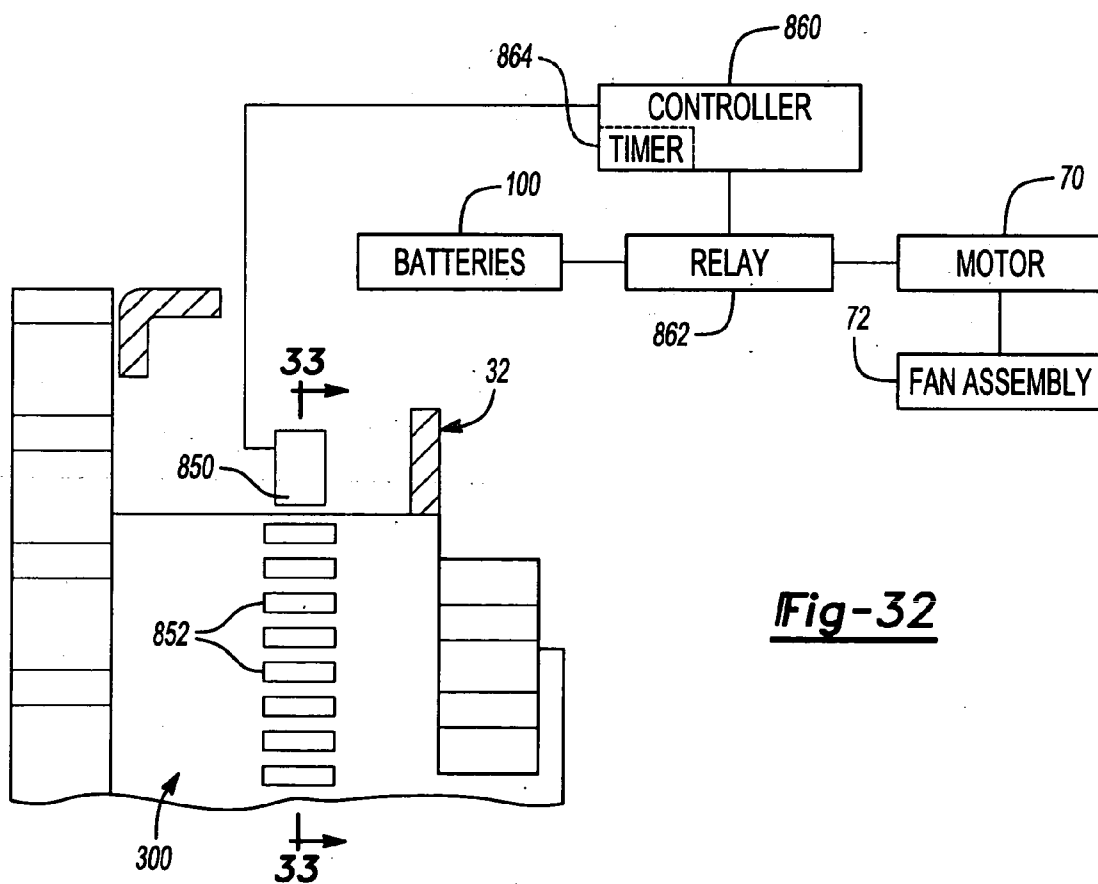


Fig-32

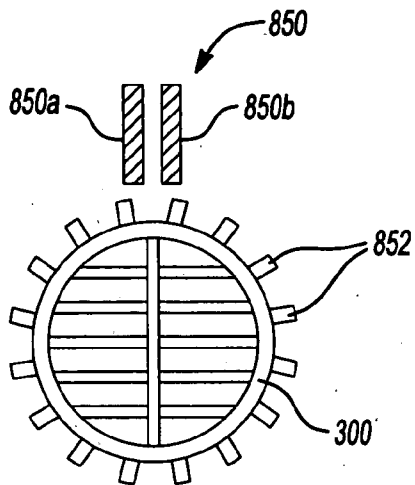


Fig-33

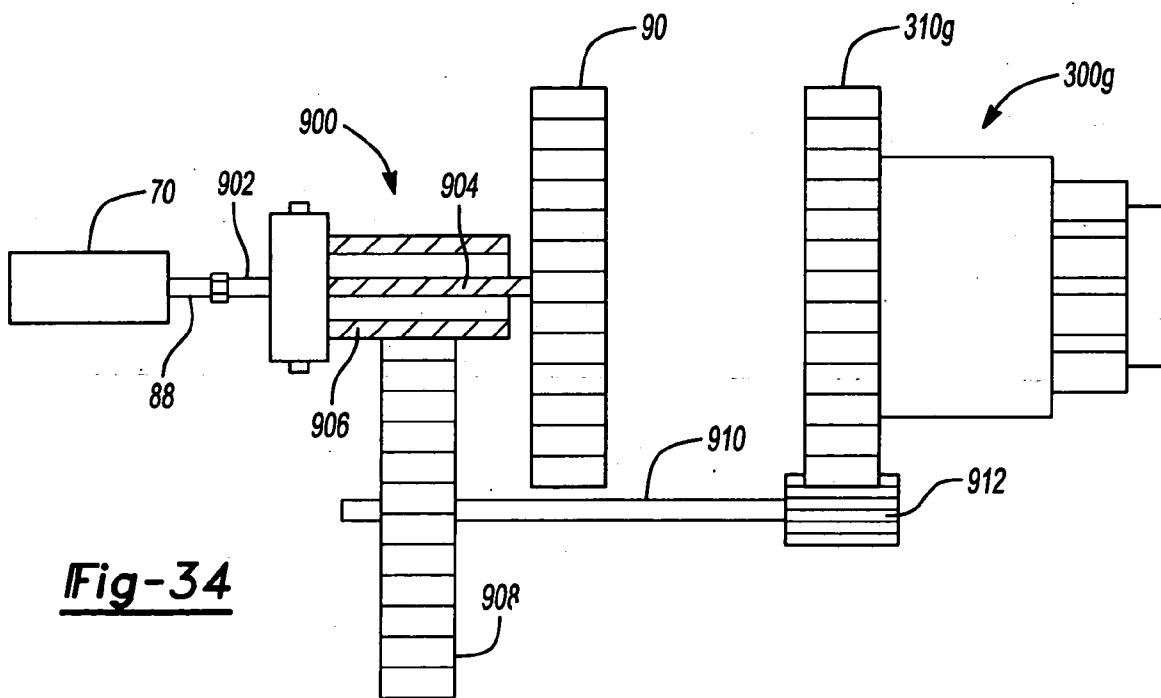


Fig-34

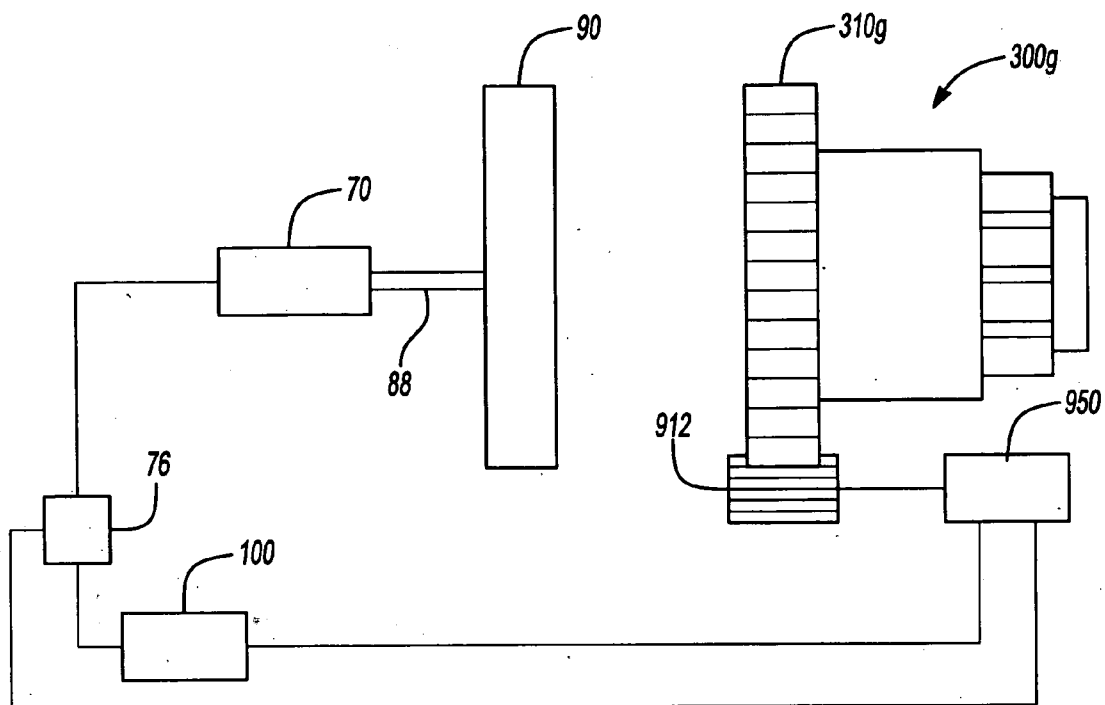


Fig-35

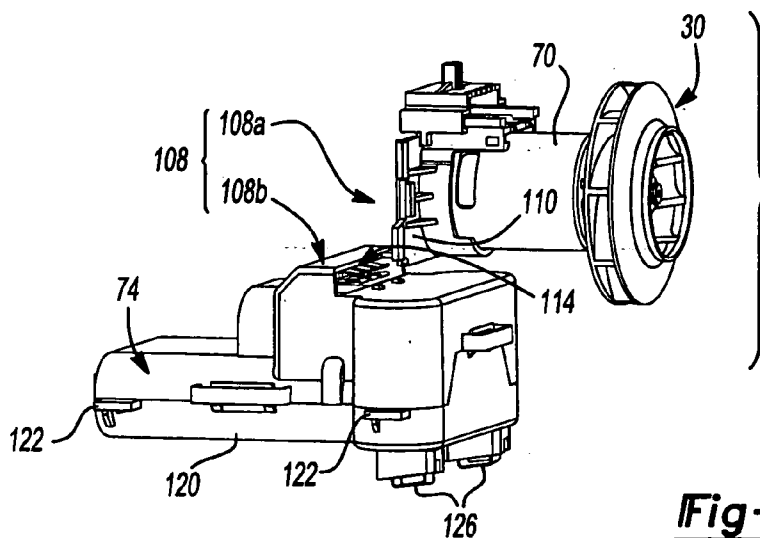


Fig-36

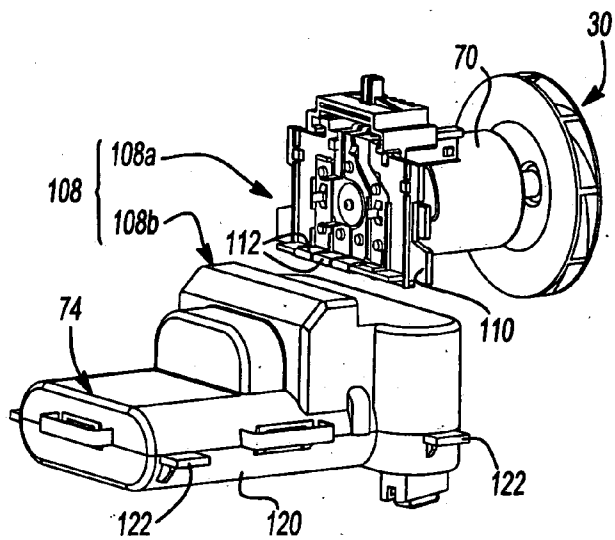


Fig-37

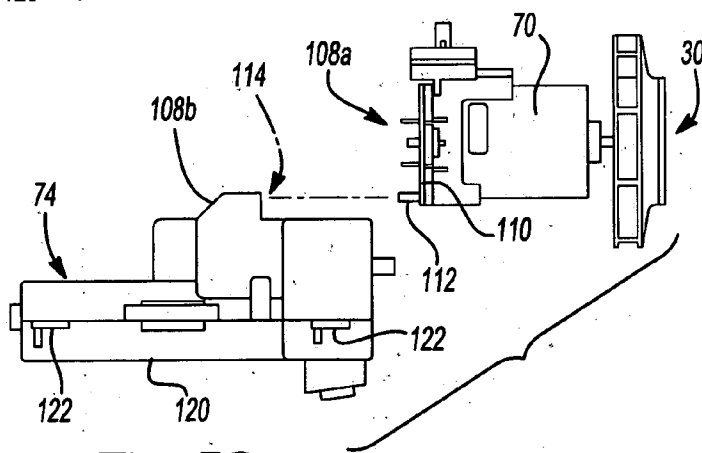


Fig-38

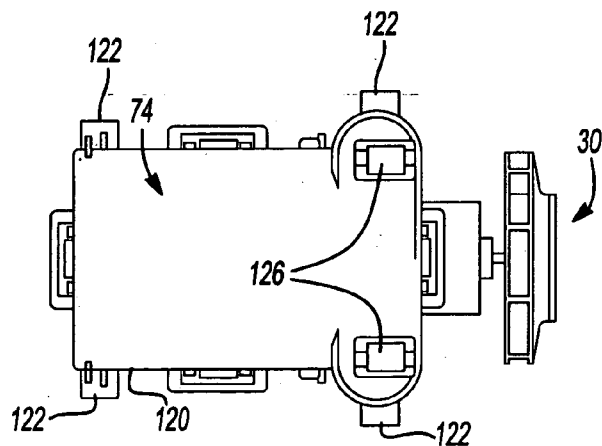
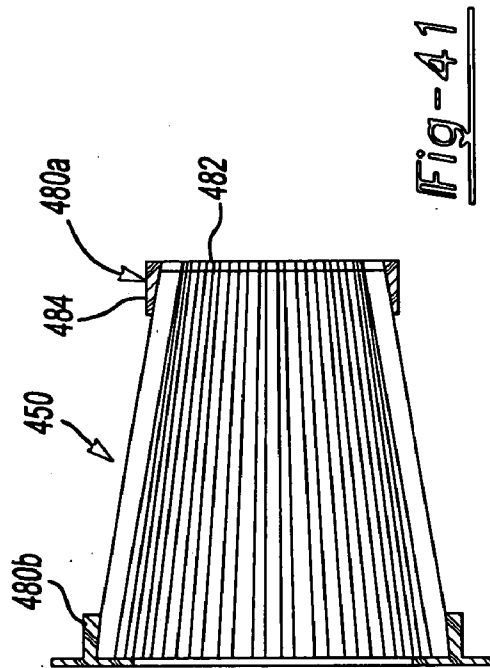
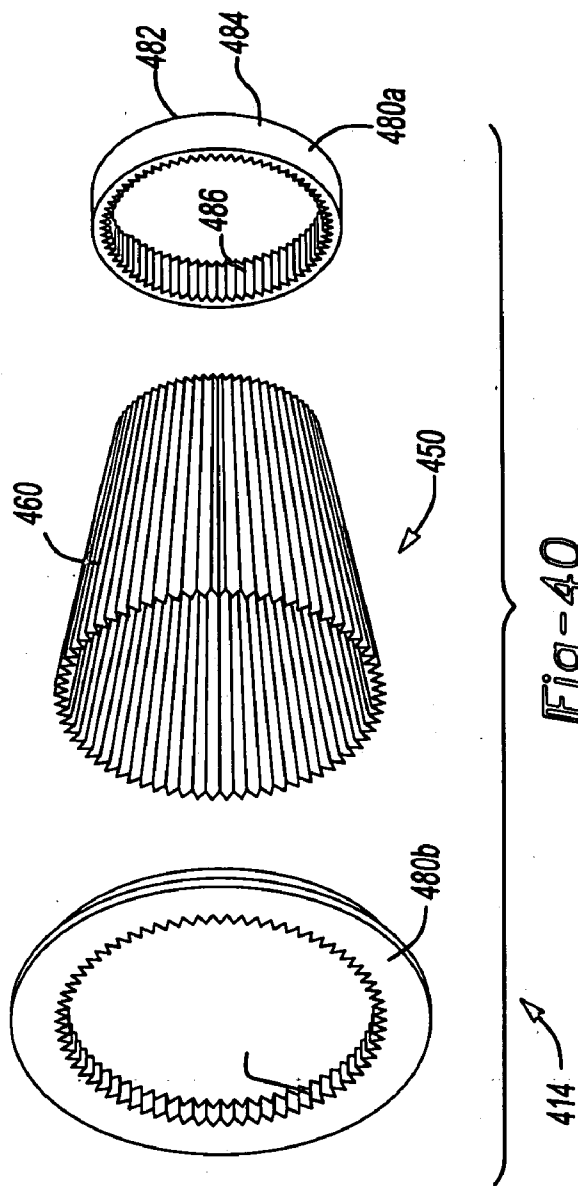


Fig-39



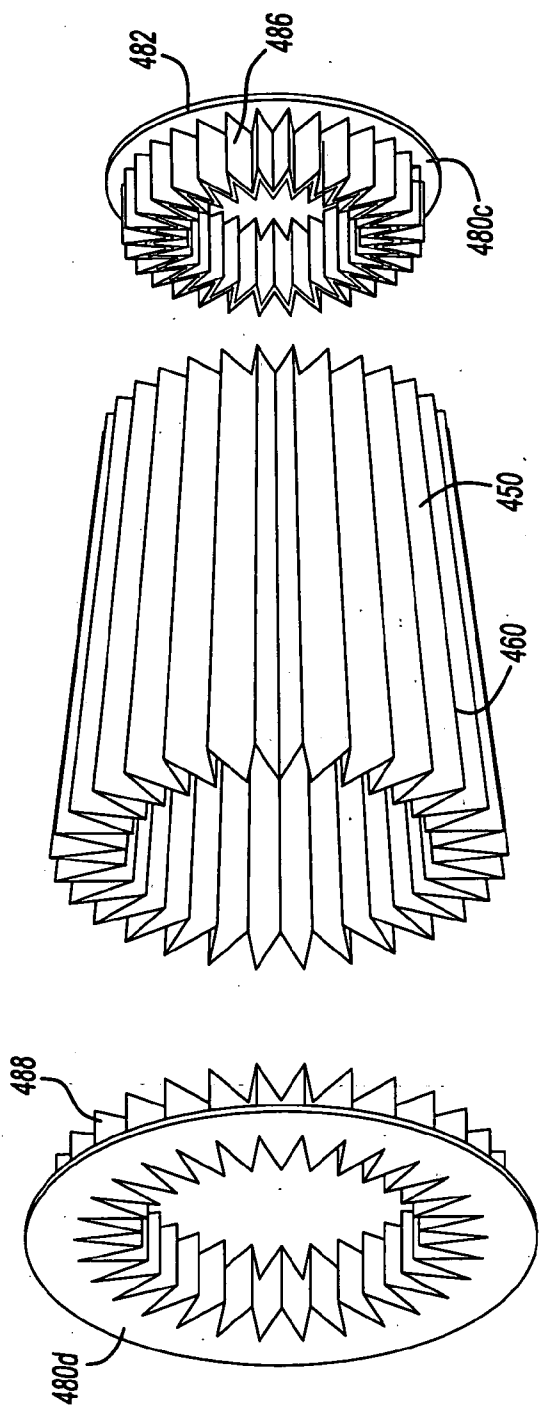


Fig-42

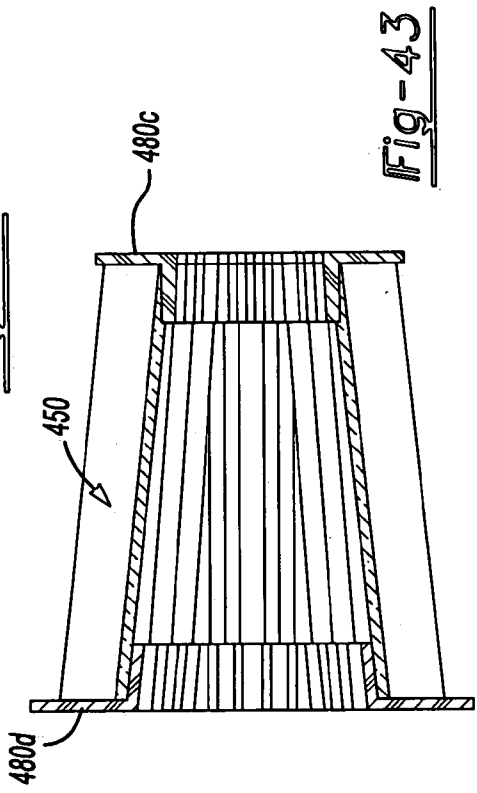


Fig-43

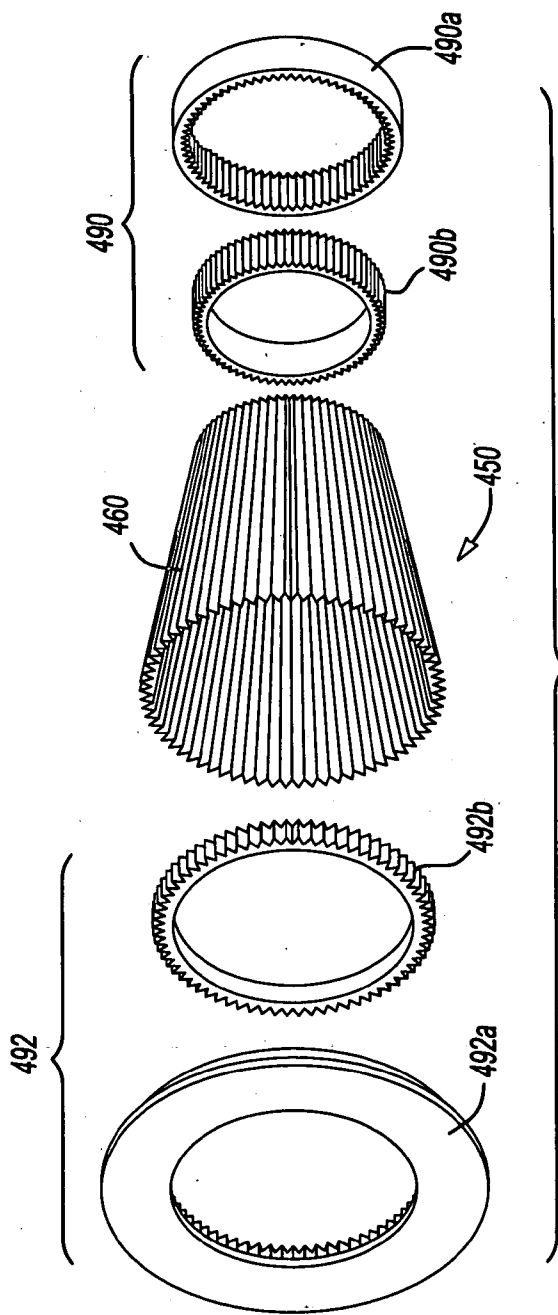


Fig-44

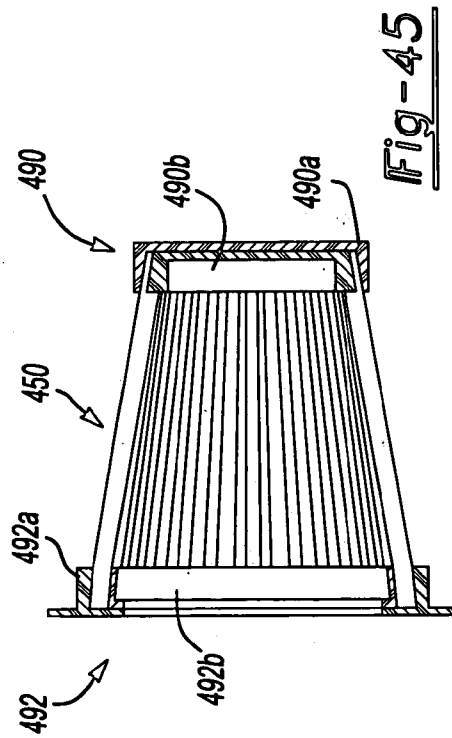


Fig-45

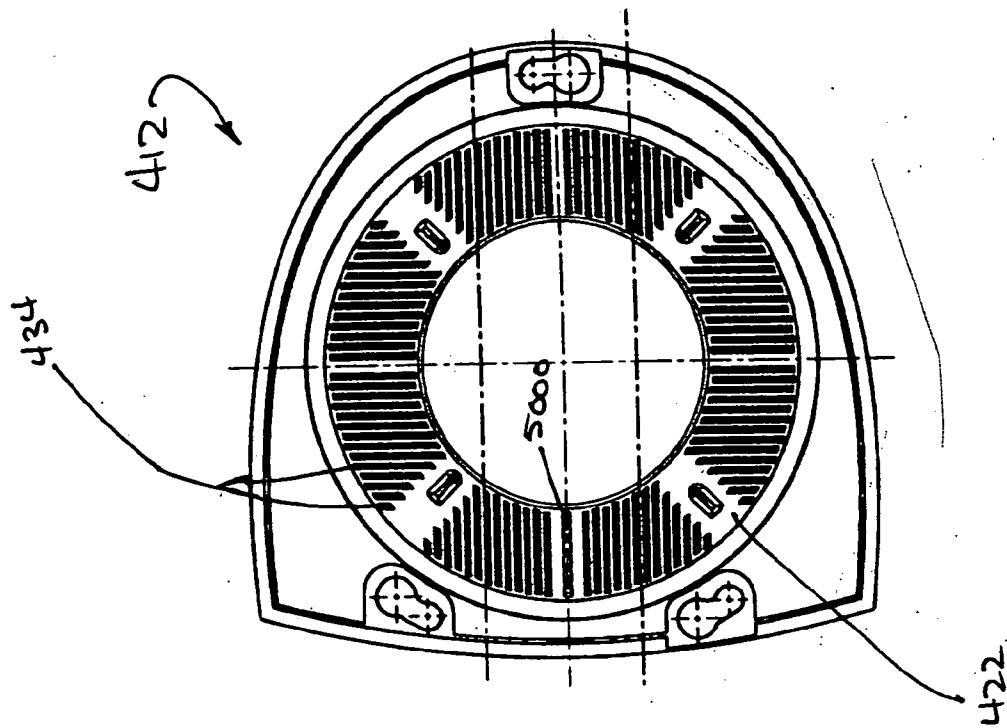


FIG. 46

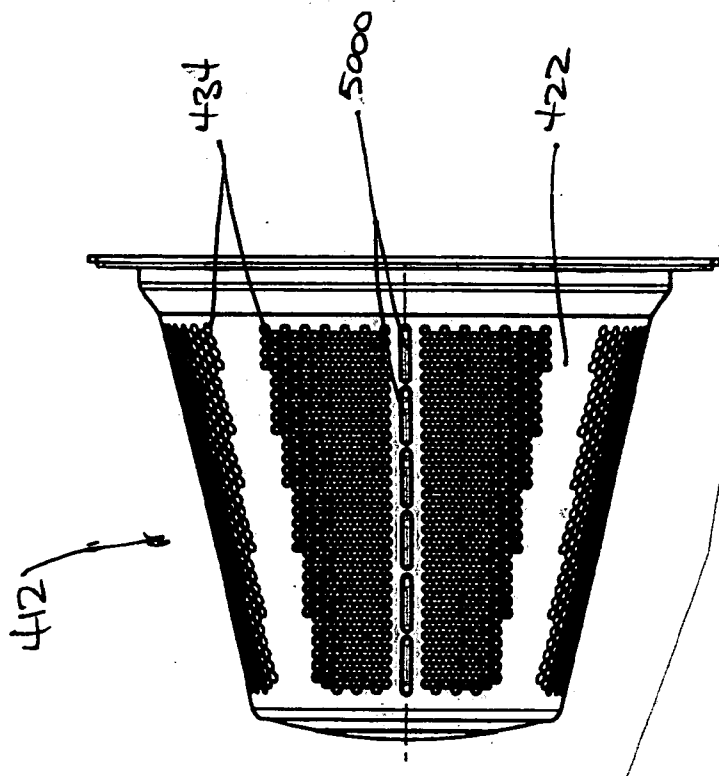


FIG. 47

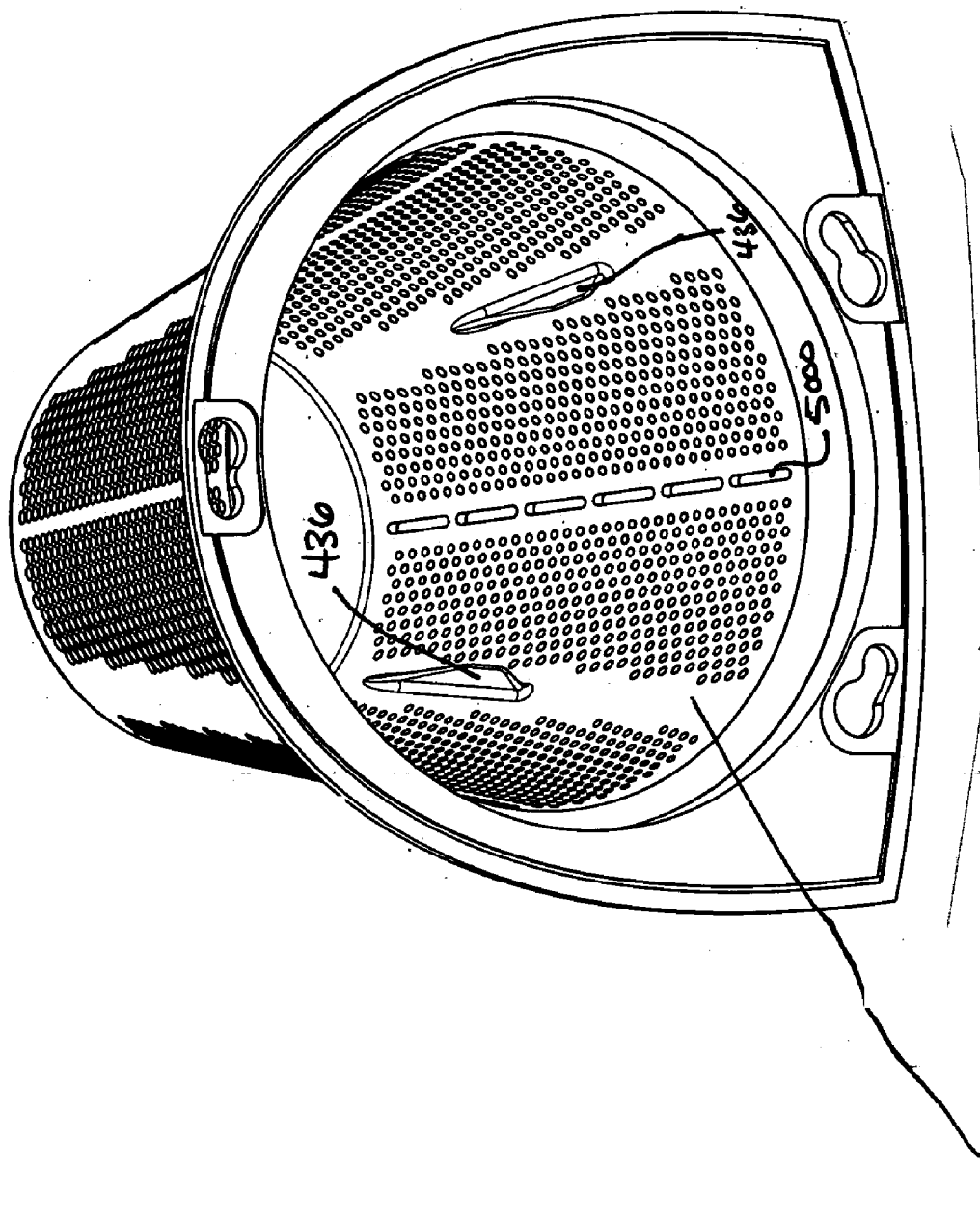


FIG. 48

HAND-HELD CORDLESS VACUUM CLEANER

[0001] The present invention generally relates to hand-held portable vacuum cleaners and improvements thereto.

[0002] Typically, hand-held portable vacuum cleaners employ a motor that is powered by either a main supply of electricity (i.e., a source of alternating current power) or a battery pack, which may be rechargeable, to drive an impeller. Rotation of the impeller generates an air flow which entrains therein dirt and debris which enter the vacuum cleaner via an inlet. One or more filters may be employed to retain the dirt and debris within the vacuum.

[0003] One problem with such vacuum cleaners concerns the relatively rapid rate with which the efficiency and performance of such vacuum cleaners may deteriorate. Specifically, the use of such vacuums to collect relatively small sized particles can rapidly load the filter and substantially reduce the amount of air that passes therethrough. When filter loading is encountered in the known hand vacuum configurations, the user must disassemble the vacuum, remove the filter, clean (or dispose of and replace) the filter and replace the filter. In some situations, the user may be reluctant to perform the tasks of removing and cleaning the filter due to the unwholesomeness of the material that has accumulated on the filter. In situations where the filter is heavily loaded, the vacuum will have a relatively low efficiency and consequently, vacuuming tasks will take longer, the vacuum will experience greater wear, and if battery powered, the user will be able to perform relatively fewer vacuuming tasks per charge.

SUMMARY OF THE INVENTION

[0004] In one form, the present teachings provide a hand-held portable vacuum having a housing, an impeller that is at least partially disposed in the housing, a dirt cup and a HEPA filter. The dirt cup, which is removably attached to the housing, includes an inlet and defines a container for storage of dirt and debris therein. The HEPA filter is disposed between the impeller and the inlet.

[0005] In another form, the present teachings provide provides a method for filtering a dirt and debris laden air flow. The method includes: providing a hand-held vacuum with a housing, an impeller, an inlet, a container and a primary filter, the housing including a handle that permits a user to employ the hand-held vacuum for vacuuming with a single hand, the impeller being disposed within the housing, the inlet being configured to receive the dirt and debris laden air flow therethrough, the container being configured to retain dirt and debris removed from the dirt and debris laden air flow and the primary filter being disposed between the impeller and the inlet; rotating the impeller to generate the dirt and debris laden air flow; and swirling the dirt and debris laden air flow about the interior of the container.

[0006] In yet another form, the present teachings provide a hand-held portable vacuum including a housing with a handle, a dirt cup, an impeller at least partially disposed in the housing, a filter and a filter cleaning device. The dirt cup, which is removably attached to the housing, has an inlet and defines a container for storage of dirt and debris therein. The filter, which is disposed between the impeller and the inlet, is formed with a plurality of pleats. The filter cleaning device is coupled to at least one of the housing and the dirt cup and

includes at least one rib and a hub. The hub is coupled to one of the filter and the rib and configured to rotate the one of the filter and the rib about the other one of the filter to generate contact between the rib and the filter to at least partially dislodge accumulated dirt and debris from the pleats.

[0007] In a further form, the present teachings provide a hand-held portable vacuum including a housing with a handle, a dirt cup, an impeller, a filter and a means for swirling the dirt and debris laden air in the dirt cup. The dirt cup, which is removably attached to the housing, has an inlet and defining a container for storage of dirt and debris therein. The impeller is at least partially disposed in the housing and operable for generating an air flow that flows through the inlet. The filter is disposed between the impeller and the inlet.

[0008] Further areas of applicability of the present teachings will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Additional advantages and features of the present invention will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, wherein:

[0010] **FIG. 1** is a perspective view of a vacuum kit constructed in accordance with the teachings of the present invention;

[0011] **FIG. 2** is a side elevation view of a portion of the vacuum kit of **FIG. 1** illustrating the vacuum in greater detail;

[0012] **FIG. 3** is a longitudinal section view of the vacuum of **FIG. 2**;

[0013] **FIG. 4** is a perspective view of a portion of the vacuum of **FIG. 2** illustrating the dirt cup in greater detail;

[0014] **FIG. 5** is a longitudinal section view of the dirt cup of **FIG. 4**;

[0015] **FIG. 6** is a longitudinal section view of a portion of the vacuum of **FIG. 2** illustrating the dirt cup assembly in greater detail;

[0016] **FIG. 7** is a sectional view taken along the line 7-7 of **FIG. 6**;

[0017] **FIG. 8** is a perspective view illustrating the interior of the dirt cup assembly;

[0018] **FIG. 9** is a perspective view of a portion of the dirt cup assembly illustrating the elbow in greater detail;

[0019] **FIG. 10** is a top view of a portion of the vacuum of **FIG. 2** illustrating the housing assembly in greater detail;

[0020] **FIG. 11** is a side elevation view of a portion of the housing assembly illustrating a housing shell in greater detail;

[0021] **FIG. 12** is an exploded perspective view of a portion of the housing assembly;

[0022] FIG. 13 is a elevation view of a portion of the vacuum of FIG. 2 illustrating the exhaust grille in greater detail;

[0023] FIG. 14 is section view taken along the line 14-14 of FIG. 13;

[0024] FIG. 15 is a side elevation view of a portion of the vacuum of FIG. 2 illustrating the cleaning wheel in greater detail;

[0025] FIG. 16 is a front elevation view of the housing assembly;

[0026] FIG. 17 is a side elevation view of the housing assembly;

[0027] FIG. 18 is a perspective view of a portion of the housing assembly illustrating the prefilter in greater detail;

[0028] FIG. 19 is a longitudinal section view of the prefilter;

[0029] FIG. 20 is a longitudinal section view of the primary filter;

[0030] FIG. 21 is a longitudinal section view of a portion of the housing assembly illustrating the second seal portion of the primary filter in sealing engagement with the prefilter;

[0031] FIG. 22 is an exploded perspective view of the vacuum and recharging base of FIG. 1;

[0032] FIG. 23 is an exploded perspective view of the vacuum and recharging base illustrating one means by which the, vacuum and recharging base may be keyed to one another;

[0033] FIG. 24 is a schematic illustration of a portion of an injection mold for forming the mating key that is associated with the vacuum in the example provided;

[0034] FIG. 25 is a perspective view of a family of vacuums and recharging bases constructed in accordance with the teachings of the present invention;

[0035] FIG. 26 is a perspective view of an alternately constructed prefilter;

[0036] FIG. 27 is a longitudinal section view similar to that of FIG. 3 but illustrating the prefilter of FIG. 26;

[0037] FIG. 28 is a perspective view of another alternately constructed prefilter;

[0038] FIG. 29 is a perspective view of an alternately constructed vacuum;

[0039] FIG. 30 is an exploded perspective view of the vacuum of FIG. 29;

[0040] FIG. 31 is a partial longitudinal section view of another alternately constructed vacuum illustrating a lock-out device for inhibiting the operation of the cleaning wheel;

[0041] FIG. 32 is a schematic illustration of another alternately constructed vacuum illustrating an electronic lock-out device for inhibiting the operation of the motor when the cleaning wheel is rotated;

[0042] FIG. 33 is a sectional view taken along the line 33-33 of FIG. 32;

[0043] FIG. 34 is a schematic illustration of yet another alternately constructed vacuum illustrating a drive system for rotating the cleaning wheel under a source of power;

[0044] FIG. 35 is a schematic illustration of still another alternately constructed vacuum illustrating another drive system for rotating the cleaning wheel under a source of power;

[0045] FIG. 36 is an exploded perspective view of a portion of the vacuum of FIG. 2 illustrating the battery pack and motor assembly in greater detail;

[0046] FIG. 37 is another exploded perspective view of the battery pack and motor assembly;

[0047] FIG. 38 is an exploded side elevation view of the battery pack and motor assembly;

[0048] FIG. 39 is a bottom plan view of the battery pack as coupled to the motor assembly;

[0049] FIG. 40 is an exploded perspective view of an alternately constructed primary filter;

[0050] FIG. 41 is a longitudinal section view of the primary filter of FIG. 40;

[0051] FIG. 42 is an exploded perspective view of another alternately constructed primary filter;

[0052] FIG. 43 is a longitudinal section view of the primary filter of FIG. 42;

[0053] FIG. 44 is an exploded perspective view of yet another alternately constructed primary filter;

[0054] FIG. 45 is a longitudinal section view of the primary filter of FIG. 44;

[0055] FIG. 46 is a rear view of another prefilter constructed in accordance with the teachings of the present invention;

[0056] FIG. 47 is a bottom view of the prefilter of FIG. 46; and

[0057] FIG. 48 is a perspective view of yet another prefilter constructed in accordance with the teachings of the present invention.

DESCRIPTION OF VARIOUS EMBODIMENTS

[0058] With reference to FIG. 1 of the drawings, a vacuum kit constructed in accordance with the teachings of the present invention is generally indicated by reference numeral 10. The vacuum kit 10 may include a hand-held cordless vacuum 10a and an optional set of accessories 10b. With reference to FIGS. 2 and 3, the vacuum 10a may include a dirt cup assembly 12 and a housing assembly 14. In the particular example provided, the dirt cup assembly 12 includes an inlet housing or dirt cup 20 and an elbow 22, while the housing assembly 14 may include motor assembly 30, an outlet housing or housing 32, a filter system 34, a filter cleaning system 36 and a latch release 38 having a conventional latch mechanism 40 and a conventional retaining tab 42 that may be integrally formed with the housing 32.

[0059] In FIGS. 4 and 5, the dirt cup 20 includes a wall member 50 that defines a container-like housing structure 52 and an inlet port 54 that may be formed through the housing structure 52 and which may extend rearwardly therefrom. A

pair of securing apertures **56a** and **56b** may be formed in and through the housing structure **52**, respectively, and a plurality of prefilter locating tabs **58** may extend inwardly from the wall member **50** about the inside perimeter of the housing structure **52**. Both the securing apertures **56a** and **56b** and the prefilter locating tabs **58** will be discussed in additional detail, below.

[0060] The inlet port **54** may have a generally rectangular cross-sectional shape that extends rearwardly from the housing structure **52** and terminates at a rearward face **60**. As will be discussed in greater detail, below, the front end of the inlet port **54** may be configured to frictionally engage various components of the accessory set **10b** (FIG. 1); while the rear end of the inlet port **54** may be configured to frictionally engage the elbow **22**, which is shown in FIG. 6.

[0061] With reference to FIGS. 6 through 9, the elbow **22** may include an attachment portion **62** that may be sized to frictionally but removably engage the rear end of the inlet port **54** and a body portion **64** that turns the incoming air flow in a desired manner as will be discussed in greater detail, below. The body portion **64** may be sized so as not to choke or diffuse the air flow that is provided through the inlet port **54**. The interior of the dirt cup **20** (i.e., a cross section taken perpendicular to the longitudinal axis of the dirt cup **20**) may be at least somewhat circular in shape (i.e., lacking sharp corners—see, FIG. 7) so as to promote the swirling of the inlet air flow about the longitudinal axis of the dirt cup **20**.

[0062] In FIG. 3, the motor assembly **30** may include a motor **70**, a fan assembly **72**, a battery pack **74** and a power switch **76**. The motor **70** may be a conventional DC motor having a motor output shaft **88**. The fan assembly **72** may be a conventional centrifugal fan that includes a fan or impeller **90**, which may be coupled for rotation with the output shaft **88**, and a fan housing **92**. The fan housing **92** includes an inlet aperture **94** that may be centered about the rotational axis of the impeller **90**, and one or more discharge apertures **96**, which may be located on a bottom side of the fan housing **92** generally transverse to the inlet aperture **94**. Air that is discharged from the discharge aperture **96** may be guided through an associated flow channel **98** that is also integrally formed with the fan housing **92** in the particular example provided. The flow channel **98** may direct the air downwardly and somewhat rearwardly.

[0063] The battery pack **74** conventionally includes a plurality of rechargeable batteries **100**, which are adapted to be electrically coupled to a source of electrical power, as through the recharging base **75** that is illustrated in FIG. 1. The battery pack **74** may be coupled to the motor **70** and the power switch **76** in a conventional and well known manner. In the alternative, the battery pack **74** may be coupled to the motor **70** by way of an integrated snap connector **108** as illustrated in FIGS. 36 through 39. The snap connector **108** may have a first portion **108a** that may be integrated with the motor **70** and a second portion **108b** that may be integrated with the battery pack **74**. The first portion **108a** may include a circuit board **110** with a plurality of terminals, such as blade-type male terminals **112**. The circuit board **110** may include all of the integrated circuits and solid state components that are employed for controlling the distribution of electrical power from the battery pack **74** to the motor **70**, as well as for controlling the charging of the battery pack **74**

(e.g., timers). The second portion **108b** may include a plurality of mating terminals, such as blade receiving terminals **114**, that matingly engage the terminals of the first portion **108a**. In the particular embodiment illustrated, the blade receiving terminals **114** slidably receive the blade-type male terminals **112** to permit the motor assembly **30** to be coupled to the battery pack **74** prior to their installation to the housing **32**.

[0064] The battery pack **74** may further include a housing **120** having a pair of engagement features **122** that co-engage mating features **124** (FIG. 11) to permit the battery pack **74** to be coupled to the housing **32** without separate fasteners, etc. In the particular embodiment illustrated, the engagement features **122** are tabs and the mating features **124** are slots that are configured to receive an associated one of the tabs to thereby fixedly but removably couple the battery pack **74** to the housing **32**. At least one of the tabs may be a cross-tab (i.e., a tab with two portions that are skewed to one another) that is configured to engage an associated mating feature **124** in a manner that inhibits vertical and horizontal movement of the cross-tab relative to the associated mating feature **124**. In the particular embodiment illustrated, the structure into which the cross-tab is received defines a cross-slot (i.e., a slot with two portions for receiving the two portions of the cross-tab), but as those skilled in the art will appreciate from this disclosure, one portion of the cross-tab may be disposed in the slot while the other portion of the cross-tab abuts an end of the structure that defines the slot. Additionally, the housing **120** may house a pair of charging terminals **126** that may be configured to extend through the housing **32** so as to be accessible by the recharging base **75** (FIG. 1) when the vacuum **10a** is coupled thereto.

[0065] One suitable power switch **76** is described in detail in U.S. Pat. No. 5,544,274, which is hereby incorporated by reference as if fully set forth herein. Briefly, the power switch **76** may include a conventional slide switch **76a** that selectively enables or disables the transmission of electric power therethrough to close or open the electrical circuit between the batteries **100** and the motor **70**. The slide switch **76a** may be fixedly coupled to the circuit board **110** in the particular example provided and employed to move contacts into and out of electrical connection with terminals on the circuit board **110**.

[0066] With reference to FIGS. 3, 10 and 11, the housing **32** of the particular embodiment provided may include a pair of housing shells **150a** and **150b** and an exhaust deflector **154**. The housing shells **150a** and **150b** may be configured to be coupled together in a conventional and well known manner to define a switch mounting structure **160**, a switch aperture **162**, a latch mounting structure **164**, the retaining tab **42** and a handle **168**. The switch mounting structure **160** may be conventionally configured to receive therein and support the power switch **76** of the motor assembly **30** such that the power switch **76** extends through the switch aperture **162** so as to be actuate-able by the user of the vacuum **10a**.

[0067] The latch mounting structure **164** may be configured to receive therein and support a conventional latch mechanism **40** having a latch member **170** for engaging the securing aperture **56a** in the housing structure **52** of the dirt cup assembly **12** and a spring (not shown) for, biasing the latch member **170** upwardly relative to the housing **32**.

[0068] The retaining tab **42** extends outwardly from the housing **32** and defines an abutting wall **174**. The retaining

tab 42 may be configured to project through the securing aperture 56b when the dirt cup assembly 12 is coupled to the housing assembly 14 to permit the abutting wall 174 to cooperate with the rear edge of the securing aperture 56b to thereby limit forward movement of the dirt cup assembly 12 relative to the housing assembly 14.

[0069] In the example provided, the handle 168 is integrally formed with the housing shells 150a and 150b and may extend between the forward and rearward portions of the housing 32 and above the body of the housing 32 to define therebetween a handle aperture 180 that is sized to receive the hand of the user of the vacuum 10a. Those skilled in the art will appreciate, however, that the handle 168 may be otherwise positioned and/or a discrete component that is joined or fastened to the remainder of the housing 32 in a known manner.

[0070] Except as noted below, each of the housing shells 150a and 150b may be constructed in an identical manner so that further description of the housing shell 150a will suffice for both. With primary reference to FIG. 11 and additional reference to FIG. 12, the housing shell 150a includes a wall member 186 that may define a front wall 188, a central cavity 196, an exhaust cavity 200 and a recessed area 202 through which an elliptical through-hole 204 is formed. The wall member 186 may also define a motor mount 206 and a hub mount 208, both of which being disposed in the central cavity 19.6.

[0071] The motor mount 206 may include first and second mount portions 206a and 206b, respectively, that are employed to fixedly couple the motor 70 to the housing 32. The motor mount 206 may be configured to receive the motor 70 in a snap-fit manner so that discrete fasteners and the like are not required.

[0072] The hub mount 208 may include structure which, in association with the fan housing 92 in the example provided, serves to maintain the filter cleaning system 36 in a desired location along a longitudinal axis of the vacuum 10a relative to the filter system 34. In the example provided, the hub mount 208 includes first and second bearing portions 208a and 208b, respectively, which are axially spaced apart along an axis that is coincident with a rotational axis of the motor 70. The first bearing portion 208a may be semi-circular in shape so as to form a circular aperture when the housing shells 150a, 150b are coupled to one another. The second bearing portion 208b may include a rear wall 210 that may be generally transverse to the rotational axis of the motor 70.

[0073] As is apparent from the discussion above, the fan housing 92 may form the inlet aperture 94 and one or more discharge apertures 96 through which air is introduced and discharged, respectively, from the fan assembly 72. In the particular example provided, the fan housing 92 forms a volute that terminates at the discharge aperture 96. The flow channel 98 may serve as a fluid conduit which couples the discharge aperture 96 with the exhaust cavity 200.

[0074] With specific reference to FIG. 13, the exhaust deflector 154 may include a frame 270 and a plurality of flow guiding vanes 272 that are set into the frame 270 and fixedly coupled thereto. The flow guiding vanes 272 of the particular embodiment illustrated are shaped so as to direct the air exiting the exhaust cavity 200 both downwardly and rearwardly.

[0075] With additional reference to FIGS. 3 and 14, the frame 270 of the exhaust deflector 154 may extend upwardly of the flow guiding vanes 272 to create a pocket 276 into which may be fitted an optional exhaust filter 280. The exhaust filter 280 operates to filter the air that exits the exhaust cavity 200 and thereby prevents fine dust particles from being expelled from the vacuum 10a. The exhaust filter 280 may be formed from a non-woven mesh fabric so as to be washable should it become undesirably dirty or clogged. Those skilled in the art will appreciate from this disclosure, however, that the exhaust filter 280 may be formed from another washable filter media or may alternately be a disposable type filter (e.g., paper). Those skilled in the art will also appreciate from this disclosure that the exhaust filter may be configured to provide HEPA (high efficiency particulate air) filtration or ULPA (ultra low penetration air) filtration. As used herein, a "HEPA" filter will be understood as being capable of removing 99.97% of particles as small as 0.3 μm from an air flow, while a "ULPA" filter will be understood as being capable of removing 99.999% of particles as small as 0.12 μm from an airflow.

[0076] Returning to FIGS. 3 and 13, the frame 270 may also include a pair of trunnions 284 and a pair of clip structures 286. The trunnions 284 permit the exhaust deflector 154 to be pivotably coupled to the housing 32. More specifically, each of the housing shells 150a and 150b may include a recess (not specifically shown) for receiving an associated one of the trunnions 284. Each trunnion 284 is illustrated as being coupled to a portion of the frame 270 that may be deflected laterally inward (i.e., toward the centerline of the exhaust deflector 154) so that the trunnions 284 may be installed to their respective recess when the housing shells 150a and 150b are coupled to one another. With the trunnions 284 engaged to recesses, the exhaust deflector 154 may be pivoted between a closed position, wherein the rear surface of the exhaust deflector 154 covers the exhaust cavity 200, and an open position, wherein the exhaust deflector 154 substantially clears the exhaust cavity 200.

[0077] The clip structures 286 are configured to resiliently deflect in response to the application of a modest force to the exhaust deflector 154 to permit the exhaust deflector 154 to be secured to or released from the wall member 186 when the exhaust deflector 154 is moved into or out of the closed position. As will be apparent to those of ordinary skill in the art, engagement of the clip structures 286 to the wall member 186 effectively maintains the exhaust deflector 154 in the closed position. Those skilled in the art will also appreciate that features such as recesses or tabs 288 may be formed into the wall member 186 to serve as points that enhance or improve the ability of the clip structures 286 to engage the wall member 186.

[0078] Returning to FIGS. 3 and 13, the top of the frame 270 of the exhaust deflector 154 may be arcuately shaped to define a finger grip 290 that is configured to receive the thumb or finger of the user of the vacuum 10a so that the thumb or finger may be employed to move the exhaust deflector 154 out of the closed position. The finger grip 290 may include a gripping feature, such as a raised lip, that permits the user to pry downwardly and outwardly on the exhaust deflector 154 with their thumb or finger to thereby disengage the clip structures 286 from the wall member 186.

[0079] With renewed reference to FIG. 12, the filter cleaning system 36 may include a cleaning wheel 300 that

housed by the housing 32. With additional reference to FIGS. 3, 15 and 16, the cleaning wheel 300 may be generally hollow and may include a gripping portion 302, a hub portion 304, a filter drive portion 306 and a filter engagement portion 308. The gripping portion 302 may be an annular ring that may be coupled to the rearward side of the hub portion 304 and which may include a plurality of circumferentially spaced apart recesses 310. The hub portion 304 may define a bearing surface 312 that may be journally supported by the housing 32. The filter drive portion 306 may be formed on a wall 314 that is coupled to the hub portion 304 generally transverse to the bearing surface 312.

[0080] In the particular example provided, the filter drive portion 306 includes a plurality of radially extending drive tabs 316 that are circumferentially spaced apart from one another and collectively oriented concentric with the bearing surface 312. Those skilled in the art will appreciate from this disclosure, however, that the filter engagement portion 308, through frictional engagement or other engagement with the primary filter 414, may also serve in whole or in part as the filter drive portion 306.

[0081] The filter engagement portion 308 may be an elongated annular structure that may extend forwardly from the wall 314 of the filter drive portion 306. The cleaning wheel 300 may also include a grille 320 which inhibits the passage of relatively large objects from passing through the cleaning wheel 300 and contacting the impeller 90.

[0082] The cleaning wheel 300 may be installed over the fan housing 92 prior to the installation of the motor 70 and fan assembly 72 to the housing 32, thereby permitting these components to be collectively assembled to one of the housing shells (e.g., housing shell 150a) substantially simultaneously. The cleaning wheel 300 may be positioned relative to the housing 32 such that gripping portion 302 partially extends through the elliptical through-holes 204 in the recessed areas 202 of the housing 32 as shown in FIG. 17. Once the cleaning wheel 300 has been installed to the housing 32, movement of the cleaning wheel 300 in an axial direction along the rotational axis of the motor 70 may be limited through contact between the gripping portion 302 and housing 32 along the perimeter of the elliptical through-holes 204. Additionally or alternatively, contact with the fan housing 92 and the rear wall 210 of the second bearing portion 208b (FIG. 11) may be employed to limit movement of the cleaning wheel 300 axially along the rotational axis of the motor 70.

[0083] The first and second bearing portions 208a and 208b of the hub mount 208, however, cooperate with the bearing surface 312 to limit the movement of the cleaning wheel 300 vertically and horizontally relative to the rotational axis of the motor 70, but permit the cleaning wheel to be rotated about the rotational axis of the motor 70. The recesses 310 in the gripping portion are specifically configured to be gripped by the thumb and/or fingers of a user of the vacuum 10a to rotate the cleaning wheel 300.

[0084] In FIGS. 3 and 12, the filter system 34 may include an intake filter 400 and the above-discussed optional exhaust filter 280. The intake filter 400 may include a prefilter 412 and a primary filter 414. In FIG. 18 and with additional reference to FIGS. 10 and 16, the prefilter 412 may include a filter flange 420, a prefilter body 422 and a securing means 424 for releasably securing the prefilter 412 to the housing

32. The filter flange 420 may extend radially outwardly from the prefilter body 422 and may be configured to abut the front face 188 of the housing 32. The filter flange 420 may be unitarily formed with the remainder of the prefilter 412 from a material that is structural, such as polyethylene or polpropylene. Those skilled in the art will appreciate, however, that the filter flange 420 could alternatively include a resilient band of material (not shown) that is coupled to the remainder of the filter flange 420, via a mechanical connection, adhesives or overmolding, and employed to sealingly engage at least one of the housing 32 and the dirt cup 20.

[0085] With additional reference to FIG. 19, the prefilter body 422 may have a truncated cone shape, with a front wall 430 and a side wall 432 that has a plurality of filtering apertures 434 formed therethrough. The filtering apertures 434 may be sized to prevent relatively coarse dirt and debris from contacting the primary filter 414 (FIG. 3). In the example provided, the filtering apertures 434 are about 0.020 inch (0.5 mm) to about 0.040 inch (1.0 mm) in diameter. In the particular embodiment provided, one or more ribs 436 are formed on the interior surface 438 of the side wall 432. The ribs 436 will be discussed in greater detail, below.

[0086] As those of ordinary skill in the art will appreciate from this disclosure, any appropriate means may be employed to removably couple the filter flange 420 to one or both of the housing 32 and the dirt cup 20. Preferably, the securing means 424 will not automatically detach from the housing 32 when the dirt cup 20 is removed from the housing 32.

[0087] In the particular example provided, the securing means 424 is illustrated in FIG. 18 to include a plurality of holes 440 that are configured to receive therethrough corresponding pegs 442 that extend from the front face 188 of the housing 32 as illustrated in FIG. 16. The holes 440 may be shaped to directly correspond to the shape of the pegs 442, but in the example illustrated, include first and second portions 440a and 440b, respectively, that intersect one another. The first portion 440a is relatively large and configured to receive therethrough an associated peg 442, which is illustrated in FIG. 10 to include a relatively large head portion 442a and a somewhat smaller body portion 442b. In contrast, the second portion 440b is configured only to receive therethrough the body portion 442b of the associated peg 442. Accordingly, once the prefilter 412 has been installed over the pegs 442, it may be rotated to position the body portion 442b of the pegs 442 into the second portion 440b of the holes 440. As the head portion 442a of the pegs 442 is relatively larger than the second portion 440b, the filter flange 420 will remain attached to the housing 32 when the dirt cup 20 is removed, unless the filter flange 420 is rotated to align the pegs 442 with the first portion 440a of the holes 440.

[0088] To guard against undesired rotation of the filter flange 420 relative to the housing 32 when the dirt cup 20 has been removed from the rear housing, the securing means 424 may include a resilient finger 440c that contacts the body portion 442b of an associated peg 442 to inhibit rotation of the filter flange 420 unless a force in excess of a predetermined force has been applied to rotate the filter flange 420 in a desired rotational direction relative to the housing 32.

[0089] In FIG. 20, the primary filter 414 may have a filter body 450 with first and second seal portions 452 and 454, respectively, disposed on opposite sides thereof. The filter body 450 may have a shape that is similar to that of the prefilter body 422 (FIG. 19) and in the example provided, is illustrated to have a truncated cone shape. The filter body 450 may be formed from any appropriate filter media, such as paper, plastic or fabric and is preferably formed with a plurality of pleats 460. Also preferably, the filter media is wear resistant or includes a wear resistant outer layer 462. Furthermore, the filter body 450 is preferably formed from a filter media that provides HEPA or ULPA filtration. One such suitable filter media is manufactured by W. L. Gore & Associates, a Delaware Corporation having a place of business in Elkton, Md.

[0090] In the example provided, the pleats 460 are formed such that their outer ends or peaks 464 lie along a straight line that intersects the axis of a theoretical cone (not shown) that includes the peak 464 of each pleat 460 on the filter body 450. Alternatively, the pleats 460 may be formed such that their peaks 464 are straight but skewed to the axis of the theoretical cone or generally helical in shape. For reasons that will be apparent from the discussion below, however, the pleats 460 should be formed relative to the theoretical cone in a manner that is consistent with the ribs 436 on the interior surface 438 of the filter housing 432.

[0091] The first seal portion 452, which is coupled to the smaller end of the filter body 450, may be a plate-like structure that is formed from a suitable material and is sealingly bonded to a lower end of the filter body 450. Alternatively, the first seal portion 452 may be wholly or partially formed from an appropriate filter material, such as the material from which the filter body 450 is manufactured, and bonded or otherwise sealingly coupled to the filter body 450.

[0092] The second seal portion 454 may be an annular flange that may be sealingly bonded to an upper end of the filter body 450. With additional reference to FIGS. 12 and 21, the second seal portion 454 may include a body 470 that defines a receiving aperture 472, a primary seal 474 which is disposed about the perimeter of the receiving aperture 472 and sized to sealingly engage the seal engaging portion 308 of the cleaning wheel 300 (FIG. 15), a secondary seal 476 that sealingly engages the interior surface 438 of the prefilter body 422 of the prefilter 412, and a plurality of drive tabs 478. The drive tabs 478, which extend radially outward and are circumferentially spaced apart from one another, are configured to engage the drive tabs 316 that are formed on the filter drive portion 306 of the cleaning wheel 300.

[0093] With the primary filter 414 installed to the cleaning wheel 300 such that the primary seal 474 sealingly engages the seal engaging portion 308 and the drive tabs 316 and 478 are meshingly engaged with one another, the prefilter 412 may be positioned over the primary filter 414 such that the first portion 440a of the through-holes 204 in the filter flange 420 are aligned to the pegs 442 on the housing 32. The prefilter 412 may be urged toward the housing 32 such that the pegs 442 are fitted through the through-holes 204 and thereafter the prefilter 412 is rotated to position the pegs 442 within the second portion 440b of the through-holes 204. With the dirt cup 20 coupled to the housing assembly 14, the prefilter locating tabs 58 urge the filter flange 420 rearwardly

toward the front face 188 of the housing 32 so that the secondary seal 476 sealingly engages the prefilter body 422 of the prefilter 412.

[0094] While the primary filter 414 has been illustrated and described as including first and second seal portions 452 and 454 which are bonded directly to the filter body 450, the primary filter 414 may be formed in various other manners. For example, the primary filter 414 may include a pair of discretely formed, caps 480a and 480b as illustrated in FIGS. 40 and 41. The cap 480a may be generally cup shaped, with a closed top 482 and a side wall 484 with a plurality of teeth 486 formed about the inside perimeter of the side wall 484. The cap 480b may be an annular ring that similarly includes a plurality of teeth 488 formed about its inside perimeter. The caps 480a, 480b may be secured to the opposite ends of the filter body 450 through an adhesive, heat staking or sonic welding, for example, so that the teeth 486 and 488 of the caps 480a and 480b meshingly engage the pleats 460 of the filter media. The first seal portion 452 may be integrally formed with, molded onto or bonded to the annular cap 480b. The second seal portion 454 is optional in this embodiment, as the cap 480a may be formed with a closed configuration, rather than the annular shape of the cap 480b.

[0095] The embodiment of FIGS. 42 and 43 is similar to that discussed above in that it likewise employs a pair of discretely formed caps 480c and 480d. However, the teeth 486 and 488 are formed on the exterior surfaces of the caps 480c and 486d so as to meshingly engage the pleats 460 from the interior of the filter body 450.

[0096] The embodiment of FIGS. 44 and 45 employs a pair of ring sets 490 and 492. The ring set 490 may include an outer ring 490a, which may be similar to the cap 480a, and an inner ring 490b, which may be similar to the cap 480c. The outer and inner rings 490a and 490b are assembled to the filter body 450 such that the filter media is sandwiched therebetween and secured to the filter body 450 and/or to one another via an adhesive, heat staking or sonic welding, for example. Likewise, the ring set 492 includes an outer ring 492a, which may be similar to the cap 480b, and an inner ring 492b, which may be similar to the cap 480d. The outer and inner rings 492a and 492b are assembled to the filter body 450 such that the filter media is sandwiched therebetween. The outer and inner rings 492a and 492b are secured to the filter body 450 and/or to one another via an adhesive, heat staking or sonic welding, for example.

[0097] With reference to FIGS. 3 and 8, when the vacuum 10a is operated, the fan assembly 72 expels air from the fan housing 92 which creates a negative pressure differential relative to atmospheric conditions and causes a dirt and debris laden air flow to rush into the dirt cup 20 through the inlet port 54. When coupled to the inlet port 54, the elbow 22 directs the dirt and debris laden air that is flowing through the inlet port 54 toward the interior wall of the dirt cup 20, causing the dirt and debris laden air to swirl about the interior of the dirt cup. In the particular example provided, the outlet 500 of the elbow 22 is configured to direct the dirt and debris laden air flow in a direction to the side and rear of the dirt cup 20. Those of ordinary skill in the art will appreciate from this disclosure, however, that the elbow 22 may be configured to direct the dirt and debris laden air flow in a direction generally transverse to the inlet port 54, that

the outlet **500** of the elbow **22** may or may not lie in the same “plane” as the inlet port **54** (i.e., the centerline of the elbow **22** at the outlet **500** may or may not lie in a plane that contains the centerline of the inlet port **54**) and that any portion of the elbow **22** between the outlet **22** and the inlet port **54** may be formed with a desired shape (e.g., helical) to enhance the swirling effect produced by the elbow **22** and the dirt cup **20**.

[0098] In some situations, the swirling effect may be so strong as to create centrifugal force that causes the dirt and debris to move outwardly toward and collect against the dirt cup **20**. The swirling effect may also slow the collection of dirt and debris on the prefilter **412** and the primary filter **414** to thereby provide improved efficiency of the vacuum **10a**. Improved efficiency is particularly important with cordless vacuums, as it permits extended operation on a given battery charge. Those of ordinary skill in the art will readily appreciate in view of this disclosure that the swirling effect may not be desirable under some circumstances and as such, the elbow **22** may be removable from the inlet port **54**.

[0099] With reference to FIGS. 3, 12, 19 and 20, the vacuum **10a** may be additionally and further maintained in an efficient state by rotating the cleaning wheel **300** as needed or at a desired interval when the impeller **90** is not rotating to at least partially clear accumulated dirt and debris from the pleats **460** of the primary filter **414**. More specifically, as the primary filter may be coupled to the cleaning wheel **300**, rotation of the cleaning wheel **300** causes contact between the ribs **436** and an associated set of the pleats **460** which may deflect the pleats **460** and vibrate the pleats **460** after the pleat **460** has rotated past the rib **436**. The force of the impact, the deflection of the pleat **460** and its subsequent vibration may cooperate to dislodge particles of dirt and debris from both the prefilter **412** and the primary filter **414**.

[0100] Those skilled in the art will appreciate from this disclosure that various modifications may be made to the prefilter **412** to aid in discharging dirt and debris that are dislodged from the primary filter **414** and/or to slow the rate with which the pleats **460** of the primary filter **414** wear. For example, the prefilter **412** may be constructed with one or more apertures **5000** as shown in FIGS. 46 and 47. The apertures **5000** are relatively larger than the filtering apertures **434** so that dirt and debris that are dislodged from the primary filter **414** (FIG. 20) during cleaning, e.g., rotation of the cleaning wheel **300** (FIG. 15), may more readily fall through the prefilter body **422** and collect in the dirt cup **20** (FIG. 1). In the example of FIG. 48, the prefilter body **422** is constructed such that at least a portion of the ribs **436** are shifted along the longitudinal axis of the prefilter body **422**. In the particular example provided, each of the ribs **436** is shifted so that no two ribs **436** contact the same area of the pleats **460** (FIG. 20).

[0101] Returning to FIGS. 1 and 3, the tool set **10b** may include a brush tool **500** and a crevice tool **502** that may be fixedly but removably engaged to the front end of the inlet port **54** via a friction fit. Unlike the known configurations of accessories, the brush tool **500** and crevice tool **502** each employ a body portion **504** having first and second portions **506** and **508** with a U-shaped aperture **510** formed therebetween. The U-shaped aperture **510** permits a relatively large degree of flexure between the first and second portions **506**

and **508** so as to ensure high quality friction fit and associated seal between the body portion **504** and inlet port **54** of the dirt cup **20**.

[0102] In the particular example provided, the brush tool **500** may be stored in a cavity **518** formed in the rear of the housing **32**, while the crevice tool **502** may be coupled to a bottom face **520** of the housing **32**. One or more resilient clips **522** may be employed to retain the particular accessory to the housing **32**.

[0103] With reference to FIG. 22, the recharging base **75** is illustrated in association with the vacuum **10a**. The recharging base **75** may include a base **1000**, a charging circuit **1002**, a pair of terminals **1004** and a key **1006**. The base **1000** may be a molded structure and may be configured to slidably receive the vacuum **10a** such that a pair of mating terminals **1014** and a mating key **1016** matingly engage the terminals **1004** and the key **1006**, respectively. The charging circuit **1002** may be configured in a conventional and well known manner to receive electrical power from a source of A.C. power and provide a source of D.C. power of a predetermined voltage to the terminals **1004**.

[0104] In the particular example provided, the terminals **1004**, which may be mounted to the base **1000**, may extend outwardly from the base **1000** so as to contact associated ones of the mating terminals **1014** when the vacuum **10a** is fully received into the base **1000**. As the terminals **1014** are electrically coupled to the battery pack **74**, contact between the terminals **1004** and **1014** permits electrical energy to be transmitted from the charging circuit **1002** to the batteries **100**.

[0105] The key **1006** and the mating key **1016** coordinate with one another to permit the base **1000** to fully receive the vacuum **10a**. In the particular example provided, the key **1006** includes a pedestal **1028**, a flange **1030** and optionally one or more engagement tabs **1032**, while the mating key **1016** includes a receiver **1040**. The pedestal **1028** of the key **1006** may be coupled to the base **1000** in any conventional manner, including for example, threaded fasteners and/or features that are integrally formed onto and/or into the pedestal **1028** and base **1000** that permit the pedestal **1028** and the base **1000** to be engaged to one another in a snap-fit manner. The flange **1030** may be coupled to the pedestal **1028**, extending upwardly therefrom so as to protrude from a corresponding aperture **1036** in the base **1000** when the key **1006** and the base **1000** are coupled to one another. If employed, the engagement tabs **1032** extend from the flange **1030** in the example provided.

[0106] The receiver **1040** may be coupled to the housing **32** in any conventional manner, including for example, threaded fasteners and/or features that are integrally formed onto and/or into the receiver **1040** and housing **32** that permit the receiver **1040** and the housing **32** to be engaged to one another in a snap-fit manner. The receiver **1040** of the mating key **1016** may optionally include one or more slots **1042** for receiving the engagement tabs **1032**. The engagement tabs **1032** and slots **1042** are positioned such that they must engage one another before the terminals **1020** and **1022** may contact one another. Those of ordinary skill in the art will appreciate from this disclosure that although the vacuum **10a** has been described thus far as including slots **1042** for receiving engagement tabs **1032** that are associated with the recharging base **75**, the slots **1042** and engagement

tabs **1032** may alternatively be associated with the recharging base **75** and the vacuum **10a**, respectively.

[**0107**] With reference to **FIG. 23**, the interchangeable nature of the charging system of the present invention is illustrated. Specifically, several terminal block (**1004**) and key (i.e., **1006a**, **1006b**, **1006c**, **1006d**, and **1006e**) combinations are illustrated as being interchangeable with the base **1000**, while several receivers (**1040a**, **1040b**, **1040c**, **1040d**, and **1040e**) are illustrated in association with the vacuum **10a**. Significantly, the injection molds for each of the key and the receiver employ exchangeable tooling segments that permit the molds to be readily converted so that they may be employed to form each of the various key configurations and receiver configurations. With reference to **FIG. 24**, five tooling segments **1050a**, **1050b**, **1050c**, **1050d** and **1050e** are employed in conjunction with a base mold **1052** to produce each of the receiver combinations.

[**0108**] One especially significant aspect of providing various key and mating key combinations is the ability to provide a family of similar vacuums having different batteries (i.e., different voltages) yet which utilize as many common components as possible. In this regard, the various key and mating key combinations are employed to “key” a particular vacuum to a particular recharging base so as to prevent a vacuum from being coupled to a recharging base having a charging circuit that provides a charging voltage in excess of that which the batteries of the vacuum are designed to be charged.

[**0109**] With reference to **FIG. 25**, a family of hand-held cordless vacuums is generally indicated by reference numeral **2000**. The family of vacuums **2000** includes vacuums **2002a**, **2004a**, **2006a**, **2008a** and **2010a**, which are associated with recharging bases **2002b**, **2004b**, **2006b**, **2008b** and **2010b**, respectively. The vacuums **2002a**, **2004a** and **2006a** are generally identical to vacuum **10a** and differ from one another only in the design charging voltage of their respective battery packs **74**. For example, the vacuum **2002a** may have a design charging voltage of 14.4 volts, the vacuum **2004a** may have a design charging voltage of 12 volts and the vacuum **2006a** may have a design charging voltage of 9.6 volts. The vacuums **2008a** and **2010a** are similar to the vacuum **10a** (**FIG. 1**) except that they lack a filter cleaning system **36** and may have design charging voltages of 7.2 volts and 4.8 volts, respectively. The recharging bases **2002b**, **2004b**, **2006b**, **2008b** and **2010b** are generally identical to the recharging base **75** (**FIG. 1**) and differ from one another only in the charging voltage that they output.

[**0110**] As those skilled in the art will appreciate from this disclosure, the recharging bases (i.e., the keys) may be configured so that they will only engage one vacuum (i.e., mating key). However, it is permissible for a recharging base (i.e., key) to receive more than one type of vacuum (i.e., mating key) so long as the charging voltage provided by the recharging base will not exceed the design charging voltage of any vacuum that may be engaged thereto. In the particular example provided, any member of the family of vacuums **2000** may be engaged to the recharging base **2010b**. Furthermore, the vacuum **2004a** may also be engaged to the charging bases **2004b**, **2006b**, and **2008b**.

[**0111**] While the vacuum **10a** has been described thus far as employing an elbow to impart a swirling action to an

incoming dirt and debris laden air flow and a manually rotatable cleaning wheel for use in dislodging particles of dirt and debris from a filter, those skilled in the art will appreciate that the invention, in its broader aspects, may be constructed somewhat differently. For example, the vacuum **10c** may employ one or more vanes to swirl the incoming dirt and debris laden air flow as shown in **FIGS. 26 and 27**. In this example, the vacuum **10c** is identical to the vacuum **10a** described above, except that the elbow **22** (**FIG. 3**) is not employed and a prefilter **412c** has been substituted for the prefilter **412**. The prefilter **412c** is substantially similar to the prefilter **412**, except for the inclusion of a plurality of flow guiding vanes **600** on the front wall **430c** of the prefilter body **422c**. The flow guiding vanes **600** are disposed axially in-line with the inlet port **54c** such that the axially directed incoming dirt and debris laden air flow is turned by the flow guiding vanes **600** outwardly toward the interior surface of the wall of the dirt cup **20c**. As with the elbow **22**, the flow guiding vanes **600** may be configured aggressively, wherein the entire flow is turned outwardly at the interior surface of the dirt cup **20c**, or somewhat less aggressively, wherein the flow is turned outwardly but retains a portion of its original axial velocity.

[**0112**] As those of ordinary skill in the art will appreciate from this disclosure, vanes **600d** for swirling the incoming dirt and debris laden air flow may be additionally or alternatively formed on another surface, such as the exterior surface **620** of the side wall **432d** of the prefilter **412d**, as illustrated in **FIG. 28**.

[**0113**] Alternatively, the vacuum **10e** may be configured as is shown in **FIGS. 29 and 30**. In this embodiment, the housing assembly **14e** defines a filter recess **700** into which the filter system **34e** is disposed. The filter system **34e** includes a hat-shaped prefilter **412e** and a hat-shaped primary filter **414e**. The prefilter **412e** includes a filter flange **420e** and a prefilter body **422e**, while the primary filter **414e** includes a filter flange **710** and a filter body **712**. A nozzle **720** is pivotally coupled to the housing assembly **14e** and unlike the dirt cup **20** of **FIG. 1**, the nozzle **720** has no capacity for the storage of the dirt and debris that is drawn up by the vacuum **10e**. Rather, coarse dirt and debris are retained in the prefilter **412e** while finer dirt and debris which pass through the prefilter **412e** are contained by the primary filter **414e**. Pivoting of the nozzle **720** into the closed position causes the nozzle **720** to compress the filter flange **420e** and filter flange **710** against one another such that a seal is formed between the nozzle **720** and the housing assembly **14e**.

[**0114**] The nozzle **720** includes an outlet **730** that directs an incoming flow of dirt and debris laden air tangentially into the prefilter **412e**, thereby generating a swirling effect that tends to reduce the accumulation of dirt and debris against the side wall **432e** of the prefilter **412e**. This configuration is highly advantageous in that it permits the user to not only perform vacuuming operations with a single hand, but also to empty the vacuum **10e** of dirt and debris with a single hand. More specifically, the user need only access the latch release **38** to unlatch the nozzle **720** from the housing assembly **14e** to permit the nozzle **720** to pivot into the open condition. A detent (not specifically shown) may be employed to retain the nozzle **720** in the open condition. The

user need only grasp the handle **168** of the housing assembly **14e** and overturn the vacuum **10e** to empty the contents of the prefilter **412e**.

[0115] As is apparent from the discussion above, rotation of the cleaning wheel **300** when the impeller **90** is rotating renders the cleaning action relatively less effective (as compared to when the impeller **90** is not rotating) since dirt and debris that are dislodged when the cleaning wheel **300** is rotated tends to be immediately drawn back into the primary filter **414**. Accordingly, it is within the scope of the present invention to include with the vacuum **10a** a device that either locks the cleaning wheel **300** or electrically disables the fan assembly **72** when the cleaning wheel **300** is rotated. In FIG. 31, a lock-out device **800** is illustrated to be coupled to the power switch **76** for translation therewith. When the power switch **76** is activated, a lock-out member **802** translates into locking engagement with one of the circumferentially spaced apart recesses **310** in the gripping portion **302** of the cleaning wheel **300** to prevent the cleaning wheel **300** from being rotated. In FIG. 32, a sensor **850** is employed to detect the rotation of the cleaning wheel **300** relative to the housing **32** and generate a sensor signal in response thereto. In the particular example provided, the sensor **850** includes a pair of spaced apart contacts **850a** and **850b** which are normally not in contact with one another but which are urged into electrical contact with one another by actuating features **852** that are formed on the cleaning wheel **300**. In response to receipt of the sensor signal, a controller **860** is employed to inhibit the flow of electricity from the batteries **100** to the motor **70** to thereby deactivate the fan assembly **72**. In the example provided, the controller **860** employs a conventional relay **862** to inhibit the flow of electricity from the batteries **100** to the motor **70**. In this latter embodiment, the controller **860** may include a timer **864** which maintains the motor **70** in a deactivated state for a predetermined amount of time after receipt of the sensor signal.

[0116] In the embodiments of FIGS. 34 and 35, the cleaning wheel is illustrated to be driven by a motor rather than manually operated. In FIG. 34, a clutch **900** having an input shaft **902**, which is coupled to the output shaft **88** of the motor **70**, a first output shaft **904**, to which the impeller **90** is coupled for rotation therewith, and a second output shaft **906**, which is concentric with the first output shaft **904**, which is meshingly engaged with an idler gear **908**. A shaft **910** couples an output pinion **912**, which is meshingly engaged with teeth **310g** formed on the cleaning wheel **300g**, for rotation with the idler gear **908**. The clutch **900** is normally operable in first condition, wherein rotary power is transmitted to the first output shaft **904** but not the second output shaft **906**, and a second condition, wherein rotary power is transmitted to the second output shaft **906** but not the first output shaft **904**. The clutch **900** is preferably electronically controlled, so that the user need only press a button to change the condition of the clutch **900** from the first condition to the second condition (such as by translating the power switch **76** (FIG. 3) in a direction opposite that which is normally employed to actuate the vacuum **10a**). As noted above, the clutch **900** is normally operable in the first condition, so that when the button is released, the clutch **1900** will revert to the first condition. In the embodiment of FIG. 35, a second motor **950** is employed to rotate the cleaning wheel **300**.

[0117] While the invention has been described in the specification and illustrated in the drawings with reference to various embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention as defined in the claims. Furthermore, the mixing and matching of features, elements and/or functions between various embodiments is expressly contemplated herein so that one of ordinary skill in the art would appreciate from this disclosure that features, elements and/or functions of one embodiment may be incorporated into another embodiment as appropriate, unless described otherwise, above. Moreover, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment illustrated by the drawings and described in the specification as the best mode presently contemplated for carrying out this invention, but that the invention will include any embodiments falling within the foregoing description and the appended claims.

What is claimed is:

1. A hand-held portable vacuum comprising:

a housing;

a dirt cup having an inlet and defining a container for storage of dirt and debris therein, the dirt cup being removably attached to the housing;

an impeller at least partially disposed in the housing;

a HEPA filter disposed between the impeller and the inlet, the HEPA filter being formed with a plurality of pleats;

means for swirling the incoming air about the dirt cup; and

a filter cleaning device coupled to at least one of the housing and the dirt cup, the filter cleaning device including at least one rib and a hub, the hub being coupled to one of the HEPA filter and the rib and configured to rotate the one of the HEPA filter and the rib about the other one of the HEPA filter to generate contact between the rib and the HEPA filter to at least partially dislodge accumulated dirt and debris from the pleats.

2. The hand-held vacuum of claim 1, wherein the swirling means includes a flow deflector associated with the inlet of the dirt cup.

3. The hand-held vacuum of claim 2, wherein the flow deflector is an elbow.

4. The hand-held vacuum of claim 1, wherein the swirling means includes a plurality of vanes disposed in an axially spaced relation to the inlet.

5. The hand-held vacuum of claim 4, wherein the vanes are associated with a prefilter, the vanes being disposed between the inlet and the HEPA filter.

6. The hand-held vacuum of claim 1, wherein the hub includes a gripping portion that extends through the housing and is manually rotatable.

7. A hand-held portable vacuum comprising:

a housing;

an impeller at least partially disposed in the housing;

- a dirt cup having an inlet and defining a container for storage of dirt and debris therein, the dirt cup being removably attached to the housing; and
- a HEPA filter disposed between the impeller and the inlet.
- 8.** The hand-held portable vacuum of claim 7, wherein the HEPA filter is formed with a plurality of pleats.
- 9.** The hand-held portable vacuum of claim 8, further comprising a filter cleaning device associated with at least one of the housing and the dirt cup, the filter cleaning device including at least one rib and a hub, the hub being coupled to one of the HEPA filter and the rib and configured to rotate the one of the HEPA filter and the rib about the other one of the HEPA filter to generate contact between the rib and the HEPA filter to at least partially dislodge accumulated dirt and debris from the pleats.
- 10.** The hand-held portable vacuum of claim 9, wherein the hub is rotatably coupled to the housing.
- 11.** The hand-held portable vacuum of claim 10, wherein the HEPA filter is sealingly attached to the hub.
- 12.** The hand-held portable vacuum of claim 10, wherein the hub includes a plurality of drive tabs that meshingly engage a plurality of drive tabs formed on the HEPA filter.
- 13.** The hand-held portable vacuum of claim 10, further comprising a prefilter, the prefilter having a prefilter body that surrounds the HEPA filter, the prefilter body having an open end which is sealingly engaged with the HEPA filter.
- 14.** The hand-held portable vacuum of claim 10, further comprising a prefilter, the prefilter having a prefilter body that surrounds the HEPA filter, the rib extending from an interior surface of the prefilter body.
- 15.** The hand-held portable vacuum of claim 7, further comprising a prefilter, the prefilter having a prefilter body that surrounds the HEPA filter
- 16.** The hand-held portable vacuum of claim 15, wherein the prefilter body has an open end and the prefilter and HEPA filter are sealingly engaged to close the open end.
- 17.** A method for filtering a dirt and debris laden air flow, the method comprising:
- providing a hand-held vacuum with a housing, an impeller, an inlet, a container and a primary filter, the housing including a handle that permits a user to employ the hand-held vacuum for vacuuming with a single hand, the impeller being disposed within the housing, the inlet being configured to receive the dirt and debris laden air flow therethrough, the container being configured to retain dirt and debris removed from the dirt and debris laden air flow and the primary filter being disposed between the impeller and the inlet;
- rotating the impeller to generate the dirt and debris laden air flow; and
- swirling the dirt and debris laden air flow about the interior of the container.
- 18.** The method of claim 17, further comprising removing the container from the housing to empty the container.
- 19.** The method of claim 18, wherein the container and the inlet are fixedly coupled to one another.
- 20.** The method of claim 17, further comprising pivoting the inlet relative to the housing to gain access to the container.
- 21.** The method of claim 20, further comprising rotating the housing with the single hand grasping the handle to overturn the vacuum and empty the container.

- 22.** A hand-held portable vacuum comprising:
- a housing having a handle;
- a dirt cup having an inlet and defining a container for storage of dirt and debris therein, the dirt cup being removably attached to the housing;
- an impeller at least partially disposed in the housing;
- a filter disposed between the impeller and the inlet, the filter being formed with a plurality of pleats;
- a filter cleaning device coupled to at least one of the housing and the dirt cup, the filter cleaning device including at least one rib and a hub, the hub being coupled to one of the filter and the rib and configured to rotate the one of the filter and the rib about the other one of the filter to generate contact between the rib and the filter to at least partially dislodge accumulated dirt and debris from the pleats.
- 23.** The hand-held vacuum of claim 22, wherein the hub is rotatably coupled to the housing.
- 24.** The hand-held portable vacuum of claim 23, wherein the hub includes a gripping portion that extends through the housing and is manually rotatable.
- 25.** The hand-held portable vacuum of claim 23, wherein the filter is sealingly attached to the hub.
- 26.** The hand-held portable vacuum of claim 23, wherein the hub includes a plurality of drive tabs that meshingly engage a plurality of drive tabs formed on the filter.
- 27.** The hand-held portable vacuum of claim 23, further comprising a prefilter with a prefilter body that surrounds the filter, the prefilter body having an open end which is sealingly engaged with the filter, the rib extending from an interior surface of the prefilter body.
- 28.** The hand-held portable vacuum of claim 27, wherein the prefilter body has an open end and the prefilter and filter are sealingly engaged to close the open end.
- 29.** The hand-held portable vacuum of claim 27, wherein the prefilter body has a truncated cone shape.
- 30.** The hand-held portable vacuum of claim 29, wherein the filter has a truncated cone shape.
- 31.** The hand-held portable vacuum of claim 22, wherein the filter has a truncated cone shape.
- 32.** A hand-held portable vacuum comprising:
- a housing having a handle;
- a dirt cup having an inlet and defining a container for storage of dirt and debris therein, the dirt cup being removably attached to the housing;
- an impeller at least partially disposed in the housing, the impeller being operable for generating an air flow that flows through the inlet;
- a filter disposed between the impeller and the inlet; and
- means for swirling the air flow about the dirt cup.
- 33.** The hand-held vacuum of claim 32, wherein the swirling means includes a flow deflector associated with the inlet of the dirt cup.
- 34.** The hand-held vacuum of claim 33, wherein the flow deflector is an elbow.
- 35.** The hand-held vacuum of claim 32, wherein the swirling means includes a plurality of vanes disposed in an axially spaced relation to the inlet.

36. The hand-held vacuum of claim 35, wherein the vanes are associated with a prefilter, the vanes being disposed between the inlet and the filter.

37. A hand-held portable vacuum comprising:

a housing having a handle;

a dirt cup having an inlet and defining a container for storage of dirt and debris therein, the dirt cup being removably attached to the housing;

an impeller at least partially disposed in the housing, the impeller being operable for generating an air flow that flows through the inlet;

a filter disposed between the impeller and the inlet; and

a flow deflector associated with the inlet of the dirt cup, the flow deflector being configured to direct the air flow toward an interior surface of the dirt cup in a manner that causes dirt and debris entrained in the air flow to swirl about the interior surface of the dirt cup.

38. The hand-held vacuum of claim 37, wherein the flow deflector is an elbow that is coupled to the inlet.

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