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(54) **UPRIGHT VACUUM CLEANER**

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(52) **U.S. Cl.** ..... **15/182**; 15/179; 300/21

(57) **ABSTRACT**

A vacuum cleaner brushroll having a pulley with a generally circular pulley surface surrounding at least one opening located radially inward of the pulley surface, and an elongated shaft passing through the central opening. The pulley may surrounds and be captured in place by a mounting portion of the elongated shaft that is formed as continuous single structure. A mounting portion of the shaft comprising a continuous structure having a reduced cross section into which the pulley fits may be located within and on either side of the pulley's central opening. A process for making a brushroll is also provided.

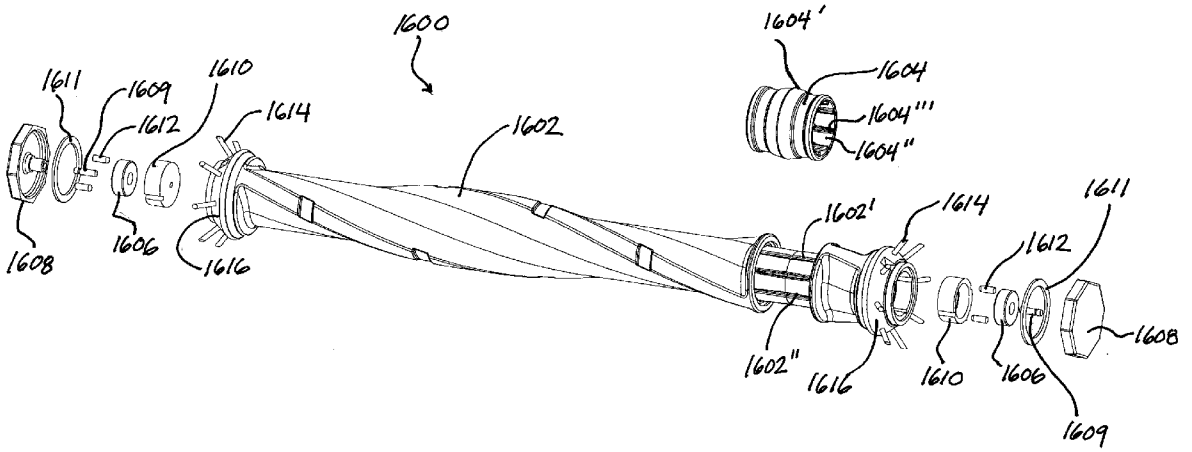


Fig. 1

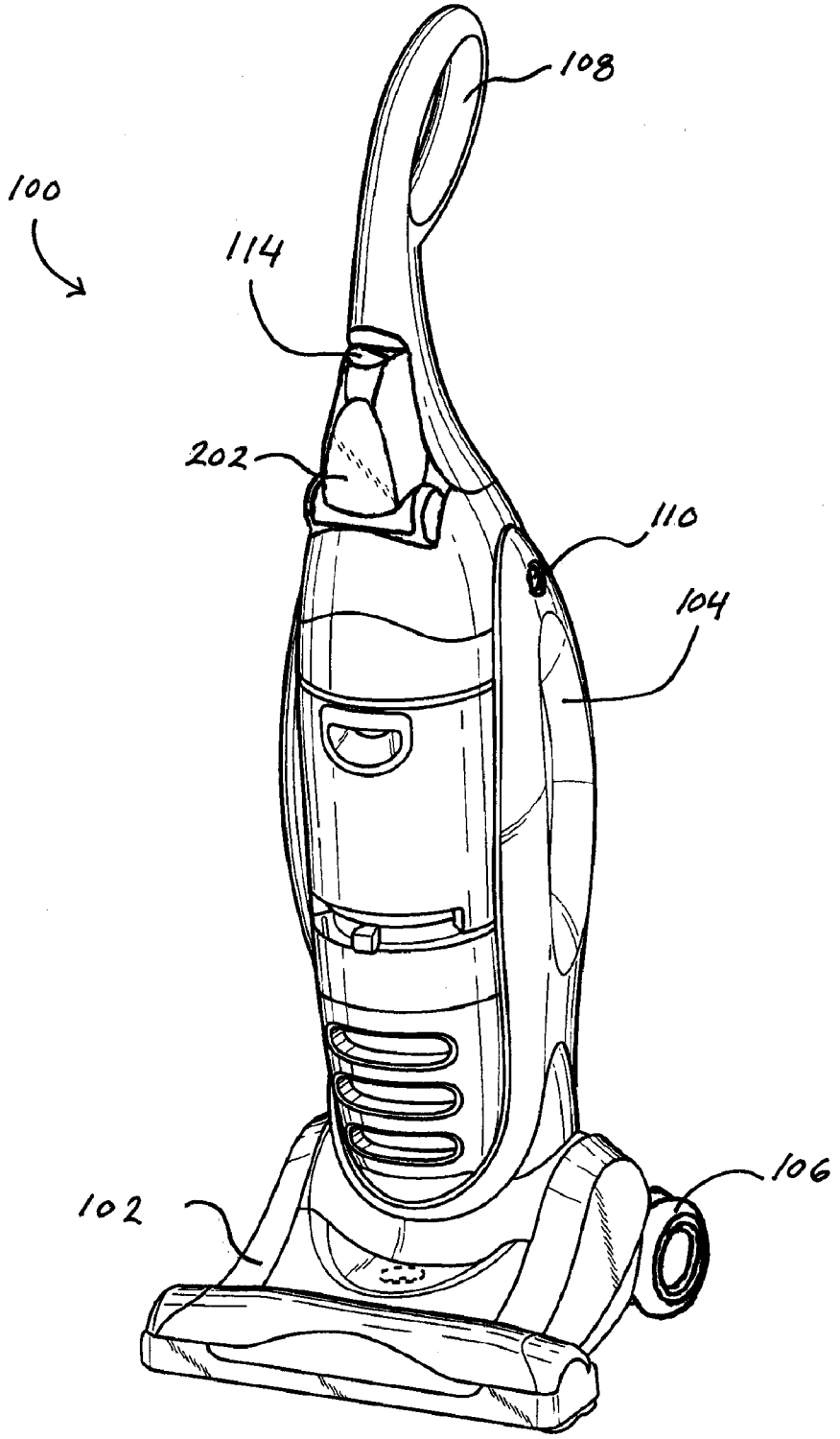
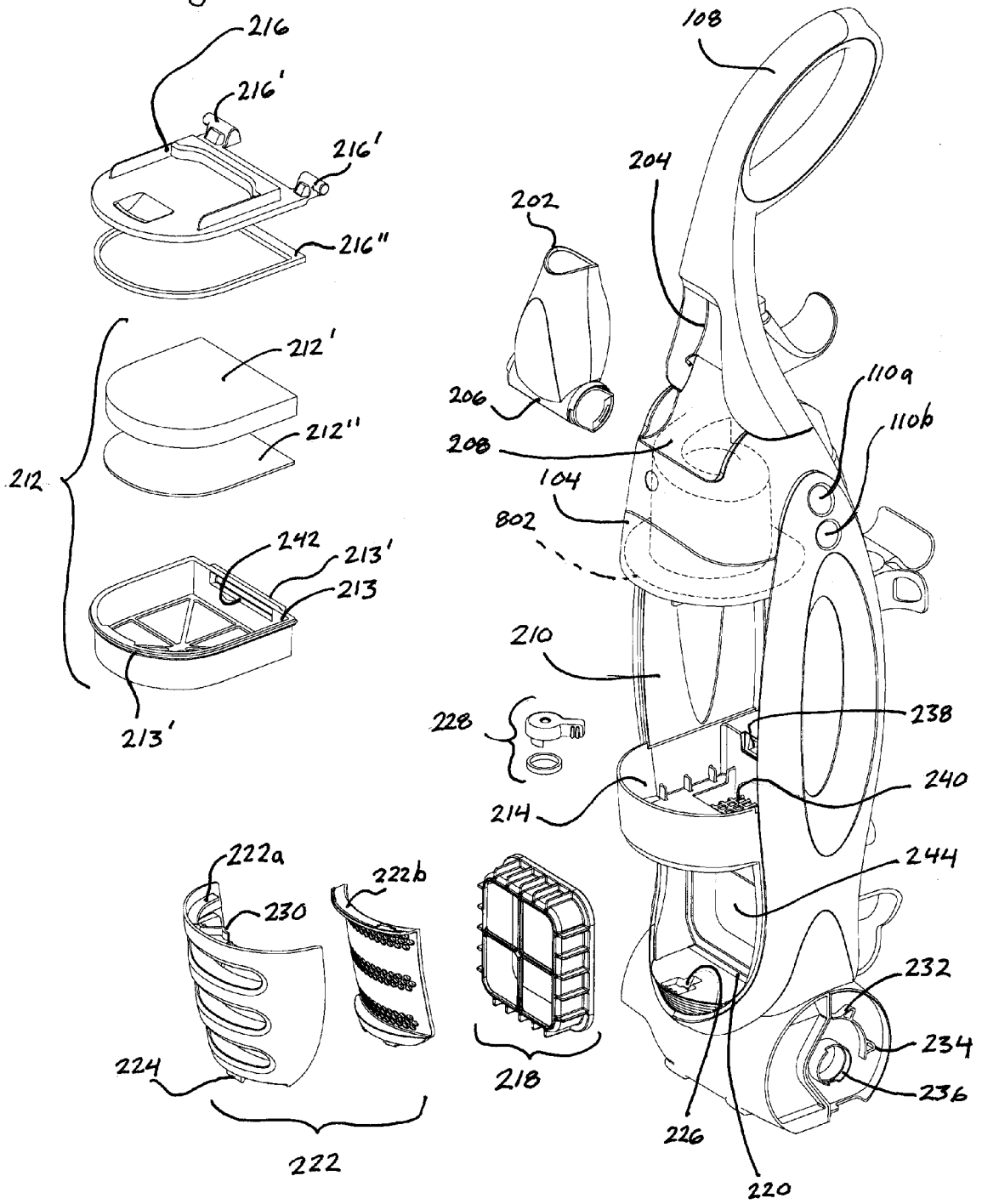


Fig. 2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216'
216'
216"
212'
212"
212
242
213'
213
213'
108
204
202
206
208
104
802
110a
110b
210
228
238
240
214
244
222a
222b
230
224
222
218
232
234
236
226
220

Fig. 3B

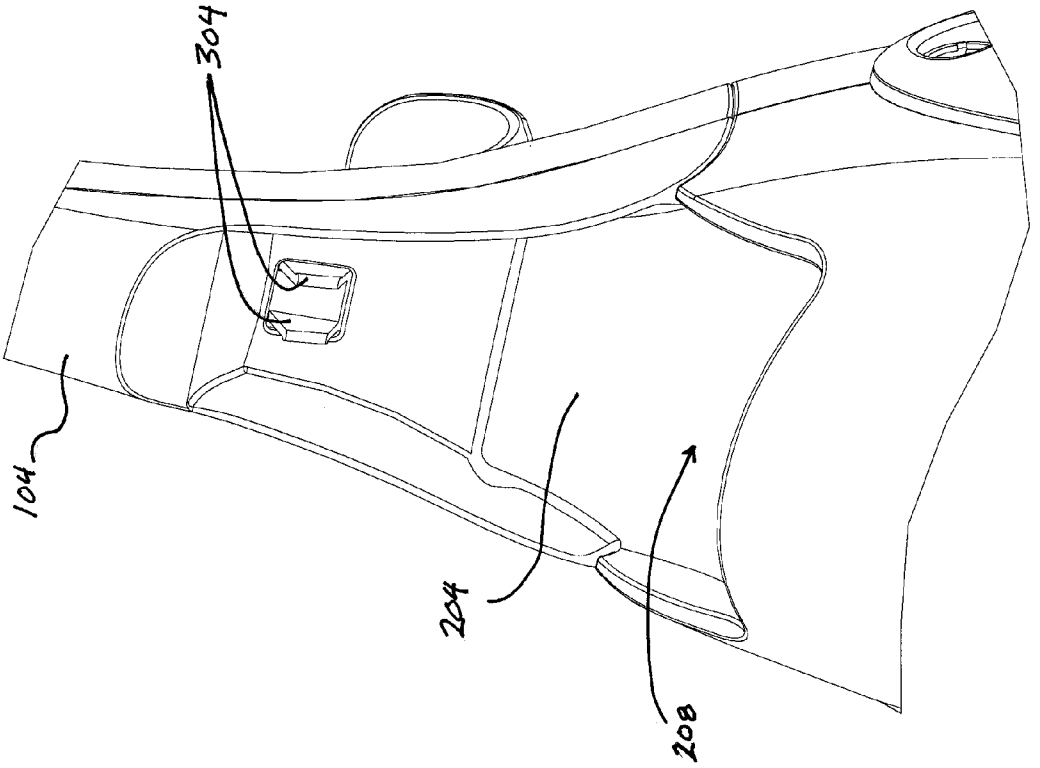



Fig 3A

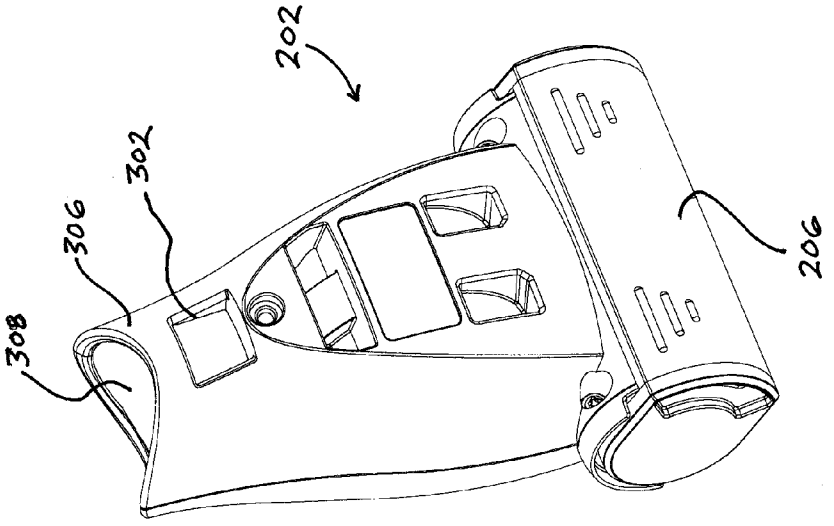


Fig. 4

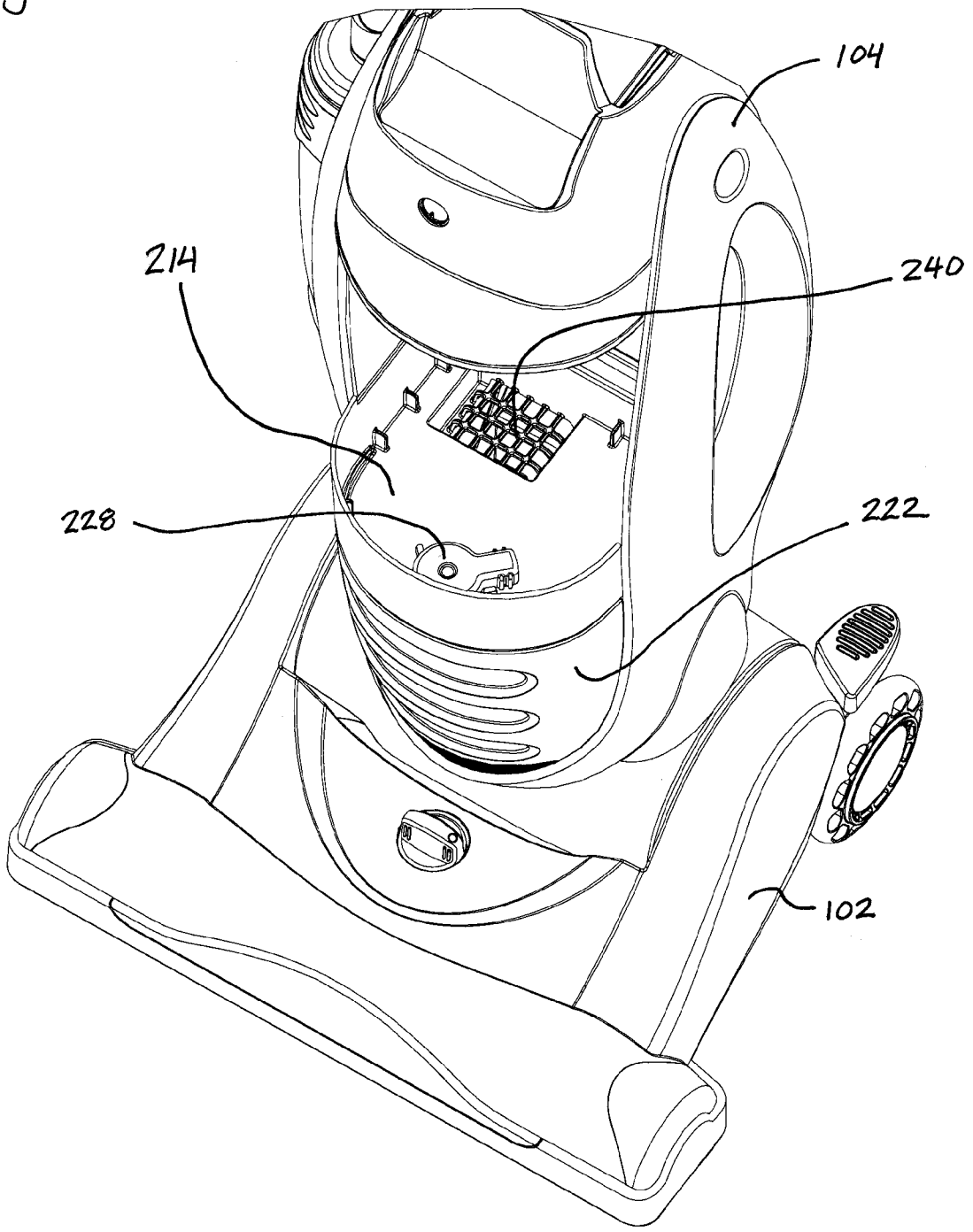


Fig. 5

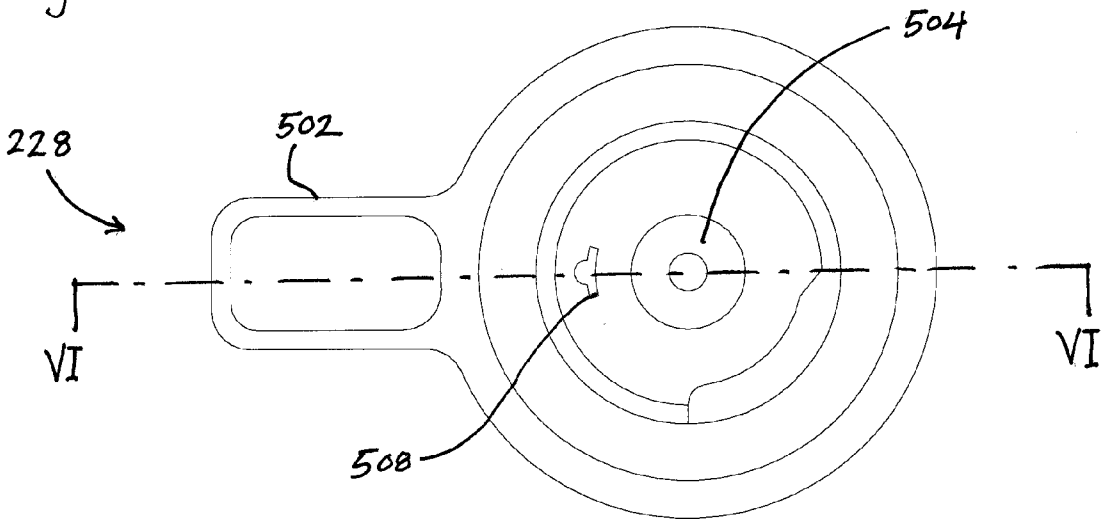



Fig. 6

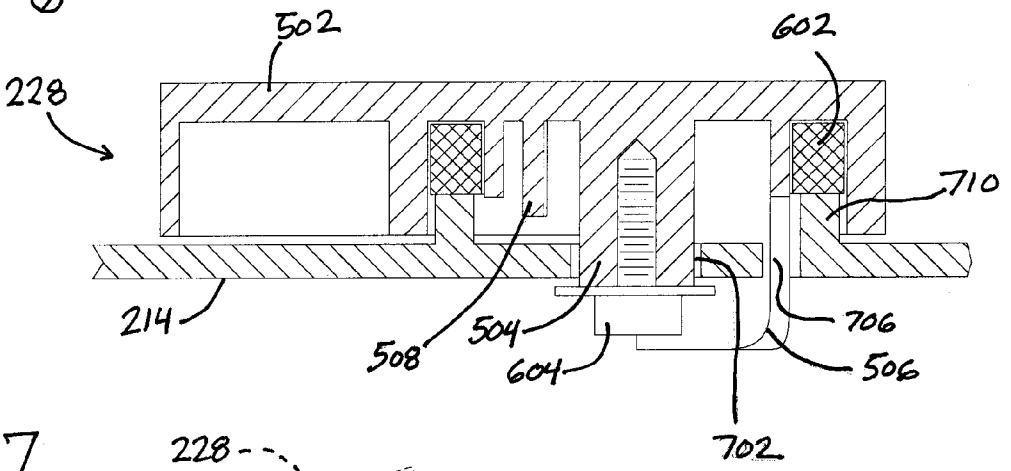



Fig. 7

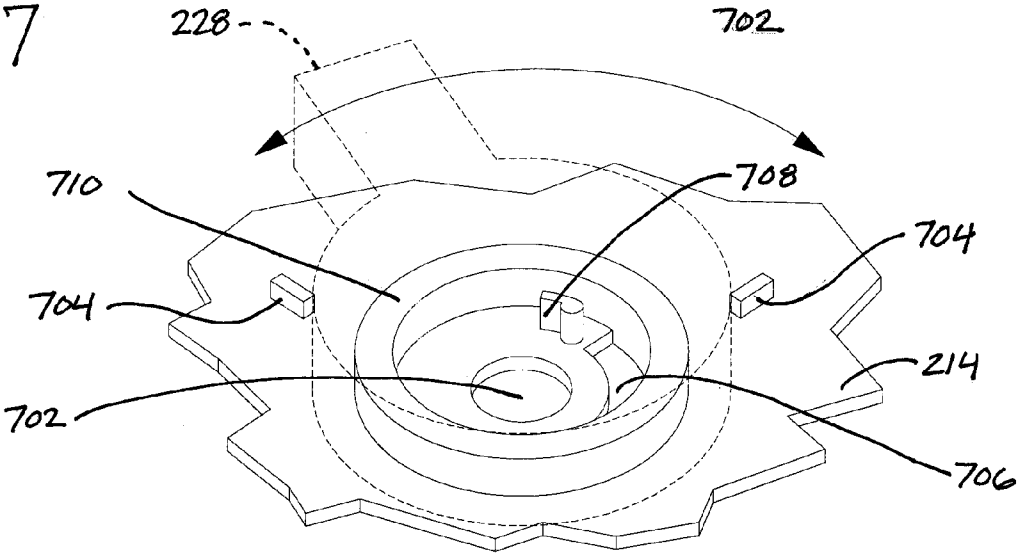


Fig. 8

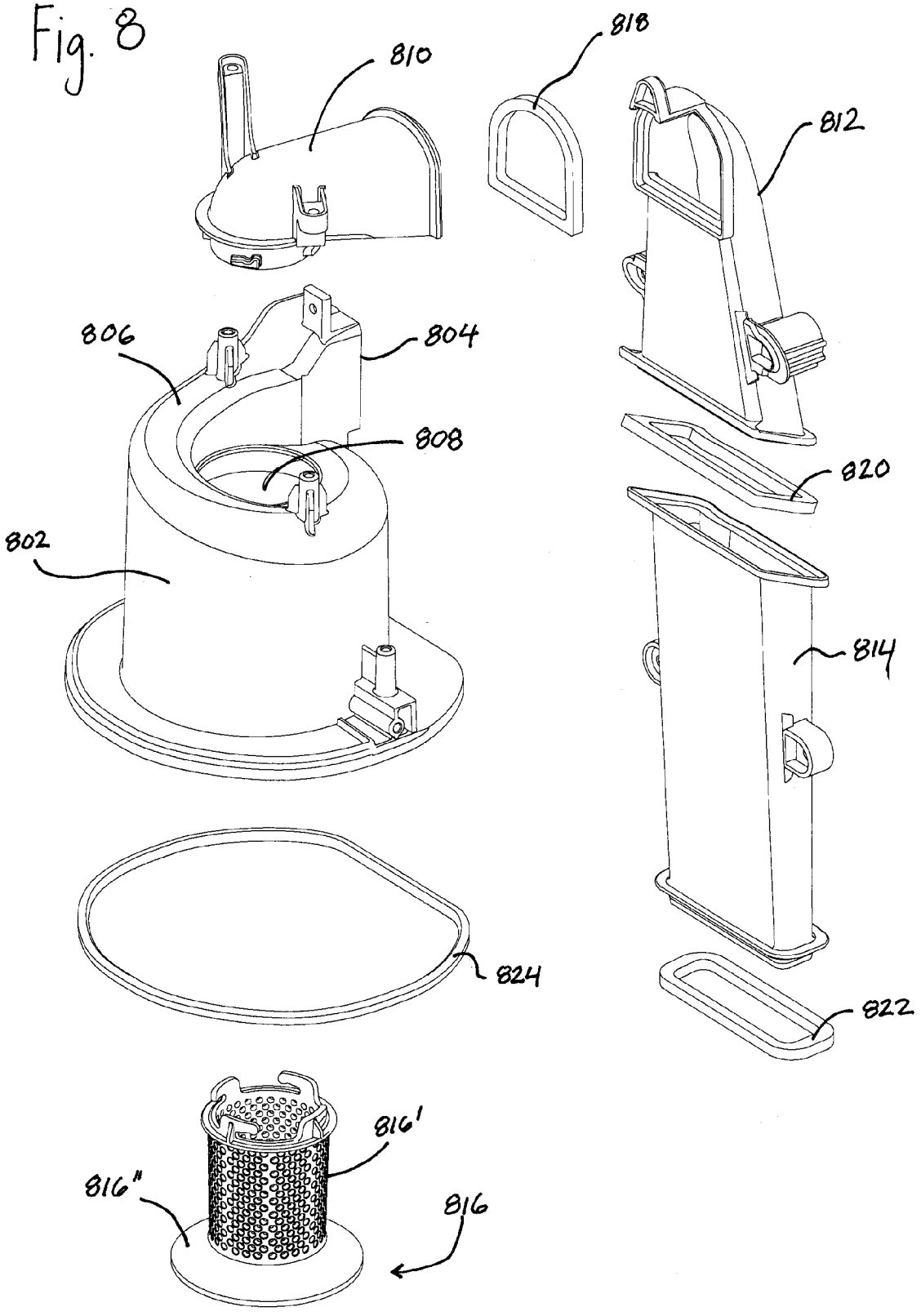
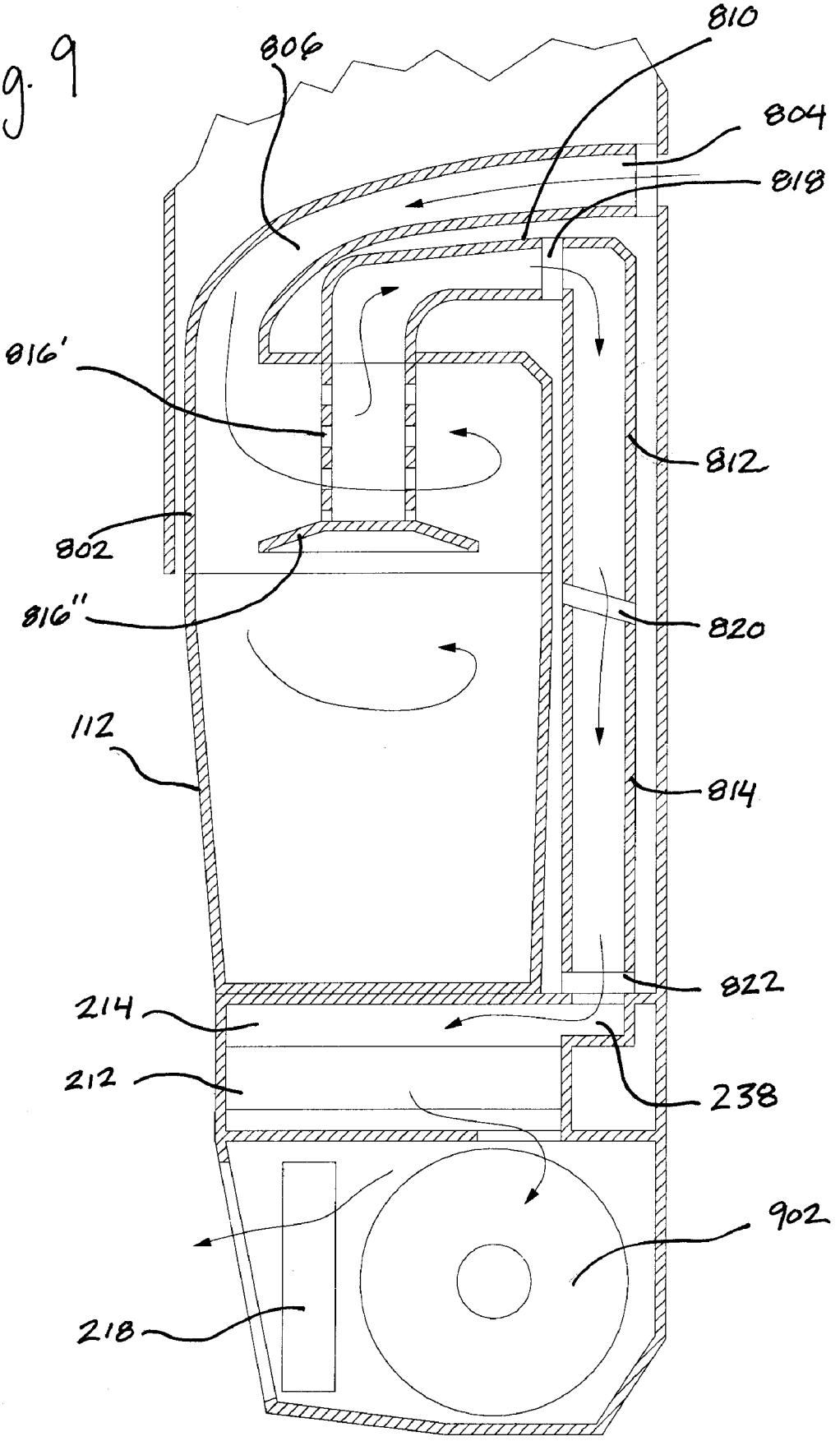


Fig. 9


806
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816'
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802
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112
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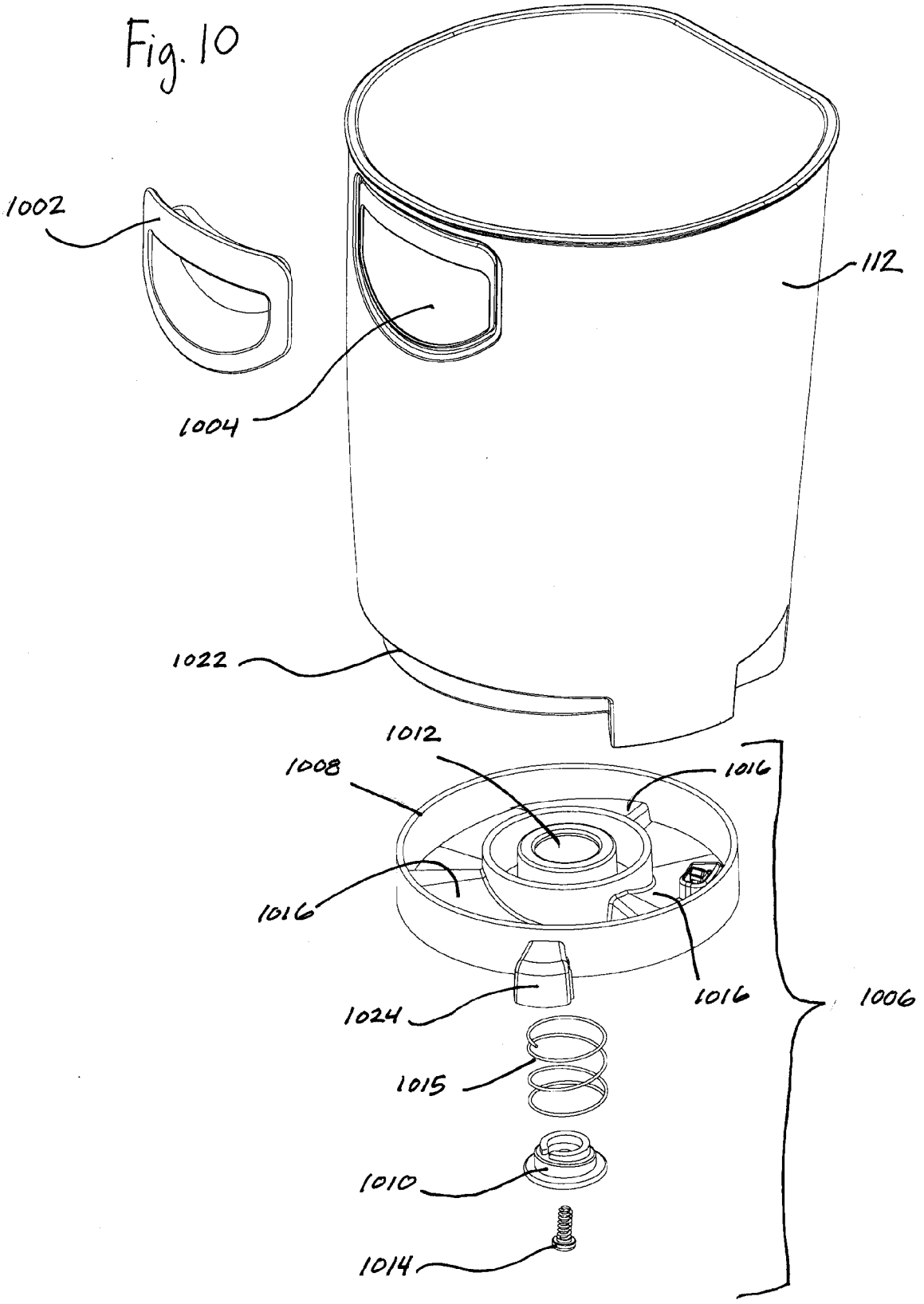
214
212
238
902
218

Fig. 10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1014

Fig. 12

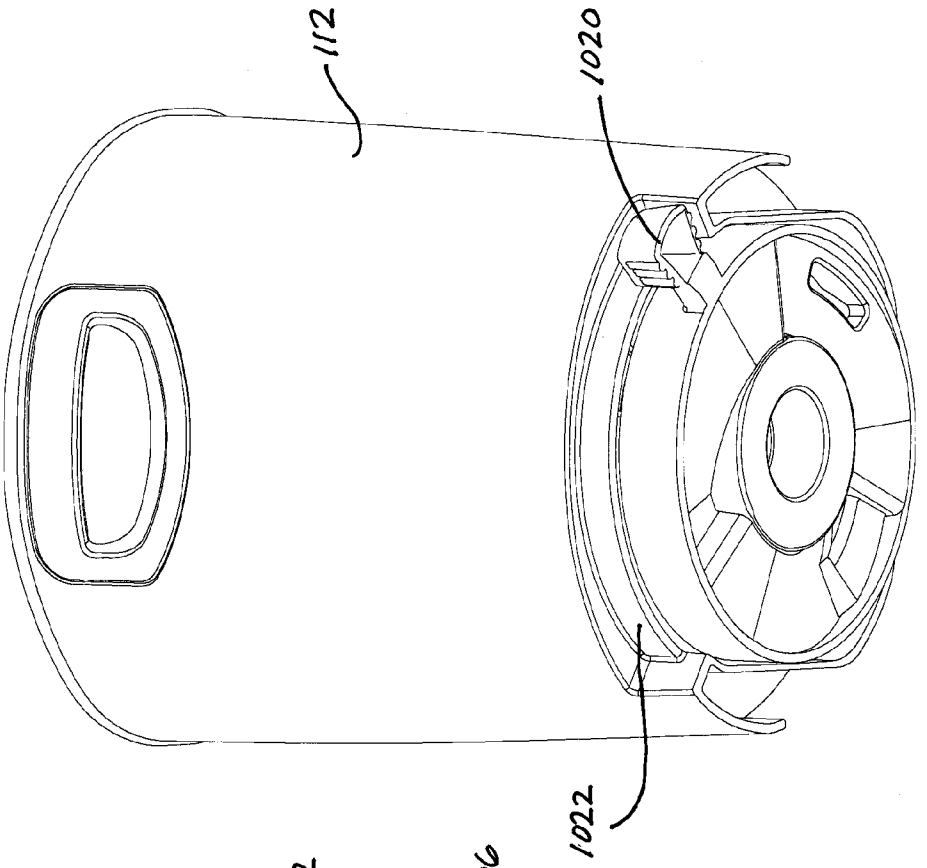
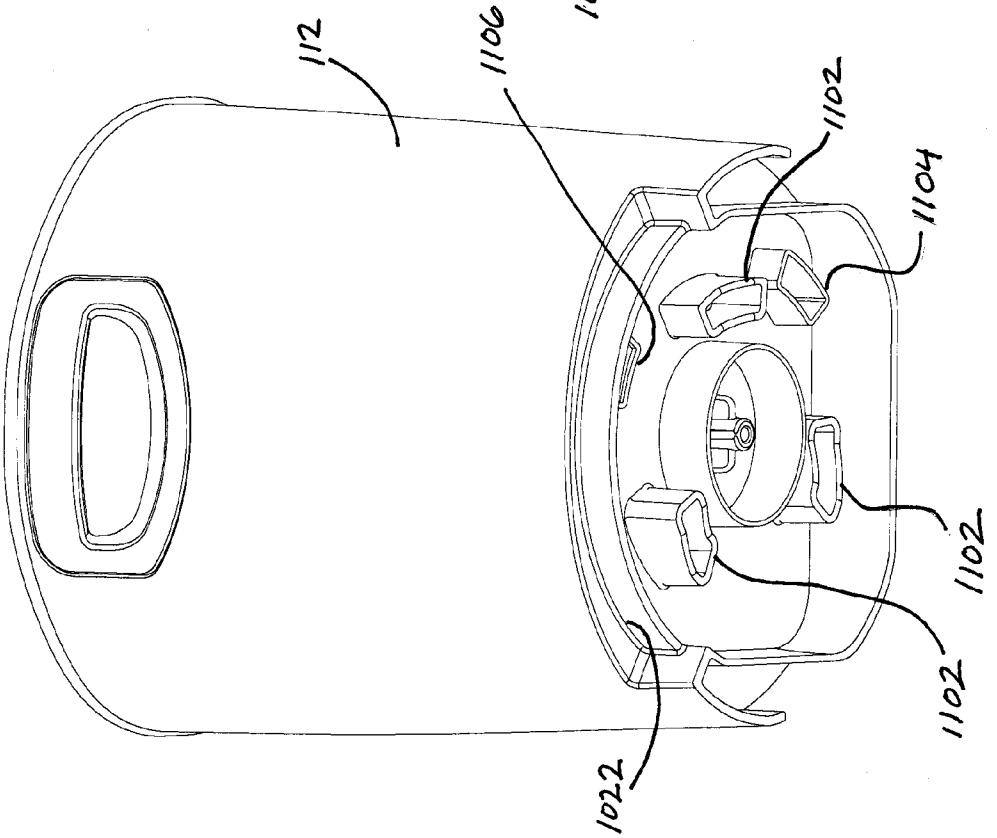



Fig. 11



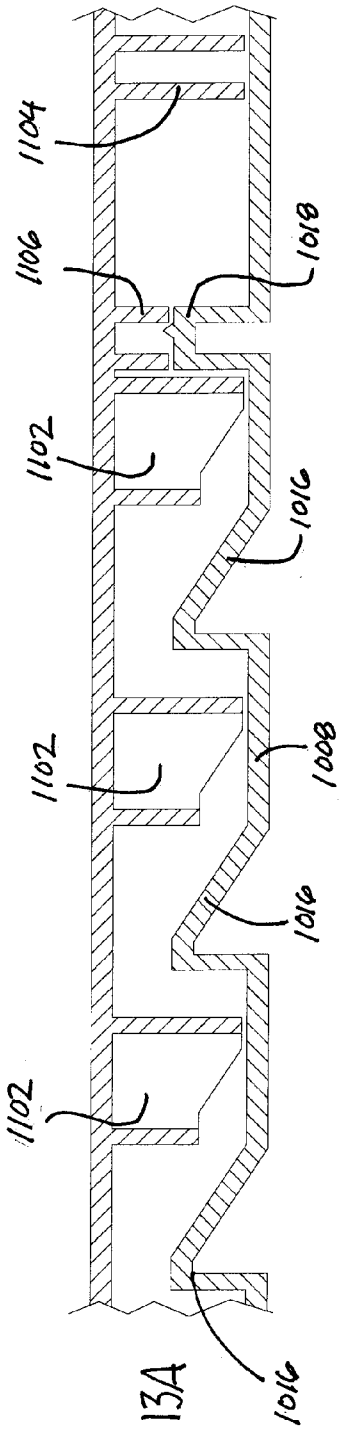



Fig 13A

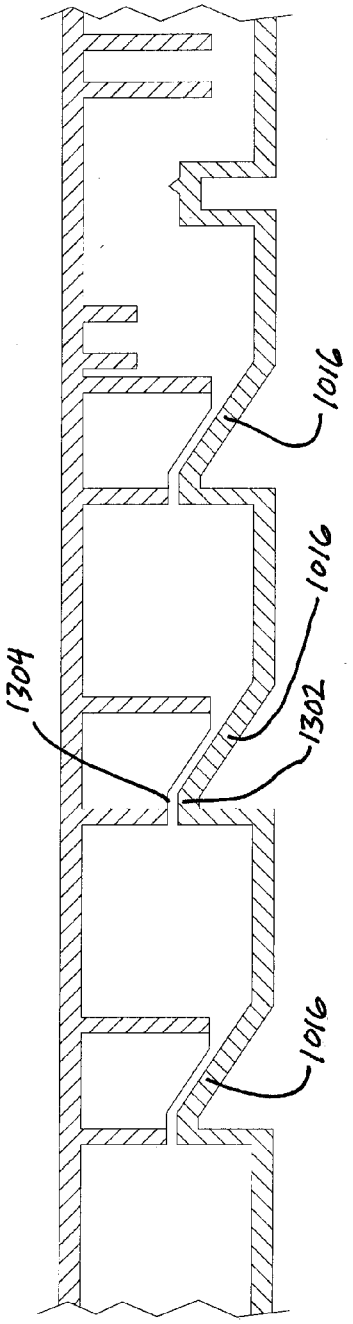



Fig. 13B

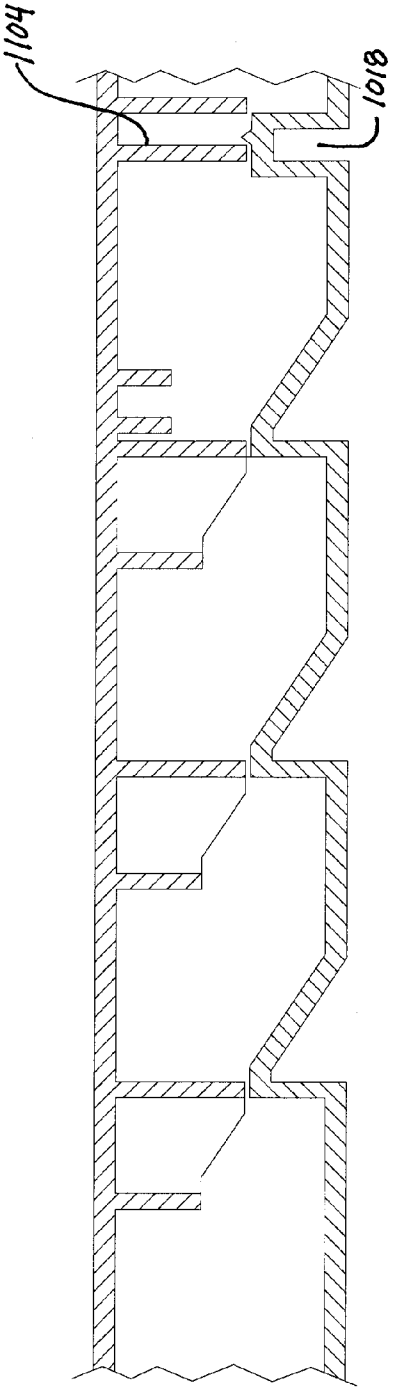



Fig. 13C

Fig. 14

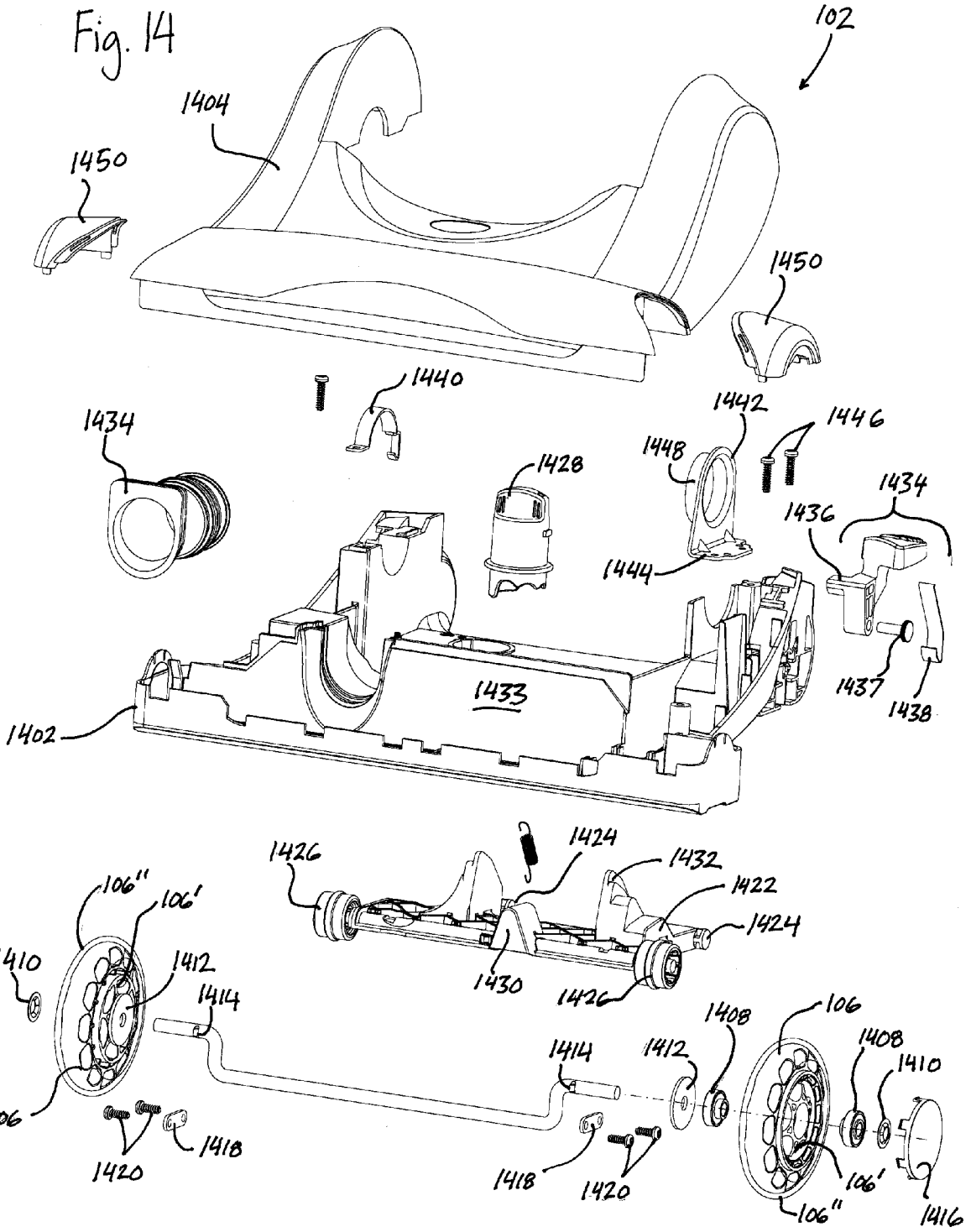

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Fig. 19

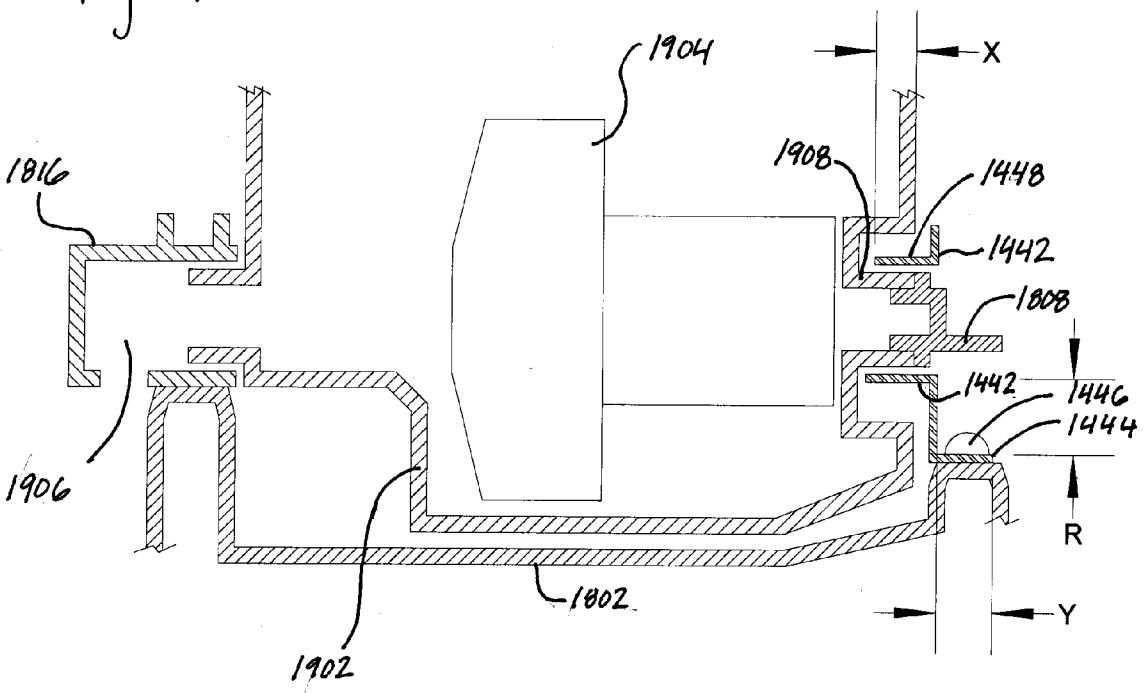
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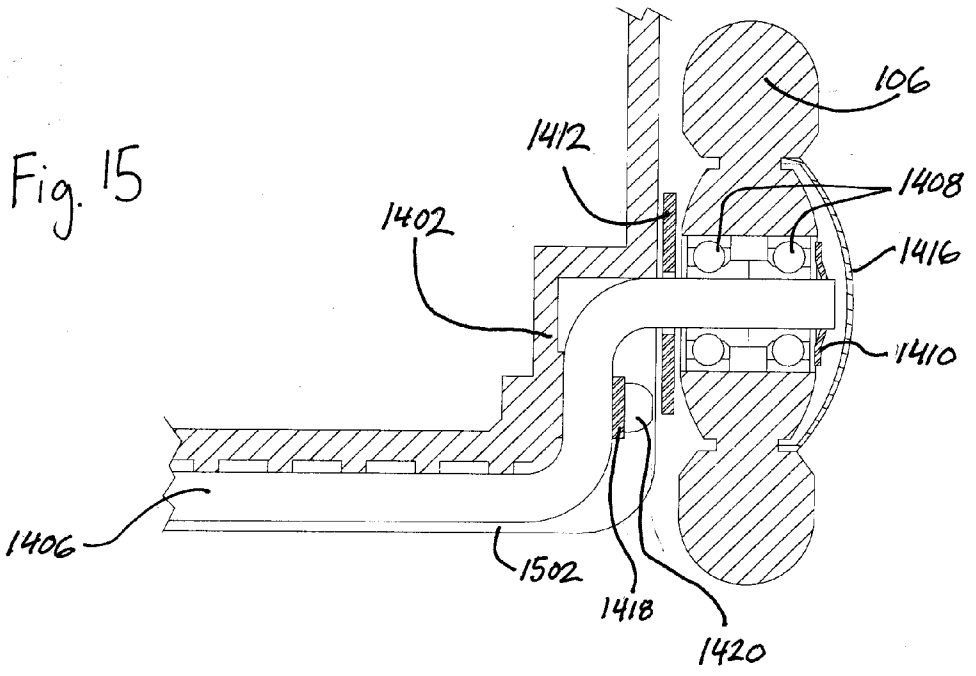
Fig. 15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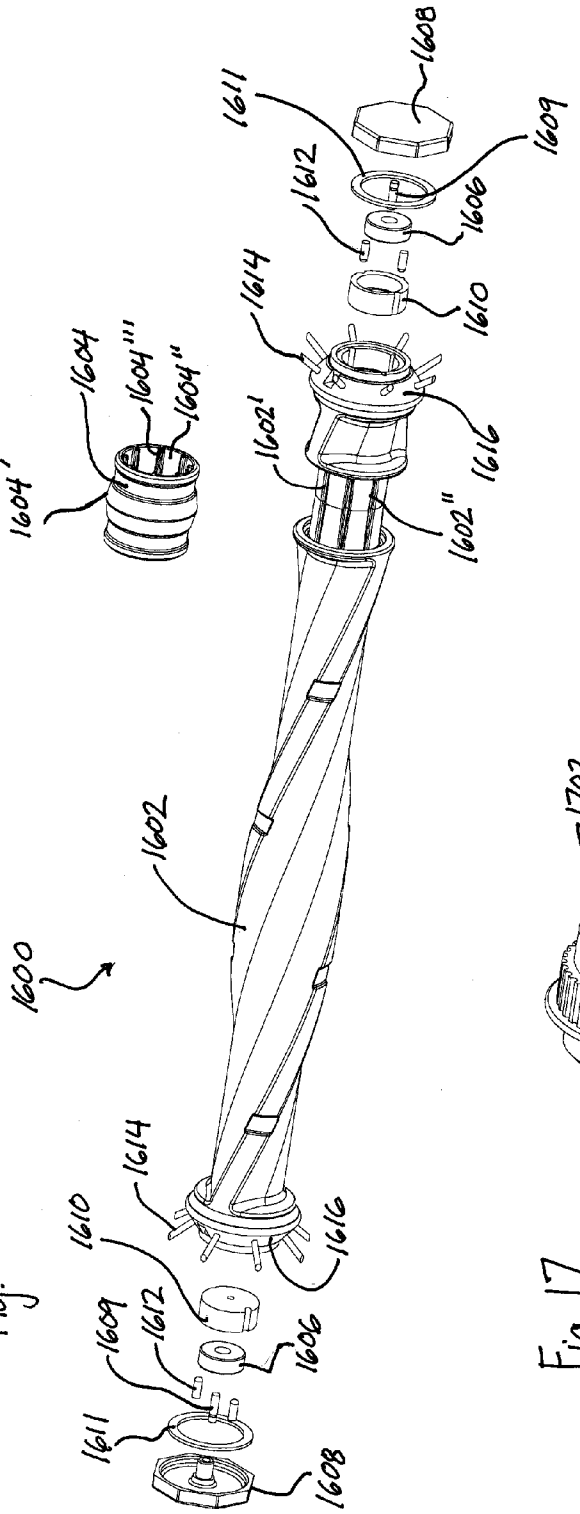
1600
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Fig. 16

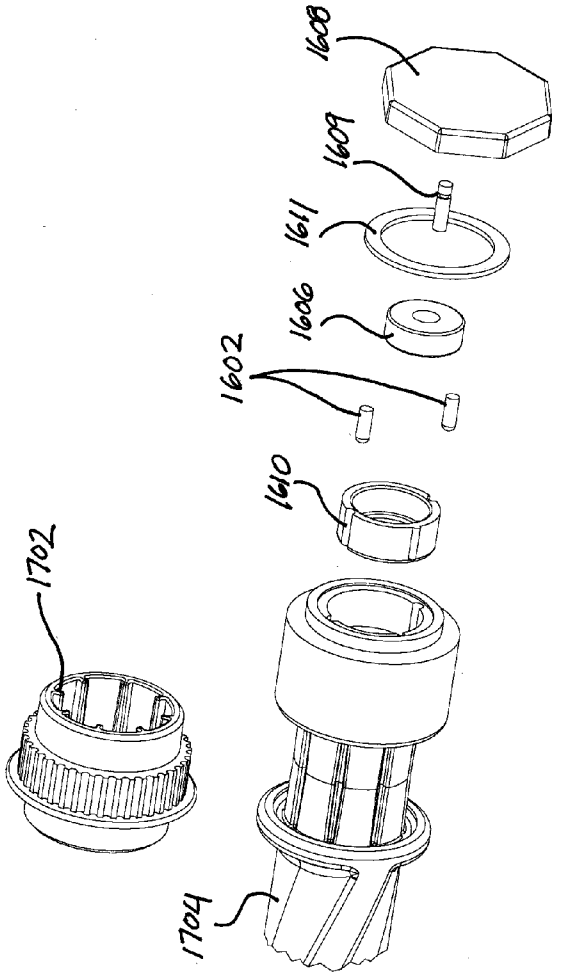
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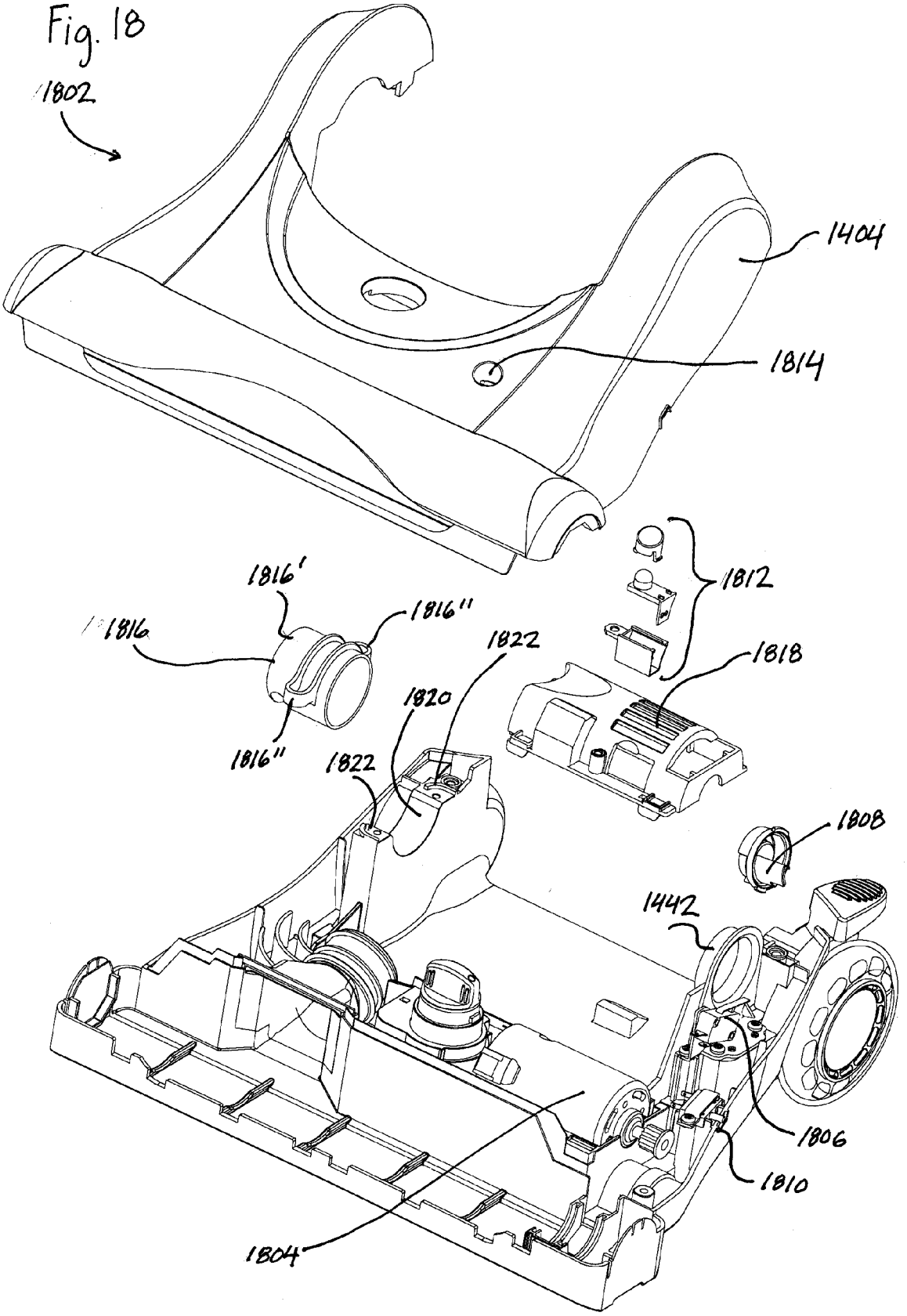
Fig. 17

Fig. 18


1802
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1806
1810
1804

# UPRIGHT VACUUM CLEANER

## FIELD OF THE INVENTION

**[0001]** The present invention relates to features for use with vacuum cleaners, such as upright vacuum cleaners, wet extractors, stick vacuums, canister vacuums, central vacuums, and the like.

## BACKGROUND OF THE INVENTION

**[0002]** Vacuum cleaning devices, such as upright and canister vacuum cleaners, wet extractors, stick vacuums, electric brooms and other devices, are in widespread use as a tool to clean floors, upholstery, stairs, and other surfaces. Known vacuum cleaning devices have various features that are intended to improve their cleaning effectiveness. For example, a common feature on upright vacuums is a rotating brushroll, and numerous variations of such brushrolls are known in the art. Another feature is the provision of various types of filtration systems, such as vacuum bags, disposable or reusable filters, cyclone separators, and combinations thereof. Still other features relate to controlling the manner in which the vacuum cleaner addresses the surface being cleaned, such as nozzle height adjustment mechanisms.

**[0003]** While the prior art provides various features relating to cleaning effectiveness and user convenience, there still exists a need for improvement of and alternative designs for these and other features of vacuum cleaning devices.

## SUMMARY OF THE INVENTION

**[0004]** In a first exemplary aspect, an embodiment of the invention provides a vacuum cleaner brushroll having a pulley with a generally circular pulley surface surrounding at least one opening located radially inward of the pulley surface, and an elongated shaft passing through the central opening. The pulley surrounds and is captured in place by a mounting portion of the elongated shaft. The mounting portion includes a continuous, single structure.

**[0005]** In another exemplary aspect, an embodiment of the invention provides a vacuum cleaner brushroll having a pulley with a generally circular pulley surface surrounding at least one opening located radially inward of the pulley surface. An elongated shaft passes through the at least one central opening. A mounting portion of the elongated shaft is located within and on either side of the central opening. The mounting portion includes a continuous structure having a reduced cross section into which the pulley fits.

**[0006]** In another exemplary aspect, an embodiment of the invention provides a vacuum cleaner brushroll manufactured by a process. The process includes forming a pulley having a generally circular pulley surface and at least one opening located radially inward of the pulley surface, and forming an elongated shaft from a continuous piece of material that passes through the at least one opening and at least partially surrounds the pulley to structurally interlock the pulley in place on the elongated shaft.

**[0007]** The recitation of this summary of the invention is not intended to limit the claimed invention, and examples of other aspects, embodiments, modification and features of the invention are described herein, and still other aspects, embodiments, modification and features of the claimed invention will be apparent to persons of ordinary skill in view of the disclosures herein. Furthermore, this recitation of this summary of the invention, and the other disclosures provided herein, are not intended to diminish the scope of the claims in this or any prior or subsequent related or unrelated application.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** The present invention is described in detail with reference to the examples of embodiments shown in the following figures in which like parts are designated by like reference numerals.

**[0009]** FIG. **1** is an isometric view of a upright vacuum cleaner.

**[0010]** FIG. **2** is a partially-exploded and fragmented view of a rear housing for a vacuum cleaner.

**[0011]** FIG. **3** is a fragmented and partially disassembled view of an accessory tool and vacuum cleaner housing mount for the accessory tool.

**[0012]** FIG. **4** is a fragmented isometric view of the rear housing of FIG. **2**.

**[0013]** FIG. **5** is a bottom plan view of a filter latch.

**[0014]** FIG. **6** is a cutaway view of the filter latch of FIG. **5**, as shown along line VI-VI thereof, and as shown mounted to a vacuum cleaner housing.

**[0015]** FIG. **7** is a fragmented isometric view of a the filter latch of FIG. **5**, as shown mounted to a vacuum cleaner housing.

**[0016]** FIG. **8** is an exploded view of a dirt separation system for a vacuum cleaner.

**[0017]** FIG. **9** is a schematic diagram illustrating the airflow through the dirt separation system of FIG. **8**.

**[0018]** FIG. **10** is an exploded isometric view of a dirt cup and cam plate assembly.

**[0019]** FIG. **11** is an oblique front view of the dirt cup of FIG. **10**.

**[0020]** FIG. **12** is an oblique from view of the dirt cup and cam plate assembly of FIG. **10**.

**[0021]** FIGS. **13**A, **13**B and **13**C are panoramic schematic diagrams illustrating the operation of a dirt cup and cam plate assembly.

**[0022]** FIG. **14** is an exploded isometric view of a vacuum cleaner base.

**[0023]** FIG. **15** is a partially cut away view of a wheel mounting arrangement for a vacuum cleaner base.

**[0024]** FIG. **16** is an exploded isometric view of a vacuum cleaner brushroll.

**[0025]** FIG. **17** is a fragmented and exploded isometric view of a vacuum cleaner brushroll.

**[0026]** FIG. **18** is an exploded isometric view of a vacuum cleaner base.

**[0027]** FIG. **19** is a cutaway view of a connection between a vacuum cleaner base and rear housing.

## DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTIONS

**[0028]** The present disclosure provides numerous inventive features for vacuum cleaners. For brevity, a number of these features and alternative embodiments of the invention are described with reference to their exemplary use in an upright vacuum cleaner, such as the vacuum cleaner **100** shown in FIG. **1**. It will be appreciated however, that the features described herein can be used in various other contexts. For example, the various features described herein can be used with canister vacuums, stick vacuums, portable and handheld vacuums, shop vacuums, wet extractors, central vacuum sys-

tems, and so on. Furthermore, the various features described herein may be used separately from one another or in any combination thereof. The present disclosure illustrating the use of the various inventions described herein are not intended to limit the inventions in any way.

**[0029]** As shown in FIG. **1**, the exemplary vacuum cleaner **100** comprises a base **102** to which a rear housing **104** is pivotally mounted. The base **102** is supported for movement over the ground by a pair of rear wheels **106** and a front wheel carriage (not visible) which will be described elsewhere herein. A grip **108** is provided at the top of the of the rear housing, and is shaped to receive an operator's hand, as known in the art.

**[0030]** The vacuum cleaner **100** may be powered by an electrical cord (not shown) or batteries (not shown), as known in the art. One or more power controls **110** are provided on the vacuum cleaner. Such controls **110** may be located anywhere on the vacuum cleaner, such as on the rear housing **104**, the base **102**, or on an associated power cord (not shown). The exemplary power control **110** is provided on the rear housing **104** at a position approximately half way up the housing, which allows the grip **108** and a portion of the rear housing **104** connected to the grip **108** to be easily removed from the vacuum cleaner **100** to make it more compact for shipping. In the shown embodiment, the power control is used to operate a vacuum motor (not shown), but other controls may be provided such as a separate brushroll motor control, wet extractor fluid deposition controls, and the like.

**[0031]** The vacuum cleaner **100** also includes a dirt collection system. Typical vacuum cleaner dirt collection systems include bags, cyclone chambers, and filters, and any such device may be used with various embodiments of the invention. In the shown exemplary embodiment, the dirt collection system comprises a removable dirt cup **112** and cyclone chamber **802** (FIG. **8**) that are located on the rear housing **104**. Alternatively, the dust collection bin **112** and/or cyclone chamber **802** may be replaced by another type of device, and may be partially or entirely mounted on the base **102**. For example, a suitable alternative dust collection device would be a bag chamber or external bag that is mounted on the base **102** or rear housing **104**.

**[0032]** A suitable vacuum fan and motor **902** (FIG. **9**) are provided in the base **102** or rear housing **104**, as known in the art. Such vacuum fans and motors typically comprise an electric motor that operates a suction fan to generate a working airflow through the vacuum cleaner **100**. The working airflow picks up debris from a surface being cleaned, and deposits such debris in the dirt collection system. In some cases, the working airflow passes through the suction fan before it is deposited into the dirt collection system (in which case the dirt collection system operates at higher than atmospheric pressure), and in other cases the working airflow passes through the dirt collection system before it passes through the suction fan (in which case the dirt collection system operates a lower than atmospheric pressure). Embodiments of the invention may be used with either type of system.

**[0033]** Referring now to FIG. **2**, the details of an embodiment of a rear housing **104** are shown and described in more detail. As may be seen in FIG. **2**, the rear housing shown in this embodiment is generally the same as the embodiment of FIG. **1**, but differs in that this embodiment comprises a dual control system having a first control **110**A that is used to provide primary power to the machine and a second control **110**B that is used to control only a brushroll motor that is located in the base housing. Such a brushroll motor is described subsequently herein.

**[0034]** Located at the top of the rear housing **104** (or elsewhere on the vacuum cleaner **100**) is an optional accessory cleaning tool **202**. The tool **202** fits within a corresponding recess **204** in the rear housing **104**. An exemplary manner in which the accessory cleaning tool **202** can be mounted to the rear housing **104** is shown in greater detail in FIG. **3**. Here, it can be seen that the accessory cleaning tool **202** is provided with an opening **302** located on the rear portion of the tool housing **306**, and this opening **302** fits over a pair of snap fingers **304** located within the recess. The snap fingers **304** and opening **302** are shaped and sized such that one or both of the snap fingers **304** must be flexed towards one another to fit into the opening **302**, and, once inserted, are held in place by corresponding ridges or other shapes on the fingers **304** and/or opening **302**. The accessory cleaning tool **202** is installed in the rear housing **104** by resting a front portion of the tool **206** into a corresponding lower portion **208** of the recess **204** and pressing the accessory cleaning tool **202** into the recess **204** to engage the opening **302** snaps with the snap fingers **304**.

**[0035]** The accessory cleaning tool **202** may comprise any conventional accessory tool for a vacuum cleaner, such as a crevice tool, upholstery brush, duster, or floor brush. In the present case, the accessory cleaning tool **202** comprises what is known as a turbo tool, which is an accessory tool that uses a turbine that is operated by the suction air flow from the vacuum cleaner to drive a brushroll located in the tool. The turbine can use clean air drawn from above the surface being cleaned, or dirty air drawn from the surface itself. Such devices are generally known in the art, however, the present invention provides a unique divergence from conventional designs. In particular, the accessory cleaning tool **202** comprises a housing **306** having an inlet at one end **206**, and an outlet **308** at the other end, as known in the art, but the outlet **308** is shaped as a receptacle into which a corresponding accessory suction hose telescopically fits. This differs from typical prior art constructions, in which the outlet is formed as a receptacle that protrudes from the end of the housing **306**. The present stemless construction is expected to provide a number of advantages over conventional turbo tool designs. For example, the stemless turbo tool is more compact than conventional devices, and can be better integrated into a recess **204** in the vacuum cleaner housing. In addition, the outlet **308** and recess **204** may be shaped such that the stemless outlet **308** provides an opening **114** into which a user can insert a finger to help remove the accessory cleaning tool **202** from the housing **104**, as best seen in FIG. **1**.

**[0036]** Referring again to FIG. **2**, in the shown exemplary embodiment, the vacuum cleaner includes a cyclonic-type primary dirt separation system having a cyclone chamber **802** located above a dirt cup opening **210** into which the dirt cup **112** can be selectively installed. The opening **210** is provided on the front face of the rear housing **104**, but it will be understood that the opening **210** can be located on other sides of the housing **104**, on the back of the housing **104**, or on the base **102**. In addition, while the opening **210** is shown as a hollow recess into which the dirt cup **112** fits, it may instead comprise a shelf-like structure onto which a dirt cup **210** fits. This latter construction is sometimes used when a cyclone chamber is provided as an attachment to the top of the dirt cup **210**, or when the dirt cup **210** itself forms a cyclone chamber. These alternative constructions are, of course, possible with

embodiments of the present invention. As suggested before, the present disclosure also contemplates that the cyclone and dirt cup **210** can be replaced by a vacuum bag contained in the opening **210** by a removable cover or chamber in other embodiments.

**[0037]** Located at the bottom of the dirt cup opening **210** (or bag chamber) is a filter chamber **214** into which an optional pre-motor filter **212** can be installed. The pre-motor filter **212** is provided between the primary dirt collecting system and the vacuum fan, and serves as an additional dirt filtration stage. In the shown exemplary embodiment, air exiting the cyclone **802** and dirt cup **112** enters the filter chamber **214** through an inlet **238** located at the rear of the chamber **214**, passes through the filter **212**, and exits to the vacuum fan through an outlet **240** located at the bottom of the chamber **212**. The outlet **240** may include a grate-like structure to help prevent large particles from passing to the vacuum fan if the filter **212** catastrophically fails, or if the vacuum cleaner **100** is operated without the filter **212** in place.

**[0038]** The pre-motor filter **212** may comprise any suitable filtration medium or media. In the shown exemplary embodiment, the pre-motor filter **212** comprises a foam first filter layer **212'** and a paper or non-woven second filter layer **212"** that may be mounted in a filter tray **213**. One or both of the layers **212'**, **212"** may be removable from the tray **213** to allow them to be cleaned separately. Any suitable filter media may be used, such as open-cell foams, electrostatic filters, and high efficiency (HEPA, ULPA, etc.) filters, and such filters may be shaped in any suitable way, such as being flat, pleated, conical, cylindrical, and so on.

**[0039]** The filter tray **213** is provided to give structural support to the filter layers **212'**, **212"**. In addition, the pre-motor filter tray **213** may be provided with features to help control the airflow in the filter chamber **214** to ensure that the air generally passes through the filter **212** instead of going around it. In the shown exemplary embodiment, the filter tray **213** includes an opening **242** that corresponds with the inlet **238** into the pre-motor filter chamber **214** to provide airflow to the filter **212**. An overmolded perimeter seal **213'** surrounds the opening **242** and fits against the pre-motor filter chamber inlet **238** to seal airflow therethrough. The perimeter seal **213'** (or a separate seal, if desired) also extends around the filter tray **213** to seal against the internal walls of the filter chamber **214** and help prevent air from bypassing the filter **212** on its way to the chamber outlet **240**. Thus, the filter tray seal **213** provides two seals to prevent air from bypassing the filter **212**. Of course, other types and configurations of seals may be used, if desired.

**[0040]** In the exemplary embodiment, the filter camber **214** is open towards the dirt cup opening **210**, and the filter **212** is inserted into the chamber **214** by removing the dirt cup **112** and placing the filter into the chamber **214**. The top of the filter chamber **214** is closed by a trap door **216**, which fits over and encloses the filter **212** when it is installed. The trap door **116** may be pivotally mounted by pivots **216'** that fit, for example, into corresponding bosses in the dirt cup opening **210** or filter chamber **214**. In such an embodiment, the trap door **216** can be pivoted upward to insert or remove the pre-motor filter **212**. In order to ensure that the user is aware of the presence for the pre-motor filter, the trap door **216** may be provided with suitable markings and/or made from a transparent material that allows the user to see the filter.

**[0041]** The exemplary trap door **216** also includes a door seal **216"** that is molded into or adhered to the bottom of the trap door **216** to seal against the top of the filter tray **213**. This forms a seal that prevents air from leaking into the filter **212** through the trap door **216**, which could decrease the efficiency of the vacuum cleaner **100**. To further help with sealing, the dirt cup **112** might also be equipped to press down on the trap door **216** and filter tray **213** when it is installed, which will help the tray perimeter seal **213'** and door seal **216"** form airtight seals.

**[0042]** Other arrangements for the pre-motor filter may, of course, be used with other embodiments. For instance, the trap door **216** may be installed or mounted in other ways, such as by being provided as a simple removable cover that fits over the filter **212** after it is installed. As another example, the filter tray **213** may include an integral or removable cover to replace the trap door **216**. Such a cover would seal over the top of the filter **212** and provide an enclosed air path from the tray opening **242** to the chamber outlet **240**. In such a case, the filter tray **213** may be held in place by fasteners or by being pressed down by the dirt cup **112** when the cup **112** is installed. Other arrangements for mounting pre-motor filters are known in the art, and may be used with other embodiments of the present invention, as will be appreciated by those of ordinary skill in the art in view of the present disclosure.

**[0043]** The pre-motor filter **212**, filter tray **213**, chamber **214** and/or trapdoor **216** may be equipped with a lockout feature that prevents the vacuum cleaner **100** from operating when the filter **212** is removed. Electrical microswitches that detect the presence of the filter **212** and spring-loaded mechanical locks that prevent insertion of the dirt cup **112** when the filter **212** is absent are examples of such devices. These and other devices are generally known in the art.

**[0044]** Also located on the rear housing **104** is an optional post-motor filter **218** for filtering air that exits the vacuum fan. The post-motor filter **218** may be any suitable type, shape, or performance grade. An exemplary pleated HEPA ("high efficiency particle air") filter is shown. The post-motor filter **218** fits into a post-motor filter recess **220** located, in the exemplary embodiment, towards the bottom of the rear housing **104** and immediately adjacent the vacuum fan outlet **244**.

**[0045]** A post-motor filter cover **222** may be provided to fit over the post-motor filter **218** and hold it in place in the second recess **220**. As shown, the post-motor filter cover **222** may comprise an assembly of multiple parts **222**A, **222**B that are assembled together to provide the required structure and/or aesthetic appearance. Of course, the multiple parts may instead be formed as a single molded or formed part. Furthermore, the cover **222** may be attached to the filter **218**, or formed as part of the filter **218** itself. The post-motor filter cover **222** is held in place at its bottom end by a tab **224** that fits into a corresponding notch **226** located in the second recess **220** (or vice-versa). At its top, the post-motor filter cover **222** is attached to the rear housing by a filter latch **228**. The filter latch **228** compresses the filter cover **222** against the post-motor filter **218** to help seal the post-motor filter **218** against the vacuum fan outlet **244**. This seal helps ensure that air exiting the vacuum cleaner **100** is filtered before exhausting to the atmosphere.

**[0046]** Referring to FIGS. **4** through **7**, the construction and operation of the exemplary filter latch are described in greater detail. As shown in FIG. **4**, the filter latch is located at the bottom of the pre-motor filter recess **214**, but it may located elsewhere. FIG. **5** is a bottom view of the filter latch **228**, FIG. **6** is a cut-away side view of the filter latch as seen along line VI-VI of FIG. **5** and at is appears when installed in the

housing, and FIG. **7** is a partially cut-away isometric front view of the portion of the filter recess **214** at which the filter latch **228** mounts.

**[0047]** As shown in FIGS. **5** and **6**, the filter latch comprises a generally circular device having a handle **502** extended from its perimeter. The handle **502** may, of course, be replaced by any suitable gripping structure. The filter latch **288** has a generally dome-like shape that opens downwardly, and a number of protrusions that extend downward generally within the dome-like structure. The first protrusion is a boss **504** that is used to pivotally mount the filter latch **228** to the housing in the filter recess **214**. As shown in FIGS. **6** and **7**, the housing **214** has a corresponding hole **702** into which the boss fits and, when so installed, a screw **604** is threaded into the bottom of the boss **504** to fix the latch **228** in place. The screw **604** is tightened enough to hold the latch **228**, but does not clamp the latch **228** against the wall of the recess **214**. This can be accomplished by making the boss **504** protrude slightly beyond the thickness of the recess wall, as shown, providing a shoulder on the screw **604**, or by other suitable means. Once installed, the filter latch can pivot back and forth through an arc of travel as shown by the arrow in FIG. **7**. The range of this rotational travel is limited by a pair of protrusions **704** that extend up from the surface of the filter recess **214**.

**[0048]** A latching arm **506** also extends downwardly from the bottom of the filter latch **228**. The latching arm **506** extends through a corresponding slot **706** through the bottom of the filter recess **214**. The slot **706** is generally arcuate in shape and extends far enough to allow the latch arm **506** to move unobstructed as the filter latch **228** is rotated to the limits of its travel. The latch arm **506** is shaped and positioned to engage with a corresponding hook **230** located on the top of the post-motor cover filter **222** (see FIG. **2**). When the filter latch **228** is rotated to its counterclockwise position, the latch arm **506** clears the hook **230**, and allows the post-motor filter cover **222** to be removed from the rear housing **104**. When the filter latch is in its full clockwise position, the latch arm **506** engages the hook **230** and holds the post-motor filter cover **222**, and thus the filter **218**, against the housing **104**. The hook **230** and/or the latch arm **506** may be provided with a cam surface or ramp-like shape that causes the latch arm **506** to apply progressively greater force to pull the hook **230** (and thus the cover **222**) against the housing **104**. The use of this filter latching arrangement allows the user to use relatively little effort to press the post-motor filter **218** into place with a relatively large amount of force. This is an improvement over prior art post-motor filters and filter covers that required the user to exert a relatively great amount of force to lock the filter in place and form a seal between the filter and the vacuum outlet.

**[0049]** The filter latch **228** is also provided with a feature that snaps it into the locked position. In one embodiment, this feature can simply comprise a detent located on the camming surfaces (either the hook **230** or the latch arm **506**). In another exemplary embodiment, shown in FIG. **7**, this feature comprises a third protrusion **508** extending from the bottom of the filter latch **228**, which protrusion **508** is positioned to engage with a corresponding protrusion **708** extending from the bottom of the filter recess **214**. When the filter latch **228** is rotated in the far clockwise position, the cam lock protrusion **508** snaps over filter recess protrusion **708** and holds the filter latch **228** in position. Of course, any other suitable detent or holding device may be used instead.

**[0050]** In the exemplary embodiment, the filter latch **228** is located within the pre-motor filter recess **214**, which is subjected to the negative pressure generated by the vacuum fan when it is operating. In contrast, the latch arm **506** extends through the wall of the recess **214** to an area that is at ambient pressure. Thus, there may be a tendency for air to bleed through the slot **706** or the hole **702** from the atmosphere into the post-motor filter chamber **214** vacuum, and thence into the vacuum fan. Such an air leak might reduce the efficiency of the vacuum cleaner **100**. To counteract such air bleeding, the filter latch is provided with an annular facing seal **602** that is arranged to surround both the screw boss **504** and the latch arm **506**. The seal **602** engages a corresponding cylindrical wall **710** that extends slightly upwards from the filter recess **214** and helps prevent air from passing through the boss hole **702** and latch arm slot **706**. Of course, other seal arrangements may be used instead, and the seal **602** may be omitted if the filter latch **228** is positioned to be at a location where air bleeding is not an issue, such as on the exterior of the housing **104**.

**[0051]** Referring back to FIG. **2**, the rear housing **104** also includes, at its lower end, various features to allow it to be mounted to the base **102**. For example, the rear housing **104** may include a cylindrical mounting boss **236** that pivotally engages a corresponding structure on the base **102**. While a conventional mounting arrangement may be used in some embodiments, the present disclosure also provides an example of a novel pivoting mounting arrangement that may be used with the boss **236** subsequently herein. Located radially outward form the mounting boss **236** are a first protrusion **232** and a second protrusion **234**. The protrusions **232**, **234** are positioned to engage the protrusion **1436** of a corresponding handle release mechanism **1434** (FIG. **14**) to lock the rear housing **104** in a full upright position and a reclined position relative to the base **102**, as generally known in the art or described elsewhere herein.

**[0052]** Referring now to FIGS. **8** and **9** an embodiment of one dirt separation system that may be used with the vacuum cleaner of the present invention is described in detail. In the shown embodiment, the dirt separation system comprises a cyclonic separator having a removable dust bin located below it. As noted before, other types of cyclone separators, multi-stage cyclone separators, water filtration separators, wet extractor recovery tanks, dust collection filtration bags, and the like, may be used. The exemplary cyclone separation system comprises a cyclone chamber **802** having an inlet **804** that can be connected to one or more suction inlets on the vacuum cleaner **100**. The inlet **804** extends into the cyclone chamber by way of a helical ramp **806**, which induces a downward motion to the incoming air and, because the inlet **804** enters the cyclone chamber **802** in a tangential manner, also induces a swirling motion in the airflow. Alternatively, the inlet may be perpendicular to the cyclone chamber **802**, in which case it may be desirable to include an airflow diverting structure to initiate cyclonic airflow motion within the cyclone chamber **802**. A gasket **824** may be provided at the bottom of the cyclone chamber to seal against the top of the dirt cup **112**.

**[0053]** As shown by the arrows in FIG. **9**, the air enters the cyclone chamber and begins a cyclonic motion therein. Located below the cyclone chamber is the dirt cup **112**. As the air circulates within the cyclone chamber **802** and the dirt cup **112**, dirt and other entrained solids fall out of the airstream and are deposited in the dust collection chamber **112**. The air

then circulates up and around a cyclone filter **816** which is mounted over the cyclone outlet **808**. As shown, the cyclone filter **816** comprises a perforated shroud **816'** having a disk-like plate **816"** attached to its bottom end. The plate **816"** helps prevent particles and objects from rising up and covering or entering the shroud **816'**. It will be appreciated that the disk-like shroud may be removed or modified in other embodiments, and the filter itself may be shaped in a non-cylindrical shape or may be replaced with other devices such a pleated filter or the like. Such variations will be understood by persons of ordinary skill in the art.

**[0054]** After passing through the cyclone outlet **808**, the air passes through a first outlet tube **810**, a second outlet tube **812**, and a third outlet tube **814**. These separate outlet tubes are connected to one another by respective gaskets **818**, **820**, and **822** to help prevent air from leaking into the working airflow at the tube junctions. In a preferred embodiment the third outlet tube **814** is positioned in the dirt cup opening **210**, and can be removed by the user if it becomes clogged. To help assess whether a clog exists, the third tube **814** also may be made from a transparent material. It will be understood that the foregoing arrangement of three tubes is exemplary, and the multiple outlet tube shown herein may be consolidated into a single tube, into two tubes or into various other numbers of tubes.

**[0055]** As best shown in FIG. **9**, the third outlet tube **814** is fluidly connected with the recess **214** into which the pre-motor filter **212** is installed, and the airflow passes from the third tube **814**, through the pre-motor filter chamber inlet **238**, and then through the pre-motor filter **212**. Next, the airflow enters through the vacuum fan **902**, and exhausts through the post-motor filter **218** to the atmosphere.

**[0056]** Referring now to FIGS. **10-12** an exemplary embodiment of a dirt cup **112** is described in detail. As shown in FIG. **10**, the dirt cup **112** has a generally cup-like structure to which a handle **1002** is attached to facilitate removing and carrying the dirt cup **112**. If desired, the handle **1002** also may be suitable for lifting the entire vacuum cleaner **100**. In the exemplary embodiment, the handle **1002** is provided as a separate part that is attached to a corresponding opening **1004** located at the front of the dirt cup **112** by ultrasonic bonding, adhesives, or the like. Of course, the handle **1002** may be omitted or modified in other ways, if desired.

**[0057]** The exemplary dirt cup **112** also includes an elevator lock system **1006**. The elevator lock **1006** includes a cam plate **1008** that is rotatably mounted to the bottom of the dirt cup **112** by a cap **1010**. The cap **1010** is affixed to the bottom of the cup **112** by a screw **1014**. When assembled, the cap **1010** passes through a hole **1012** through the center of the cam plate **1008**, and is shaped and sized such that it holds as a cam plate **1008** close to the dirt cup **112**, but allows the cam plate **1008** to rotate through an arc of travel. A knob **1024** or other gripping surface is provided on the cam plate **1008** to facilitate its rotation. The knob **1024** is positioned in a slot **1022** on the lower end of the dirt cup **112** to limit the cam plate's range of movement, but other blocking members may be used to control the cam plate's range of movement, if desired. Such other mechanisms will be readily appreciated by persons of ordinary skill in the art in view of the present disclosure.

**[0058]** The cap **1010** is also shaped and sized to allow the cam plate **1008** to move vertically with respect to the bottom of the dirt cup **112**. A spring **1015** may be positioned between the cap **1010** and the cam plate **1008** to bias the cam plate **1008** upwards towards the dirt cup **1012**.

**[0059]** The exemplary cam plate **1008** has one or more ramp-like cam surfaces **1016** on its upper surface. These cam surfaces **1016** are arranged in a pattern around the circumference of the cam plate **1008** and positioned to engage corresponding protrusions **1102** extending from the bottom of the dirt cup **112**, as best shown in FIG. **11**. As the cam plate **1008** is rotated, the cam surfaces **1016** engage the protrusions **1102** to move the cam plate **1008** away from the bottom of the dirt cup **112**. The operation of the cam plate **1008** is illustrated in FIGS. **13**A through **13**C. In these three figures, the cam plate and the protrusions extending from the bottom of the dirt cup **112** are shown in a panoramic view—that is, they are shown as they would appear to a person viewing them from the center of the cam plate **1008**. FIG. **13**A depicts the cam plate **1008** when it is arranged with the cam surfaces **1016** disengaged from the protrusions **1102**, in which case the cam plate **1008** is biased towards the dirt cup **112** by the spring **1015**, and the overall height of the dirt cup **112** and cam plate **1008** assembly is at a minimum. In this position, the dirt cup **112** can be freely removed from or inserted into the opening **210** (FIG. **2**). Turning to FIG. **13**B, once the dirt cup and elevator lock are inserted into the opening **210**, the cam plate **1008** is rotated, and the cam surfaces **1016** begin to engage the protrusions **1102** to move the cam plate **1008** away from the dirt cup **112**. If desired, the cam surfaces **1016** and/or protrusions **1102** may be provided with detents or matching surfaces **1302**, **1304** that allow the cam plate **1008** to remain in a partially-extended position. As shown in FIG. **13**C, when the cam plate **1008** is fully rotated, it continues to move away from the dirt cup **112** until it reaches its fully rotated position, as shown. In this position, the overall height of the dirt cup **112** and cam plate **1008** assembly is maximized, and the dirt cup **112** is pressed against the gasket **824** (FIG. **8**) to seal it to the cyclone chamber **802**. In addition, if a trap door **216** is used to contain a pre-motor filter **212**, the dirt cup **112** and cam plate **1008** also may press down on the trap door **116** to help seal the airflow passing through the pre-motor filter **212**.

**[0060]** Locking features may be provided to hold the cam plate **1008** in one or both of the retraced (FIG. **13**A) or extended (FIG. **13**C) positions. Resilient tabs, detents, or other devices may be used for this purpose. In the exemplary embodiment, the cam plate **1008** includes a resilient tab **1018** that extending from its upper surface, and the dirt cup **112** has two additional protrusions **1104**, **1106** extending down from it. As shown in FIGS. **13**A and **13**C, the resilient tab **1018** engages one protrusion **1106** when the cam plate **1008** is in the fully retracted position, and the other protrusion **1104** when it is in the fully extended position. Of course, one or both of these locking features may be removed or modified in other embodiments.

**[0061]** It will be understood that the drawings of FIGS. **13**A through **13**C are schematic representations of the operation of the device. In this exemplary representation, the protrusions **1102**, **1104**, **1106** are shown in a serial arrangement, as are the cam surfaces **1016** and resilient tab **1018**. In alternative embodiments, such as the one shown in FIGS. **10** through **12**, the cam surfaces, resilient tab, and/or the protrusions may be arranged around different circumferential radii of the cam plate. For example, it can be seen in the embodiment of FIG. **10** that the cam surfaces **1016** are located closer to the central rotating axis of the cam plate **1008**, whereas the resilient tab **1018** is located further from the cam plate **1008** axis. Thus, the cam plates, resilient tab, and protrusions can be arranged either around the same circumferential radius in a serial pat-

tern, or may be arranged at various locations around the cam plate **1008** and dirt cup **112**. it will also be appreciated that the rotating cam plate **1008** may be replaced by a linearly-actuated cam, or other cup elevating and locking devices, and such devices may be mounted on the dirt cup **112**, as shown, or on the rear housing **104**.

**[0062]** Referring now to FIG. **14**, an embodiment of a base **102** that may be used with the present invention is described. The exemplary base **102** comprises a lower base frame **1402** to which an upper base frame **1404** is removably attached. When attached, the lower and upper base frames **1402**, **1404** form an enclosure that retains and supports the working parts of the base **102**. It will be understood that any suitable alternative construction for the base may be used in other embodiments.

**[0063]** As previously noted, a pair of wheels **106** support the base **102** for movement over the ground. While conventional wheels may be used in various embodiments, the wheels **106** in the shown exemplary embodiment comprise hard plastic hubs **106'** having resilient coatings **106"**. The resilient coatings **106"** may comprise a urethane coating having a hardness of about 78 A to 82 A, which is expected to provide suitable low-slip contact with typical household surfaces and help absorb shocks that might be transmitted to the user during use. It is also desirable, but not required, for the wheels **106** to have a minimum diameter of about 72 millimeters, and more preferably of about 95 millimeters. Both wheels sizes, but the latter diameter in particular, are believed to be suitable for use with upright vacuum cleaners to help the vacuum cleaner roll over common household obstacles. The wheels **106** are mounted to conventional stub axles or to a solid wheel axle **1406** by respective sets of two bearings **1408**, and retained by a threaded fastener, a push nut **1410** or other known devices. A washer **1412** may be provided inboard of each of the wheels **106** to limit their movement and prevent interference with the base frames **1402**, **1404**. The exemplary washers **1412** slide over the axle **1406** or stub axles, and engage protrusions **1414** that limit the movement of the washers and wheels towards the center of the base **102**. A hubcap **1416** may be provided to cover the push nut **1410**, bearings **1408**, and axle **1406**.

**[0064]** In the illustrated exemplary embodiment, the wheel axle **1406** comprises a rod that extends wholly or partially across the width of the base. Both wheels **106** are mounted to the axle. The axle **1406** is bent along its length to form a generally U-shaped structure. It has been found that this construction allows the rear housing (not shown in FIG. **14**) to pivot downwardly and rearwardly with respect to the base **102** further than would be possible if the axle **1406** extended straight between the two wheels **106**. Referring to FIG. **15**, one embodiment of how the bent axle **1406** can be attached to be base frame **1402** is shown. Here, the bent axle **1406** is fitted into a groove that extends along the width of the lower base frame **1402**. The axle **1406** may be retained by snap fitment or additional fasteners. For example, as shown a retaining plate **1418** is provided at each end of the axle **1406**, and each retaining plate **1418** is attached to the lower base frame **1402** by a pair of screws **1420**. When assembled, the retaining plates **1418** capture the axle **1406** in place against the lower base frame **1402**. Of course, the axle **1406** may be attached to the upper base frame **1404** and/or other parts of the base, if desired, and other variations may be made to the foregoing exemplary embodiment.

**[0065]** It has been found that using a bent, full-width axle (that is, an axle having a bent portion to accommodate the rear housing movement and to which both wheels are attached) provides an advantage over conventional stub axles that are used to mount wheels to vacuum cleaner bases. In particular, the bent axle allows the rear housing to be made both wider and with less plastic material because it is no longer necessary to provide a large boss into which to mount the stub axle. Such large bosses were required in the prior art because the stub axles were mounted in a cantilevered arrangement into the sides of the base, and loads applied to the wheels, particularly impact loads, applied a high bending moment to the stub axles that would cause them to pull out of the housing if there was insufficient support. With a bent, full-width axle, the bending moments are absorbed by the axle material, rather than the base material, and the vacuum cleaner may have improved dimensional tolerances and stability.

**[0066]** Referring back to FIG. **14**, the base may also be provided with an adjustable height wheel carriage **1422**. The wheel carriage **1422** is provided on the bottom of the lower base frame **1402**, and mounted by pivots **1424**. The wheel carriage **1422** has a pair of front wheels **1426**, that support the front of the base **102**. The wheel carriage **1422** can be adjusted to raise and lower the height of the base **102** relative to the ground to accommodate vacuuming over different types of surface, as known in the art. For example, it may be desirable to raise the base **102** when vacuuming over long-pile carpets, and lower the base **102** when vacuuming over relatively short-pile carpets or uncarpeted floors. In the shown embodiment, this height adjustment is accomplished by using a rotating cam **1428** that engages a protrusion **1430** that extends from the upper surface of the wheel carriage. Such rotating cam height adjustment mechanisms are well known in the art, and this or other types of height adjusting mechanisms may be used interchangeably.

**[0067]** The wheel carriage **1422** also may have with additional protrusions **1432** that engage the rear housing **104** when the rear housing **104** is raised to the full upright position. When the rear housing **104** is fully raised, surfaces on the rear housing **104** press against the protrusions **1432**, thereby pressing down and lowering the wheel carriage **1422**. This is particularly useful in so-called single-motor vacuum cleaner designs in which the vacuum fan motor located in the rear housing directly drives a brushroll in the base by way of a belt. When the protrusions **1432** are pressed down to lower the carriage **1422** and raise the base **102**, it prevents the brushroll from abrading the carpet when the vacuum cleaner is operated while it is upright. In other embodiments, other devices, such as a belt clutch, may be used to prevent the brushroll from damaging the carpet or floor when the vacuum is tilted to the upright position. Such alternatives are known in the art.

**[0068]** The exemplary base **102** also includes a brushroll chamber **1433** located at the front of the base **102** and formed, in the shown embodiment, by the assembled lower and upper base frames **1402**, **1404**. The brushroll chamber **1433** is open towards the bottom of the base **102** through a brushroll slot, as known in the art, and is fluidly connected to the vacuum source by way of a connecting hose **1434** that extends out the back of the brushroll chamber **1433**. A brushroll, such as those described subsequently herein or others, is rotatably mounted in the brushroll chamber **1433** and driven by a motor shaft (not shown) extending through the rear housing **104** by way of a belt (not shown). If desired, the upper and/or lower housing **1404**, **1402** may include one or more windows **1450**

through which the brushroll may be viewed during operation, and such windows may be provided with a light to help see the brushroll. In the shown exemplary embodiment, the windows **1450** are provided at or near the ends of the brushroll chamber **1433**, but such windows **1450** may be located elsewhere. Such windows **1450** may be constructed in various ways, such as by being pre-molded and inserted into the mold for the upper base frame to have the upper base frame **1404** molded around the windows **1450** to lock them in place.

**[0069]** Still referring to FIG. **14**, the base **102** may also have a handle release mechanism **1434**. The handle release mechanism **1434** is pivotally mounted to the base **102**, and includes a protrusion **1346** that extends from the mechanism **1434** to engage corresponding locking protrusions on the rear housing **104**, such as the first and second protrusions **232**, **234** shown on the exemplary rear housing in FIG. **2**. In the shown embodiment, the handle release mechanism **1434** is pivotally mounted on one side of the base **102** by a pivot pin **1437**, and a return spring **1438** is provided to bias the handle release mechanism **1434** into the engaged position. This or other handle release mechanisms may be used in embodiments of the invention.

**[0070]** The lower base frame **1402** also comprises structures to pivotally mount the rear housing. In the shown exemplary embodiment, these mounting structures comprise a conventional retainer strap **1440**, which mounts to a cylindrical boss located on one side of the rear housing **104**. At the other side, the rear housing **102** is attached to the lower base frame **1402** by a mounting plate **1442**. The mounting plate **1442** comprises a base plate **1444** that is mounted to the lower base frame **1402** by screws **1446**, and an upwardly extending structure that has a collar **1448** extending from it. The collar **1448** fits over the cylindrical boss **236** that extends from the side of the rear housing **102**, as seen in FIG. **2**. An embodiment of this construction is described in more detail subsequently herein.

**[0071]** Turning now to FIGS. **16** and **17**, two embodiments of brushrolls **1600** are shown. The first embodiment, shown in FIG. **16**, comprises an elongated shaft **1602** to which bristles (not shown) are attached. An example of a typical bristle pattern is to have two helical rows of bristles extending at approximately right angles from the shaft **1602**, but other patterns may be used. In the embodiment of FIG. **16**, edge cleaning bristles **1614** are mounted to each end of the shaft **1602**. The edge cleaning bristles **1614** are arranged in a radial pattern around the shaft **1602**, and extend away from the pulley **1604** at angles of about 45 to 80 degrees relative to the longitudinal axis of the shaft **1602**. These bristles **1614** are oriented to clean at or near the ends of the brushroll. The edge cleaning bristles **1614** may also be mounted on a beveled end portion **1616** of the shaft **1602**, which may facilitate inserting the bristles and promote improved wear or cleaning performance.

**[0072]** The shaft **1602** may be driven by one or both ends, or may be driven at some point between its ends by a belt (not shown). When a belt is used to drive the shaft **1602**, the shaft **1602** preferably includes a pulley to receive and be driven by the belt. In some embodiments, the pulley can be integrally formed with the shaft, but in the exemplary embodiments, a pulley **1604** is provided as a separate part that fits over the shaft **1602**. In one such embodiment, the pulley **1604** has a generally circular outer pulley surface **1604'** that is adapted to engage a drive belt or gear, and a central opening **1604"** passing through the pulley **1604**. In the shown embodiment, the pulley surface **1604'** has a crowned profile suitable for use with flat belts, ribbed belts ("poly-V" belts) and possibly cogged belts, but other surfaces may be used, such as a helical or straight gear tooth surface.

**[0073]** The pulley **1604** can be placed over the shaft **1602** in a number of ways. For example, the pulley **1604** can be made from two semi-circular parts that are placed around the shaft **1602** and attached to one another by snap fitment, fasteners, adhesives, or other mechanisms. In the shown exemplary embodiment, the pulley **1604** is provided as a ring-shaped cast plastic or metal part and the shaft **1602** is molded directly into the pulley **1604**. In this embodiment, the pulley **1604** is captured in place at a portion of the shaft **1602** having a reduced cross-section **1602'**. The pulley **1604** may include ribs **1604'"** or a non-circular profile that fits over corresponding slots **1602"** or non-circular profile on the reduced cross-section portion **1602'** of the shaft to prevent the pulley **1604** from rotating on the shaft **1602**. Alternatively, ribs and slots may be located on the opposite structure. As other alternatives, or the pulley **1604** may be rotationally fixed to the shaft **1602** by friction, bonding with the shaft, mechanical fasteners, welding, axially-extending protrusions, replacing the single opening **1604"** with multiple separate openings, or by other mechanism and means.

**[0074]** An example of a process that may be used to accomplish this is a two-part molding process in which the pulley **1604** is molded separately, then placed into an empty brushroll mold, after which the brushroll material is injected in to the brushroll mold to conform to the pulley **1604**. Using this process, the pulley **1604** can be captured in place on the brushroll by a portion of the brushroll that is formed as a continuous single structure—that is, a portion of the brushroll that does not have to be assembled from multiple parts to capture the pulley in place. The resulting brushroll has a pulley **1604** that is structurally interlocked with the shaft **1602**, at least with respect to axial movement, and no fasteners are needed to position the pulley **1604** on the shaft **1602**. In addition, although no fasteners may be needed to interlock the pulley **1604** with the shaft **1602**, a fastener (such as a pin or screw) may be inserted to pass through the pulley **1604** and shaft **1602** to help prevent the pulley **1604** from rotating on the shaft **1602**. This latter embodiment would be useful if the pulley **1604** and/or shaft **1602** is provided without ribs or another non-circular profile. Of course, in this or other embodiments, other additional parts may be added to the brushroll or pulley after the molding process. While the foregoing embodiments illustrate the pulley **1604** as being a continuous surface that extends entirely around the shaft **1602**, this is not strictly required, and one or more slots or grooves may be formed in the pulley **1604** to allow for stress relief or thermal expansion or contraction, or for other reasons. Such slots or grooves may extend all the way to the central opening **1604"**.

**[0075]** This two-part pulley and shaft brushroll construction can provide several advantages. For example, in many instances a brushroll is provided with felt seals on either side of the pulley and belt to prevent dirt and debris from becoming entrapped between the belt and the pulley. The use of such seals is helpful to prevent the inclusion of dirt, but the felt seals often rub against the pulley surface and generate heat by friction. As such, the pulley must be manufactured from a material that can withstand this heat without becoming damaged during use, such as a material with a relatively high melting point. Such materials may be relatively expensive. As

such, the present construction allows the pulley **1604** to be made out of a relatively expensive heat-resistant material but allows the shaft **1602** to be made out of a relatively inexpensive material that may have all of the proper properties for use as a brushroll but may have a relatively low melting point (e.g., lower than the melting point of the pulley) or otherwise be unsuitable to withstand the temperature created by the friction between the felt seals and the pulley.

**[0076]** Another example of how this construction may be advantageous is shown in the embodiment of FIG. **17**. Here it is shown that the pulley **1702** is provided as a toothed gear pulley **1702**. Such as gear pulley **1702** might, like the previous embodiment, require high temperature resistance because it may rub against felt seals during use. In addition, the gear pulley **1702** may need to made from a relatively strong material to withstand driving forces. As with the prior embodiment, the gear pulley **1702** may be constructed from a relatively expensive material that has the thermal and strength properties required for its use, but the pulley shaft **1704** may be constructed out of a relatively less expensive material that may not satisfy the strength and temperature requirements required at the location of the pulley. Furthermore, even if there is no requirement from a heat resistance or strength standpoint to form the pulley **1702** separately from the shaft **1704**, it may still be economical to form the gear pulley **1702** separately in a higher-precision molding process to ensure that the teeth are properly dimensioned to receive the corresponding toothed drive belt.

**[0077]** The brushroll **1600** may be mounted to the base in any suitable way. In the shown exemplary embodiments, the brushroll **1600** is mounted by a bearing **1606** at each end of the shaft **1602**. Each bearing **1606** is mounted on a end cap **1608** by a pin **1609** that fits in the inner race of the bearing **1606**. The end caps **1608** fit within correspondingly-shaped slots on either side of the brushroll chamber **1432**, as known in the art. The outer races of the bearings **1606** are mounted to the brushroll shaft **1602** by cups **1610**, which are inserted to hollow ends of the shaft **1602** and staked in place by pins **1612**. A felt seal **1611** and/or other seals may be provided between each end cap **1608** and the brushroll shaft **1602** to help prevent dirt and other contaminants from contacting the bearings **1606**.

**[0078]** Referring to FIG. **18**, an embodiment of another base **1802** is provided. The base **1802** includes a separate brushroll motor **1804** that can be used to drive a brushroll independently of the operation of the vacuum motor. Such vacuum cleaner constructions are typically referred to as two-motor vacuum cleaners. The brushroll motor **1804** is operated by the main power supply or an alternative energy source, and may have a motor switch **1806** that turns the brushroll motor **1804** off when the rear housing is raised to the upright position. Such a switch **1806** may be provided adjacent the mounting plate **1442** and be operated by a protrusion **1808** that extends from the rear housing. A reset button **1810** also may be provided in the power circuit to the brushroll motor **1804** to operate as a circuit breaker should the brushroll motor **1804** become locked or overheat during use. In addition, a motor indictor light **1812** may be provided to indicate the status of the brushroll motor **1804** to the operator. The exemplary motor indicating light **1812** is visible through an opening **1814** through the upper base frame **1404**. Suitable reset buttons **1810**, motor switches **1806**, and motor indicator lights **1812** are generally known in the art.

**[0079]** The exemplary base **1802** is also illustrated having an alternative mounting structure for the rear housing **102**. As shown in FIGS. **18** and **19**, one side of the rear housing **1902** (FIG. **19**) is mounted by a mounting plate **1442**, such as the one described previously herein, or by a conventional strap or clip. The other side of the rear housing **1902** is mounted by a mounting cap **1816**. The mounting cap **1816** has a cylindrical body **1816'** and a pair of integrally-formed screw bosses **1816"**. The cylindrical body **1816'** fits into a corresponding opening **1820** on the base **1802**, and the two bosses **1816"** attach at corresponding mounting posts **1822** on the base **1802**. The mounting cap **1816** pivotally mounts the rear housing **1902** to the base **1802**, and provides a passage **1906** for electrical wires, vacuum hoses, and/or other devices extending from the rear housing **1902** to the base **1802**. In the shown exemplary embodiment, the mounting cap **1816** provides a conduit for a vacuum hose (not shown) extending between the brushroll motor **1804** and the vacuum fan **1904**. This vacuum hose conveys motor dust, such as carbon dust and other debris that may be generated by the motor, into the vacuum fan to be cleaned from the air stream. To facilitate the operation of such a vacuum hose, the motor **1804** may be covered by a separate motor cover **1818** that seals the motor **1804** except for ventilation slots located through the cover. This helps direct the airflow across the motor and into the vacuum hose so that it may be passed through one or more of the vacuum cleaner filters to be cleaned before being exited to the ambient air. In addition, electrical cables or wires for the brushroll motor **1804** or other devices in the base **1802** may be passed through the mounting cap passage **1906**. The use of the mounting cap **1816** with a passage through it helps direct wires, hoses, and other flexible elements (such as extractor fluid supply lines) from the rear housing **1902** to the base **1802** in an efficient and safe manner.

**[0080]** The manner in which the exemplary mounting plate **1442** mounts the rear housing **1902** to the base **1802** is also shown in FIG. **19**. Here it is shown that the mounting plate **1442** includes a collar **1448** that extends axially into the side of the rear housing **1902** by a distance X, and slips over a corresponding mounting boss **1908** that is recessed into the side of the rear housing **1902** to pivotally mount the rear housing **1902**. This construction is facilitated by offsetting the mounting collar base plate **1444**, and thus the mounting screws **1446**, axially (distance Y) from the collar **1448**. In contrast, conventional mounting straps locate the mounting screws in the same plane as the strap, and this construction typically requires the entire rear housing mounting boss to extend from the side of the rear housing to allow access to the screw or screws that are used to secure the mounting strap. In addition, the base plate **1444** and mounting screws **1446** may be radially offset (distance R) from the collar **1448**, which allows the width of the base to be reduced at the location of the mounting boss **1908**. This feature allows the base to be provided with a more streamlined appearance, may allow the rear housing **1902** to be made wider relative to the base **1802**, and may contribute to weight savings.

**[0081]** The present disclosure describes a number of new, useful and nonobvious features and/or combinations of features that may be used alone, with upright vacuum cleaners, canister vacuum cleaners or other types of cleaning device, or in other ways. The embodiments described herein are all exemplary, and are not intended to limit the scope of the inventions in any way. It will be appreciated that the inventions described herein can be modified and adapted to differ-

ent uses, and all such modifications and adaptations are included in the scope of this disclosure.

We claim:

**1**. A vacuum cleaner brushroll comprising:

a pulley comprising a generally circular pulley surface surrounding at least one opening located radially inward of the pulley surface; and

an elongated shaft passing through the central opening;

wherein the pulley surrounds and is captured in place by a mounting portion of the elongated shaft that comprises a continuous single structure.

**2**. The vacuum cleaner brushroll of claim **1**, wherein the pulley comprises a material having a relatively high melting point, and the mounting portion comprises a material having a relatively low melting point.

**3**. The vacuum cleaner brushroll of claim **1**, wherein the at least one opening comprises radially-extending ribs that extend into corresponding slots in the mounting portion.

**4**. The vacuum cleaner brushroll of claim **1**, wherein the at least one opening comprises a plurality of openings.

**5**. The vacuum cleaner brushroll of claim **1**, wherein the at least one opening comprises a non-circular profile.

**6**. The vacuum cleaner brushroll of claim **1**, wherein the pulley surface comprises a crowned surface adapted to receive a flat belt or a ribbed belt.

**7**. The vacuum cleaner brushroll of claim **1**, wherein the pulley surface comprises a plurality of teeth that are adapted to receive a cogged belt.

**8**. The vacuum cleaner brushroll of claim **1**, wherein the pulley surface comprises a continuous surface that extends entirely around the elongated shaft.

**9**. A vacuum cleaner brushroll comprising:

a pulley comprising a generally circular pulley surface surrounding at least one opening located radially inward of the pulley surface; and

an elongated shaft passing through the at least one central opening;

wherein a mounting portion of the elongated shaft located within and on either side of the central opening comprises a continuous structure having a reduced cross section into which the pulley fits.

**10**. The vacuum cleaner brushroll of claim **9**, wherein the pulley comprises a material having a relatively high melting point, and the mounting portion comprises a material having a relatively low melting point.

**11**. The vacuum cleaner brushroll of claim **9**, wherein the at least one opening comprises radially-extending ribs that extend into corresponding slots in the mounting portion.

**12**. The vacuum cleaner brushroll of claim **9**, further comprising:

an opening located at a first end of the elongated shaft;

a bearing cup that at least partially fits within the opening;

a bearing that at least partially fits within the opening; and

one or more pins at least partially positioned within the opening and between the opening and an outer surface of the bearing cup to thereby hold the bearing cup in the opening.

**13**. The vacuum cleaner brushroll of claim **9**, further comprising a plurality of edge cleaning bristles protruding from the elongated shaft and away from the pulley at an angle of about 45 degrees to 80 degrees relative to the central axis of the elongated shaft.

**14**. The vacuum cleaner brushroll of claim **13**, wherein the edge cleaning brushrolls protrude from a beveled end portion of the elongated shaft.

**15**. The vacuum cleaner brushroll of claim **9**, wherein the pulley surface comprises a crowned surface adapted to receive a flat belt or a ribbed belt.

**16**. The vacuum cleaner brushroll of claim **9**, wherein the pulley surface comprises a plurality of teeth that are adapted to receive a cogged belt.

**17**. The vacuum cleaner brushroll of claim **9**, wherein the pulley surface comprises a continuous surface that extends entirely around the elongated shaft.

**18**. A vacuum cleaner brushroll manufactured by a process comprising:

forming a pulley having a generally circular pulley surface and at least one opening located radially inward of the pulley surface;

forming an elongated shaft from a continuous piece of material that passes through the at least one opening and at least partially surrounds the pulley to structurally interlock the pulley in place on the elongated shaft.

**19**. The vacuum cleaner brushroll manufactured by the process of claim **18**, wherein the pulley comprises a material having a relatively high melting point, and the elongated shaft comprises a material having a relatively low melting point.

**20**. The vacuum cleaner brushroll manufactured by the process of claim **18**, further comprising forming radially-extending ribs in the at least one opening.

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