US007867307B2

(12) **United States Patent**
Bates et al.

(10) **Patent No.: US 7,867,307 B2**
(45) **Date of Patent: Jan. 11, 2011**

(54) **CYCLONIC SEPARATING APPARATUS FOR A CLEANING APPLIANCE**

(75) Inventors: **Adam James Bates**, Malmesbury (GB); **Timothy Nicholas Stickney**, Malmesbury (GB)

(73) Assignee: **Dyson Technology Limited**, Wiltshire (GB)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 261 days.

(21) Appl. No.: **12/243,484**

(22) Filed: **Oct. 1, 2008**

(65) **Prior Publication Data**

US 2009/0100633 A1 Apr. 23, 2009

(30) **Foreign Application Priority Data**

Oct. 18, 2007 (GB) 0720341.7

(51) **Int. Cl.**
B01D 45/12 (2006.01)

(52) **U.S. Cl.** **55/343**; 55/349; 55/429; 55/433; 55/DIG. 3

(58) **Field of Classification Search** ..... 55/343, 55/346, 349, 429, 432, 433, 459.1, DIG. 3
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,486,618	A		12/1969	Wikdahl
4,687,497	A		8/1987	Owen et al.
5,000,767	A	*	3/1991	Sanders et al. 55/302
6,607,572	B2	*	8/2003	Gammack et al. 55/343
6,835,222	B2		12/2004	Gammack

FOREIGN PATENT DOCUMENTS

GB	2 386 827	A	10/2003
GB	2 441 300	A	3/2008
JP	2002-326041		11/2002
JP	2003-156002		5/2003
JP	2003-528704		9/2003
JP	2004-229827		8/2004
KR	10-2007-0012988		1/2007
WO	WO-02/067742	A2	9/2002

OTHER PUBLICATIONS

GB Search Report, dated Feb. 12, 2008, directed to corresponding GB Patent Application No. GB0720341.7; 1 page.
International Search Report and Written Opinion mailed on Jan. 5, 2009, directed to counterpart International Patent Application No. PCT/GB2008/003376; 14 pages.

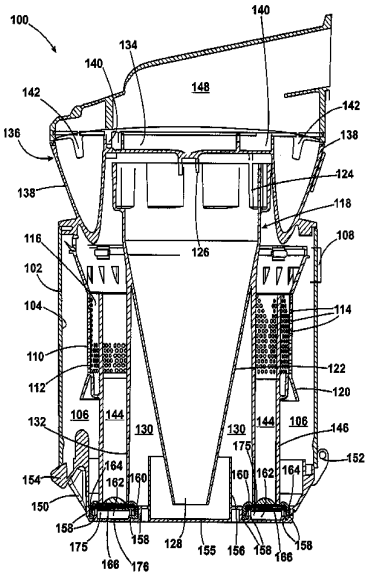
* cited by examiner

Primary Examiner—Robert A Hopkins
(74) *Attorney, Agent, or Firm*—Morrison & Foerster LLP

(57) **ABSTRACT**

A cyclonic separating apparatus for a cleaning appliance includes a plurality of cyclonic separators arranged in series for separating particles from a dirt- and dust-laden airflow, at least two or three collectors for collecting separated dirt and dust, and a closure member movable between a closed position in which the closure member closes an end of each collector and an open position in which separated dirt and dust can be emptied from the collectors. The ends of the collectors are separated by dividing walls. A expandable seal is provided between the closure member and the dividing walls to seal when the closure member is in the closed position. The expandable seal is able to seal effectively even if the closure member is misaligned, incorrectly fitted or if dirt and dust is present between the surfaces to be sealed.

15 Claims, 6 Drawing Sheets



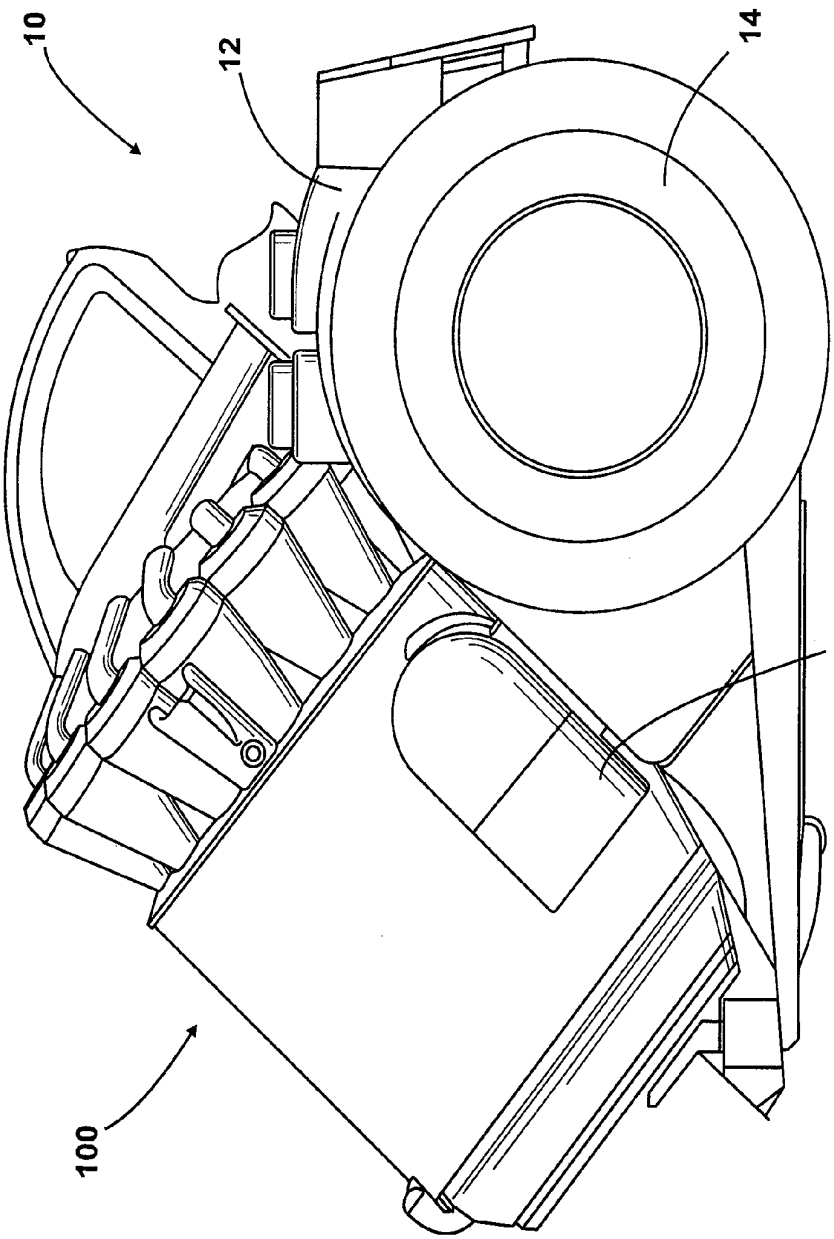


Fig. 1

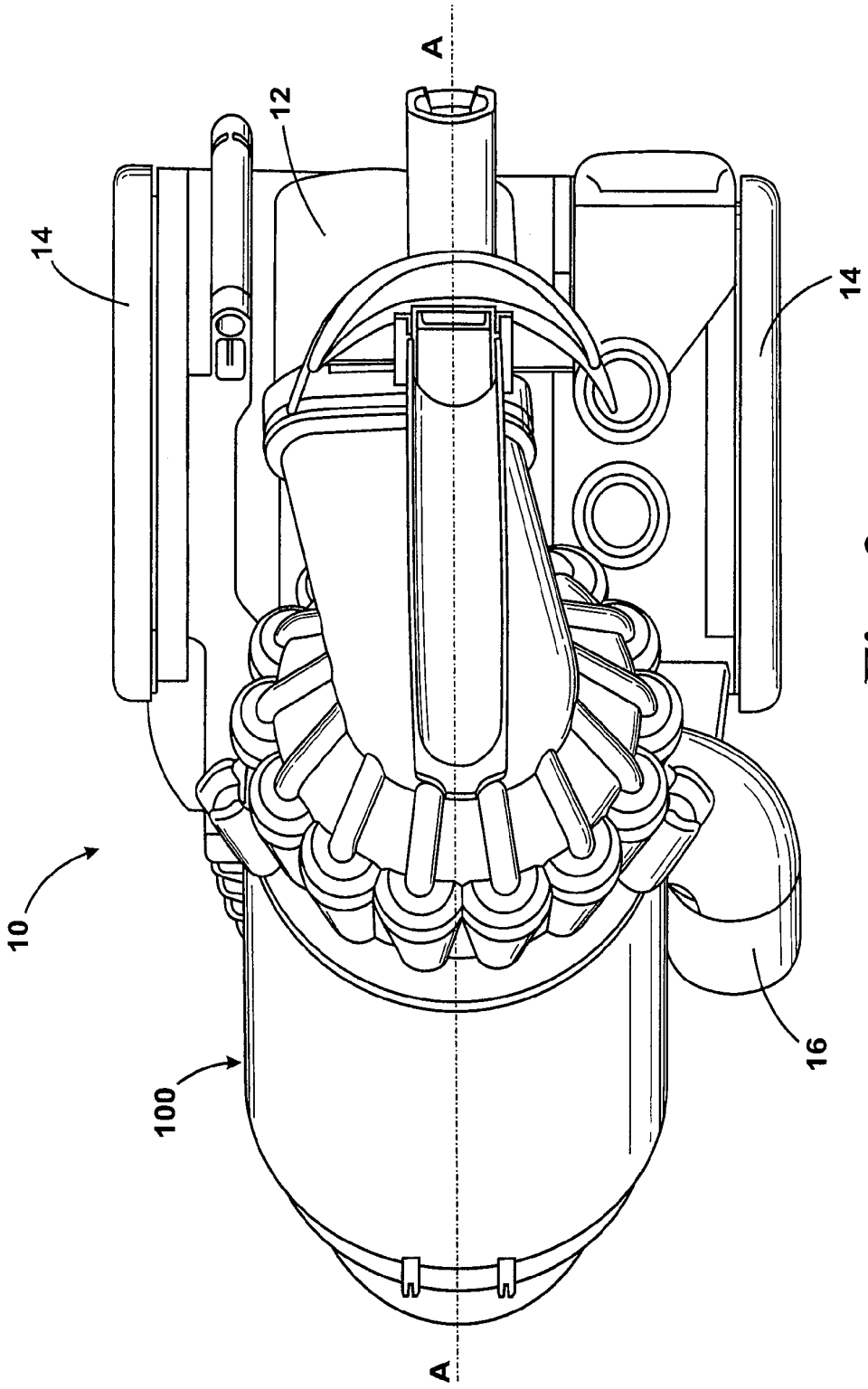


Fig. 2

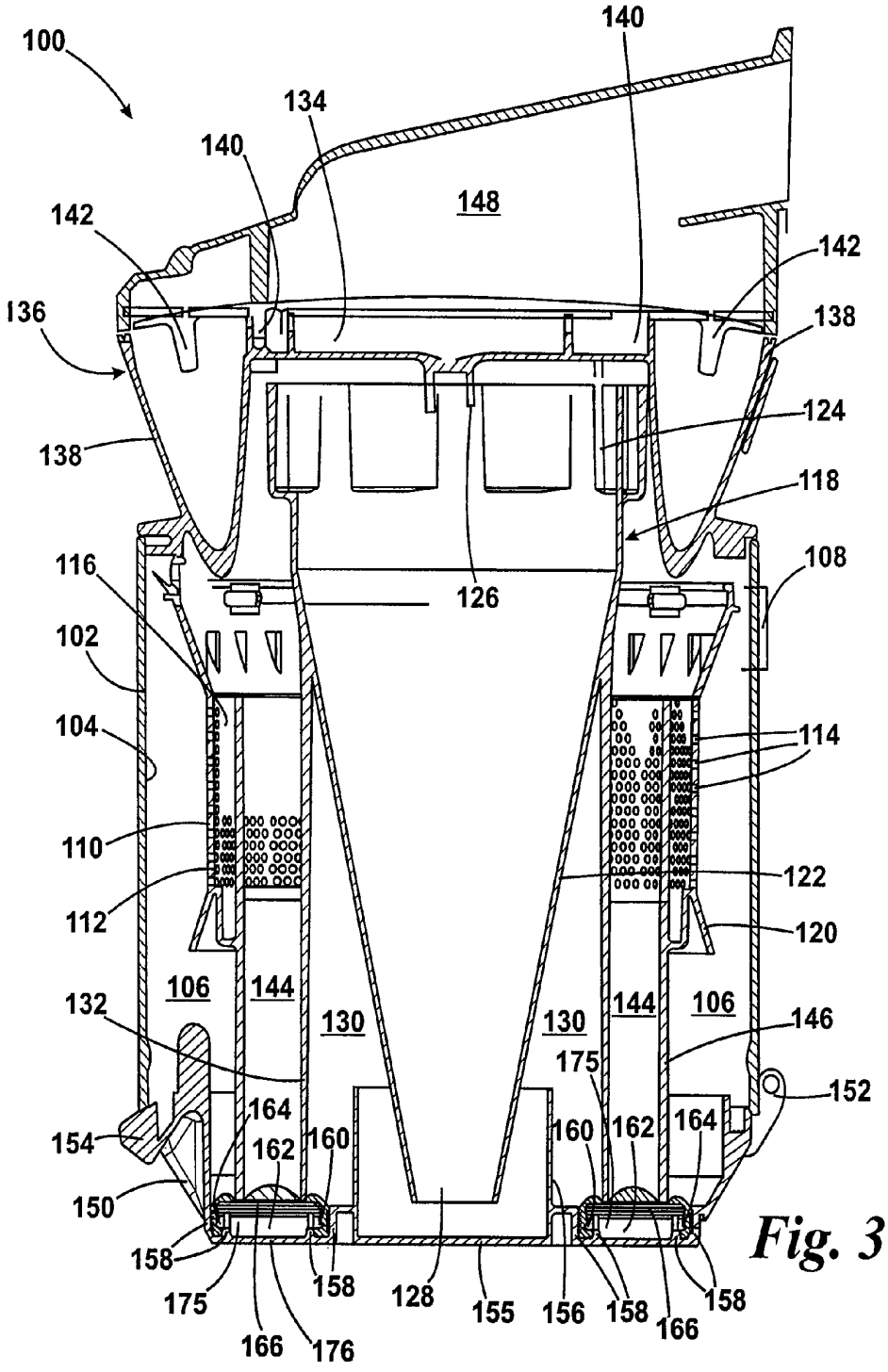

100
140
134
140
148
142
142
136
138
138
124
118
116
108
126
102
104
114
110
122
112
120
106
144
130
130
144
106
146
132
175
152
164
160
162
164
154
162
160
150
158
158
175
158
128
155
156
158
166
158
166
176

Fig. 3

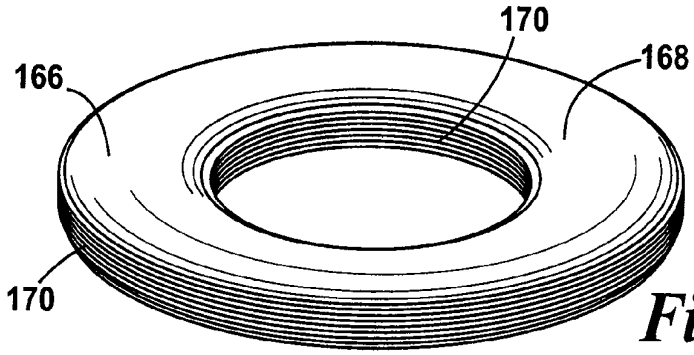


Fig. 4

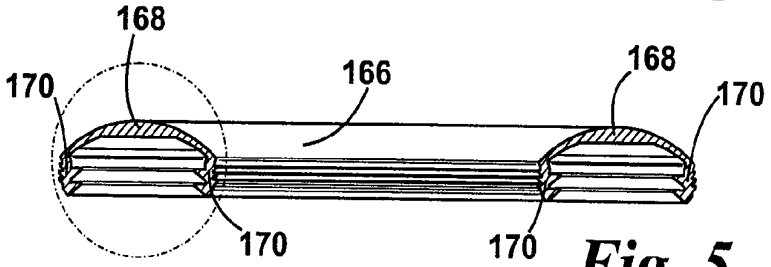


Fig. 5

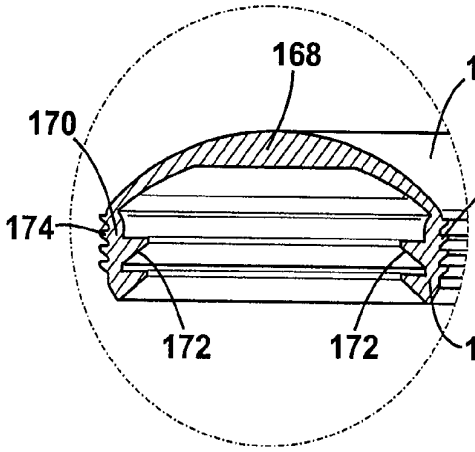


Fig. 6

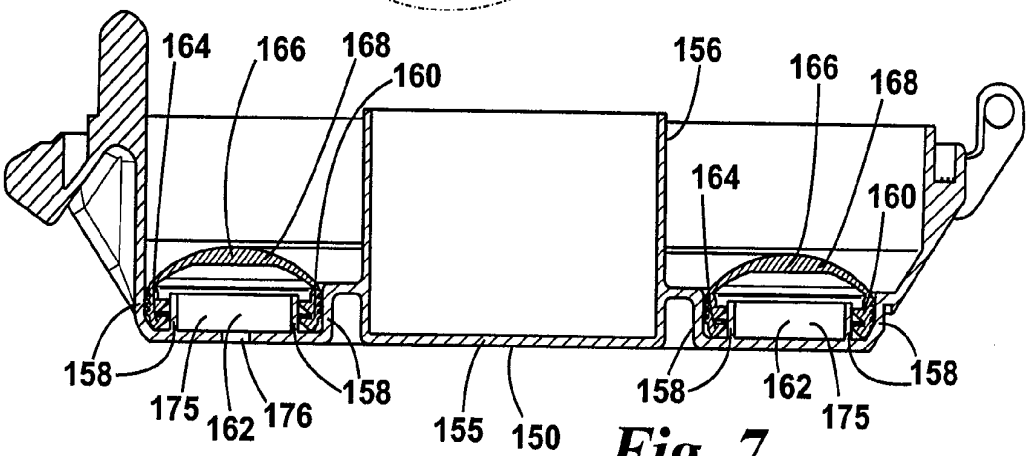


Fig. 7

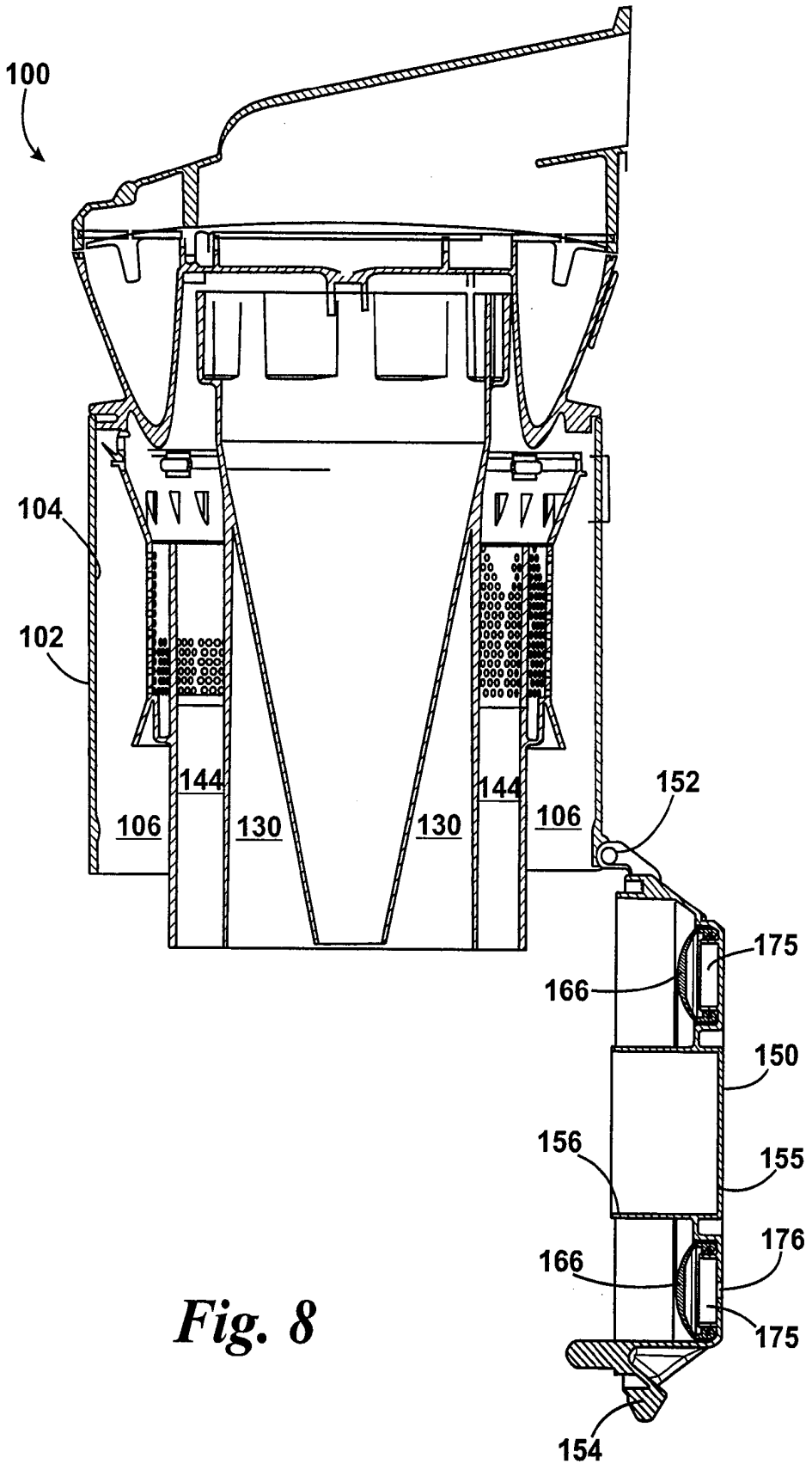

100
104
102
144
106
130
130
144
106
152
175
166
150
156
155
176
166
175
154

Fig. 8

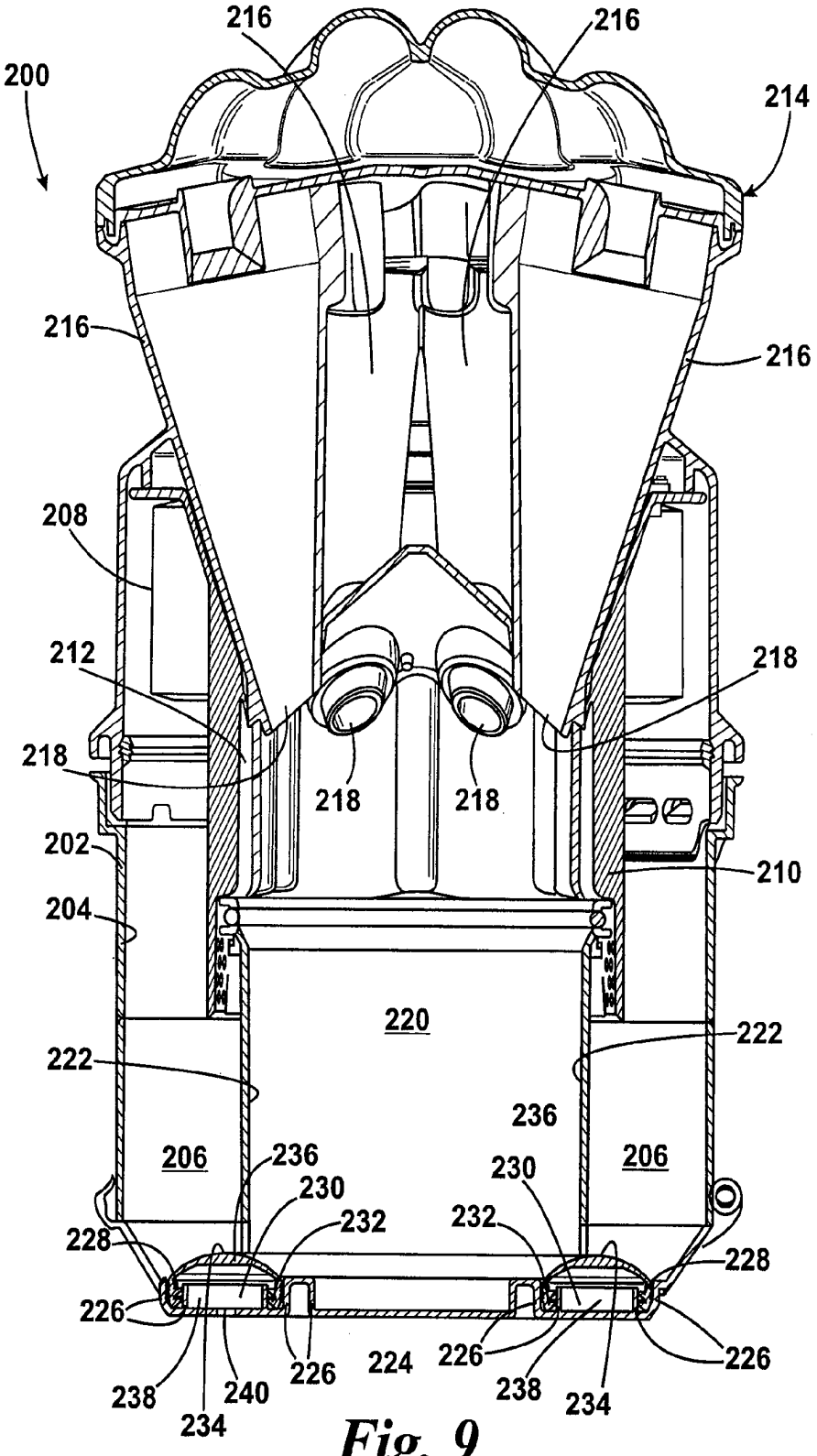

200
216
216
214
216
216
208
212
218
218
218
218
218
202
210
204
220
222
222
236
206
236
230
206
230
232
232
228
228
226
226
226
224
226
238
240
238
234
234

Fig. 9

CYCLONIC SEPARATING APPARATUS FOR A CLEANING APPLIANCE

REFERENCE TO RELATED APPLICATIONS

This application claims the priority of United Kingdom Application No. 0720341.7, filed Oct. 18, 2007, the contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to cyclonic separating apparatus for a cleaning appliance. Particularly, but not exclusively, the present invention relates to cyclonic separating apparatus for a vacuum cleaner.

BACKGROUND OF THE INVENTION

Vacuum cleaners which utilise cyclonic separating apparatus are well known. Examples of such vacuum cleaners are shown in EP 0 042 723, EP 1 370 173 and EP 1 268 076. In general, an airflow in which dirt and dust is entrained enters a first cyclonic separator via a tangential inlet which causes the airflow to follow a spiral or helical path within the first cyclonic separator so that the dirt and dust is separated from the airflow. Relatively clean air passes out of the chamber while the separated dirt and dust is collected in a first collector. In some applications, and as described in EP 0 042 723, the airflow is then passed to a second cyclonic separator which is capable of separating finer dirt and dust than the first cyclonic separator. The cleaned airflow then exits the cyclonic separating apparatus, and the separated fine dirt and dust is collected in a second collector.

The absence of a bag in a cyclonic vacuum cleaner can create difficulties for the disposal of the dirt and dust which is collected by the cleaner. When the collectors of a vacuum cleaner such as that described in EP 0 042 723 become full, a user typically removes the cyclonic separating apparatus from the main body of the machine and tips the collectors upside down. Often it may be necessary for the user to dislodge the dirt manually, which can be inconvenient.

An improved arrangement is disclosed in EP 1 023 864, which describes a vacuum cleaner with separating apparatus which can be removed from a main body of the cleaner for emptying. A lower closure of the separating apparatus is attached by way of a hinge to the remainder of the separating apparatus and the closure can be released by pressing a release button. Although it is desirable to provide a separating apparatus which can be emptied in this way, it can be difficult to seal the lower closure reliably against the remainder of the separating apparatus.

An improved sealing arrangement is described in EP 1 370 172. The described vacuum cleaner has a first and a second cyclonic separator, each having a separate collector. The collectors are annular and the first collector surrounds the second collector. Attached to the lower end of an annular wall separating the two collectors is a depending annular seal. A hinged closure member is connected to the base of the first collector and which can be released to empty the two collectors. When the closure member is moved to a closed position, the seal is wiped against a part of the closure member, ensuring that the sealing surface is clear of dirt and dust, and allowing the seal to be stretched slightly by engagement with the closure member when in the closed position. This helps to maintain the sealing action.

An alternative sealing arrangement is used on a range of vacuum cleaners sold by Dyson™ under the trade name DC12™. These vacuum cleaners also have two cyclonic separators, each having a separate collector. In this arrangement, a hinged closure member carries a small annular seal which seals against a wall separating the two collectors.

However, a problem associated with both of the above arrangements is that the seal may become less effective with use; for example, the seal may become worn or brittle and may not seal correctly. Also, with an arrangement using a movable closure member, there is a risk that the user may not return the closure member to the correct closed position after emptying the collectors. The above situations may lead to ineffective sealing between the collectors and leaks occurring therebetween. This is undesirable because separated dirt and dust can move between the collectors and may become re-entrained in the airflow, reducing the efficiency at which the cyclonic separating apparatus operates. Leaks between collectors may also lead to unwanted pressure drops, again reducing the efficiency at which the cyclonic separating apparatus operates.

SUMMARY OF THE INVENTION

It is an object of the present invention to improve the sealing of a closure member to the remainder of the cyclonic separating apparatus. It is a further object of the invention to provide a seal which is able to seal efficiently at least two collectors.

According to the invention, there is provided cyclonic separating apparatus for a cleaning appliance, the cyclonic separating apparatus comprising a plurality of cyclonic separators arranged in series for separating particles from a dirt- and dust-laden airflow, a plurality of collectors for collecting the separated dirt and dust, and a closure member movable between a closed position in which the closure member closes an end of each collector and an open position in which separated dirt and dust can be emptied from the collectors, the ends of the collectors being separated by at least one dividing wall, wherein an expandable seal is provided to seal between the closure member and the at least one dividing wall when the closure member is in the closed position.

By providing an expandable seal which seals between the at least one dividing wall and the closure member, the seal is able to seal effectively even if the closure member is misaligned, incorrectly fitted or if dirt and dust is present between the surfaces to be sealed. This is because the seal is able to expand in order to seal tightly between the surfaces to be sealed.

Preferably, the seal is expandable in response to a pressure difference across a surface of the seal. By providing a seal which is able to expand or contract depending upon the pressure differential applied across a surface thereof, reliable and effective sealing between collectors can be achieved when the cyclonic separating apparatus is in use. Further, when the apparatus is switched off, the parts being sealed can be separated easily.

Preferably, the seal is located over a channel formed on the closure member. More preferably, the channel and seal form a cavity which is open to the atmosphere. By providing a channel in this manner, the seal can be conveniently located on the closure member, and a cavity can be formed by the seal and the channel. The cavity is adapted to be open to the

atmosphere which allows a pressure differential to be created across the surface of the seal when the cyclonic separating apparatus is in use.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG. **1** is a side view of a cylinder vacuum cleaner including cyclonic separating apparatus according to a first embodiment of the invention;

FIG. **2** is a plan view of the cylinder vacuum cleaner of FIG. **1**;

FIG. **3** is a side section taken along the line A-A of FIG. **2** showing the cyclonic separating apparatus removed from the cylinder vacuum cleaner of FIG. **1**;

FIG. **4** is perspective view of a seal of the cyclonic separating apparatus of FIG. **3**;

FIG. **5** is a side section of the seal of FIG. **4**;

FIG. **6** is an enlarged view of a part of FIG. **5**;

FIG. **7** is a side section of a closure member forming part of the cyclonic separating apparatus of FIG. **3**;

FIG. **8** is a side section of the cyclonic separating apparatus of FIG. **3**, with the closure member in an open state; and

FIG. **9** is a side section through cyclonic separating apparatus according to a second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

A cylinder vacuum cleaner **10** incorporating cyclonic separating apparatus according to a first embodiment of the invention is shown in FIGS. **1** and **2**. The vacuum cleaner **10** has a main body **12** housing a motor and fan unit (not shown) and to which a pair of wheels **14** is attached. The wheels **14** allow the main body **12** of the vacuum cleaner **10** to be manoeuvred across a floor surface. A dirty air inlet **16** is formed on the main body **12**. A hose and wand assembly (not shown) can be connected to the dirty air inlet **16** in order to enable a user to clean a floor surface.

Cyclonic separating apparatus **100** according to a first embodiment of the invention is releasably attached to the main body **12**. The interior of the cyclonic separating apparatus **100** is in communication with the dirty air inlet **16** through which a dirt-laden airflow enters the cyclonic separating apparatus **100**. The cyclonic separating apparatus **100** can be removed from the main body **12** for emptying purposes.

The cyclonic separating apparatus **100** is shown in more detail in FIG. **3**, in which the cyclonic separating apparatus **100** is shown removed from the remainder of the vacuum cleaner **10** for clarity. The cyclonic separating apparatus **100** comprises a substantially cylindrical outer wall **102**. The outer wall **102** defines a first cyclonic separator **104** and a first collector **106**. Dirt and dust is both separated by the first cyclonic separator **104** and collected in the first collector **106** in this region. An inlet **108** is formed in the outer wall **102**. The inlet **108** forms a communication path between the dirty air inlet **16** and the interior of the first cyclonic separator **104**. The air inlet **108** is arranged tangentially to the first cyclonic separator **104** so that the incoming air is forced to follow a helical path around the interior of the outer wall **102**.

A shroud **110** is located inwardly of the outer wall **102** of the first cyclonic separator **104**. The shroud **110** comprises a cylindrical wall **112** having a plurality of through-holes **114**. The shroud **110** surrounds an outlet **116** from the first cyclonic separator **104**. The outlet **116** provides a communication path between the first cyclonic separator **104** and a second cyclonic separator **118**. A lip **120** is provided at the base of the shroud **110**. The lip **120** helps prevent separated dirt and dust from being re-entrained back into the airflow within the first cyclonic separator **104**.

The second cyclonic separator **118** comprises a single cyclone **122**. The single cyclone **122** has an air inlet **124** and an air outlet **126**, both of which are located at a first end of the single cyclone **122**. A cone opening **128** is located at a second end of the single cyclone **122**. A second collector **130** is also located at the second end of the single cyclone **122** and is in communication with the cone opening **128**. The second collector **130** is delimited by a cylindrical wall **132** which depends from an outer surface of the single cyclone **122** and which is located inwardly of the shroud **110**. The air outlet **126** of the single cyclone **122** is in communication with a duct **134**. The duct **134** provides a communication path between the second cyclonic separator **118** and a third cyclonic separator **136**.

The third cyclonic separator **136** comprises a plurality of high-efficiency cyclones **138** arranged in parallel. In this embodiment, fourteen high-efficiency cyclones **138** are provided. Each high-efficiency cyclone **138** has a tangentially-arranged air inlet **140** and an air outlet **142**. Each air inlet **140** and air outlet **142** is located at a first end of the respective high-efficiency cyclone **138**. A cone opening (not shown) is located at a second end of each high-efficiency cyclone **138**.

A third collector **144** is located at the second end of the high-efficiency cyclones **138** and is in communication with the cone openings of the high-efficiency cyclones **138**. The third collector **144** is delimited by the cylindrical wall **132** and a cylindrical wall **146** which is located between the shroud **110** and the cylindrical wall **132**. The cylindrical wall **146** depends from an upper part of the shroud **110** and is also connected to the shroud at a point approximately half way down the cylindrical wall **146**. Therefore, the third collector **144** is an annular chamber located between the first collector **106** and the second collector **130**.

The first, second and third collectors **106**, **130**, **144** are arranged concentrically. The second and third collectors **130**, **144** are arranged inside the first collector **106**. The second collector **130** is also arranged inside the third collector **144**. The ends of the collectors **106**, **130**, **144** are separated by dividing walls **132**, **146**. The ends of the first and third collectors **106**, **144** are divided by cylindrical wall **146**, and the ends of the second and third collectors **130**, **144** are divided by cylindrical wall **132**.

The air outlets **142** of the high-efficiency cyclones **138** are in communication with an outlet **148**. The outlet **148** provides an airflow path from the cyclonic separating apparatus **100** into other parts of the vacuum cleaner **10**. Located downstream of the outlet **148** is a pre-motor filter (not shown), the motor and fan unit and a post-motor filter (not shown).

A closure member **150** closes the lower end of the cyclonic separating apparatus **100**. The closure member **150** is pivotably mounted on the lower end of the outer wall **102** by means of a hinge **152**. The closure member **150** is retained in a closed position (as shown in FIG. **3**) by means of a catch **154**. The closure member **150** comprises a base **155** and an inner annular wall **156** extending into the second collector **130**. The inner annular wall **156** helps to reduce the risk of dirt and dust separated by the single cyclone **122** of the second cyclonic separator **118** being re-entrained into the airflow leaving the single cyclone **122**.

The closure member **150** also includes four further annular walls **158** concentric with and arranged radially outside the inner annular wall **156**. Adjacent annular walls **158** delimit three concentric, annular channels **160**, **162**, **164**. The three

annular channels **160**, **162**, **164** comprise a relatively wide channel **162** flanked by two relatively narrow channels **160**, **164**.

An annular seal **166** is attached to the closure member **150**. The annular seal **166** is shown in more detail in FIGS. **4** to **6**. In these figures, the annular seal **166** is shown removed from the remainder of the cyclonic separating apparatus **100**. The annular seal **166** has a convex upper surface **168** and two side walls **170** which depend therefrom. The annular seal **166** is manufactured from a flexible material such as a rubber.

The convex upper surface **168** has an increased thickness towards the uppermost portion thereof. The side walls **170** have a sawtooth profile on both an internal surface **172** and an external surface **174** thereof. This is shown most clearly in FIG. **6**. On the internal surfaces **172**, the sawtooth profile comprises two teeth which define two circumferential grooves around the internal surfaces **172** of the side walls **170**. The sawtooth profile on the external surfaces **174** comprises four smaller teeth which define four circumferential grooves around the external surfaces **174**.

FIG. **7** shows a cross-section of the closure member **150** with the annular seal **166** attached thereto. Each side wall **170** of the annular seal **166** is located in a respective relatively narrow annular channel **160**, **164** of the closure member **150**. The annular seal **166** is held in place by the engagement of the teeth located on the inner and outer surfaces **172**, **174** of the side walls **170** of the annular seal **166** with the annular walls **158** of the closure member **150**. As a result, the upper surface **168** of the annular seal **166** covers the relatively wide annular channel **162** of the closure member **150** to define a cavity **175**.

A plurality of through-holes **176** (although only one is shown in FIG. **7**) are formed in the base **155** of the closure member **150** to provide a communication path between the cavity **175** and the external atmosphere. Therefore, the cavity **175** will remain at atmospheric pressure, irrespective of the pressure inside the cyclonic separating apparatus **100**. However, due to the speed of the airflow within the cyclonic separating apparatus **100**, the pressure within the cyclonic separating apparatus **100** will be below atmospheric, resulting in a pressure drop across the upper surface **168** of the annular seal **166**. Due to its flexible nature, the annular seal **166** will change shape depending upon the magnitude of the pressure difference established across the convex upper surface **168** thereof. In other words, the annular seal **166** is an expandable seal as it is able to expand, or inflate, when there is a positive pressure in the cavity relative to that within the cyclonic separating apparatus **100**. The operation of the annular seal **166** is described in more detail below.

The annular seal **166** is shown in a "relaxed" position in FIG. **7**, in which there is no pressure difference across the convex upper surface **168** of the annular seal **166**. When the closure member **150** is closed (as shown in FIG. **3**), the upper surface **168** of the annular seal **166** will be compressed by the ends of the cylindrical walls **132**, **146** to effect a seal between closure member **150** and the three collectors **106**, **130**, **144** even when there is no pressure drop across the upper surface **168** of the annular seal **166**.

In use, the motor and fan unit draws a flow of dirt-laden air through the hose and wand, into the dirty air inlet **16**, through the inlet **108** and into the cyclonic separating apparatus **100**. Due to the tangential arrangement of the inlet **108**, the airflow is forced to follow a helical path around the interior of the outer wall **102**. Therefore, larger dirt and dust particles are separated by cyclonic motion in the first cyclonic separator **104**. These particles are collected in the first collector **106**.

The partially-cleaned airflow then flows back up the interior of the first cyclonic separator **104** and exits the first cyclonic separator **104** via the through-holes **114** in the shroud **110**. Once the airflow has passed through the shroud **110**, it enters the outlet **116** and from there enters the inlet **124** of the single cyclone **122** of the second cyclonic separator **118**. The single cyclone **122** has a diameter smaller than the outer wall **102** of the first cyclonic separator **104** and is tapered. Therefore, the single cyclone **122** is able to separate smaller particles of dirt and dust from the partially-cleaned airflow than the first cyclonic separator **104**. Separated dirt and dust exits the single cyclone **122** via the cone opening **128** and is collected in the second collector **130**. The cleaned air then flows back up the centre of the single cyclone **122**, exits the single cyclone **122** through the air outlet **126** and passes into the duct **134**.

From duct **134**, the airflow is then divided between the tangential air inlets **140** of the high-efficiency cyclones **138** of the third cyclonic separator **136**. Each of the high-efficiency cyclones **138** has a diameter smaller than that of both the first cyclonic separator **104** and the single cyclone **122** of the second cyclonic separator **118**. Therefore, the high-efficiency cyclones **138** are able to separate even finer particles of dirt and dust from the airflow than either of the first or second cyclonic separators **104**, **118**. Separated dirt and dust exits the high-efficiency cyclones **138** via the cone openings and passes into the third collector **144** where it is collected.

Cleaned air then flows back up the high-efficiency cyclones **138**, exits the high-efficiency cyclones **138** through the air outlets **142** and enters the outlet **148**. The cleaned air then passes from the outlet **148** sequentially through the pre-motor filter, the motor and fan unit, and the post-motor filter before being exhausted from the vacuum cleaner **10** through the air vents (not shown) located on the outer surface of the vacuum cleaner **10**.

While the vacuum cleaner **10** is in use and the cyclonic separating apparatus **100** is operating, the speed of the airflow within the cyclonic separating apparatus **100** will be greater than the speed of the atmospheric air surrounding the vacuum cleaner **10**. Therefore, the air pressure within the cyclonic separating apparatus **100** will be lower than atmospheric pressure. Consequently, there will be a pressure drop (or differential) across the convex upper surface **168** of the annular seal **166**. The pressure in the cavity **175** beneath the annular seal **166** will be positive relative to the pressure in the cyclonic separating apparatus **100**. This will cause the annular seal **166** to expand, or inflate, and push upwards against the ends of the cylindrical walls **132**, **146**. Therefore, the annular seal **166** is able to seal effectively between the three separate collectors **106**, **130**, **144** even if the collectors **106**, **130**, **144** are not fully sealed when the vacuum cleaner **10** is switched off; for example, due to a worn seal, a misaligned closure member **150** or the presence of dirt and dust between the annular seal **166** and the cylindrical walls **132**, **146**.

When a cleaning operation is finished, the collectors **106**, **130**, **144** of the cyclonic separating apparatus **100** may be full of dirt and dust, and require emptying. To do this, the user switches off the vacuum cleaner **10**. When the vacuum cleaner **10** is switched off, the air pressure within the cyclonic separating apparatus **100** will return to atmospheric pressure. Therefore, there will be no pressure drop across the upper surface **168** of the annular seal **166** and so the annular seal **166** will contract, or deflate.

The user releases the cyclonic separating apparatus **100** from the main body **12** by pressing a release button (not shown), removes the cyclonic separating apparatus **100** from the remainder of the vacuum cleaner **10** and places it over a

suitable receptacle such as a dustbin. The user then presses a further release button (not shown) in order to release the catch **154**.

This action releases the closure member **150**, pushing the closure member **150** away from the wall **102** and allowing the closure member **150** to pivot downwardly about the hinge **152** as shown in FIG. **8**. Since the annular seal **166** is deflated, the closure member **150** can be opened easily. The dirt and dust collected in the first, second and third collectors **106**, **130**, **144** can thus be emptied conveniently and efficiently. The first, second and third collectors **106**, **130**, **144** are emptied simultaneously during this process.

When the cyclonic separating apparatus **100** has been emptied as described above, the user manually moves the closure member **150** back into the closed position shown in FIG. **3**. The cyclonic separating apparatus **100** can then be replaced on the main body **12** of the vacuum cleaner **10** (as shown in FIGS. **1** and **2**) for further cleaning operations.

FIG. **9** shows a side section through cyclonic separating apparatus **200** according to a second embodiment of the invention. The cyclonic separating apparatus **200** is suitable for use in the vacuum cleaner **10** of FIG. **1** in place of the cyclonic separating apparatus **100** of the first embodiment. The cyclonic separating apparatus **200** differs from the cyclonic separating apparatus **100** of the first embodiment in that the cyclonic separating apparatus **200** has only two cyclonic separators.

The cyclonic separating apparatus **200** comprises a substantially cylindrical outer wall **202**. The outer wall **202** defines a first cyclonic separator **204** and a first collector **206**. An inlet **208** is formed in the outer wall **202**. The inlet **208** is arranged tangentially to the first cyclonic separator **204** in the manner of the inlet **108** of the first embodiment.

A shroud **210** is located inwardly of the outer wall **202**. The shroud **210** is similar to the shroud **110** of the first embodiment and will not be described any further. A passageway **212** is located downstream of the shroud **210** and provides a communication path between the first cyclonic separator **204** and a second cyclonic separator **214**.

The second cyclonic separator **214** comprises a plurality of high-efficiency cyclones **216** arranged in parallel. In this embodiment, six high-efficiency cyclones **216** are provided. Each high-efficiency cyclone **216** has a cone opening **218** in communication with a second collector **220**. The second collector **220** is delimited by a cylindrical wall **222** which depends from a lower part of the shroud **210**. The first and second collectors **206**, **220** are arranged concentrically, with the second collector **220** being arranged inside the first collector **206**. The ends of the collectors **206**, **220** are separated by the dividing wall **222**.

A closure member **224** closes the lower end of the cyclonic separating apparatus **200**. The closure member **224** is pivotably mounted on the lower end of the outer wall **202** in a similar manner to the closure member **150** of the first embodiment. The closure member **224** includes four annular walls **226** which delimit three concentric, annular channels **228**, **230**, **232**. The three annular channels **228**, **230**, **232** comprise a relatively wide channel **230** flanked by two relatively narrow channels **228**, **232**.

An annular seal **234** is attached to the closure member **224**. The annular seal **234** is the same as the annular seal **166** of the first embodiment. However, in this embodiment, the annular seal **234** only seals between the closure member **224** and a single dividing wall **222**. As previously, an upper surface **236** of the annular seal **234** covers the relatively wide annular channel **230** of the closure member **224** to define a cavity **238**. A plurality of through-holes **240** (although only one is shown in FIG. **9**) are formed in the closure member **224** to provide a communication path between the cavity **238** and the external atmosphere. Therefore, the cavity **238** will remain at atmospheric pressure irrespective of the pressure inside the cyclonic separating apparatus **200**.

The annular seal **234** is shown in a "relaxed" position in FIG. **9**, in which there is no pressure difference across an upper surface **236** of the annular seal **234**. However, like the annular seal **166** of the first embodiment, the annular seal **234** will change shape depending upon the magnitude of the pressure difference established across the upper surface **236** thereof when the vacuum cleaner **10** is switched on.

In use, a flow of dirt and dust laden air flows through the inlet **208** and into the cyclonic separating apparatus **200**. Larger dirt and dust particles are separated by cyclonic motion in the first cyclonic separator **204**, and these particles are collected in the first collector **206**. The partially-cleaned airflow exits the first cyclonic separator **204** via through-holes (not shown) in the shroud **210**, and is divided between the plurality of high-efficiency cyclones **216** of the second cyclonic separator **214**. Dirt and dust is separated in the high-efficiency cyclones **216** and exits via the cone openings **218** to be collected in the second collector **220**. The cleaned air then passes back up through the plurality of high-efficiency cyclones **216** and out of the cyclonic separating apparatus **200**. The remainder of the operation of the cyclonic separating apparatus **200** is identical to that of the cyclonic separating apparatus **100** as described in the first embodiment.

While the vacuum cleaner **10** is in use and the cyclonic separating apparatus **200** is operating, the pressure in the cavity **238** beneath the annular seal **234** will be positive relative to the pressure in the cyclonic separating apparatus **200**. Therefore, the annular seal **234** will expand—the upper surface **236** will be pushed upwards to seal against the end of the dividing wall **222**. Therefore, the annular seal **236** is able to seal effectively between the two separate collectors **206**, **220** even if the collectors **206**, **220** are not fully sealed when the vacuum cleaner **10** is switched off.

The invention is not limited to the detailed description given above. Variations will be apparent to the person skilled in the art. For example, other types of expandable seals may be used; the seal need not be expandable, or inflatable, in response to a pressure difference across a surface of the seal. For example, a thermally-expandable seal which expands when heated may be used. Additionally, the seal need not be annular. Other arrangements, for example, square, rectangular or cylindrical shapes could be used. The seal may also take the form of a sheet.

More than one seal may be used; for example, an individual expandable seal may be located between each dividing wall and the closure member. Additionally, the seal need not be located on the closure member. Other arrangements could be used; for example, the seal could be located on the end of the dividing wall between collectors, or may be located on a separate member between the dividing walls and the closure member.

A part of the cyclonic separating apparatus other than the base may be movable for emptying purposes. Other forms, arrangements and locations of closure members may be used. For example, the side or top of the cyclonic separating apparatus may be movable (or openable). Further, the closure member need not be pivotable. Other opening arrangements for the closure member may be used; for example, sliding, retracting or rotating closure members.

More than three cyclonic separators may be provided. Additionally, more than one collector may be provided with a cyclonic separator. For example, two cyclonic separators may

be provided with one of the cyclonic separators having two collectors associated therewith. Further, any number of cyclones may be used in each cyclonic separator.

The cleaning appliance need not be a cylinder vacuum cleaner. The invention is applicable to other types of vacuum cleaner, for example, upright machines, stick-vacuums or hand-held cleaners. Further, the present invention is applicable to other types of cleaning appliances, for example, a wet and dry machine or a carpet shampooer.

The invention claimed is:

1. A cyclonic separating apparatus for a cleaning appliance, comprising:

a plurality of cyclonic separators arranged in series for separating particles from a dirt- and dust-laden airflow,

a plurality of collectors for collecting the separated dirt and dust,

a closure member movable between a closed position in which the closure member closes an end of each collector and an open position in which separated dirt and dust can be emptied from the collectors, the ends of the collectors being separated by at least one dividing wall, and

an expandable seal to seal between the closure member and the at least one dividing wall when the closure member is in the closed position, wherein the seal is expandable in response to a pressure difference across a surface of the seal.

2. The cyclonic separating apparatus of claim **1**, wherein the seal is located on the closure member.

3. The cyclonic separating apparatus of claim **2**, wherein the seal is located over a channel formed on the closure member.

4. The cyclonic separating apparatus of claim **3**, wherein the channel and seal form a cavity which is open to the atmosphere.

5. The cyclonic separating apparatus of claim **1**, wherein the seal is annular.

6. The cyclonic separating apparatus of claim **1**, wherein first and second cyclonic separators are provided in series and have first and second collectors respectively.

7. The cyclonic separating apparatus of claim **6**, wherein a wall of the first collector forms at least a part of an outer wall of the cyclonic separating apparatus and has an air inlet formed therein.

8. The cyclonic separating apparatus of claim **6**, wherein the second cyclonic separator comprises a plurality of cyclones in parallel.

9. A cleaning appliance comprising the cyclonic separating apparatus of claim **1**.

10. A vacuum cleaner comprising the cleaning appliance of claim **9**.

11. A cyclonic separating apparatus, for a cleaning appliance, comprising:

a plurality of cyclonic separators arranged in series for separating particles from a dirt- and dust-laden airflow,

a plurality of collectors for collecting the separated dirt and dust,

a closure member movable between a closed position in which the closure member closes an end of each collector and an open position in which separated dirt and dust can be emptied from the collectors, the ends of the collectors being separated by at least one dividing wall, and

an expandable seal to seal between the closure member and the at least one dividing wall when the closure member is in the closed position,

wherein first and second cyclonic separators are provided in series and have first and second collectors respectively, and

wherein the second collector is arranged inside the first collector.

12. A cyclonic separating apparatus, for a cleaning appliance, comprising:

a plurality of cyclonic separators arranged in series for separating particles from a dirt- and dust-laden airflow,

a plurality of collectors for collecting the separated dirt and dust,

a closure member movable between a closed position in which the closure member closes an end of each collector and an open position in which separated dirt and dust can be emptied from the collectors, the ends of the collectors being separated by at least one dividing wall, and

an expandable seal to seal between the closure member and the at least one dividing wall when the closure member is in the closed position,

wherein first and second cyclonic separators are provided in series and have first and second collectors respectively, and

further comprising a third cyclonic separator in series with, and downstream of, the first and second cyclonic separators, the third cyclonic separator having a third collector.

13. The cyclonic separating apparatus of claim **12**, wherein the third collector is arranged inside the first collector.

14. The cyclonic separating apparatus of claim **12**, wherein the third cyclonic separator comprises a plurality of cyclones in parallel.

15. A cyclonic separating apparatus for a cleaning appliance, comprising:

a plurality of cyclonic separators arranged in series for separating particles from a dirt- and dust-laden airflow,

a plurality of collectors for collecting the separated dirt and dust,

a closure member movable between a closed position in which the closure member closes an end of each collector and an open position in which separated dirt and dust can be emptied from the collectors, the ends of the collectors being separated by at least one dividing wall, and

an expandable seal to seal between the closure member and the at least one dividing wall when the closure member is in the closed position,

wherein first and second cyclonic separators are provided in series and have first and second collectors respectively, and

wherein the collectors are substantially cylindrical and arranged concentrically with respect to one another.

* * * * *