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**Conrad**

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(54) **CYCLONIC AIR TREATMENT MEMBER AND SURFACE CLEANING APPARATUS INCLUDING THE SAME**

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(51) **Int. Cl.**

***B01D 50/00*** (2006.01)
***B04C 5/08*** (2006.01)
***B04C 5/187*** (2006.01)
***B04C 9/00*** (2006.01)
***A47L 9/16*** (2006.01)
(Continued)

(52) **U.S. Cl.**

CPC ............. ***B04C 5/08*** (2013.01); ***A47L 9/1608*** (2013.01); ***A47L 9/1691*** (2013.01); ***B04C 5/187*** (2013.01); ***B04C 9/00*** (2013.01); *A47L 5/225* (2013.01); *A47L 5/24* (2013.01); *A47L 9/1683* (2013.01);
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(58) **Field of Classification Search**

CPC .. B04C 5/08; B04C 5/187; B04C 9/00; B04C 2009/005; B04C 2009/004; A47L 9/1691; A47L 9/1608; A47L 5/24; A47L 9/1683; A47L 9/165; A47L 5/225
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

750,769 A 1/1904 Jackson
6,406,505 B1 6/2002 Oh et al.
(Continued)

FOREIGN PATENT DOCUMENTS

GB 2370006 B 10/2003

OTHER PUBLICATIONS

"Lupe Cordless Vacuum Cleaner. Powerful. Enduring. Flexible." retrieved at https://www.kickstarter.com/projects/lupepablo/lupe-cordless-vacuum-cleaner-powerful-enduring-flexible; published at least as early as Jun. 18, 2019.
(Continued)

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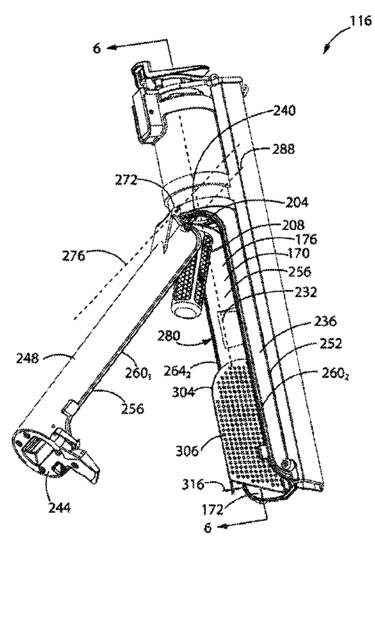
(57) **ABSTRACT**

A surface cleaning apparatus includes an air flow path, a cyclone bin assembly, and a suction motor. The air flow path extends from a dirty air inlet to a clean air outlet. The cyclone bin assembly is provided in the air flow path, and includes a cyclone chamber, a cyclone air inlet, a cyclone air outlet, a cyclone axis of rotation, and an axially extending cyclone chamber sidewall extending between first and second axially opposed ends. The cyclone chamber sidewall has first portion that is moveably mounted with respect to a second portion of the cyclone chamber sidewall between a closed position in which the first and second portions meet at a first juncture and a second juncture and an open position in which the cyclone chamber is opened. The first juncture extends at an angle to a plane that is transverse to the cyclone axis of rotation.

**20 Claims, 30 Drawing Sheets**



(51) **Int. Cl.**
*A47L 5/22* (2006.01)
*A47L 5/24* (2006.01)

(52) **U.S. Cl.**
CPC .. *B04C 2009/004* (2013.01); *B04C 2009/005* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 6,782,583 | B2 * | 8/2004 | Oh | A47L 9/104 15/350 |
| 7,803,207 | B2 | 9/2010 | Conrad | |
| 7,882,593 | B2 | 2/2011 | Beskow et al. | |
| 7,922,794 | B2 | 4/2011 | Morphey | |
| 7,958,597 | B2 | 6/2011 | Frantzen et al. | |
| 8,069,529 | B2 | 12/2011 | Groff et al. | |
| 8,156,609 | B2 | 4/2012 | Milne et al. | |
| 8,236,077 | B2 | 8/2012 | Gomiciaga-Pereda et al. | |
| 8,424,154 | B2 | 4/2013 | Beskow et al. | |
| 8,549,704 | B2 | 10/2013 | Milligan et al. | |
| 8,567,008 | B2 | 10/2013 | Conrad | |
| 8,607,406 | B2 | 12/2013 | Miefalk et al. | |
| 8,607,407 | B2 | 12/2013 | Conrad | |
| 8,640,304 | B2 | 2/2014 | Conrad | |
| 8,769,764 | B2 | 7/2014 | Crouch et al. | |
| 9,009,912 | B2 | 4/2015 | Conrad | |
| 9,027,198 | B2 | 5/2015 | Conrad | |
| 10,327,612 | B2 * | 6/2019 | Conrad | A47L 9/0613 |
| 10,729,296 | B2 * | 8/2020 | Kah, Jr. | A47L 9/2857 |
| 2003/0037406 | A1 * | 2/2003 | Wright | B01D 46/2411 15/353 |
| 2006/0090290 | A1 | 5/2006 | Lau | |
| 2006/0101611 | A1 * | 5/2006 | Oh | A47L 9/1691 15/353 |
| 2006/0230715 | A1 * | 10/2006 | Oh | B01D 45/14 55/337 |
| 2011/0289720 | A1 | 12/2011 | Han et al. | |
| 2014/0216333 | A1 * | 8/2014 | Hoversten | B04C 3/06 118/308 |
| 2014/0366310 | A1 | 12/2014 | Conrad | |
| 2017/0303758 | A1 * | 10/2017 | Conrad | A47L 9/1641 |
| 2018/0303301 | A1 * | 10/2018 | Conrad | B01D 45/08 |
| 2018/0368639 | A1 * | 12/2018 | Peters | A47L 9/165 |
| 2018/0368640 | A1 * | 12/2018 | Griffiths | B04C 5/185 |
| 2019/0082925 | A1 * | 3/2019 | Conrad | A47L 5/36 |
| 2019/0133389 | A1 * | 5/2019 | Nam | A47L 9/2857 |
| 2020/0196814 | A1 * | 6/2020 | Grebing | A47L 9/1608 |

OTHER PUBLICATIONS

International Search Report and Written Opinion, received in connection to international patent application No. PCT/CA2020/050054, dated Apr. 8, 2020.

* cited by examiner

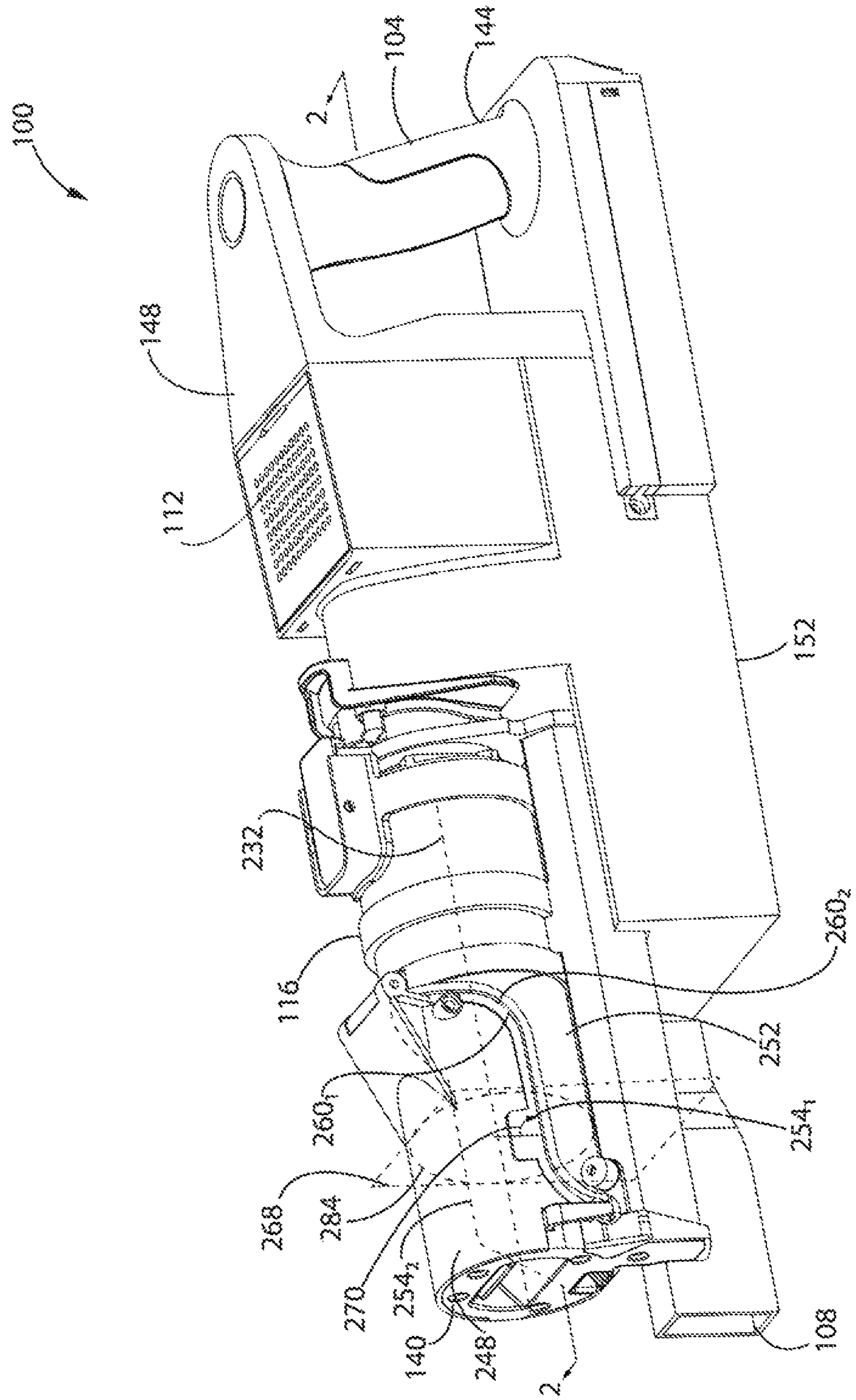

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FIG. 1

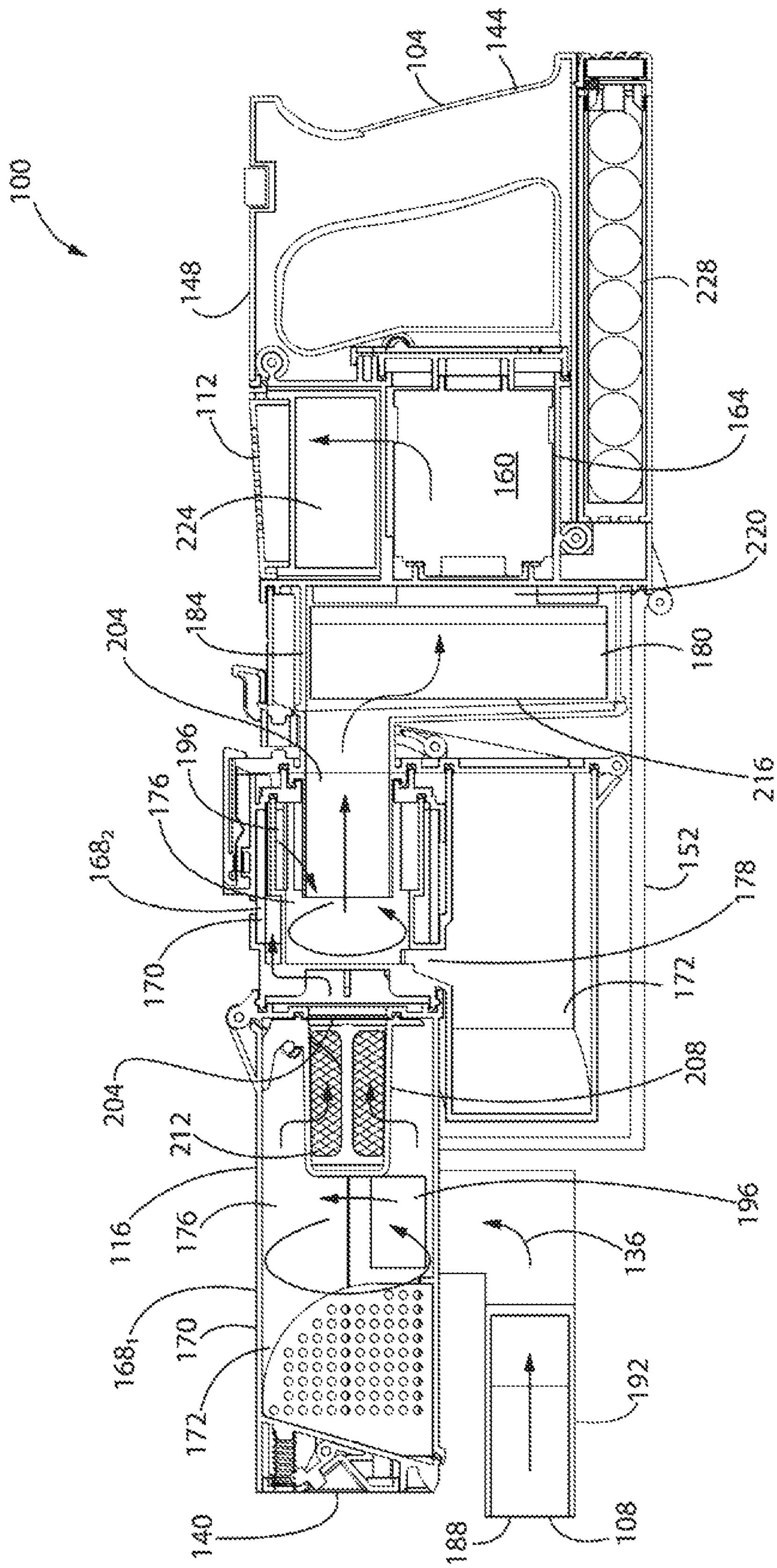
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FIG. 2

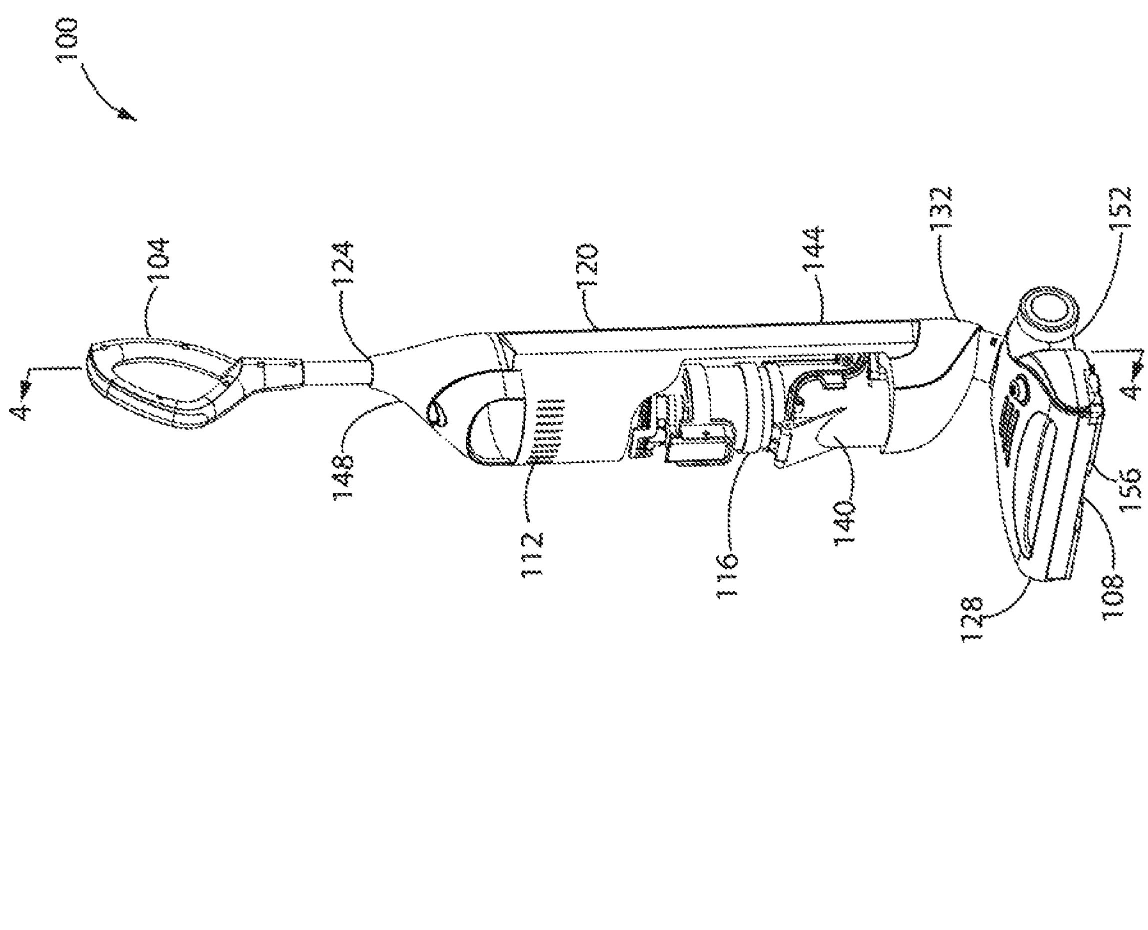
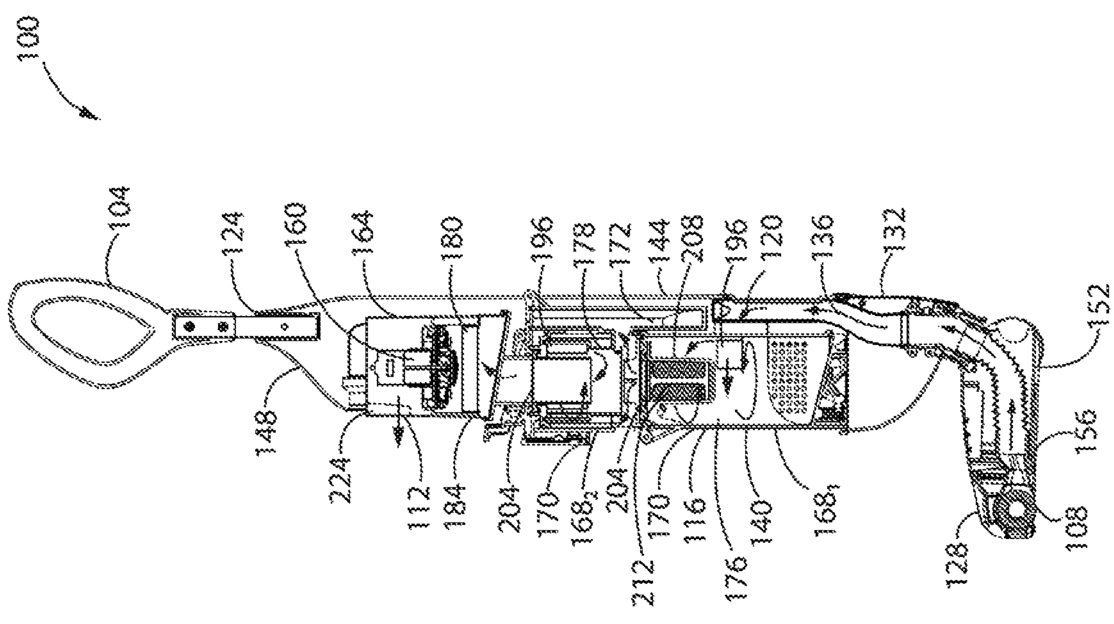



FIG. 3

FIG. 4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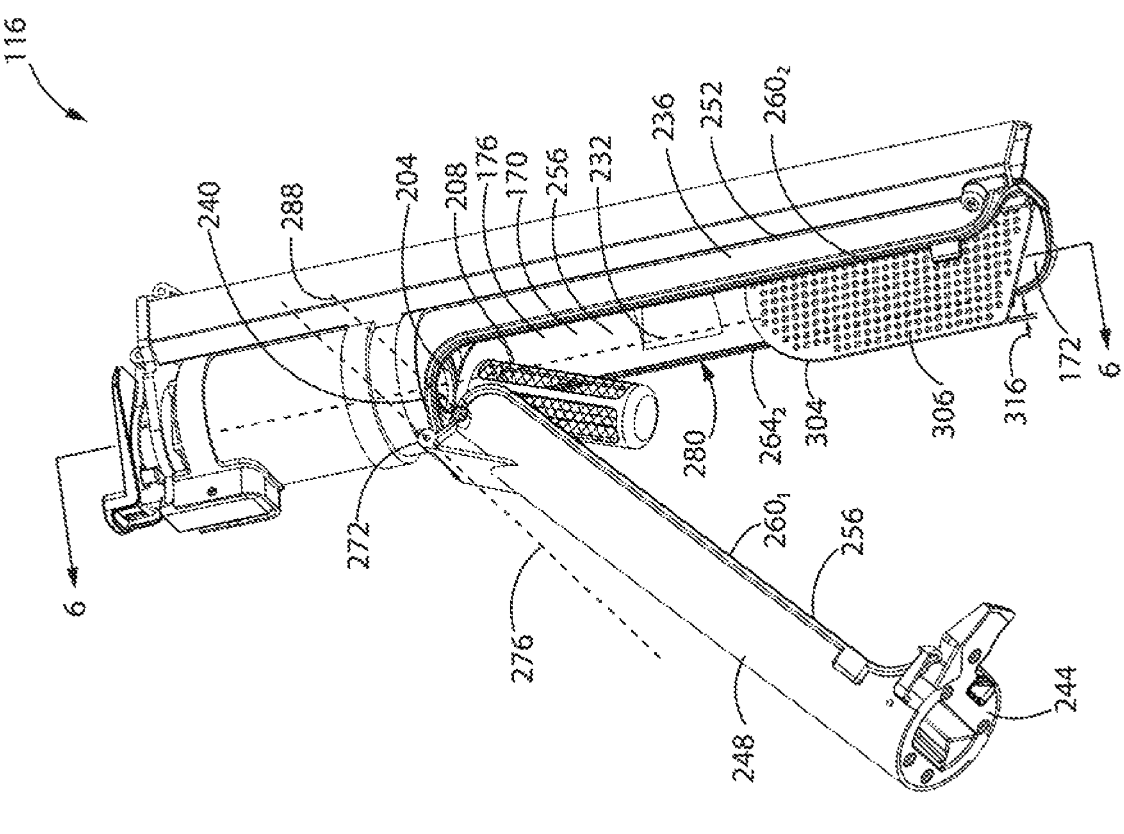
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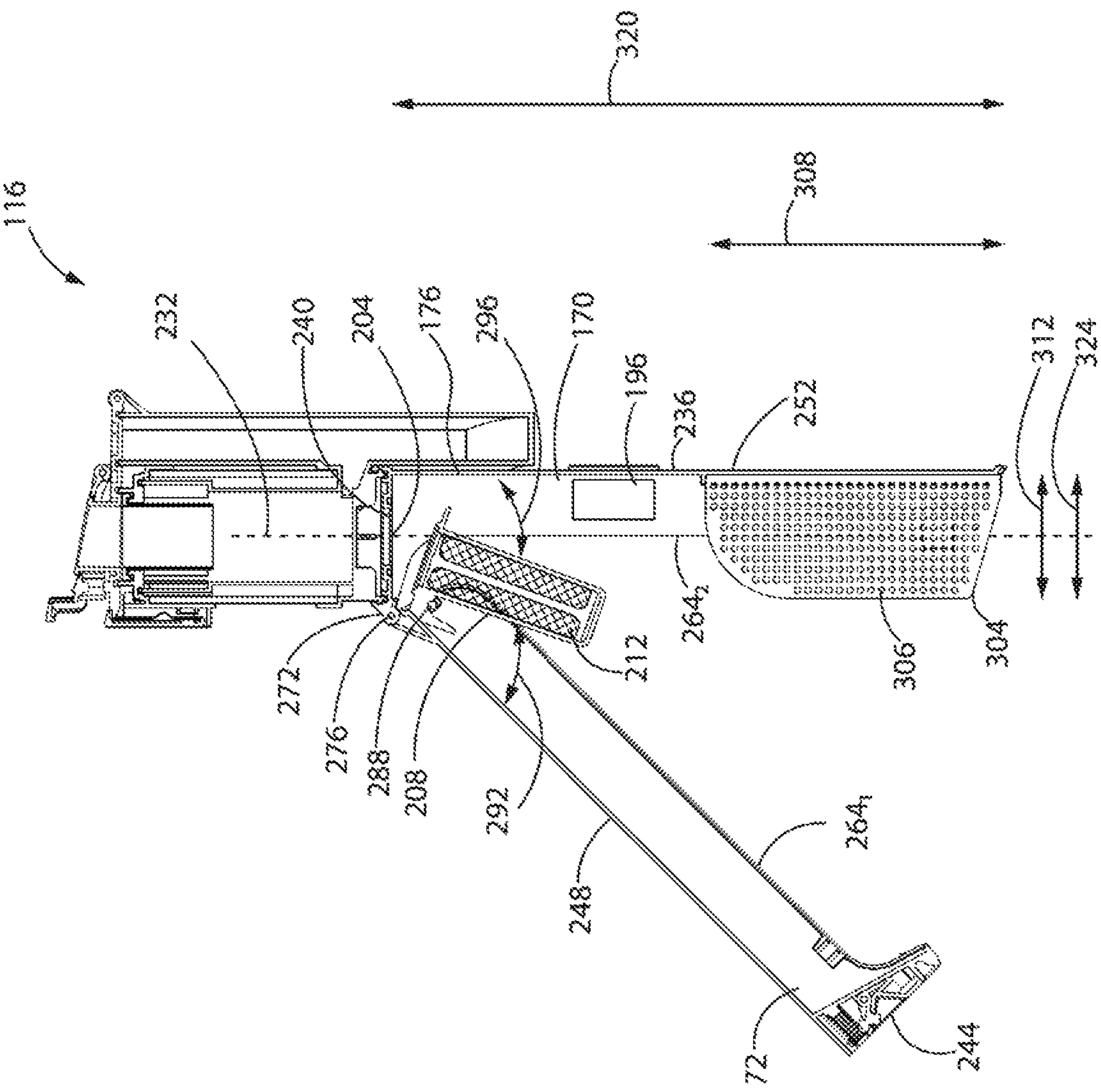
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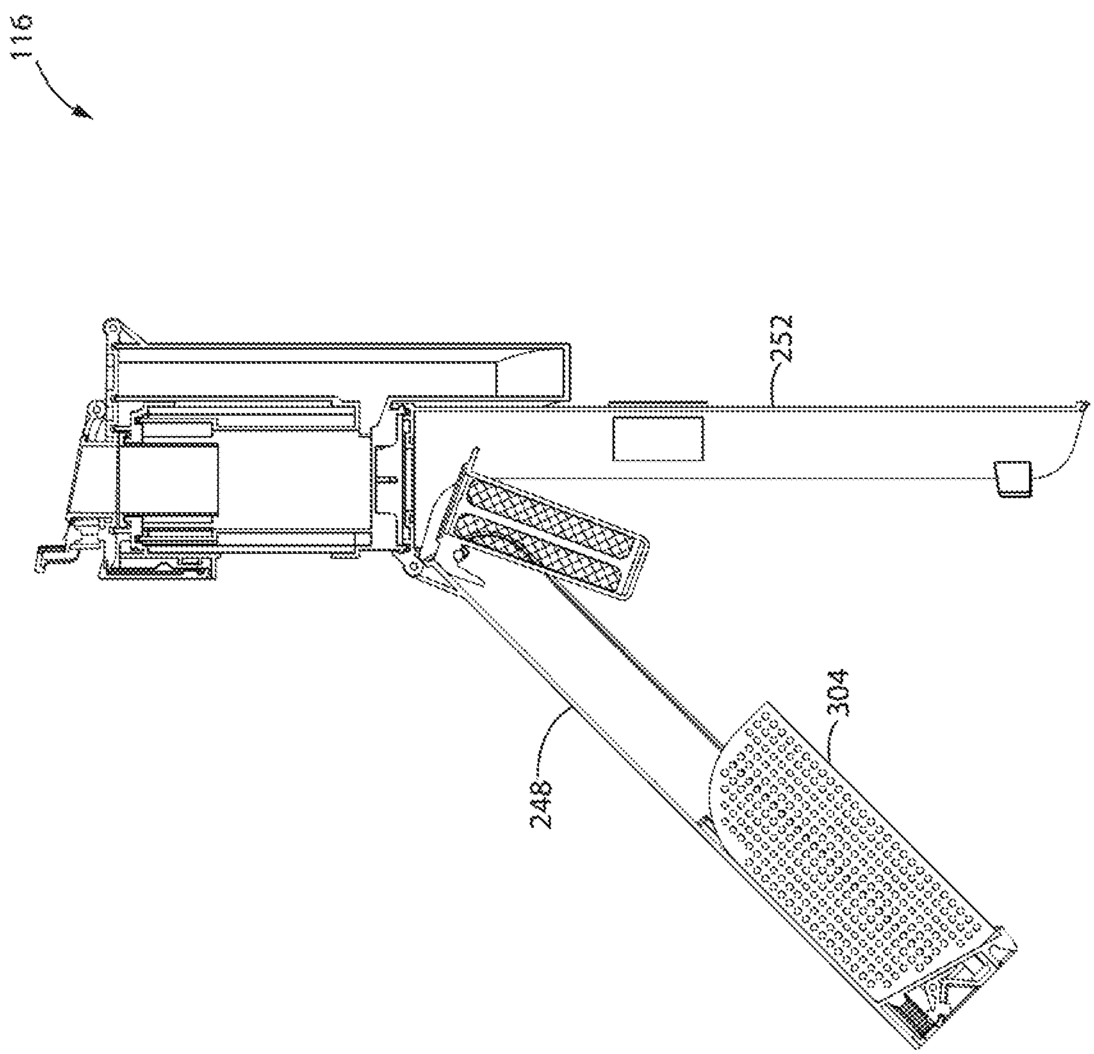
FIG. 6

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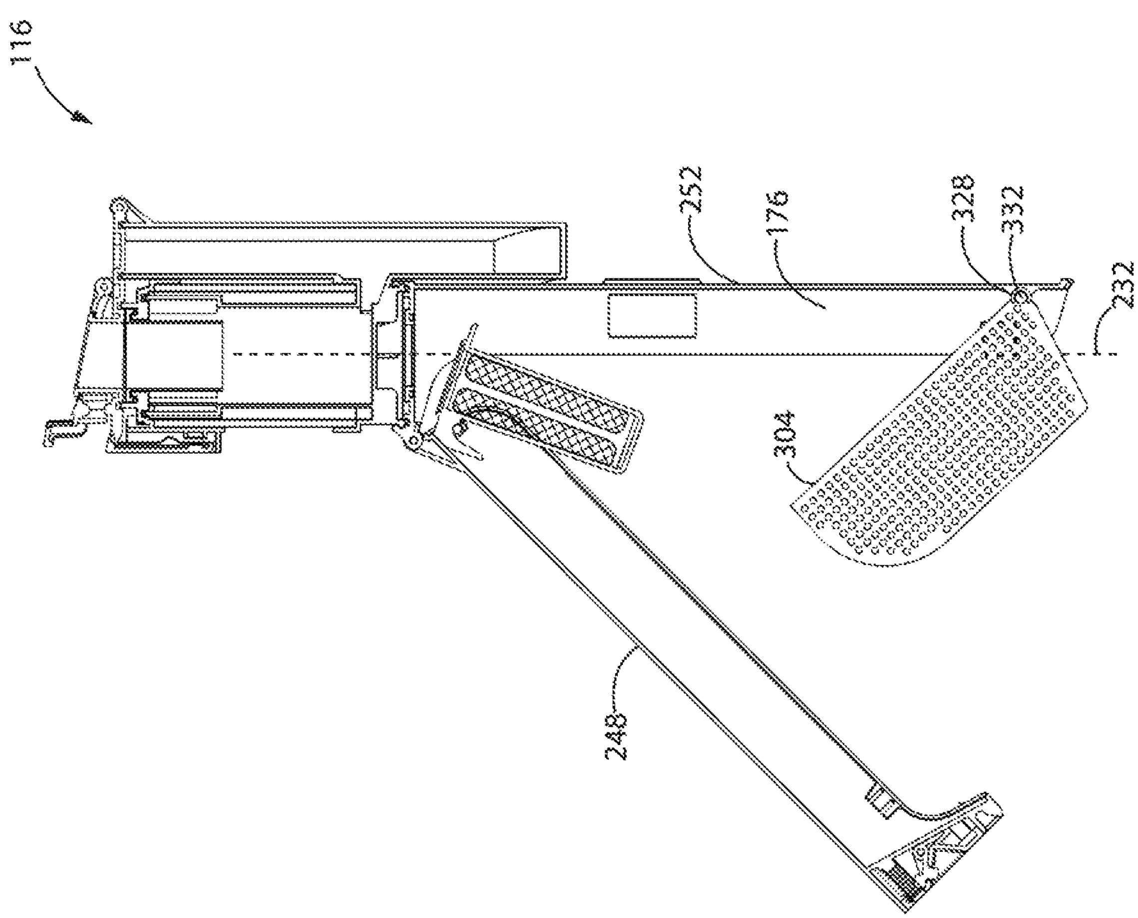


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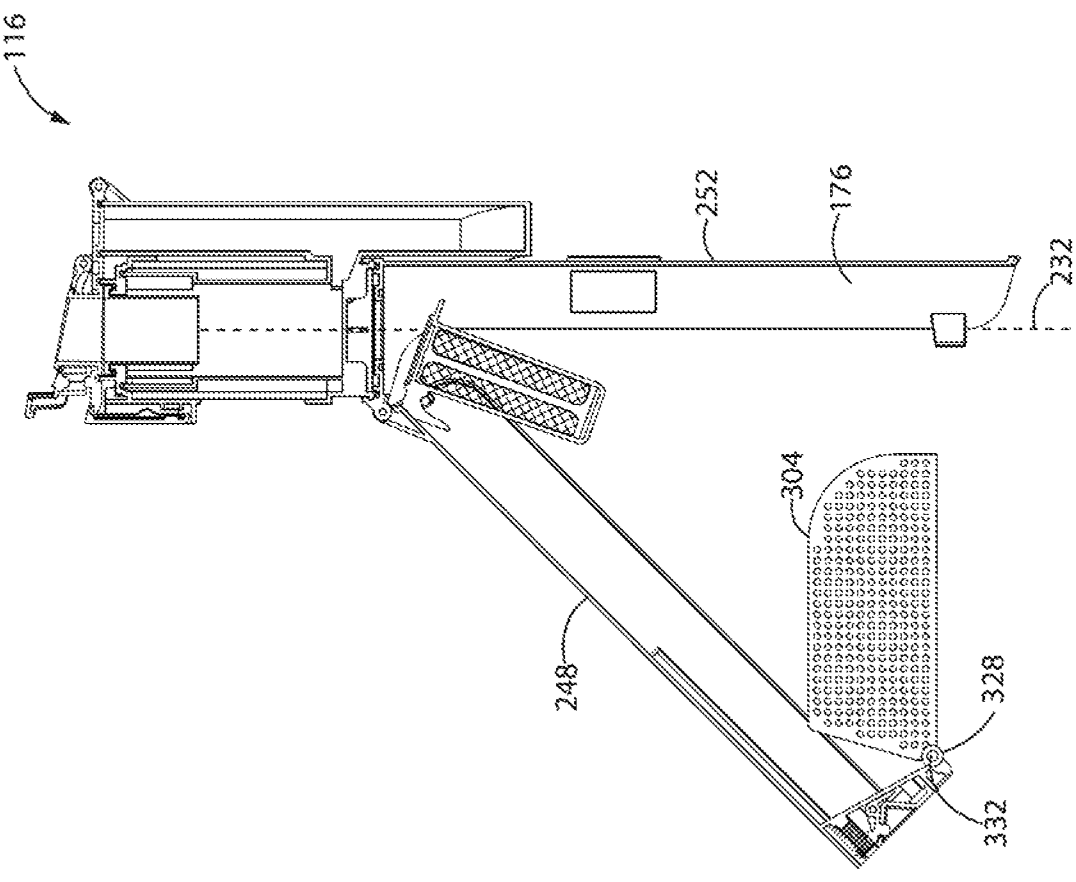


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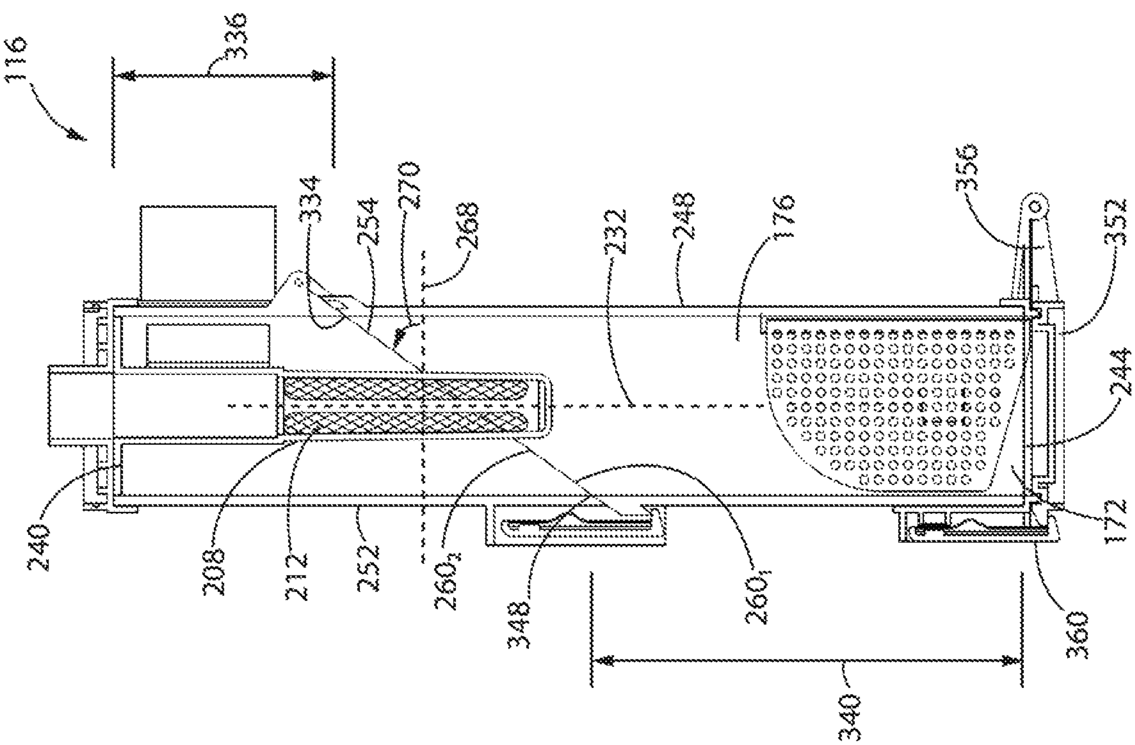
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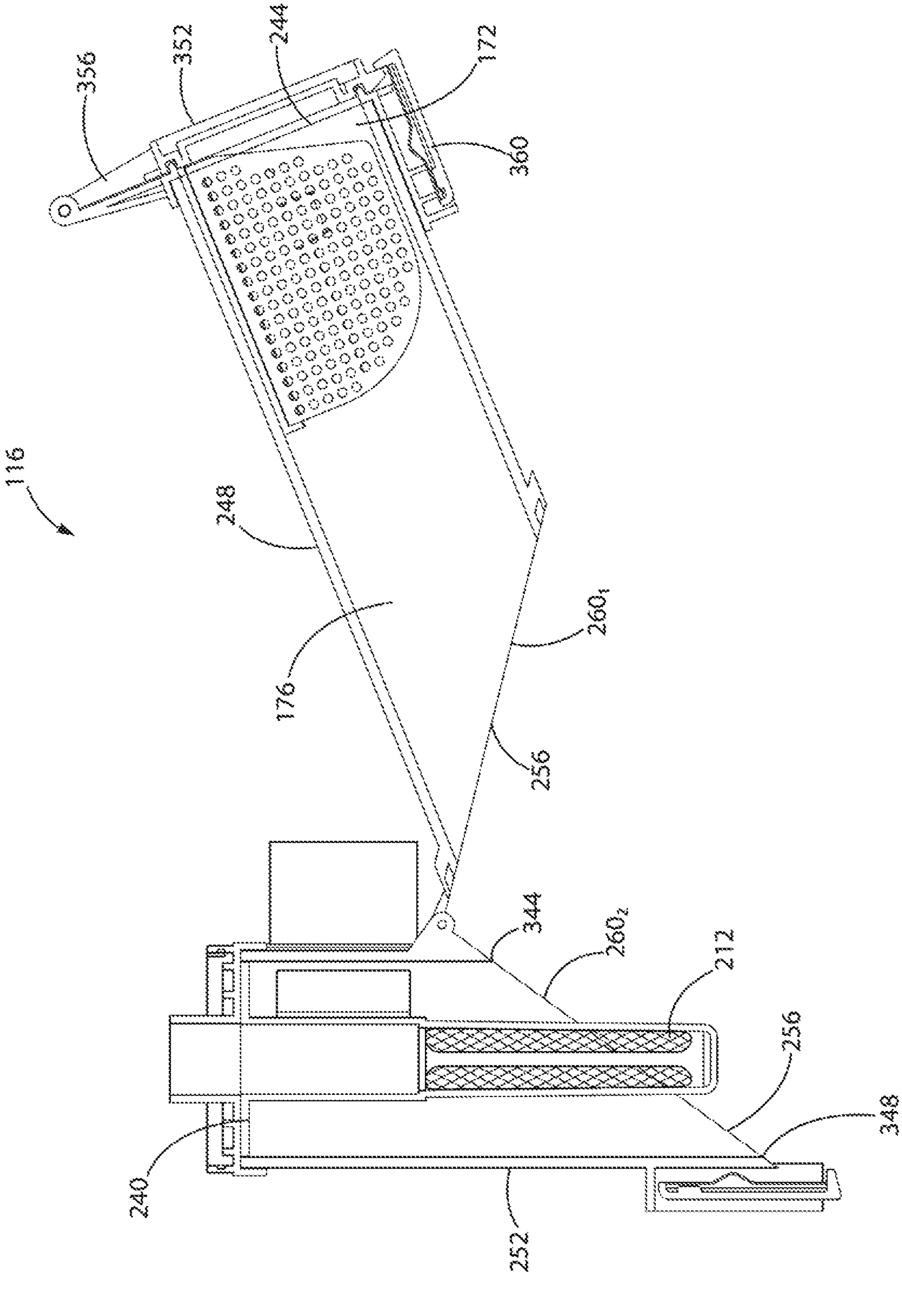
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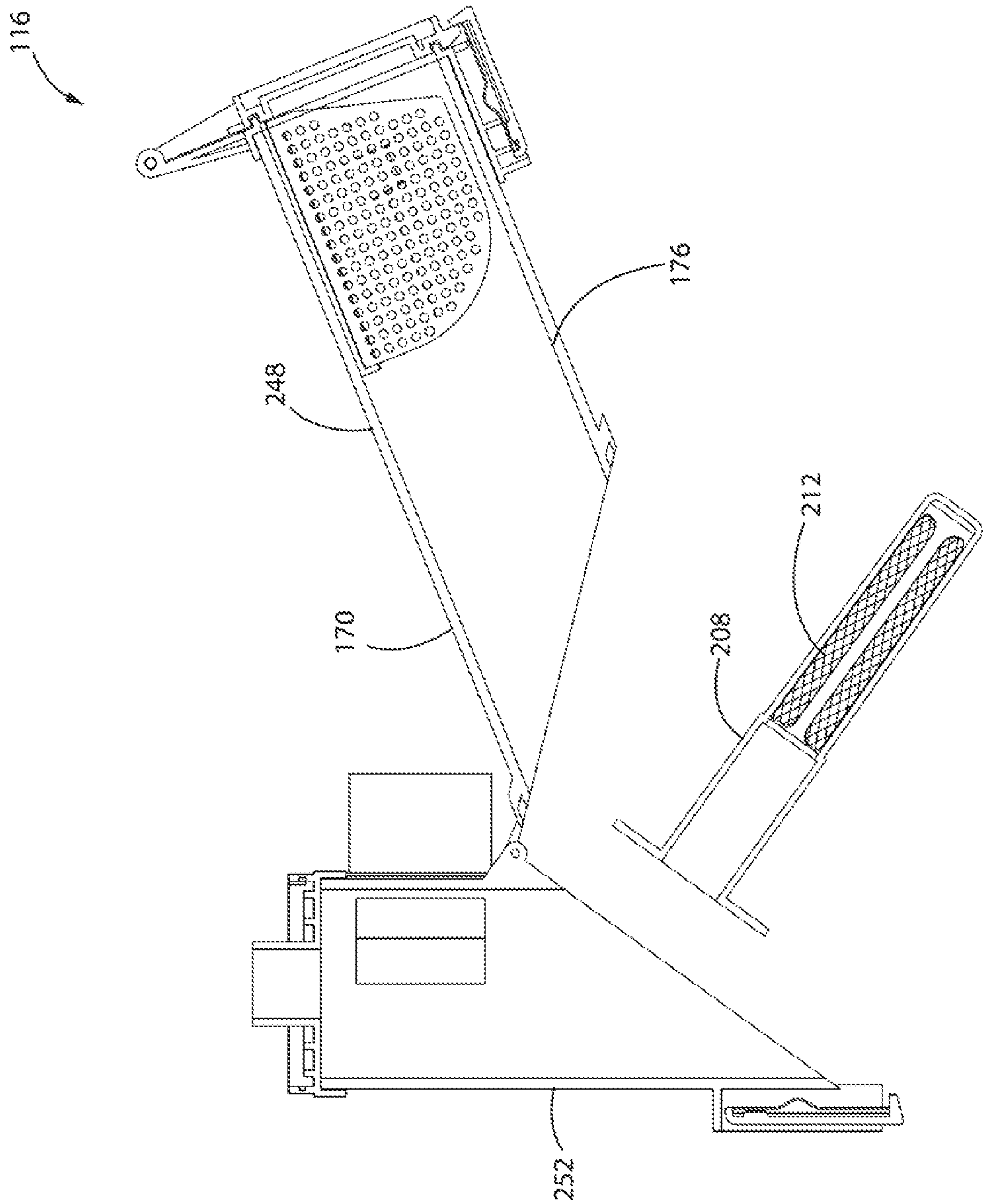
FIG. 11

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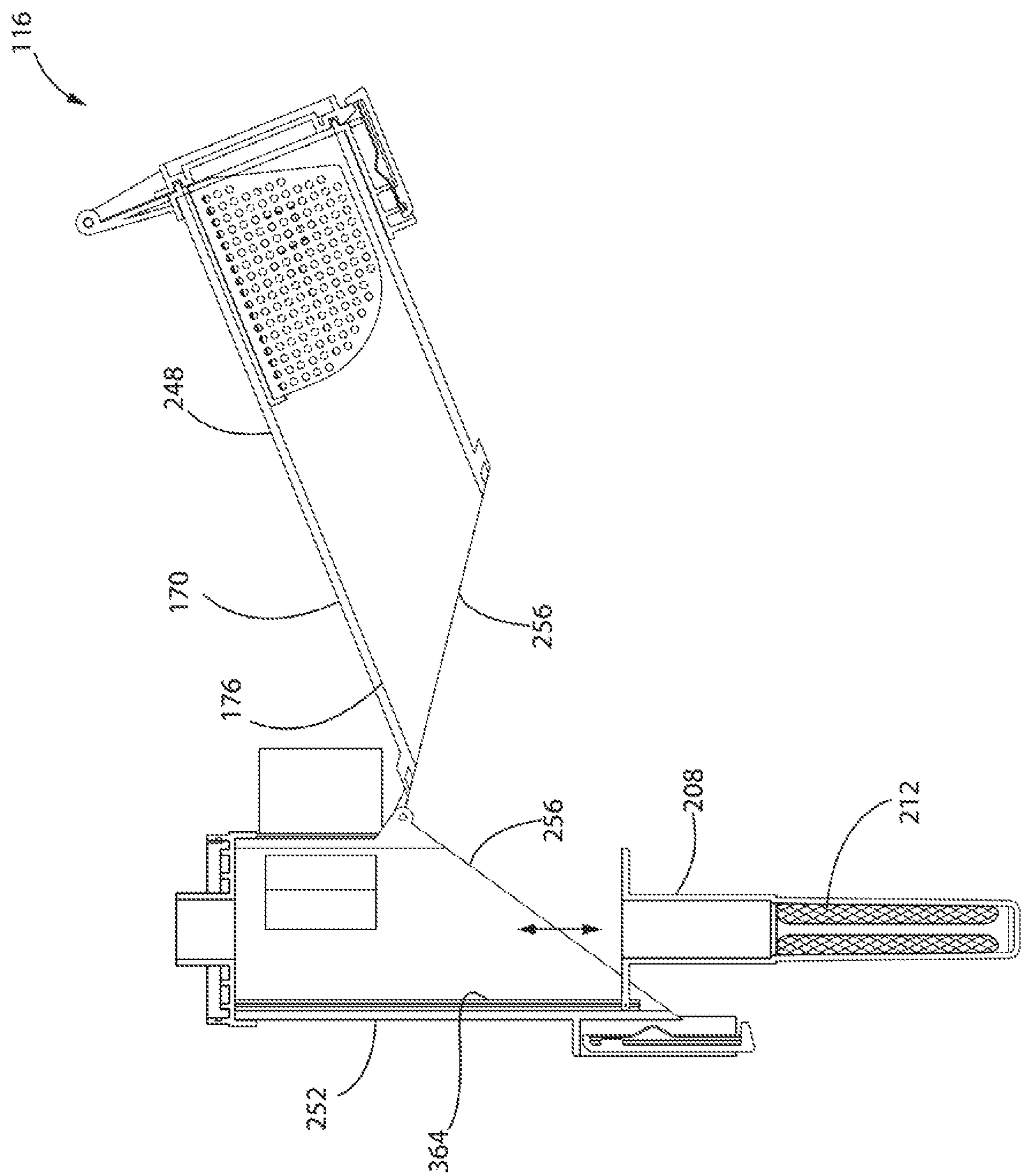


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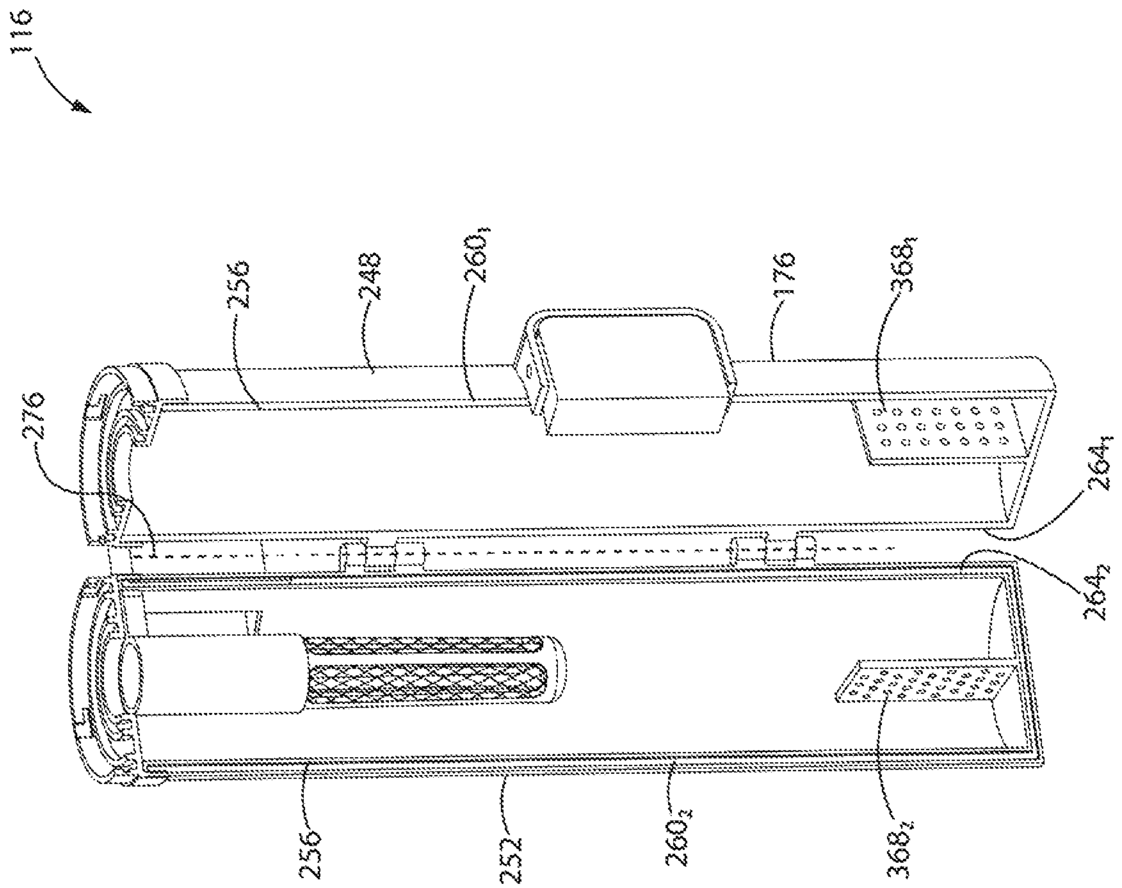


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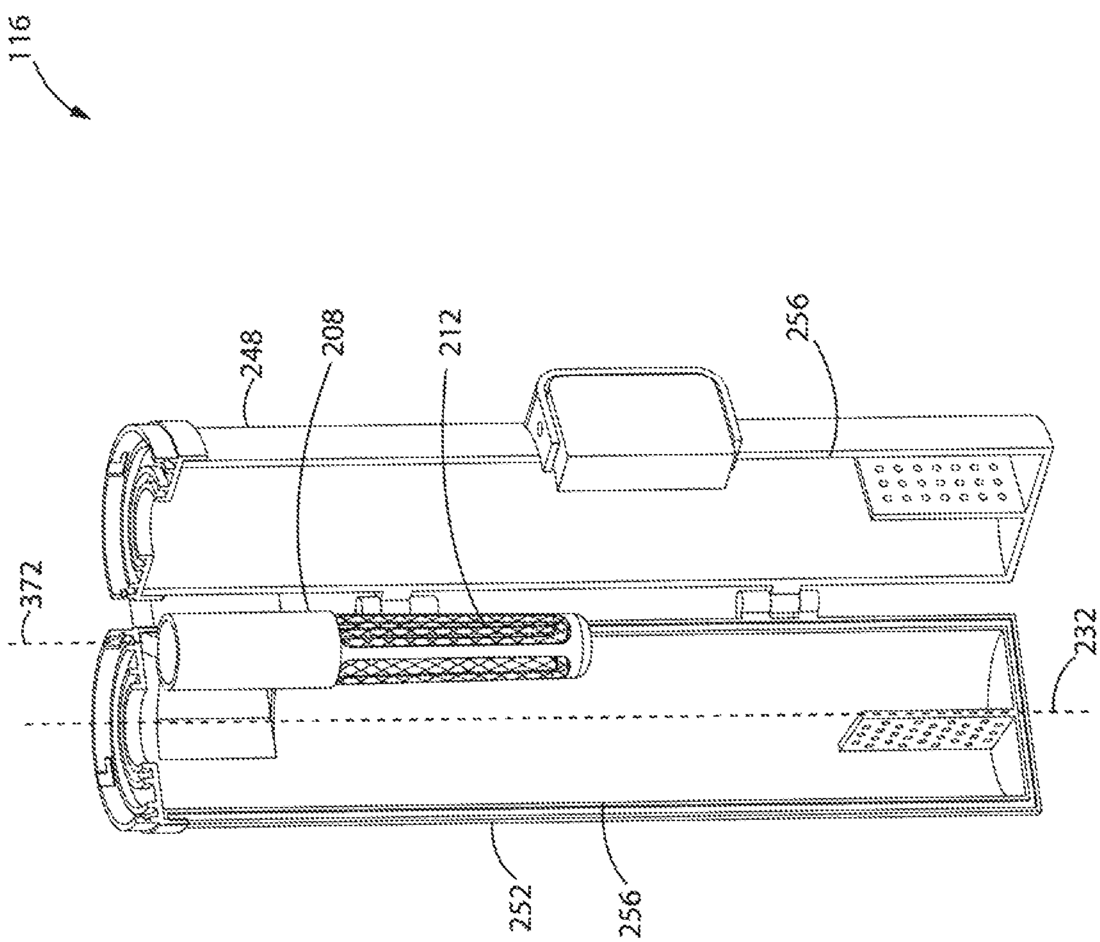


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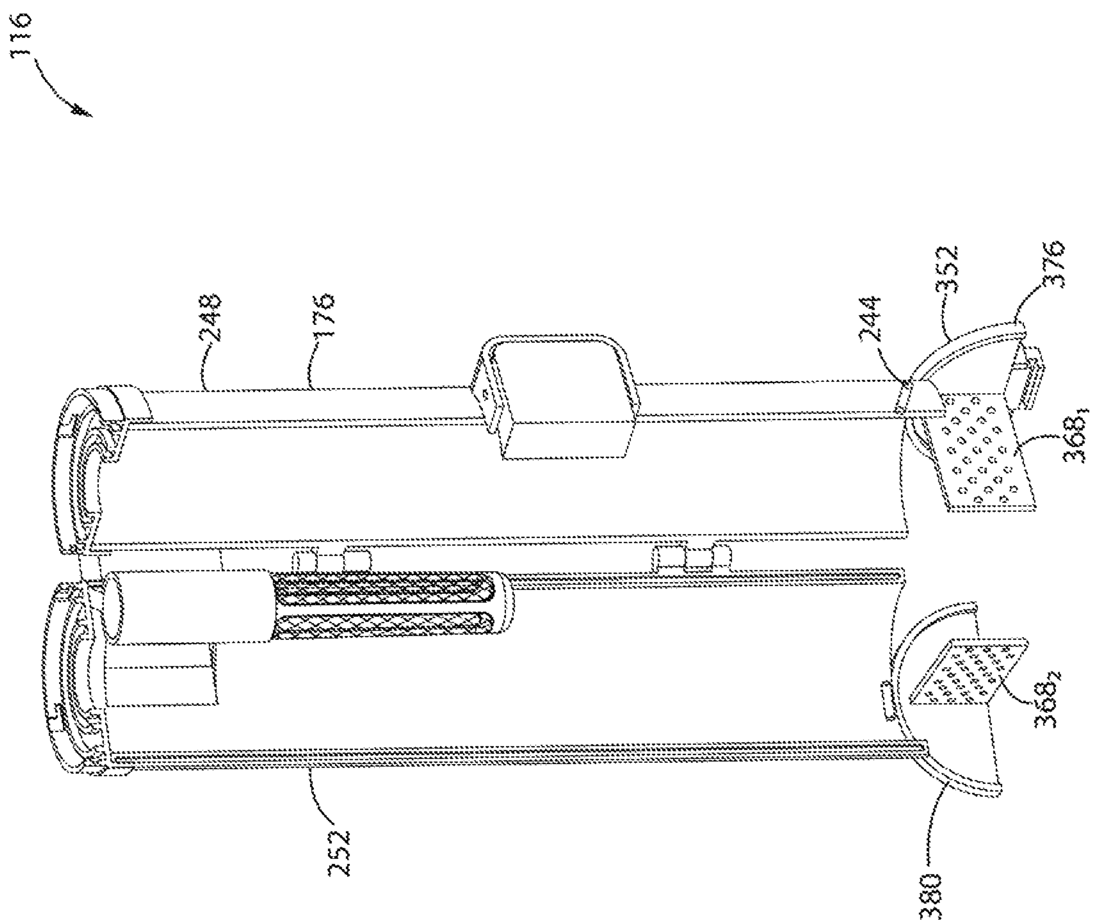


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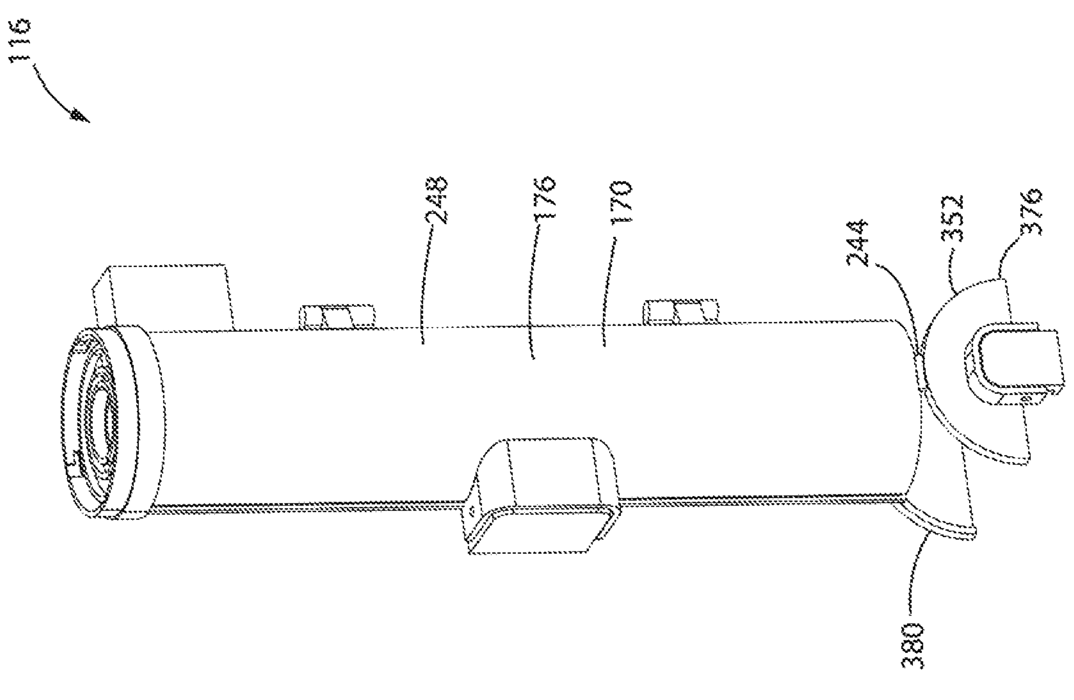
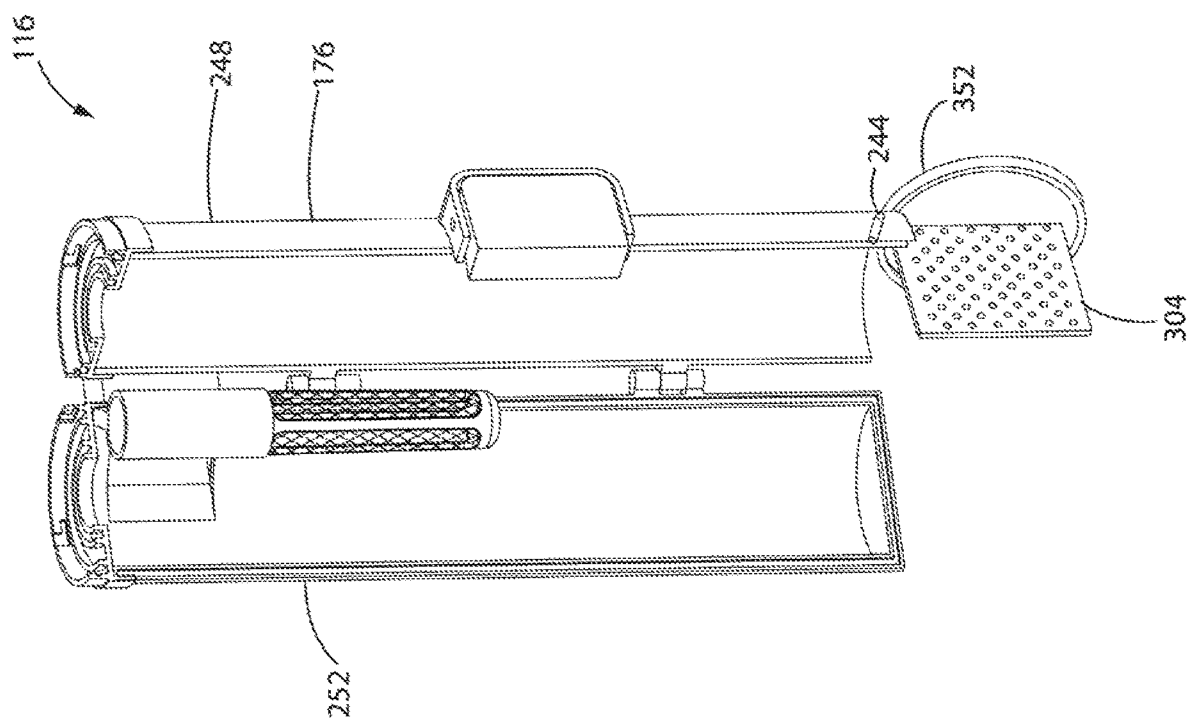



FIG. 17

FIG. 18



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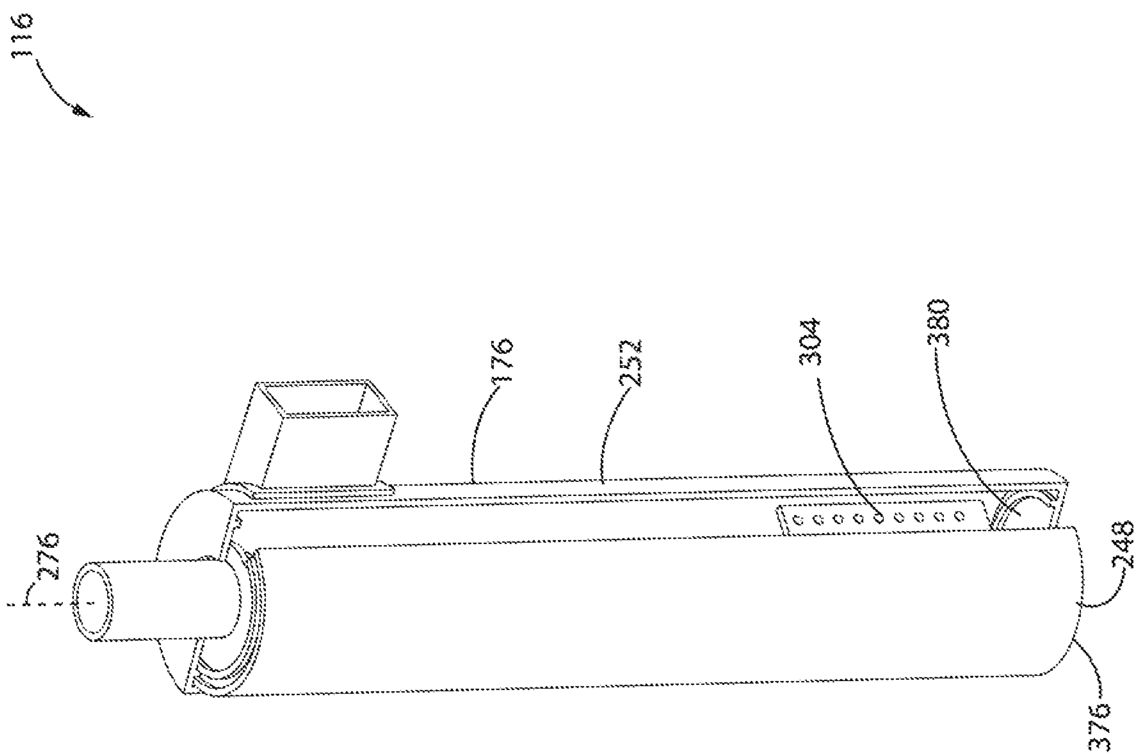


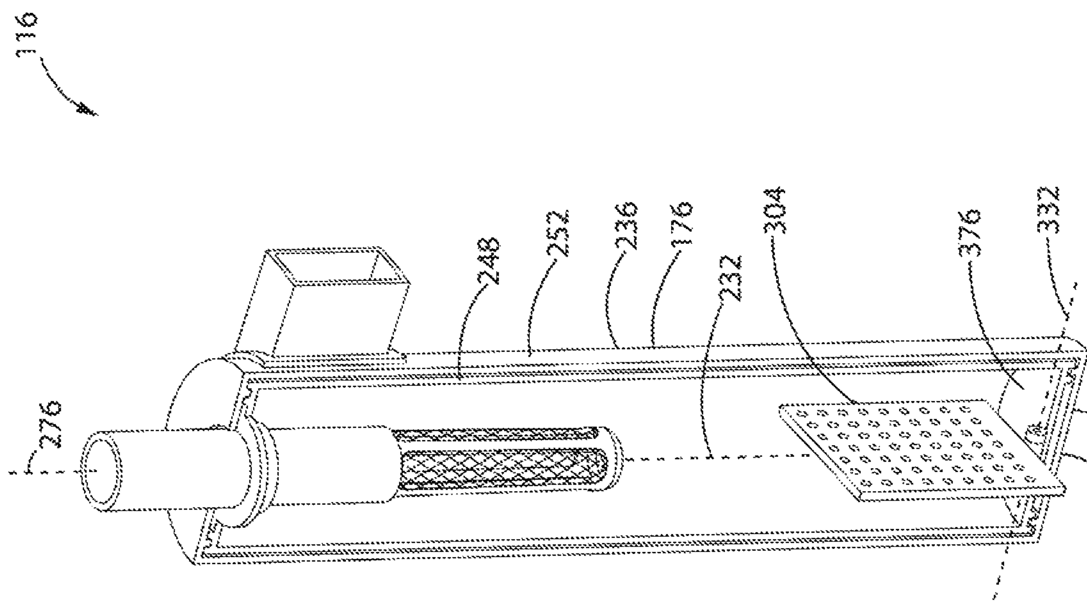
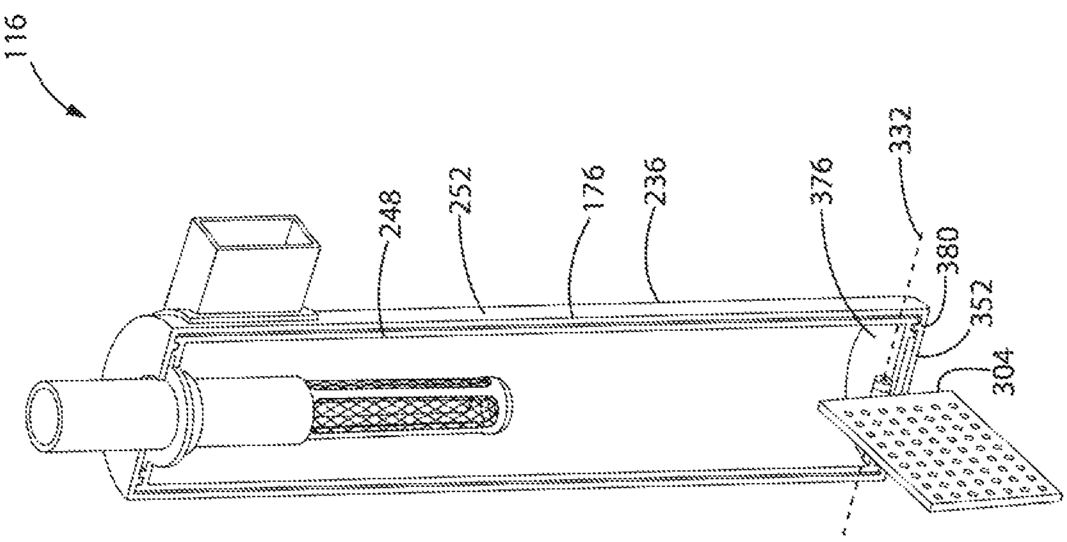
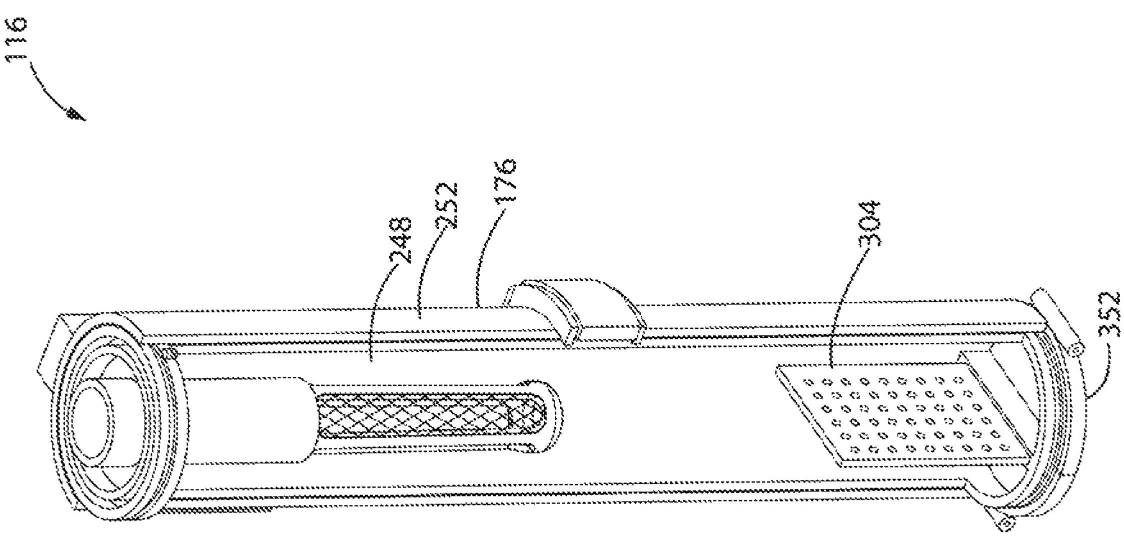



FIG. 20

FIG. 21



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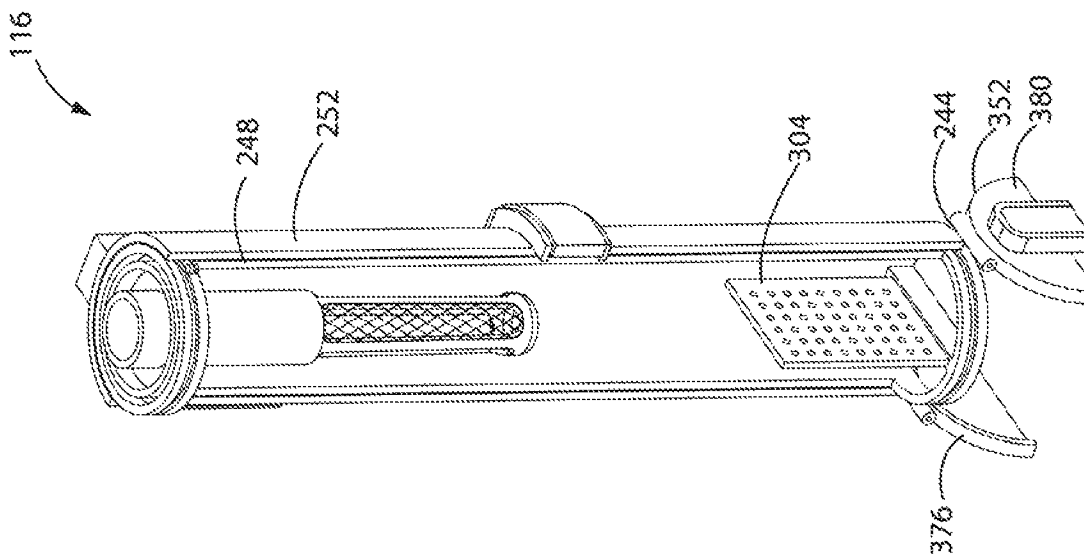


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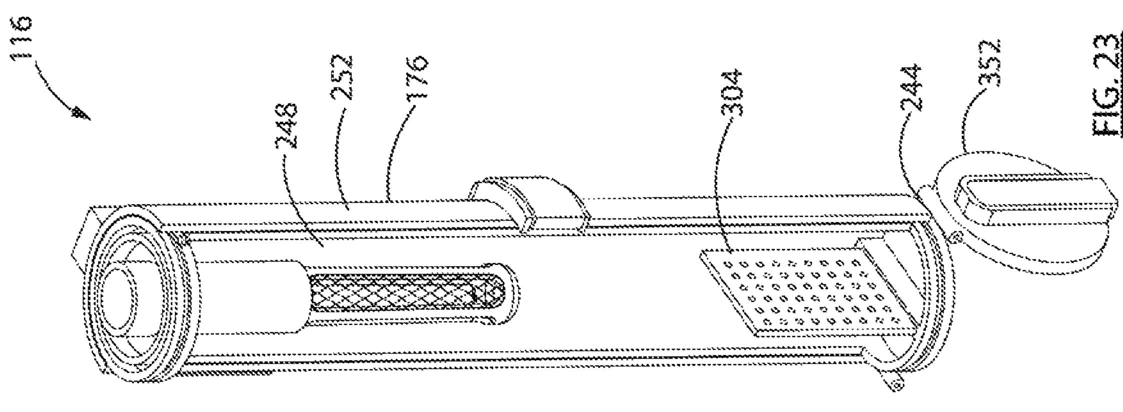
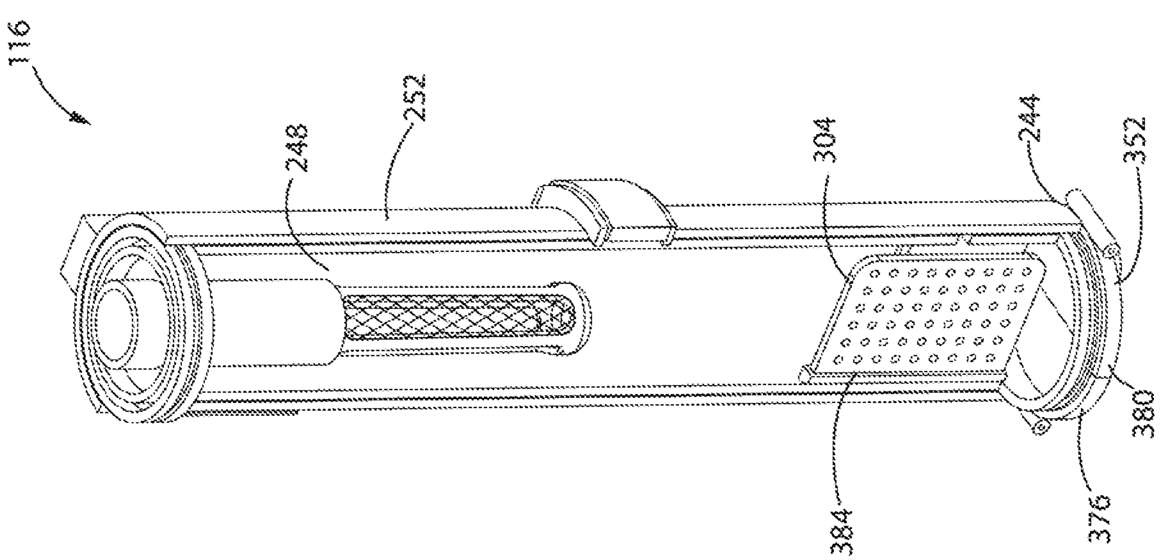
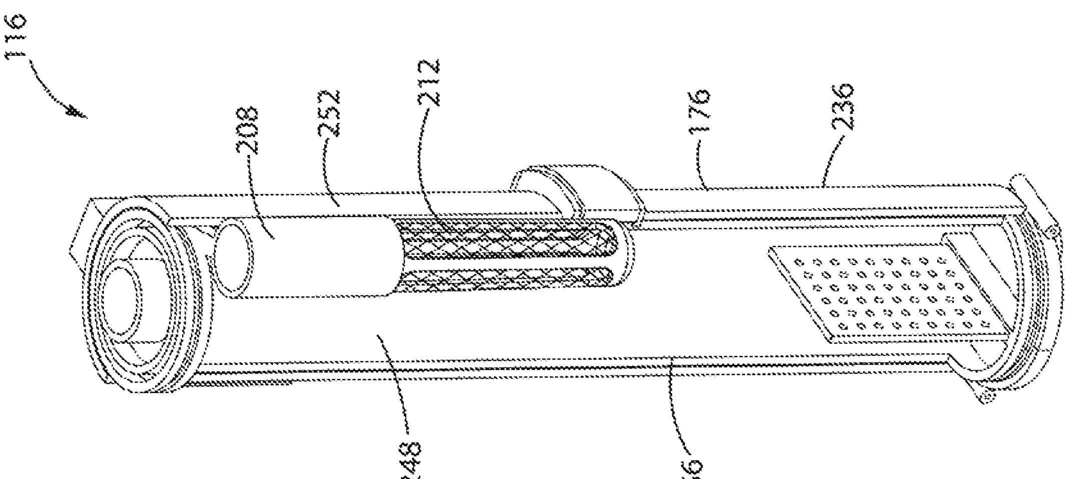



FIG. 23

FIG. 25



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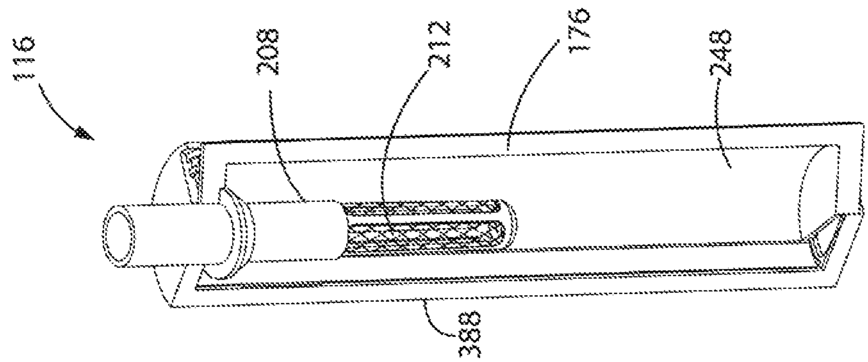


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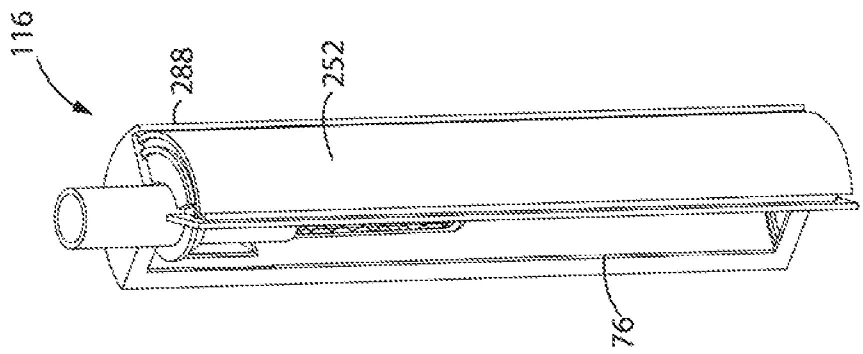


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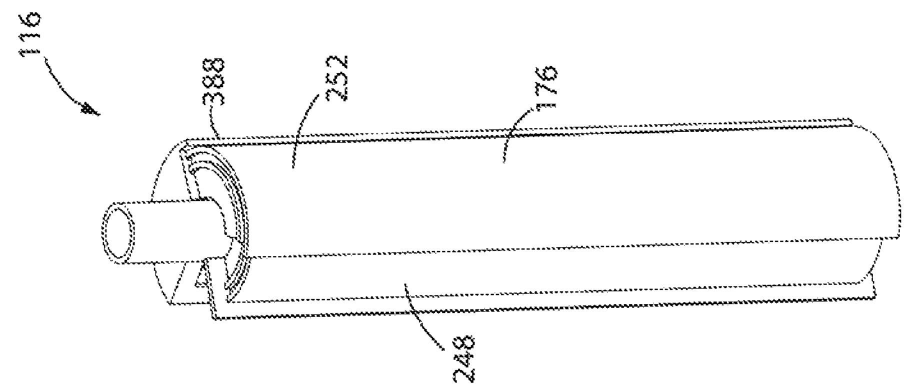


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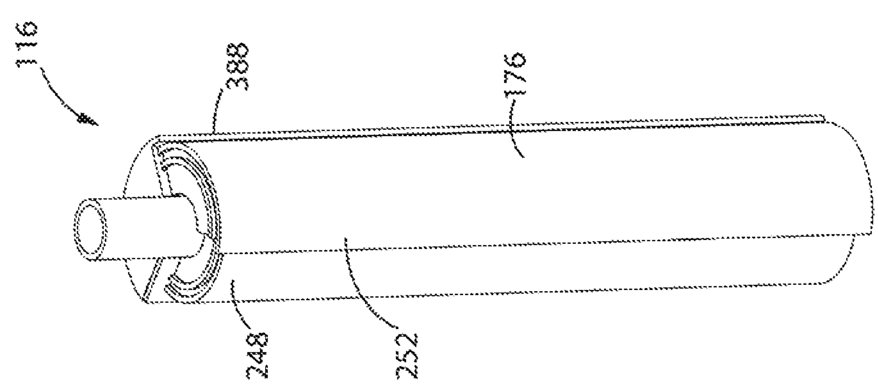
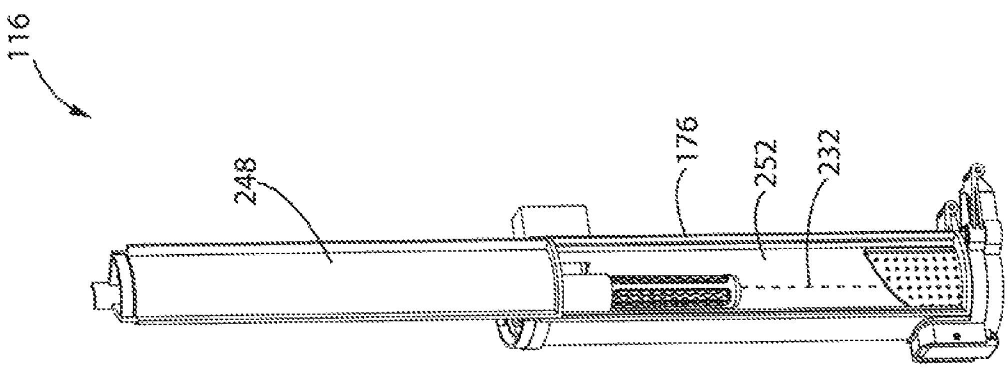
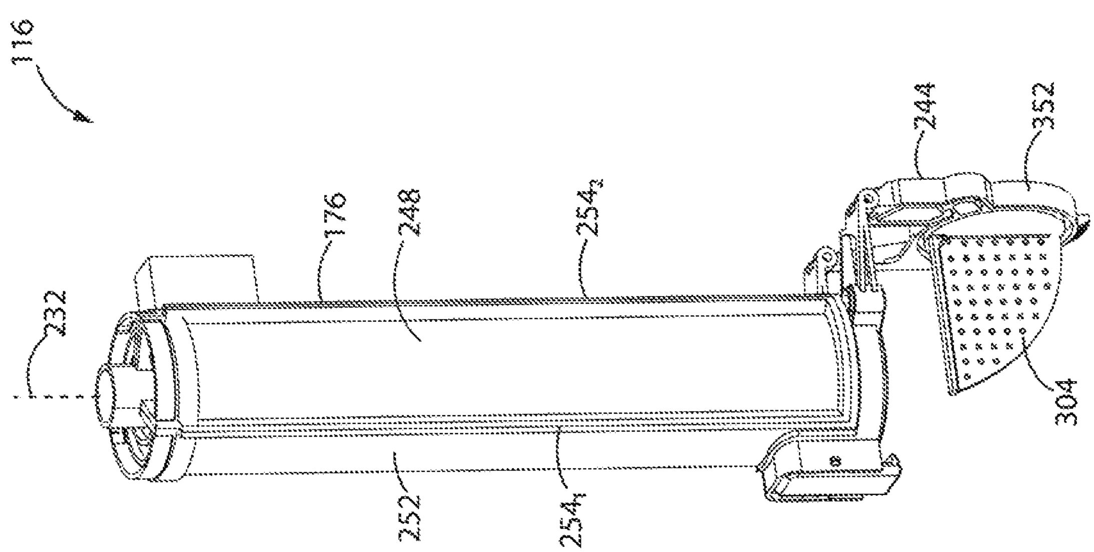



FIG. 27

FIG. 31



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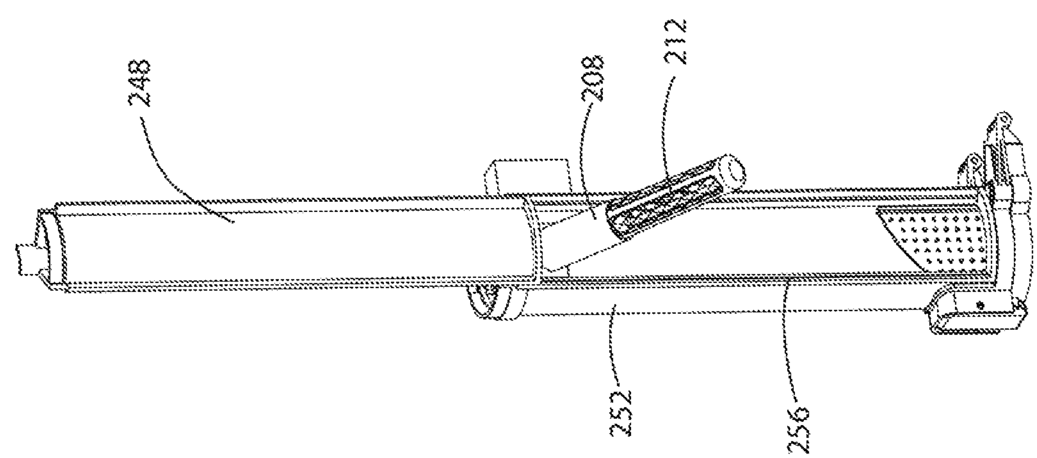


FIG. 33

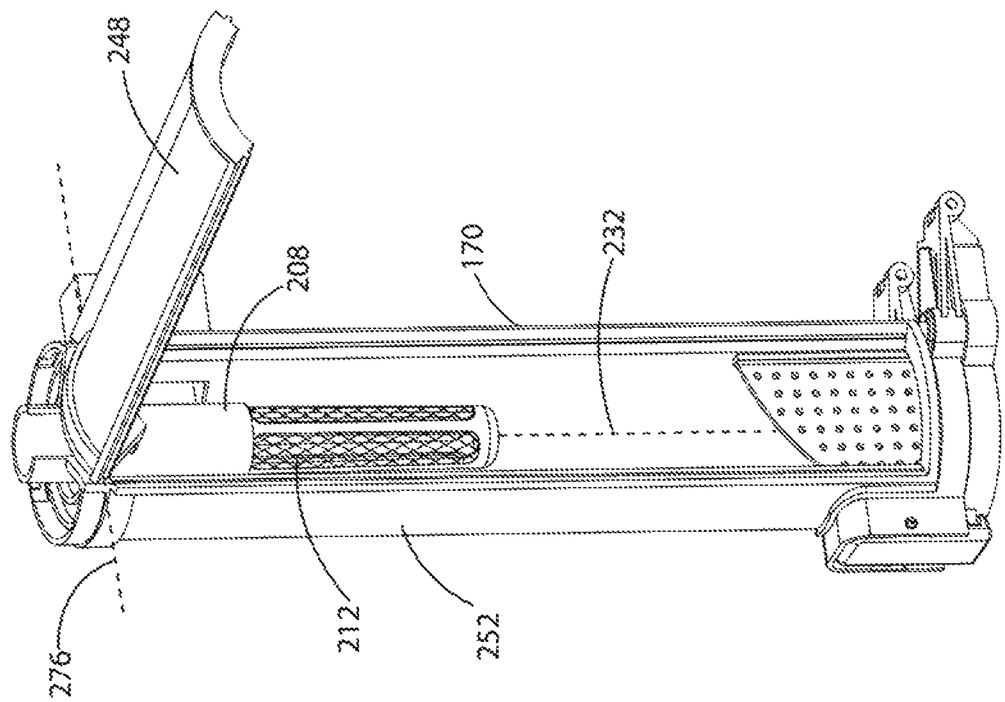


FIG. 34

# CYCLONIC AIR TREATMENT MEMBER AND SURFACE CLEANING APPARATUS INCLUDING THE SAME

## FIELD

This application relates to the field of cyclonic air treatment members and surface cleaning apparatus including the same.

## INTRODUCTION

The following is not an admission that anything discussed below is part of the prior art or part of the common general knowledge of a person skilled in the art.

Various types of surface cleaning apparatus are known, including upright surface cleaning apparatus, canister surface cleaning apparatus, stick surface cleaning apparatus, central vacuum systems, and hand carriable surface cleaning apparatus such as hand vacuums. Further, various designs for cyclonic hand vacuum cleaners, including battery operated cyclonic hand vacuum cleaners, are known in the art.

## SUMMARY

This summary is intended to introduce the reader to the more detailed description that follows and not to limit or define any claimed or as yet unclaimed invention. One or more inventions may reside in any combination or sub-combination of the elements or process steps disclosed in any part of this document including its claims and figures.

In one aspect, a cyclone assembly is provided wherein one or more portions of the sidewall of the cyclone chamber is moveable with respect to another portion of the cyclone sidewall (from a closed position to an open position) so as to open the sidewall and provide a wider opening at an end (e.g., a lower end) of the cyclone chamber. The wider opening assists a user in emptying the cyclone chamber. For example, if a hairball is formed in the cyclone chamber, a wider opening may allow the hairball to fall out of the cyclone chamber when the cyclone chamber sidewall is in the open position.

It will be appreciated that the sidewall may open along a plane that extends generally parallel to the axis of rotation of the cyclone chamber. Accordingly, a first sidewall portion and a second sidewall portion may meet at a juncture that extends generally axially. The juncture may extend along the entire length of the cyclone chamber or only part way from one axial end of the cyclone chamber part way towards another axial end of the cyclone chamber.

The cyclone chamber may also have an openable end wall at, e.g., the lower end of the cyclone chamber. The openable end wall may be openable concurrently with opening the sidewall or independently of opening the sidewall (e.g., prior to opening the sidewall or subsequently to opening the sidewall).

In accordance with this aspect, there is provided a surface cleaning apparatus comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;

(b) a cyclone bin assembly provided in the air flow path, the cyclone bin assembly comprising a cyclone chamber, a cyclone air inlet, a cyclone air outlet, a cyclone axis of rotation, an axially extending cyclone chamber sidewall extending between first and second axially opposed ends; and,

(c) a suction motor provided in the air flow path,

wherein the cyclone chamber sidewall has first portion that is moveably mounted with respect to a second portion of the cyclone chamber sidewall between a closed position in which the first and second portions meet at a first juncture and a second juncture and an open position in which the cyclone chamber is opened, and wherein the first juncture extends at an angle to a plane that is transverse to the cyclone axis of rotation.

The first juncture may extend generally axially.

The first portion may be pivotally mounted to the surface cleaning apparatus about a pivot axis and the pivot axis may extend through the cyclone chamber.

The cyclone air outlet may be provided at the first opposed end and the second opposed end may comprise an end wall that is moveable with the first portion.

The cyclone air outlet may comprise a screen and the screen may be moveably mounted with respect to one of the sidewall portions. Optionally, the screen may be pivotally mounted to one of the sidewall portions. Alternately, or in addition, the screen may be removable after the first portion is moved to the open position.

The cyclone air outlet may be provided at the first opposed end, the cyclone air outlet may comprise a screen, the second opposed end may comprise an end wall and the surface cleaning apparatus may further comprise a generally axially extending member provided in the cyclone chamber at the opposed end.

The cyclone air outlet may be provided at the first opposed end and the second opposed end may comprise an end wall that is moveable mounted with respect to the first and second portions. Optionally, the end wall may be pivotally mounted to one of the first and second portions.

The first portion may be pivotally mounted to the surface cleaning apparatus about a pivot axis and the pivot axis may extend generally axially.

The pivot axis may be positioned external to the cyclone chamber. For example, the pivot axis may comprise a piano hinge. Accordingly, the pivot axis may be aligned with the cyclone axis of rotation.

The pivot axis may extend through the cyclone chamber and each of the first and second portions may comprise an axial cylindrical segment. Accordingly, the first juncture may extend generally axially.

The second juncture may extend generally parallel to the first juncture and may be angularly spaced around the cyclone chamber from the first juncture, whereby the first portion is axially translatable with respect to the second portion.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the described embodiments and to show more clearly how they may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

FIG. **1** is a perspective view of a surface cleaning apparatus in accordance with an embodiment;

FIG. **2** is a cross-sectional view taken along line **2-2** in FIG. **1**;

FIG. **3** is a perspective view of a surface cleaning apparatus in accordance with an embodiment;

FIG. **4** is a cross-sectional view taken along line **4-4** in FIG. **3**;

FIG. **5** is a perspective view of an air treatment member in an open position, in accordance with an embodiment;

FIG. **6** is a cross-sectional view taken along line **6-6** in FIG. **5**;

FIG. **7** is a cross-sectional view taken along line **6-6** in FIG. **5**, in accordance with another embodiment;

FIG. **8** is a cross-sectional view taken along line **6-6** in FIG. **5**, in accordance with another embodiment;

FIG. **9** is a cross-sectional view taken along line **6-6** in FIG. **5**, in accordance with another embodiment;

FIG. **10** is a cross-sectional view of an air treatment member, in a closed position, in accordance with another embodiment;

FIG. **11** is a cross-sectional view of the air treatment member of FIG. **10**, in an open position;

FIG. **12** is a cross-sectional view of the air treatment member of FIG. **10**, in an open position, with a cyclone outlet passage removed in accordance with an embodiment;

FIG. **13** is a cross-sectional view of the air treatment member of FIG. **10**, in an open position, with the cyclone outlet passage translated in accordance with an embodiment;

FIG. **14** is a perspective view of an air treatment member in an open position, in accordance with an embodiment;

FIG. **15** is a perspective view of an air treatment member in an open position and with the cyclone outlet passage rotated out of a cyclone chamber, in accordance with an embodiment;

FIG. **16** is a perspective view of an air treatment member in an open position with the cyclone outlet passage rotated out of the cyclone chamber and an open end door in accordance with an embodiment;

FIG. **17** is a perspective view of the air treatment member of FIG. **16** with a closed sidewall and an open end door in accordance with an embodiment;

FIG. **18** is a perspective view of an air treatment member in an open position with an open end door in accordance with an embodiment;

FIG. **19** is a perspective view of an air treatment member with a sidewall portion opened slightly;

FIG. **20** is a perspective view of the air treatment member of FIG. **19** with the sidewall portion opened fully;

FIG. **21** is a perspective view of the air treatment member of FIG. **19** with the sidewall portion opened fully and an axially extending member rotated;

FIG. **22** is a perspective view of an air treatment member in an open position in accordance with an embodiment;

FIG. **23** is a perspective view of an air treatment member in an open position and with an open end door in accordance with an embodiment;

FIG. **24** is a perspective view of the air treatment member of FIG. **22** in the open position and with open end doors;

FIG. **25** is a perspective view of an air treatment member in an open position in accordance with an embodiment;

FIG. **26** is a perspective view of the air treatment member of FIG. **25** in the open position with the cyclone outlet passage rotated out of the cyclone chamber;

FIGS. **27-30** are perspective views of the air treatment member transitioning from a closed position in FIG. **27** to an open position in FIG. **30**, in accordance with an embodiment;

FIG. **31** is a perspective view of an air treatment member with an axially translatable sidewall portion, in an open position, in accordance with an embodiment;

FIG. **32** is a perspective view of the air treatment member of FIG. **31** with the sidewall portion in a closed position and an open end wall;

FIG. **33** is a perspective view of the air treatment member of FIG. **31** in an open position with the cyclone outlet passage rotated out of the cyclone chamber in accordance with an embodiment; and,

FIG. **34** is a perspective view of an air treatment member in an open position in accordance with an embodiment.

## DESCRIPTION OF EXAMPLE EMBODIMENTS

Numerous embodiments are described in this application, and are presented for illustrative purposes only. The described embodiments are not intended to be limiting in any sense. The invention is widely applicable to numerous embodiments, as is readily apparent from the disclosure herein. Those skilled in the art will recognize that the present invention may be practiced with modification and alteration without departing from the teachings disclosed herein. Although particular features of the present invention may be described with reference to one or more particular embodiments or figures, it should be understood that such features are not limited to usage in the one or more particular embodiments or figures with reference to which they are described.

The terms "an embodiment," "embodiment," "embodiments," "the embodiment," "the embodiments," "one or more embodiments," "some embodiments," and "one embodiment" mean "one or more (but not all) embodiments of the present invention(s)," unless expressly specified otherwise.

The terms "including," "comprising" and variations thereof mean "including but not limited to," unless expressly specified otherwise. A listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an" and "the" mean "one or more," unless expressly specified otherwise.

As used herein and in the claims, two or more parts are said to be "coupled", "connected", "attached", "joined", "affixed", or "fastened" where the parts are joined or operate together either directly or indirectly (i.e., through one or more intermediate parts), so long as a link occurs. As used herein and in the claims, two or more parts are said to be "directly coupled", "directly connected", "directly attached", "directly joined", "directly affixed", or "directly fastened" where the parts are connected in physical contact with each other. As used herein, two or more parts are said to be "rigidly coupled", "rigidly connected", "rigidly attached", "rigidly joined", "rigidly affixed", or "rigidly fastened" where the parts are coupled so as to move as one while maintaining a constant orientation relative to each other. None of the terms "coupled", "connected", "attached", "joined", "affixed", and "fastened" distinguish the manner in which two or more parts are joined together.

Further, although method steps may be described (in the disclosure and/or in the claims) in a sequential order, such methods may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of methods described herein may be performed in any order that is practical. Further, some steps may be performed simultaneously.

As used herein and in the claims, two elements are said to be "parallel" where those elements are parallel and spaced apart, or where those elements are collinear.

Some elements herein may be identified by a part number, which is composed of a base number followed by an alphabetical or subscript-numerical suffix (e.g. **112*a***, or $\mathbf{112}_1$). Multiple elements herein may be identified by part numbers that share a base number in common and that differ by their suffixes (e.g. $\mathbf{112}_1$, $\mathbf{112}_2$, and $\mathbf{112}_3$). All elements with a common base number may be referred to collectively or generically using the base number without a suffix (e.g. **112**).

General Description of a Hand Vacuum Cleaner

Referring to FIGS. **1-4**, the following is a general discussion of embodiments of an apparatus **100**, which provides a basis for understanding several of the features that are discussed herein. As discussed subsequently, each of the features may be used individually or in any particular combination or sub-combination in these or in other embodiments disclosed herein.

Embodiments described herein include an improved cyclonic air treatment member **116**, and a surface cleaning apparatus **100** including the same. Surface cleaning apparatus **100** may be any type of surface cleaning apparatus, including for example a hand vacuum cleaner as shown in FIG. **1-2**, a stick vacuum cleaner, an upright vacuum cleaner as shown in FIG. **3-4**, a canister vacuum cleaner, an extractor, or a wet/dry type vacuum cleaner.

In FIGS. **1-2**, surface cleaning apparatus **100** is illustrated as a hand vacuum cleaner, which may also be referred to also as a "handvac" or "hand-held vacuum cleaner". As used herein, a hand vacuum cleaner is a vacuum cleaner that can be operated to clean a surface generally one-handedly. That is, the entire weight of the vacuum may be held by the same one hand used to direct a dirty air inlet of the vacuum cleaner with respect to a surface to be cleaned. For example, handle **104** and dirty air inlet **108** may be rigidly coupled to each other (directly or indirectly), such as being integrally formed or separately molded and then non-removably secured together (e.g. adhesive or welding), so as to move as one while maintaining a constant orientation relative to each other. This is to be contrasted with canister and upright vacuum cleaners, whose weight is typically supported by a surface (e.g. a floor) during use. When a canister vacuum cleaner is operated, or when an upright vacuum cleaner is operated in a 'lift-away' configuration, a second hand is typically required to direct the dirty air inlet at the end of a flexible hose.

In the example of FIGS. **3-4**, upright vacuum cleaner **100** is shown including an upright section **120**. Handle **104** is connected to an upper end **124** of upright section **120**, and a surface cleaning head **128** (also referred to as a 'floor cleaning head') is movably (e.g. pivotably) connected to a lower end **132** of upright section **120**. Upright section **120** may be movable (e.g. pivotable) relative to surface cleaning head **128** between a storage position (shown) and a rearwardly reclined floor cleaning position.

Referring to FIGS. **1-4**, surface cleaning apparatus **100** includes an air treatment member **116** (which may be permanently affixed to the main body or may be removable in part or in whole therefrom for emptying), a dirty air inlet **108**, a clean air outlet **112**, and an air flow path **136** extending between the dirty air inlet **108** and the clean air outlet **112**.

Surface cleaning apparatus **100** has a front end **140**, a rear end **144**, an upper end (also referred to as the top) **148**, and a lower end (also referred to as the bottom) **152**. In the embodiment of FIGS. **1-2**, dirty air inlet **108** is at a lower portion of apparatus front end **140** and clean air outlet **112** is at a rearward portion of apparatus **100** proximate apparatus rear end **144**.

It will be appreciated that dirty air inlet **108** and clean air outlet **112** may be positioned in different locations of apparatus **100**. For example, FIGS. **3-4** show an example in which dirty air inlet **108** is located at a lower end **156** of surface cleaning head **128**, and clean air outlet **112** is located on apparatus front end **140**.

Referring again to FIGS. **1-4**, a suction motor **160** is provided to generate vacuum suction through air flow path **136**, and is positioned within a motor housing **164**. Suction motor **160** may be a fan-motor assembly including an electric motor and impeller blade(s). In the illustrated embodiment, suction motor **160** is positioned in the air flow path **136** downstream of air treatment member **116**. In this configuration, suction motor **160** may be referred to as a "clean air motor". Alternatively, suction motor **160** may be positioned upstream of air treatment member **116**, and referred to as a "dirty air motor".

In the illustrated embodiments, apparatus **100** is shown having two cyclonic cleaning stages $\mathbf{168}_1$ and $\mathbf{168}_2$ arranged in series with each other. It will be appreciated that air treatment member **116** may include a single cleaning stage (e.g., first cyclonic cleaning stage $\mathbf{168}_1$ or second cyclonic cleaning stage $\mathbf{168}_2$) or two or more cyclonic cleaning stages (e.g., both first and second cleaning stages $\mathbf{168}_1$ and $\mathbf{168}_2$). Each cyclonic cleaning stage **168** may include one cyclone **170** as shown, or many cyclones arranged in parallel with each other, and may include one dirt collection chamber **172** or many dirt collection chambers **172**, of any suitable configuration. For example, FIG. **2** exemplifies an embodiment wherein second cyclonic cleaning stage $\mathbf{168}_2$ includes a cyclone chamber **176** having a dirt outlet **178** to an external dirt collection chamber **172**. Each cyclone **170** may have its own dirt collection chamber as shown. Alternatively or in addition, two or more cyclones **170** may share a common dirt collection chamber. Alternately, as also exemplified in FIG. **2**, a cyclone $\mathbf{168}_1$ may have a dirt collection region in a portion of the cyclone chamber (e.g., a lower end of a cyclone chamber or an end of the cyclone chamber distal to the air outlet end of the cyclone chamber).

Air treatment member **116** is configured to remove particles of dirt and other debris from the air flow. In the illustrated example, air treatment member **116** includes a cyclone assembly (also referred to as a "cyclone bin assembly") having at least a first cyclonic cleaning stage $\mathbf{168}_1$ with a cyclone **170** and a dirt collection chamber **172** (also referred to as a "dirt collection region", "dirt collection bin", "dirt bin", or "dirt chamber"). Cyclone **170** has a cyclone chamber **176**. As exemplified, dirt collection chamber **172** may be external to the cyclone chamber **176** (i.e. dirt collection chamber **172** may have a discrete volume from that of cyclone chamber **176**), or dirt collection chamber **172** may be a dirt collection region located partially or entirely within a volume of cyclone chamber **176**. Cyclone **170** and dirt collection chamber **172** may be of any configuration suitable for separating dirt from an air stream and collecting the separated dirt respectively.

Referring to FIGS. **2** and **4**, surface cleaning apparatus **100** may include a pre-motor filter **180** provided in the air flow path **136** downstream of air treatment member **116** and upstream of suction motor **160**. Pre-motor filter **180** may be formed from any suitable physical, porous filter media. For example, pre-motor filter **180** may be one or more of a foam filter, felt filter, HEPA filter, or other physical filter media. In some embodiments, pre-motor filter **180** may include an electrostatic filter, or the like. As shown, pre-motor filter **180** may be located in a pre-motor filter housing **184** that is external to the air treatment member **116**.

As shown in FIG. **2**, dirty air inlet **108** may be the inlet end **188** of an air inlet conduit **192**. Optionally, inlet end **188** of air inlet conduit **192** can be used as a nozzle to directly clean a surface. Alternatively, or in addition to functioning as a nozzle, air inlet conduit **192** may be connected (e.g. directly connected) to the downstream end of any suitable accessory tool such as a rigid air flow conduit (e.g., an above floor cleaning wand), a crevice tool, a mini brush, and the like. As shown, dirty air inlet **108** may be positioned forward of air treatment member **116**, although this need not be the case.

In the embodiments of FIGS. **2** and **4**, the air treatment member **116** comprises one or more cyclonic cleaning stages **168**, the air treatment air inlet is a cyclone air inlet **196** (e.g. a tangential air inlet of first stage $\mathbf{168_1}$), and the air treatment member air outlet is a cyclone air outlet **204** (e.g. of second stage $\mathbf{168_2}$). In operation, after activating suction motor **160**, dirty air enters apparatus **100** through dirty air inlet **108** and is directed along air inlet conduit **192** to the cyclone air inlet **196** of first stage $\mathbf{168_1}$. As shown, cyclone air inlet **196** may direct the dirty air flow to enter cyclone chamber **176** in a tangential direction so as to promote cyclonic action. Dirt particles and other debris may be disentrained (i.e. separated) from the dirty air flow as the dirty air flow travels through first cyclonic stage $\mathbf{168_1}$—from the respective cyclone air inlet **196** to cyclone air outlet **204**. The disentrained dirt particles and debris may collect in dirt collection chamber or region **172** of first stage $\mathbf{168_1}$, where the dirt particles and debris may be stored until the dirt collection region is emptied. From cyclone air outlet **204**, the air may flow downstream through second stage $\mathbf{168_2}$—from the respective cyclone air inlet(s) **196** to cyclone air outlet **204**, whereby separated dirt particles may discharge through dirt outlet **178** into dirt collection chamber **172**.

Air exiting a cyclone chamber **176** may pass through an outlet passage **208** located upstream of the cyclone air outlet **204**. Cyclone chamber outlet passage **208** may also act as a vortex finder to promote cyclonic flow within cyclone chamber **176**. In some embodiments, cyclone outlet passage **208** may include a screen or shroud **212** (e.g. a fine mesh screen) in the air flow path **136** to remove large dirt particles and debris, such as hair, remaining in the exiting air flow.

From cyclone air outlet **204** of second stage $\mathbf{168_2}$, the air flow may be directed into pre-motor filter housing **184** at an upstream side **216** of pre-motor filter **180**. The air flow may pass through pre-motor filter **180**, and then exit through pre-motor filter housing air outlet **220** into motor housing **164**. At motor housing **164**, the clean air flow may be drawn into suction motor **160** and then discharged from apparatus **100** through clean air outlet **112**. Prior to exiting the clean air outlet **112**, the treated air may pass through a post-motor filter **224**, which may include one or more layers of filter media.

Power may be supplied to suction motor **160** and other electrical components of apparatus **100** from an onboard energy storage member **228** (FIG. **2**) which may include, for example, one or more batteries or other energy storage device. In the example of FIG. **2**, apparatus **100** includes a battery pack **228**. Battery pack **228** may be permanently connected to apparatus **100** and rechargeable in-situ, or removable from apparatus **100**. In the example shown, battery pack **228** is located below handle **104**. Alternatively or in addition to battery pack **228**, power may be supplied to apparatus **100** by an electrical cord (not shown) connected to apparatus **100** that can be electrically connected to mains power by at a standard wall electrical outlet.

Cyclone

Embodiments herein relate to an openable cyclone sidewall. This feature may be used by itself in any surface



cleaning apparatus or in any combination or sub-combination with any other feature or features described herein.

A cyclone separates dirt and debris from an air stream that is moved through a cyclone chamber. Separated dirt and debris may be collected in a dirt collection chamber that is external to the cyclone chamber (e.g., vie a cyclone chamber dirt outlet) or separated dirt and debris may be collected in a dirt collection region that is interior of the cyclone as exemplified by cyclone $\mathbf{168_1}$ of FIG. **2**. A cyclone may be emptyable through an openable end door. However, some separated dirt and debris may collect on other interior surfaces of the cyclone, which may not be easily removed through the openable end door. For example, dirt and debris may accumulate or become entangled on the screen of a vortex finder of the cyclone. If not removed, this dirt and debris will occupy space inside the cyclone thereby reducing the volume available for cyclonic flow, which may reduce the dirt separation efficiency of the air treatment member. According to this aspect, a cyclone chamber is openable other than by merely opening the end of the cyclone chamber.

FIGS. **5-6** exemplify a cyclone, which may be referred to as a cyclonic air treatment member **116**, in accordance with an embodiment. As shown, cyclone bin assembly includes a cyclone **170** with a cyclone chamber **176**, a cyclone air inlet **196**, a cyclone air outlet **204**, and a cyclone axis of rotation **232** (also referred to as cyclone axis **232**). The cyclone chamber **176** has a cyclone chamber sidewall **236** that extends axially between the chamber first end **240** and the chamber second end **244**.

As exemplified, in accordance with this aspect, cyclone chamber sidewall **236** comprises a first portion **248** and a second portion **252** which are moveably mounted with respect to each other so as to provide an area to access the interior of the cyclone chamber that is larger than the cross sectional area of the end wall of the cyclone at second end **244**. As exemplified, first portion **248** is moveable relative to sidewall second portion **252** between a closed position (FIG. **1**) and an open position (FIGS. **5-6**). In the closed position (FIG. **1**), sidewall first portion **248** may meet (e.g. seal to) sidewall second portion **252** at first and second junctures $\mathbf{254_1}$ and $\mathbf{254_2}$. This closes cyclone chamber **176** so that cyclone **170** can function to separate dirt and debris from air flow moving through cyclone chamber **176**. In the open position, sidewall first portion **248** is at least partially separated (e.g. spaced apart from) sidewall second portion **252** to define opening(s) **256** into cyclone chamber **176**. Dirt and debris collected, accumulated, or tangled within cyclone chamber **176** can be easily removed through cyclone chamber opening(s) **256**.

Referring to FIGS. **1**, **5**, and **6**, each juncture **254** may be defined where an edge of sidewall first portion **248** meets an edge of sidewall second portion **252** in the closed position. As shown, first portion **248** may include first edge $\mathbf{260_1}$, second portion **252** may include first edge $\mathbf{260_2}$, and edges **260** may abut each other in the closed position to define first juncture $\mathbf{254_1}$. Similarly, first portion **248** may include second edge $\mathbf{264_1}$, second portion **252** may include second edge **2642**, and edges **264** may abut each other in the closed position to define second juncture $\mathbf{254_2}$. In the open position (FIGS. **5-6**), both edges **260**, **264** may be moved apart to create an opening **256** into cyclone chamber **176** for emptying dirt and debris contained inside or, as exemplified in FIG. **14**, one of the edges **260**, **264** may be moved apart to create an opening **256** into cyclone chamber **176**.

Edges **260**, **264** may be the plastic edges of the cyclone chamber side wall that abut each other or, alternately, a gasket or the like may be provided to assist in providing a seal along the juncture. The edges may be planar or an alternate shape to assist in providing a seal, such as tongue and groove.

One or both of junctures **254** may extend at a (non-zero) angle **270** to a plane **268** that is transverse to cyclone axis **232**. For example, as exemplified in FIG. **5**, the juncture may extend axially (perpendicular to plane **268**) or at an angle between 0° and 90° exclusive, as exemplified in FIG. **10**.

A sidewall first portion **248** that opens along junctures **254** angled in this way can provide an opening **256** into cyclone chamber **176**, which has an axial dimension and which has a greater cross-sectional area than opening the end wall of a cyclone, thereby providing better access to dirt and debris contained inside cyclone chamber **176**. In contrast, an cyclonic air treatment member having only an end wall door, may require the user to reach their hand and arm through the open end wall door into the cyclone chamber to clear dirt and debris (e.g. accumulated or tangled on a vortex finder), which may be unpleasant for the user.

Sidewall first portion **248** may be moveably mounted with respect to sidewall second portion **252**, sidewall second portion **252** may be moveably mounted with respect to sidewall first portion **248** or both sidewall portions **248**, **252** may be moveable with respect to each other.

In the illustrated example, junctures **$254_1$** and **$254_2$** extend axially parallel to cyclone axis **232**. When sidewall first portion **248** is moved relative to sidewall second portion **252** to separate sidewall first portion **248** from sidewall second portion **252** along junctures **254**, the resulting cyclone chamber opening **256** extends axially (i.e. along an axial length of cyclone chamber **176**). An advantage of this design is that the axial dimension of cyclone chamber opening **256** provides a large opening **256** and thereby improves user-access to dirt and debris that may be located throughout cyclone chamber **176**. For example, when sidewall first portion **248** is moved to the open position, cyclone chamber opening **256** may allow user access to debris at both cyclone chamber ends **240**, **244** without having to unpleasantly reach a length of their arm into the dirty and dusty cyclone chamber **176**.

Sidewall first portion **248** may be movably mounted with respect to sidewall second portion **252** in any manner that allows sidewall first portion **248** to move between a closed position (FIG. **1**) and an open position (FIGS. **5-6**). For example, sidewall first portion **248** may be rotatable (e.g., as exemplified in FIGS. **27-30**), pivotable (as exemplified in FIGS. **5** and **14**), translatable (as exemplified in FIG. **31**), or any combination thereof, relative to sidewall second portion **252**.

Referring to FIGS. **5-6**, sidewall first portion **248** is pivotable relative to sidewall second portion **252**. As exemplified, sidewall first portion **248** is connected to cyclone **170** by a hinge **272** that defines a rotation axis **276** (sometimes referred to as a 'pivot axis').

Rotation axis **276** may have any position suitable to allow sidewall first portion **248** to pivot relative to sidewall second portion **252** between the closed and open positions. For example, rotation axis **276** may be positioned external to cyclone chamber **176** as shown, or rotation axis **276** may extend through cyclone chamber **176**. As shown, positioning rotation axis **276** external cyclone chamber **176** can allow hinge **272** to be located outside of cyclone chamber **176**, such that hinge **272** does not interfere with air flow through cyclone chamber **176** and does not occupy space within cyclone chamber **176**. Rotation axis **276** may also be located at any location along the axial length of the cyclone. For example, axis **276** may be located at one end of the cyclone chamber as exemplified in FIG. **5**, or at an intermediate location along the length of the cyclone sidewall.

Rotation axis **276** may have any orientation suitable to allow sidewall first portion **248** to pivot relative to sidewall second portion **252** between the closed and open positions. For example, rotation axis **276** may be oriented transverse to cyclone axis **232** (see, e.g., FIG. **5**), or rotation axis **276** may extend axially (e.g. parallel to cyclone axis **232**, see e.g., FIG. **14**). An advantage of the design of FIG. **5** is that the end of sidewall first portion **248** distal to axis **276** may rotate farther away from sidewall second portion **252** in the open position per degree of rotation. Accordingly, rotation axis **276** positioned and oriented as shown may provide greater user access to a lower end of the interior of cyclone chamber **176** to remove the contained dirt and debris.

Hinge **272** may be any device suitable to (directly or indirectly) connect sidewall first portion **248** to sidewall second portion **252** and allow sidewall first portion **248** to rotate relative to sidewall second portion **252** between the closed and open positions. For example, hinge **272** may have a multi-part design as shown, or hinge **272** may be a single-part living hinge. As compared to a single-part living hinge **272**, a multi-part hinge **272** typically provides greater strength and working life (e.g. number of rotations before failure). A single-part living hinge **272** allows chamber first end **240** to be integrally formed with cyclone **170**, which reduces the number of components, which in turn can reduce manufacturing and assembly costs.

Referring to FIGS. **1**, **5**, and **6**, a cyclone chamber opening **256** may have an area **280** that is larger than an opening provided by an openable door at cyclone end wall **244**. For example, opening area **280** may be greater than a cross-sectional area **284** measured on a plane **268** that is perpendicular to cyclone axis **232**. The comparatively larger opening area **280** provides greater user access to remove dirt and debris from an interior of cyclone chamber **176** as compared to an end wall door. In some embodiments, opening area **280** may be at least 120% (e.g. 120% to 500%) of chamber cross-sectional area **284**. In the illustrated example, the opening area **280** of each cyclone chamber opening **256** is at least 200% of chamber cross-sectional area **284**.

Referring to FIGS. **5-6**, one or more parts of cyclone chamber **176** or dirt collection chamber **172** may be movable with sidewall first portion **248** to the open position. This can allow those part(s) to be reoriented in the open position in a way that provides greater user access to dirt and debris collected on those part(s), and/or that allows dirt and debris collected on those part(s) to fall out of chamber(s) **172**, **176** by gravity (e.g. into a waste bin below). In general, the more dirt and debris that falls out of chamber(s) **172**, **176** by gravity alone, results in less unpleasant user-contact with dirt and debris to clean out chamber(s) **172**, **176**.

In the illustrated example, cyclone chamber second end wall **244** is connected to sidewall first portion **248** so that cyclone chamber second end wall **244** rotates with sidewall first portion **248** to the open position. This tilts the surface of cyclone chamber second end wall **244** towards an axial (e.g. vertical) orientation, which can allow dirt and debris collected on cyclone chamber second end wall **244** to fall out of chambers **172**, **176** by gravity. This also removes cyclone chamber second end wall **244** from sidewall second portion **252** so that dirt and debris associated with sidewall second portion **252** can fall out of chambers **172**, **176** by gravity instead of forming a pile on cyclone chamber second end wall **244** at the bottom end.

In an alternative embodiment, cyclone chamber second end wall **244** may remain with sidewall second portion **252** when sidewall first portion **248** is moved to the open position.

In any embodiment, cyclone chamber second end wall **244** may be openable, e.g., it may be pivotably mounted to one of the sidewall portions **248**, **252**.

As mentioned previously, FIGS. **10-11** exemplify an embodiment wherein the juncture extends at an angle between 0° and 90° exclusive to transverse plane **268**. The sidewall portions **248**, **252** meet along a sidewall juncture **254** in the closed position (FIG. **10**) and may be pivoted away from each other to the open position (FIG. **11**). In the open position, edges **260** of sidewall portions **248**, **252** are spaced apart, and each sidewall portion **248**, **252** has a cyclone chamber opening **256**.

In accordance with this embodiment, sidewall juncture **254** forms (non-zero) angles to both cyclone axis **232** and transverse plane **268**. Accordingly, sidewall juncture **254** has an axial extent or dimension that creates comparatively large area chamber openings **256** in the open position, but that does not extend axially parallel to cyclone axis **232**. As compared to a sidewall juncture that is parallel to cyclone axis **232**, the illustrated sidewall juncture **254** has a shorter linear length, which may result in less cost, less complexity, and greater reliability in maintaining an air tight seal along sidewall juncture **254** in the closed position.

Sidewall juncture **254** may be located anywhere between cyclone chamber ends **240**, **244**. Preferably, sidewall juncture **254** is spaced apart from cyclone chamber end **240**, **244**. This positions sidewall juncture **254** more centrally between cyclone chamber ends **240**, **244** whereby in the open position, the maximum distance from cyclone chamber openings **256** to an interior surface of cyclone chamber **176** is reduced. For example, sidewall juncture **254** may be spaced from cyclone chamber first end **240** by a distance **336**, spaced from cyclone chamber second end **244** by a distance **340**, and each of distances **336** and **340** may be at least 10%, 20%, 30%, 40% or 50% (e.g. 10% to 50%, 20% to 40%) of cyclone chamber height **320**.

Still referring to FIGS. **10-11**, sidewall juncture **254** has a first end **344** having a first axial position, a second end **348** having a second axial position, and some or all of screen **212** has an axial position located between the axial positions of the sidewall juncture ends **344**, **348**. As shown in FIG. **11**, this can allow some or all of screen **212** to extend out of a cyclone chamber opening **256** when the cyclone is in the open position, which can provide easy user-access to surfaces of screen **212** for cleaning.

As with the embodiment of FIGS. **5** and **6**, cyclone second end **244** may be a movable (e.g. pivotable, translatable, and/or removable) end wall **352**. As exemplified, cyclone second end **244** includes an openable door **352**. Door **352** can be opened to empty the majority of loose dirt and debris contained in cyclone chamber **176**. This can mitigate loose dirt and debris spilling uncontrollably when moving sidewall first portion **248** to the open position. An openable door **352** may be provided at one or both ends of the cyclone and, e.g., may be pivotably connected to one or both of sidewall portions **248**, **252**. In the illustrated example, openable door **352** is pivotably connected by a hinge **356** to sidewall first portion **248**, and a latch **360** is provided to removably secure openable door **352** closed.

As mentioned previously, FIG. **14** exemplifies an axially extending pivot axis **276**. An advantage of this design is that in the open position, each sidewall portion is opened and the cyclone chamber openings **256** may extend the full axial length of cyclone chamber **176**. This provides easy user-access to dirt and debris located anywhere inside of cyclone chamber **176**. It will be appreciated that the hinge may extend along only part of the axial length of the sidewall.

Sidewall portions **248**, **252** can have any circumferential angular extent. For example, sidewall first portion **248** may have a circumferential angular extent of between 25° and 335°. More preferably, the circumferential angular extent may be more balanced as between sidewall portions **248**, **252** so that each sidewall portion **248**, **252** has a conveniently large cyclone chamber opening **256** in the open position. For example, the circumferential angular extent of sidewall first portion **248** may be between 135° and 225°. In the illustrated example, both sidewall portions **248** have an angular extent of about 180°. This provides each sidewall portion **248**, **252** with a similarly large cyclone chamber opening **256**.

Sidewall first portion **248** may be pivotably mounted about an axial rotation axis **276**. This allows cyclone **170** to have a relatively smaller footprint when in the open position so that all of cyclone **170** can be underlied by a standard sized waste bin that is collecting dirt and debris falling from cyclone **170**. In the illustrated example, rotation axis **276** is parallel to cyclone axis **232**. In some embodiments, sidewall hinge **272** is a piano hinge that is provided on an exterior of the sidewall and extends axially along sidewall portions **248**, **252**.

Hinge **272** may extend from one end of the cyclone chamber to the other end of the cyclone chamber as exemplified in FIG. **14**, or it may extend along only part of the axial length. For example, it may extend from one end of the cyclone chamber towards the other end or it may extend along only part of an intermediate section of the sidewall between the first and second axially opposed cyclone ends. In such a case, the sidewall portion that opens may define a door having upper and lower ends that mate with the other sidewall portion along upper and lower edges that extend around a portion of the perimeter of the sidewall.

FIGS. **19-21** exemplify an alternate embodiment wherein the axis **276** extends in the direction of the cyclone axis of rotation **232** but wherein the axis **276** extends through the cyclone chamber. Optionally, as exemplified, rotation axis **276** is coaxial or collinear with cyclone axis **232**. Sidewall first portion **248** is rotatable about axis **276** relative to sidewall second portion **252** from a closed position to an open position (FIG. **20**) in which sidewall portions **248**, **252** are partially or completely nested with one another. For example, sidewall first portion **248** may nest within sidewall second portion **252** as shown, or vice versa. An advantage of this design is that it may provide even greater exposure to interior surfaces of cyclone chamber **176**. Further, this design may reduce the time and effort required to clean out cyclone chamber **176** because the act of nesting one sidewall portion into the other may empty the outer sidewall portion into the inner sidewall portion or out of cyclone chamber **176**. Thus, the user may have only to attend to emptying dirt and debris associated with the inner sidewall portion. Also, an open position in which sidewall portions **248**, **252** are nested may reduce the footprint of cyclone chamber **176**, which may make it possible or easier to empty cyclone chamber **176** into a waste bin below without spilling.

Each sidewall portion **248**, **252** is exemplified as an axial cylindrical segment. In the example shown, each sidewall portion **248**, **252** has a circumferential angular extent of approximately 180°. This allows the sidewall portions **248**, **252** to completely nest with each other in the open position (FIG. **20**). In other embodiments, the circumferential angular extent of each sidewall portion **248**, **252** may differ from 180°. For example, the inner sidewall portion **248** may have an angular extent of greater than or less than 180°.

It will be appreciated that cyclone chamber sidewall **236** may include any number of sidewall portions, which are mounted so that they can move relative to each other between a closed position and an open position. Accordingly, while FIGS. **20-21** show an embodiment in which cyclone chamber sidewall **236** includes two sidewall portion **248**, **252** that are each an axial cylindrical segment, and which are nested in the open position (FIG. **21**), a larger number of segments may be provided. This may permit cyclone chamber **176** to have an open position that provides even greater user-access to the interior volume, surfaces, and contents of cyclone chamber **176**. In turn, this may make it easier for the user to clean cyclone chamber **176** of dirt and debris.

For example, FIGS. **27-30** show an example including three sidewall portions **248**, **252**, **388**, each of which is an axial cylindrical segment, and which are nested in the open position (FIG. **30**). Sidewall portions **248**, **252**, **388** may have the same circumferential angular extent as shown (e.g. approximately 120°), or one or more (or all) of sidewall portions **248**, **252**, **388** may have a different circumferential angular extent as compared to each other sidewall portion **248**, **252**, **388**. As shown, the larger number of sidewall portions **248**, **252**, **388** may result in a larger portion of cyclone outlet passage **208** being located outside of cyclone chamber **176** when in the open position, even where cyclone outlet passage **208** is not movably mounted (i.e. where cyclone outlet passage **208** is rigidly connected to cyclone **170**). In the illustrated example, cyclone chamber **176** spans approximately 120° in the open position such that approximately 240° (i.e. about two thirds) of cyclone outlet passage **208** is positioned outside of cyclone chamber **176**.

As mentioned previously, FIGS. **31-32** exemplify an embodiment in which sidewall first portion **248** is axially translatable to the open position as shown. Depending on the manner in which cyclonic air treatment member **116** is connected to the surface cleaning apparatus, this design may prevent cyclone chamber **176** from being opened while connected to the surface cleaning apparatus. As shown, sidewall portions **248**, **252** may meet (e.g. be sealed) at first and second junctures **254**. First juncture $254_1$ may be parallel to second juncture $254_2$ and angularly spaced around cyclone chamber **176** from second juncture $254_2$. In the example shown, both junctures **254** extend axially (e.g. parallel to cyclone axis **232**).

FIG. **34** exemplifies an embodiment in which sidewall first portion **248** is an axial cylindrical segment, which is pivotably mounted to cyclone **170** so that it can rotate about a rotation axis **276**, which is transverse (e.g. perpendicular) to cyclone axis **232**.

Moveable Screen

Embodiments herein relate to a moveable screen or vortex finder. This feature may be used by itself in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein.

As exemplified in FIGS. **5-6**, cyclone **170** may include a cyclone outlet passage (e.g. vortex finder) **208** including a screen **212** that may collect larger dirt particles and debris (e.g. hair) which remains entrained in the air flow exiting the cyclone **170**. When sidewall first portion **248** is in an open position, a portion of screen **212** may remain in close proximity to one of sidewall portions **248**, **252**, and that proximity may make user access to clean that portion of screen **212** difficult (e.g. the clearance may be too small for a user's fingers). In some embodiments, cyclone outlet passage **208** may be movably mounted with respect to one or both of the sidewall portions **248**, **252**. This can allow the user better access to clean surfaces of screen **212**.

In accordance with this aspect, the cyclone outlet passage (e.g. vortex finder) **208** is moveable so as to permit easier access to more of the perimeter of the outlet passage and, optionally, all of the perimeter of the outlet passage.

Cyclone outlet passage **208** may be movably mounted with respect to one or both sidewall portions **248**, **252** in any manner suitable to improve user-access to some or all of the outer surface of screen **212**. For example, cyclone outlet passage **208** may be removable from cyclone **170**, or cyclone outlet passage **208** may be rotatable, translatable, or both while remaining connected to cyclone **170**.

As exemplified in FIGS. **5-6** and **7-9**, cyclone outlet passage **208** is movably mounted with respect to both sidewall portions **248**, **252**. As shown, when sidewall first portion **248** is moved to the open position, cyclone outlet passage **208** is movable away from sidewall portion **252**, concurrently, or subsequently, outlet passage **208** may be moved away from sidewall portion **248**. This increases the clearances between screen **212** and both sidewall portions **248**, **252**, which can greatly improve user-access to clean surfaces of screen **212**.

In the illustrated example, cyclone outlet passage **208** is pivotable about a rotation axis **288** relative to sidewall portion **248**. As shown, this allows cyclone outlet passage **208** to rotate away from sidewall portion **248** when in the open position. Accordingly, when the sidewall portions are pivoted open and the screen is pivoted to the open position shown in FIG. **6**, clearances **292**, **296** between screen **212** and sidewall portions **248**, **252** respectively increase to provide greater user-access to the outer surface of screen **212** for cleaning. See also FIG. **33**.

In the example shown, cyclone outlet passage **208** is pivotably connected to sidewall first portion **248**. Alternatively, cyclone outlet passage **208** may be pivotably connected to sidewall second portion **252** or to another portion of cyclone **170**.

FIG. **12** exemplifies an alternate embodiment wherein cyclone outlet passage **208**, including screen **212**, is removable from cyclone **170** after sidewall first portion **248** is moved to the open position. This can allow cyclone outlet passage **208** to be most easily cleaned, and optionally replaced if it is a consumable item or damaged.

FIG. **13** exemplifies an embodiment in which cyclone outlet passage **208**, including screen **212**, is translatable relative to sidewall portions **248**, **252**. As shown, cyclone outlet passage **208** may be translatably connected to one of the sidewall portions, e.g., sidewall portion **252**, whereby cyclone outlet passage **208** can move along track **364** through cyclone chamber opening **256**. This moves screen **212** out of cyclone chamber **176** so that it can be easily cleaned of dirt and debris by the user.

As exemplified in FIGS. **14-16**, cyclone outlet passage **208** (including screen **212**) may be pivotable about an axial screen rotation axis **372**. As shown, this design allows cyclone outlet passage **208** to be rotated out of the cyclone chamber to provide easy user-access to surfaces of screen **212** for cleaning. In this example, screen rotation axis **372** is shown as parallel to cyclone axis **232**. In other embodiments, screen rotation axis **372** may be oriented at a (non-zero) angle to cyclone axis **232**. A similar design is useable in the embodiment of FIG. **26**.

Dual End Walls

Embodiments herein relate to a cyclone chamber wherein the end wall comprises two or more end wall segments, one or more of which, and optionally, each of which, is openable. This feature may be used by itself in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein.

An advantage of this design is that each openable sidewall portion may have part of the end wall **244**. This can facilitate sealing the cyclone chamber when the sidewall portions are in the closed position.

As exemplified in FIG. **14**, half of the end wall **244** may be fixedly mounted to each sidewall portion **248**, **252**.

Alternately, as exemplified in FIGS. **16-17**, each end wall portion may be openable. As exemplified therein, cyclone chamber **176** may include an openable end wall **352** at chamber second end **244**. As shown, openable end wall **352** may include a first wall portion **376** movably (e.g. pivotably) connected to sidewall first portion **248** and a second wall portion **380** movably (e.g. pivotably) connected to sidewall second portion **252** as shown. An advantage of this design is that upon opening end wall **352** to empty dirt and debris from cyclone chamber **176** into a waste bin below, the end wall portions **376**, **380** may tend to funnel the falling dirt and debris into a waste bin below. This may mitigate the dirt and debris spilling laterally outside of the waste bin upon opening end wall **352**.

FIGS. **19-21** exemplify the use of two end wall segments in a rotational opening design. As shown, in the open position (FIG. **20**), end wall portion **376** may overlie end wall portion **380**. As compared with an end wall **352** that remains whole (e.g. if the design of end wall **352** of FIG. **18** were used and end wall **352** was mounted in a fixed position to a sidewall portion), this design may reduce the effective surface area of end wall **352** in the open position so that dirt and debris can fall out of cyclone chamber **176** more easily. Furthermore, this design may make cleaning cyclone chamber **176** easier in that the act of moving wall second portion **380** under wall first portion **376** may automatically push dirt and debris collected on wall second portion **380** out of cyclone chamber **176**.

FIG. **24** exemplifies the use of two end wall segments in a rotational opening design wherein door portions **376**, **380** are separately openable.

Vertical Screen

Embodiments herein relate to vertical screen. This feature may be used by itself in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein.

In accordance with this aspect, a cyclone chamber is provided with an axially extending member which may be planar and which may be porous (e.g., it may have a plurality of openings therein). Axially extending member **304** may be provided in the cyclone chamber **176** (e.g. the dirt collection region **172** of the cyclone chamber **176**) at chamber second end **244**.

Axially extending member **304** may help to disentrain dirt and debris from the air flow. Alternatively or in addition, axially extending member **304** may help to prevent dirt and debris being re-entrained into the air flow inside the cyclone chamber **176** (e.g. inside the dirt collection region **172** of the cyclone chamber **176**). Axially extending member **304** can have any configuration suitable for providing one or both of these functions. For example, axially extending member **304** may include a coarse or fine screen, an apertured panel, or high air permeability physical filter media that can allow the air flow to continue circulating while providing some obstruction to dirt and debris and/or providing collecting surfaces for dirt and debris.

An example of such a design is shown in FIGS. **5-6** wherein a single axially extending member **304** is located at chamber second end **244**.

In the illustrated example, axially extending member **304** is formed as a thin panel (e.g. plate) with a plurality of small apertures **306**. For example, axially extending member **304** may include at least 50 apertures, such as for example 50 to 5,000 apertures. Axially extending member **304** has an axial height **308** and transverse width **312**, each of which is far greater than its thickness **316**. An advantage of this design is that it provides axially extending member **304** with a large surface area (defined by height **308** and width **312**) for obstructing and/or collecting dirt and debris, and a small volume so as to occupy only a small portion of cyclone chamber **176**. For example, each of height **308** and width **312** may be at least 500% (e.g. 500% to 100,000%) of thickness **316**. As shown, height **308** may be 25% or more of cyclone chamber height **320** (e.g. 25% to 75% of cyclone chamber height **320**), and width **312** may be 25% or more of cyclone chamber width **324** (FIG. **1**, e.g. 25% to 100% of cyclone chamber width **312**). In the illustrated example, height **308** is approximately 50% of cyclone chamber height **320**, and width **324** is approximately 100% of cyclone chamber width **312**.

Axially extending member **304** may be connected to one or more of the sidewall portions. As exemplified in FIGS. **5-6**, axially extending member **304** may remain connected to the sidewall portion that does not have the end wall **244** attached thereto. Therefore, as exemplified, axially extending member **304** remains connected to sidewall second portion **252** when sidewall first portion **248** is moved to the open position. This allows dirt and debris that falls by gravity from axially extending member **304** (naturally or by the user brushing axially extending member **304**) to fall out of cyclone chamber **176** without interference by cyclone second end wall **244**, which in this example remains connected to sidewall first portion **248**.

FIG. **7** shows an alternative embodiment in which axially extending member **304** remains connected to sidewall first portion **248** (the sidewall portion with end wall **244** attached thereto) when sidewall first portion **248** moves to the open position.

Axially extending member may be fixedly mounted to a sidewall portion or it may be moveably mounted thereto. Alternately, axially extending member **304** may be movable (e.g. pivotably, translatably, and/or removably) connected to one or more sidewall portions. This can allow surfaces of axially extending member **304** to move away from sidewall portion(s) **248**, **252** where there is greater clearance and therefore better access for the user to clean those surfaces.

As exemplified in FIGS. **8-9** axially extending member **304** is pivotably connected to a sidewall portion **248**, **252**. In FIG. **8**, axially extending member **304** is pivotably connected to the sidewall portion that remains in position and In FIG. **9**, axially extending member **304** is pivotably connected to the sidewall portion that moves to the open position. The pivoting connection may be formed by a hinge **328** that defines a rotation axis **332**. As shown, rotation axis **332** may extend through cyclone chamber **176**. In the example shown, rotation axis **332** is transverse to (e.g. perpendicular to) cyclone axis **232**. FIG. **21** also exemplifies an embodiment wherein axially extending member **304** may be pivoted about rotation axis **332** away from sidewall first portion **248**.

If the cyclone has more than one end wall portion, then it will be appreciated that two or more of the sidewall portions may be provided with an axially extending member **304**. Accordingly, axially extending member **304** may include first and second separable parts, whereby in the open position, the first part remains connected to one sidewall portion and the second part remains connected to another sidewall portion. An example of such a design is shown in FIG. **14**. As exemplified therein, axially extending member **304** has two separable parts $\mathbf{368_1}$ and $\mathbf{368_2}$. In the open position, part $\mathbf{368_1}$ remains connected to sidewall first portion **248** (e.g. portion **376** of movable end wall **352**), and part $\mathbf{368_2}$ remains connected to sidewall second portion **252** (e.g., portion **380** of movable end wall **352**).

It will be appreciated that while axially extending member **304** may be mounted to, and moveable with part or all of end wall **352**, **276**, **280** (see for example FIG. **32**), in alternate embodiments, axially extending member **304** may remain in the cyclone chamber when part or all of end wall **352**, **376**, **380** is moved to an open position (see for example FIGS. **23**-**24**).

While the above description provides examples of the embodiments, it will be appreciated that some features and/or functions of the described embodiments are susceptible to modification without departing from the spirit and principles of operation of the described embodiments. Accordingly, what has been described above has been intended to be illustrative of the invention and non-limiting and it will be understood by persons skilled in the art that other variants and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto. The scope of the claims should not be limited by the preferred embodiments and examples, but should be given the broadest interpretation consistent with the description as a whole.

The invention claimed is:

**1**. A vacuum cleaner comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;

(b) a cyclone bin assembly provided in the air flow path, the cyclone bin assembly comprising a cyclone chamber, a cyclone air inlet, a cyclone air outlet, a cyclone axis of rotation, an axially extending cyclone chamber sidewall extending between first and second axially opposed ends; and,

(c) a suction motor provided in the air flow path,

wherein the cyclone chamber sidewall has a first portion that is moveably mounted with respect to a second portion of the cyclone chamber sidewall between a closed position in which the first and second portions meet at a first juncture and a second juncture and an open position in which the cyclone chamber is opened and, in a plane that is transverse to the cyclone axis of rotation, the first portion comprises an arc shaped portion that extends between the first and second junctures, and

wherein the first juncture extends at a non-zero angle to the plane that is transverse to the cyclone axis of rotation.

**2**. The vacuum cleaner of claim **1** wherein the first juncture extends generally axially.

**3**. The vacuum cleaner of claim **1** wherein the first portion is pivotally mounted to vacuum cleaner about a pivot axis and the pivot axis extends through the cyclone chamber.

**4**. The vacuum cleaner of claim **1** wherein the cyclone air outlet is provided at the first opposed end and the second opposed end comprises an end wall that is moveable with the first portion.

**5**. The vacuum cleaner of claim **1** wherein the cyclone air outlet comprises a screen and the screen is moveably mounted with respect to one of the sidewall portions.

**6**. The vacuum cleaner of claim **5** wherein the screen is pivotally mounted to one of the sidewall portions.

**7**. The vacuum cleaner of claim **5** wherein the screen is removable after the first portion is moved to the open position.

**8**. The vacuum cleaner of claim **1**, wherein the cyclone air outlet is provided at the first opposed end, the cyclone air outlet comprises a screen, the second opposed end comprises an end wall and the vacuum cleaner further comprises a generally axially extending member provided in the cyclone chamber at the opposed end.

**9**. The vacuum cleaner of claim **1** wherein the cyclone air outlet is provided at the first opposed end and the second opposed end comprises an end wall that is moveable mounted with respect to the first and second portions.

**10**. The vacuum cleaner of claim **9** wherein the end wall is pivotally mounted to one of the first and second portions.

**11**. The vacuum cleaner of claim **1** wherein the first portion is pivotally mounted to the vacuum cleaner about a pivot axis and the pivot axis extends generally axially.

**12**. The vacuum cleaner of claim **11** wherein the pivot axis is positioned external to the cyclone chamber.

**13**. The vacuum cleaner of claim **11** wherein the pivot axis comprises a piano hinge.

**14**. The vacuum cleaner of claim **11** wherein the pivot axis is aligned with the cyclone axis of rotation.

**15**. The vacuum cleaner of claim **11** wherein the pivot axis extends through the cyclone chamber and each of the first and second portions comprises an axial cylindrical segment.

**16**. The vacuum cleaner of claim **15** wherein the first juncture extends generally axially.

**17**. The vacuum cleaner of claim **2** wherein the second juncture that extends generally parallel to the first juncture and is angularly spaced around the cyclone chamber from the first juncture, whereby the first portion is axially translatable with respect to the second portion.

**18**. A vacuum cleaner comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;

(b) a cyclone bin assembly provided in the air flow path, the cyclone bin assembly comprising a cyclone chamber, a cyclone air inlet, a cyclone air outlet, a cyclone axis of rotation, an axially extending cyclone chamber sidewall extending between first and second axially opposed ends; and,

(c) a suction motor provided in the air flow path,

wherein the cyclone chamber sidewall has a first axially extending portion that is moveably mounted with respect to a second axially portion of the cyclone chamber sidewall between a closed position in which the first and second portions abut and an open position in which the cyclone chamber is opened and, in a plane that is transverse to the cyclone axis of rotation, the first portion comprises an arc shaped portion that extends between the first and second junctures.

**19**. The vacuum cleaner of claim **18** wherein the first axially extending portion of the sidewall is pivotally mounted to the vacuum cleaner about a pivot axis and the pivot axis is generally transverse to the cyclone axis of rotation.

**20**. The vacuum cleaner of claim **19** wherein the cyclone air outlet is provided at the first opposed end, the pivot axis is provided at the first opposed end, the cyclone air outlet comprises a screen and the screen is moveably mounted with respect to the second axially extending portion of the sidewall.

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