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Conrad

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(54) **SURFACE CLEANING APPARATUS WITH DIRT ARRESTER HAVING AN AXIAL STEP**

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(51) **Int. Cl.**

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B04C 5/185	(2006.01)
B04C 5/26	(2006.01)
B04C 9/00	(2006.01)
B04C 5/13	(2006.01)
B01D 45/16	(2006.01)
B04C 5/28	(2006.01)
B01D 50/00	(2006.01)

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

CPC ***A47L 9/1658*** (2013.01); ***A47L 9/1683*** (2013.01); ***B01D 45/12*** (2013.01); ***B01D 45/16*** (2013.01); ***B04C 5/13*** (2013.01); ***B04C 5/185*** (2013.01); ***B04C 5/26*** (2013.01); ***B04C 5/28*** (2013.01); ***B04C 9/00*** (2013.01); *B01D 50/002* (2013.01); *B04C 2009/002* (2013.01)

(58) **Field of Classification Search**

CPC A47L 9/1608; A47L 5/24; A47L 9/1683; B04C 5/185; B04C 5/26; B04C 9/00; B04C 5/28; B04C 2009/002; B01D 45/16; B01D 50/002; B01D 45/12

See application file for complete search history.

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(57) **ABSTRACT**

A surface cleaning apparatus has a cyclone chamber having a longitudinal cyclone axis of rotation wherein the dirt outlet is defined by a gap between the sidewall of the cyclone and a plate positioned at the dirt outlet end of the cyclone, which gap extends around all of the perimeter of the plate. The plate is stepped in the axial direction.

20 Claims, 19 Drawing Sheets

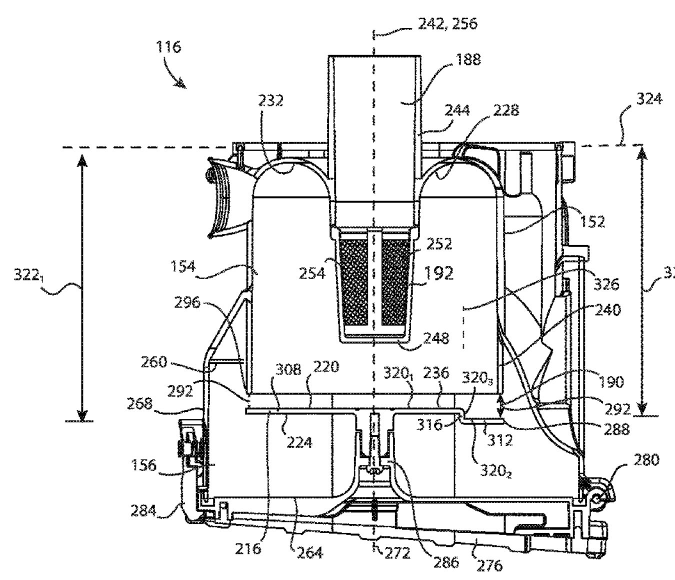

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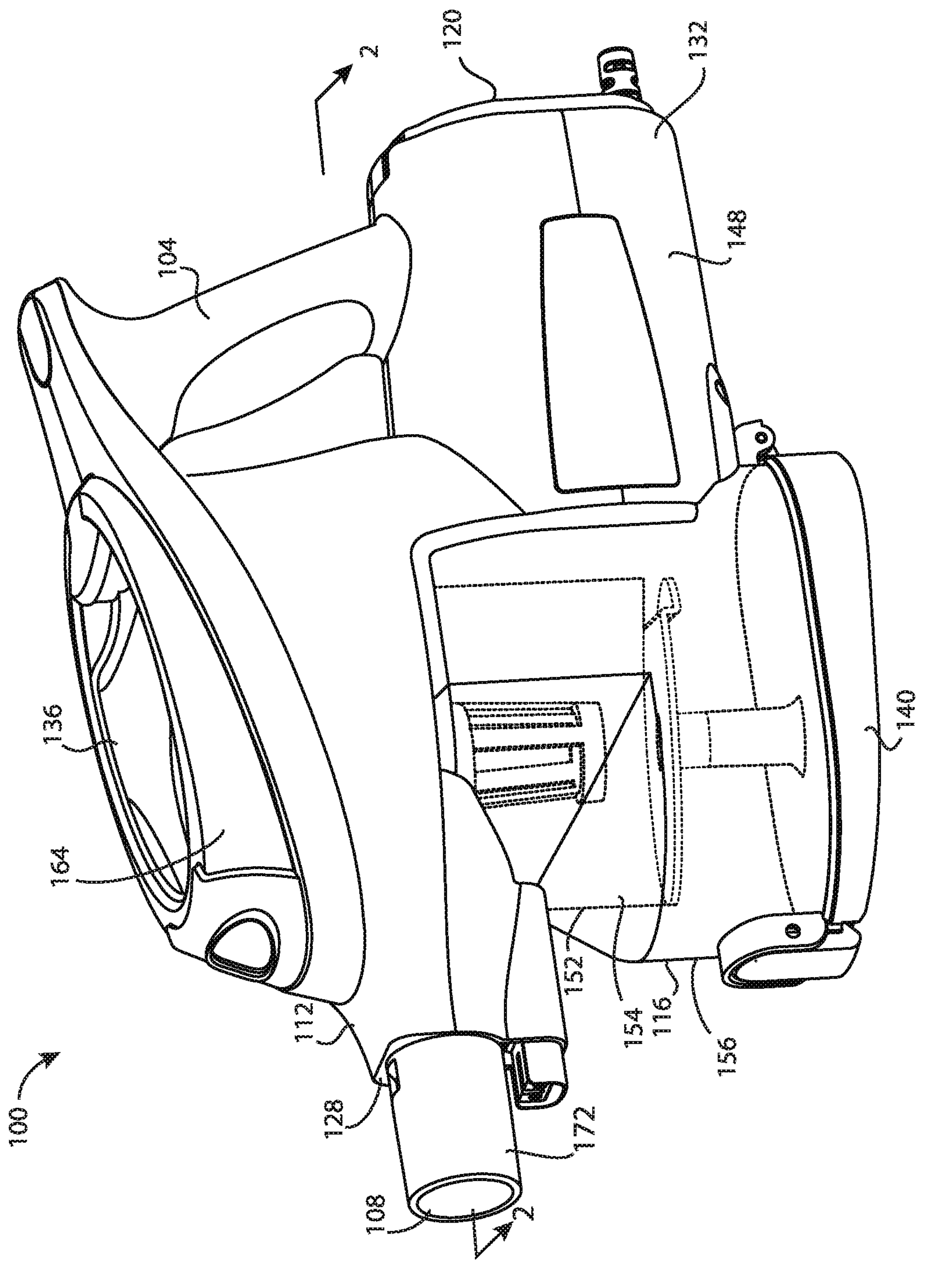
FIG. 1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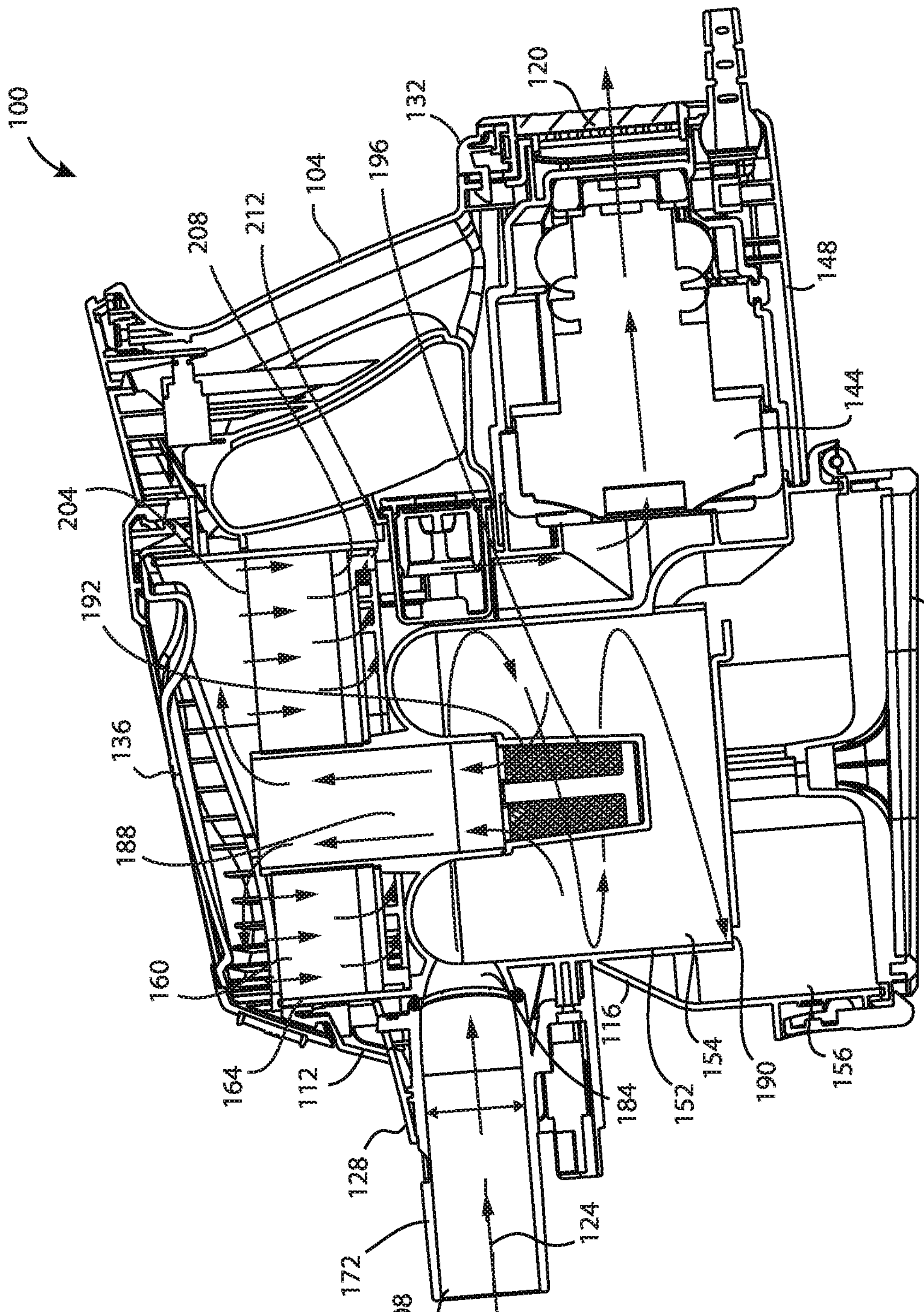
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FIG. 2

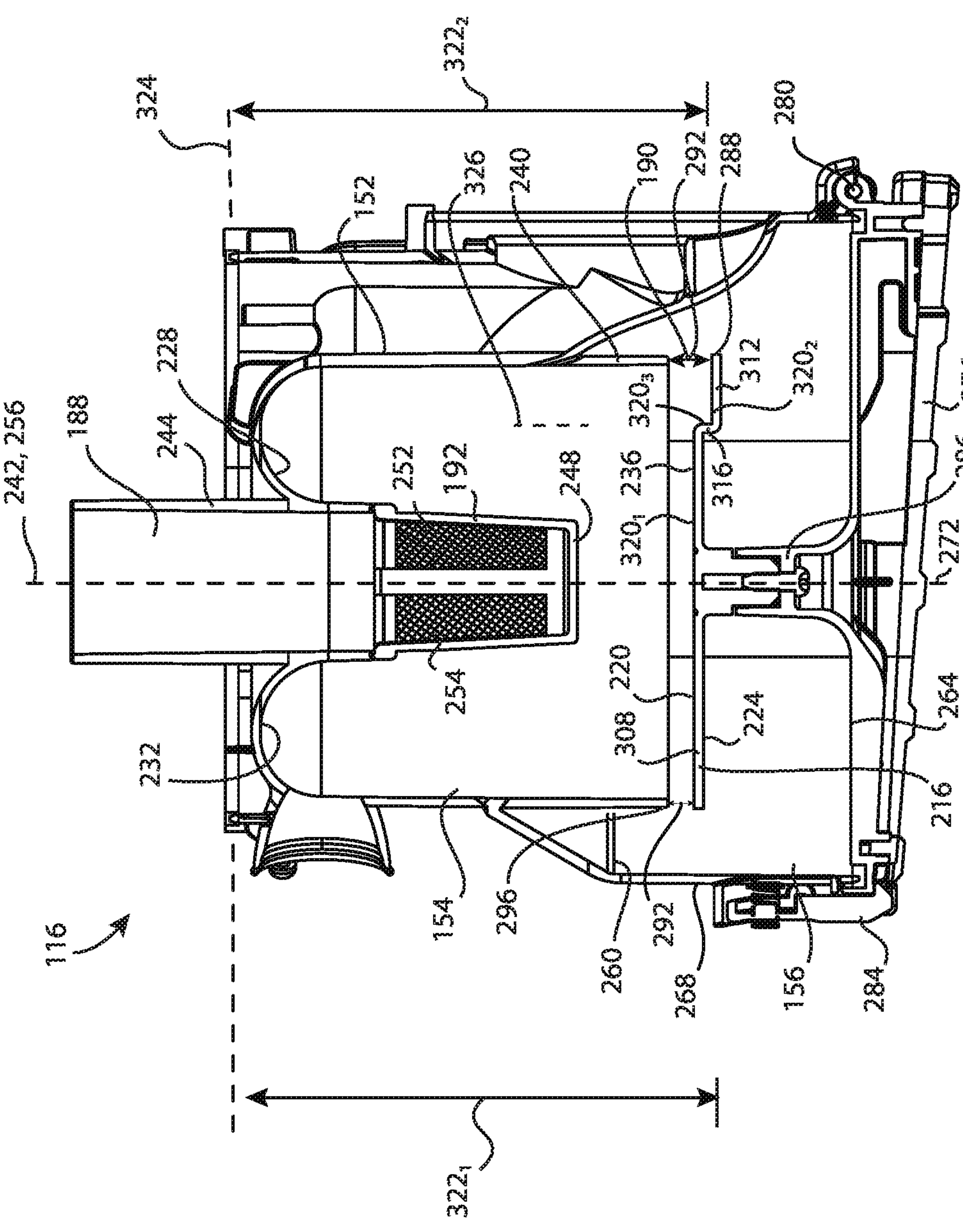
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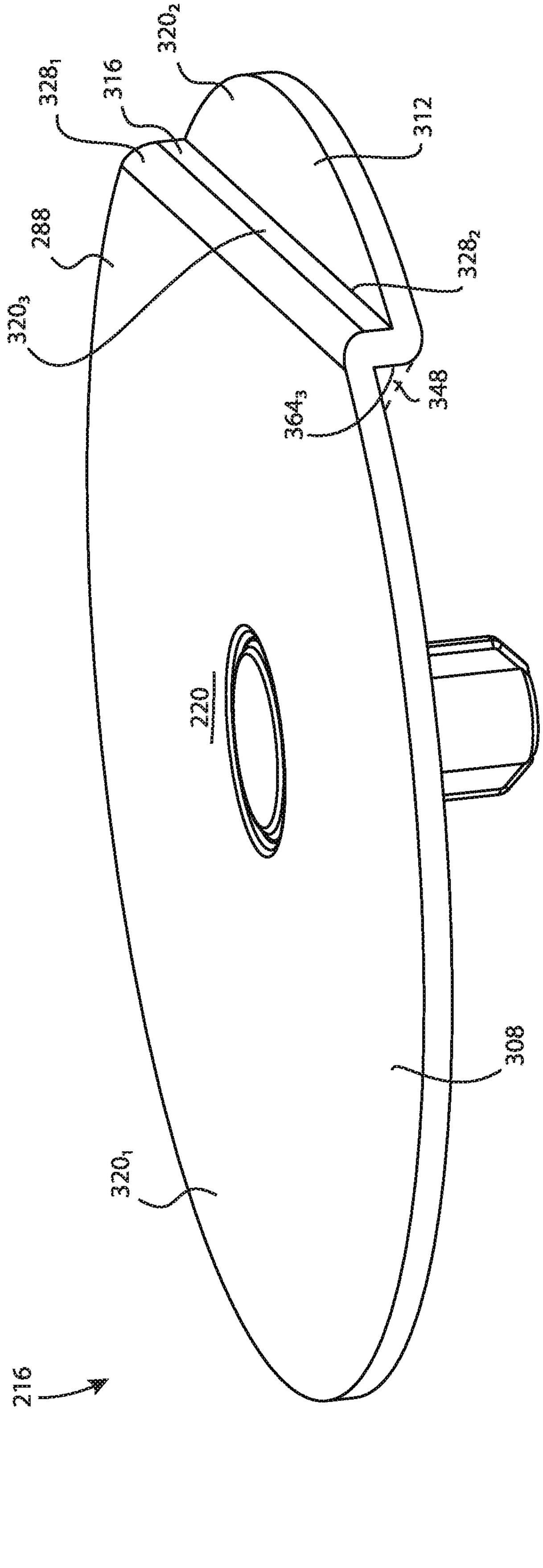
FIG. 3



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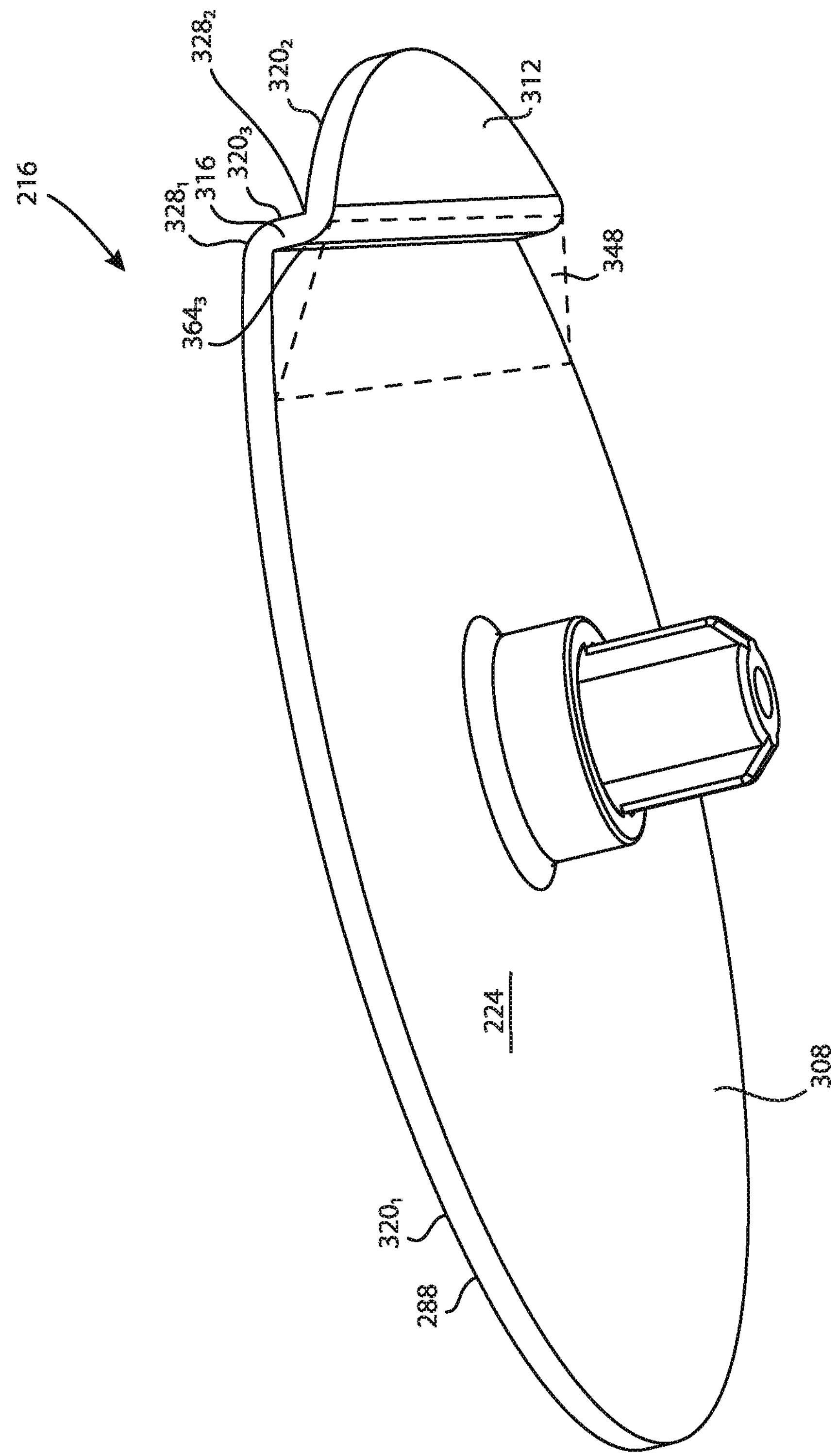

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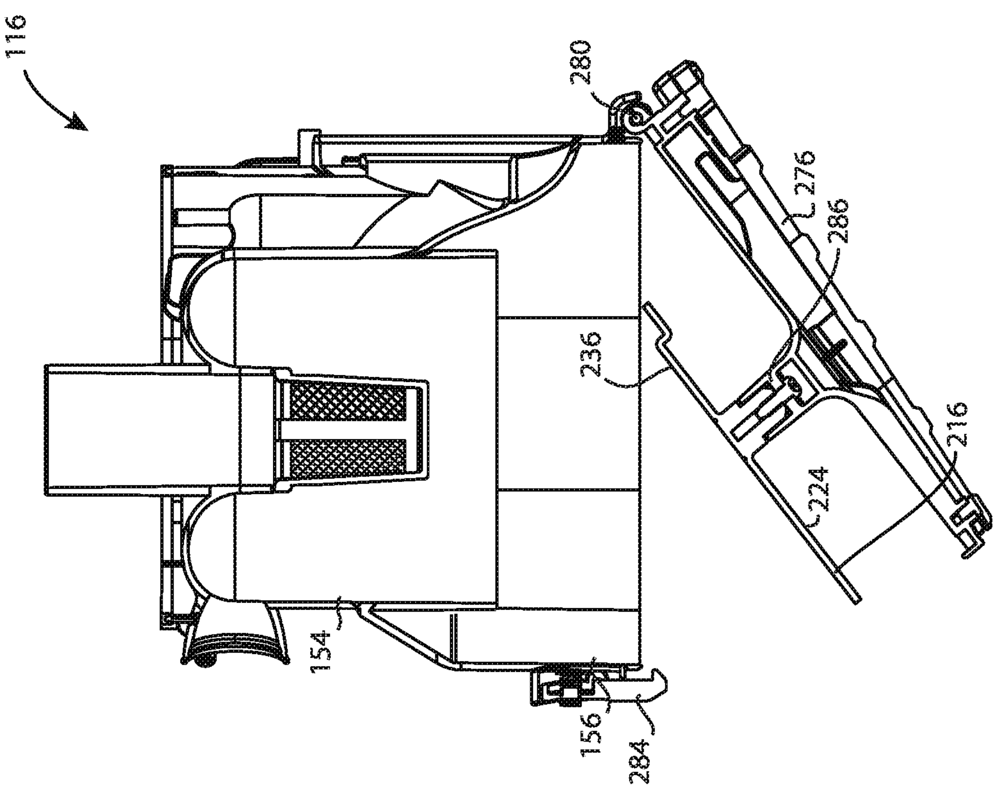

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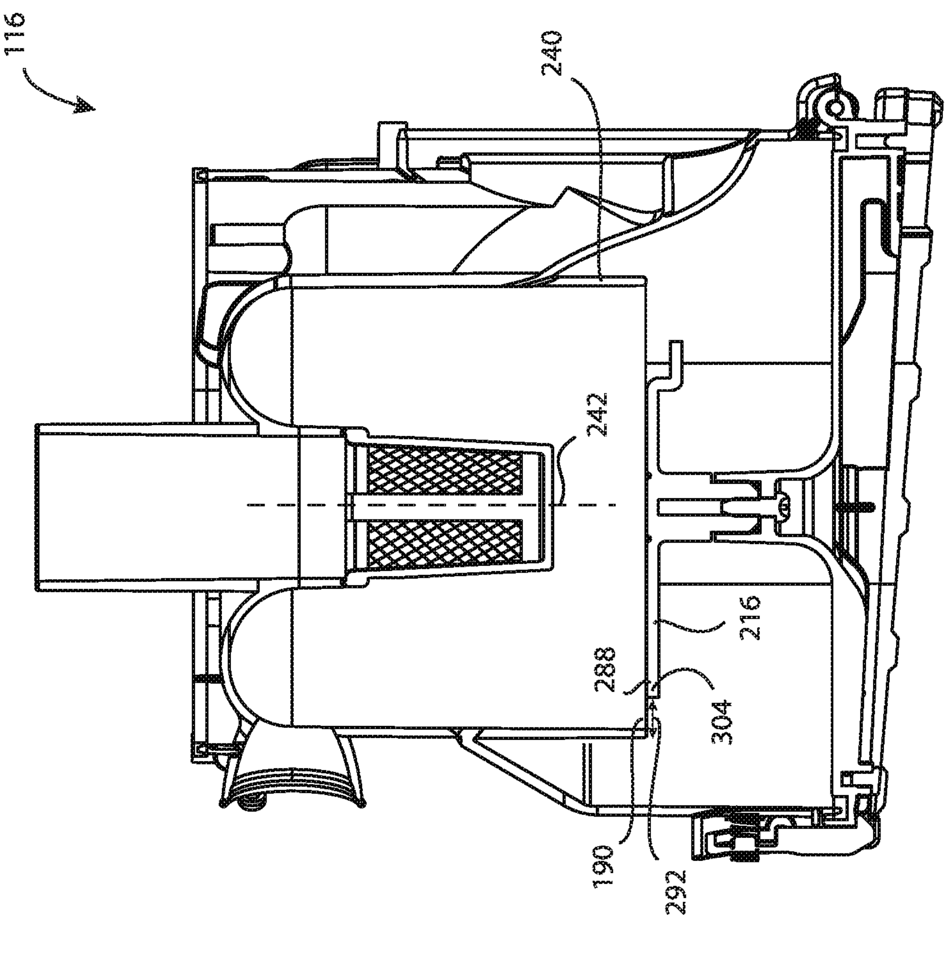

FIG. 7

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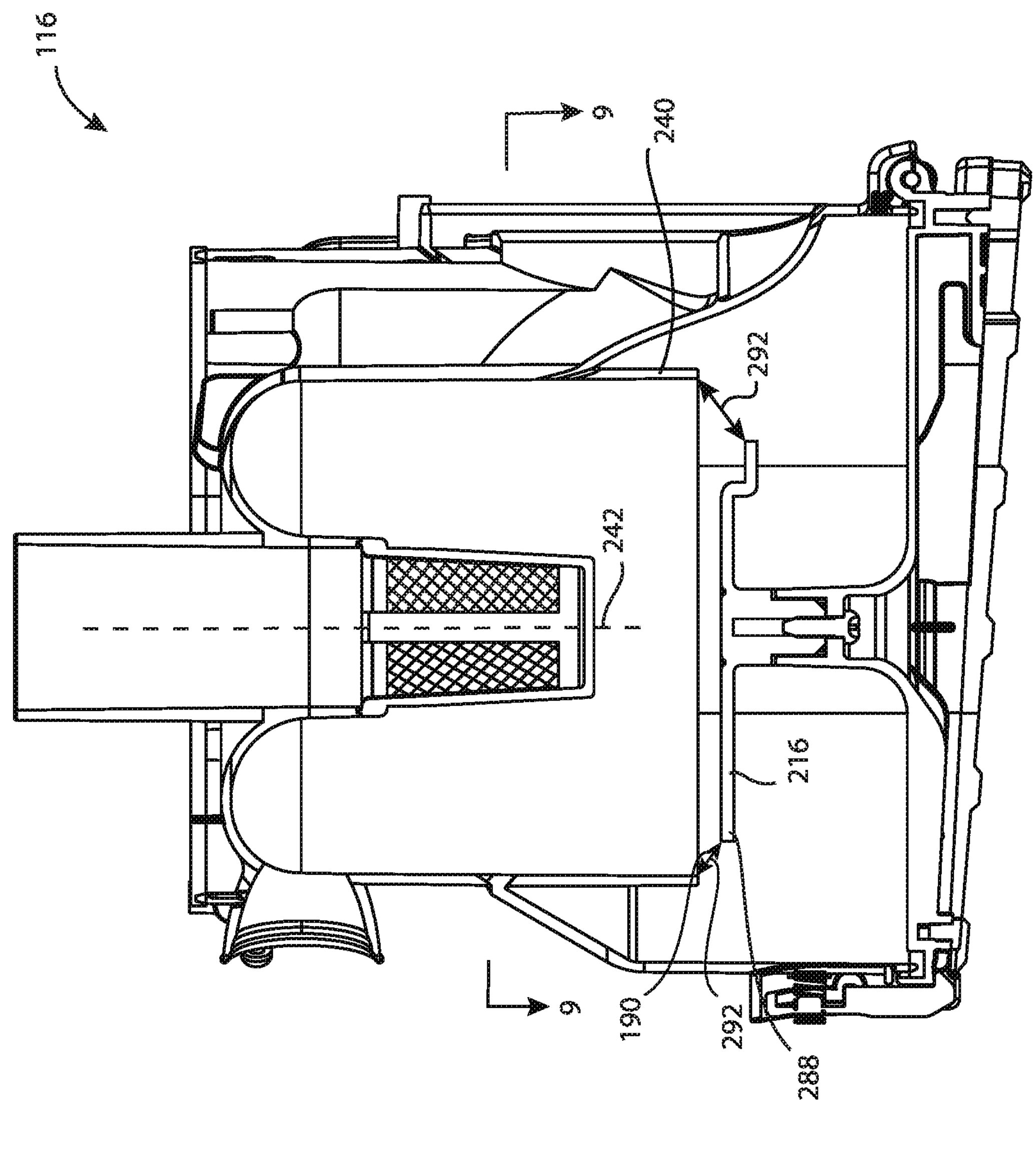

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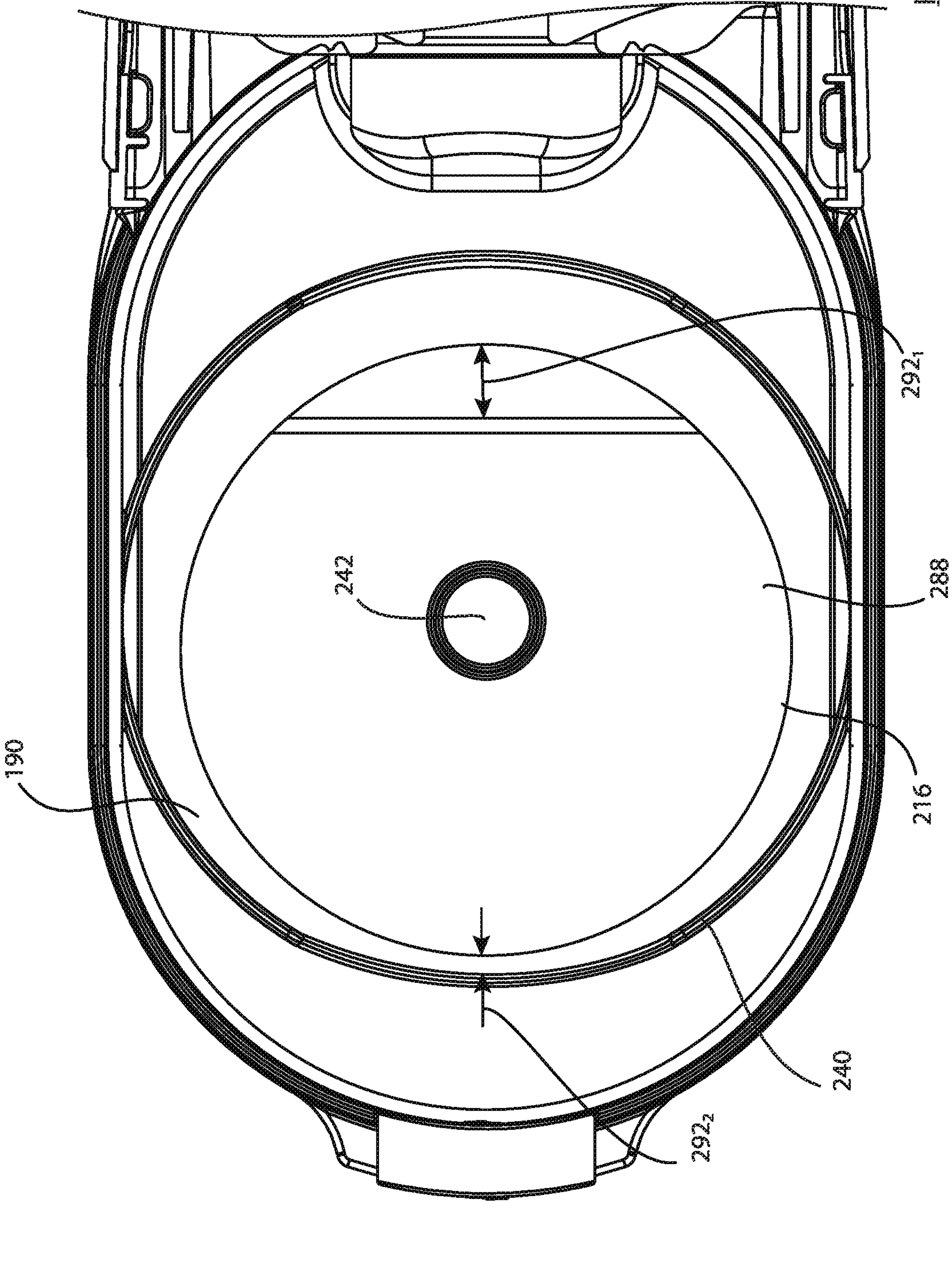

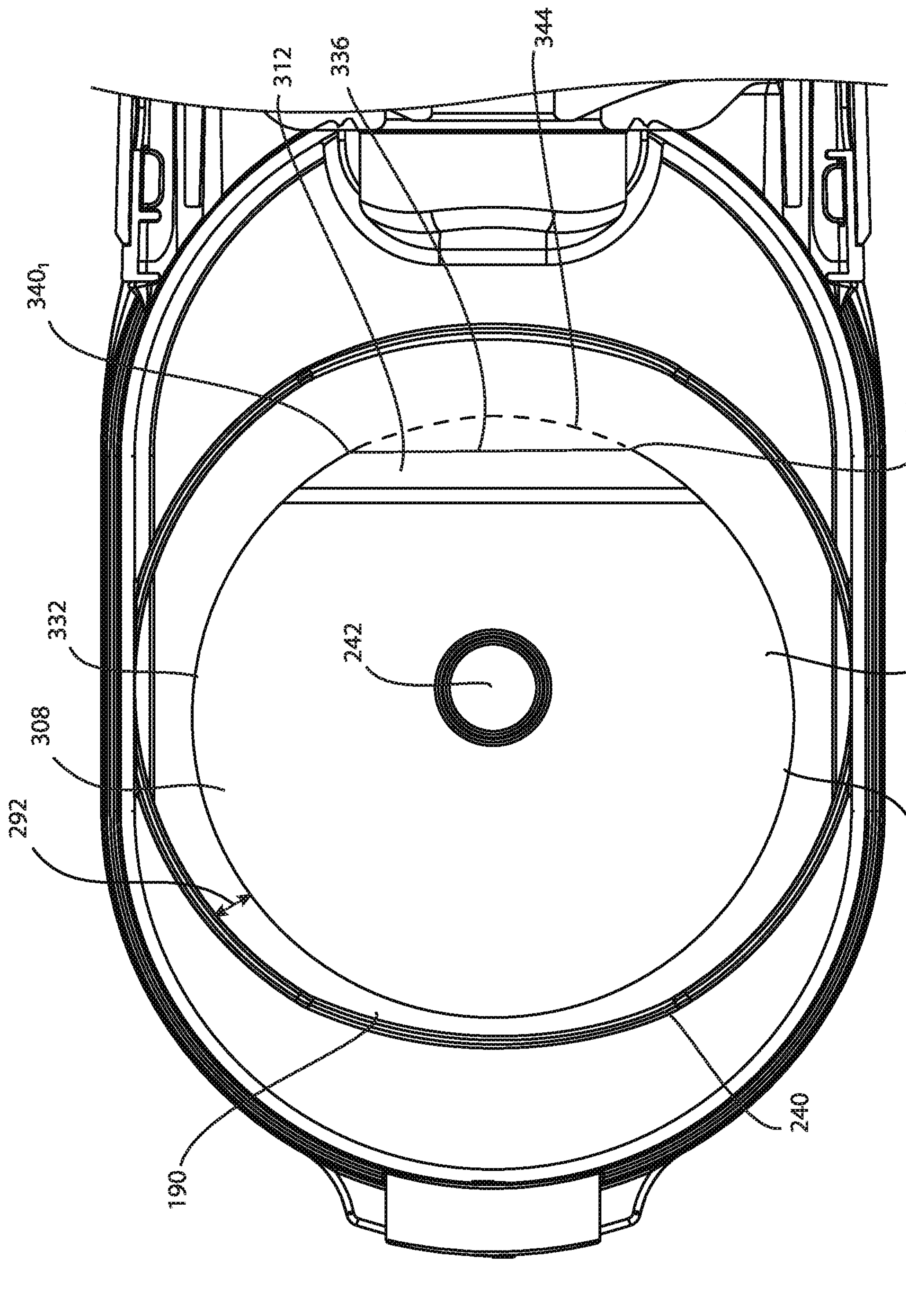

FIG. 10

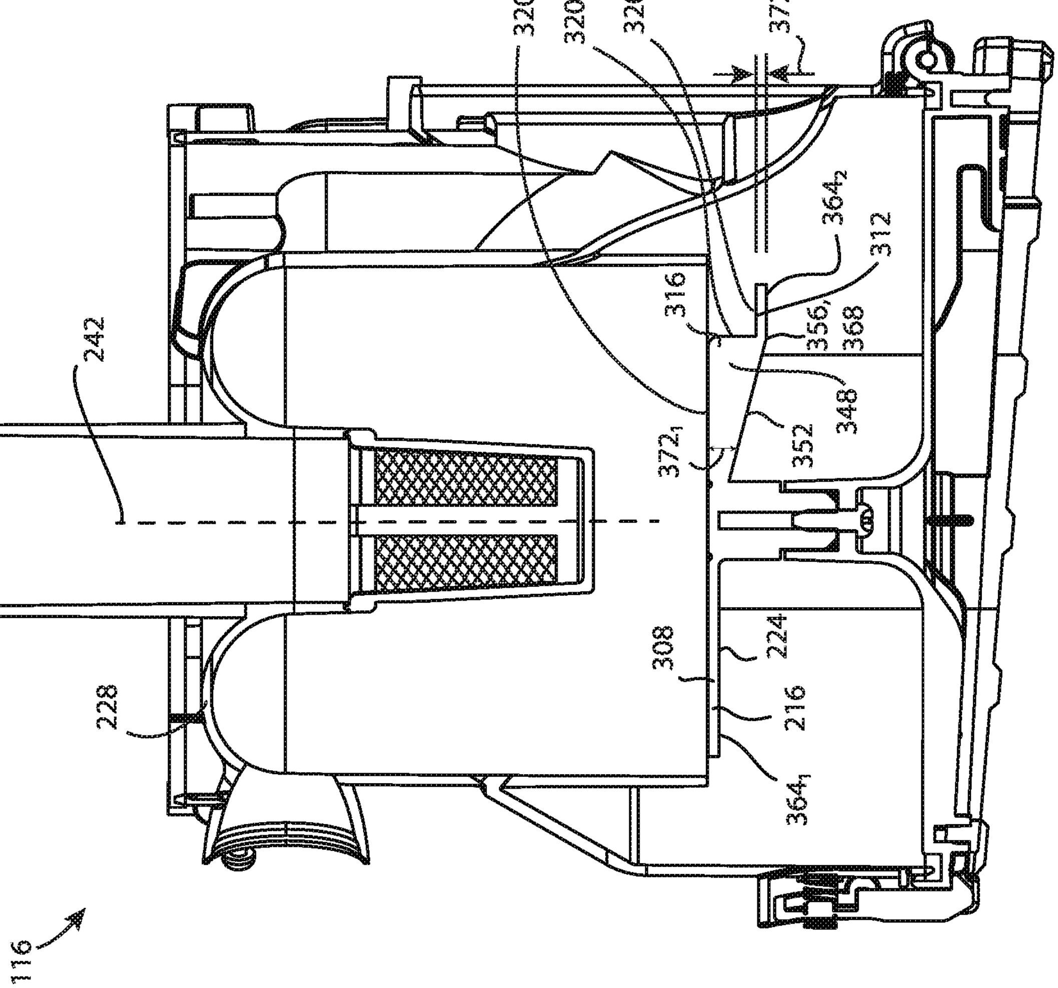
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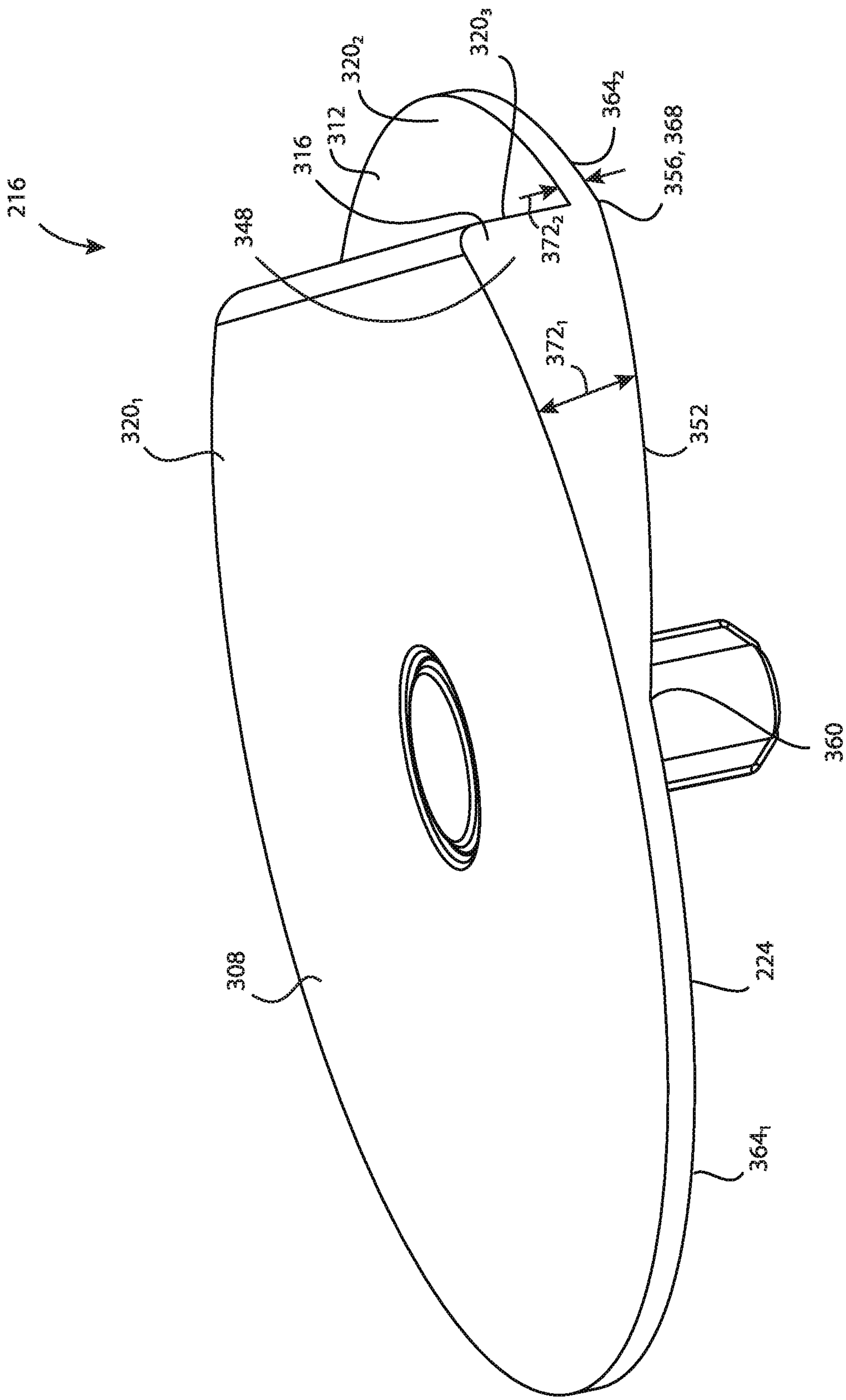
FIG. 11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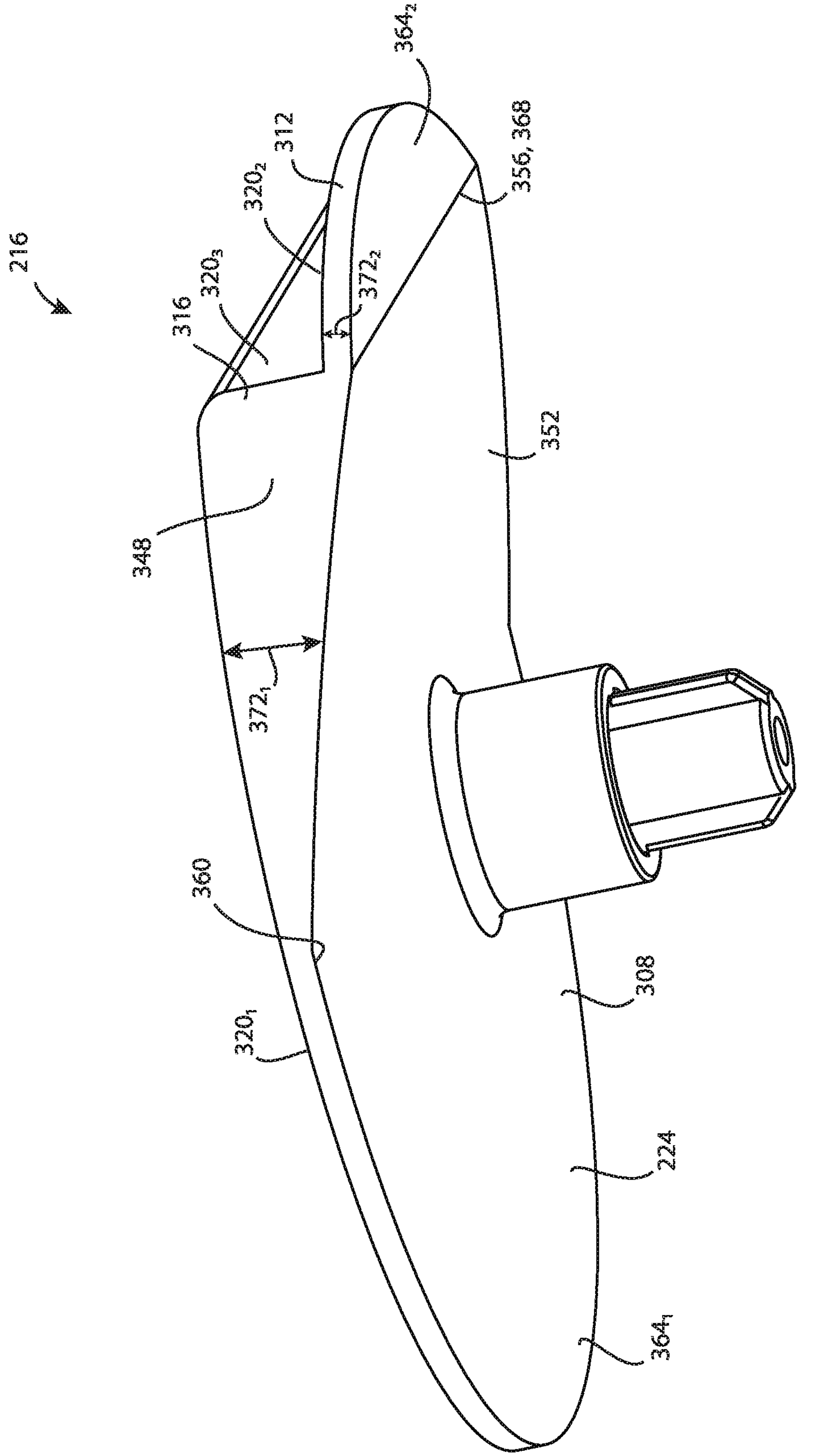
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FIG. 13

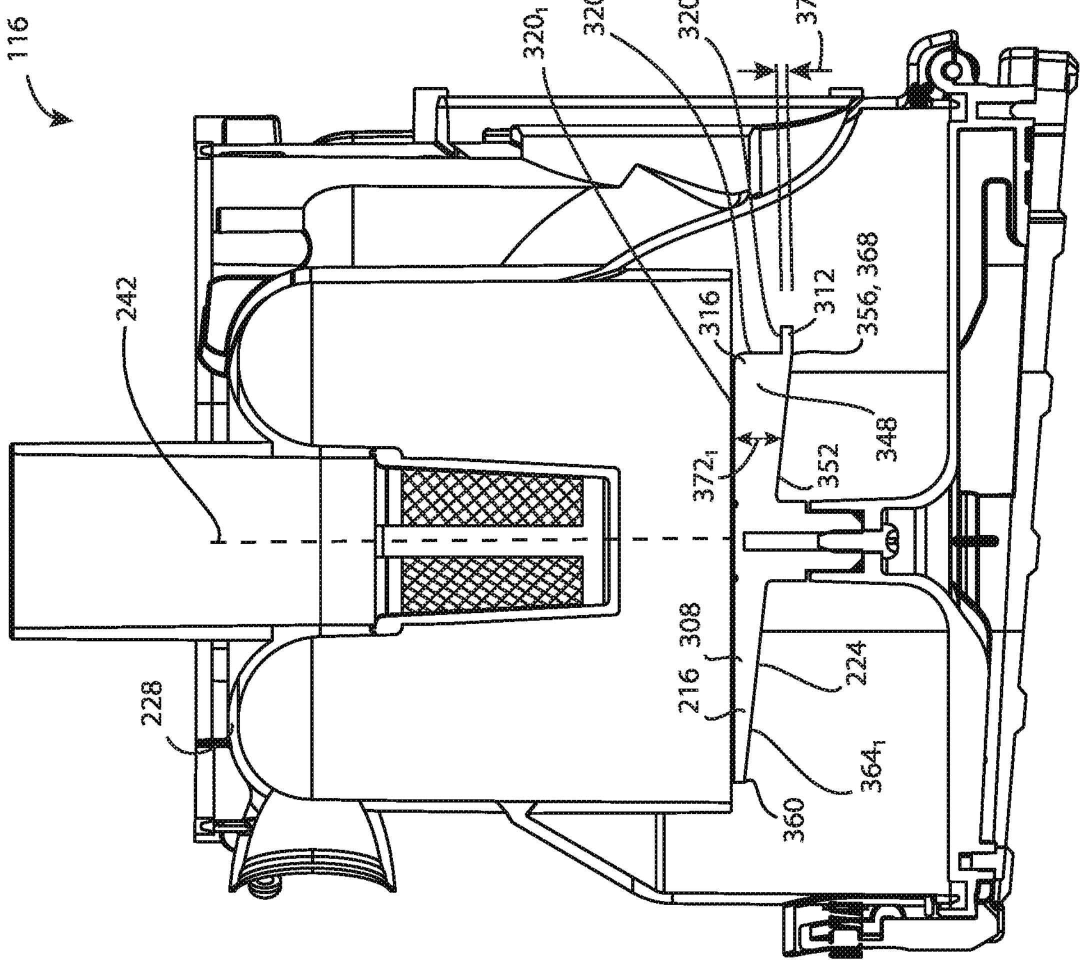
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FIG. 14

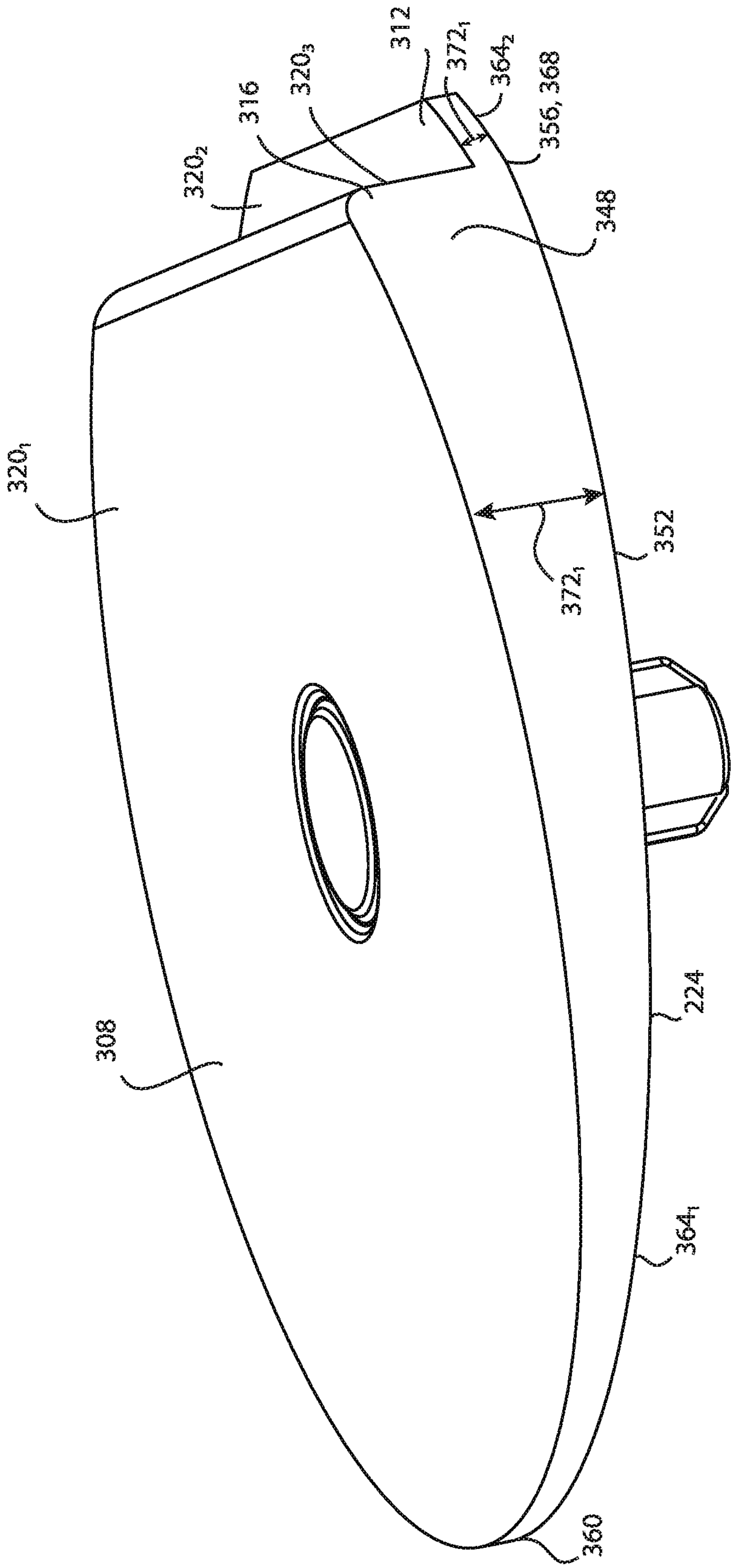
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FIG. 15

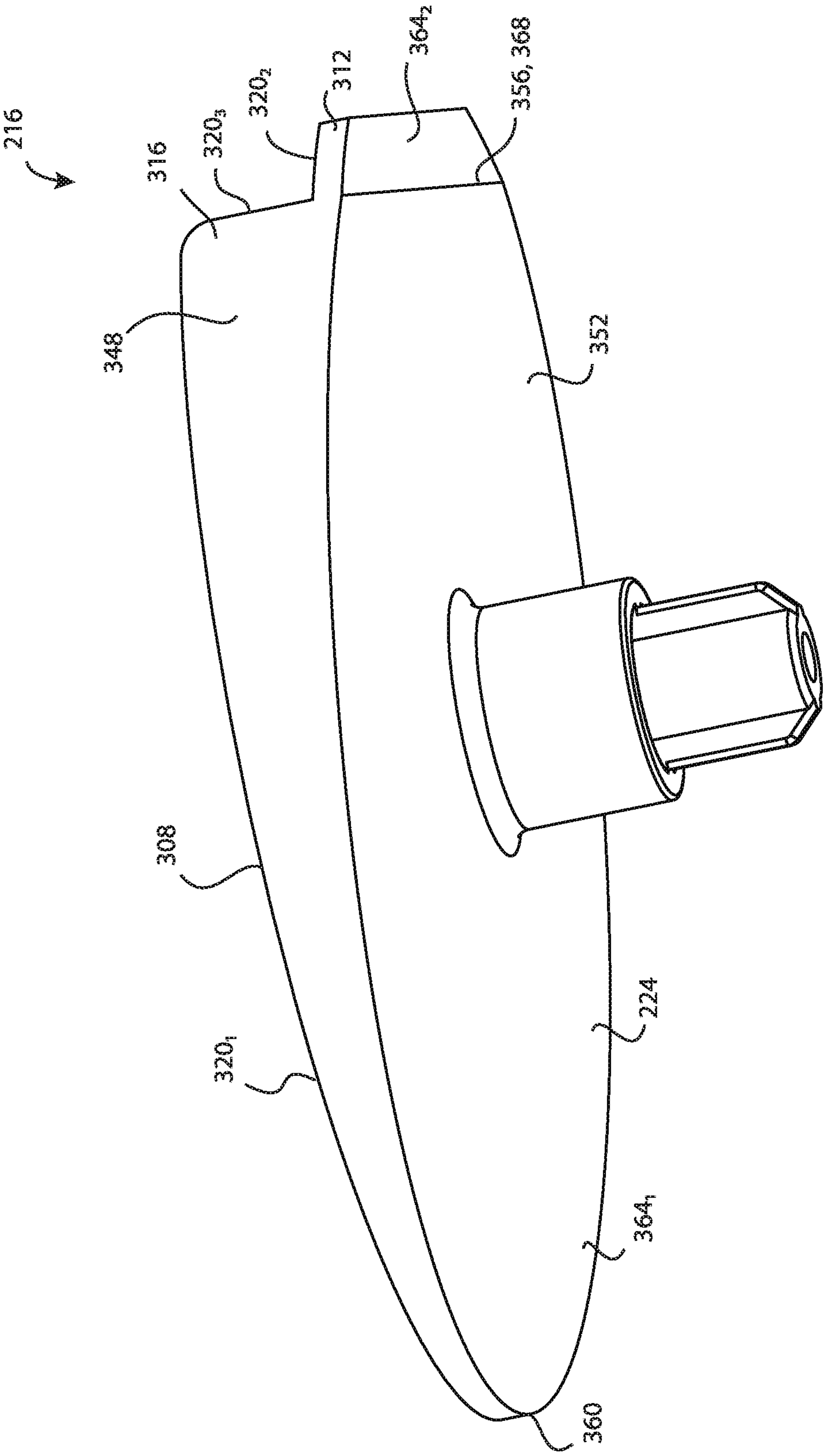
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FIG. 16

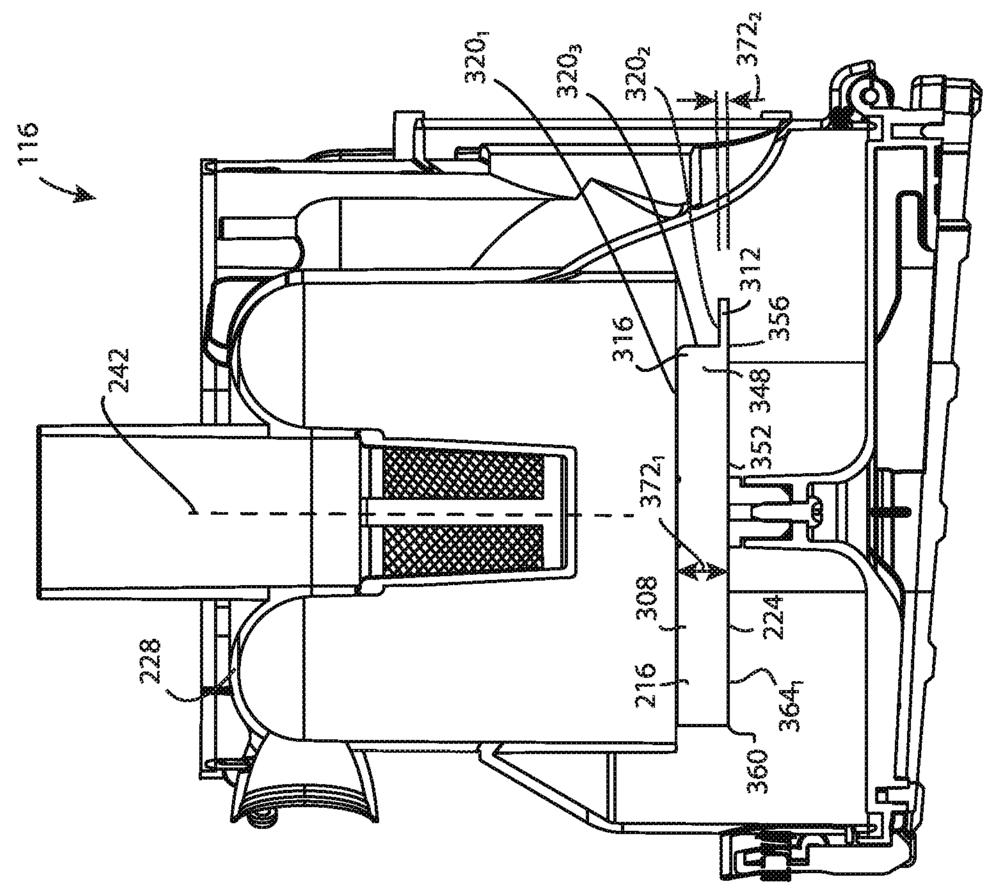
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FIG. 17

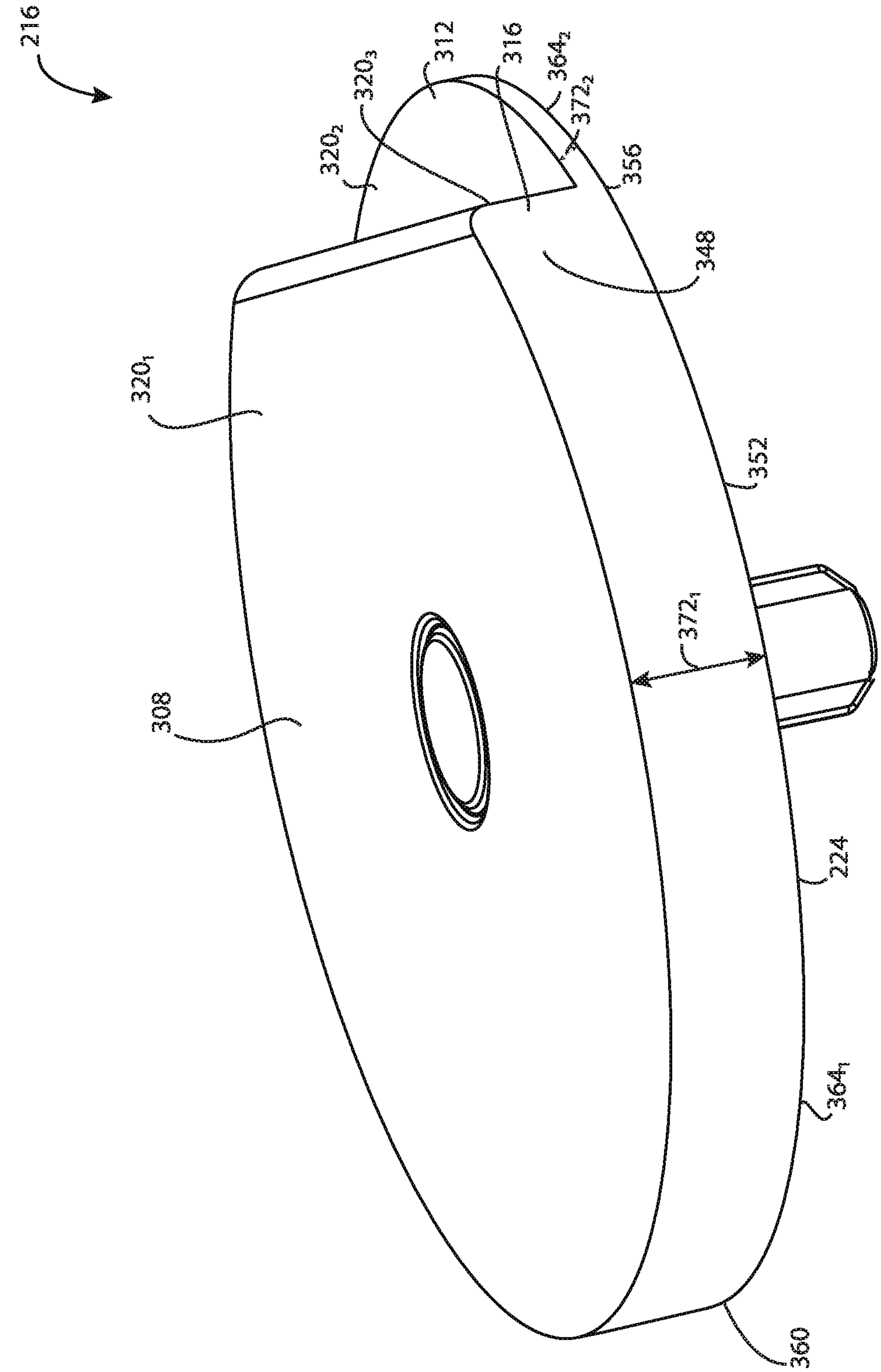
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FIG. 18

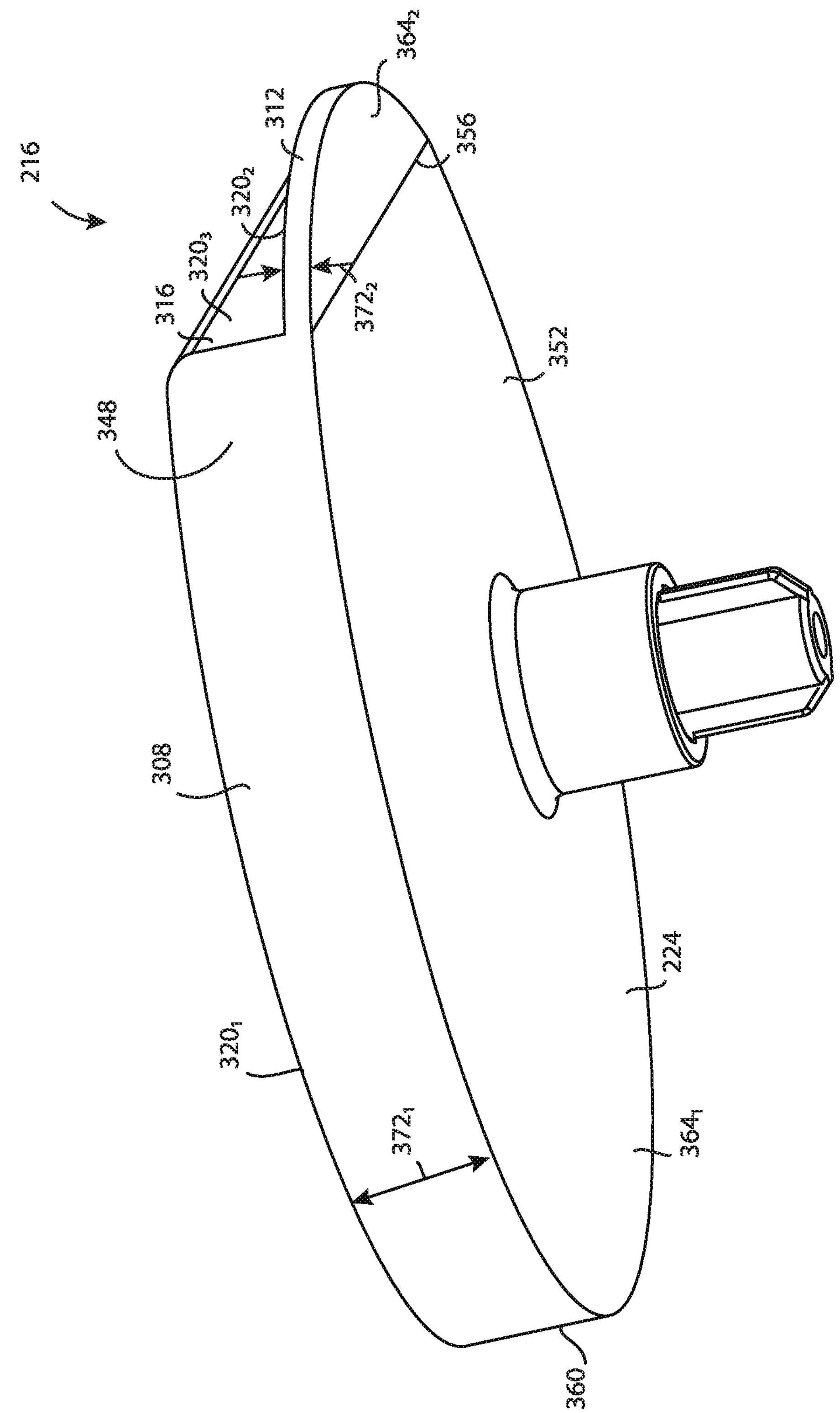
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FIG. 19

SURFACE CLEANING APPARATUS WITH DIRT ARRESTER HAVING AN AXIAL STEP

FIELD

This disclosure relates generally to surface cleaning apparatus. In a preferred embodiment, the surface cleaning apparatus comprises a cyclonic separator including a plate (also referred to as an arrester plate) at the dirt outlet and of a cyclone chamber wherein the plate has an axial step.

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. Such surface cleaning apparatus include vacuum cleaners, including upright vacuum cleaners, hand carriable vacuum cleaners, canister-type vacuum cleaners and Shop-Vac™ type vacuum cleaners. Some vacuum cleaners include a cyclonic separator (also referred to as a cyclone bin assembly) having a cyclone chamber, a dirt collection chamber, and a plate at the dirt outlet end. See for example Conrad (U.S. Pat. No. 8,640,304).

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.

According to a first aspect of this disclosure, which may be used by itself or in combination with one or more other aspects of this disclosure, a cyclone is provided at the dirt outlet end of the cyclone chamber with a plate that is stepped in the axial direction. The dirt outlet is defined at least in part by a gap between the plate and the sidewall of the cyclone chamber. Stepping the plate in the axial direction enables a portion of the plate to define a larger dirt outlet so as to enable larger dirt to exit the cyclone chamber.

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 and a suction motor provided in the air flow path;

(c) the cyclone comprising a cyclone chamber having a central longitudinal axis, the cyclone having a first end having a first end wall, an axially spaced apart second end, a cyclone chamber sidewall located between the first and second ends, a cyclone air inlet provided at the first end, a cyclone air outlet provided at the first end and a dirt outlet provided at the second end, wherein a reference plane that is perpendicular to the central longitudinal axis extends through the cyclone chamber; and,

(d) a plate located at the second end, the plate having a plate perimeter, a first portion,

- (i) a second portion and a transition portion provided between the first and second portions, each of the first, second and transition portions of the plate having a cyclone chamber face wherein the cyclone chamber faces of the first and second portions of the plate face towards the first end and border different portions of the plate perimeter,
- (ii) the second portion is spaced in a direction parallel to the central longitudinal axis further from the reference plane than the first portion,
- (iii) the dirt outlet comprises a spacing between the cyclone chamber sidewall and the second portion of the plate,
- (iv) the plate also having a dirt chamber face and a step volume, the step volume positioned axially between the cyclone chamber faces of the first and transition portions and the dirt chamber face whereby the dirt chamber face comprises a closure portion which underlies the step volume; and,

(e) a dirt collection region in communication with the cyclone chamber via the dirt outlet.

In any embodiment, the closure portion may extend at an angle to the central longitudinal axis.

In any embodiment, the first portion of the plate may be thicker than the second portion of the plate.

In any embodiment, a thickness of the first portion of the plate may increase towards the transition portion of the plate.

In any embodiment, a first discontinuity may be provided between the cyclone chamber face of the first portion of the plate and the cyclone chamber face of the transition portion and a second discontinuity may be provided between the cyclone chamber face of the transition portion and the cyclone chamber face of the second portion of the plate.

In any embodiment, the transition portion may extend generally axially.

In any embodiment, the first portion of the plate and the second portion of the plate may be generally planar.

In any embodiment, the dirt chamber face of the plate may be generally continuous.

In any embodiment, the dirt collection region may be axially spaced from and opposed to the first end of the cyclone.

In any embodiment, the closure portion may be planar.

In any embodiment, the closure portion may extend from a first end proximate a dirt chamber face of the second portion towards or across the central longitudinal axis to a second end, and the first end of the closure portion may be laterally spaced from the second end of the closure portion.

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

(a) an air flow path extending from a dirty air inlet to a clean air outlet and including a cyclone chamber and a suction motor;

(b) a dirt collection region external to the cyclone chamber; and,

(c) a plate positioned between the cyclone chamber and the dirt collection region and defining a dirt outlet from the cyclone chamber to the dirt collection region, the plate having a cyclone chamber face facing the cyclone chamber, an opposed dirt collection face facing the dirt collection region, and first, second, and transition portions, wherein cyclone chamber faces of the first and second portions are connected by a cyclone chamber face of the transition portion and are different axial distances from a transverse plane that extends through the cyclone and that is perpendicular to a central longitudinal axis of the cyclone, and the dirt collection face closes a step volume bordered by the first and transition portions.

In any embodiment, the first portion of the plate may be thicker than the second portion of the plate.

In any embodiment, the dirt chamber face of the plate may be generally continuous.

In any embodiment, the dirt collection region may be axially spaced from and opposed to the first end of the cyclone.

In any embodiment, a first discontinuity may be provided between the cyclone chamber face of the first portion of the plate and the cyclone chamber face of the second portion of the plate.

In any embodiment, the first portion of the plate and the second portion of the plate maybe generally planar.

In any embodiment, the closure portion may extend at an angle to the central longitudinal axis.

In any embodiment, the closure portion may be planar.

In any embodiment, the closure portion may extend from a first end proximate a dirt chamber face of the second portion towards or across the central longitudinal axis to a second end, and the first end of the closure portion may be laterally spaced from the second end of the closure portion.

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

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

(b) a cyclone provided in the air flow path, the cyclone comprising a cyclone chamber, a cyclone air inlet, a cyclone air outlet, a dirt outlet, a central longitudinally extending axis, the cyclone chamber having first and second axially opposed ends;

(c) a suction motor positioned in the air flow path;

(d) a dirt collection region external to the cyclone chamber; and,

(e) a plate positioned at the second end of the cyclone chamber, the plate having a cyclone chamber face facing the cyclone chamber, the cyclone chamber face having first and second portions, wherein the first portion of the cyclone chamber face and the second portion of the cyclone chamber face are different axial distances from a transverse reference plane that extends through the cyclone chamber and that is perpendicular to the central longitudinally extending axis of the cyclone, wherein an annular gap between the plate and the cyclone extends around all of the plate and defines the dirt outlet of the cyclone chamber.

In any embodiment, the annular gap may have a radial distance between the plate and the cyclone and the radial distance may be constant.

In any embodiment, the annular gap may have a radial distance between the plate and the cyclone and the radial distance may vary at different locations around the plate.

In any embodiment, the plate may have a perimeter and the perimeter may extend generally continuously.

In any embodiment, the plate has a perimeter and the perimeter has two discontinuities.

In any embodiment, the plate may have a segment removed. Optionally, the annular gap may have a radial distance between the plate and the cyclone, the radial distance may vary at different locations around the plate and the radial distance may be increased at a location of the plate from which the segment has been removed. Alternately, or in addition, the second portion may be a greater axial distance from the transverse plane than the first portion and the location of the plate from which the segment has been removed may be the second portion.

In any embodiment, the second portion may be a greater axial distance from the transverse plane than the first portion and the second portion has a segment removed. Optionally, the annular gap may have a radial distance between the plate and the cyclone and the radial distance may be increased at a location of removal of the segment.

In any embodiment, the plate may be positioned between the cyclone chamber and the dirt collection region, the plate may have a dirt collection face facing the dirt collection region.

In any embodiment, the cyclone air inlet and the cyclone air outlet may be provided at the first end of the cyclone chamber, the cyclone air outlet may comprise a vortex finder and porous member positioned between the cyclone chamber and an inlet of the vortex finder, and the vortex finder and porous member may be spaced from the cyclone chamber face of the plate.

In any embodiment, the plate may be moveably mounted between a closed position, in which the plate is positioned for operation of the cyclone and an open position wherein the plate is moved to provide access to the cyclone chamber.

In any embodiment, the dirt collection region has an end wall facing the plate and the end wall may be openable. Optionally, the plate may be supported by the end wall and is moveable with the end wall.

In any embodiment, the plate has a dirt collection face facing the dirt collection region and the surface cleaning apparatus may further comprise a support member extending between the end wall and the dirt collection face. Optionally, the cyclone air inlet and the cyclone air outlet may be provided at the first end of the cyclone chamber, the cyclone air outlet may comprise a vortex finder and porous member positioned between the cyclone chamber and an inlet of the vortex finder, and the vortex finder and porous member may be spaced from the cyclone chamber face of the plate.

In any embodiment, the plate has a perimeter, the cyclone has a generally axially extending sidewall and the annular gap may be provided between the perimeter of the plate and the sidewall.

In any embodiment, the cyclone has an axially extending sidewall and the sidewall has an end face and at least a portion of the end wall may face the plate.

Optionally, the plate has a perimeter, the dirt collection region has a sidewall and the annular gap may be provided between the perimeter of the plate and the sidewall.

DRAWINGS

The drawings included herewith are for illustrating various examples of articles, methods, and apparatus of the teaching of the present specification and are not intended to limit the scope of what is taught in any way.

In the drawings:

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 cross-sectional view taken along line **2-2** in FIG. **1** of a cyclone bin assembly of the surface cleaning apparatus of FIG. **1** when removed from the remainder of the surface cleaning apparatus;

FIG. **4** is a top perspective view of an arrester plate of the cyclone bin assembly of FIG. **3**;

FIG. **5** is a bottom perspective view of the arrester plate of FIG. **4**;

FIG. **6** is the cross-sectional view of FIG. **3** with the cyclone bin assembly in an open position;

FIG. **7** is a cross-sectional view of a cyclone bin assembly having an arrester plate in accordance with another embodiment;

FIG. **8** is a cross-sectional view of a cyclone bin assembly having an arrester plate in accordance with another embodiment;

FIG. **9** is a cross-sectional view taken along line **9-9** in FIG. **8**;

FIG. **10** is a cross-sectional view taken along line **9-9** in FIG. **8** with an arrester plate in accordance with another embodiment;

FIG. **11** is a cross-sectional view a cyclone bin assembly with an arrester plate in accordance with another embodiment;

FIG. **12** is a top perspective view of the arrester plate of the cyclone bin assembly of FIG. **11**;

FIG. **13** is a bottom perspective view of the arrester plate of the cyclone bin assembly of FIG. **11**;

FIG. **14** is a cross-sectional view a cyclone bin assembly with an arrester plate in accordance with another embodiment;

FIG. **15** is a top perspective view of the arrester plate of the cyclone bin assembly of FIG. **14**;

FIG. **16** is a bottom perspective view of the arrester plate of the cyclone bin assembly of FIG. **14**;

FIG. **17** is a cross-sectional view a cyclone bin assembly with an arrester plate in accordance with another embodiment;

FIG. **18** is a top perspective view of the arrester plate of the cyclone bin assembly of FIG. **17**; and,

FIG. **19** is a bottom perspective view of the arrester plate of the cyclone bin assembly of FIG. **17**.

DESCRIPTION OF VARIOUS EMBODIMENTS

Various apparatuses, methods and compositions are described below to provide an example of an embodiment of each claimed invention. No embodiment described below limits any claimed invention and any claimed invention may cover apparatuses and methods that differ from those described below. The claimed inventions are not limited to apparatuses, methods and compositions having all of the features of any one apparatus, method or composition described below or to features common to multiple or all of the apparatuses, methods or compositions described below. It is possible that an apparatus, method or composition described below is not an embodiment of any claimed invention. Any invention disclosed in an apparatus, method or composition described below that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicant(s), inventor(s) and/or owner(s) do not intend to abandon, disclaim, or dedicate to the public any such invention by its disclosure in this document.

The terms "an embodiment," "embodiment," "embodiments," "the embodiment," "the embodiments," "one or more embodiments," "some embodiments," "one embodiment", and the like 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.

Furthermore, it will be appreciated that for simplicity and clarity of illustration, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the example embodiments described herein. However, it will be understood by those of ordinary skill in the art that the example embodiments described herein may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the example embodiments described herein. Also, the description is not to be considered as limiting the scope of the example embodiments described herein.

General Description of a Vacuum Cleaner

Referring to FIGS. **1-2**, an exemplary embodiment of a surface cleaning apparatus is shown generally as **100**. The following is a general discussion of apparatus **100** which provides a basis for understanding several of the features which are discussed herein. As discussed subsequently, each of the features may be used individually or in any particular combination or sub-combination in this or in other embodiments disclosed herein.

Embodiments described herein include an improved cyclone assembly **116**, and a surface cleaning apparatus **100** including the same. Surface cleaning apparatus **100** may be any type of cyclonic surface cleaning apparatus, including for example a hand vacuum cleaner, a stick vacuum cleaner, a canister vacuum cleaner, and an upright 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 such as by an 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, and 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.

Still referring to FIGS. **1-2**, surface cleaning apparatus **100** includes a main body **112** having an air treatment member **116** (which may be permanently affixed to the main body or may be removable therefrom for emptying), a dirty air inlet **108**, a clean air outlet **120**, and an air flow path **124** extending between the dirty air inlet **108** and the clean air outlet **120**.

Surface cleaning apparatus **100** has a front end **128**, a rear end **132**, an upper end (also referred to as the top) **136**, and a lower end (also referred to as the bottom) **140**. In the embodiment shown, dirty air inlet **108** is at an upper portion of apparatus front end **128** and clean air outlet **120** is at a rearward portion of apparatus **100** at apparatus rear end **132**. It will be appreciated that dirty air inlet **108** and clean air outlet **120** may be positioned in different locations of apparatus **100**.

A suction motor **144** is provided to generate vacuum suction through air flow path **124**, and is positioned within a motor housing **148**. Suction motor **144** may be a fan-motor assembly including an electric motor and impeller blade(s). In the illustrated embodiment, suction motor **144** is positioned in the air flow path **124** downstream of air treatment member **116**. In this configuration, suction motor **144** may be referred to as a "clean air motor". Alternatively, suction motor **144** may be positioned upstream of air treatment member **116**, and referred to as a "dirty air motor".

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 a single cyclonic cleaning stage with a single cyclone **152** and a dirt collection chamber **156** (also referred to as a "dirt collection region", "dirt collection bin", "dirt bin", or "dirt chamber"). Cyclone **152** has a cyclone chamber **154**, and dirt collection chamber **156** may be external to the cyclone chamber **154** (i.e. dirt collection chamber **156** may have a discrete volume from that of cyclone chamber **154**). Cyclone **152** and dirt collection chamber **156** may be of any configuration suitable for separating dirt from an air stream and collecting the separated dirt, respectively and may be in communication by a dirt outlet of the cyclone chamber.

In alternate embodiments, air treatment member **116** may include a cyclone assembly having two or more cyclonic cleaning stages arranged in series with each other. Each cyclonic cleaning stage may include one or more cyclones arranged in parallel with each other and one or more dirt collection chambers, of any suitable configuration. The dirt collection chamber(s) may be external to the cyclone chambers of the cyclones. Alternatively, one or more (or all) of the dirt collection chamber(s) may be internal to one or more (or all) of the cyclone chambers. For example, the internal dirt collection chamber(s) may be configured as a dirt collection area within the cyclone chamber.

Referring to FIG. **2**, hand vacuum cleaner **100** may include a pre-motor filter **160** provided in the air flow path **124** downstream of air treatment member **116** and upstream of suction motor **144**. Pre-motor filter **160** may be formed from any suitable physical, porous filter media. For example, pre-motor filter **160** may be one or more of a foam filter, felt filter, HEPA filter, or other physical filter media. In some embodiments, pre-motor filter **160** may include an electrostatic filter, or the like. As shown, pre-motor filter **160** may be located in a pre-motor filter housing **164** that is external to the air treatment member **116**.

In the illustrated embodiment, dirty air inlet **108** is the inlet end **168** of an air inlet conduit **172**. Optionally, inlet end **168** of air inlet conduit **172** can be used as a nozzle to directly clean a surface. Alternatively, or in addition to functioning as a nozzle, air inlet conduit **172** 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 embodiment of FIG. **2**, the air treatment member comprises a cyclone **152**, the air treatment air inlet is a cyclone air inlet **184**, and the air treatment member air outlet is a cyclone air outlet **188**. Accordingly, in operation, after activating suction motor **144**, dirty air enters apparatus **100** through dirty air inlet **108** and is directed along air inlet conduit **172** to the cyclone air inlet **184**. As shown, cyclone air inlet **184** may direct the dirty air flow to enter cyclone chamber **154** 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 from cyclone air inlet **184** to cyclone air outlet **188**. The disentrained dirt particles and debris may discharge from cyclone chamber **154** through a dirt outlet **190** into dirt collection chamber **156** external to the cyclone chamber **154**, where the dirt particles and debris may collect until dirt collection chamber **156** is emptied.

Air exiting cyclone chamber **154** may pass through an outlet passage **192** located upstream of cyclone air outlet **188**. Cyclone chamber outlet passage **192**, may also act as a vortex finder to promote cyclonic flow within cyclone chamber **154**. In some embodiments, cyclone outlet passage **192** may include a porous member such as a screen or shroud **196** (e.g. a fine mesh screen) in the air flow path **124** (e.g., positioned between the cyclone chamber and an inlet of the vortex finder) to remove large dirt particles and debris, such as hair, remaining in the exiting air flow. The vortex finder and porous member may be spaced from the cyclone chamber face of plate **216**. It will be appreciated that, in some embodiments, only a screen may be provided. Alternately a vortex finder may be provided without a screen or the like.

From cyclone air outlet **188**, the air flow may be directed into pre-motor filter housing **164** at an upstream side **204** of pre-motor filter **160**. The air flow may pass through pre-motor filter **160** to pre-motor filter downstream side **208**, and then exit through pre-motor filter chamber air outlet **212** into motor housing **148**. At motor housing **148**, the clean air flow may be drawn into suction motor **144** and then discharged from apparatus **100** through clean air outlet **120**.

Axially Stepped Arrester

The following is a description of a dirt arrester plate (also referred to as a "dirt arrester", "arrester plate", or simply "plate") that separates the cyclone chamber from the dirt collection chamber that may be used in any cyclone design. In accordance with this feature, the dirt collection chamber is external to the cyclone chamber and the dirt outlet from the cyclone chamber comprises or consists of a gap between the arrester plate and the cyclone chamber sidewall. In accordance with this design, the arrester plate has an 'axial step', in which a portion of the arrester plate is axially recessed to create an axially recessed step. The axial step may create a relatively larger dirt outlet gap between the cyclone chamber sidewall and the stepped portion of the arrester plate periphery, which can allow larger debris to pass through the dirt outlet.

Without being limited by theory, as compared with an entirely planar arrester plate having a generally uniformly sized dirt outlet gap, the axially stepped arrester design may provide greater separation efficiency (i.e. percentage of dirt particles of a dirty air flow separated from the air flow and retained in the dirt collection chamber) by permitting larger dirt particles to exit the cyclone chamber thereby reducing the likelihood that larger dirt particles in the cyclone chamber may produce eddy currents or otherwise interfere with the flow pattern in a cyclone chamber. Thus, the axially stepped arrester design may allow the dirt collection chamber to admit large dirt particles (e.g. stones, dry foods, etc.) while providing a high separation efficiency.

Reference is now made to FIGS. **3-5**. As shown, cyclone bin assembly **116** includes an arrester plate **216** that separates cyclone chamber **154** from dirt collection chamber **156**. Arrester plate **216** also cooperates with cyclone **152** to define dirt outlet **190** from cyclone chamber **154** into dirt collection chamber **156**.

Arrester plate **216** may define at least part of an end wall for one or both of cyclone **152** and dirt collection chamber **156**. As shown, arrester plate **216** may have a cyclone chamber face **220** that borders cyclone chamber **154**, and an opposite dirt chamber face **224** that borders dirt collection chamber **156**. Cyclone chamber face **220** may face towards an interior volume of cyclone chamber **154**. Similarly, dirt chamber face **224** may face towards an interior volume of dirt collection chamber **156**.

Cyclone **152** has a first end **228** having a first end wall **232**, a second end **236** axially spaced apart from first end **228**, and a cyclone chamber sidewall **240** positioned between the first and second ends **228** and **236**. Cyclone **152** also has a central longitudinal axis **242** (also referred to as a “cyclone axis”) that extends from the first end **228** to the second end **236**. In the example shown, cyclone second end **236** may be defined at least in part by cyclone chamber face **220** of arrester plate **216**. In some embodiments, at least a portion of cyclone chamber face **220** faces (i.e. has a surface normal pointed towards) cyclone first end **228**. It will be appreciated that, if plate **216** is spaced from sidewall **240**, then sidewall **240** will not extend to plate **216**. In some embodiments, a portion of plate **216** may abut portions of sidewall **240** while another portion, e.g., the stepped down portion, may be spaced from sidewall **240** to define part or all of the dirt outlet.

Still referring to FIGS. **3-5**, cyclone outlet passage **192** may define a vortex finder that promotes cyclonic flow within cyclone chamber **154**. As shown, cyclone outlet passage **192** may extend from a first end **244** at cyclone first end **228**, to a second end **248** within cyclone chamber **154**. Cyclone outlet passage **192** has one or more inlet openings **252** that admit air exiting cyclone chamber **154** to enter cyclone outlet passage **192** towards cyclone air outlet **188**. Cyclone outlet passage opening(s) **252** may be overlaid with a porous member **254** (e.g. a fine mesh screen), which may remove large dirt and debris from the air flow entering the cyclone outlet passage **192**. As shown, cyclone outlet passage **192** and porous member **254** may be spaced (e.g. axially) from cyclone chamber face **220** of arrester plate **216**. Cyclone outlet passage **192** may be intersected by cyclone axis **242**. As shown, cyclone outlet passage **192** may have a central longitudinal axis **256** that is parallel to cyclone axis **242** (e.g. collinear to cyclone axis **242**, or spaced apart from cyclone axis **242**).

It will be appreciated that any cyclone air outlet may be used and that the cyclone air outlet may be at various locations as is known in the art. Similarly, it will be appreciated that any cyclone air inlet **184** may be used and that the cyclone air inlet may be at various locations as is known in the art.

Dirt collection chamber **154** has a first end **260**, a second end **264** axially spaced apart from first end **260**, and a sidewall **268** that extends between the first and second ends **260** and **264**. Dirt collection chamber **154** has a longitudinal axis **272** (also referred to as a “dirt chamber axis”). Dirt chamber axis **272** may be parallel to cyclone axis **242** (e.g. collinear to cyclone axis **242**, or transversely spaced apart from cyclone axis **242**). Dirt chamber first end **260** may be defined at least in part by dirt chamber face **224** of arrester plate **216**. Dirt chamber second end **264** may include a second end wall **276**. In some embodiments, at least a portion of dirt chamber face **224** faces (i.e. has a surface normally pointed towards) dirt chamber second end **264**.

As used herein, the term “axial” and “axially” mean “in a direction parallel to the respective longitudinal axis”, such as for example cyclone axis **242** or dirt chamber axis **272**. For example, dirt chamber face **224** may be described as being axially spaced apart from cyclone chamber face **220** in that dirt chamber face **224** is spaced from cyclone chamber face **220** in a direction parallel to or along the cyclone axis **242**.

Referring to FIGS. **8-9**, cyclone dirt outlet **190** may extend around all of arrester plate periphery **288**. As shown, every point on arrester plate periphery **288** may have a (non-zero) dirt outlet gap length **292** to cyclone chamber sidewall **240**. In this way, dirt outlet **190** may form a continuous annular gap. This helps to mitigate the development of blockages caused by an accumulation of debris at locations where there is no dirt outlet **190**, e.g. because the dirt outlet **190** is obstructed. In other embodiments, arrester plate **216** may about part of sidewall **240**.

Referring to FIGS. **3** and **6**, arrester plate **216** may be movable between a closed position (FIG. **3**) and an open position (FIG. **6**). In the closed position, arrester plate **216** may act to separate cyclone chamber **154** from dirt collection chamber **156**. If plate **216** contacts part of sidewall **240**, then arrester plate **216** may at least partially close cyclone second end **236** when in the closed position. Alternately, as exemplified in FIGS. **3** and **8-10**, plate **216** may be spaced from all of sidewall **240** when in the closed position. In the open position, arrester plate **216** may be positioned to provide user access to cyclone chamber **154** (e.g. for cleaning). For example, arrester plate **216** may close less of or none of cyclone second end **236** when in the open position as compared to the closed position.

As shown, arrester plate **216** may be connected to an openable end wall **276** of dirt collection chamber **156**. Arrester plate **216** may move with end wall **276** so that when end wall **276** is opened, arrester plate **216** is displaced from (i.e. moved away from) cyclone second end **236**. This allows cyclone chamber **154** and dirt collection chamber **156** to be opened and emptied concurrently by moving end wall **276** from its closed position (FIG. **3**) to its open position (FIG. **6**). Alternately, plate **216** may be pivotally mounted to sidewall **240**, to a sidewall of the dirt chamber,

In some embodiments, plate **216** may not be openable, or it may be openable separately from the dirt chamber. For example, plate **216** may be pivotally mounted to sidewall **240** or to a sidewall of the dirt chamber and may have its own releasable lock. Accordingly, plate **216** may remain in position when end wall **276** is opened and may be separately openable.

Dirt chamber end wall **276** may be openable in any manner that allows access to empty dirt collection chamber **156**. For example, dirt chamber end wall **276** may be pivotally openable as shown, or removable from dirt collection chamber **156**. In the illustrated example, dirt chamber end wall **276** is rotatably connected to dirt collection chamber sidewall **268** by a hinge **280**, and releasably held in the closed position (FIG. **3**) by a latch **284**.

Arrester plate **216** may be connected to dirt chamber end wall **276** in any manner that allows arrester plate **216** to open concurrently as dirt chamber end wall **276** is opened. In the illustrated example, arrester plate **216** is connected to dirt chamber end wall **276** by a rigidly mounted support member **286**. Accordingly, support member **286** may be a post that rigidly connects arrester plate **216** to dirt chamber end wall **276**, whereby arrester plate **216** and dirt chamber end wall **276** move as one. In some embodiments, support member **286** may be moveable (pivotally) mounted with respect to end wall **276** and/or plate **216** may be moveable (pivotally) mounted with respect to support **268**. As shown, support member **286** may extend from dirt chamber face **224** of arrester plate **216** to dirt chamber end wall **276**. In this example, at least a portion of dirt chamber end wall **276** faces (i.e. has a surface normal pointed towards) arrester plate **216** (e.g. towards dirt chamber face **224**).

Returning to FIGS. **3-5**, cyclone dirt outlet **190** may be formed by a gap between cyclone chamber sidewall **240** and the arrester plate **216**). Dirt that is disentrained (i.e. separated) from the airflow circulating through cyclone chamber **154** (e.g. by cyclonic action within cyclone chamber **154**) may exit cyclone chamber **154** through dirt outlet **190** into dirt collection chamber **156**. The maximum size of a dirt particle that can exit through dirt outlet **190** is defined by a gap length **292**. Gap length **292** is the shortest distance between a given point on arrester plate **216** and cyclone chamber sidewall **240**.

There may be a uniform gap length **292** at every point on arrester plate periphery **288**, or gap length **292** may vary along arrester plate periphery **288**.

As exemplified in FIG. **3**, plate **216** may have a diameter similar to the diameter of cyclone chamber **154** and the cyclone axis may intersect the centre of arrester plate **216**. Accordingly the arrester plate periphery **288** (also referred to as “arrester plate perimeter”) may underlie the sidewall **240** (i.e., a projection of sidewall **240** may intersect the arrester plate periphery **288**) such that arrester plate periphery **288** underlies a free end **296** of cyclone chamber sidewall **240**. Accordingly, as exemplified in FIG. **3**, dirt outlet **190** is defined by a gap length **292**, which is solely axial. That is, the shortest distance between every point on arrester plate periphery **288** and cyclone chamber sidewall **240** is in a direction parallel to cyclone axis **242**.

It will be appreciated that the cross sectional area of plate **216** and the outlet end of the cyclone chamber **154** may vary (e.g., plate **216** may have a diameter that is smaller than or larger than the diameter of cyclone chamber **154**). The arrester plate may be coplanar with free end **296** of cyclone chamber sidewall **240** (see for example FIG. **7**) or is may be axially spaced therefrom (See for example FIG. **8**).

FIG. **7** shows an example in which arrester plate **216** has a diameter that is smaller than the diameter of cyclone chamber **154** so that at least a portion of dirt outlet **190** is defined by gap lengths **292** that are solely radial. That is, the shortest distance between at least a portion **304** of arrester plate periphery **288** and cyclone chamber sidewall **240** is in a direction that is transverse (e.g. perpendicular) to cyclone axis **242**. As shown, at least portion **304** of arrester plate periphery **288** has the same axial position as a portion of cyclone chamber sidewall **240**.

FIG. **8** shows an example in which all of dirt outlet **190** is defined by gap lengths **292** that include radial and axial components. That is, the shortest distance between at least a portion **304** of arrester plate periphery **288** and cyclone chamber sidewall **240** is in a direction that is at a non-zero and non-perpendicular angle (i.e. non-parallel and non-orthogonal) to cyclone axis **242**.

Different points on arrester plate periphery **288** may have different dirt outlet gap lengths **292**. FIG. **9** shows an example in which arrester plate **216** is off-centered relative to cyclone axis **242** whereby radial gap length **292** is greater at some points along arrester plate periphery **288** than others (e.g. compare gap length **292_1** to gap length **292_2**). Alternatively, or in addition, arrester plate periphery **288** may have an axial shape (i.e. the shape of a projection of arrester plate periphery **288** in a direction parallel to cyclone axis **242**) that differs from the axial shape of cyclone chamber sidewall **240** where cyclone chamber sidewall **240** is nearest to arrester plate periphery **288** (e.g. a triangular arrester plate periphery **288** and circular cyclone chamber sidewall **240**). This too may produce a variable gap length **292** around arrester plate periphery **288**.

Returning to FIGS. **3-5**, the illustrated arrester plate **216** is shown including an upper plateau and a peripheral step on one side. The peripheral step can provide an enlarged dirt outlet gap length across only the stepped portion of the dirt arrester periphery. An advantage of this design is that the enlarged dirt outlet gap provides clearance for large dirt particles to pass through the dirt outlet into the dirt collection chamber while optionally maintaining a smaller gap for the remainder of the perimeter of the arrester plate (if the remainder of the arrester plate is spaced from sidewall **240**). As compared with a dirt arrester that has a comparably large gap length about the entire arrester plate periphery, the illustrated axially stepped design may mitigate re-entry of dirt from the dirt collection chamber into the cyclone chamber through the dirt outlet because much of the dirt outlet retains a relatively smaller gap length. In laboratory testing, the axially stepped design produced greater dirt separation efficiency as compared with a uniformly planar arrester plate, all else being equal.

As shown, arrester plate **216** includes a first portion **308** and a second portion **312**. The first and second portions **308** and **312** are axially spaced apart and joined together by a transition portion **316** positioned between the first and second portions **308** and **312**. In the illustrated example, transition portion **316** extends from first portion **308** to second portion **312**. First, second, and transition portions **308**, **312**, and **316** may be integrally formed as shown, or discretely formed and rigidly connected together. At least the first and second portions **308** and **312** each include a portion of arrester plate periphery **288**. In the illustrated example, each of the first, second, and transition portions **308**, **312**, and **316** include a portion of arrester plate periphery **288**.

Each of first, second, and transition portions **308**, **312**, and **316** includes a cyclone chamber face **320_1**, **320_2**, and **320_3** respectively. Cyclone chamber faces **320** border the inner volume of cyclone chamber **154**. As shown, second portion cyclone chamber face **320_2** may be axially spaced (i.e. in a direction parallel to cyclone axis **242**) apart from first portion cyclone chamber face **320_1** in a direction away from cyclone first end **228**. Thus, arrester plate second portion **312** forms an axial step from the arrester plate first portion **308**. As shown, the axial separation between arrester plate first and second portions **308** and **312** may provide arrester plate periphery **288** with a greater dirt outlet gap length **292** at arrester plate second portion **312** than at arrester plate first portion **308**. This allows larger particles to pass through dirt outlet **190** at arrester plate second portion **312**, while maintaining a smaller gap at arrester plate first portion **308** to mitigate re-entry of dirt particles from dirt collection chamber **156** into cyclone chamber **154**.

As shown, cyclone chamber faces 320_1 and 320_2 of arrester plate first and second portions **308** and **312** may face towards cyclone first end **228** (e.g. towards cyclone first end wall **232**). In the illustrated example, cyclone chamber faces 320_1 and 320_2 are substantially planar and perpendicular to cyclone axis **242**. In other embodiments, one or both of cyclone chamber faces 320_1 and 320_2 may be non-planar. Alternatively or in addition, one or both of cyclone chamber faces 320_1 and 320_2 may be non-perpendicular to cyclone axis **242**.

Axial separation between cyclone chamber faces 320_1 and 320_2 may be described by their distances from a reference plane **324** (also referred to as a "transverse plane"), which is perpendicular to cyclone axis **242** and intersects the cyclone, such as at cyclone first end **228**. As shown, axial distance 322_2 from second portion cyclone chamber face 320_2 to reference plane **324** is greater than axial distance 322_1 from first portion cyclone chamber face 320_1 to reference plane **324**.

Transition cyclone chamber face 320_3 may extend at a non-zero angle to first and second portion cyclone chamber faces 320_1 and 320_2. As shown, transition cyclone chamber face 320_3 may extend substantially axially (e.g. substantially parallel to cyclone axis **242**). In the example shown, transition cyclone chamber face 320_3 extends perpendicular to first and second portion cyclone chamber faces 320_1 and 320_2. As shown, transition cyclone chamber face 320_3 may be substantially planar.

In some embodiments, transition cyclone chamber face 320_3 may be non-perpendicular to cyclone axis **242**. For example, it may extend at an acute angle to each of first and second portion cyclone chamber faces 320_1 and 320_2. Alternately, or in addition, transition cyclone chamber face 320_3 may be non-planar; for example, it may curve from first and second portion cyclone chamber face 320_1 to second portion cyclone chamber face 320_2. For example, transition cyclone chamber face 320_3 may be concave or convex.

Arrester plate second portion **312** may be smaller in size (e.g., cross sectional area in a plane parallel to reference plane **324**) than arrester plate first portion **308**. An advantage of this design is that it provides arrester plate with an enlarged dirt outlet gap length **292** across less than half of dirt outlet **190**. For example, the area of an axial projection of arrester plate second portion **312** may be smaller (e.g., less than 50%, less than 40%, less than 30%, less than 20% or less than 10%) than the area of an axial projection of arrester plate first portion **308**. In the illustrated example, the area of an axial projection of arrester plate second portion **312** is less than one half of the area of an axial projection of arrester plate first portion **308**. In addition, arrester plate second portion **312** may include less of arrester plate periphery **288** than arrester plate first portion **308** (e.g., less than 50%, less than 40%, less than 30%, less than 20% or less than 10%). In the illustrated example, arrester plate second portion **312** includes less than one quarter of arrester plate periphery **288**.

Arrester plate second portion **312** may be laterally offset (i.e. in a direction perpendicular to cyclone axis **242**) from cyclone axis **242**. As shown, arrester plate second portion **312** is axially spaced from arrester plate first portion **308** along an axial line **326** that is parallel and laterally spaced from cyclone axis **242**.

Transition cyclone chamber face 320_3 may meet first and second portion cyclone chamber faces 320_1 and 320_2 at first and second discontinuities 328_1 and 328_2 respectively. As shown, transition cyclone chamber face 320_3 extends between first and second discontinuities 328_1 and 328_2. First discontinuity 328_1 may be positioned between first portion cyclone chamber face 320_1 and transition portion cyclone chamber face 320_3, and second discontinuity may be positioned between second portion cyclone chamber face 320_2 and transition portion cyclone chamber face 320_3.

As used herein, a "discontinuity" is a macro-scale deviation or disruption of a surface pattern or shape pattern. For example, first discontinuity 328_1 is shown as a 90 degree bend that is a deviation from the planar surface of first portion cyclone chamber face 320_1, and second discontinuity is shown as a 90 degree bend that is a deviation of the planar surface of second portion cyclone chamber face 320_2. Minor deviations (e.g. seams and clearance gaps between otherwise continuous portions), and micro deviations (e.g. elements of surface texture) are not considered herein to be discontinuities. It will be appreciated that, instead of a 90 degree bend, the discontinuities may be rounded.

It will be appreciated that arrester plate **216** may have a perimeter without any angles or other discontinuities. Arrester plate periphery **288** may therefore have a continuous axial shape (i.e. the shape of a projection of arrester plate periphery **288** in a direction parallel to cyclone axis **242**) that is smooth. Accordingly, as shown in plan view in FIG. **9**, arrester plate **216** is circular.

It will be appreciated that arrester plate may be of any other shape such as elliptical or polygonal (e.g., hexagonal, square, triangle or the like). For example, as exemplified in FIG. **10**, an arrester plate periphery **288** may have a discontinuous axial shape. In the example shown, arrester plate periphery **288** has first and second portions **332** and **336** connected by two discontinuities **340**. Discontinuities **340** provide deviations from the regular (e.g. circular) shape of periphery first portion **332**, and the regular (e.g. linear) shape of periphery second portion **336**. In this example, discontinuities **340** are corners (also referred to as junctures) between first and second portions **332** and **336**.

It will be appreciated that arrester plate **216** may have an irregular perimeter. For example, the arrester plate may have a shape wherein part of the plate has been truncated to increase the size of the dirt outlet gap. The truncated portion may be any portion of the plate and may be provided on the second portion. This feature may be used with any plate that has a smooth perimeter or which has a perimeter with discontinuities.

For example, as exemplified in FIG. **10**, first and second discontinuities 340_1 and 340_2 may be provided on arrester plate second portion **312**. For example, second portion **336** of arrester plate periphery **288** may border at least a portion of arrester plate second portion **312**. As compared to arrester plate **216** were the axial shape of periphery first portion **332** continuous around the entire arrester plate periphery **288** (e.g. fully circular), a plate segment **344** has been removed where periphery second portion **336** truncates the axial shape of periphery first portion **332**. As shown, periphery second portion **336** may be formed as a cord (e.g. linear crop) to the circular axial shape of periphery first portion **332**. The removal of plate segment **344** may further enlarge dirt outlet gap lengths **292** at arrester plate second portion **312**. This allows arrester plate **216** to allow even larger particles to pass through the portion of dirt outlet **190** located between periphery second portion **336** and cyclone sidewall **240**, as compared to the same arrester plate **216** with plate segment **344** intact.

It will be appreciated that an arrester plate **216** with an axial step can create a concave (also referred to as 'hollow') step volume behind the axial face of the step. Depending on the manner in which the associated cyclone and dirt collection chambers are emptied, fibrous debris (e.g. hair) may snag or accumulate in the step volume when emptying the surface cleaning apparatus. Alternately, a hollow shape of the dirt chamber facing side of plate **216** may create eddy currents or otherwise interfere with dirt settling in the dirt collection chamber. Therefore, in some embodiments the step volume is closed by the dirt chamber face of the arrester plate. Closing the hollow step volume may be used with any axially stepped arrester described herein.

It will be appreciated that the closure portion may underlie or traverse only the transition portion, (e.g., if the transition portion extends at an angle to reference plane **324**). Alternately the closure portion my underlie both the transition portion and one or both of the first and second portions. As exemplified in FIGS. **11-19**, the closure portion underlies both the transition portion and the first portion. An advantage of this design is that the axial thickness of the second portion is not increased. It will be appreciated that the more of the first portion that the closure portion underlies, the more gradual the angle of the closure portion may be.

Referring to FIGS. **4-5**, an example arrester plate **216** is shown including an open step volume **348**. Step volume **348** is a hollow volume behind transition portion dirt chamber face $\mathbf{364_3}$. As shown, step volume **348** is bordered by transition portion **316** to one side and by first portion **308** above.

FIGS. **11-13** exemplify an embodiment of arrester plate **216** in which step volume **348** is closed by a closure portion **352** of dirt chamber face **224**. As shown, closure portion **352** may be opposed to transition portion cyclone chamber face $\mathbf{320_3}$ and to at least a portion of first portion cyclone chamber face $\mathbf{320_1}$. By closing step volume **348**, a smoother dirt chamber face of plate **216** is provided which may reduce eddy currents in the dirt collection chamber and facilitate dirt settling in the dirt collection chamber and not being reintrained into the cyclone chamber.

Closure portion **352** may have any configuration suitable to close step volume **348**. In some embodiments, closure portion **352** may be free of concavities (e.g. entirely planar as shown, entirely convex, or include both planar and convex portions). In the illustrated example, closure portion **352** extends from a first end **356** proximate dirt chamber face $\mathbf{364_2}$ of second portion **312** towards or across cyclone axis **242** to second end **360** within dirt chamber face $\mathbf{364_1}$ of first portion **308**.

FIGS. **11-13** exemplify an example in which closure portion second end **360** is proximate cyclone axis **242**. FIGS. **14-16** exemplify an example of arrester plate **216** in which cyclone axis **288** is located between closure portion first and second ends **356** and **360**. FIGS. **17-19** exemplify another example of arrester plate **216** in which cyclone axis **288** is located between closure first and second ends **356** and **360**.

Closure portion **352** may extend transverse (i.e. non-parallel) to cyclone axis **242**. For example, FIGS. **11-13** and **14-16** show examples of arrester plate **216** in which closure portion **352** is neither parallel nor perpendicular to cyclone axis **242**. As shown, closure portion first end **356** may be axially and laterally spaced apart from closure portion second end **360**. In the illustrated example, closure portion first end **356** is axially spaced from closure portion second end **360** away from cyclone chamber first end **228**. FIGS. **17-19** show an example of arrester plate **216** in which closure portion first end **356** is axially aligned and laterally spaced apart from closure portion second end **360**.

Referring again to FIGS. **11-13**, closure portion **352** may be oriented so that it diverges from cyclone chamber face $\mathbf{320_3}$ of transition portion **316** in a direction away from arrester plate second portion **312**. As shown, closure portion second end **360** may be spaced farther from cyclone chamber face $\mathbf{320_3}$ of transition portion **316** than closure portion first end **356**.

Dirt chamber face **224** may have one or more discontinuities. For example, FIGS. **11-13** and **14-16** illustrate arrester plates **216** having a dirt chamber face **224** with a discontinuity **368** at the juncture of closure portion **352** and dirt chamber face $\mathbf{364_2}$ of second portion **312**. The discontinuity is preferably rounded so as to avoid a sharp angle. In other embodiments, dirt chamber face **224** may be entirely continuous. For example, FIGS. **17-19** show an arrester plate **216** having a dirt chamber face **224** that is entirely planar. In the illustrated example, dirt chamber face **224** is perpendicular to cyclone axis **242**. In other embodiments, dirt chamber face **224** may be oriented non-perpendicular and non-parallel to cyclone axis **242**.

Plate first portion **308** may have an axial thickness $\mathbf{372_1}$ greater than axial thickness $\mathbf{372_2}$ of plate second portion **312**. FIGS. **17-19** show an example arrester plate **216** having a plate first portion **308** with a uniform thickness $\mathbf{372_1}$ that is greater than thickness $\mathbf{372_2}$ of plate second portion **312**. FIGS. **11-13** and **14-16** show example arrester plates **216** having a plate first portion **308** with a thickness $\mathbf{372_1}$ that increases towards transition portion **316**. As shown, plate thickness $\mathbf{372_1}$ may increase between closure portion first and second ends **356** and **360** towards first end **356**.

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 assembly comprising a cyclone provided in the air flow path and a dirt collection region, the cyclone comprising a cyclone chamber, a cyclone air inlet, a cyclone air outlet, a dirt outlet, a central longitudinally extending axis, the cyclone chamber having first and second axially opposed ends, the dirt collection region is external to the cyclone chamber;

(c) a suction motor positioned in the air flow path; and,

(d) a plate positioned at the second end of the cyclone chamber, the plate having a cyclone chamber face facing the cyclone chamber, the cyclone chamber face having first and second portions, wherein the first portion of the cyclone chamber face and the second portion of the cyclone chamber face are different axial distances from a transverse plane that extends through the cyclone chamber and that is perpendicular to the central longitudinally extending axis of the cyclone, wherein the plate has a perimeter and the perimeter of the plate is spaced from a sidewall of the cyclone assembly, and wherein an annular gap between the plate and the cyclone extends around all of the plate and defines the dirt outlet of the cyclone chamber.

2. The vacuum cleaner of claim **1** wherein the annular gap has a radial distance between the plate and the cyclone and the radial distance is constant.

3. The vacuum cleaner of claim **1** wherein the annular gap has a radial distance between the plate and the cyclone and the radial distance varies at different locations around the plate.

4. The vacuum cleaner of claim **1** wherein the perimeter extends generally continuously.

5. The vacuum cleaner of claim **1** wherein the perimeter has two discontinuities.

6. The vacuum cleaner of claim **1** wherein the plate has a segment removed.

7. The vacuum cleaner of claim **6** wherein the annular gap has a radial distance between the plate and the cyclone, the radial distance varies at different locations around the plate and the radial distance is increased at a location of the plate from which the segment has been removed.

8. The vacuum cleaner of claim **7** wherein the second portion is a greater axial distance from the transverse plane than the first portion and the location of the plate from which the segment has been removed is the second portion.

9. The vacuum cleaner of claim **1** wherein the second portion is a greater axial distance from the transverse plane than the first portion and the second portion has a segment removed.

10. The vacuum cleaner of claim **9** wherein the annular gap has a radial distance between the plate and the cyclone and the radial distance is increased at a location of removal of the segment.

11. The vacuum cleaner of claim **1** wherein the plate is positioned between the cyclone chamber and the dirt collection region, the plate has a dirt collection face facing the dirt collection region.

12. The vacuum cleaner of claim **1** wherein the cyclone air inlet and the cyclone air outlet are provided at the first end of the cyclone chamber, the cyclone air outlet comprises a vortex finder and porous member positioned between the cyclone chamber and an inlet of the vortex finder, and the vortex finder and porous member are spaced from the cyclone chamber face of the plate.

13. The vacuum cleaner of claim **1** wherein the plate is moveably mounted between a closed position, in which the plate is positioned for operation of the cyclone and an open position wherein the plate is moved to provide access to the cyclone chamber.

14. The vacuum cleaner of claim **13** wherein the dirt collection region has an end wall facing the plate and the end wall is openable.

15. The vacuum cleaner of claim **14** wherein the plate is supported by the end wall and is moveable with the end wall.

16. The vacuum cleaner of claim **15** wherein the plate has a dirt collection face facing the dirt collection region and the vacuum cleaner further comprises a support member extending between the end wall and the dirt collection face.

17. The vacuum cleaner of claim **16** wherein the cyclone air inlet and the cyclone air outlet are provided at the first end of the cyclone chamber, the cyclone air outlet comprises a vortex finder and porous member positioned between the cyclone chamber and an inlet of the vortex finder, and the vortex finder and porous member are spaced from the cyclone chamber face of the plate.

18. The vacuum cleaner of claim **1** wherein the cyclone has a generally axially extending sidewall and the annular gap is provided between the perimeter of the plate and the sidewall.

19. The vacuum cleaner of claim **1** wherein the cyclone has an axially extending sidewall and the sidewall has an end face and at least a portion of the end wall faces the plate.

20. The vacuum cleaner of claim **19** wherein the dirt collection region has a sidewall and the annular gap is provided between the perimeter of the plate and the sidewall.

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