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(54) **SURFACE CLEANING APPARATUS**

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CPC ***A47L 5/24*** (2013.01); ***A47L 9/102*** (2013.01); ***A47L 9/1409*** (2013.01); ***A47L 9/16*** (2013.01); ***A47L 9/1666*** (2013.01); ***A47L 9/1683*** (2013.01); ***A47L 9/2884*** (2013.01); ***A47L 9/322*** (2013.01); ***B01D 45/08*** (2013.01); ***B01D 45/16*** (2013.01); ***B01D 50/002*** (2013.01); *A47L 9/2842* (2013.01); *B01D 2279/55* (2013.01)

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See application file for complete search history.

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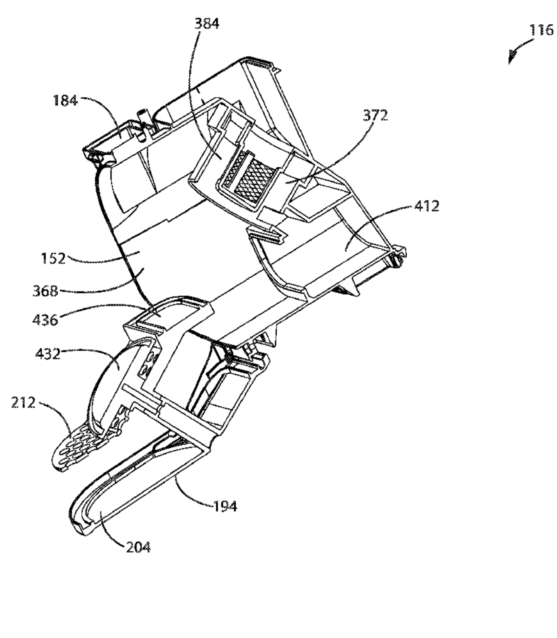
(57) **ABSTRACT**

A hand vacuum cleaner has first stage momentum separator and a second cyclonic cleaning stage that are openable concurrently.

18 Claims, 51 Drawing Sheets



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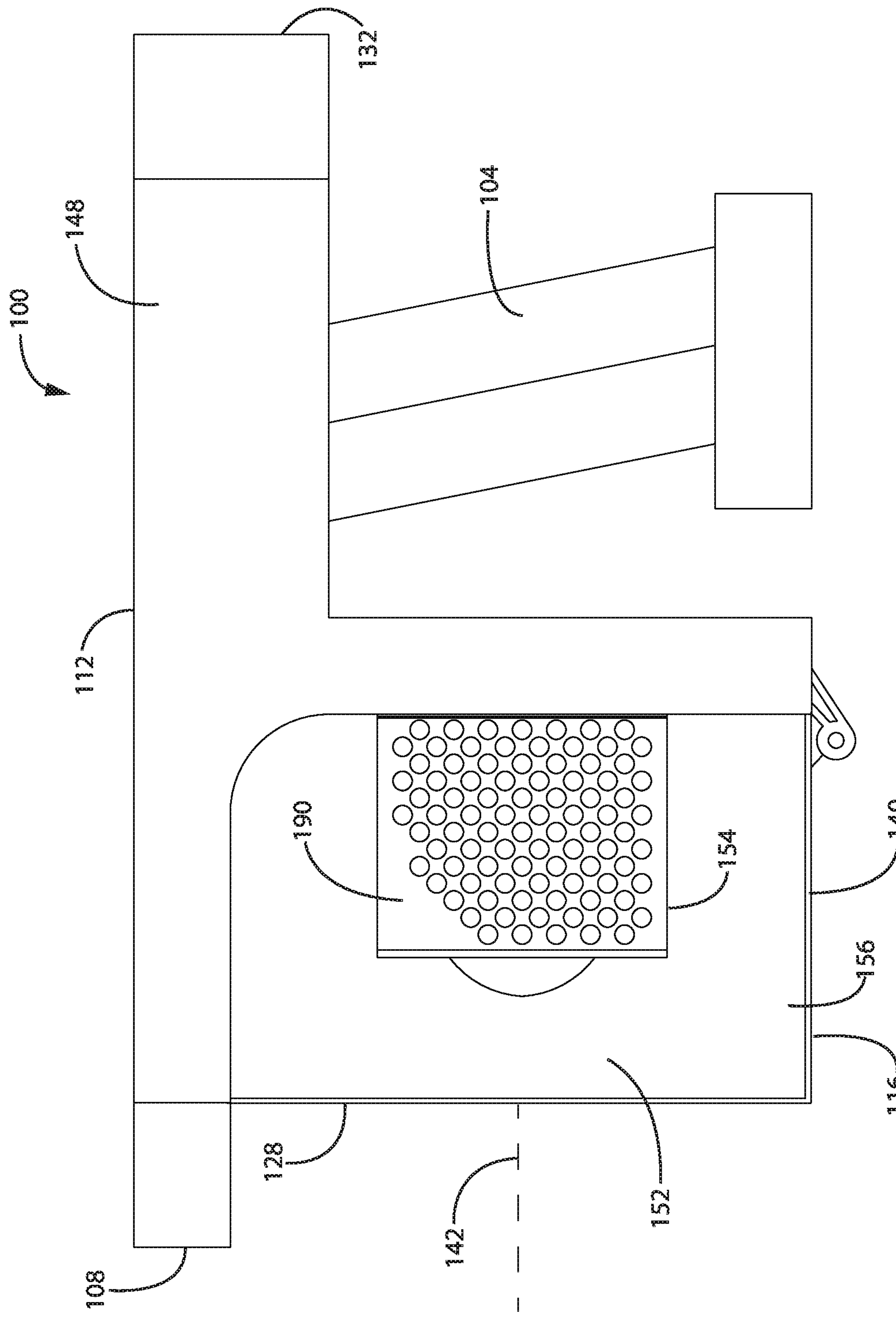
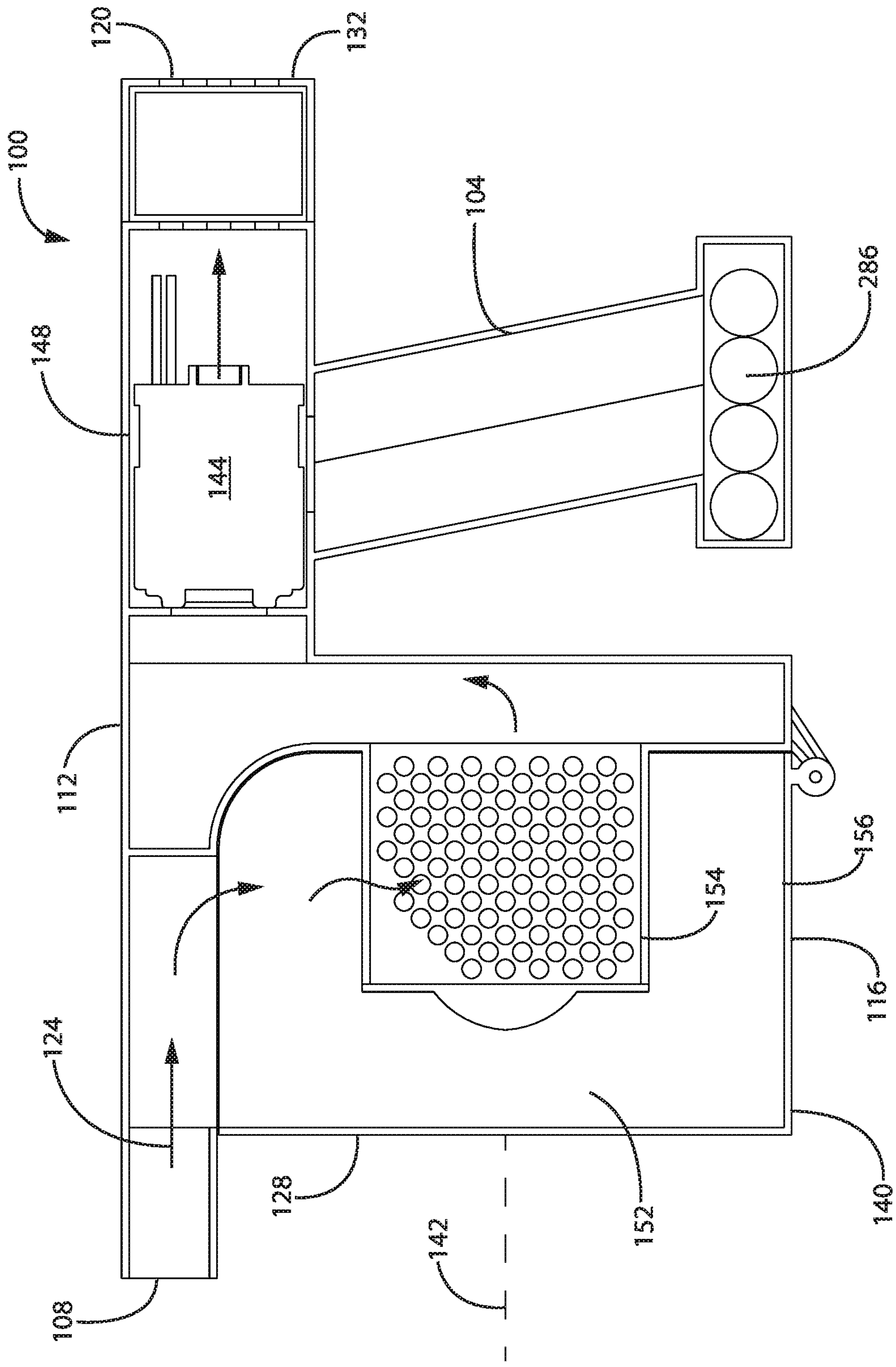


FIG. 1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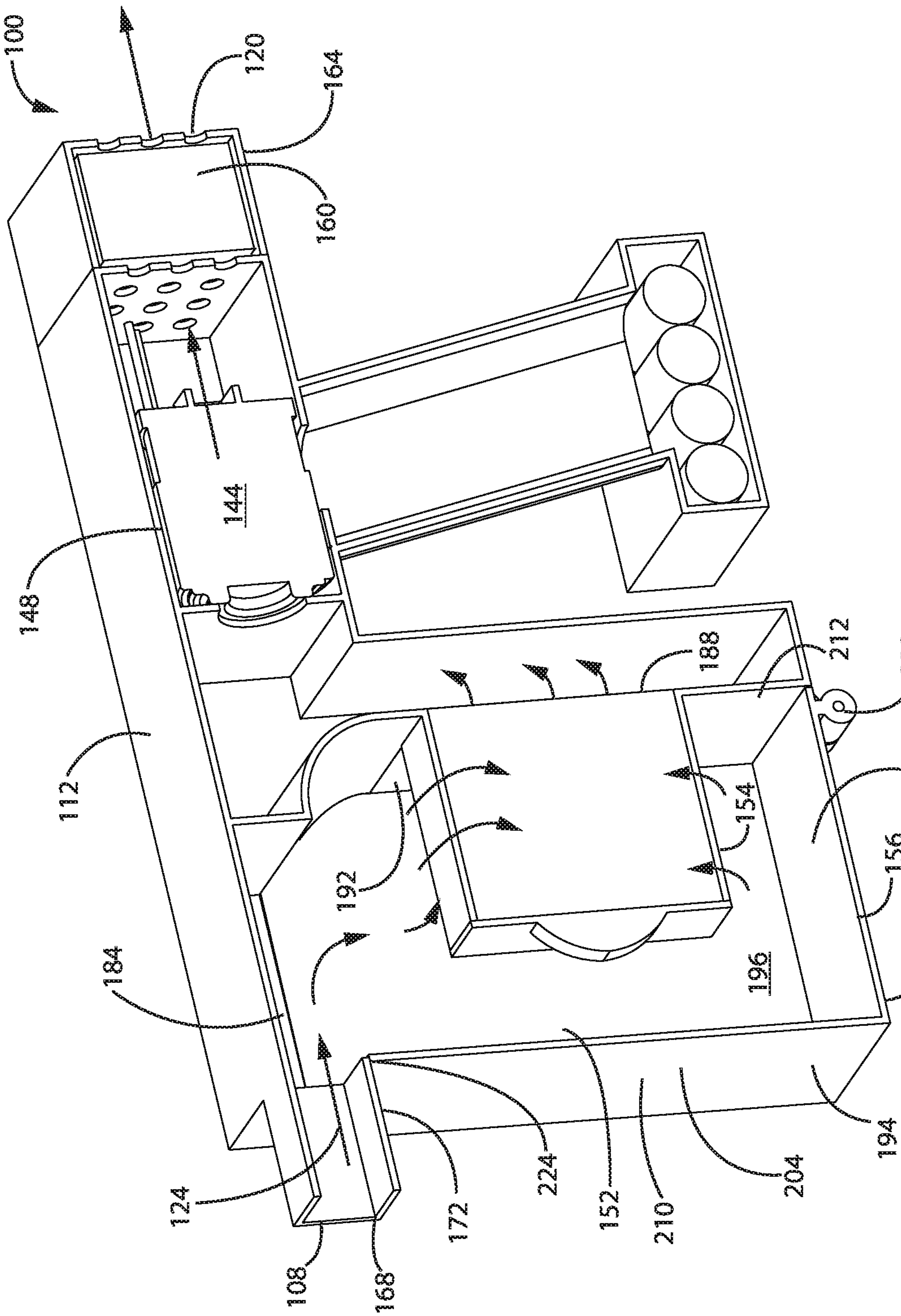
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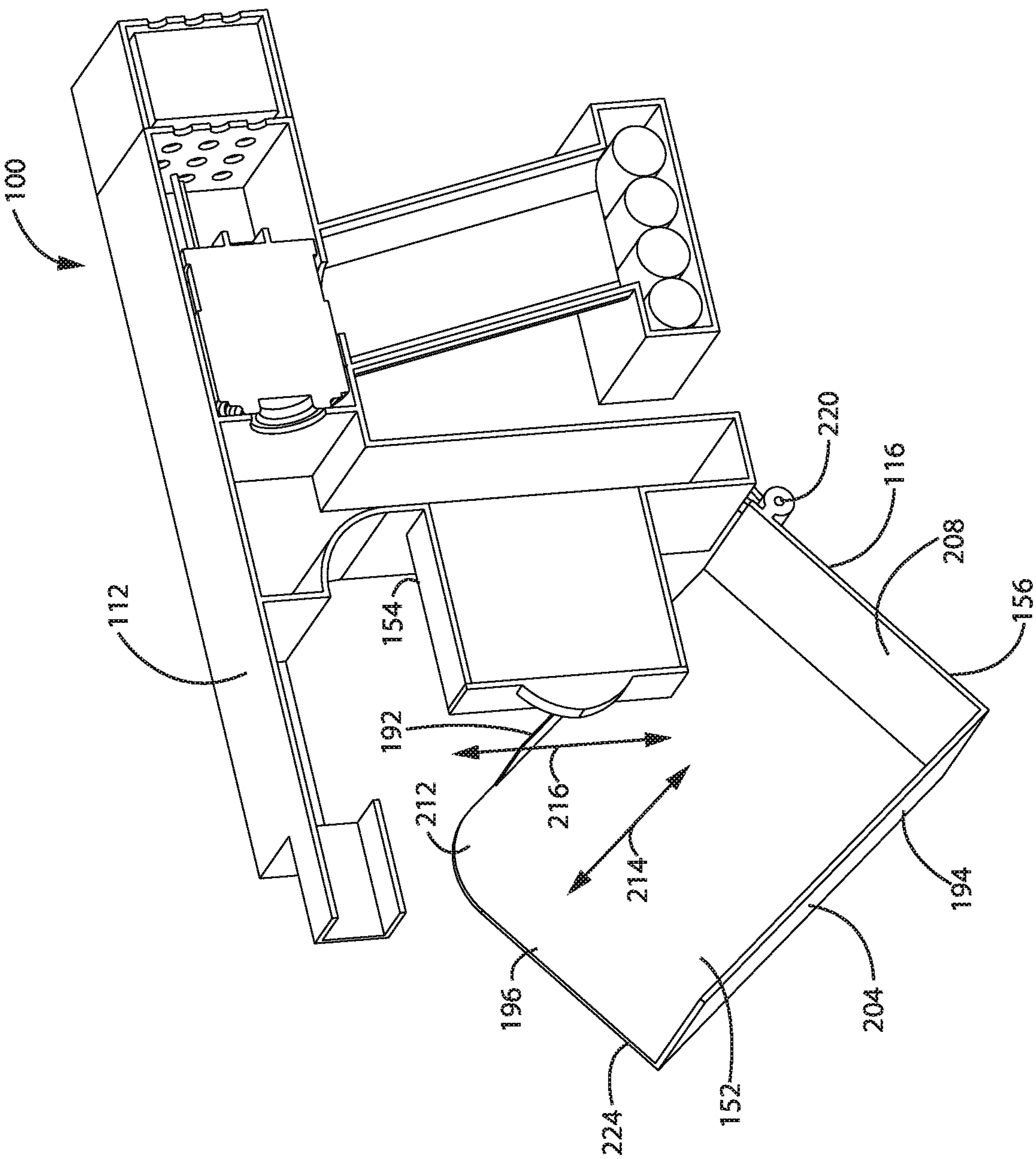
FIG. 3



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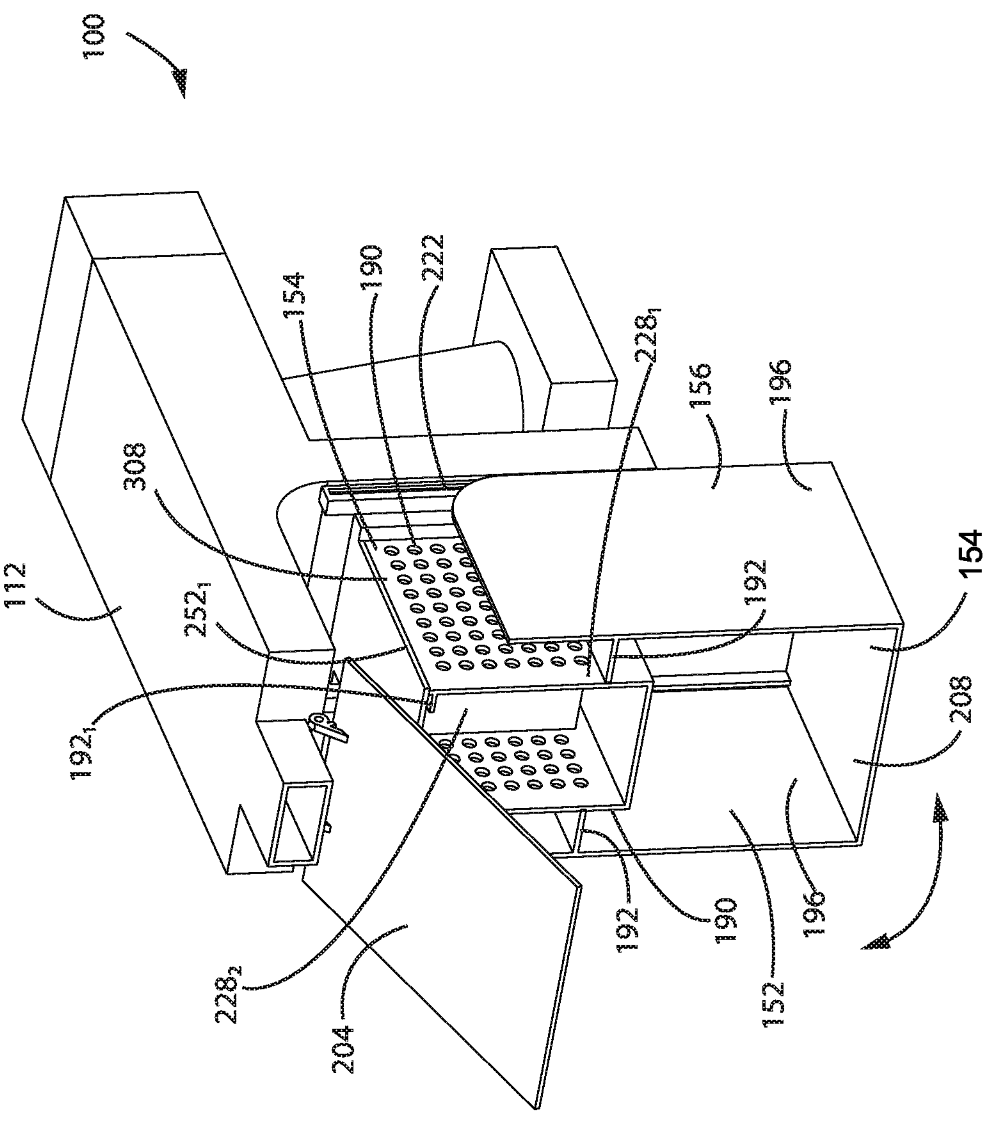
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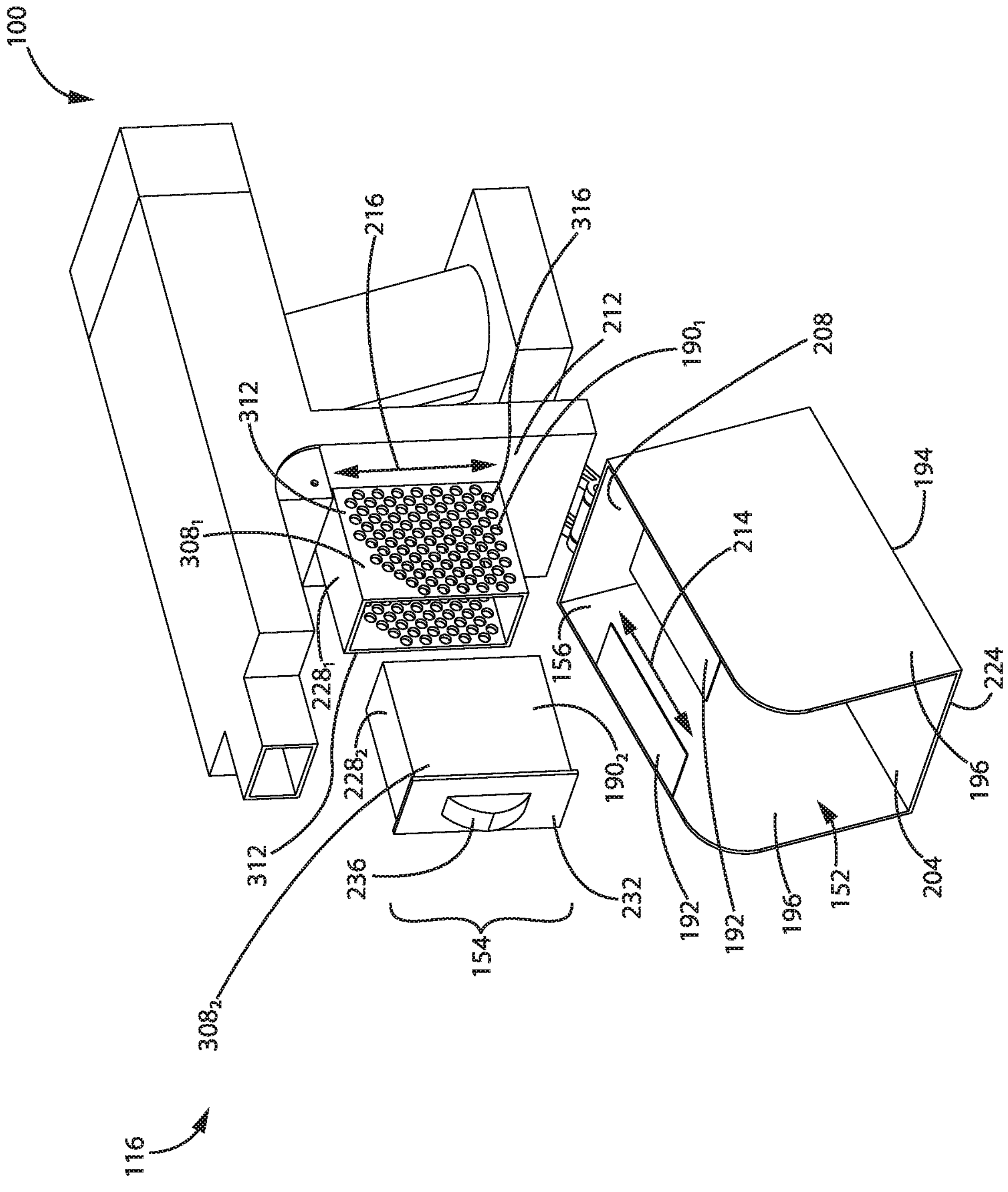
FIG. 5

FIG. 6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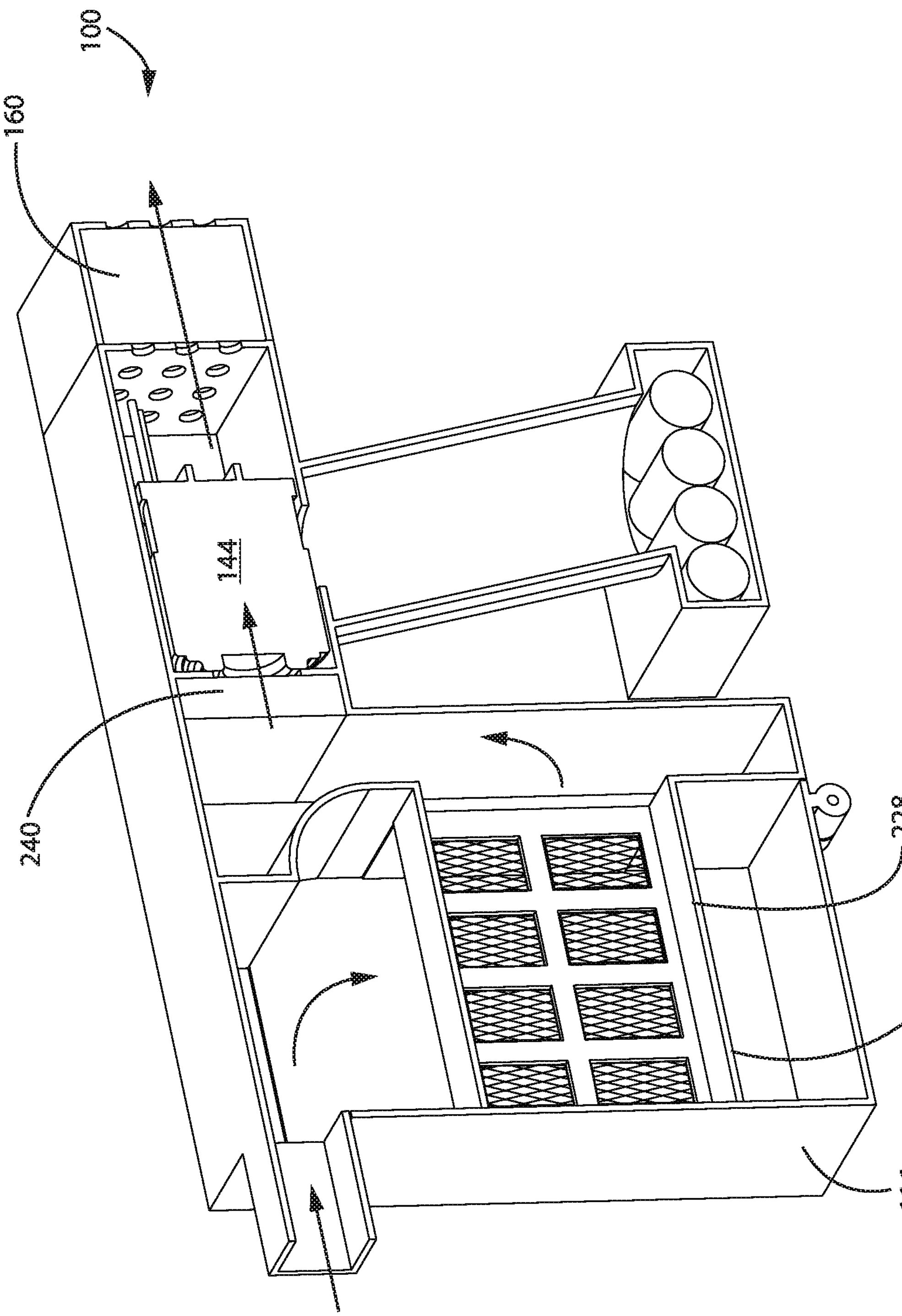


FIG. 7

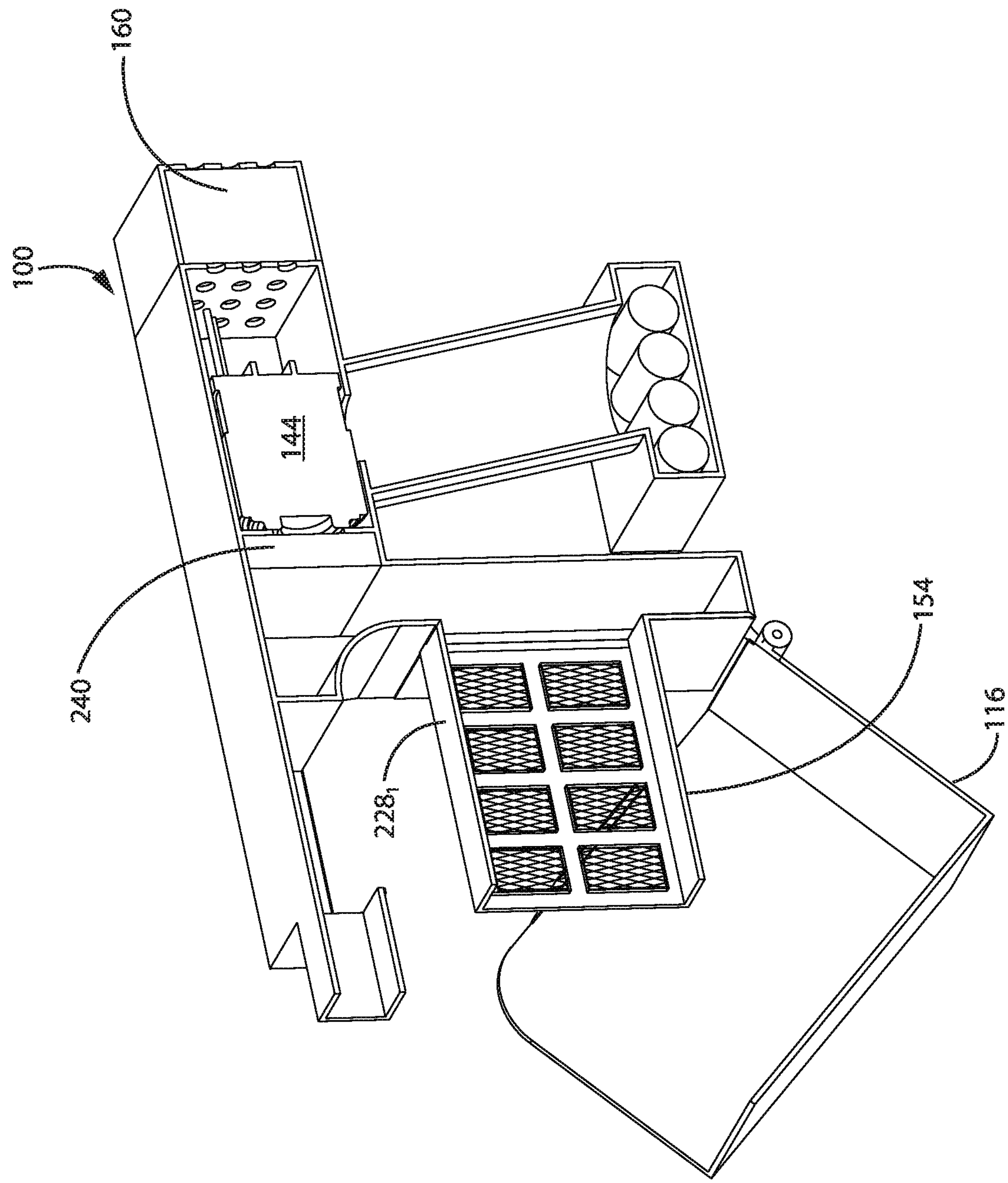


FIG. 8

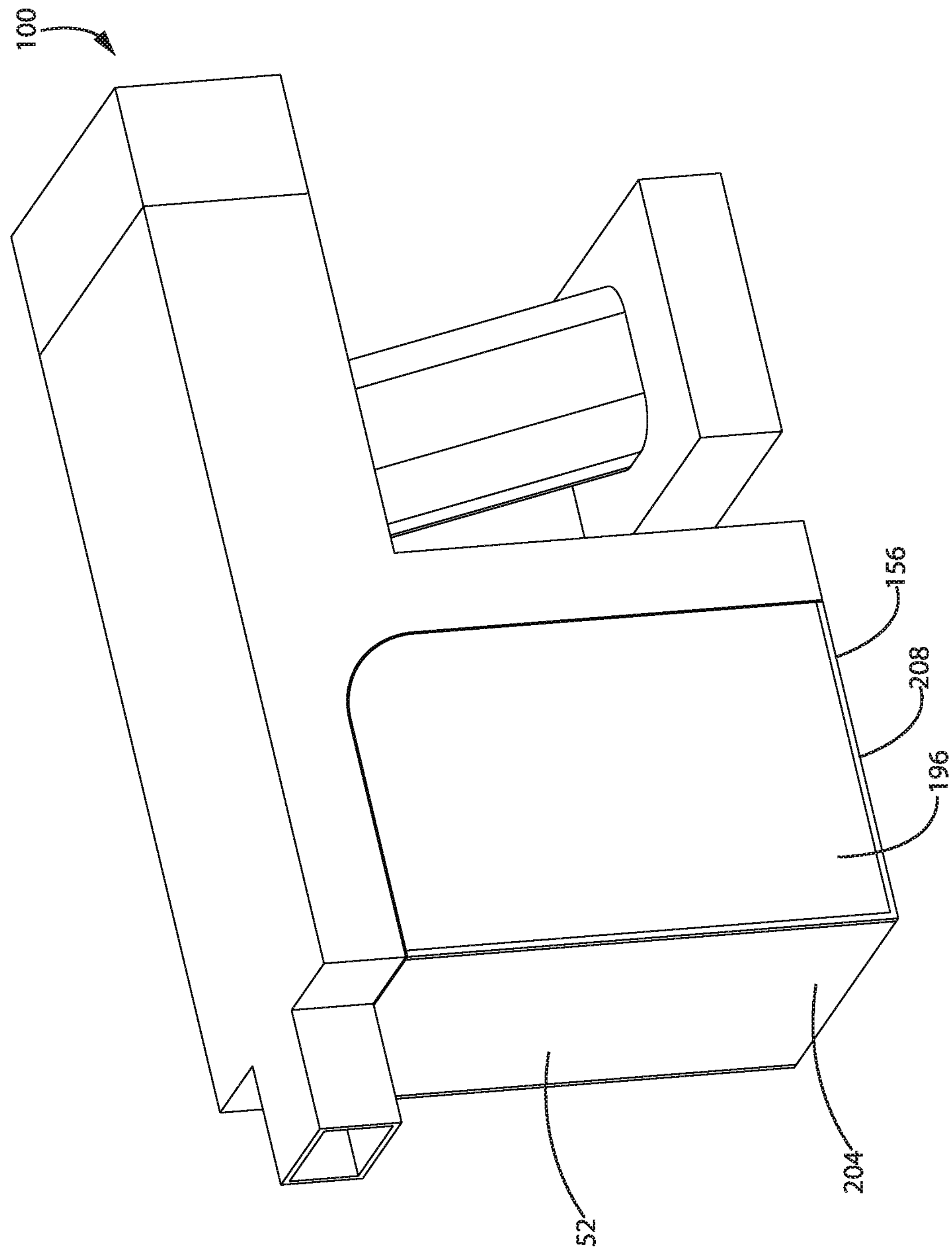


FIG. 9

FIG. 10

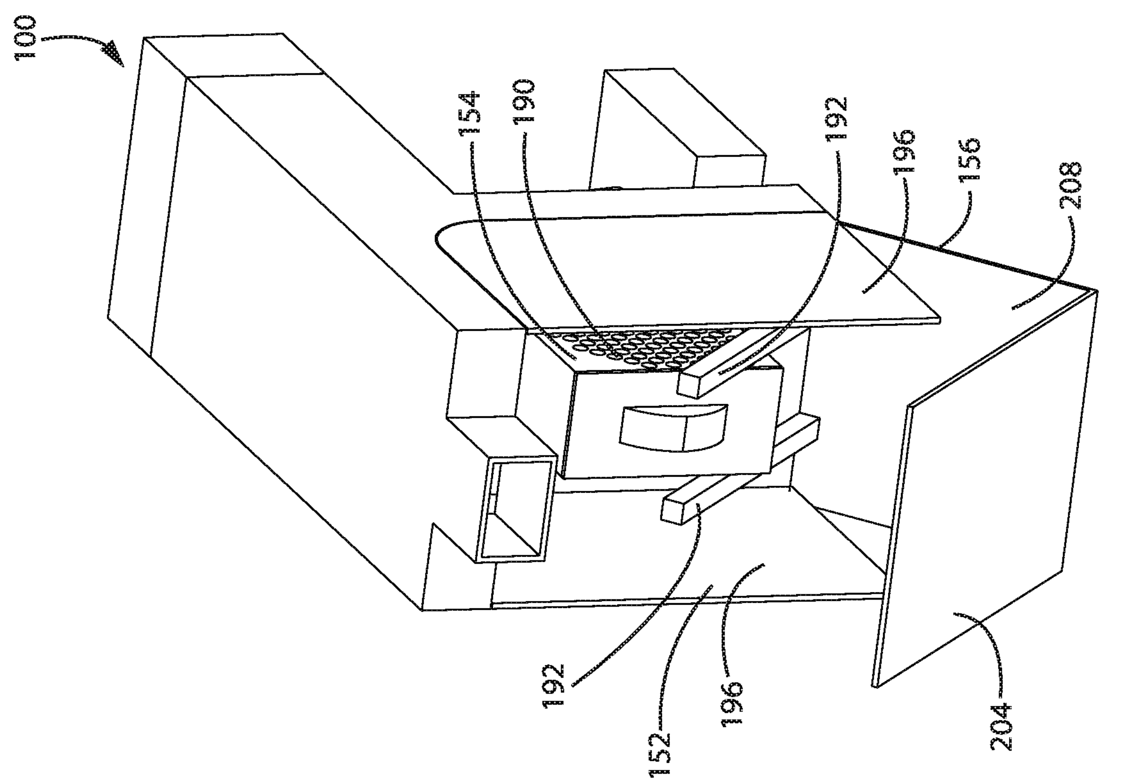
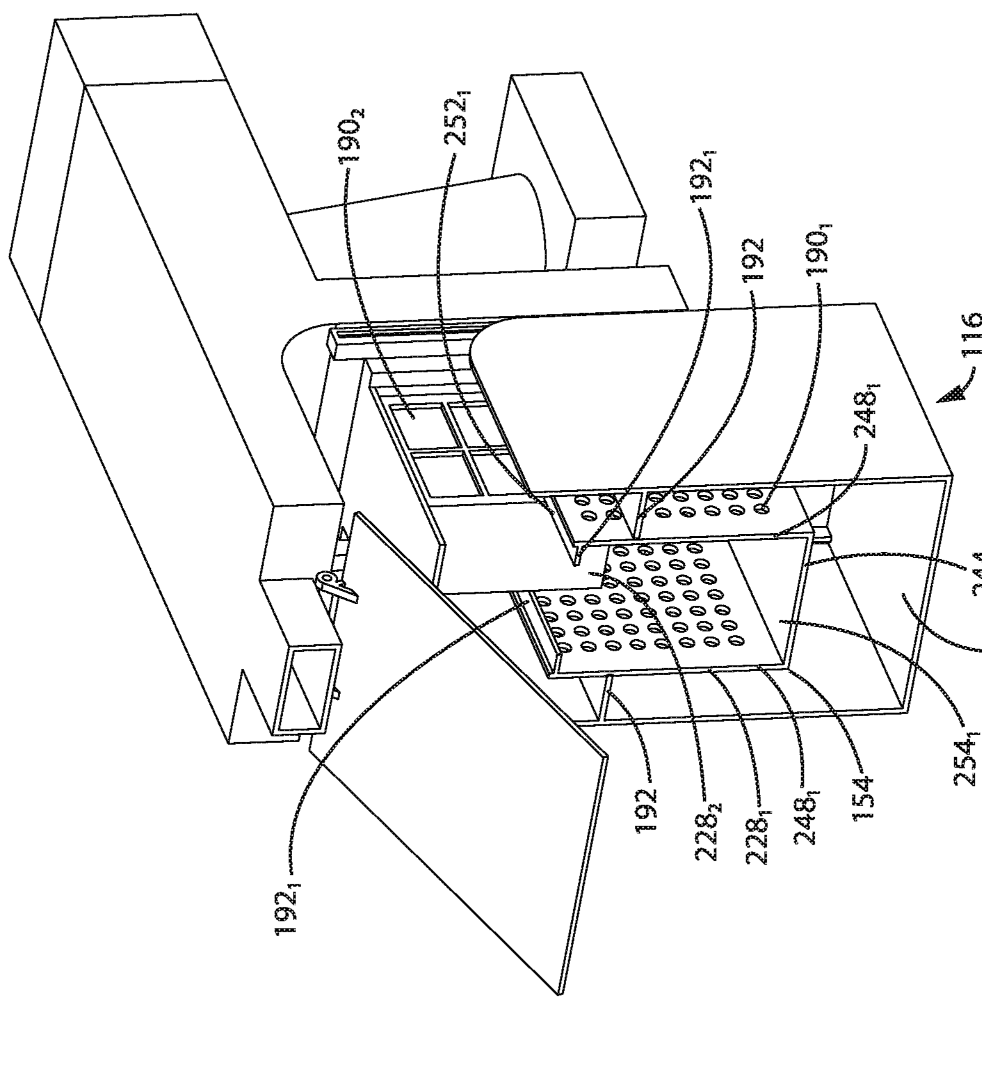


FIG. 11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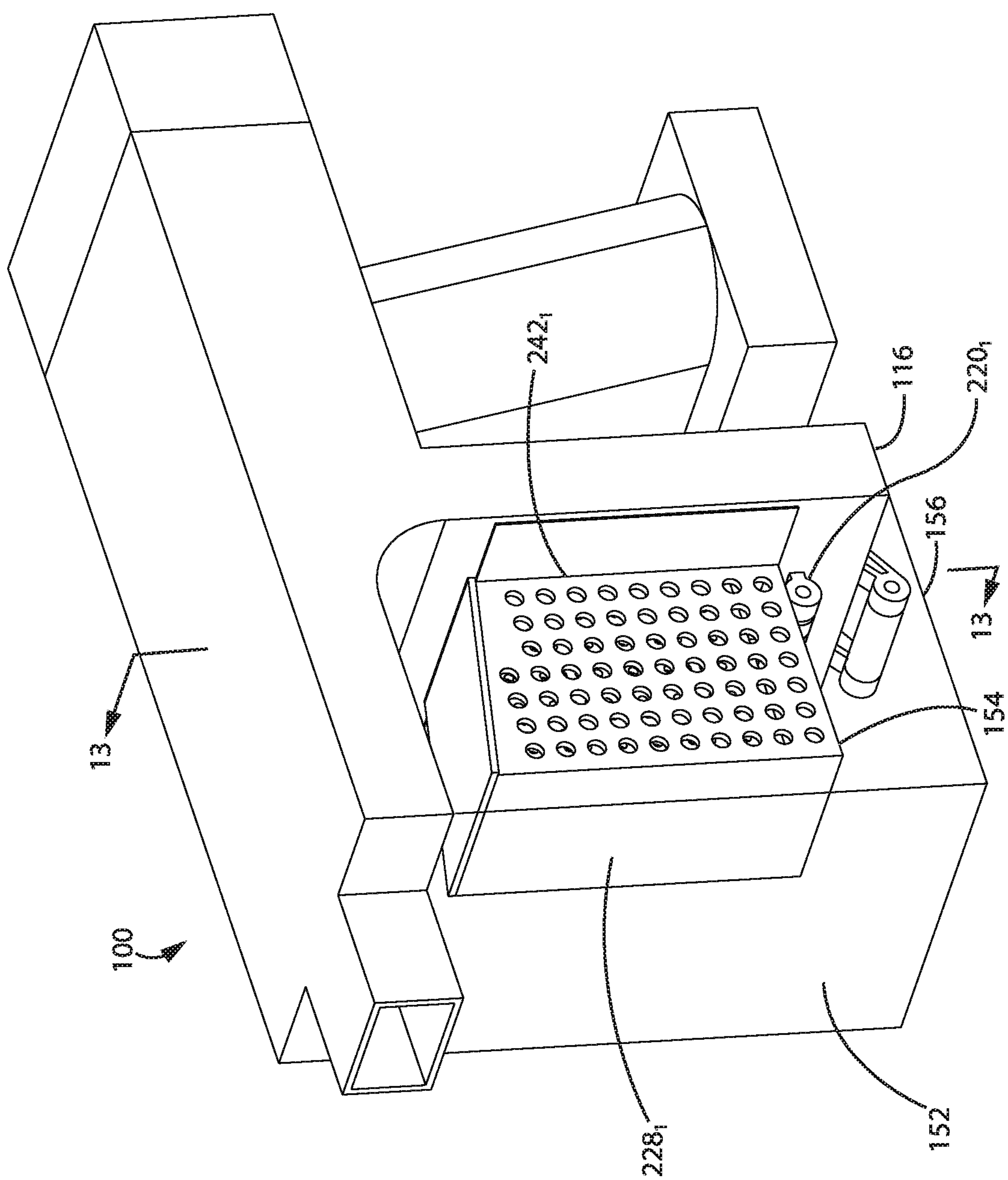


FIG. 12

FIG. 13

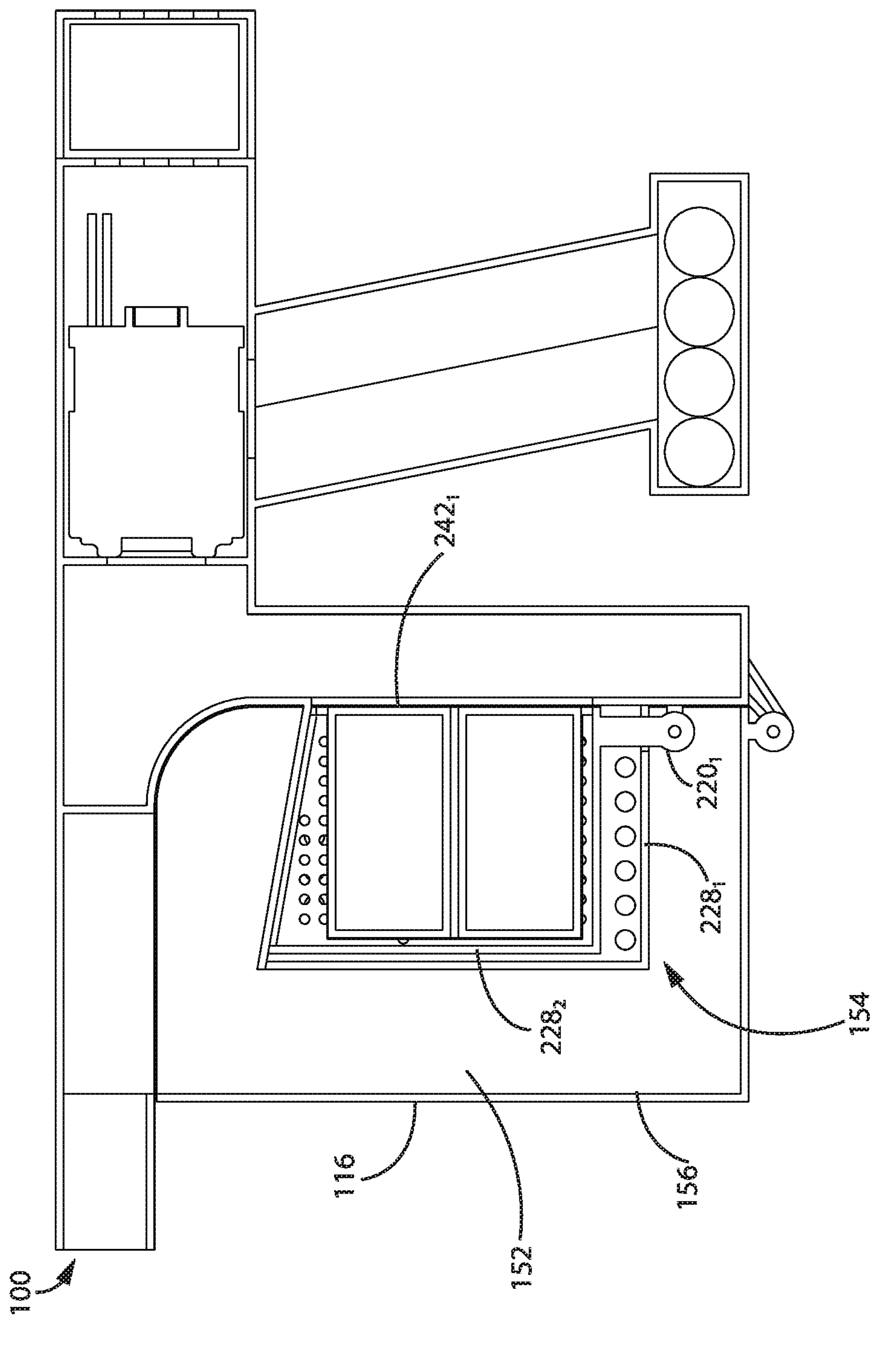


FIG. 14

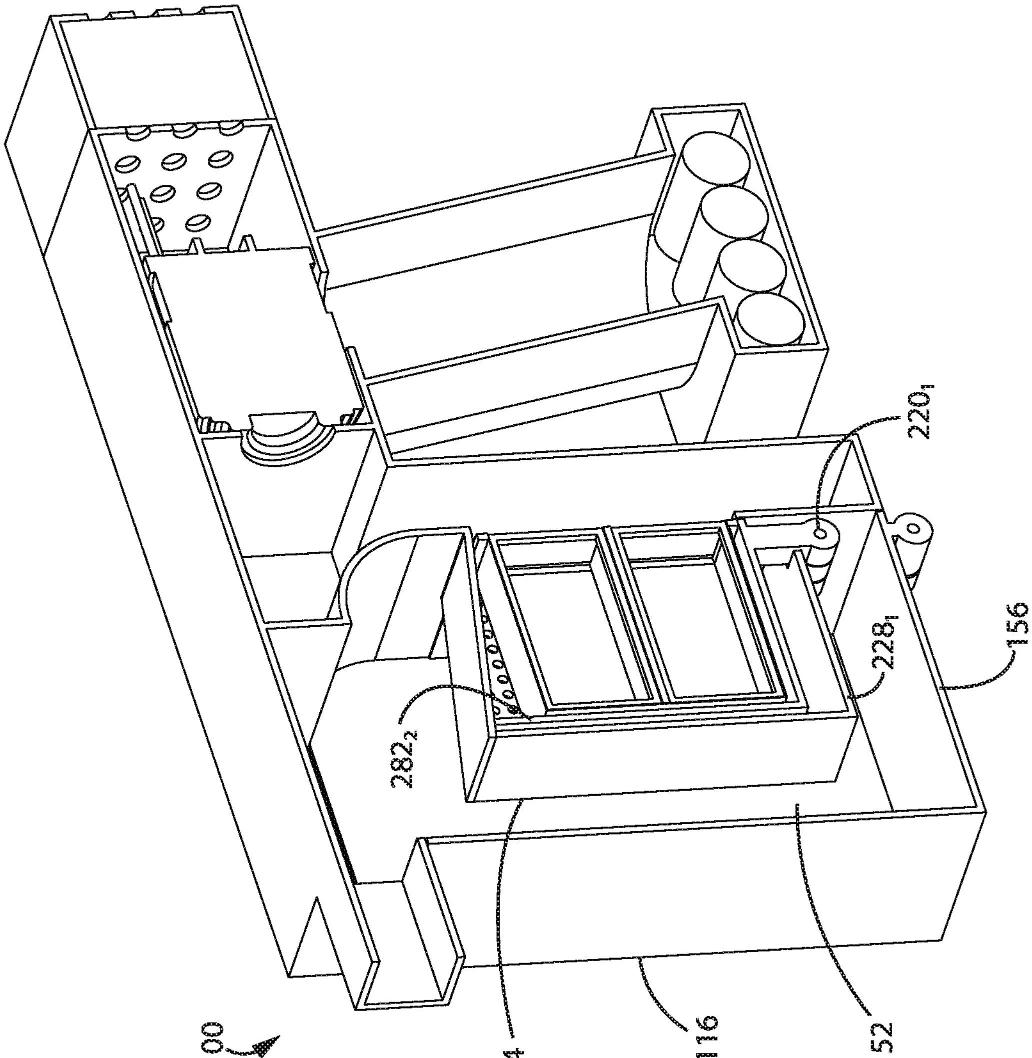


FIG. 15

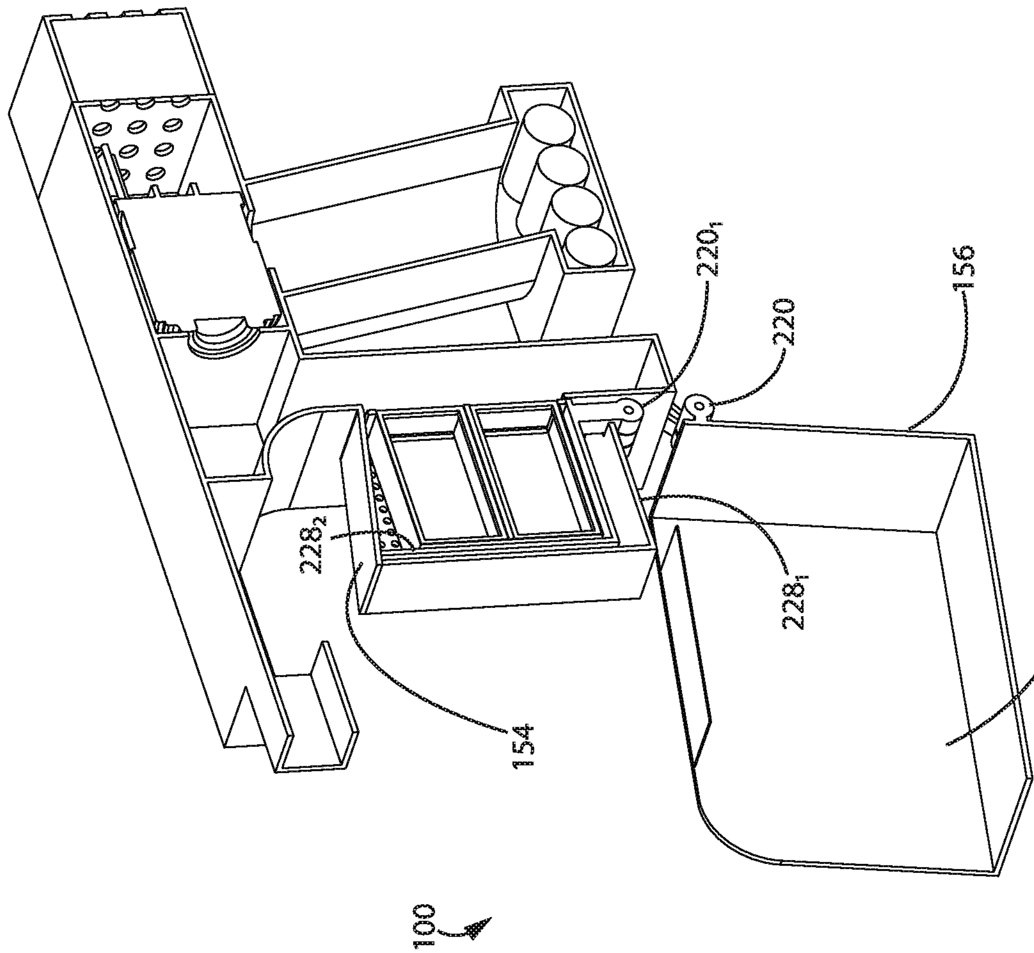
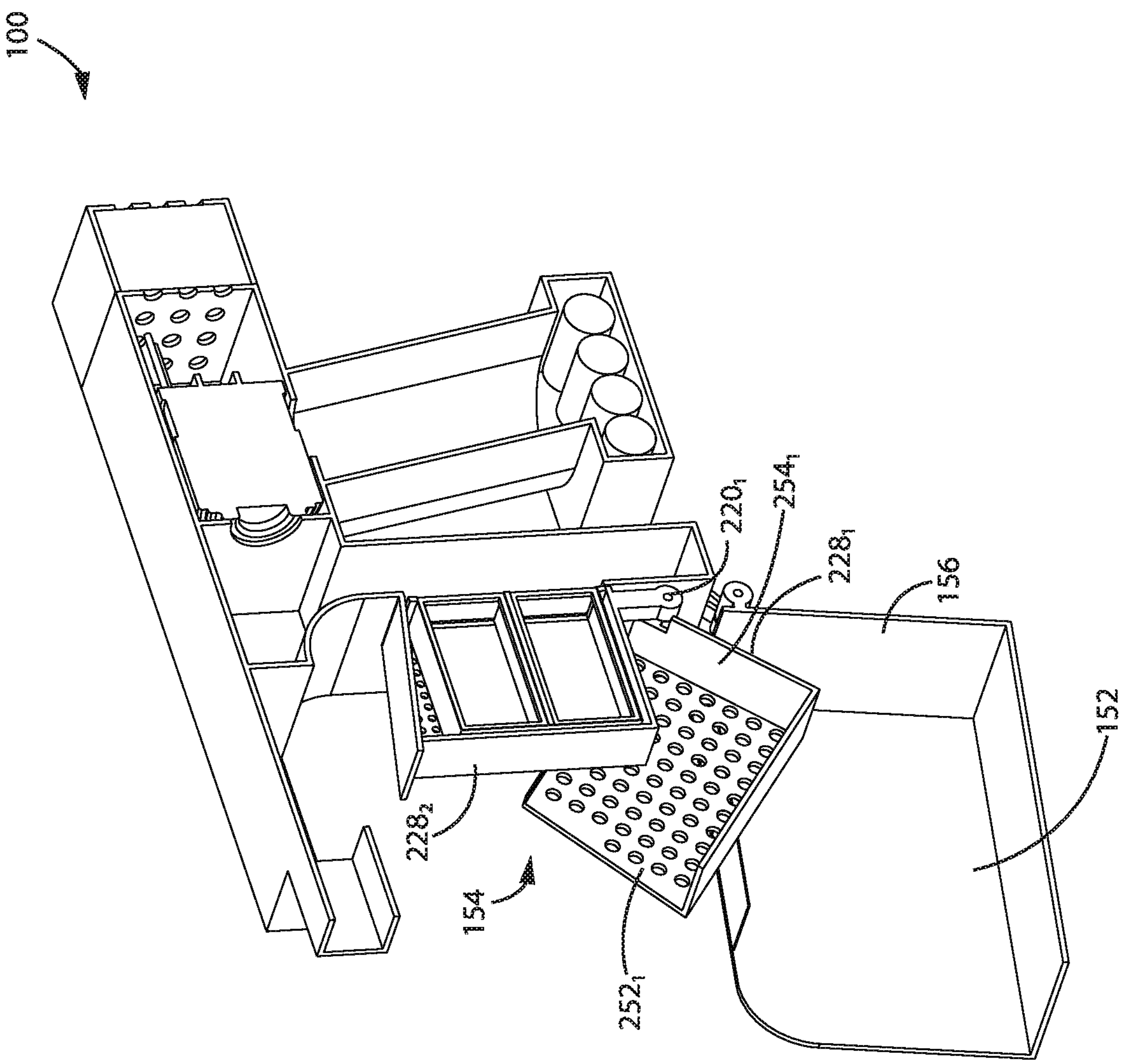


FIG. 16



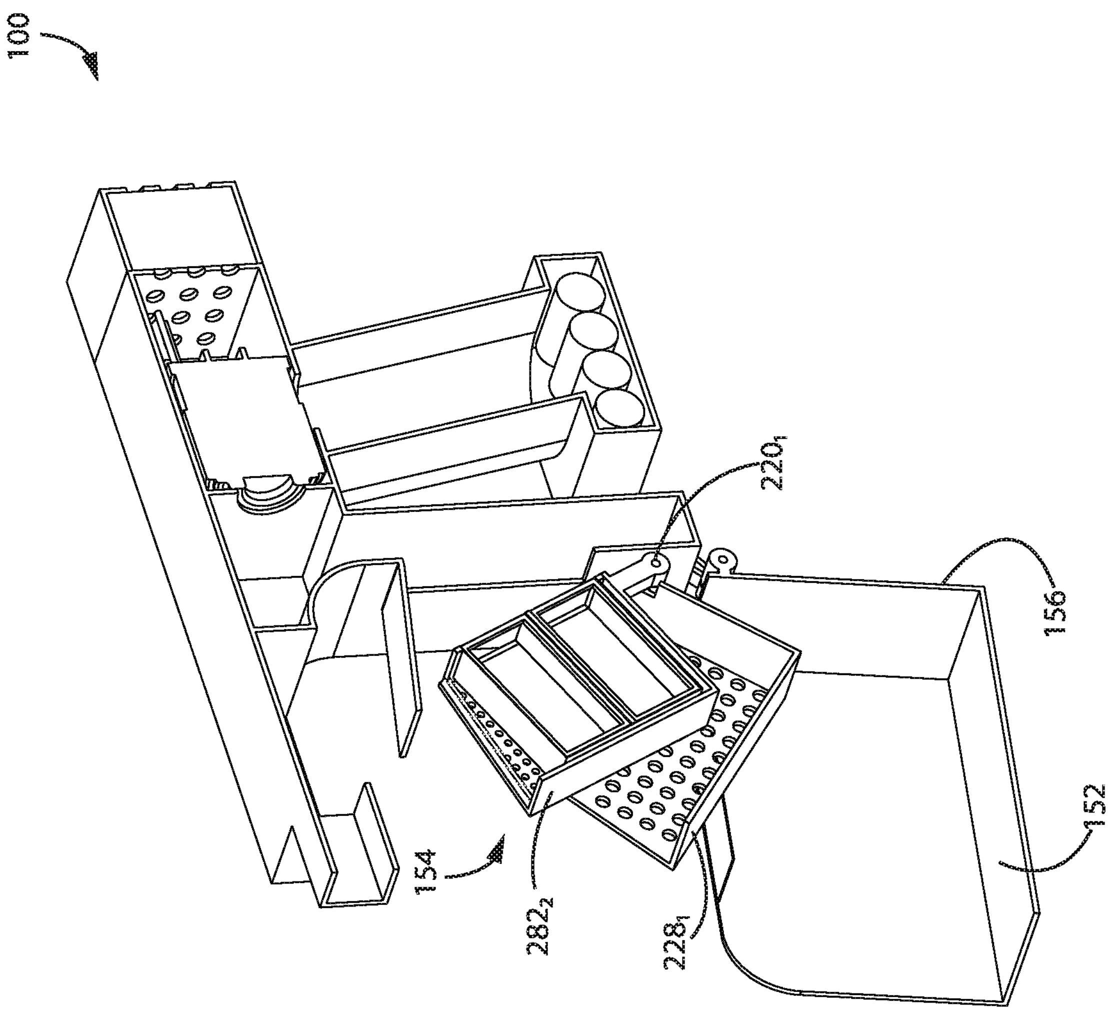


FIG. 17

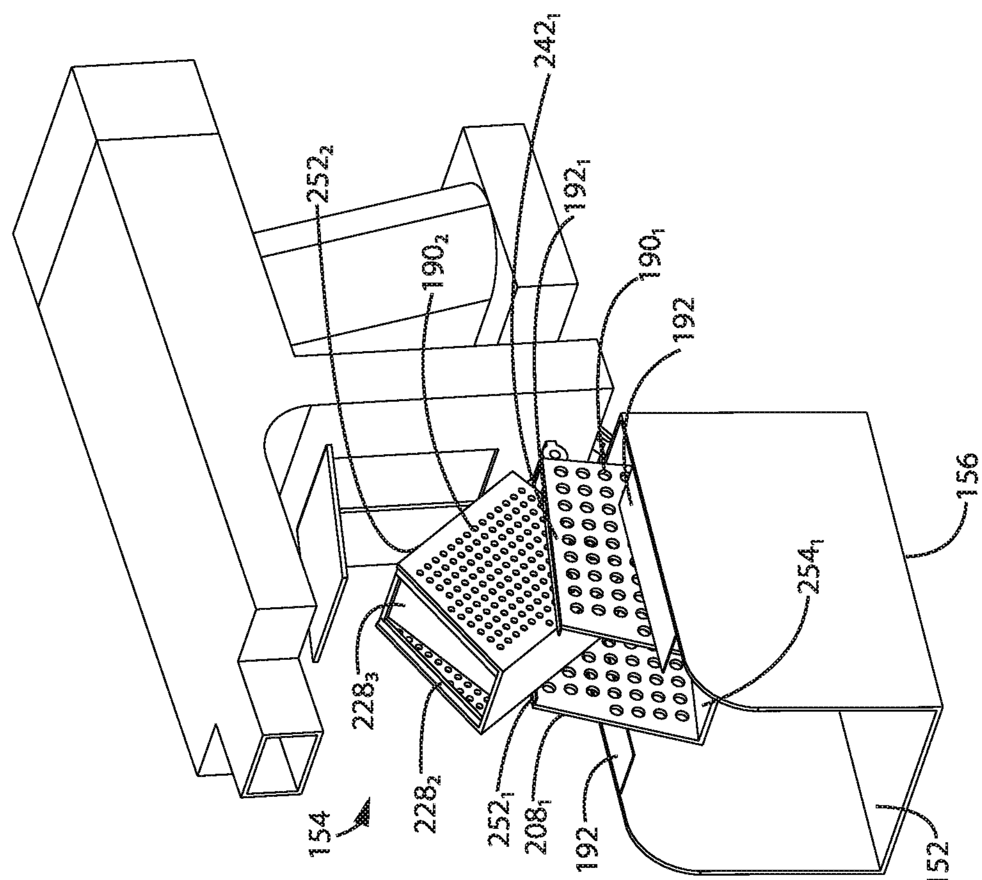

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FIG. 18

FIG. 19

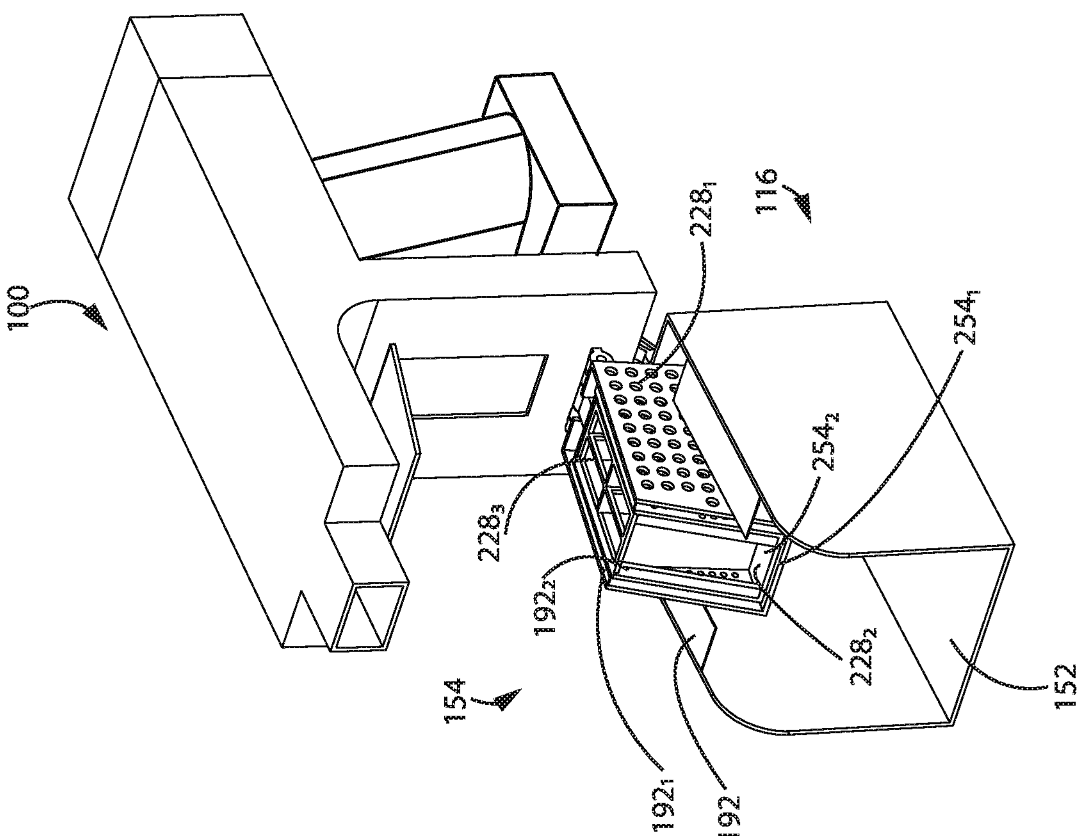
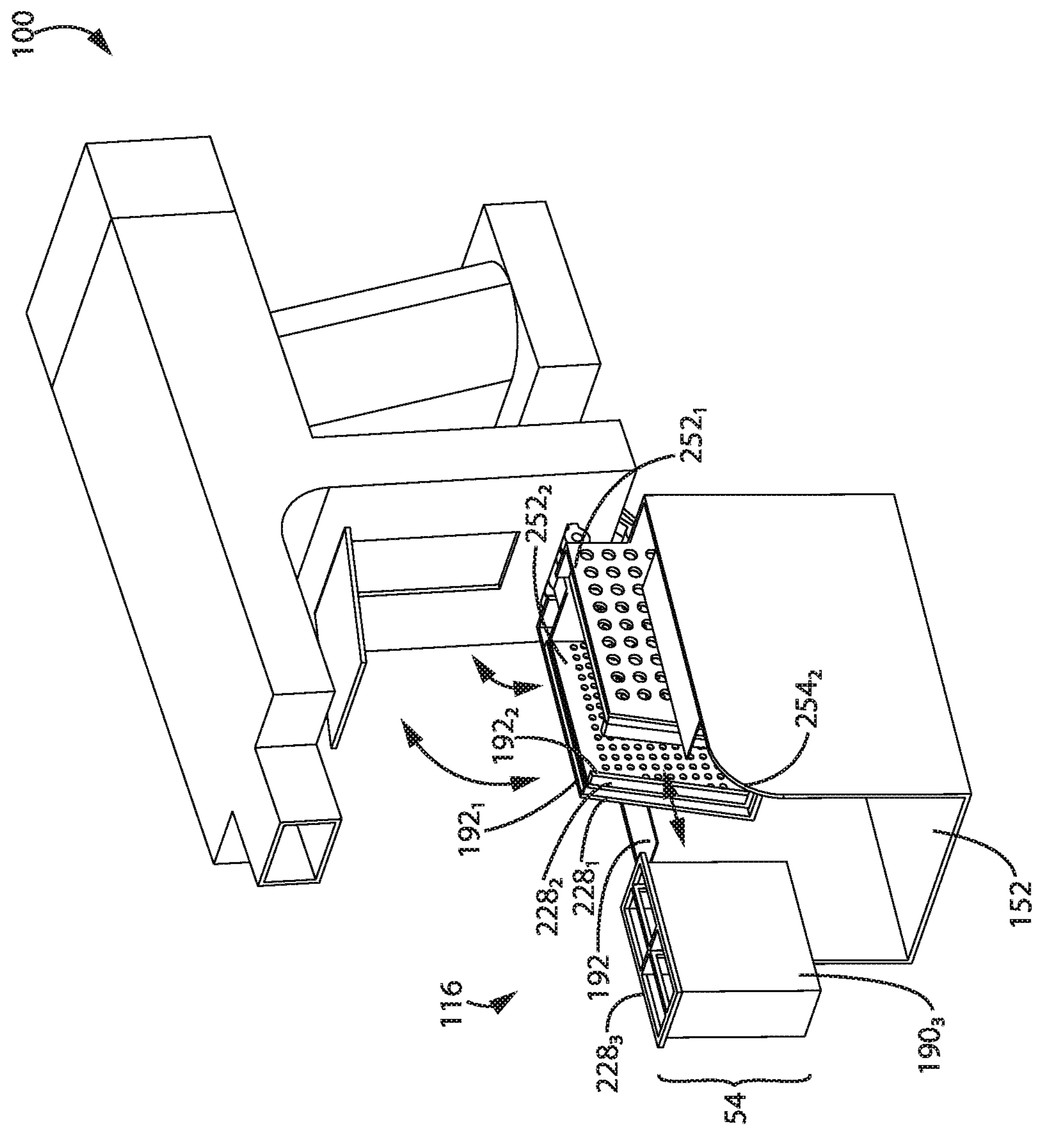


FIG. 20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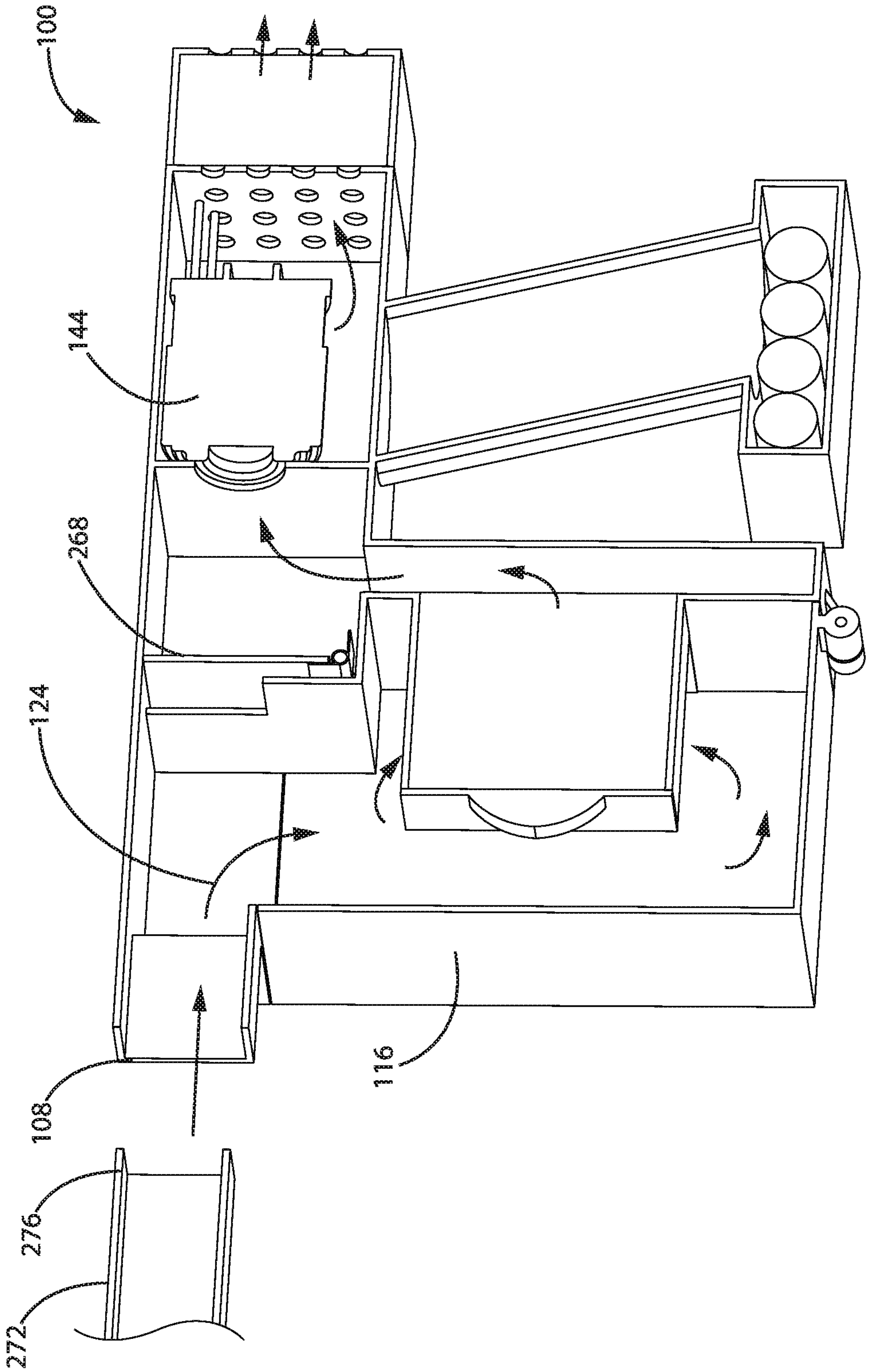


FIG. 21

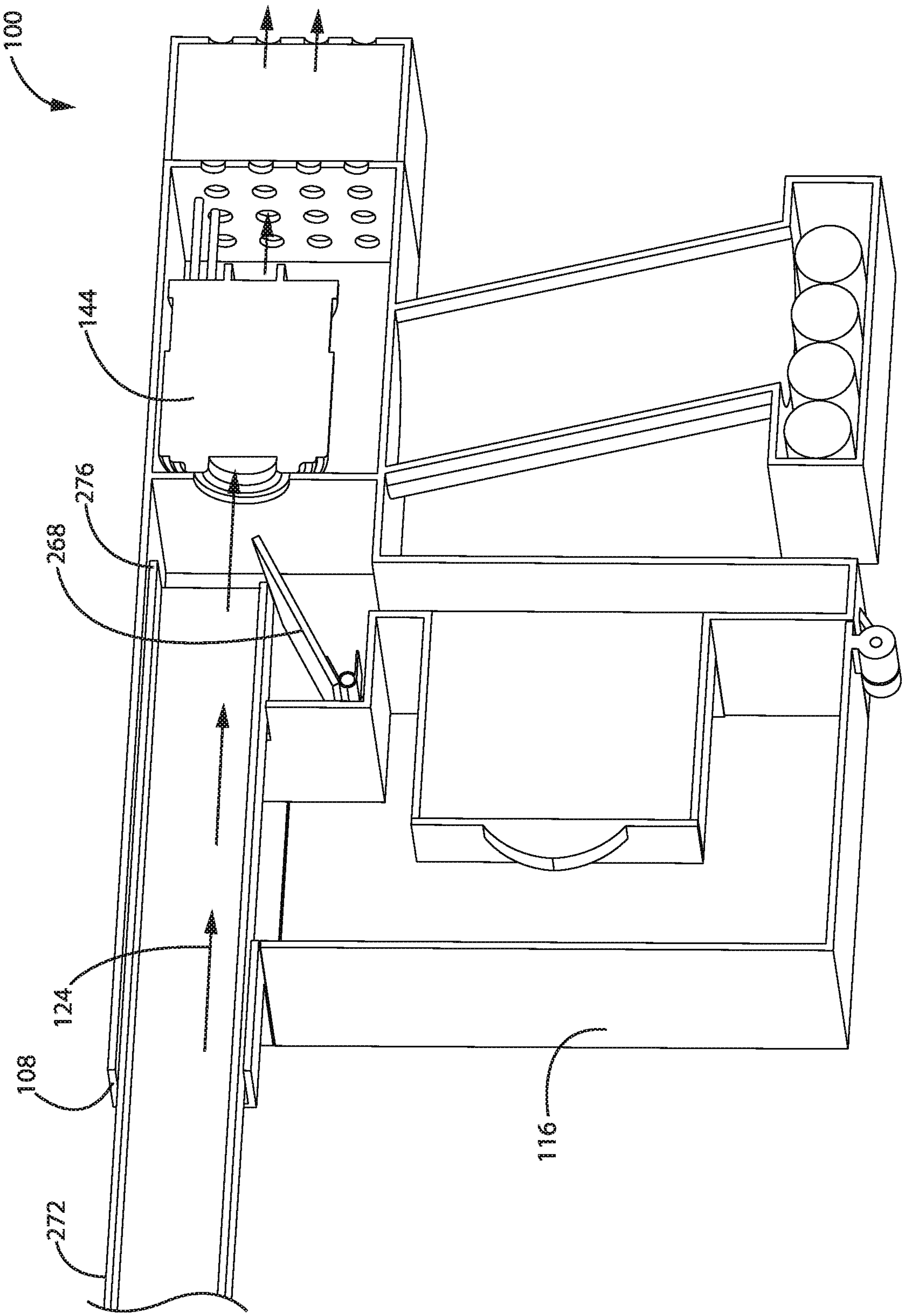
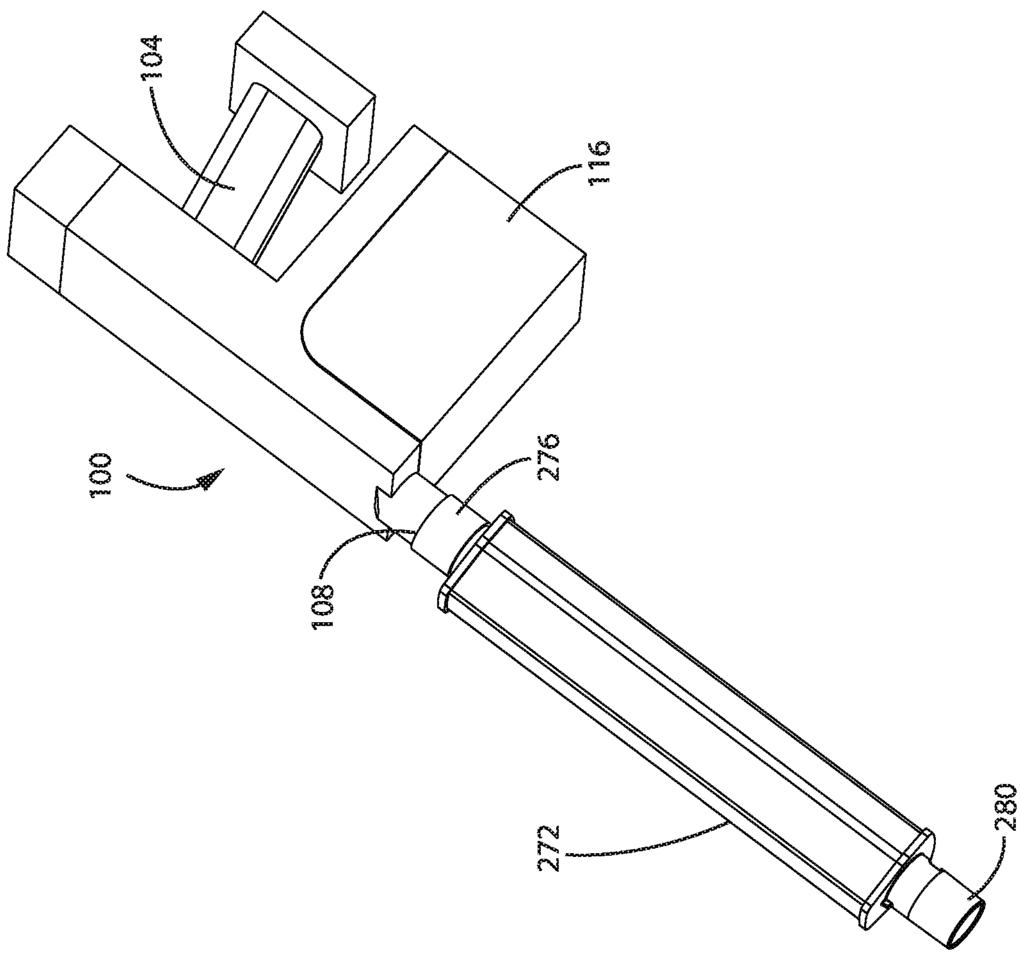


FIG. 22

FIG. 23



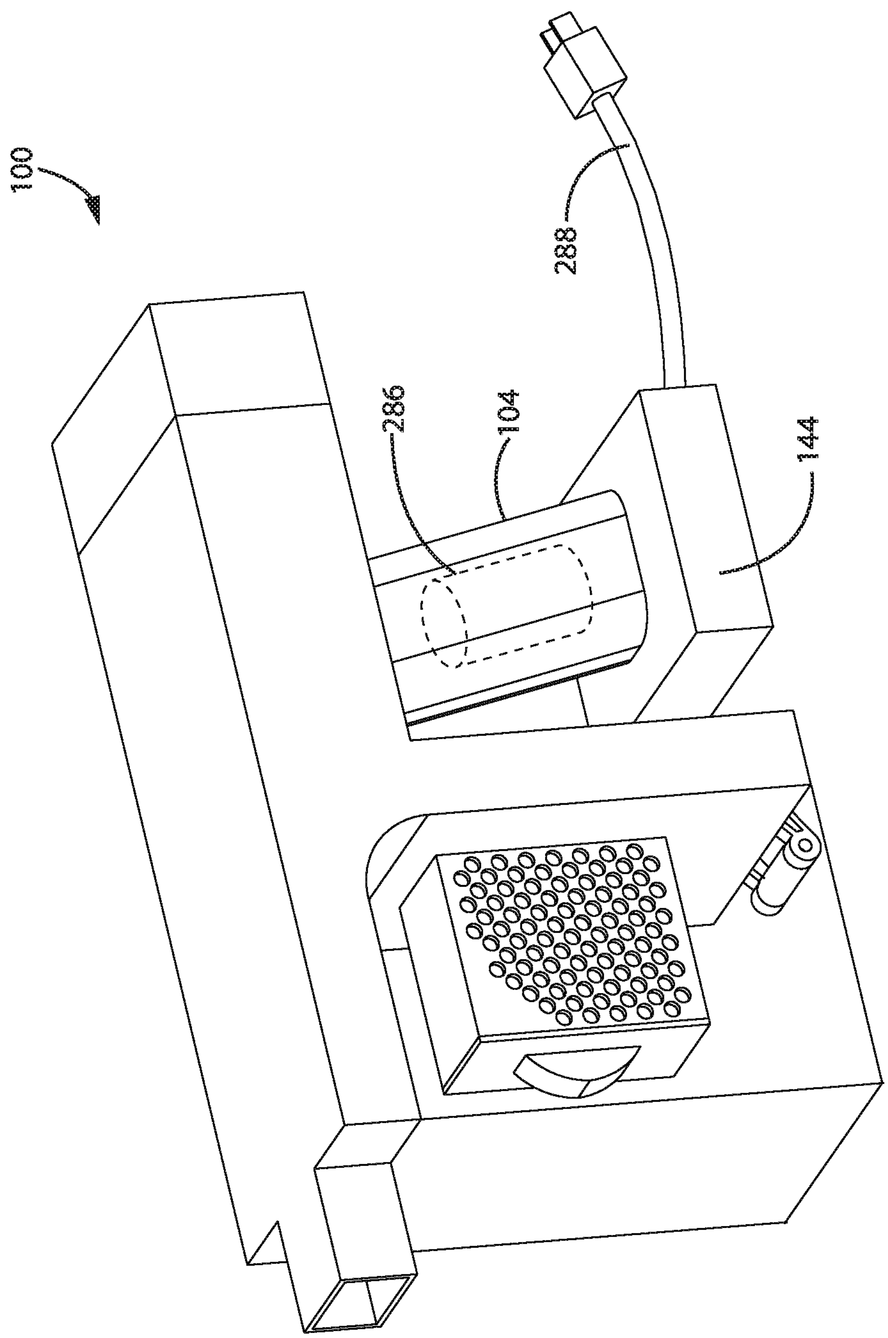


FIG. 24

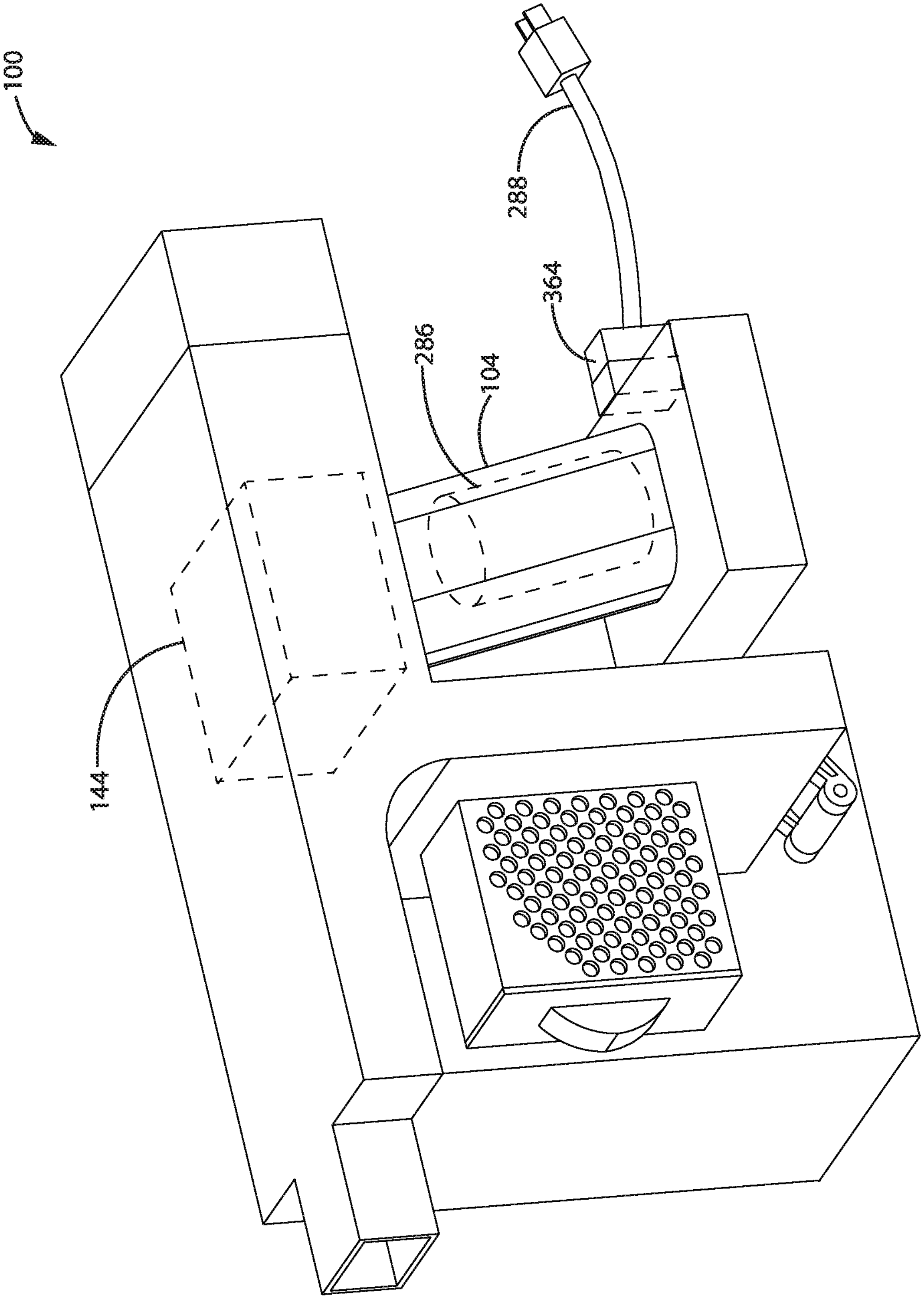


FIG. 25

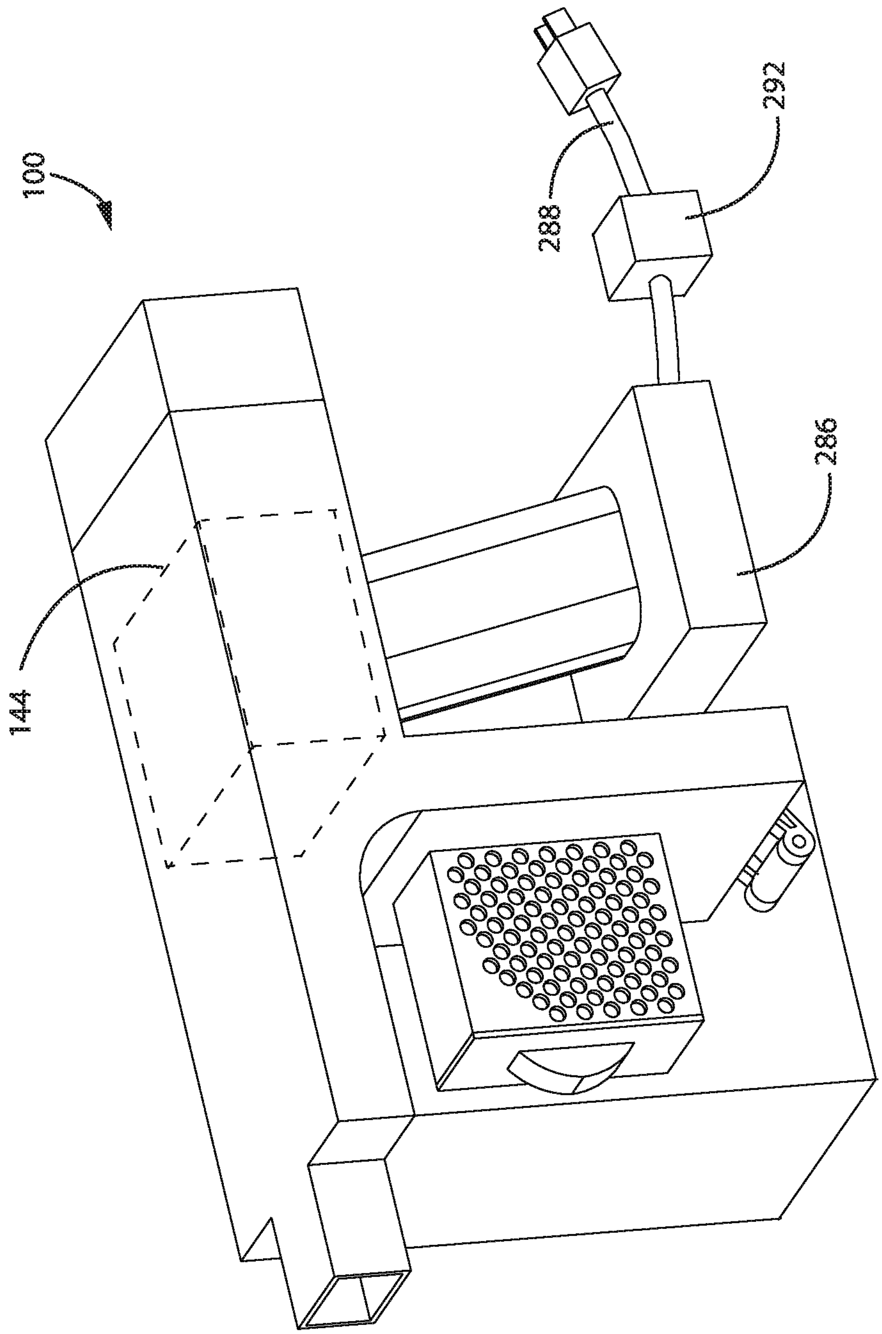


FIG. 26

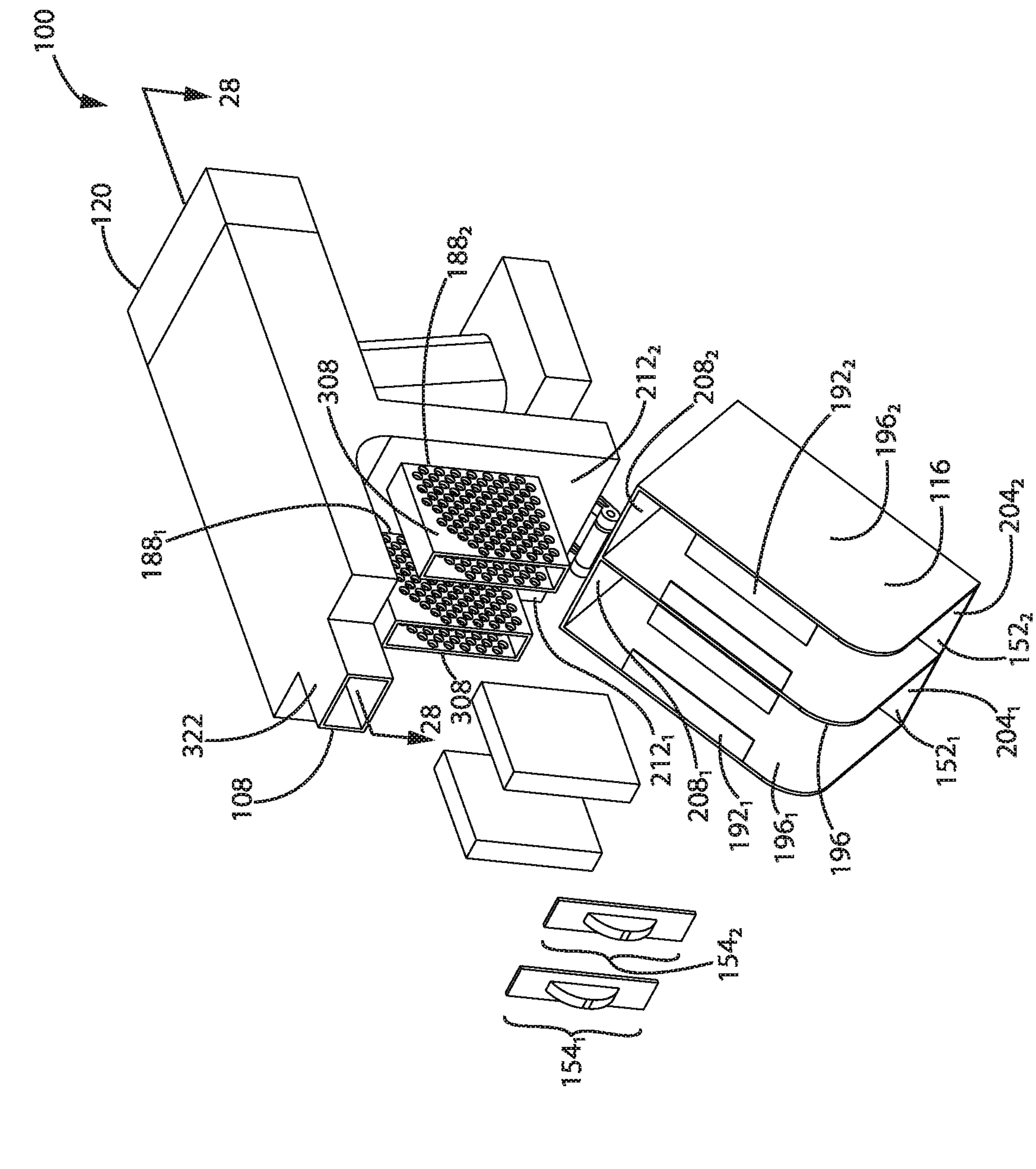

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FIG. 27

FIG. 28

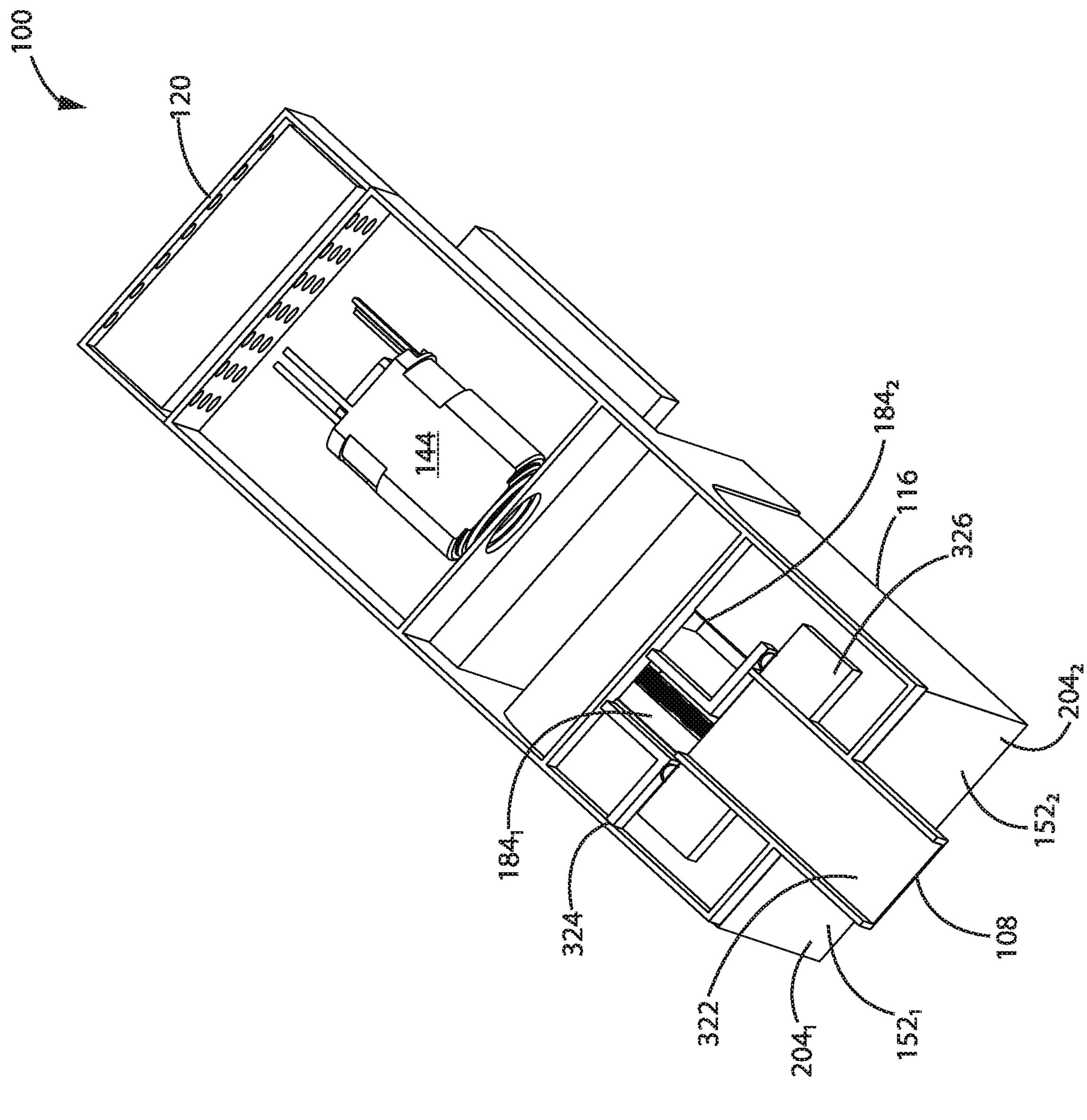
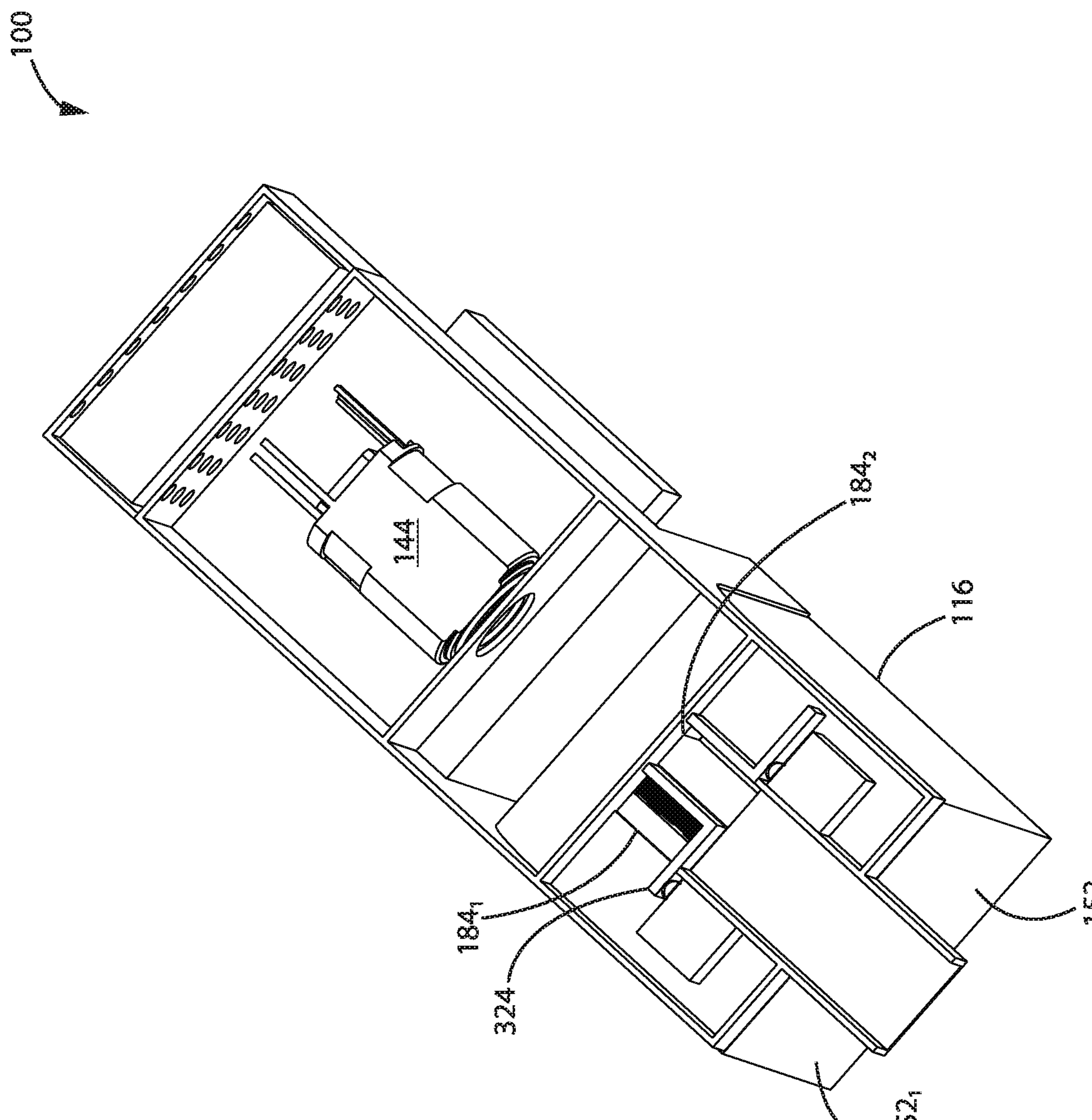


FIG. 29



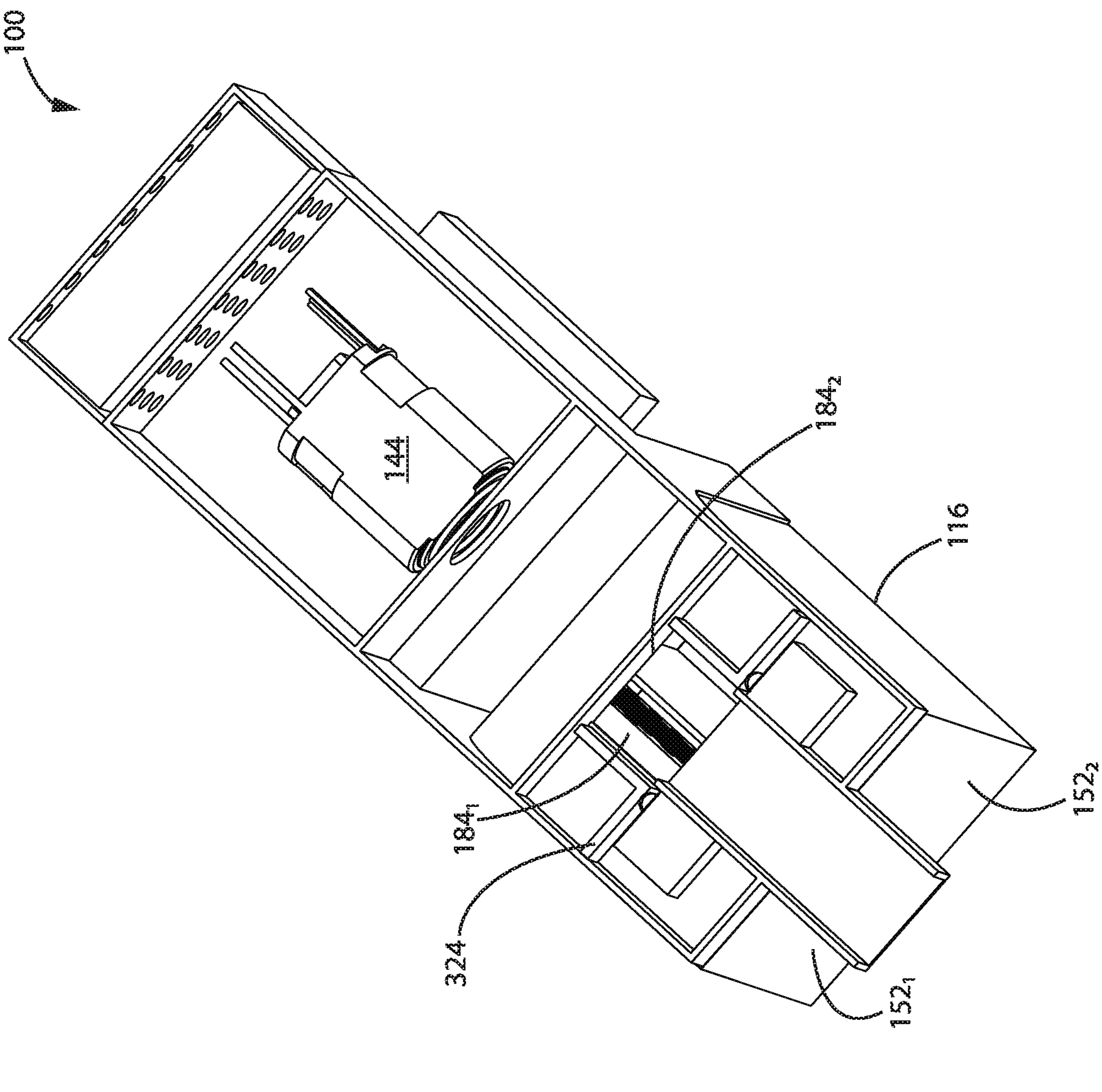


FIG. 30

FIG. 31

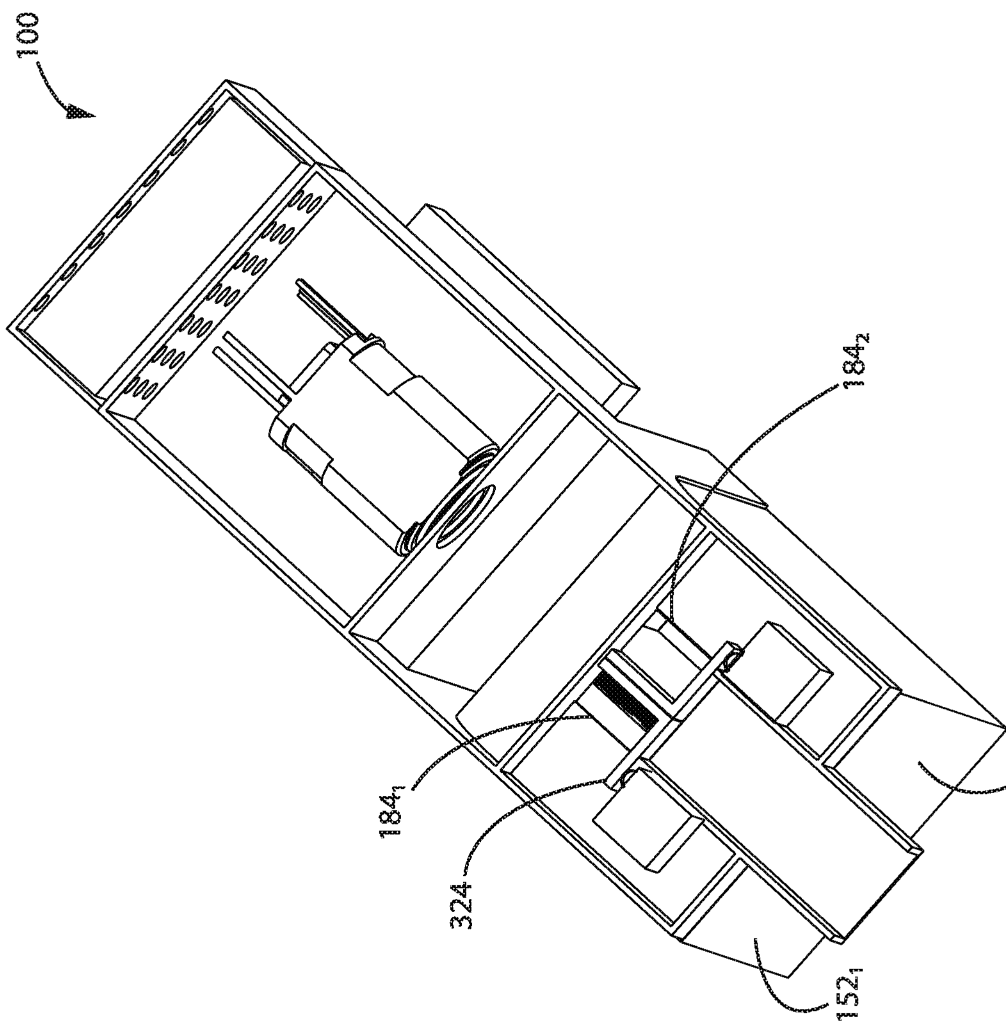
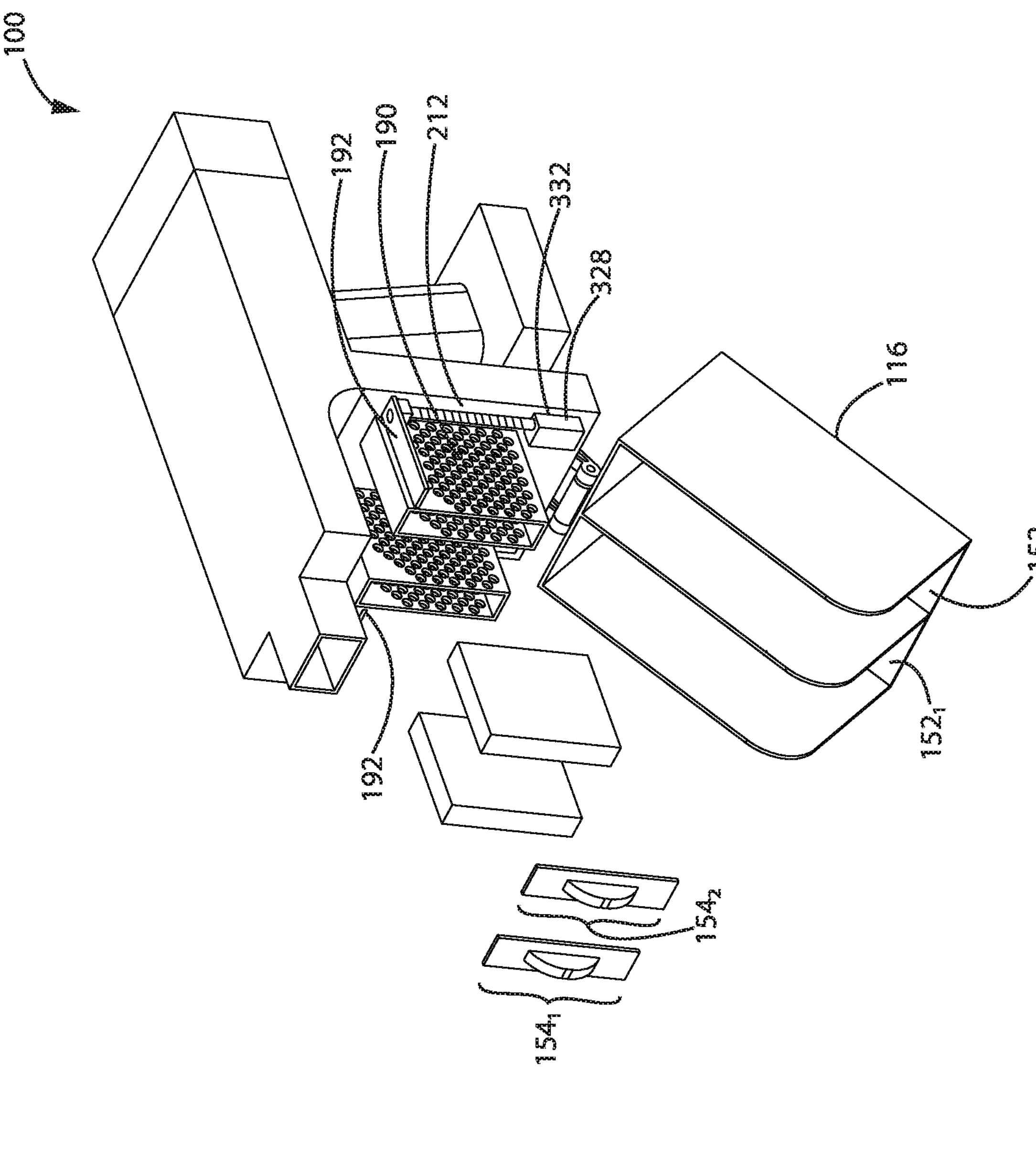


FIG. 32A



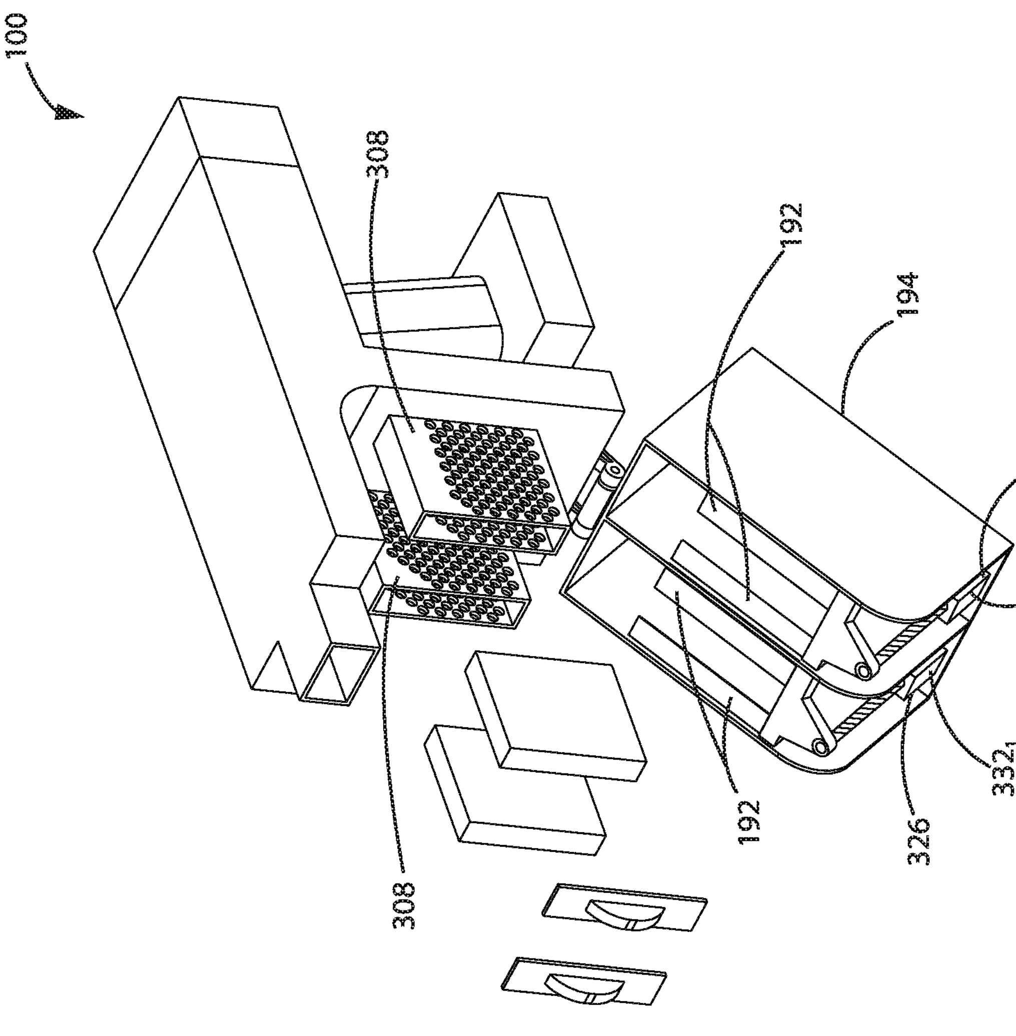


FIG. 32B

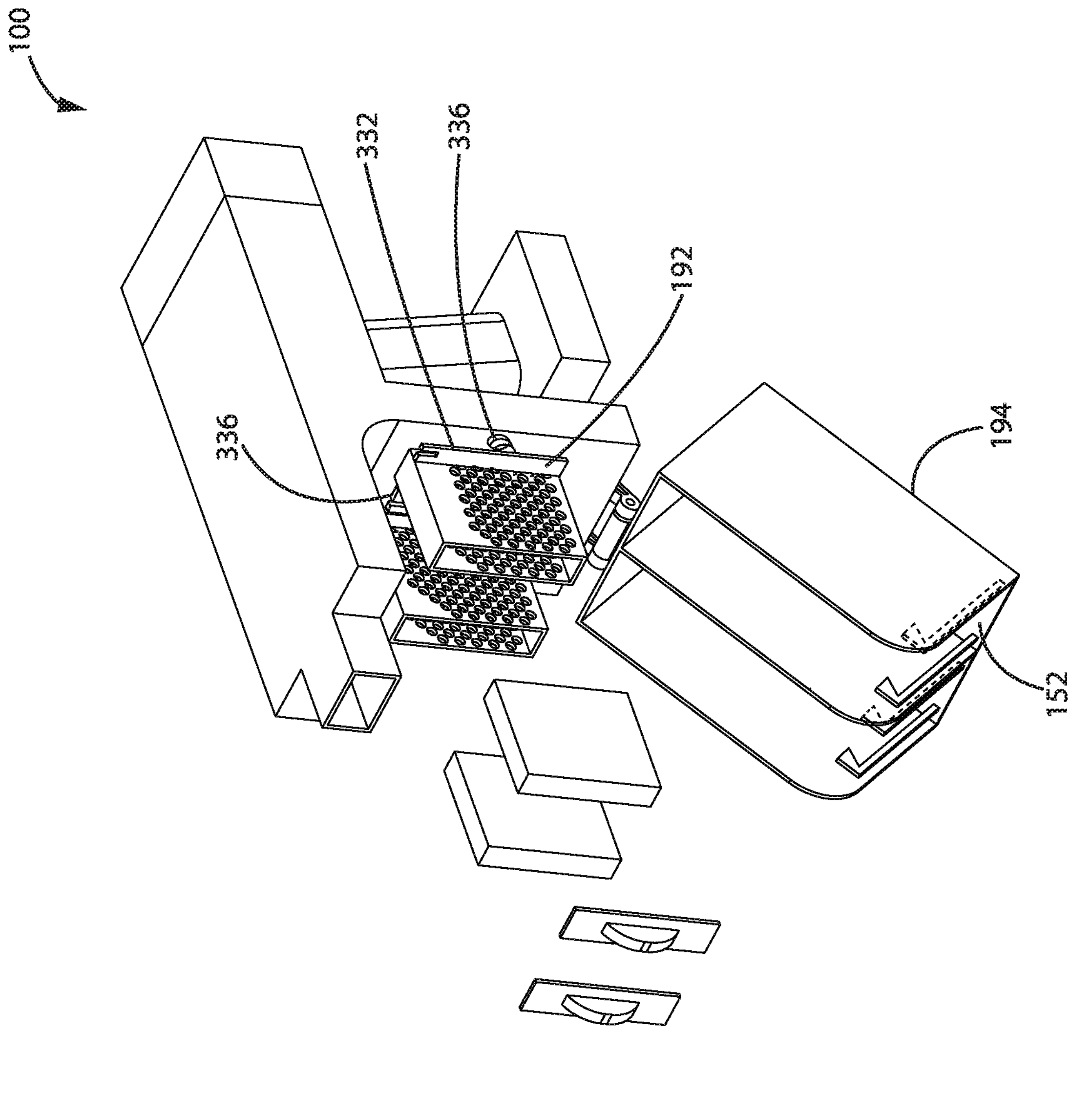


FIG. 33

FIG. 34

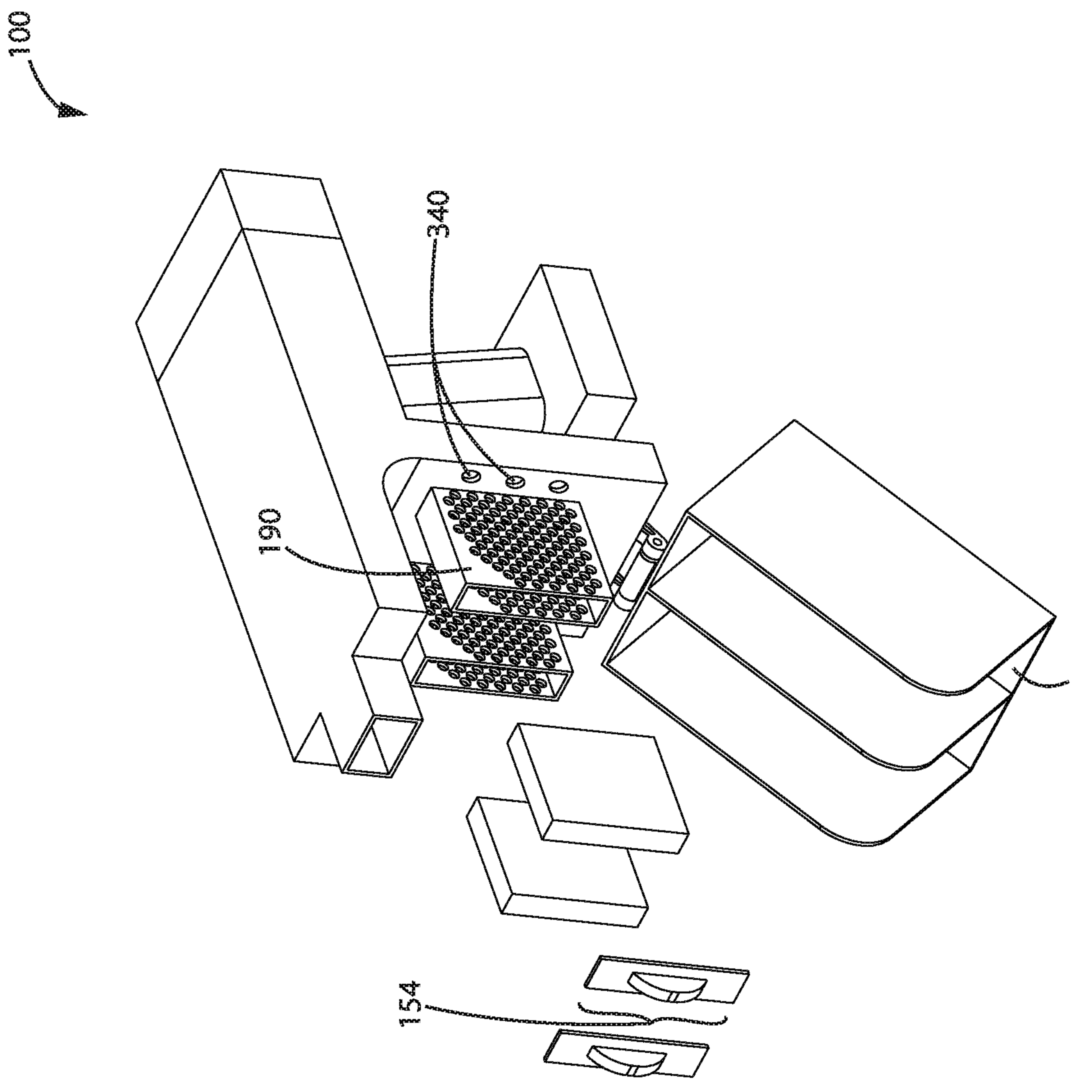
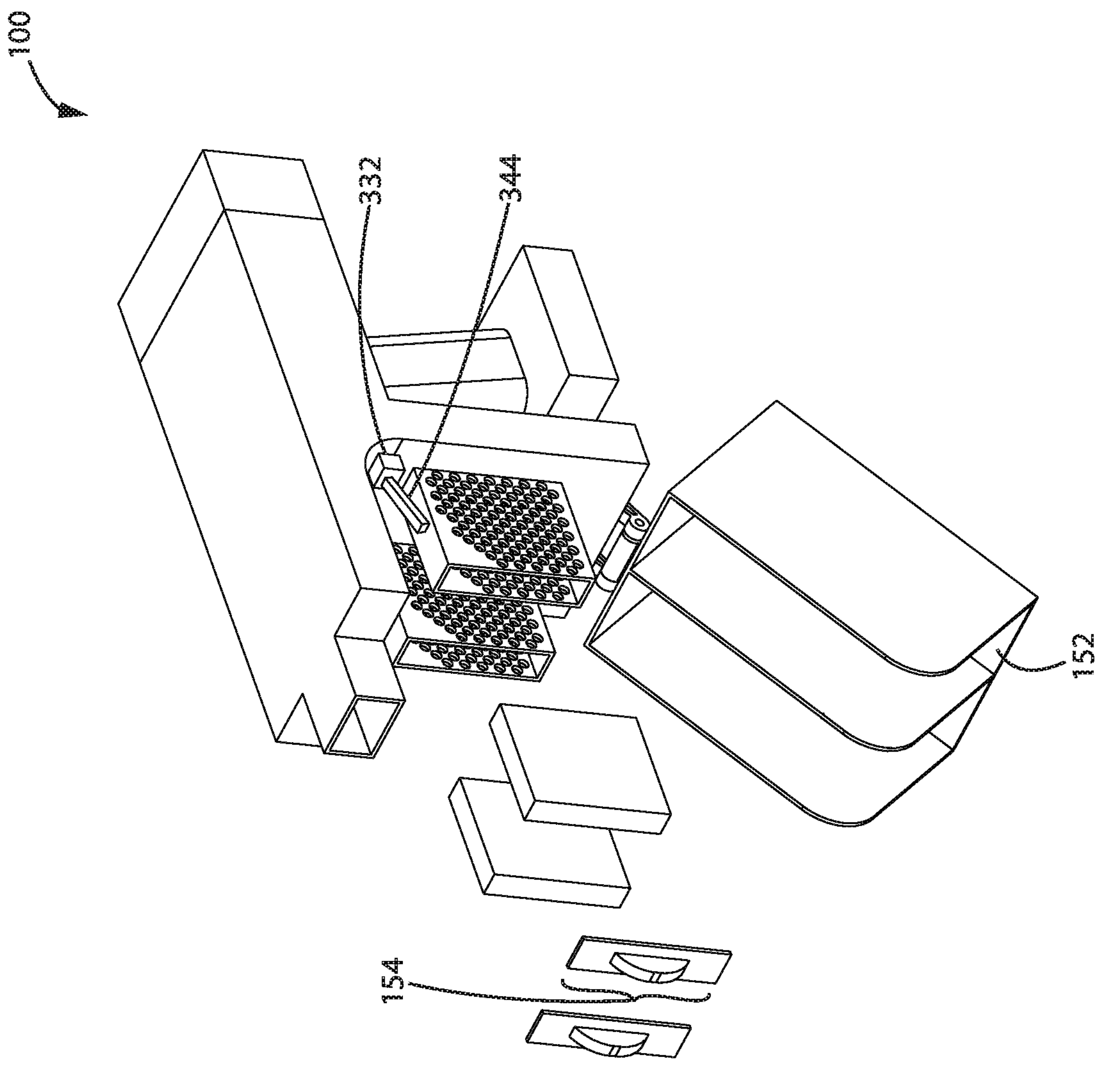
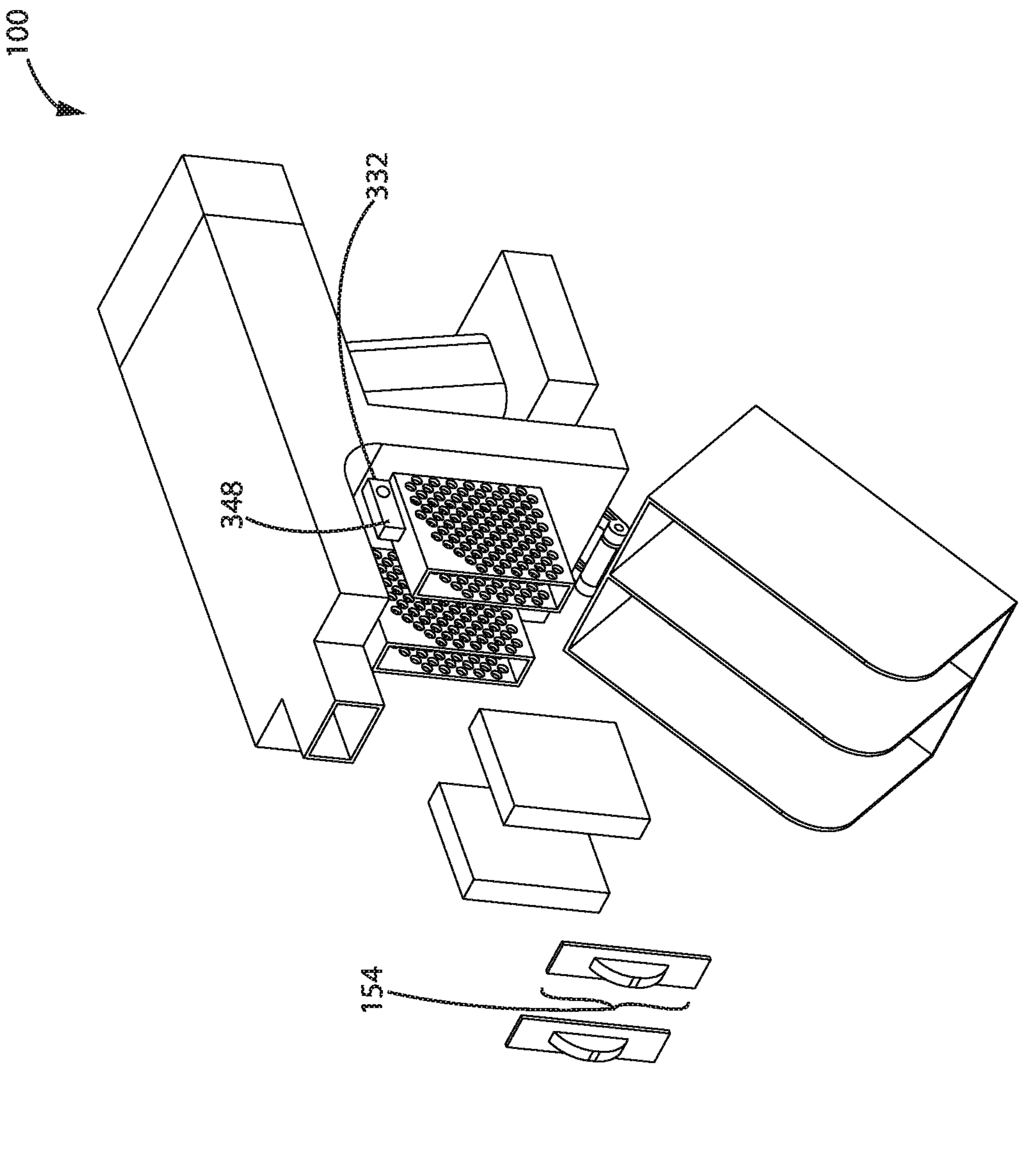


FIG. 35





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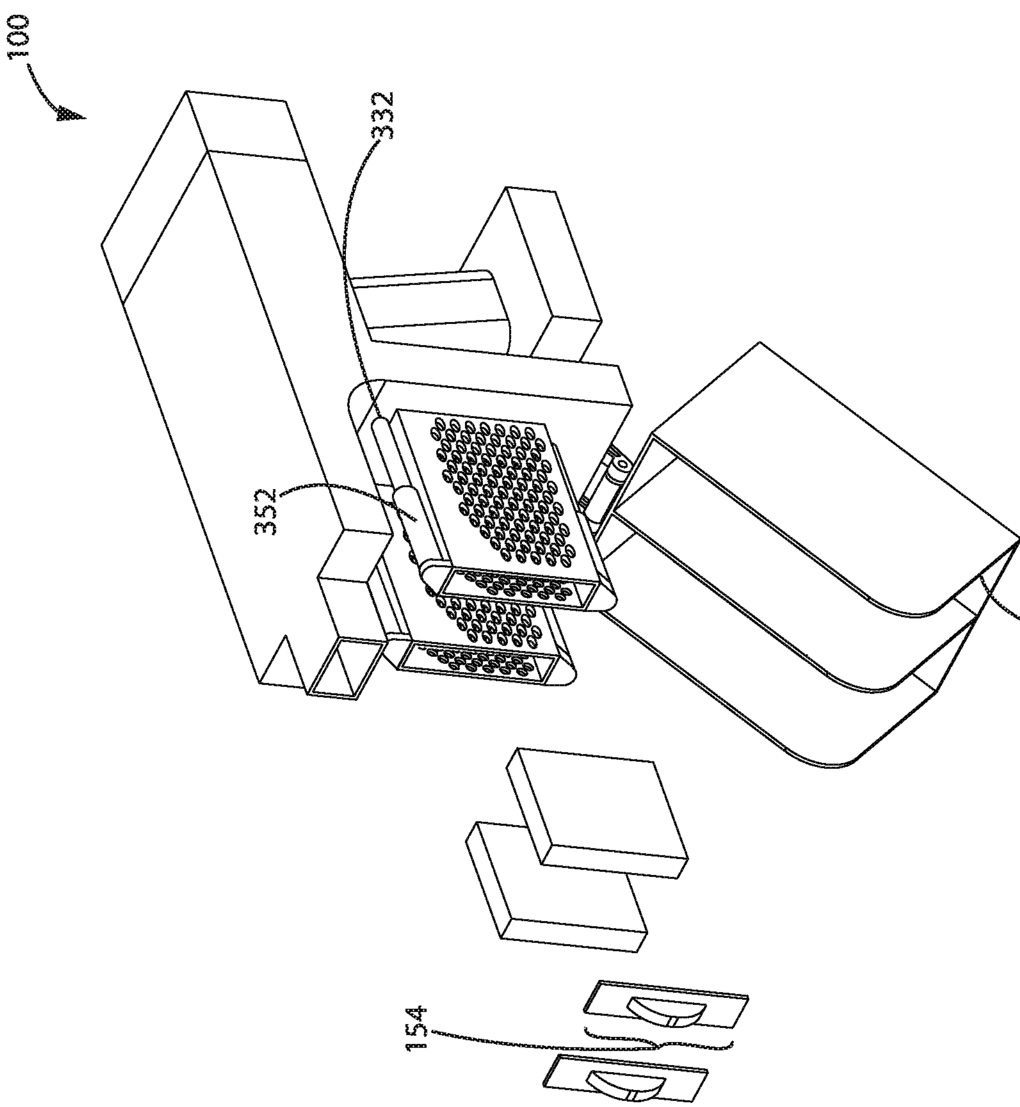
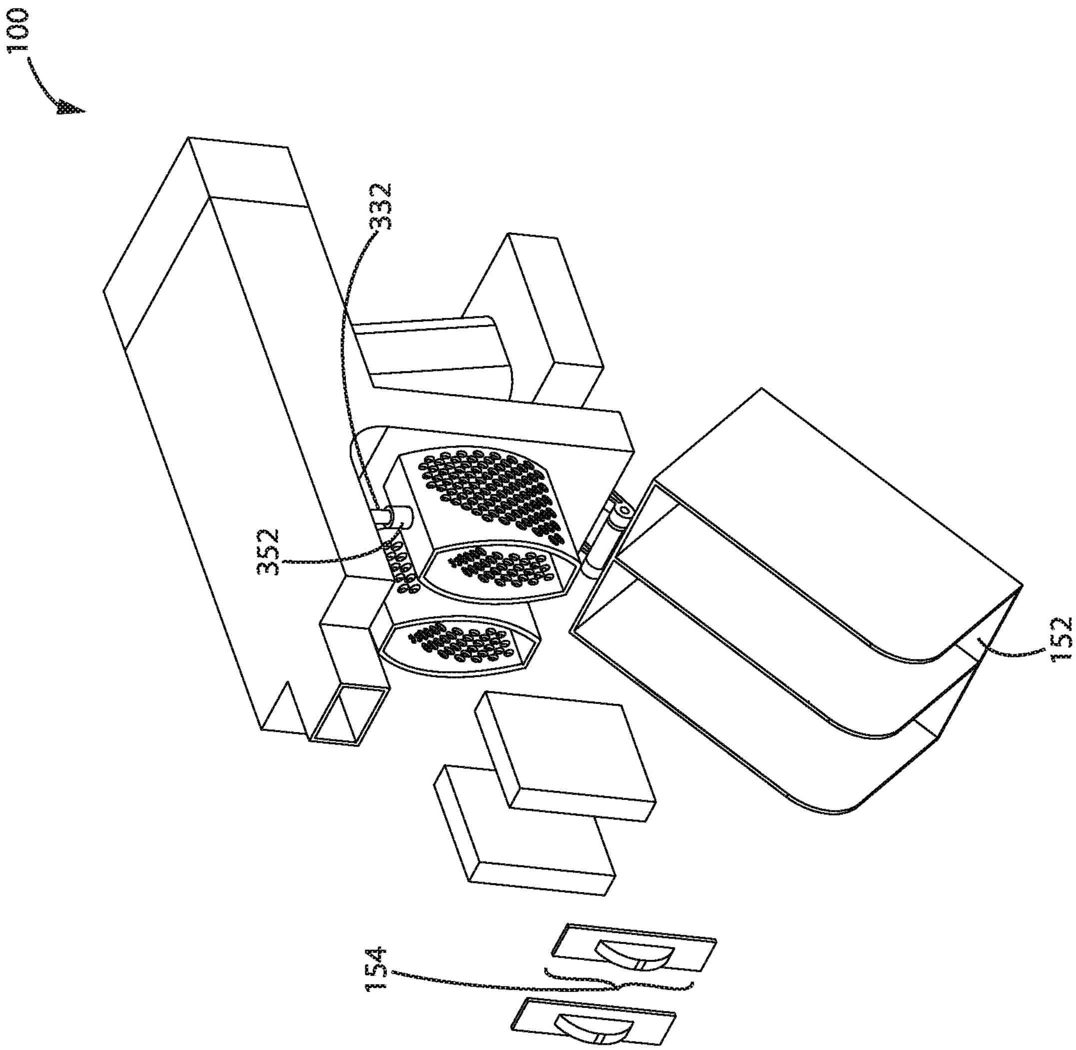


FIG. 37

FIG. 38



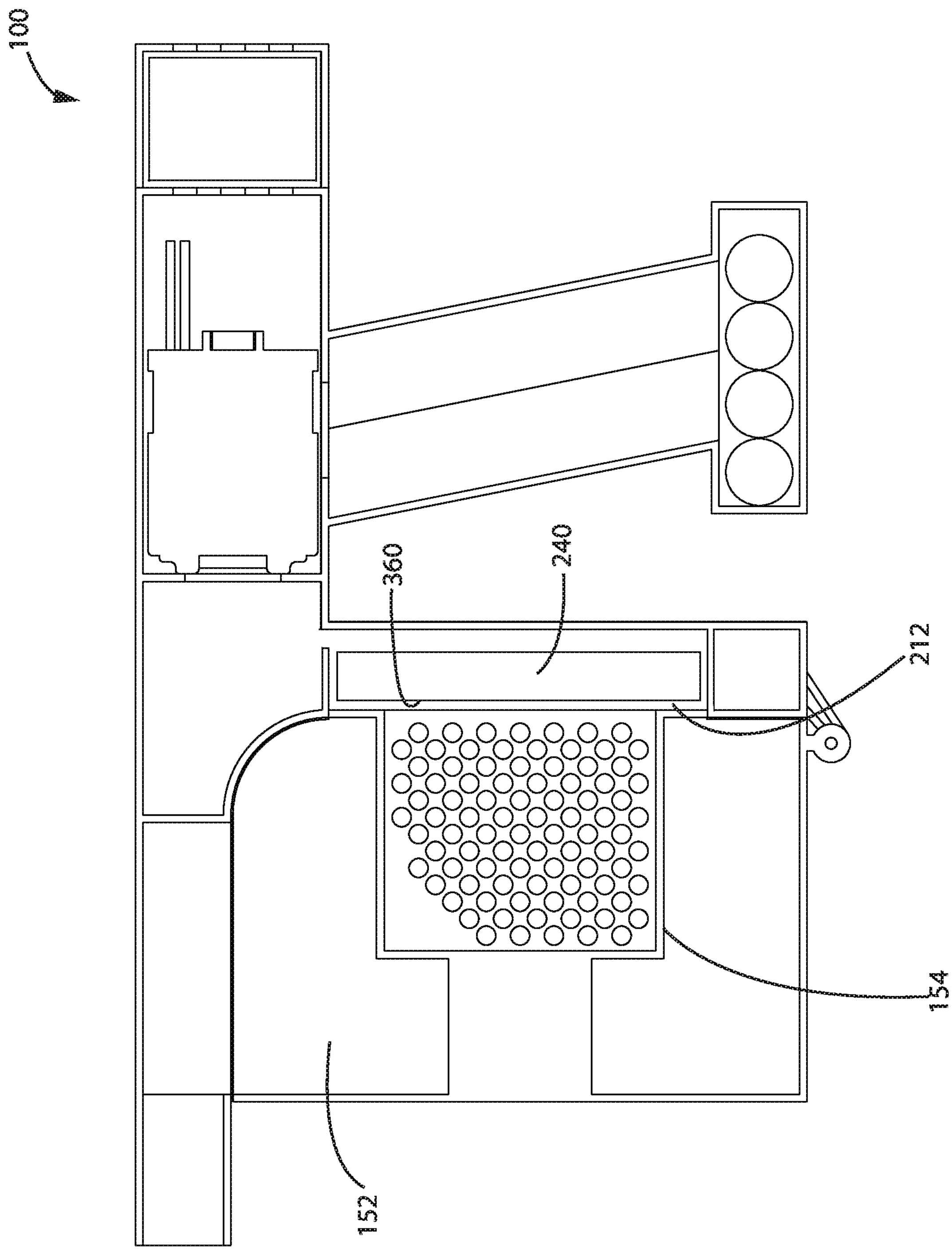


FIG. 39

FIG. 40

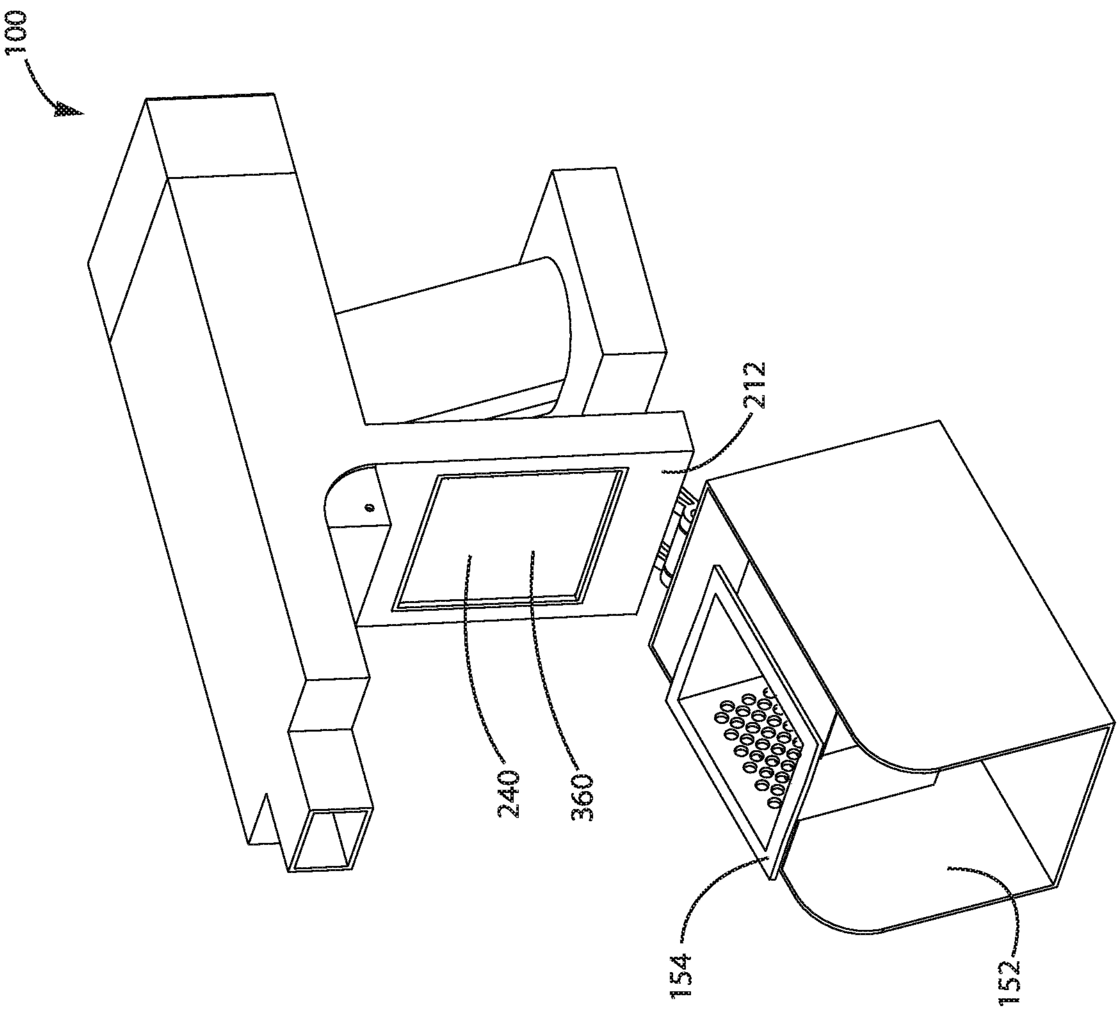


FIG. 41

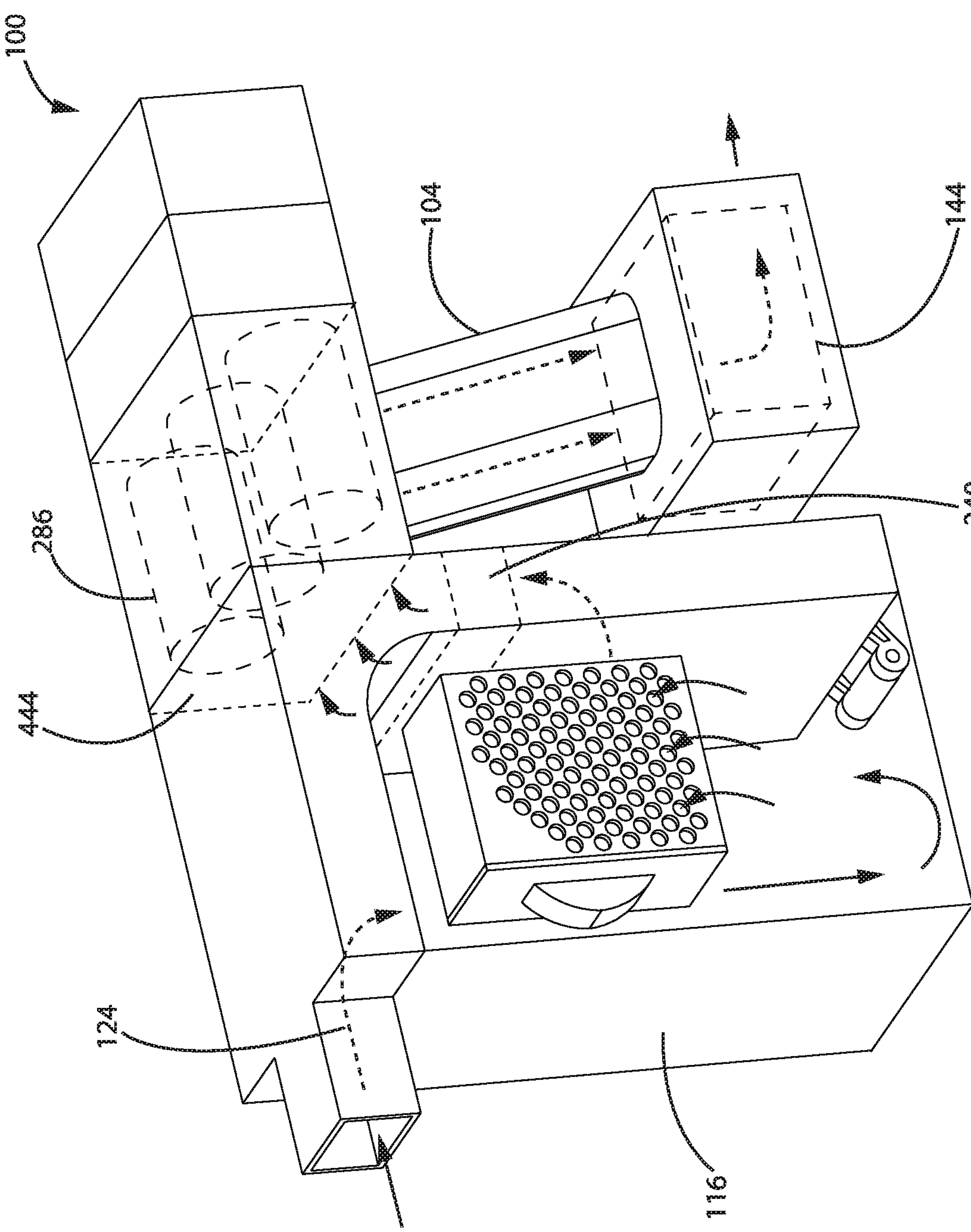
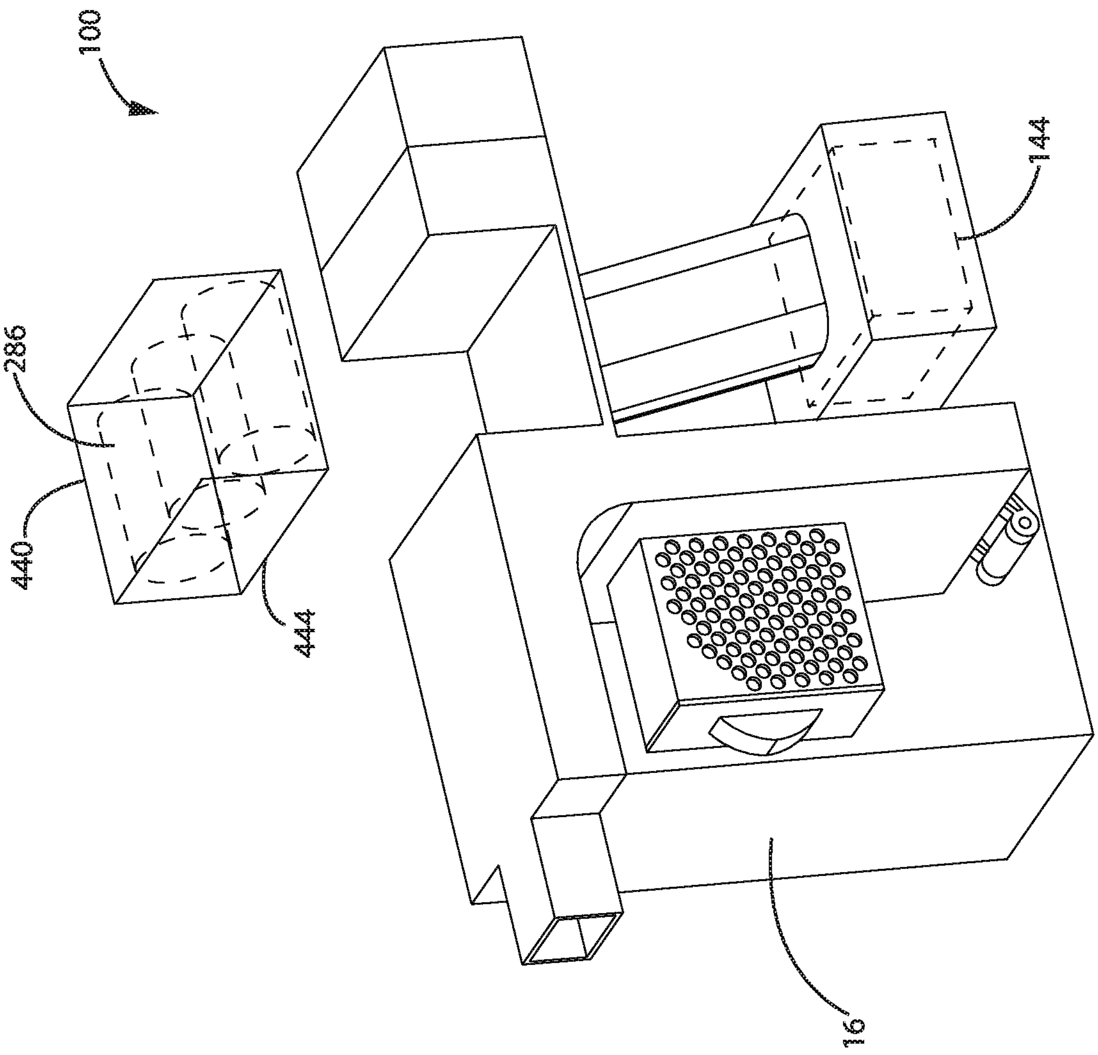


FIG.41B



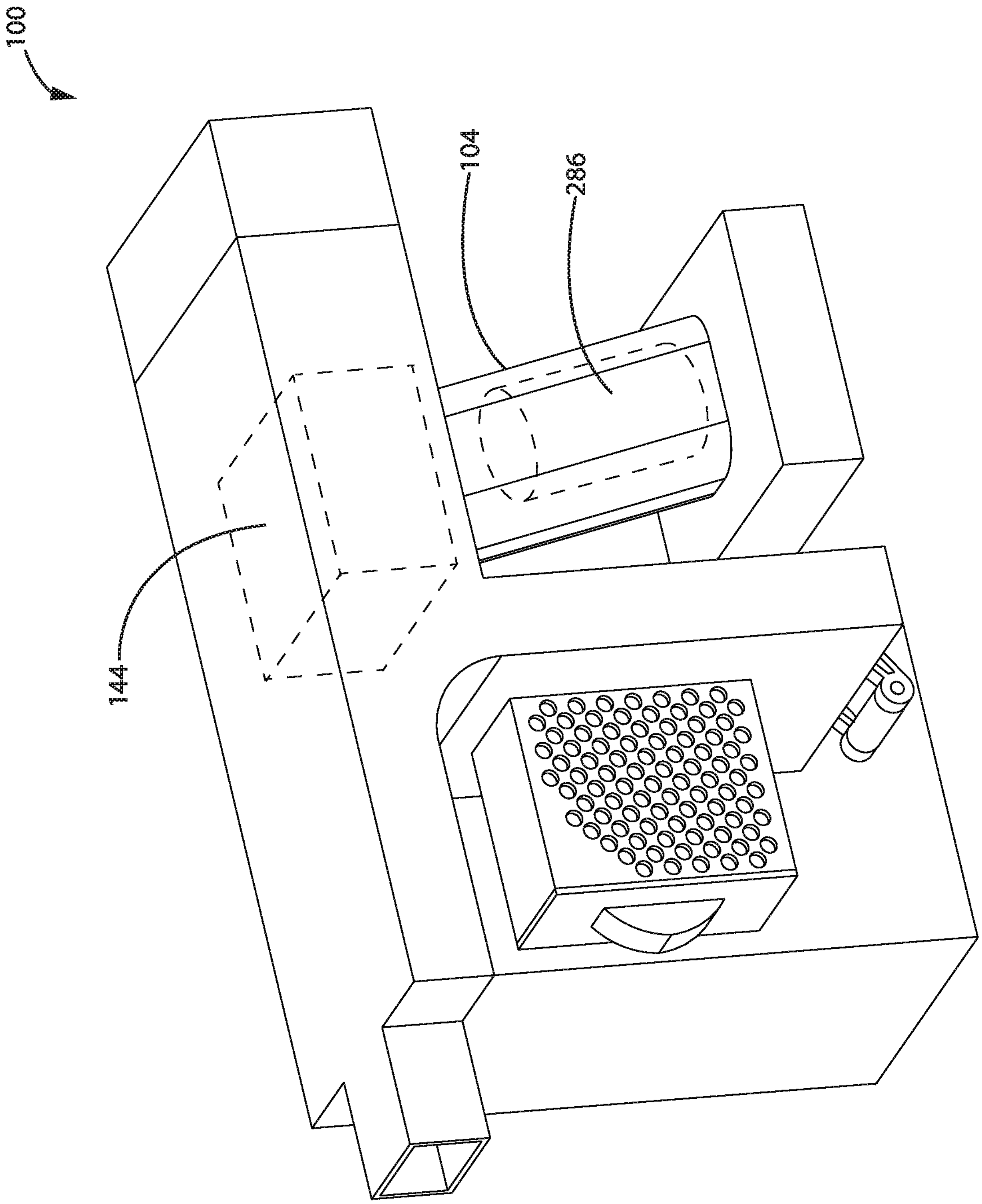


FIG. 42

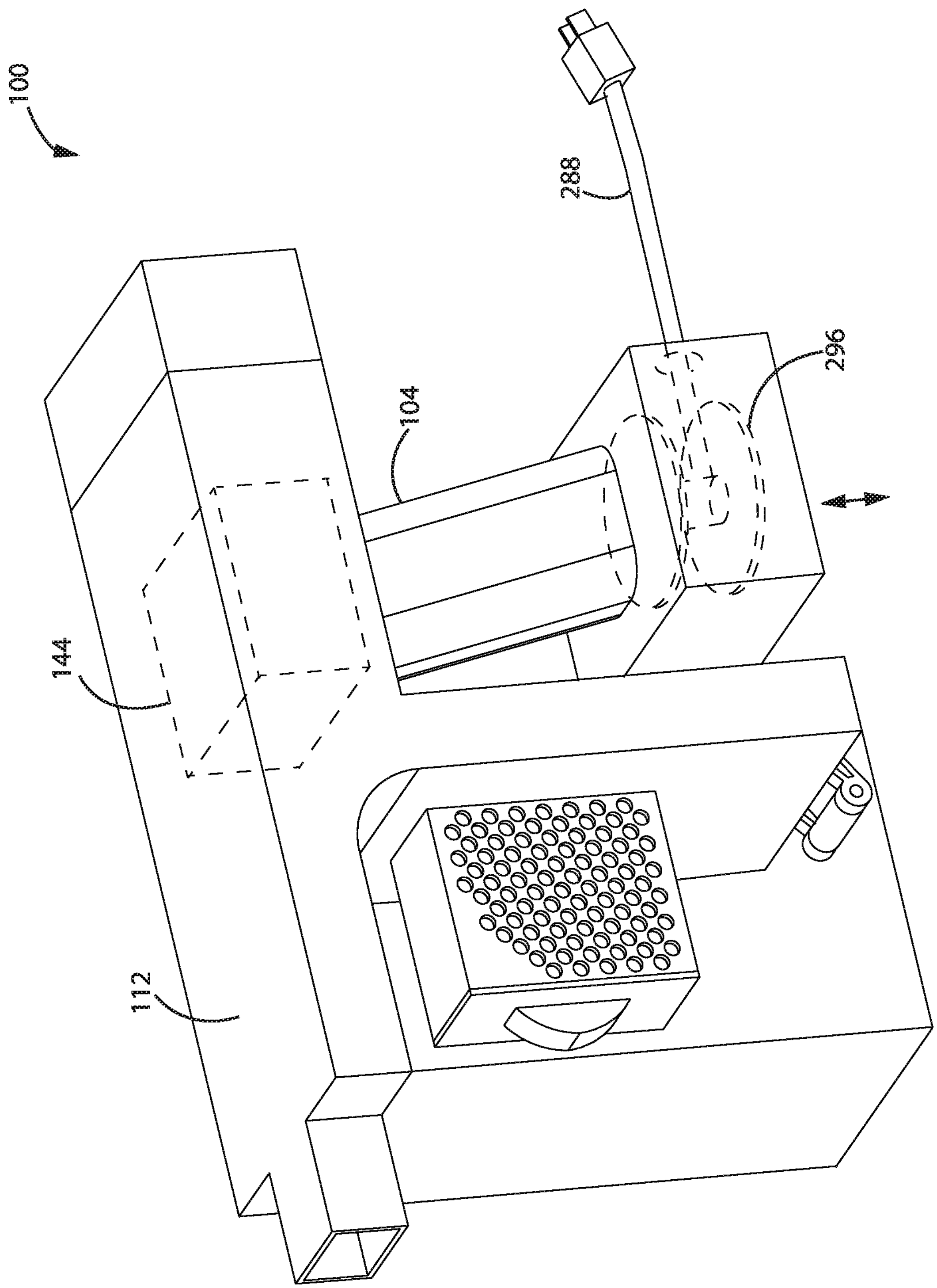


FIG. 43

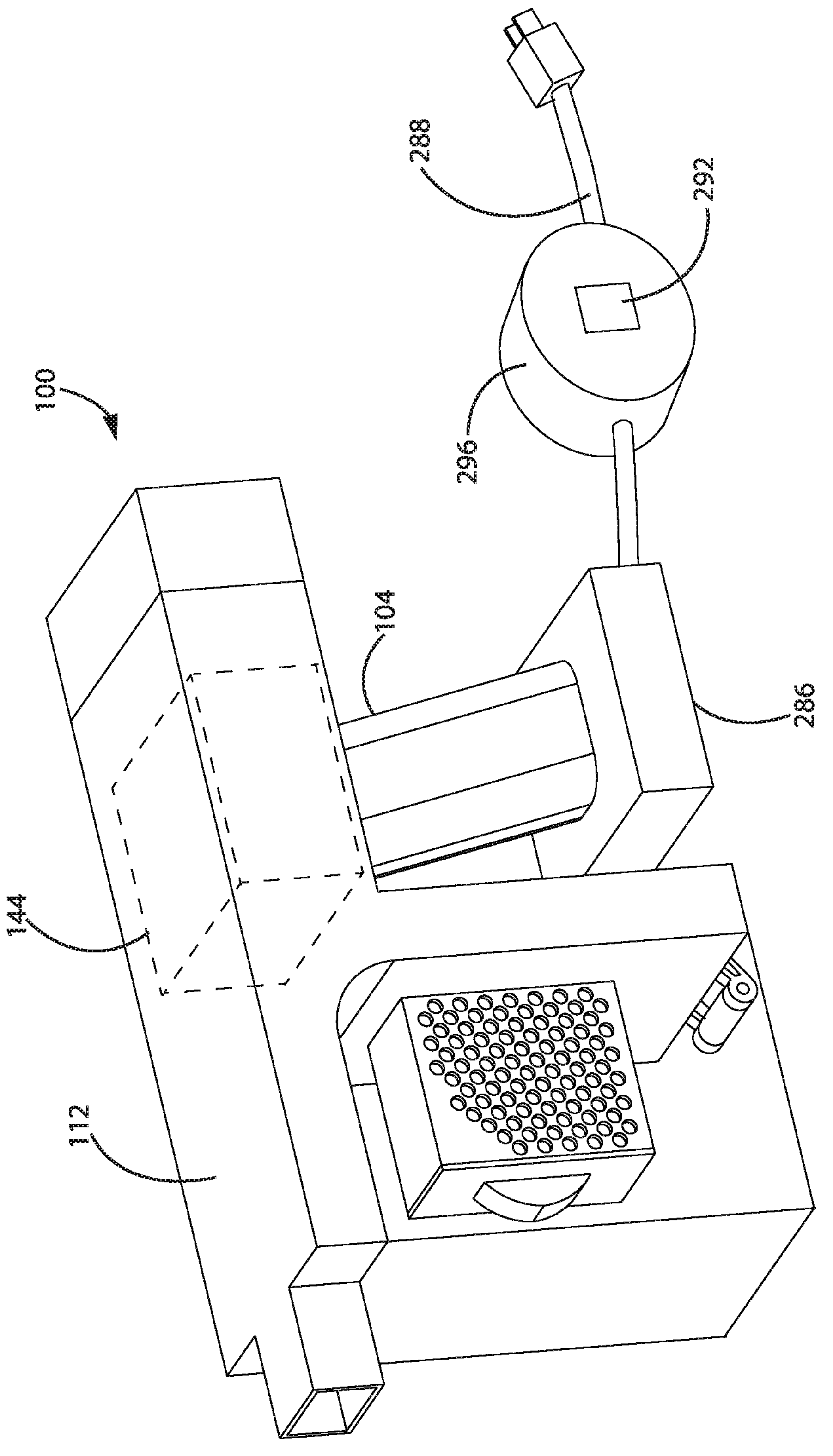
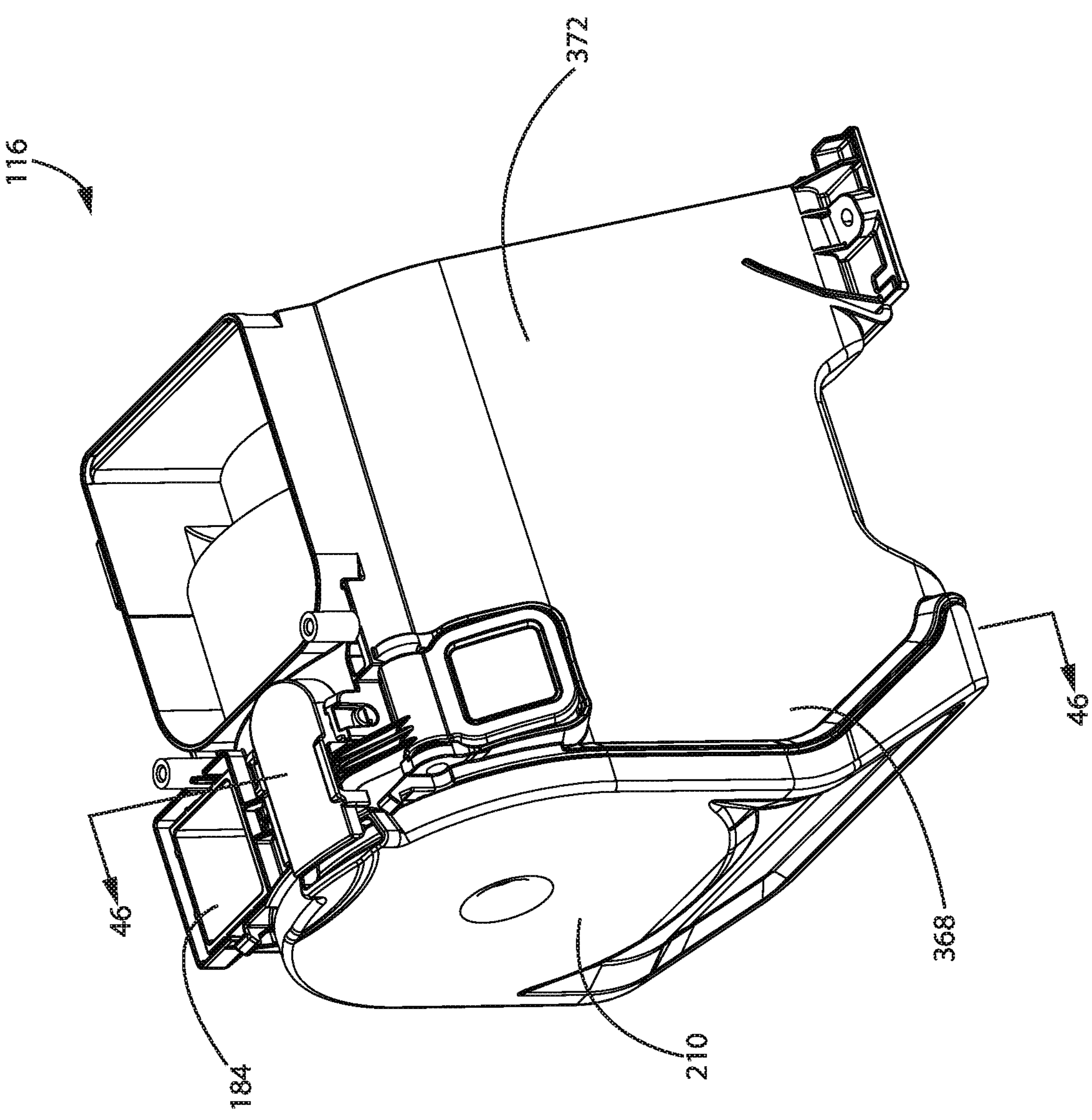


FIG. 44

FIG. 45



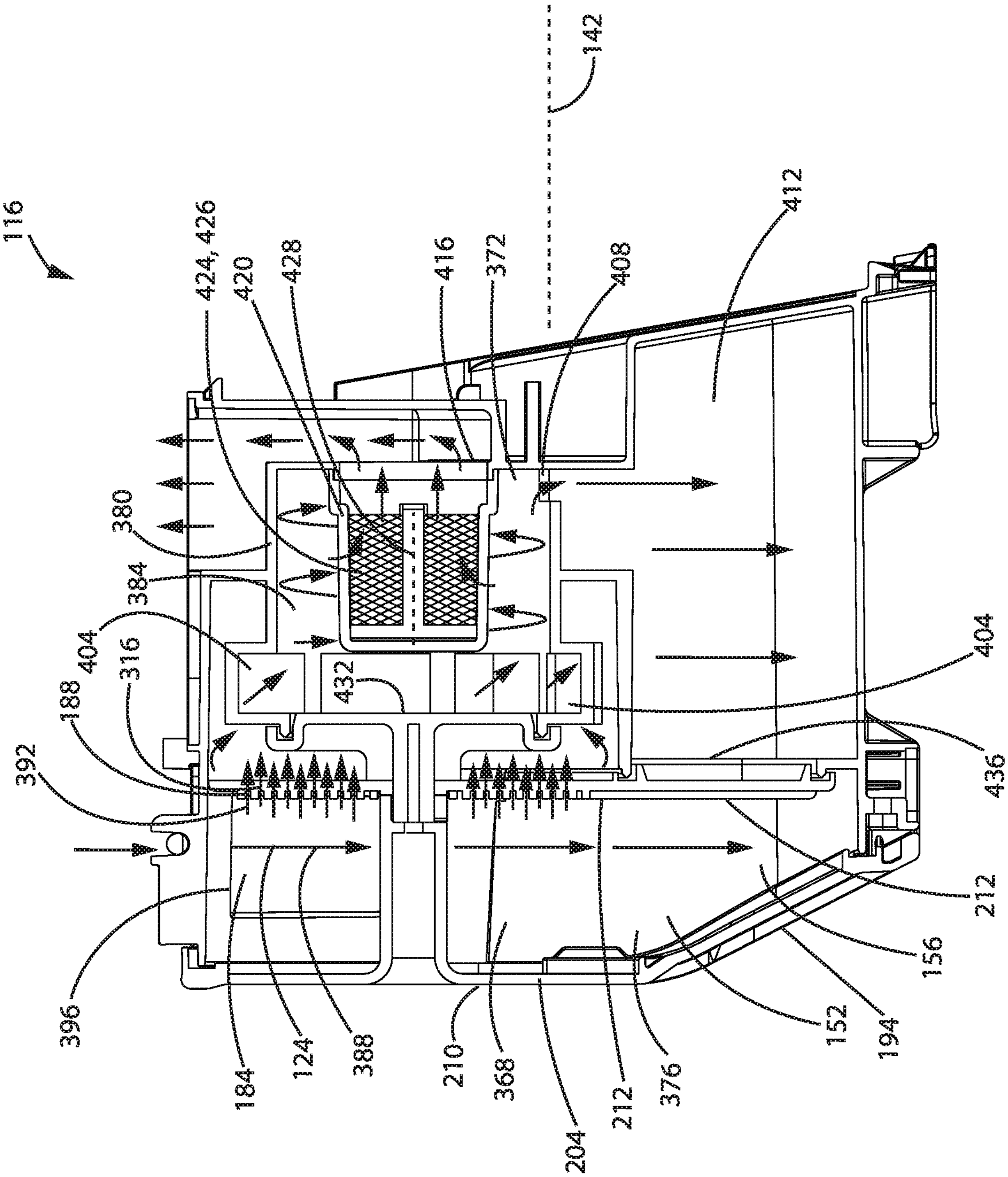

116
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FIG. 46

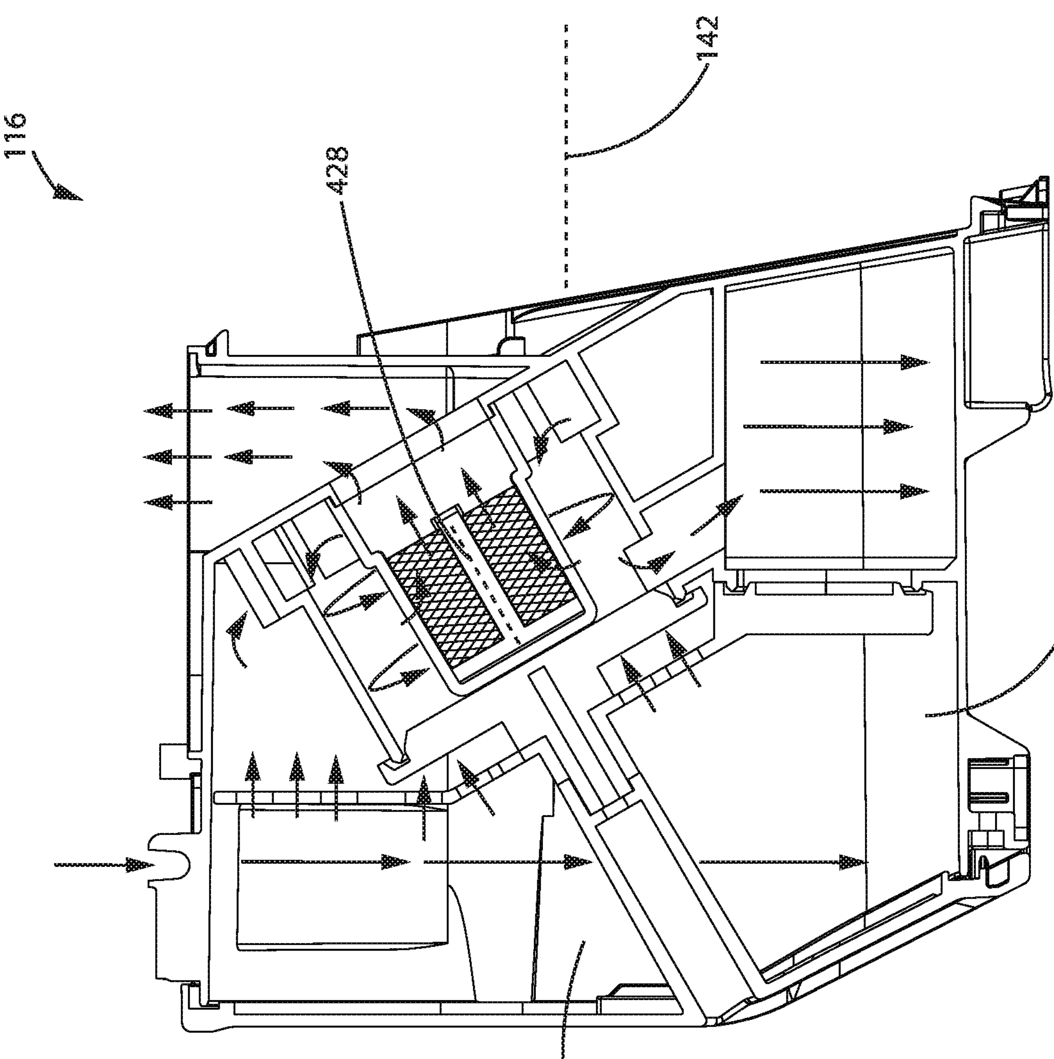

FIG. 47

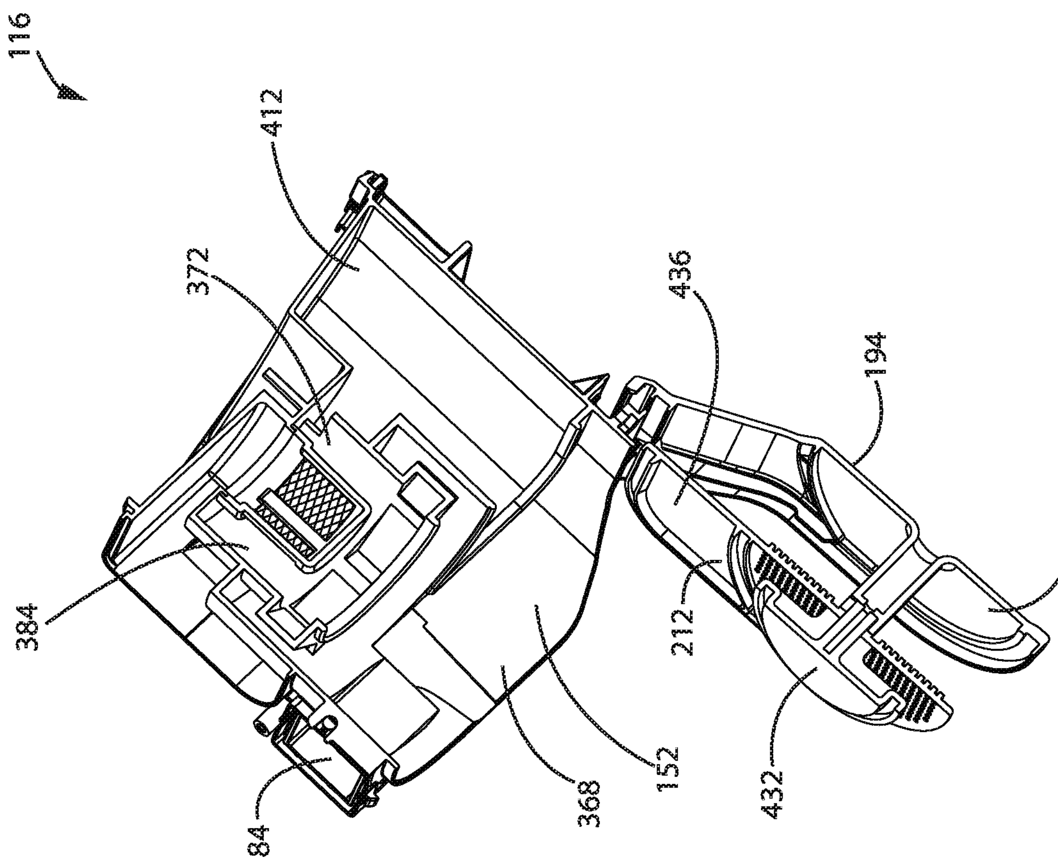

FIG. 48

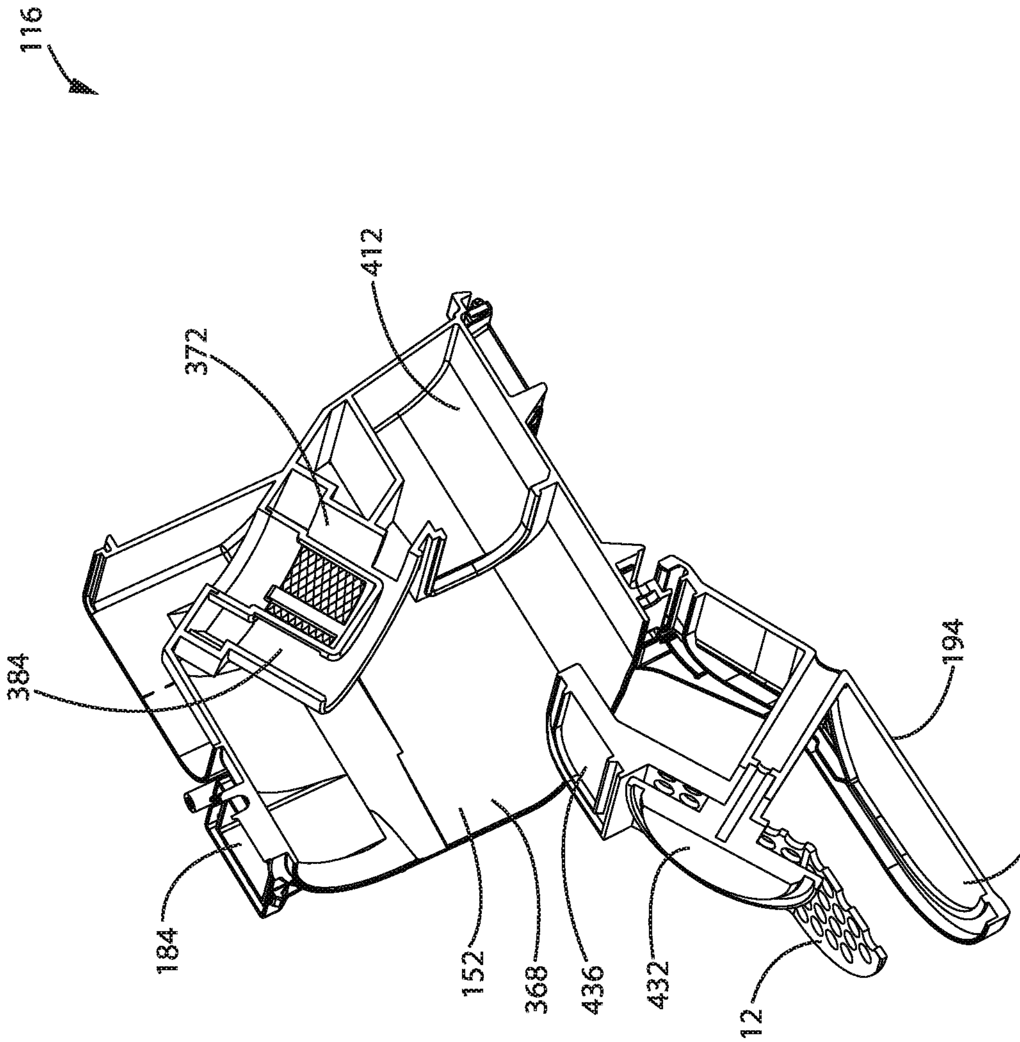

FIG. 49

SURFACE CLEANING APPARATUS

CROSS-REFERENCE

This application claims priority to U.S. provisional patent application No. 62/660,700 filed on Apr. 20, 2018.

FIELD

This disclosure relates generally to surface cleaning apparatus and, optionally, a portable surface cleaning apparatus, such as a hand vacuum cleaner. In some embodiments, the surface cleaning apparatus comprises a first stage momentum separator with a downstream air treatment member such as a cyclone. Alternately, or in addition, the surface cleaning apparatus may comprise a momentum separator having a wiper to clean an air exit screen of the momentum separator. Alternately, or in addition, the surface cleaning apparatus may comprise an on board energy storage member positioned in the air flow passage downstream of the pre-motor filter and upstream of the suction motor.

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 hand vacuum cleaners, including battery-operated hand vacuum cleaners are known in the art.

SUMMARY

In one aspect, there is provided a hand vacuum cleaner, which has an upstream momentum separator and a downstream cyclone separator wherein both the momentum separator and the cyclone are concurrently openable.

In accordance with this aspect, there is provided a hand vacuum cleaner having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

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

(b) a first cleaning stage positioned in the air flow passage downstream from the dirty air inlet, the first cleaning stage comprising a momentum separator having a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end;

(c) a second cleaning stage positioned in the air flow passage downstream from the first cleaning stage, the second cleaning stage comprising at least one cyclone, the at least one cyclone having a cyclone chamber;

(d) a front door moveably mounted between a closed position and an open position,

wherein, when the front door is moved to the open position, a wall defining part of the treatment chamber and a wall defining part of the cyclone chamber are concurrently opened.

In some embodiments, the air inlet of the treatment chamber may be located at an upper end of the treatment chamber and directs air downwardly into the treatment chamber.

In some embodiments, the air inlet of the treatment chamber may remain in position when the front door is opened.

In some embodiments, the hand vacuum cleaner may have a front wall and the front wall is the front door.

In some embodiments, the rear end of the treatment chamber may extend generally transverse to the longitudinal axis and the air outlet of the treatment chamber may comprise a plurality of openings provided in the rear wall.

In some embodiments, the rear end of the treatment chamber may comprise a rear wall that extends generally transverse to the longitudinal axis and the rear wall may be moved concurrently with the front door.

In some embodiments, the rear end of the treatment chamber may comprise a rear wall that extends generally transverse to the longitudinal axis and the rear wall may comprise a wall of a dirt collection region of the at least one cyclone.

In some embodiments, the second cleaning stage may comprise a dirt collection chamber exterior to cyclone chamber and the dirt collection chamber and the cyclone chamber are opened concurrently.

In some embodiments, an end wall of the cyclone chamber may be attached to the rear wall of the treatment chamber.

In accordance with another aspect, a hand vacuum cleaner may have an air treatment chamber, which may be a momentum separator, wherein a front and rear wall of the air treatment chamber and concurrently moveable.

In accordance with this aspect, there is provided a hand vacuum cleaner having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

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

(b) a first cleaning stage positioned in the air flow passage downstream from the dirty air inlet, the first cleaning stage comprising a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end, wherein the rear end of the treatment chamber comprises a rear wall that extends generally transverse to the longitudinal axis; and,

(c) a front door moveable mounted between a closed position and an open position,

wherein, when the front door is moved to the open position the rear wall of the treatment chamber is moved concurrently with the front door.

In some embodiments, the air inlet of the treatment chamber may be located at an upper end of the treatment chamber and directs air downwardly into the treatment chamber.

In some embodiments, the air inlet of the treatment chamber may remain in position when the front door is opened.

In some embodiments, the hand vacuum cleaner may have a front wall and the front wall is the front door.

In some embodiments, the air outlet of the treatment chamber may comprise a plurality of openings provided in the rear wall of the treatment chamber.

In some embodiments, the rear wall of the treatment chamber may comprise a wall of a dirt collection region of a second downstream cleaning stage.

In some embodiments, the second cleaning stage may comprise a dirt collection chamber exterior to a second stage treatment chamber and the dirt collection chamber and the second stage treatment chamber are opened concurrently.

In some embodiments, the second cleaning stage may comprise a cyclonic cleaning stage. In some embodiments, the cyclonic cleaning stage may comprise a cyclone chamber having an end wall and the end wall of the cyclone chamber is attached to the rear wall of the treatment chamber.

In accordance with another aspect, a hand vacuum cleaner has a first stage, which may be a momentum separator and a porous substrate (e.g., a screen or shroud) wherein the porous substrate is cleanable by a wiper.

In accordance with this aspect, there is provided a hand vacuum cleaner having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

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

(b) an air treatment member positioned in the air flow passage downstream from the dirty air inlet, the air treatment member comprising a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end, the air outlet comprising an outer porous separating member;

(c) an outer wiper travelling across at least a portion of an outer wall of the porous separating member as the outer wiper moves between a first position and a second position; and,

(d) a front door moveably mounted between a closed position and an open position, wherein the front wall is drivingly connected to the outer wiper whereby when the front door moves from the closed position to the open position, the outer wiper travels from the first position to the second position.

In some embodiments, the outer wiper may be mounted in a fixed orientation to the front door.

In some embodiments, the outer wiper may travel in an arcuate path as the front door moves from the closed position to the open position.

In some embodiments, the front door may comprise at least a substantial portion of the front wall of the treatment chamber.

In some embodiments, a porous filter media may be removably mounted downstream of the outer porous separating member and the porous filter media is removable when the front door is in the open position.

In some embodiments, the hand vacuum cleaner further comprises a hand grip attached to the porous filter media and the hand grip may be accessible when the front door is in the open position.

In some embodiments, the outer porous separating member may comprise an outer substrate having openings therein and a porous filter media may be removably positioned interior of the outer porous separating member.

In some embodiments, the outer wall may extend in more than one plane, at least a section of the outer wall that extends in more than one plane has openings therein, and the outer wiper may travel across at least a portion of the section of the outer wall that extends in more than one plane as the outer wiper moves between a first position to a second position.

In some embodiments, the outer wall may comprise first and second laterally spaced apart side walls, each of the first and second lateral side wall may extend generally longitudinally into the treatment chamber from the rear end of the treatment chamber, and the outer wiper may comprise a first lateral side outer wiper that travels across at least a portion of the first lateral side wall as the first lateral side outer wiper moves between the first position to the second position and a second lateral side outer wiper that travels across at least a portion of the second lateral side wall as the second lateral side outer wiper moves between the first position to the second position.

In some embodiments, the hand vacuum cleaner may further comprise an inner substrate having openings therein positioned inside the outer porous separating member and an inner wiper travelling across at least a portion of an outer wall of the inner substrate as the inner wiper moves between a first position to a second position.

In some embodiments, the porous separating member may comprise an outer substrate having openings therein, the outer substrate is moveable to an open position, and the inner wiper travels across at least a portion of the outer wall of the inner substrate when the outer substrate moves to the open position. The outer substrate may move to the open position when the front door moves to the open position.

In some embodiments, the hand vacuum cleaner may further comprise a further porous filter media inside the inner substrate.

In some embodiments, the outer porous separating member may comprise first and second spaced apart dirt separators, each of which is positioned in the treatment chamber.

In some embodiments, the wiper may comprise a first wiper portion that engages an outer surface of the first spaced apart dirt separator and a second wiper portion that engages an outer surface of the second spaced apart dirt separator.

In some embodiments, each of the first and second spaced apart dirt separators may comprise an outer substrate having openings therein and a further porous dirt separator is positioned interior each of the first and second spaced apart dirt separators.

In some embodiments, the hand vacuum cleaner may further comprise a vibrator in contact with the porous separating member.

In some embodiments, the outer wall of the porous separating member may be elastomeric and the hand vacuum cleaner further comprises a deformation actuator connected to the outer wall, the deformation actuator is moveable from a first position to a second position in which the outer wall is stretched compared to a configuration of the outer wall when the deformation actuator is in the first position.

In accordance with this aspect, there is also provided a hand vacuum cleaner having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

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

(b) an air treatment member positioned in the air flow passage downstream from the dirty air inlet, the air treatment member comprising a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end, the air outlet comprising an outer porous separating member that is positioned in the treatment chamber, the outer porous separating member having an outer wall that extends in more than one plane, wherein at least a section of the outer wall that extends in more than one plane has openings therein;

(c) an outer wiper travelling across at least a portion of the section of the outer wall that extends in more than one plane as the outer wiper moves between a first position and a second position; and,

(d) a moveable portion of a wall of the treatment chamber that is drivingly connected to the outer wiper whereby when the moveable portion of the wall moves from a closed position to an open position, the outer wiper travels from the first position to the second position.

In some embodiments, the outer wall may comprise first and second laterally spaced apart side walls, each of the first and second lateral side wall may extend generally longitudinally into the treatment chamber from the rear end of the treatment chamber, and the outer wiper may comprise a first lateral side outer wiper that travels across at least a portion of the first lateral side wall as the first lateral side outer wiper moves between the first position to the second position and a second lateral side outer wiper that travels across at least a portion of the second lateral side wall as the second lateral side outer wiper moves between the first position to the second position.

In some embodiments, the hand vacuum cleaner may further comprise an inner substrate having openings therein positioned inside the outer porous separating member and an inner wiper travelling across at least a portion of an outer wall of the inner substrate as the inner wiper moves between a first position to a second position.

In some embodiments, the outer porous separating member may comprise first and second spaced apart dirt separators, each of which is positioned in the treatment chamber.

In accordance with another aspect, the hand vacuum cleaner may comprise a plurality of nested porous substrates.

In accordance with this aspect, there is provided a hand vacuum cleaner having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

(a) an air flow passage extending from a dirty air inlet to a clean air outlet;
(b) an air treatment member positioned in the air flow passage downstream from the dirty air inlet, the air treatment member comprising a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end, the air outlet comprising an outer substrate having openings therein that is positioned in the treatment chamber;
(c) an inner substrate having openings therein that is positioned interior the outer substrate; and,
(d) a moveable portion of a wall of the treatment chamber that is driving connected to the outer substrate whereby when the moveable portion of the wall moves from a closed position to an open position, the outer substrate opens.

In some embodiments, the hand vacuum cleaner may further comprise an outer wiper that travels across at least a portion of the outer substrate as the outer wiper moves between a first position to a second position.

In accordance with another aspect, a hand vacuum cleaner also has a first cleaning stage, which is rotatable to an open position wherein as the first cleaning stage is opened a wiper cleans a porous substrate.

In accordance with this aspect, there is provided a hand vacuum cleaner having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

(a) an air flow passage extending from a dirty air inlet to a clean air outlet;
(b) an openable air treatment chamber positioned in the air flow passage downstream from the dirty air inlet, the air treatment chamber comprising an air treatment chamber air inlet, a porous dirt separator, a front end and a rear end, wherein a porous dirt separator comprises an air outlet of the air treatment chamber; and,
(c) the air treatment chamber having a moveable portion rotatably mounted to a main body of the hand vacuum cleaner and a stationary portion, the moveable portion is moveable between a closed position in which the air treatment chamber is closed and an open position in which the air treatment chamber is opened, wherein the porous dirt separator is provided on the stationary portion and a wiper is drivenly connected to the moveable portion,

whereby the wiper moves along at least a portion of the porous dirt separator as the moveable portion is rotated to the open position.

In some embodiments, the wiper may be provided on the moveable portion.

In accordance with another aspect, a surface cleaning apparatus such as a hand vacuum cleaner is provided with a cord reel.

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

(a) an air flow passage extending from a dirty air inlet to a clean air outlet;
(b) an air treatment member and a suction motor provided in the air flow passage;
(c) an on board energy storage member; and,
(d) a cord reel connectable to a mains, wherein the cord reel includes an AC to DC power supply.

In some embodiments, the cord reel may be removably attached to the surface cleaning apparatus.

In some embodiments, the AC to DC power supply may be located centrally in the cord reel.

In some embodiments, the cord reel may be located interior the surface cleaning apparatus.

In some embodiments, the surface cleaning apparatus may comprise a hand vacuum cleaner and the cord reel is located interior the surface cleaning apparatus. The hand vacuum cleaner may have a handle and the cord reel is located interior the handle. The handle may have a pistol grip hand grip portion and the cord reel may be located at a lower end of the hand grip portion. Alternately, or in addition, the suction motor may be located at an upper end of the hand grip portion.

In accordance with this aspect, there is also provided a hand vacuum cleaner having an upper end and a lower end, the hand vacuum cleaner comprising

(a) an air flow passage extending from a dirty air inlet to a clean air outlet;
(b) an air treatment member and a suction motor provided in the air flow passage;
(c) a handle; and,
(d) a cord reel located interior the handle.

In some embodiments, the handle may have a pistol grip hand grip portion and the cord reel is located at a lower end of the hand grip portion.

In some embodiments, the suction motor may be located at an upper end of the hand grip portion.

In some embodiments, the cord reel may include an AC to DC power supply.

In some embodiments, the AC to DC power supply may be located interior of the cord reel.

In accordance with this aspect, there is also provided a hand vacuum cleaner having an upper end and a lower end, the hand vacuum cleaner comprising:

(a) an air flow passage extending from a dirty air inlet to a clean air outlet;
(b) an air treatment member and a suction motor provided in the air flow passage;

(c) a handle;
(d) an energy storage member; and,
(e) a cord reel detachably mounted to the hand vacuum cleaner.

In some embodiments, the handle may have a pistol grip hand grip portion and the cord reel is located at a lower end of the hand grip portion.

In some embodiments, the suction motor may be located at an upper end of the hand grip portion.

In some embodiments, the energy storage member may be located in the handle.

In some embodiments, the cord reel may include an AC to DC power supply.

In some embodiments, the AC to DC power supply may be located interior of the cord reel.

In some embodiments, the energy storage member may be located in the handle.

In accordance with another aspect, a vacuum cleaner, such as a hand vacuum cleaner, has dual air treatment chambers, such as cyclone chambers or momentum separators, and a valve that may be used to adjust the air flow into a selected one or both of the air treatment chambers.

In accordance with this aspect, there is provided a surface cleaning apparatus having a front end, a rear end and a longitudinal axis extending between the front and rear ends, the surface cleaning apparatus comprising:
(a) an air flow passage extending from a dirty air inlet to a clean air outlet;
(b) an air treatment member positioned in the air flow passage downstream from the dirty air inlet, the air treatment member comprising first and second treatment chambers in parallel, each treatment chamber having an air inlet, an air outlet, a front end and a rear end; and,
(c) an air inlet passage extending from the dirty air inlet to a valve positioned upstream of the air inlet of the first treatment chamber and the second treatment chamber,
wherein the valve is adjustable to adjust an amount of air provided to each of the first and second treatment chambers.

In some embodiments, the valve may be adjustable between a first position in which air is provided only to the first treatment chamber and a second position in which air is provided only to the second treatment chamber.

In some embodiments, the valve may be adjustable to a third position in which air is provided to both the first treatment chamber and the second treatment chamber.

In some embodiments, the valve may be user actuatable.

In some embodiments, the valve may be automatically adjusted based on the rate of flow into each of the first and second treatment chambers.

In some embodiments,
(a) the air outlet of the first treatment chamber may comprise a first porous dirt separator having a first outer wall that has openings therein, the first treatment chamber further comprises a first wiper that travels across at least a portion of the first outer wall as the first wiper moves between a first position to a second position; and,
(b) the air outlet of the second treatment chamber may comprise a second porous dirt separator having a second outer wall that has openings therein, the second treatment chamber further comprises a second wiper that travels across at least a portion of the second outer wall as the second wiper moves between a first position to a second position.

In some embodiments, the valve may be adjustable between a first position in which air is provided only to the first treatment chamber when the second wiper is moved between the first and second positions and a second position in which air is provided only to the second treatment chamber when the first wiper is moved between the first and second positions.

In some embodiments, the second wiper may be moved between the first and second positions when the second treatment chamber is opened for emptying and the first wiper is moved between the first and second positions when the first treatment chamber is opened for emptying.

In some embodiments, each porous dirt separator may comprise an outer substrate having openings therein and a porous filter media is removably positioned interior of the outer porous dirt separator.

In some embodiments, each outer wall may extend in more than one plane, at least a section of the outer wall that extends in more than one plane has openings therein, and the wiper travels across at least a portion of the section of the outer wall that extends in more than one plane as the wiper moves between a first position to a second position.

In some embodiments, each outer wall may comprise first and second laterally spaced apart side walls, each of the first and second lateral side wall may extend generally longitudinally into the treatment chamber from the rear end of the treatment chamber, and the wiper may comprise a first lateral side outer wiper that travels across at least a portion of the first lateral side wall as the first lateral side outer wiper moves between the first position to the second position and a second lateral side outer wiper that travels across at least a portion of the second lateral side wall as the second lateral side outer wiper moves between the first position to the second position.

In some embodiments, the surface cleaning apparatus may further comprise an inner substrate openings therein positioned inside each of the outer substrates and an inner wiper travelling across at least a portion of an outer wall of the inner substrate as the inner wiper moves between a first position to a second position.

In some embodiments, the outer substrate may be moveable to an open position, and the inner wiper travels across at least a portion of the outer wall of the inner substrate when the outer substrate moves to the open position.

In some embodiments, the surface cleaning apparatus may further comprise a suction motor provided in the air flow passage, the suction motor is operable in a low power mode and a high power mode, wherein the valve is adjustable between a first position in which air is provided only to the first treatment chamber when the suction motor is operated in the low power mode and a second position in which air is provided to both the first and second treatment chambers when the suction motor is operated in the high power mode.

In accordance with another aspect, an energy storage member may be positioned in the air flow path through the surface cleaning apparatus at a location upstream of the suction motor whereby the air flow may cool the energy storage member during use of the surface cleaning apparatus.

In accordance with this aspect, there is provided a hand vacuum cleaner having an upper end and a lower end, the hand vacuum cleaner comprising:
(a) an air flow passage extending from a dirty air inlet to a clean air outlet;

(b) a main body having a handle, the handle having a pistol grip hand grip portion, the hand grip portion having an upper end and a lower end

(c) an air treatment member provided in the air flow passage;

(d) an on board energy storage member positioned in the air flow passage downstream of the air treatment member, the on board energy storage member is positioned at the upper end of the hand grip portion; and,

(e) a suction motor provided in the air flow passage downstream of the energy storage member, the suction motor is positioned below the energy storage member.

In some embodiments, the suction motor may be positioned at the lower end of the hand grip portion.

In some embodiments, the energy storage member may be provided in a housing and, during operation of the hand vacuum cleaner, air passes over an outer surface of a wall of the housing as the air travels from the air treatment member to the suction motor.

In some embodiments, the energy storage member may be provided in a battery pack and, during operation of the hand vacuum cleaner, air passes over an outer surface of the battery pack as the air travels from the air treatment member to the suction motor and the battery pack is removably mounted in the hand vacuum cleaner.

In some embodiments, the energy storage member may be provided in a battery pack and the battery pack is removably mounted in the hand vacuum cleaner.

In some embodiments, during operation of the hand vacuum cleaner, air may pass downwardly through the hand grip portion to the suction motor.

In some embodiments, the hand vacuum cleaner may further comprise a pre-motor filter provided in the air flow passage downstream of the air treatment member and upstream of the energy storage member.

In some embodiments, the air treatment member may comprise a treatment chamber and a pre-motor filter is provided in the air flow passage downstream of the treatment chamber and upstream of the on board energy storage member.

In accordance with this aspect, there is also provided a hand vacuum cleaner having an upper end and a lower end, the hand vacuum cleaner comprising:

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

(b) an air treatment member and a suction motor provided in the air flow passage;

(c) a pre-motor filter positioned in the air flow passage downstream from the air treatment member;

(d) an on board energy storage member positioned in the air flow passage downstream of the pre-motor filter and upstream of the suction motor; and,

(e) a handle.

In some embodiments, the air treatment member may comprise a treatment chamber.

In some embodiments, the air treatment chamber may comprise a momentum separator chamber.

In some embodiments, the air treatment chamber may comprise a cyclone chamber.

In some embodiments, the handle may have a hand grip portion having an upper end and a lower end, and the suction motor may be positioned at the lower end of the hand grip portion.

In some embodiments, during operation of the hand vacuum cleaner, air may pass downwardly through the hand grip portion to the suction motor.

In some embodiments, the energy storage member may be positioned at the upper end of the hand grip portion.

In some embodiments, the energy storage member may be provided in a housing and, during operation of the hand vacuum cleaner, air may pass over an outer surface of a wall of the housing as the air travels from the air treatment member to the suction motor.

In some embodiments, the energy storage member may be provided in a battery pack and, during operation of the hand vacuum cleaner, air may pass over an outer surface of the battery pack as the air travels from the air treatment member to the suction motor and the battery pack is removably mounted in the hand vacuum cleaner.

In some embodiments, the energy storage member may be provided in a battery pack and the battery pack is removably mounted in the hand vacuum cleaner.

DRAWINGS

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

FIG. **2** is a cross-sectional view of the surface cleaning apparatus of FIG. **1**;

FIG. **3** is a perspective view of the cross-section of FIG. **2**, with a treatment chamber in a closed position;

FIG. **4** is a perspective view of the cross-section of FIG. **2**, with the treatment chamber in an open position;

FIG. **5** is a perspective view of a surface cleaning apparatus, with a treatment chamber in an open position, in accordance with another embodiment;

FIG. **6** is a perspective view of the surface cleaning apparatus of FIG. **1**, with the treatment chamber in the open position and an inner porous separating member removed;

FIG. **7** is a perspective cross-sectional view of a surface cleaning apparatus, with a treatment chamber in a closed position, in accordance with another embodiment;

FIG. **8** is a perspective cross-sectional view of the surface cleaning apparatus of FIG. **7**, with the treatment chamber in an open position;

FIG. **9** is a perspective view of a surface cleaning apparatus, with a treatment chamber in a closed position, in accordance with another embodiment;

FIG. **10** is a perspective view of the surface cleaning apparatus of FIG. **9**, with the treatment chamber in an open position;

FIG. **11** is a perspective view of the surface cleaning apparatus of FIG. **5**, with a porous dirt separator in an open position;

FIG. **12** is a perspective view of a surface cleaning apparatus, with a treatment chamber in a closed position, in accordance with another embodiment;

FIG. **13** is a cross-sectional view taken along line **13-13** in FIG. **12**;

FIG. **14** is a perspective view of the cross-section of FIG. **13**;

FIG. **15** is a perspective cross-sectional view of FIG. **13**, with a treatment chamber in an open position;

FIG. **16** is a perspective cross-sectional view of FIG. **13**, with the treatment chamber in an open position, and a porous dirt separator partially opened;

FIG. **17** is a perspective cross-sectional view of FIG. **13**, with the treatment chamber in an open position, and a porous dirt separator further opened;

FIG. **18** is the perspective view of FIG. **13**, with the treatment chamber in an open position, and a porous dirt separator opened;

FIG. 19 is the perspective view of FIG. 13, with the treatment chamber in an open position, and a porous dirt separator fully opened;

FIG. 20 is the perspective view of FIG. 13, with the treatment chamber in an open position, and a porous dirt separator fully opened, and an inner porous separating member removed;

FIG. 21 is a perspective cross-sectional view of a surface cleaning apparatus, with a disconnected external air treatment member and a bypass valve in a first position, in accordance with an embodiment;

FIG. 22 is the perspective cross-sectional view of FIG. 21, with the external air treatment member connected and the bypass valve in a bypass position;

FIG. 23 is a perspective view of the surface cleaning apparatus of FIG. 21, with the external air treatment member connected;

FIG. 24 is a perspective view of a surface cleaning apparatus with an energy storage member in the handle, a suction motor below the energy storage member, and a power cord, in accordance with an embodiment;

FIG. 25 is a perspective view of a surface cleaning apparatus with an energy storage member in the handle, a suction motor above the energy storage member, and a removable power cord, in accordance with an embodiment;

FIG. 26 is a perspective view of a surface cleaning apparatus with an energy storage member at a lower end of the handle, a suction motor at an upper end of the handle, a power cord, and an external power supply, in accordance with an embodiment;

FIG. 27 is a perspective view of a surface cleaning apparatus having two treatment chambers in an open position and inner porous separating members removed, in accordance with another embodiment;

FIG. 28 is a cross-sectional view taken along line 28-28 in FIG. 27, with the treatment chambers in a closed position, and a valve in a first position;

FIG. 29 is the cross-sectional view of FIG. 28, with the valve in a second position;

FIG. 30 is the cross-sectional view of FIG. 28, with the valve in a third position;

FIG. 31 is the cross-sectional view of FIG. 28, with the valve in a fourth position;

FIG. 32A is a perspective view of a surface cleaning apparatus having debriding devices including wiper actuators, in accordance with an embodiment;

FIG. 32B is a perspective view of a surface cleaning apparatus having debriding devices including wiper actuators, in accordance with another embodiment;

FIG. 33 is a perspective view of a surface cleaning apparatus having debriding devices including spring actuated wipers, in accordance with another embodiment;

FIG. 34 is a perspective view of a surface cleaning apparatus having debriding devices including reverse air outlets, in accordance with an embodiment;

FIG. 35 is a perspective view of a surface cleaning apparatus having debriding devices including tapping members, in accordance with an embodiment;

FIG. 36 is a perspective view of a surface cleaning apparatus having debriding devices including vibrators, in accordance with an embodiment;

FIG. 37 is a perspective view of a surface cleaning apparatus having debriding devices including deformation actuators in accordance with an embodiment;

FIG. 38 is a perspective view of a surface cleaning apparatus having debriding devices including deformation actuators in accordance with another embodiment;

FIG. 39 is a cross-sectional view of a surface cleaning apparatus having a pre-motor filter in accordance with an embodiment;

FIG. 40 is a perspective view of the surface cleaning apparatus of FIG. 39, with a treatment chamber in an open position;

FIG. 41 is a perspective view of a surface cleaning apparatus having an energy storage member above the handle, and a suction motor below the energy storage member, in accordance with an embodiment;

FIG. 41B is a perspective view of the surface cleaning apparatus of FIG. 41, with the energy storage member removed;

FIG. 42 is a perspective view of a surface cleaning apparatus with an energy storage member in the handle and a suction motor above the energy storage member, in accordance with an embodiment;

FIG. 43 is a perspective view of a surface cleaning apparatus having a cord reel in a lower end of the handle and a suction motor above the cord reel, in accordance with an embodiment;

FIG. 44 is a perspective view of a surface cleaning apparatus having a external cord reel with a power supply, in accordance with an embodiment;

FIG. 45 is a perspective view of an air treatment member in accordance with an embodiment;

FIG. 46 is a cross-sectional view taken along line 46-46 in FIG. 45, in accordance with an embodiment;

FIG. 47 is a cross-sectional view taken along line 46-46 in FIG. 45, in accordance with another embodiment;

FIG. 48 is a perspective view of the surface cleaning apparatus of FIG. 46, with a front door in an open position; and,

FIG. 49 is a perspective view of the surface cleaning apparatus of FIG. 47, with a front door in an open position.

DESCRIPTION OF VARIOUS 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.

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 that 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 air treatment member **116**, an improved air treatment system, a surface cleaning apparatus **100** including the same and the configuration of the surface cleaning apparatus. Surface cleaning apparatus **100** may be any type of 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. 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 any of the embodiments disclosed herein, surface cleaning apparatus **100** may include a handle **104** that has a pistol grip (e.g. extends forwardly and upwardly) as shown, or that is oriented in another manner.

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 **112** 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 longitudinal axis **142** extends between the front and rear ends **128**, **132**.

A suction motor **144** is provided to generate vacuum suction through air flow path **124**, and is positioned within a motor housing **148** (which may be part of the main body **112**). 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 treatment chamber **152** having porous dirt separator **154**, and a dirt collection chamber **156** (also referred to as a "dirt collection region", "dirt collection bin", "dirt bin", or "dirt chamber"). In the illustrated example, dirt collection chamber **156** is a region of treatment chamber **152** where separated dirt may accumulate until dirt collection chamber **156** is emptied. Alternatively or in addition, air treatment member **116** may include a dirt collection chamber **156** that is external to treatment chamber **152**. Porous dirt separator **154** may include a rigid porous member (e.g., a fine mesh screen and/or a plastic shroud having a plurality of openings therein), a filter (e.g. felt, foam, PTFE, HEPA media, low penetration, paper, paper-wax, cellulose, or other filter media), or a combination of one or more rigid porous members and one or more filters. Porous dirt separator **154** and dirt chamber **156** may be of any configuration suitable for separating dirt from an air stream and collecting the separated dirt, respectively.

Referring to FIG. **3**, hand vacuum cleaner **100** may include a post-motor filter **160** provided in the air flow path **124** downstream of suction motor **144** (e.g., in a post motor filter housing **164** that may be part of main body **112**). Post-motor filter **160** may be formed from any suitable physical, porous filter media. For example, post-motor filter **160** may be one or more of a foam filter, felt filter, HEPA filter, or other physical filter media. In some embodiments, post-motor filter **160** may include an electrostatic filter, or the like. As shown, post-motor filter **160** may be located in a post-motor filter housing **164**. In other embodiments, hand vacuum cleaner **100** may have neither a post-motor filter **160** nor a post-motor filter housing **164**.

In the illustrated embodiment, dirty air inlet **108** may be the inlet end **168** of an air inlet conduit **172**. Optionally as exemplified, 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 extend forward of air treatment member **116**, although this need not be the case.

In the embodiment of FIG. **3**, air treatment member **116** comprises a treatment chamber **152** having a porous dirt separator **154** located in the air flow path between the treatment chamber air inlet **184** and a treatment chamber air outlet **188**. Treatment chamber **152** may have a front end **210**, a rear end **212**, a pair of laterally opposed sidewalls **196** extend longitudinally between the front and rear ends **210**, **212**, and front and bottom walls **204**, **208** which extend laterally and connect the left and right sidewalls **196**. As exemplified, the porous dirt separator **154** may define the location at which air exits the volume of the treatment chamber **152** and is subjected to physical filtration by passing through the porous dirt separator and the treatment chamber air outlet **188** may be characterized as the location at which air exits the air treatment member **116**.

As exemplified, the treatment chamber air inlet **184** may be at an opposite end of the air treatment member **116** from the treatment chamber air outlet **188**. The treatment chamber air inlet **184** may be located at the downstream end of the air inlet conduit **172** and forward of the porous dirt separator **154**. As exemplified, the treatment chamber air inlet **184** may be at an upper end of the air treatment chamber **116**. Accordingly, as exemplified, air may travel downwardly into the air treatment chamber **116** and then rearwardly to the porous dirt separator **154**. Accordingly, as air enters the air treatment chamber **116**, heavier dirt particles may fall downwardly to dirt collection chamber **156**. In other embodiments, the treatment chamber air inlet **184** and outlet **188** may be positioned at different locations.

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 treatment chamber air inlet **184**. Dirt particles and other debris (hereafter "dirt") may be separated from the dirty air flow as the dirty air flows through the air treatment chamber **116** and as air passes through the porous dirt separator **154** before exiting treatment chamber air outlet **188**. At least some of the separated dirt may collect within dirt chamber **156** until dirt chamber **156** is emptied. For example, if the air treatment chamber **116** is a momentum separator as exemplified, then some, e.g., the heavier, dirt may be separated from the inflow air steam by gravity due to the air flow rate decreasing as it enters the air treatment chamber **116** and/or a change in the direction of the air flow as it enters the air treatment chamber. Additional dirt may be separated by the porous dirt separator **154** due to filtration.

From treatment chamber air outlet **188**, the air flow may be directed into motor housing **148**, drawn into suction motor **144** and then discharged from apparatus **100** through post-motor filter **160** before exiting clean air outlet **120**.

Air Treatment Member Wipers

In accordance with one aspect of this disclosure, in some embodiments, the air treatment member may include one or more wipers that travel across an upstream surface of a porous dirt separator. Removing dirt that is on an exterior surface of the porous dirt separator **154** may reduce the back pressure through the air treatment chamber by removing material that may partially clog the porous dirt separator **154**. The air treatment member wipers may be used by themselves or in combination with one or more of the multi-stage perforated substrates, openable pre-motor filter chamber, the nested porous separating members, the valving for multiple treatment chambers, the debriding devices, the bypass valve, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

The air treatment chamber **152** have a moveable portion and a stationary portion. The moveable portion is moveable between a closed position, in which the air treatment chamber **152** is closed, and an open position in which the air treatment chamber **152** is emptyable. In some embodiments, one or more wipers may travel across an upstream surface **190** of a porous dirt separator **154** as the air treatment chamber **152** is opened (e.g., a door, a sidewall or other portion of the walls defining the air treatment chamber **152** is moved from the closed position to the open position).

For example, the wiper may brush, slide, or scape the porous dirt separator as the treatment chamber is opened. This may remove dirt from surfaces of the porous dirt separator, whereby the filtration capacity of the porous dirt separator may be restored (this may be referred to herein as emptying or cleaning the porous dirt separator). For example, dirt removed from the porous dirt separator by the wiper may collect in the dirt collection region of the treatment chamber that is being opened or may exit the treatment chamber with the dirt collection in the dirt collection region. In this case, the air treatment member may allow the user to clean the porous dirt separator simultaneously as the user opens the treatment chamber for emptying. This may reduce or eliminate user contact required to clean the dirty porous dirt separator, and may reduce the steps required for a user to clean the porous dirt separator and empty the treatment chamber (e.g. as compared with opening the treatment chamber and then manually removing, cleaning, and reinstalling the porous dirt separator). The openable portion of the air treatment member **116** may be driving connected to the wiper (e.g., the portion of the air treatment member **116** that opens may move a driving member and the driving member may engage and move the wiper) or the wiper may be connected (e.g., non-moveably connected) to the portion of the air treatment member **116**.

Alternately, or in addition, porous dirt separator **154** may be openable. Opening the air treatment chamber **152** may open (e.g., concurrently open) porous dirt separator **154** or enable the porous dirt separator **154** to subsequently be opened (see e.g., FIGS. **6** and **10**). Porous dirt separator **154** may house a further air treatment member, such as a second stage porous dirt separator **154** and/or a filter. Accordingly, porous dirt separator **154** may be openable for emptying and/or removing a further air treatment member, such as a second stage porous dirt separator **154** and/or a filter. For example, opening treatment chamber **152** may also provide user-access to porous dirt separator **154**, which may include one or more substrates (e.g. screens, shrouds), one or more filters (also referred to as a "physical filter media" or a 'filter media'), or combinations thereof. Dirt chamber **156** may be a region of an openable treatment chamber **152**, whereby opening treatment chamber **152** opens both of chambers **152**, **156**, as well as providing access to porous dirt separator **154**.

As exemplified in FIGS. **4** and **5**, in some embodiments, the act of opening the treatment chamber **152** may wipe dirt from some or all of an upstream surface **190** (FIG. **1**) of porous dirt separator **154**. As exemplified, porous dirt separator **154** may be positioned inside treatment chamber **152**, whereby dirt that falls from the porous dirt separator **154** may collect in treatment chamber **152** (to be poured out with the dirt that has accumulated in the treatment chamber **152**) or it may be emptied concurrently with the dirt that has already accumulated in treatment chamber **152**. As exemplified, treatment chamber **152** may include wipers **192** that make direct wiping contact with (e.g. brush, slide, or scrape) separator upstream surface **190** (FIG. **1**) during the act of opening treatment chamber **152**. Wipers **192** may be rigid (e.g. hard plastic or metal scraper or stiff brush) or flexible (e.g. silicone spatula or soft bristled brush), or include both rigid and flexible elements.

In the embodiment of FIGS. **3**, **4** and **6**, wipers **192** may be positioned proximate chamber rear end **212** (e.g., abutting or recessed into the rear end wall). An advantage of such a design is that the wipers **192** may not interfere with air flow in the treatment chamber **152**. In the embodiment of FIG. **5**, wipers **192** may be positioned proximate the upper end of the treatment chamber **152** (e.g., abutting or recessed into the upper wall).

As exemplified, wipers **192** may be moved when the treatment chamber **152** is opened. As exemplified in FIGS. **3**, **4** and **5**, wipers **192** may extend from each of chamber sidewalls **196** laterally inwardly towards porous dirt separator **154**.

Wipers **192** may make wiping contact with upstream surface **190** (FIG. **6**) on the left and right sides of porous dirt separator **154** during at least a portion (e.g. at least 25%) of the opening stroke (i.e. opening movement) of treatment chamber **152**. In the illustrated example, wipers **192** are physically in contact with upstream surface **190** (FIG. **6**) when treatment chamber **152** is in the closed position and that physical contact persists as treatment chamber **152** is moved toward the open position until the wipers **192** clear (i.e. move past) the porous dirt separator **154**. This allows wipers **192** to wipe a majority (i.e. at least 50%) of the surface area of upstream surface **190** (FIG. **6**). In some embodiments, wipers **192** may have a length **214** that is at least 50% of a dimension of the upstream surface (e.g. 50%-200% of the upstream surface dimension, or at least 100% of upstream surface dimension). The upstream surface dimension may be the upstream surface height **216** (see FIG. **6**) or the width of the upstream surface in the direction of axis **142**. Dirt that is debrided from upstream surface **190** (FIG. **6**) may fall onto chamber walls **196**, **204**, and/or **208**, and thereafter be poured out of treatment chamber **152** when treatment chamber **152** is emptied.

Treatment chamber **152** may be openable in any manner that allows wipers **192** to wipe some or all of the upstream surface **190** as treatment chamber **152** is opened, or in response to opening treatment chamber **152**. As exemplified in FIGS. **3**, **4** and **6**, air treatment chamber **152** includes a moveable portion (which comprises the front wall **204** and the side walls **196** of the treatment chamber **152**) that can move between the open and closed positions and a stationary portion (which comprises the rear wall of the air treatment chamber **152** on which porous dirt separator **154** may be mounted). Accordingly, the moveable portion surrounds at least a portion of the air treatment chamber. The moveable portion may be rotatably (e.g., pivotally) openable by, e.g., a hinge **220**. Hinge **220** may rotatably join, e.g., a lower rear end of chamber door **194** to main body **112**. As the moveable portion is opened, wipers **192** travel in an arcuate path across upstream surface **190**, which is attached to the stationary portion. For example, wipers **192** may be mounted in a fixed orientation to the moveable portion.

In some embodiments, the moveable portion may comprise part or all of the front wall **204** of the air treatment chamber **152** and may be referred to as a front door **194**. It will be appreciated that a front door **194** may comprise at least part of the side wall **196** of the air treatment chamber **152** and may include at least a substantial portion (or all) of the side wall **196** of the air treatment chamber **152**. As such, the moveable portion may alternately be referred to as a door **194**.

It will be appreciated that the air treatment chamber may be opened by translating one or more portions of the walls defining the air treatment chamber. For example, one or more sidewalls **196** may be translated in the direction of axis **142** and/or vertically (e.g., downwardly as exemplified in FIG. **5**). In the example of FIG. **5**, the moveable portion comprises the sidewalls **196** and the bottom wall **208** of the air treatment chamber.

Air treatment member **116** may include any number of wipers **192** (e.g. 1 to 20 wipers, such as for example 2 wipers in the example shown—one per side), which may collectively make direct wiping contact with any number of sides of porous dirt separator upstream surface **190** as or in response to moving treatment chamber **152** to the open position (e.g. opening chamber door **194**). For example, wiper(s) **192** may collectively make direct wiping contact with fewer than all sides of upstream surface **190** (FIG. **6**), or may collectively make direct wiping contact with all sides of upstream surface **190** (FIG. **6**), as or in response to moving treatment chamber **152** to the open position.

Turning to FIG. **6**, in the illustrated example, porous dirt separator **154** includes an outer wall **308**, and outer wall **308** includes laterally spaced apart sidewalls **312**. Sidewalls **312** may form part of, or all of, upstream surface **190**. For example, each sidewall **312** may include perforations **316** (e.g. at least 20 perforations, such as 20 to 1000 perforations). Each of sidewalls **312** may extend longitudinally into treatment chamber **152** from chamber rear end **212** as shown. Accordingly, sidewalls **312** may collectively extend in more than plane.

As shown in FIG. **6**, each wiper **192** may be configured to travel across at least a portion of a respective one of side walls **312** as or in response to moving treatment chamber **152**, **156** to the open position.

In some embodiments, as exemplified in FIG. **6**, the openable portion of treatment chamber **152** may have an open upper end **224**. When treatment chamber **152** is opened (e.g., door **194** is pivoted forwardly), the open upper end **224** (or an opening **224** at the upper end) may face forwardly and/or downwardly whereby dirt collected in treatment chamber **152** can be poured out through the open end **224**.

Alternatively or in addition to moving wiper(s) **192** across an outer wall **308** of a porous dirt separator **154** when a chamber door **194** is opened, wiper(s) **192** may move across outer wall **308** when another chamber wall (e.g. one or more of walls **196**, **204**, and **208**) is moved. FIG. **5** illustrates an example in which treatment chamber **152** includes movable sidewalls **196**, and in which moving sidewalls **196** may cause wipers **192** to move across outer wall **308**.

The movable chamber wall **196**, **204**, and/or **208** may be movable in any manner. For example, the movable wall **196**, **204**, and/or **208** may be rotatable (e.g. pivoting) and/or translatable relative to apparatus main body **112**. As exemplified in FIG. **5**, sidewalls **196** are slideably connected to main body **112**, which allows treatment chamber **152** to open by translation (e.g. downwardly slidable as shown, or forwardly slideable). Treatment chamber **152** may have any sliding connection to main body **112**. For example, treatment chamber **152** may be slideably connected to main body **112** by a rail **222**.

FIGS. **9-10** show an embodiment in which chamber sidewalls **196** may remain stationary when treatment chamber **152** is opened. For example, front and bottom walls **204** and **208** may move relative to sidewalls **196** when treatment chamber **152** is opened. As shown, the movable bottom wall **208** may be connected to one or more wipers **192** that extend upwardly from bottom wall **208** to make wiping contact with upstream surface **190** as or in response to opening treatment chamber **152**.

As exemplified in FIGS. **7** and **8**, in some embodiments porous dirt separator **154** may comprise a single stage (e.g., an inner porous separating member may not be provided interior of the porous dirt separator **154**).

Multi-Stage Perforated Substrates

In accordance with another aspect, the porous dirt separator may comprise two or more sequential perforated substrates, such as screens or shrouds, which use physical separation (a physical separation media) to separate dirt from air flow that passes through the porous separating member(s) and which may be nested. The upstream porous separating member(s) may be coarse for capturing larger dirt particles, and downstream porous separating member(s) may be fine for capturing smaller dirt particles. This arrangement of coarse and fine porous separating members may provide greater particle separation efficiency as compared with using a single porous separating member tasked with capturing dirt particles of all sizes.

The multi-stage perforated substrates may be used by itself or in combination with one or more of the air treatment member wipers, openable pre-motor filter chamber, the nested porous separating members, the valving for multiple treatment chambers, the debriding devices, the bypass valve, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

The porous dirt separator **154** may include any number of perforated substrates, such as screens or shrouds, which operate to separate dirt from air flow that flows through the perforated substrates. Accordingly, several layers of perforated substrates may be used to sequentially clean the air flowing therethrough. These may be partially or fully nested.

FIGS. **18**-**20** exemplify a porous dirt separator **154** that includes three porous separating members **228** positioned in the air flow path in series. As shown, porous dirt separator **154** may include an outer perforated substrates (porous separating member $\mathbf{228_1}$), an intermediate perforated substrates (porous separating member $\mathbf{228_2}$), and an inner filter (porous separating member $\mathbf{228_3}$). In the downstream direction, each porous separating member $\mathbf{228_N}$ may be configured to filter progressively finer dirt than the immediately upstream porous separating member $\mathbf{228_{N-1}}$.

In one example, outer porous separating member $\mathbf{228_1}$ is a coarse screen, the intermediate porous separating member $\mathbf{228_2}$ is a fine screen, and the inner porous separating member $\mathbf{228_3}$ is a filter. For example, outer screen $\mathbf{228_1}$ may have a coarse hole diameter of 0.015-0.125 inches, or more preferably 0.040 to 0.080 inches; the intermediate screen $\mathbf{228_2}$ may have a fine hole diameter of 0.005 to 0.050 inches, or more preferably 0.005 to 0.010 inches; and the inner filter $\mathbf{228_3}$ may have an even finer pore diameter of 0.01 to 1 micron, or more preferably 0.01 to 0.1 microns.

In another example, outer porous separating member $\mathbf{228_1}$ is a coarse screen, the intermediate porous separating member $\mathbf{228_2}$ is a coarse filter, and the inner porous separating member $\mathbf{228_3}$ is a fine filter. For example, outer screen $\mathbf{228_1}$ may have a coarse hole diameter of 0.015-0.125 inches, or more preferably 0.040 to 0.080 inches; the intermediate filter $\mathbf{228_2}$ may have a finer pore size of 5 to 50 microns, or more preferably 5 to 20 micron; and the inner filter $\mathbf{228_3}$ may have an even finer pore size of 0.01 to 1 microns, or more preferably 0.01 to 0.1 microns.

As discussed subsequently, and as exemplified in FIG. **18**, it will be appreciated that wipers may also be used to clean one or more nested porous separating members.

Openable Pre-Motor Filter Chamber

In accordance with another aspect, a surface cleaning apparatus may include a pre-motor filter in a pre-motor filter chamber wherein the pre-motor filter chamber is opened when the momentum separator is opened.

The openable pre-motor filter chamber may be used by itself or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, the nested porous separating members, the valving for multiple treatment chambers, the debriding devices, the bypass, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

As exemplified in FIGS. **39** and **40**, surface cleaning apparatus **100** may include a pre-motor filter **240** positioned in the air flow path **124** between the air treatment member **116** and the suction motor **144**. Pre-motor filter **240** may be configured to (e.g. have a pore size to) separate finer dirt from the air flow than air treatment member **116** and porous dirt separator **154**.

As exemplified, pre-motor filter **240** is located proximate (e.g. at or behind) chamber rear end **212**. As shown, an upstream surface **360** of pre-motor filter **240** may be visible and/or user accessible when treatment chamber **152** is opened. This can allow the user to inspect and/or clean pre-motor filter **240** in-situ to restore the dirt capacity and separation efficiency of pre-motor filter **240**. For example, upstream surface **360** may be visible and/or accessible when treatment chamber **152** is open and porous dirt separator **154** is moved away from pre-motor filter **240**. In the illustrated example, pre-motor filter **240** is accessible for user removal and replacement when treatment chamber **152** is open. This can allow the user to remove pre-motor filter **240** for cleaning, repair, and/or replacement.

In some embodiments (not shown), there may be both a filter at least partially nested within porous dirt separator **154** and a pre-motor filter **240** downstream of porous dirt separator **154**.

Nested Porous Separating Members

In accordance with another aspect, in some embodiments, a porous dirt separator includes an inner porous separating member within a movable or openable outer porous separating member. This may provide user access to inspect, clean, repair, or replace the inner porous separating member. It will be appreciated that the inner porous separating member may be partially of fully nested in the outer porous separating member.

The nested porous separating members may be used by themselves or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, openable pre-motor filter chamber, the valving for multiple treatment chambers, the debriding devices, the bypass valve, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

It will be appreciated that the outer porous separating member may include one or more wipers that wipe the inner porous separating member when the outer porous separating member is moved or opened. This can allow the inner porous separating member to be cleaned by moving the outer porous separating member.

In some embodiments, the outer porous separating member is configured to move or open simultaneously or sequentially as the treatment chamber **152** is opened. This can allow both the outer and inner porous separating members to be cleaned with a single user action of moving or opening a treatment chamber wall or door **194**.

Porous dirt separator **154** may include a porous separating member **228**$_2$ (e.g. filter or screen) within a movable or openable outer porous separating member **228**$_1$. Outer porous separating member **228**$_1$ may be openable in any manner that moves at least a portion of the outer porous separating member **228**$_1$ relative to the inner porous separating member **228**$_2$. For example, outer porous separating member **228**$_1$ may be translatably openable (as exemplified in FIGS. **5** and **11**), or rotatably openable (e.g. pivotally openable by a hinge **220**$_1$ as exemplified in FIGS. **6** and **12-17**).

As exemplified in FIG. **6**, porous dirt separator **154** includes an outer porous separating member **228**$_1$ (e.g. a screen or shroud) having an outer wall **308**$_1$ with an upstream surface **190**$_1$, and an inner porous separating member **228**$_2$ (e.g. a filter) having an outer wall **308**$_2$ with an upstream surface **190**$_2$.

In some embodiments, outer porous separating member **228**$_1$ may be more coarse (e.g. have a larger pore size), and inner porous separating member **228**$_2$ may be more fine (e.g. have a smaller pore size). In this case, air may first pass through the coarse outer porous separating member **228**$_1$ where larger (i.e. coarse) dirt and/or elongate members (e.g., hair) is removed from the air flow, and then the air may pass through the fine inner porous separating member **228**$_2$ where smaller (i.e. fine) dirt is removed from the air flow. This design may mitigate the smaller pores of the fine inner porous separating member **228**$_2$ being clogged prematurely by large dirt particles.

When treatment chamber **152** is open, the inner porous separating member **228**$_2$ may be removable from air treatment member **116**. For example, porous separating member **228**$_2$ may be removable from outer porous separating member **228**$_1$. Inner separating member **228**$_2$ may be removed from outer separating member **228**$_1$ in any manner. As exemplified in FIG. **6**, porous separating member **228**$_2$ includes a front wall **232** having a hand grip portion **236** (e.g. a handle) that a user can grasp to pull porous separating member **228**$_2$ forwardly out of outer porous separating member **228**$_1$. This allows porous separating member **228**$_2$ to be inspected, cleaned, and/or replaced. Porous separating member **228**$_2$ may be removably attached to hand grip portion **236** (e.g., hand grip portion **236** may be a filter frame).

As exemplified in FIGS. **5** and **11**, outer porous separating member **228**$_1$ may include inward facing wipers **192**$_1$ that make wiping contact with upstream surface **190**$_2$ of inner porous separating member **228**$_2$. For example, wipers **192**$_1$ may be located proximate an upper end **252**$_1$ of porous separating member **228**$_1$ and extend forwardly as shown. FIGS. **12-17** show an example in which wipers **192**$_1$ are located proximate a rear end **242**$_1$ of porous separating member **228**$_1$ and extend upwardly.

Treatment chamber **152** and outer porous separating member **228**$_1$ may be independently movable/openable as shown, or configured (e.g. mechanically or electromechanically) to open simultaneously, or configured (e.g. mechanically or electromechanically) to open in sequence (e.g. beginning with treatment chamber **152** followed by outer porous separating member **228**$_1$). Moving/opening treatment chamber **152** and separating member(s) **228** simultaneously or sequentially may conveniently simplify the use of wiper(s) **192** to clean separating member(s) **228** to a single user action.

FIGS. **5** and **11** illustrate treatment chamber **152** and outer porous separating member **228**$_1$ opening in sequence. FIGS. **15-16** illustrate another embodiment in which treatment chamber **152** and outer porous separating member **228**$_1$ open in sequence.

Returning to FIG. **11**, openable outer porous separating member **228**$_1$ may define a dirt collection region **254**$_1$ that collects dirt which falls from inner porous separating member **228**$_2$ (e.g. naturally and/or as a result of wiping upstream surface **190**$_2$ with wiper(s) **192**$_1$). For example, openable outer porous separating member **228**$_1$ may have a U-shape, cup shape, or scoop shape formed by a plurality of interconnecting walls **244**$_1$ and **248**$_1$ joined at their ends to define an inner volume to hold inner porous separating member **228**$_2$. As shown in FIG. **16**, openable outer porous separating member **228**$_1$ may have an open upper end (or upper opening) **252**$_1$, which may provide a dirt outlet to pour out dirt from dirt collection region **254**$_1$ when the outer porous separating member **228**$_1$ is opened. For example, dirt collection region **254**$_1$ may be emptied simultaneously with dirt chamber **156**, as shown.

FIGS. **18-20** show an example of a porous dirt separator **154** that includes three porous separating members **228** positioned in the air flow path in series. In some embodiments, one or both of the outer and intermediate porous separating members **228**$_1$ and **228**$_2$ may be openable. Each openable porous separating member **228**$_1$ and/or **228**$_2$ may be configured with inwardly directed wipers **192**$_1$ or **192**$_2$ respectively that are configured to wipe the upstream surface **190**$_2$ or **190**$_3$ of the immediately next downstream porous separating member **228**$_2$ or **228**$_3$ respectively. Further, the openable porous separating members **228**$_1$ and/or **228**$_2$ may each define a dirt collection region **254**$_1$ or **254**$_2$ that collects dirt which falls from the immediately next downstream porous separating member **228**$_2$ or **228**$_3$ (e.g. naturally and/or from wiping upstream surface **190**$_2$ or **190**$_3$). Any or all of the openable porous separating members **228**$_1$ and/or **228**$_2$ may have an open upper end **252**$_1$ or **252**$_2$ that may provide a dirt outlet to pour out collected dirt when the porous separating member **228**$_1$ or **228**$_2$ is opened. As described above, the openable porous separating members **228**$_1$ and/or **228**$_2$ may be configured to open simultaneously with dirt chamber **156** or in sequence. For example, treatment chamber **152**, porous separating member **228**$_1$ and porous separating member **228**$_2$ may open in sequence in this order, such as by translating each one relative to the others in a cascading telescoping manner.

Valving for Multiple Treatment Chambers

In accordance with another aspect, in some embodiments, the air treatment member includes two treatment chambers, and a valve is provided to control the amount of air flow delivered from the dirty air inlet to each of the treatment chambers. For example, the valve may have a first position in which air is provided only to the first treatment chamber, a second position in which air is provided only to the second treatment chamber, and optionally a third position in which air is provided to both treatment chambers.

The valving for multiple treatment chambers may be used by itself or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, openable pre-motor filter chamber, the nested porous separating members, the debriding devices, the bypass valve, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

The valve may be moved to the first or second position when the suction motor is operating in a low power mode in order to maintain sufficient air velocity and suction across the active treatment chamber for efficient dirt separation. For example, in a low power mode, using one of two air treatment chambers reduces the size of the air treatment chamber that is in use and enables a higher air flow rate compared to both air treatment chambers being used. The valve may be moved to the third position when the suction motor is operating in a high power mode in order to benefit from the porous dirt separator of both treatment chambers (i.e., using both air treatment chambers may enable a high rate of air flow while reducing the back pressure).

In some embodiments, the valve may change position based on the flow rate of air through each suction chamber. For example, as the porous dirt separator of one treatment chamber reaches capacity, the air flow through that treatment chamber may drop, and the valve may change position to direct more air through the other treatment chamber in which the porous dirt separator has greater remaining dirt capacity. This may improve the dirt separation efficiency and air flow efficiency of the air treatment member.

In some embodiments, the valve may change position to reduce or inhibit air flow through a treatment chamber while the porous dirt separator inside is being debrided (e.g. cleaned by a wiper). This may mitigate the airflow through that treatment chamber interfering with the debriding operation.

Referring to FIGS. **27-28**, surface cleaning apparatus **100** may include an air treatment member **116** having first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$. Each treatment chamber **152** may include an air inlet **184**, an air outlet **188**, and a porous dirt separator **154** in the air flow path between the air inlet **184** and air outlet **188**. The treatment chambers **152** and porous dirt separators **154** may have any configuration described herein in connection with multi-chamber or single chamber designs. Treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$ may be fluidly positioned in parallel in the air flow path between the dirty air inlet **108** and clean air outlet **120**.

As shown, an air inlet passage **322** may extend from dirty air inlet **108** to a valve **324** positioned upstream of the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$. Valve **324** may be manually (e.g. by user selection) or automatically (e.g. by electronic logic) adjustable to control the amount of air provided to each of the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$.

Each treatment chamber **152** may have any configuration suitable for defining an air flow path that is parallel to the other treatment chamber **152**. For example, each treatment chamber **152** may include a front wall **204**, a rear wall **212**, a bottom wall **208**, and sidewalls **196**. In the illustrated example, the two treatment chambers **152** share a common dividing wall **196**. In alternate embodiments, the air treatment chambers **152** may be of any other design.

Valve **324** may have any configuration suitable for controlling the amount of air provided to each of the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$. For example, valve **324** may include solely manually operated (i.e. by hand) mechanical parts, or valve **324** may include electromechanical parts (e.g. electrically powered actuator **326**) that responds to commands generated by manual user selections and/or electronic logic.

Valve **324** may be adjustable (e.g. movable) between different positions that provide different amounts of air to the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$. FIGS. **28-31** show four example positions. In FIG. **28**, valve **324** is in a first position in which valve **324** removes the second treatment chamber $\mathbf{152}_2$ from the air flow path so that air is provided only to the first treatment chamber $\mathbf{152}_1$. In FIG. **29**, valve **324** is in a second position in which valve **324** removes the first treatment chamber $\mathbf{152}_1$ from the air flow path so that air is provided only to the second treatment chamber $\mathbf{152}_2$. In FIG. **30**, valve **324** is in a third position in which valve **324** positions both the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$ in the air flow path, so that air is provided to both the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$. In FIG. **31**, valve **324** is in a fourth position in which valve **324** removes both the first and second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$ from the air flow path, so that air is provided to neither the first nor second treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$ (e.g., in a bypass mode as discussed herein). Valve **324** may be adjustable to all or any subset of these positions. Further, valve **324** may provide variations on these positions in which valve **324** may restrict but not fully inhibit air flow through one or both treatment chambers $\mathbf{152}_1$, $\mathbf{152}_2$.

In some embodiments, the position of valve **324** may be automatically adjusted based on the flow rate of air through each of the first and second treatment chambers **152**. For example, a reduction in air flow through a treatment chamber **152** may indicate that the dirt separator **154** of that treatment chamber **152** is reaching its dirt capacity (e.g., the pores are partially or fully clogged). In response to an air flow rate through the first treatment chamber $\mathbf{152}_1$ being less than a threshold flow rate or less than a threshold fraction of the flow rate through the second treatment chamber, valve **324** may move to reduce or stop air flow through the first treatment chamber $\mathbf{152}_1$, whereby a greater fraction (or all) air flow may be directed through the second treatment chamber $\mathbf{152}_2$. This may improve the dirt separation efficiency and air flow efficiency of apparatus **100** by directing more (or all) of the air flow through an air treatment chamber **152** that has a dirt separator **154** with relatively greater dirt capacity.

Turning to FIG. **27**, in some embodiments, each treatment chamber **152** may include one or more wipers **192** (or other debriding devices described below) that are movable across the outer wall **308** of the dirt separator **154** in the treatment chamber **152**. For example, first treatment chamber $\mathbf{152}_1$ may include first wiper(s) $\mathbf{192}_1$ associated with first porous dirt separator $\mathbf{154}_1$, and second treatment chamber $\mathbf{152}_2$ may include second wiper(s) $\mathbf{192}_2$ associated with second porous dirt separator $\mathbf{154}_2$. As shown, wipers **192** may move across the outer walls **308** of their respective dirt separators **154** when the treatment chambers **152** are opened.

Reference is now made to FIG. **32**A. In some embodiments, one or both treatment chambers **152** may include one or more wipers **192** that include wiper actuators (e.g. electromechanical wiper actuators **328**). Wiper actuators **328** may be activated in response to manual user selection (e.g. pressing a button), and/or opening treatment chambers **152**, and/or other electronic logic (e.g. flow rate through the treatment chamber **152** having the associated wiper **192**). Moreover, wiper(s) **192** of first treatment chamber $\mathbf{152}_1$ may be activated independently of the wiper(s) **192** of second treatment chamber $\mathbf{152}_2$, and vice versa.

In some embodiments, valve **324** (e.g., FIG. **28**) may adjust position to reduce or stop air flow through one of treatment chambers **152**, while the wiper(s) **192** in that treatment chamber **152** is activated to clean the dirt separator **154** in that treatment chamber **152**. While the dirt separator **154** is being cleaned, air flow may continue through the other treatment chamber **152**. This design can allow dirt separators **154** to be cleaned individually, without stopping air flow through air treatment member **116**, so that the user can continue cleaning with apparatus **100** uninterrupted. By cleaning the dirt separators **154**, the dirt capacity of the dirt separators **154** can be improved or restored thereby improving the dirt separation efficiency and air flow efficiency of apparatus **100**.

Referring to FIG. **28-30**, in some embodiments, the position of valve **324** may be adjusted based on the selected power level of the suction motor **144**. For example, valve **324** may move automatically to the first or second position to provide air flow only to one of the treatment chambers **152** when the suction motor **144** is operating in a low power mode. This may help to maintain an air velocity and suction across the air treatment member **116** that is sufficient for efficient dirt separation. Further, valve **324** may move automatically to the third position to provide air flow to both treatment chambers **152** when suction motor **144** is operating in a high power mode in order to benefit from the dirt separators **154** of both treatment chambers **152**.

Debriding Devices

In accordance with another aspect, in some embodiments, the air treatment member may include one or more debriding devices. A debriding device as described subsequently may assist in cleaning a dirt separator and/or may be capable of being triggered by electronic logic.

The debriding device may be used by itself or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, openable pre-motor filter chamber, the nested porous separating members, the valving for multiple treatment chambers, the bypass valve, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

As exemplified in FIG. **32**A, as an alternative to wipers, or in addition to wipers, surface cleaning apparatus **100** may include one or more other debriding devices **332**. The debriding devices **332** may be activated automatically to debride upstream surface(s) **190** of porous dirt separator **154**. For example, the debriding device(s) **332** of a treatment chamber **152** may be activated automatically in response to the air flow rate through that treatment chamber **152** falling below a threshold flow rate or below a fraction of the flow rate through the other treatment chamber **152**. This can allow the debriding device(s) **332** to improve or restore the dirt capacity and separation performance of the porous dirt separator **154** in that treatment chamber **152**. Alternatively, or in addition, debriding devices **332** of one or both treatment chambers **152** may be activated automatically when the surface cleaning apparatus is turned off, and/or when one or both treatment chambers **152** are opened for emptying, and/or when activated manually (e.g. by a user device, such as a button). The debriding devices may include one or more of:

(i) electromechanically driven wipers (e.g. wipers that are rotated by motors, like windshield wipers on a car),
(ii) spring actuated wipers that are energized when the dirt chamber or porous separating member is opened or closed,
(iii) reversed air pressure (e.g. activated by repositioning one or more valves), which reverses the air flow across the dirty upstream surface **190**,
(iv) tapping on the porous separating member (e.g. with a manually or automatically actuated tapping member),
(v) vibrator (e.g. solenoid, speaker, or offset weight motor),
(vi) manual or electromechanical elongation (e.g. stretching) and/or contraction (e.g. compression) of the porous separating member, or
(vii) other deformation of the porous separating member (e.g. inflation, like a balloon).

FIG. **32**B shows an example debriding device **332** that includes a wiper **192** that is moved across outer wall **308** by a wiper actuator **326**. Wiper actuator **326** can be any electromechanical device that can be activated to move wiper actuator **326** across outer wall **308**. For example, wiper actuator **326** may be a linear actuator as shown, or a rotary actuator (e.g. motor). As exemplified in FIG. **32**A, wiper actuator **326** may be positioned proximate chamber rear end **212** and oriented to move wiper **192** vertically. As exemplified in FIG. **32**B, wiper actuator is connected to openable door **194**, and oriented to move wiper longitudinally. An advantage to the design of FIG. **32**B is that wipers **192** may move across separator outer wall **308** when wiper actuator **326** is activated, and also when door **194** is moved (e.g. opened and/or closed).

FIG. **33** shows an example debriding device **332** that includes spring-actuated wipers **192**. As shown, wipers **192** may include a spring member **336** that may be energized automatically as the treatment chamber **152** is opened and/or closed. The spring actuation may make wipers **192** move with greater speed as compared with synchronizing the movement of wipers **192** to the movement of a treatment chamber wall such as door **194**.

FIG. **34** shows an example debriding device **332** that includes one or more valved air outlets **340**, which may be opened to direct streams of airflow into the associated treatment chamber **152** across the upstream surface **190** of the dirt separator **154**. The streams of airflow may impinge upon the upstream surface **190** to help clean the dirt separator **154**, thereby restoring its dirt capacity and separation efficiency.

FIG. **35** shows an example debriding device **332** that includes a tapping member **344** that may be manually or electromechanically actuated to tap upon dirt separator **154**, and thereby cause dirt held by the dirt separator **154** to fall away.

FIG. **36** shows an example debriding device **332** that includes a vibrator **348**. Vibrator **348** can be any device that can generate vibrations in dirt separator **154**, which are effective at causing dirt held by dirt separator **154** to fall away. For example, vibrator **348** may be or include one or more of a solenoid, speaker, or offset weight motor.

FIGS. **37-38** show examples of debriding devices **332** that include a deformation actuator **352**. Deformation actuator **352** may be any device that can generate a dimensional deformity of dirt separator **154** (e.g. stretch, contraction, or inflation). For example, deformation actuator **352** may be or include one or more linear actuators connected to dirt separator **154**, and that can be activated to deform dirt separator **154** longitudinally. In FIG. **37**, deformation actuator **352** is configured to stretch and/or contract dirt separator **154**. In FIG. **38**, deformation actuator **352** is configured to inflate dirt separator **154**. The deformation may cause relative movement between the dirt separator **154** and the dirt held thereon, whereby the dirt may detach and fall away.

Bypass Valve

In accordance with another aspect, in some embodiments, the surface cleaning apparatus may include a bypass valve that can be used in connection with an external air treatment member. The bypass valve may move to a first position when the external air treatment member is disconnected from the apparatus. In the first position, the valve may configure the air flow path through the apparatus so that the air treatment member of the surface cleaning apparatus (e.g., an internal air treatment member) is positioned in the air flow path. The bypass valve may move to a second position when the external air treatment member is connected to the apparatus. In the second position, the valve may configure the air flow path through the apparatus so that the internal air treatment member is excluded from the air flow path. This may mitigate the internal air treatment member creating unnecessary backpressure when the external air treatment member is acting to separate dirt from the air flow.

The bypass valve may be used by itself or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, openable pre-motor filter chamber, the nested porous separating members, the valving for multiple treatment chambers, the debriding devices, the power components configurations and the use of a sequential momentum separator and cyclone as disclosed herein.

As exemplified in FIGS. **21-22**, in any embodiment disclosed herein, surface cleaning apparatus **100** may include a bypass valve **268**. Bypass valve **268** is movable between a first position (FIG. **21**) and a second position (FIG. **22**, also referred to as a bypass position). In the bypass position (FIG. **22**), bypass valve **268** reconfigures the air flow path **124** from dirty air inlet **108** to suction motor **144** to bypass air treatment member **116** (i.e. air treatment member **116** is not positioned in the air flow path **124**). In the first position (FIG. **21**), the air flow path is configured so that some or all of the air flow traveling from dirty air inlet **108** to suction motor **144** passes through air treatment member **116** (i.e. air treatment member **116** is positioned in the air flow path **124**).

Turning to FIGS. **21-23**, bypass valve **268** may be used in connection with an external air treatment member **272** (e.g., a cyclone contained within the attachment shown in these Figures). In the example shown, a downstream end **276** of external air treatment member **272** is removably connectable to dirty air inlet **108**. A floor cleaning head (not shown) may be connected to upstream end **280** or the upstream end **280** may be used as a nozzle to clean surfaces directly. The bypass valve **268** may be automatically or manually moved to the bypass position (FIG. **22**) when the surface cleaning apparatus **100** is connected to the external air treatment member **272** so that dirty air is cleaned by the external air treatment member **272** and then travels to the suction motor **144** bypassing the air treatment member **116** of the surface cleaning apparatus **100**. The bypass valve **268** may be automatically or manually moved to the first position (FIG. **21**) when the surface cleaning apparatus **100** is disconnected from the external air treatment member **272** in order to resume cleaning the dirty air flow using air treatment member **116**.

Power Components Configuration

In accordance with another aspect, in some embodiments, the surface cleaning apparatus may include one or more (or all) of a power cable, energy storage member (e.g. battery or supercapacitor), cord reel, and an AC to DC power supply. These components may have various positional arrangements in different embodiments, which may improve the ergonomics of the surface cleaning apparatus (e.g. reduced weight, better weight balance, or greater portability)

The power components configurations may be used by themselves or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, openable pre-motor filter chamber, the nested porous separating members, the valving for multiple treatment chambers, the debriding devices, the bypass valve and the use of a sequential momentum separator and cyclone as disclosed herein.

Turning to FIG. **2**, in any of the embodiments disclosed herein, surface cleaning apparatus **100** may be configured as a cordless (e.g. battery powered) device, or a corded (e.g. mains powered) device, or both. In embodiments including a cordless configuration, the suction motor **144** and energy storage member **286** (e.g. battery or supercapacitor) may be positioned in any suitable location. For example, the suction motor **144** may be positioned above handle **104** with the energy storage member **286** below handle **104** as exemplified. This configuration may help to lower the center of gravity of apparatus **100** where the energy storage member **286** is relatively large and heavy.

FIGS. **41-41**B exemplify an alternative embodiment in which the suction motor **144** may be positioned below handle **104** with energy storage member **286** positioned above handle **104**. As shown, this configuration may locate energy storage member **286** in the air flow path **124** upstream of suction motor **144**. This can allow the air flow to cool energy storage member **286**. Energy storage members (e.g. batteries and supercapacitors) may be damaged by overheating, which may occur during operation, and using the air flow upstream of the suction motor may assist in cooling the energy storage member during use.

In the illustrated example, energy storage member **286** is provided in a battery pack **440** having an outer wall **444**. As shown, the air flow may pass over an outer surface of battery pack **440** (i.e. over an outer surface of wall **444**) and/or through a battery pack as the air travels from air treatment member **116** to suction motor **144**. As shown in FIG. **41**B, battery pack **440** may be removably mounted to surface cleaning apparatus **100**. This can allow battery pack **440** to be charged externally and to be swapped with another pre-charged battery pack.

In some embodiments, a pre-motor filter **240** may be positioned downstream of treatment chamber **152** and upstream of energy storage member **286**. The pre-motor filter **240** may further clean the air flow before the air flow makes contact with the energy storage member **286** (e.g. before making contact with battery pack **440**) to mitigate dirtying energy storage member **286** or the outer surface of battery pack **440** with dirt remaining in the air flow. Dirt on the outer wall of a battery pack would be an insulator and reduce heat dissipation from the battery pack.

FIG. **42** shows an example in which suction motor **144** may be positioned above handle **104** with energy storage member **286** inside handle **104**. This configuration may position the center of mass of the energy storage member **286** where the user grasps surface cleaning apparatus **100**. This may mitigate energy storage member **286** moving the apparatus center of mass away from the user's hand position when energy storage member **286** is connected to apparatus **100** (e.g. when operating in a cordless configuration) as compared to when energy storage member **286** is disconnected from apparatus **100** (e.g. when operating in a corded configuration with the battery removed). Alternatively, FIG. **24** shows an embodiment in which suction motor **144** is positioned below handle **104** with energy storage member **286** inside handle **104**.

Turning to FIG. **25**, in embodiments including a corded configuration, the cord **288** may be removable to reconfigure into a cordless (e.g. battery powered) configuration. For example, an electrical connector **364** may provide a removable connection between cord **288** and apparatus **100**. This may reduce the weight of apparatus **100** when operated in a cordless configuration, as compared with a cordless configuration that requires carrying cord **288**.

As shown in FIG. **26**, apparatus **100** may include an AC to DC power supply **292** in association with power cord **288** to supply DC power to the suction motor **144** and/or other electrically powered elements of apparatus **100**. This may permit apparatus **100** to use a DC suction motor **144** that can be directly powered by energy storage member **286** in the cordless configuration, without suffering the energy loss associated with a DC to AC converter. In turn, this may extend the cordless runtime of apparatus **100** all else being equal. In other embodiments, power cord **288** may connect directly to mains power to supply AC power to suction motor **144** as shown in FIG. **25**. For example, apparatus **100** may include an internal AC to DC power supply, or a suction motor **144** compatible with AC power.

Referring to FIGS. **43-44**, cord **288** may be associated with a cord reel **296**. Cord reel **296** may be internal to main body **112** or rigidly connected to main body **112** (e.g. rigidly connected to apparatus **100** interior to handle **104**). For example, FIG. **43** shows an embodiment of apparatus **100** including a cord reel **296** at a lower end of handle **104**, and that is optionally detachable from apparatus **100**. This can allow the user to remove cord reel **296** in order to reduce the weight of apparatus **100** when operating in a cordless configuration.

In other embodiments, cord reel **296** may be positioned external to apparatus **100** as shown in FIG. **44**.

As exemplified in FIG. **44**, cord reel **296** may include an AC to DC power supply **292**. For example, AC to DC power supply **292** may be located centrally in cord reel **292**. Cord **288** may be detachably connected to apparatus **100**, which may allow the user to remove cord **288** and cord reel **296** to reduce the weight of apparatus **100** when operating in a cordless configuration.

Sequential Momentum Separator and Cyclone

In accordance with another aspect, in some embodiments, the surface cleaning apparatus includes a first stage momentum separator and a second stage cyclonic separator downstream of the first stage. For example, the momentum separator may efficiently separate large dirt particles from the air flow, and the cyclonic separator may efficiently separate small particles from the air flow. In some embodiments, the air treatment member may have a front door that concurrently opens a wall of the momentum separator and a wall of the cyclonic separator. This can allow both of the first and second cleaning stages to be opened in a single act (i.e. by opening the front door), and then emptied of dirt concurrently.

The use of a sequential momentum separator and cyclone may be used by itself or in combination with one or more of the air treatment member wipers, the multi-stage perforated substrates, openable pre-motor filter chamber, the nested porous separating members, the valving for multiple treatment chambers, the debriding devices, the bypass valve and the power components configurations disclosed herein.

As exemplified in FIGS. **45-46**, air treatment member **116** may include a first cleaning stage **368** and a second cleaning stage **372**. First cleaning stage **368** may include a momentum separator **376** having a treatment chamber **152** with an inlet **184**, an outlet **188**, a front end **210**, and a rear end **212**. Second cleaning stage **372** is downstream of first cleaning stage **368** along air flow path **124**, and include at least one cyclone with a cyclone chamber **384**. The second cleaning stage **372** may be axially rearward of the momentum separator **376**.

Momentum separator **376** may separate relatively large particles from the air flow by causing the air flow to decelerate sharply in treatment chamber **152** between chamber inlet **184** and outlet **188** and/or to change the direction of air flow through the momentum separator. For example, chamber inlet **184** may be positioned and oriented to direct air entering treatment chamber **152** to deflect off of a wall of treatment chamber **152** before exiting through outlet **188**. The sudden deceleration generated by this deflection may cause large dirt particles (which have the greatest momentum of the dirt in the air flow) to disentrain from the air flow. The disentrained dirt particles may collect in treatment chamber **152** (e.g. in a dirt region **156**).

As exemplified in FIGS. **45-46**, chamber inlet **184** may be positioned and oriented to direct air entering treatment chamber **152** in an inlet flow direction **388** (e.g., downwardly) that is transverse to an outlet flow direction **392** through chamber outlet **188** (axially in the direction of axis **142**). This may inhibit the air entering treatment chamber **152** from exiting through chamber outlet **188** before experiencing a sudden deceleration that will separate large dirt particles from the air flow. This can allow the dirt particles to collect in a lower portion of treatment chamber **152** where gravity can assist with retaining the separated dirt particles in treatment chamber **152** until they are emptied from apparatus **100**. As shown, treatment chamber air outlet **188** may define a generally rearwardly outlet flow direction **392**, which is transverse to the generally downward inlet flow direction **388**.

In some embodiments, treatment chamber air outlet **188** may be located at chamber rear end **212**. For example, chamber rear end **212** may extend transverse to longitudinal axis **142**, and may include a rearwardly oriented air outlet **188**. Air outlet **188** can have any configuration that provides an exit for air leaving treatment chamber **152** towards cyclone chamber **384**. For example, chamber air outlet **188** may include one opening (e.g. as in a conduit) or a plurality of openings **316** (e.g. a perforated substrate, such as a screen, a rigid plastic member with openings therethrough or other porous dirt separator) as exemplified. A chamber air outlet **188** including a porous dirt separator with a plurality of openings **316** may assist with separating large dirt particles remaining in the air flow before the air flow exits treatment chamber **152**.

Cyclone **380** may have any configuration suitable for cyclonically separating particles of dirt from the air stream exiting first cleaning stage **368**. As shown, cyclone chamber **384** may include one cyclone air inlet or a plurality of air inlets **404** as shown. Inlet(s) **404** may direct the air entering cyclone chamber **384** in a tangential direction that promotes cyclonic flow within cyclone chamber **384**. The cyclonic movement of the air flow may cause dirt particles in the air flow to separate. As shown, cyclone chamber **384** may have a dirt outlet **408** through which separated dirt particles may exit cyclone chamber **384** and enter dirt chamber **412**. Air exits cyclone chamber **384** through cyclone air outlet **416**, which may be any air outlet known in the art. In some embodiments, an outlet passage **420** may be located immediately upstream of cyclone air outlet **416** (the rear end of passage **420**). As shown, outlet passage **420** may include inlets **424** defined by a screen **426** (e.g. fine mesh) which may help separate dirt remaining in the air flow exiting cyclone chamber **384**. Alternatively or in addition to having a screen **426**, outlet passage **420** may act as a vortex finder that may promote the cyclonic flow pattern within cyclone chamber **384**.

FIG. **46** exemplifies an embodiment in which cyclone chamber **384** is oriented with a substantially horizontal cyclone axis **428** (e.g. parallel to longitudinal axis **142**). FIG. **47** shows an alternative embodiment in which cyclone axis

428 is oriented at an angle to vertical and horizontal. As shown, this design may provide momentum separator **376** with a larger dirt collection region **156**. As exemplified, the cyclone is rearward of the momentum separator. Accordingly, air may travel generally rearwardly (e.g., axially in FIG. **46**) from the openings or perforations in the porous substrate to the cyclone air inlet, thereby reducing back pressure through the hand vacuum cleaner.

Referring to FIGS. **46** and **48-49**, air treatment member **116** may include a front door **194** that is movably mounted between a closed position (FIG. **46**) and an open position (FIG. **47**). Front door **194** may be rotatably movable as shown, movable in translation or removable for example. As shown, when front door **194** is opened, walls of both cleaning stages **368**, **372** may be concurrently opened. This can allow both cleaning stages **368**, **372** to be simultaneously opened for emptying by a single act of opening front door **194**.

For example, the front wall **194** may have attached thereto the porous substrate (treatment chamber rear wall **212** having outlet **188**) and the front wall **432** of the cyclone chamber. As exemplified, the porous substrate (treatment chamber rear wall **212**) may be spaced rearwardly from the front wall **194** by a first support member (e.g., a column) and the front wall **432** of the cyclone chamber may be spaced rearwardly from the porous substrate by a second support member (e.g., a column). Opening front door **194** may open at least a portion of treatment chamber front wall **204**, and at least a portion of cyclone chamber front wall **432**. As shown, front door **194** may include some or all of front wall **204**. Further, front door **194** may be a front wall of the surface cleaning apparatus. In the illustrated example, treatment chamber air inlet **184** remains in position when front door **194** is opened.

If the cyclone has an external dirt chamber **412**, then in some embodiments, opening front door **194** may concurrently open cyclone chamber **384** and dirt chamber **412**. This can allow both of cyclone chamber **384** and dirt chamber **412** to be emptied when front door **194** is open.

As exemplified, the treatment chamber rear wall **212** may move concurrently with front door **194**. Alternately, or in addition, rear wall **212** may be connected to or form some or all of a wall of cyclone chamber **384** and a wall of dirt chamber **412**. In the illustrated example, treatment chamber rear wall **212** is connected to an end wall **432** of cyclone chamber **384**, and treatment chamber rear wall **212** forms an end wall **436** of dirt chamber **412**. When front door **194** is opened, treatment chamber rear wall **212**, cyclone chamber wall **432**, and dirt chamber wall **436** may move as well, whereby treatment chamber **152**, cyclone chamber **384**, and dirt chamber **412** may be opened concurrently. This design may also permit chambers **152**, **384**, and **412** to be emptied concurrently when front door **194** is opened.

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 hand vacuum cleaner having an exterior front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

(a) an air flow passage extending from a dirty air inlet provided at the exterior front end to a clean air outlet, the dirty air inlet being an entrance for air into the hand vacuum cleaner;

(b) a first cleaning stage positioned in the air flow passage downstream from the dirty air inlet, the first cleaning stage comprising a momentum separator having a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end;

(c) a second cleaning stage positioned in the air flow passage downstream from the first cleaning stage, the second cleaning stage comprising at least one cyclone, the at least one cyclone having a cyclone chamber;

(d) an exterior front facing door moveably mounted between a closed position and an open position,

wherein, when the exterior front facing door is moved to the open position, a wall defining part of the treatment chamber and a wall defining part of the cyclone chamber are concurrently opened and wherein, when the hand vacuum cleaner is in use, the hand vacuum cleaner has a front wall and the front wall comprises the exterior front facing door.

2. The hand vacuum cleaner of claim **1** wherein the air inlet of the treatment chamber is located at an upper end of the treatment chamber and directs air downwardly into the treatment chamber.

3. The hand vacuum cleaner of claim **1** wherein the air inlet of the treatment chamber remains in position when the exterior front facing door is opened.

4. The hand vacuum cleaner of claim **1** wherein the front wall is the exterior front facing door.

5. The hand vacuum cleaner of claim **1** wherein the rear end of the treatment chamber extends generally transverse to the longitudinal axis and the air outlet of the treatment chamber comprises a plurality of openings provided in the rear wall.

6. The hand vacuum cleaner of claim **1** wherein the rear end of the treatment chamber comprises a rear wall that extends generally transverse to the longitudinal axis and the rear wall is moved concurrently with the exterior front facing door.

7. The hand vacuum cleaner of claim **1** wherein the rear end of the treatment chamber comprises a rear wall that extends generally transverse to the longitudinal axis and the rear wall comprises a wall of a dirt collection region of the at least one cyclone.

8. The hand vacuum cleaner of claim **1** wherein the second cleaning stage comprises a dirt collection chamber exterior to cyclone chamber and the dirt collection chamber and the cyclone chamber are opened concurrently.

9. The hand vacuum cleaner of claim **1** wherein an end wall of the cyclone chamber is attached to the rear wall of the treatment chamber.

10. A hand vacuum cleaner having an exterior front end, a rear end and a longitudinal axis extending between the front and rear ends, the hand vacuum cleaner comprising:

(a) an air flow passage extending from a dirty air inlet provided at the exterior front end to a clean air outlet, the dirty air inlet being an entrance for air into the hand vacuum cleaner;

(b) a first cleaning stage positioned in the air flow passage downstream from the dirty air inlet, the first cleaning stage comprising a treatment chamber, the treatment chamber having an air inlet, an air outlet, a front end and a rear end, wherein the rear end of the treatment chamber comprises a rear wall that extends generally transverse to the longitudinal axis; and,

(c) an exterior front facing door moveable mounted between a closed position and an open position, the front facing door is spaced from the rear wall,

wherein a member extends rearwardly from the exterior facing door to the rear wall, whereby when the exterior front facing door is moved to the open position the rear wall of the treatment chamber is moved concurrently with the exterior front facing door and wherein, when the hand vacuum cleaner is in use, the hand vacuum cleaner has a front wall and the front wall comprises the exterior front facing door.

11. The hand vacuum cleaner of claim **10** wherein the air inlet of the treatment chamber is located at an upper end of the treatment chamber and directs air downwardly into the treatment chamber.

12. The hand vacuum cleaner of claim **10** wherein the air inlet of the treatment chamber remains in position when the exterior front facing door is opened.

13. The hand vacuum cleaner of claim **10** wherein the front wall is the exterior front facing door.

14. The hand vacuum cleaner of claim **10** wherein the air outlet of the treatment chamber comprises a plurality of openings provided in the rear wall of the treatment chamber.

15. The hand vacuum cleaner of claim **10** wherein the rear wall of the treatment chamber comprises a wall of a dirt collection region of a second downstream cleaning stage.

16. The hand vacuum cleaner of claim **15** wherein the second cleaning stage comprises a dirt collection chamber exterior to a second stage treatment chamber and the dirt collection chamber and the second stage treatment chamber are opened concurrently.

17. The hand vacuum cleaner of claim **15** wherein the second cleaning stage comprises a cyclonic cleaning stage.

18. The hand vacuum cleaner of claim **17** wherein the cyclonic cleaning stage comprises a cyclone chamber having an end wall and the end wall of the cyclone chamber is attached to the rear wall of the treatment chamber.

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