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(54) HANDHELD SURFACE CLEANING APPARATUS

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CPC ***A47L 9/2884*** (2013.01); ***A47L 5/24*** (2013.01); ***A47L 9/122*** (2013.01); ***A47L 9/127*** (2013.01); ***A47L 9/1608*** (2013.01); ***A47L 9/1625*** (2013.01); ***A47L 9/1641*** (2013.01); ***A47L 9/1666*** (2013.01); ***A47L 9/1683*** (2013.01); ***A47L 9/1691*** (2013.01); ***A47L 9/322*** (2013.01)

(58) **Field of Classification Search**

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See application file for complete search history.

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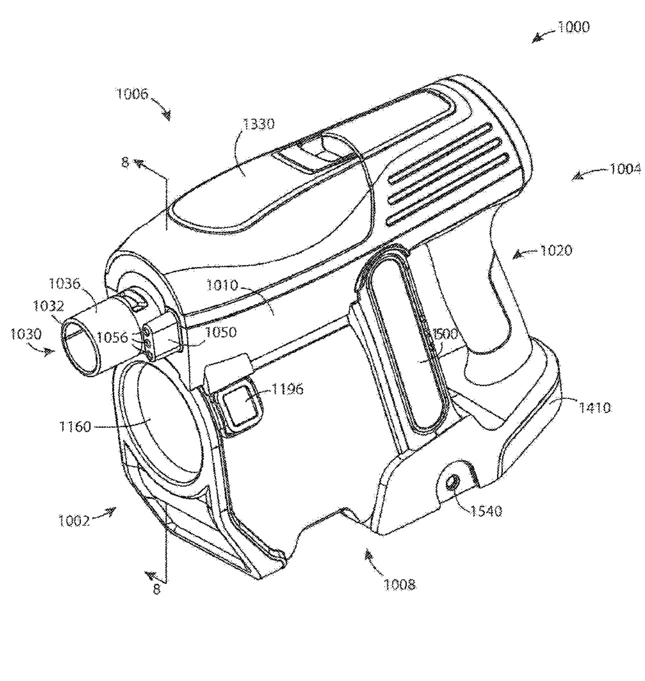
(57) **ABSTRACT**

A hand vacuum cleaner has an air flow path extending from a dirty air inlet to a clean air outlet. A cyclone assembly including a dirt collection region is positioned in the air flow path, a pre-motor filter is positioned downstream from the cyclone chamber and a suction motor is positioned upstream of a clean air outlet. A battery pack is positioned such that at least a portion of the battery pack is positioned rearward of the dirt collection region and at least a portion of the battery pack underlies at least a portion of one or both of the cyclone assembly and the pre-motor filter.

18 Claims, 50 Drawing Sheets



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International Search Report and Written Opinion received in connection to International patent application No. PCT/CA2017/050014, dated Apr. 5, 2017.

* cited by examiner

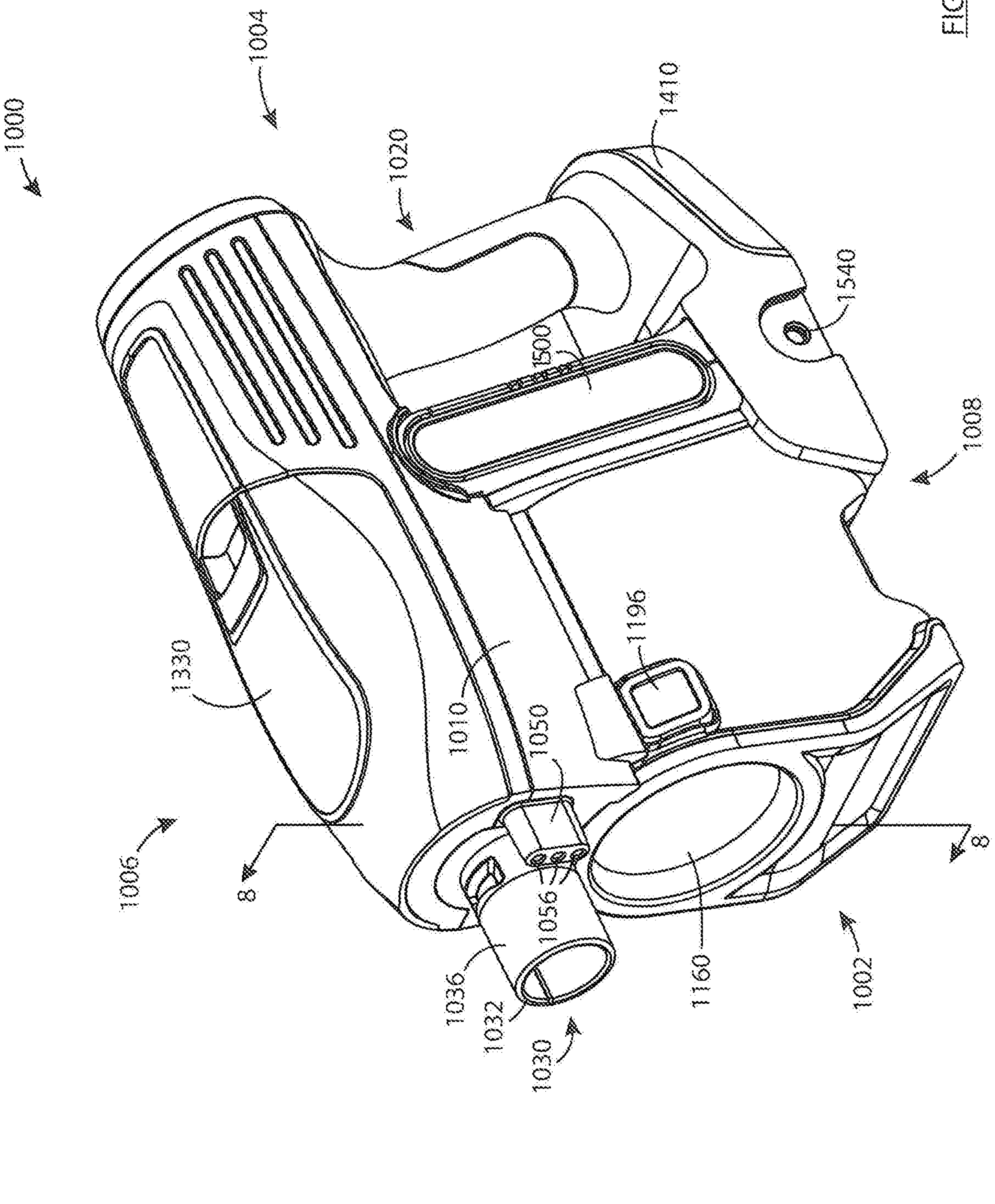
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FIG. 1

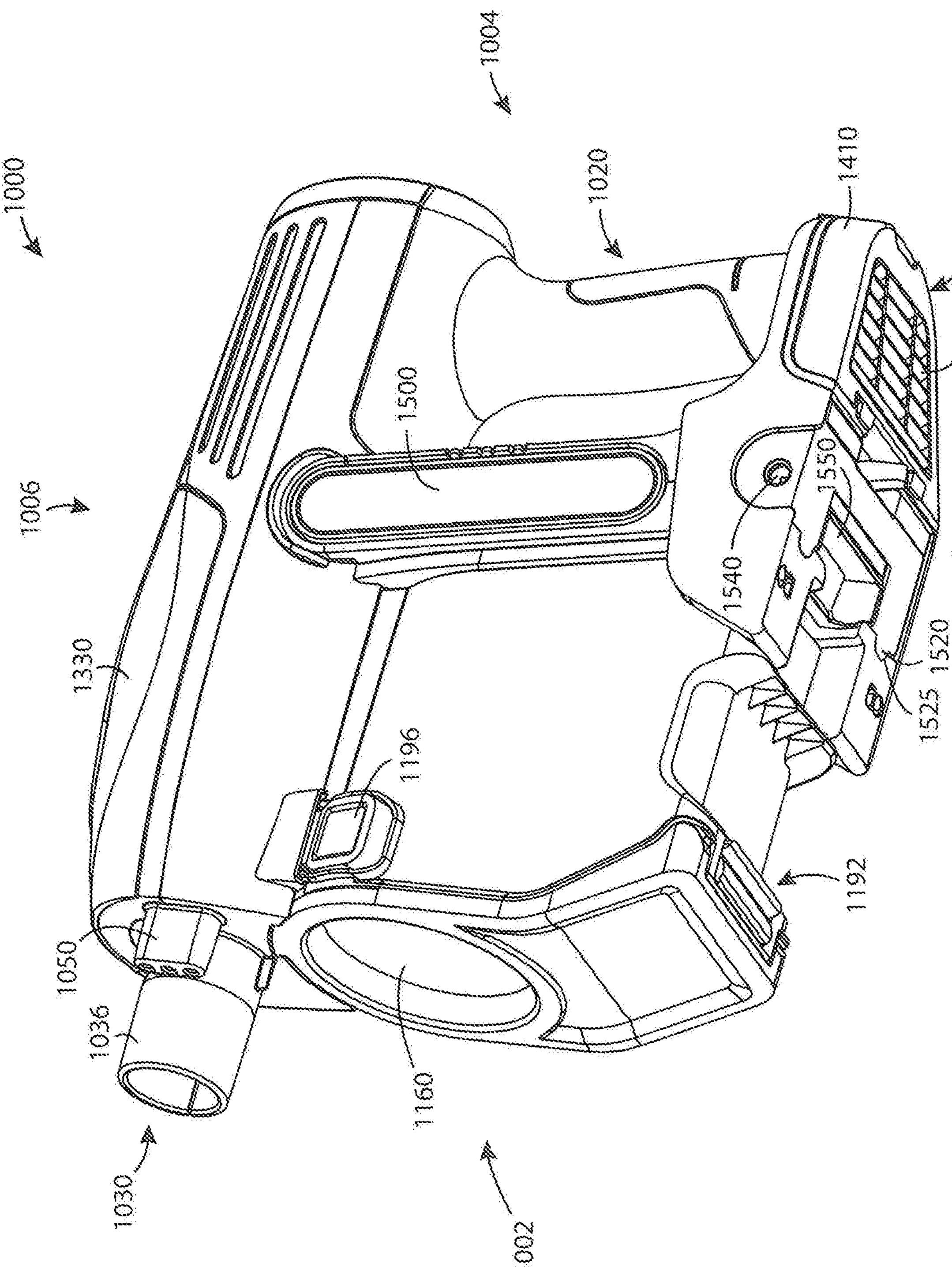
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FIG. 2

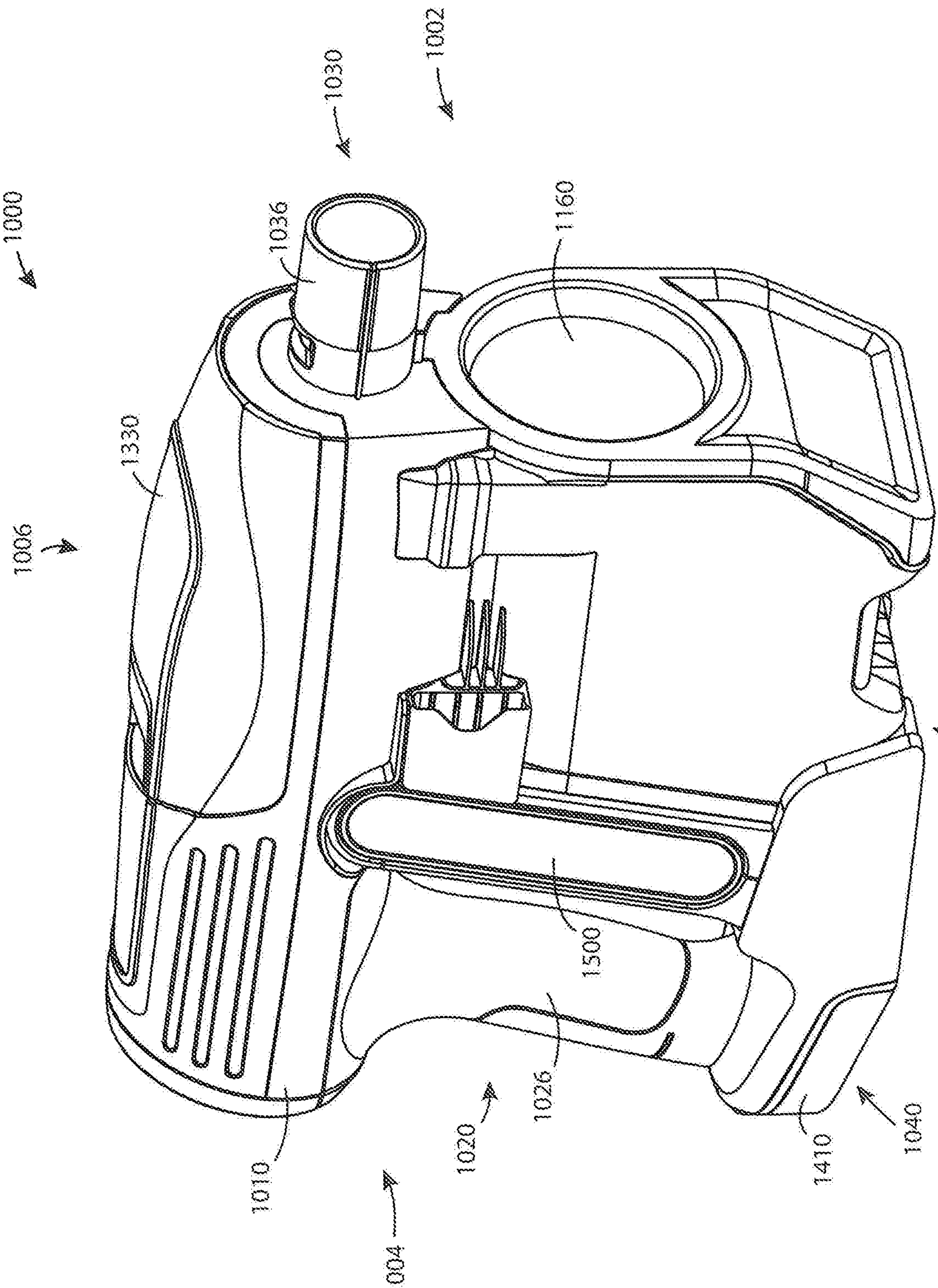
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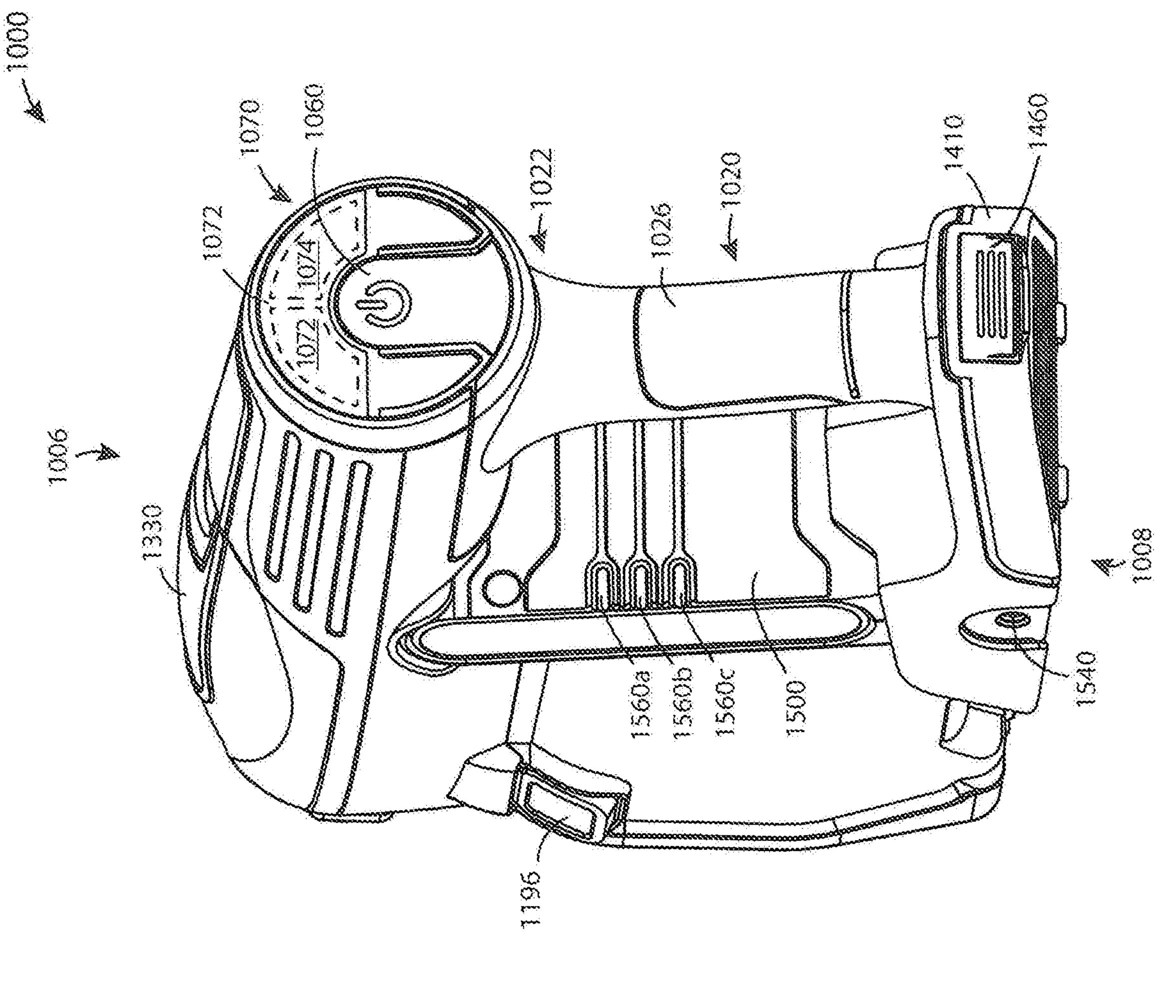
FIG. 3

FIG. 4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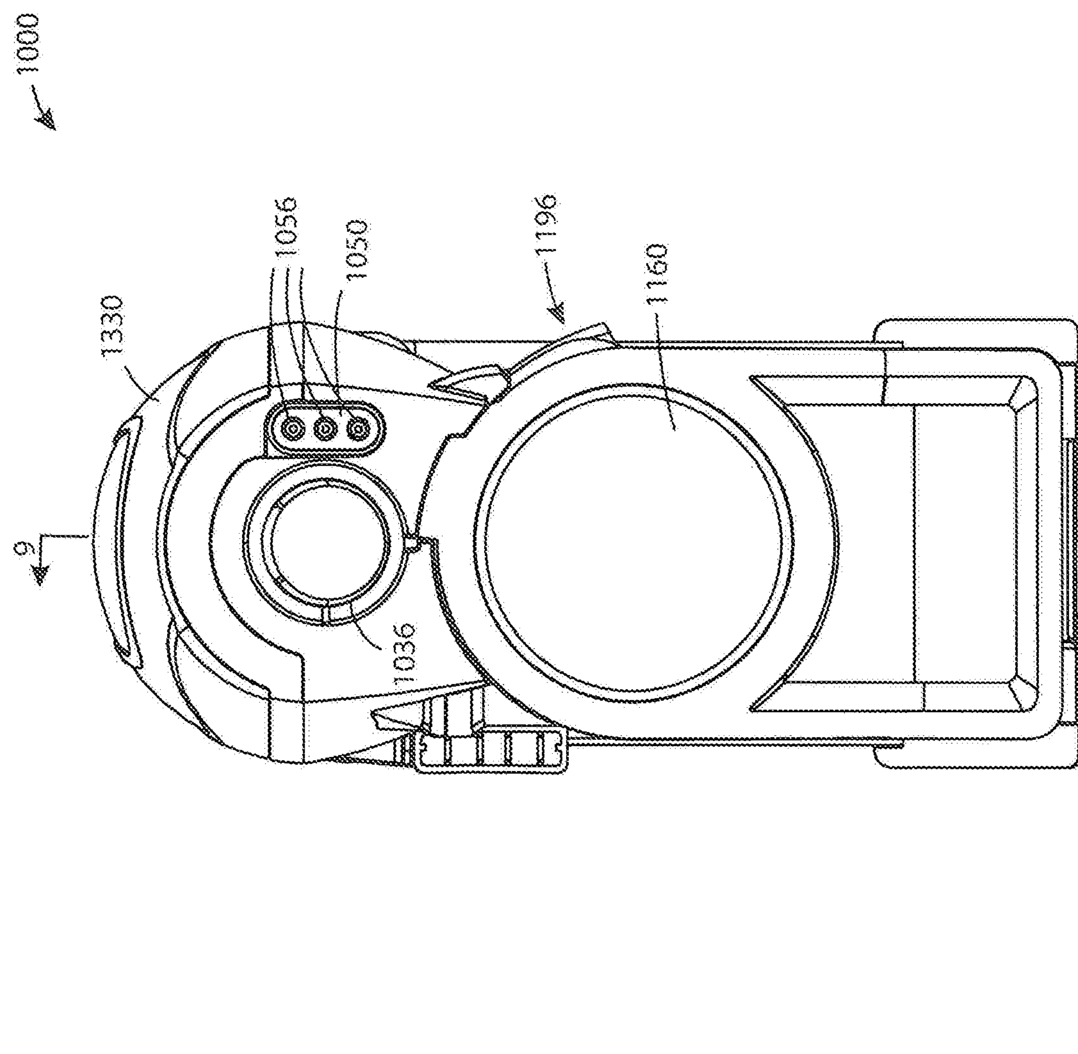
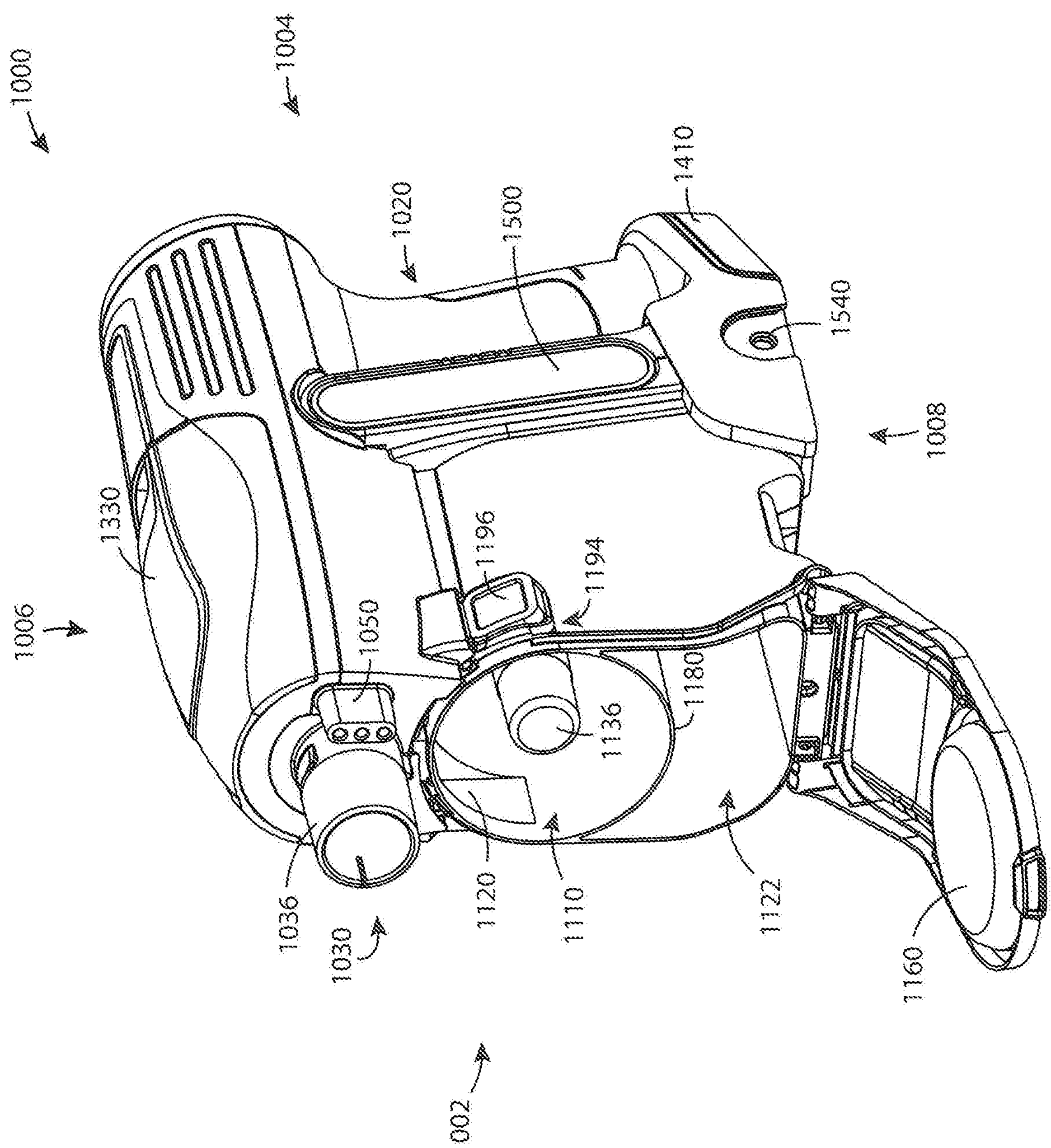


FIG. 5

FIG. 6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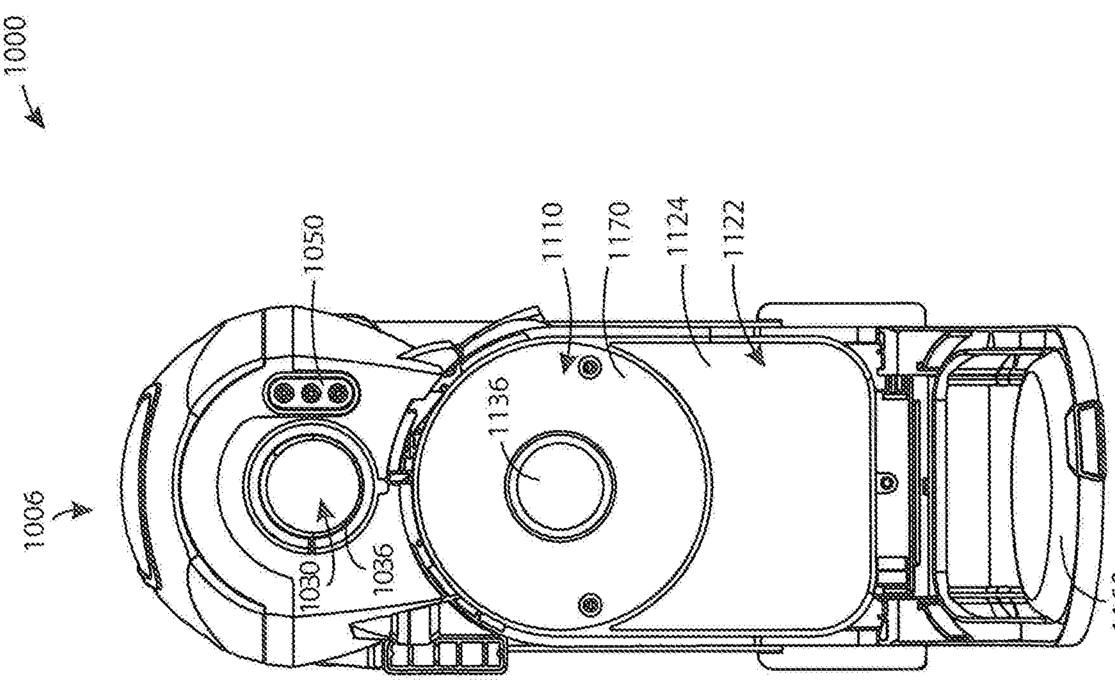
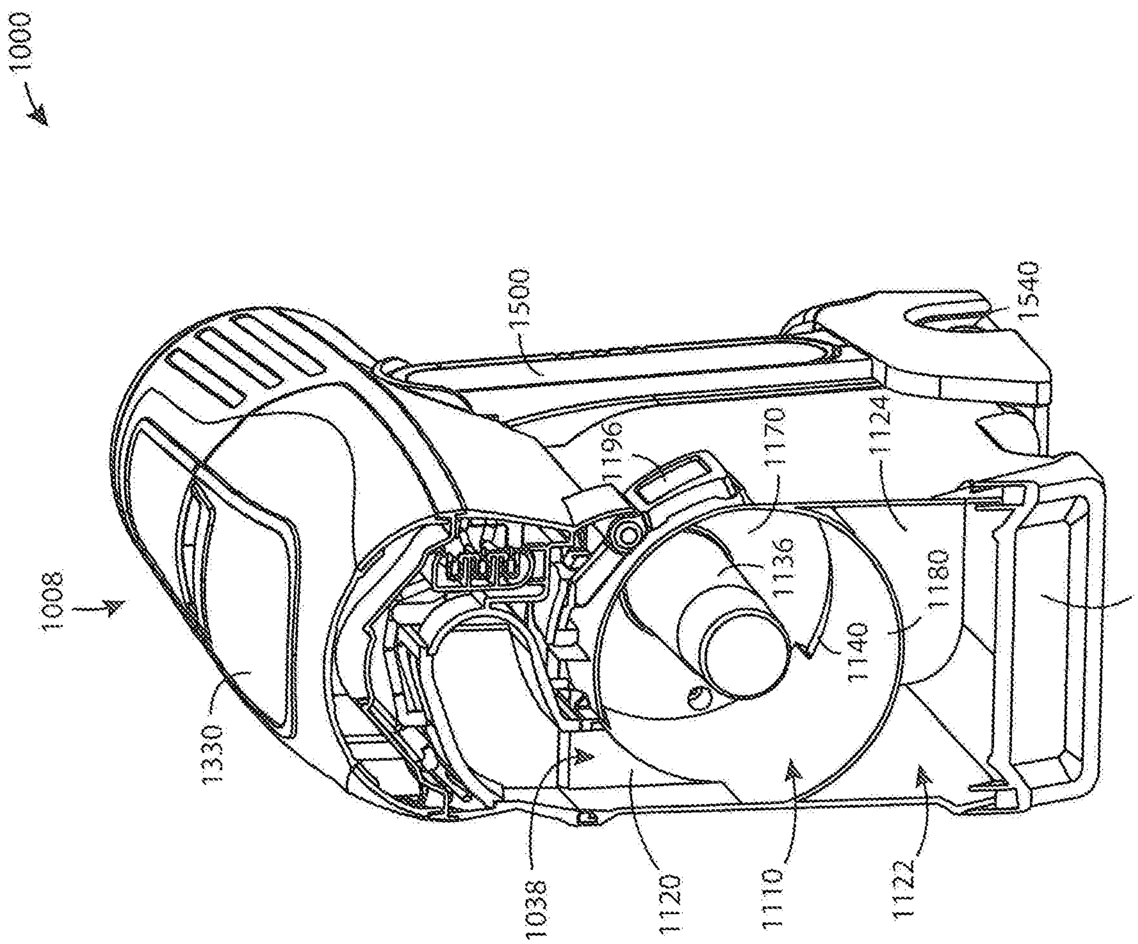


FIG. 7

FIG. 8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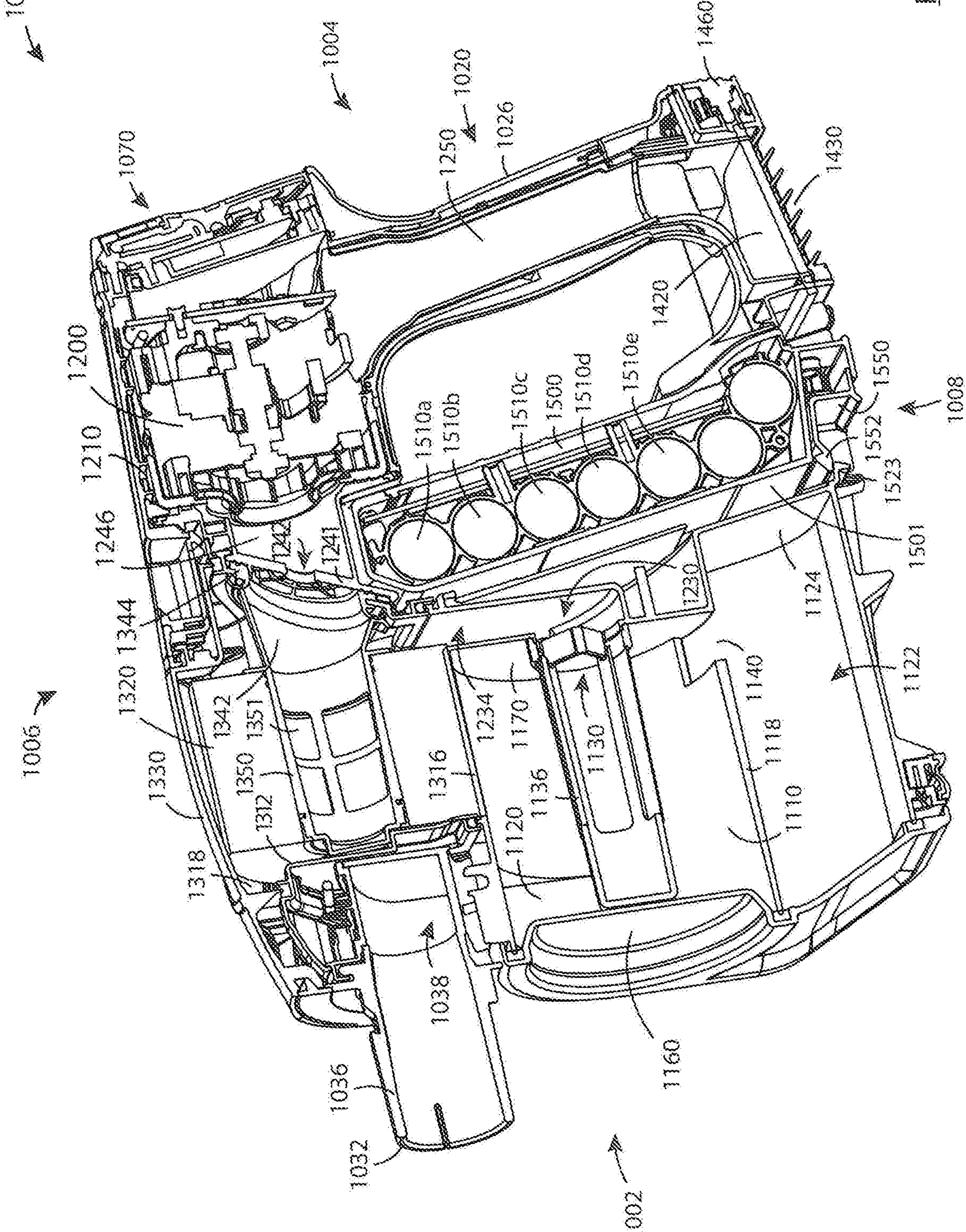
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FIG. 9

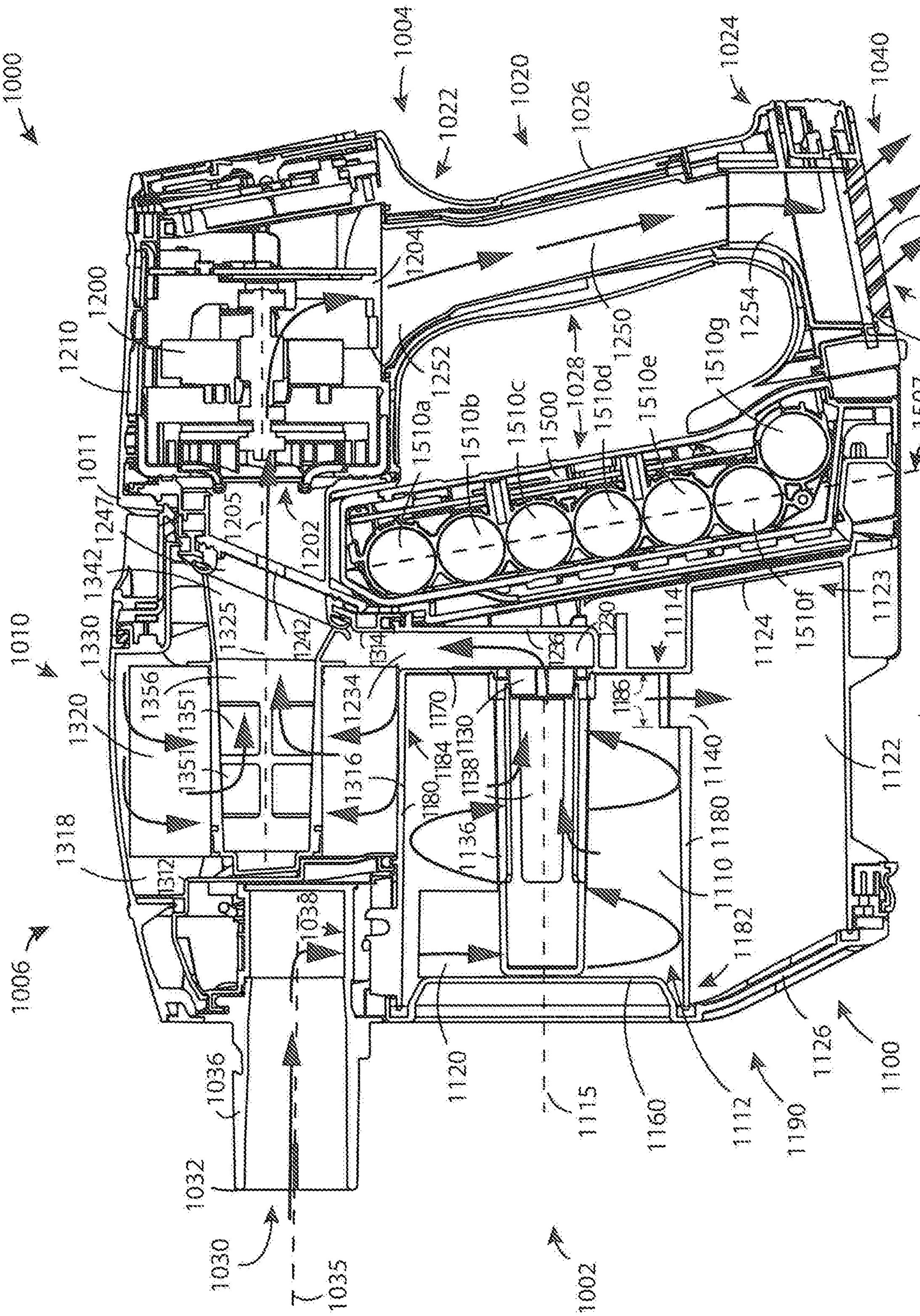
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FIG. 10

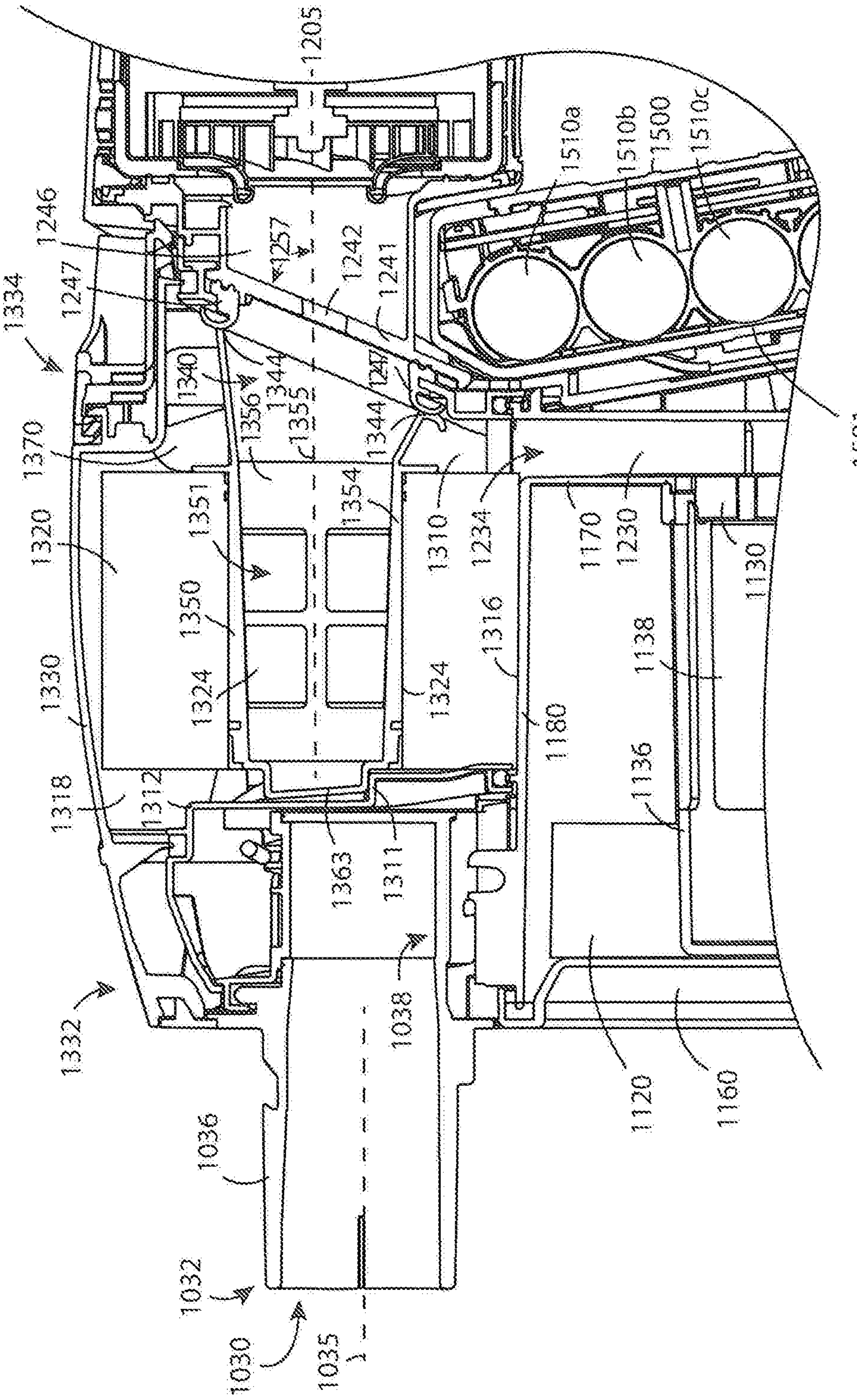
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FIG. 11

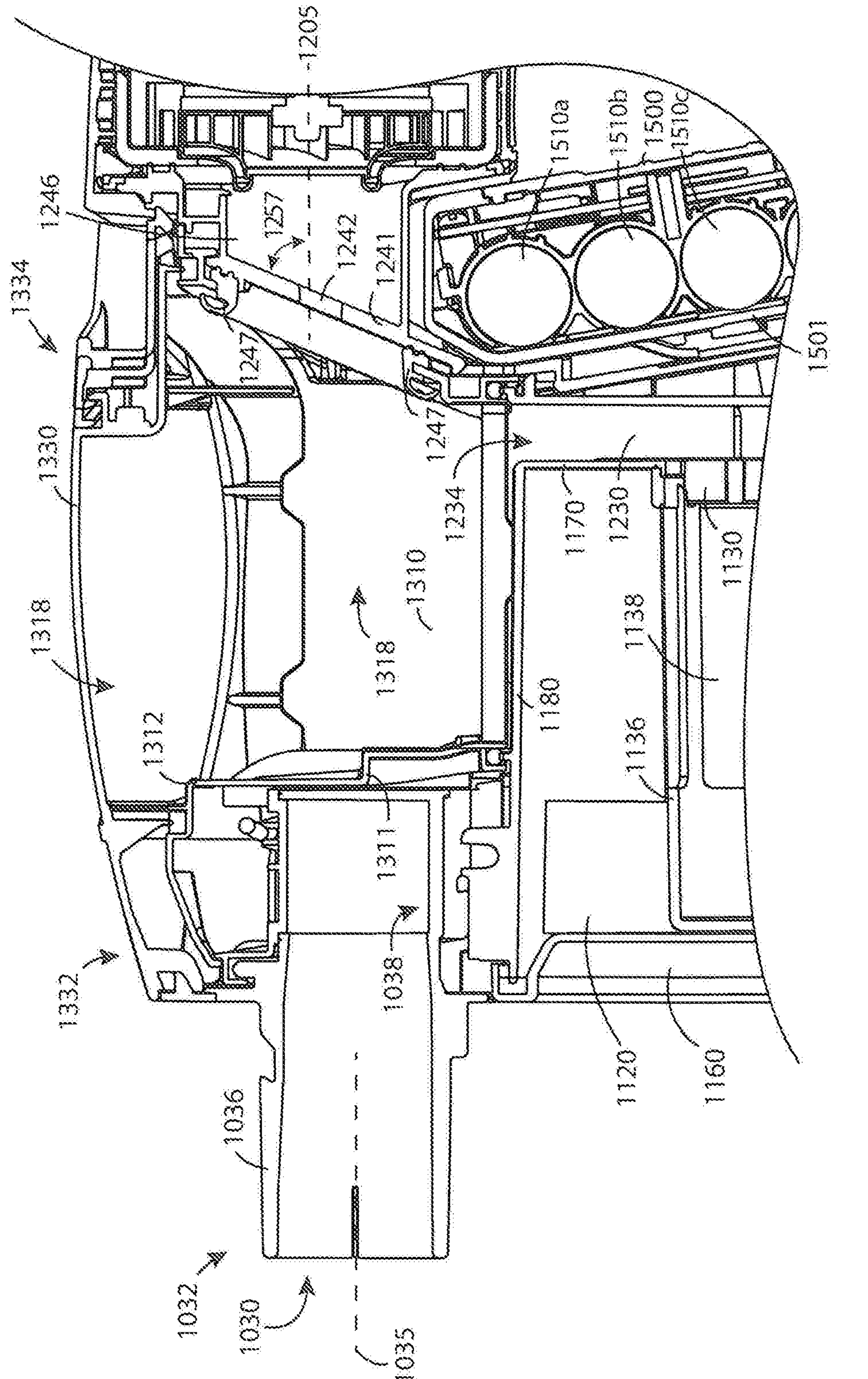
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FIG. 12

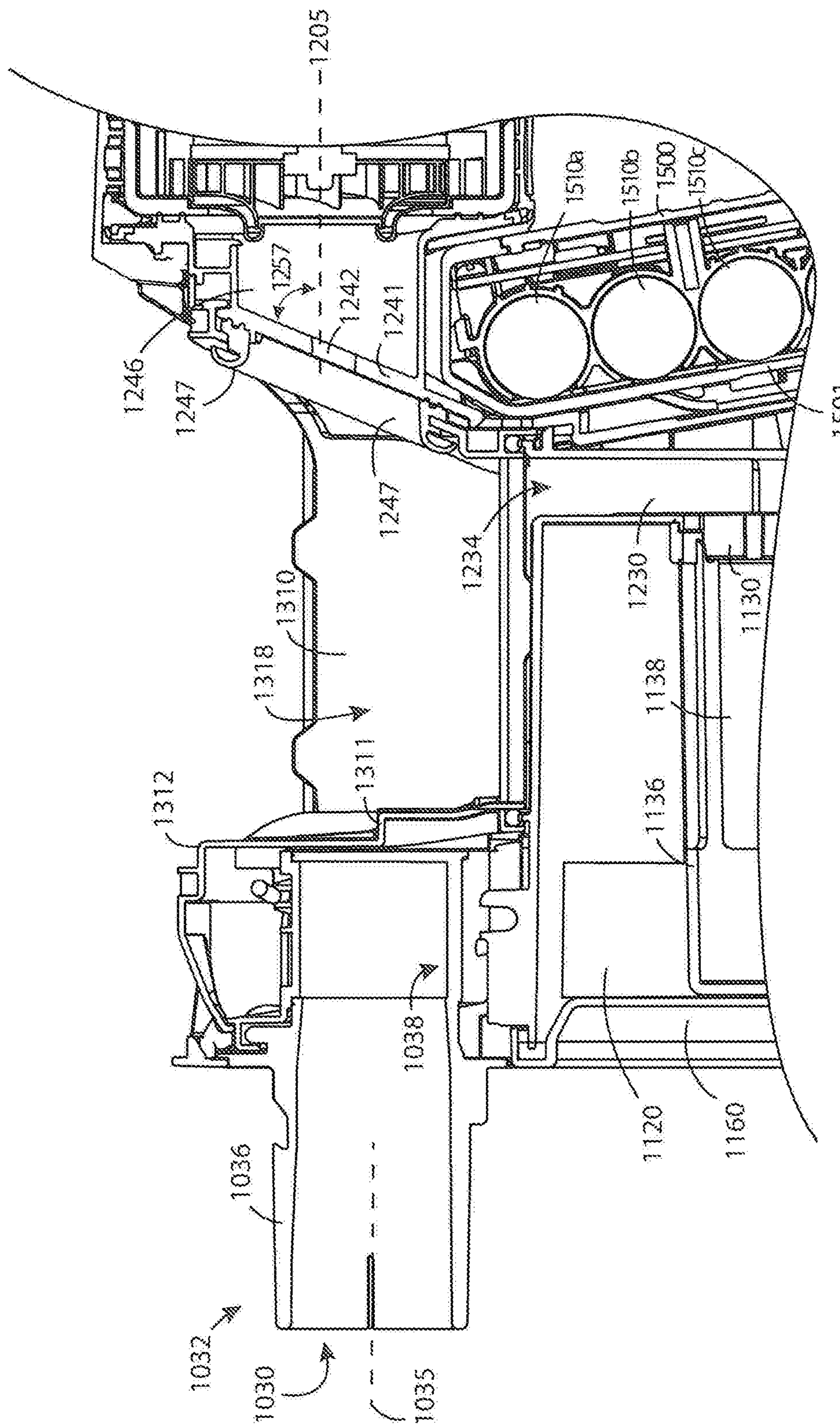
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FIG. 13

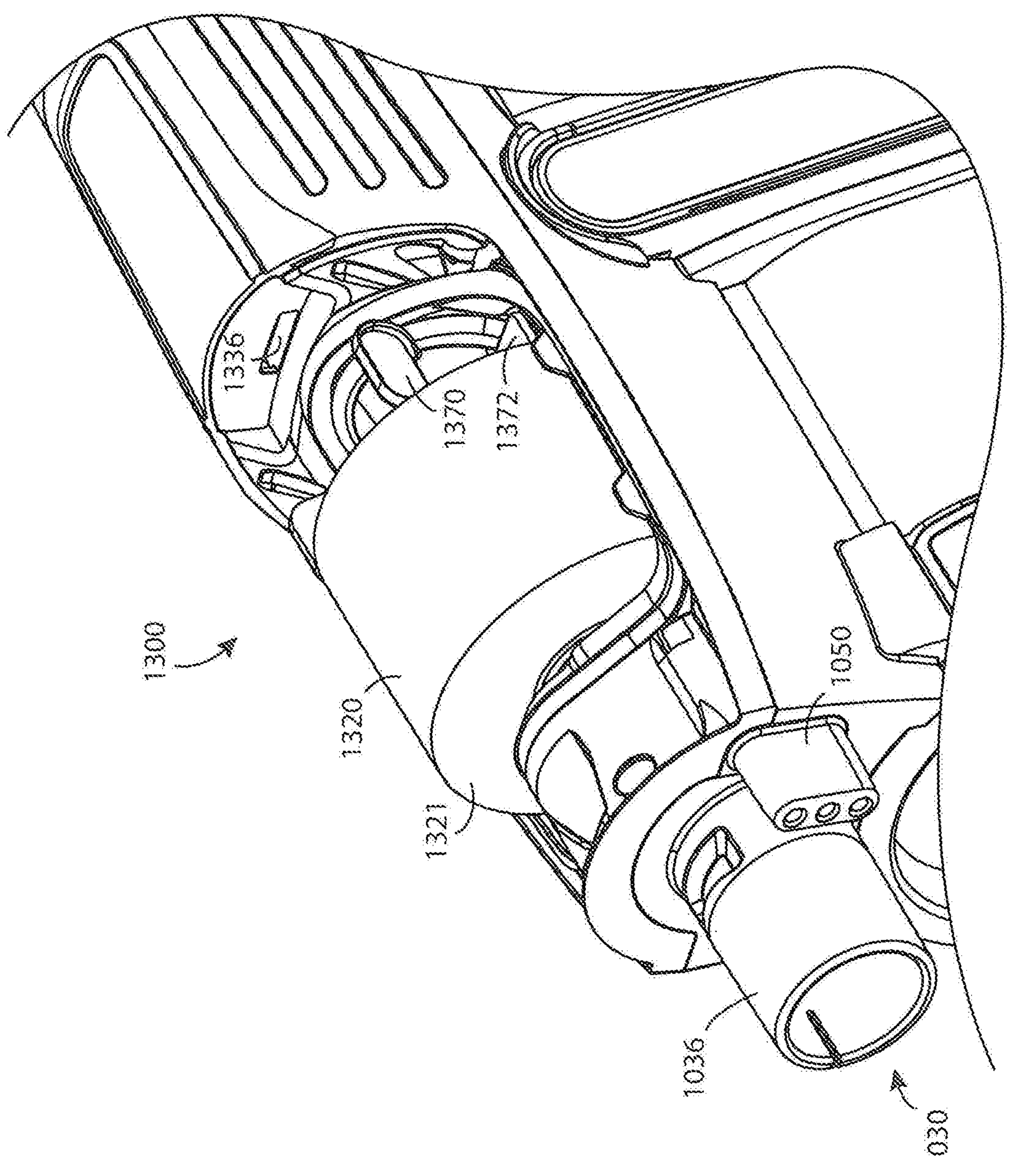

FIG. 14

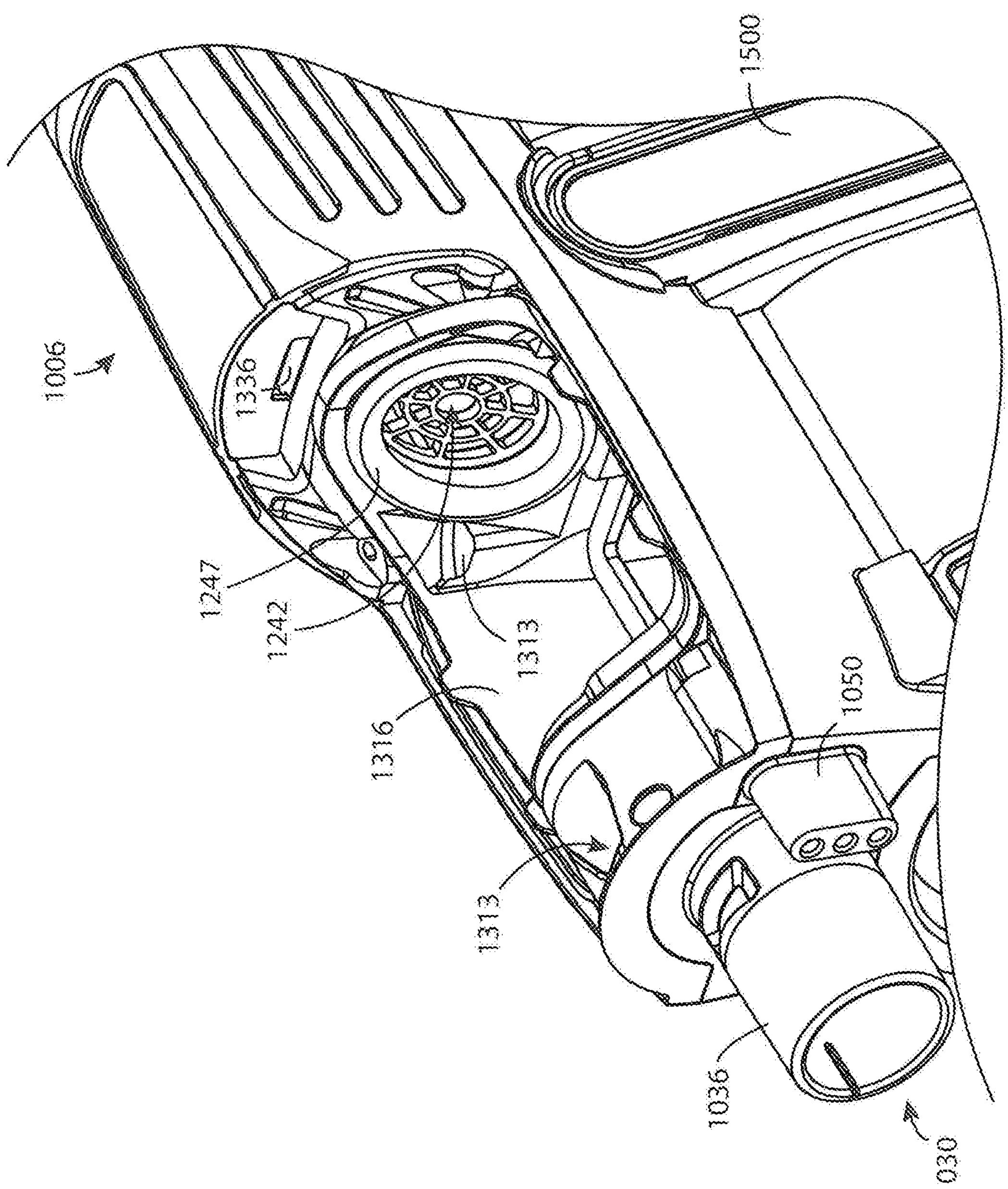

FIG. 15

FIG. 16

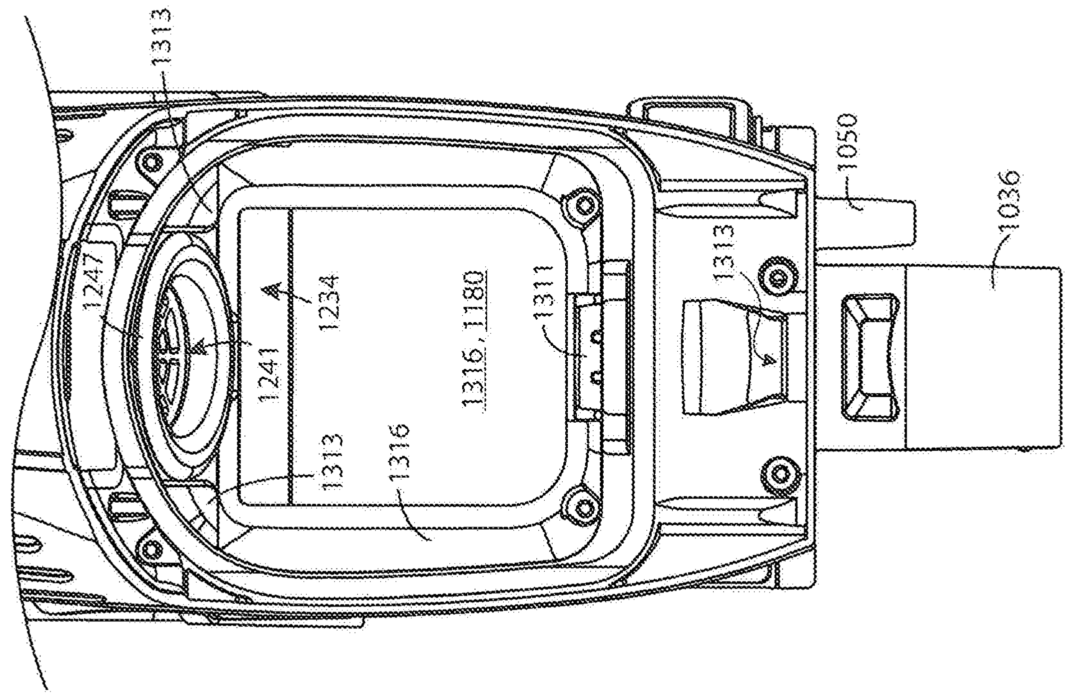
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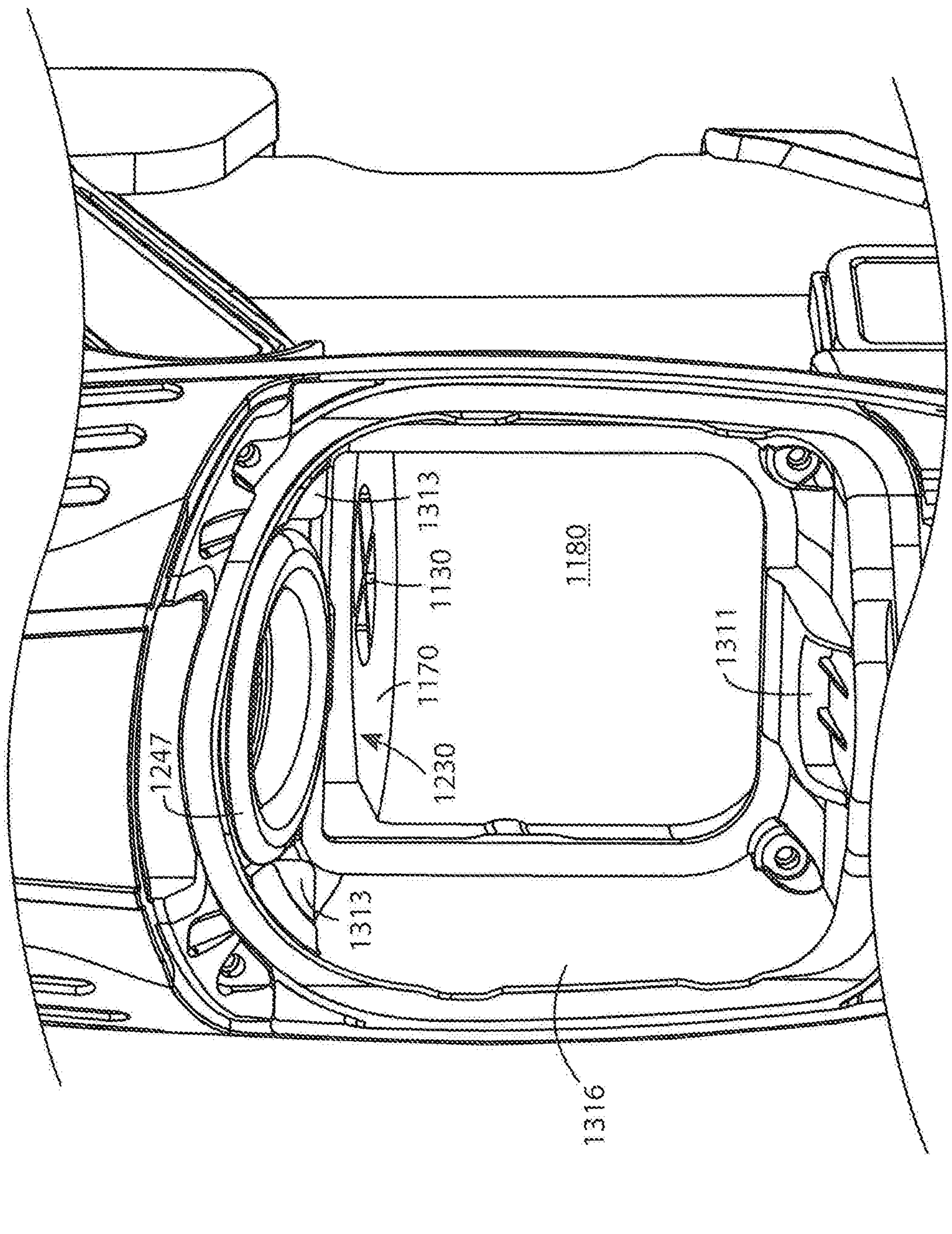
FIG. 17



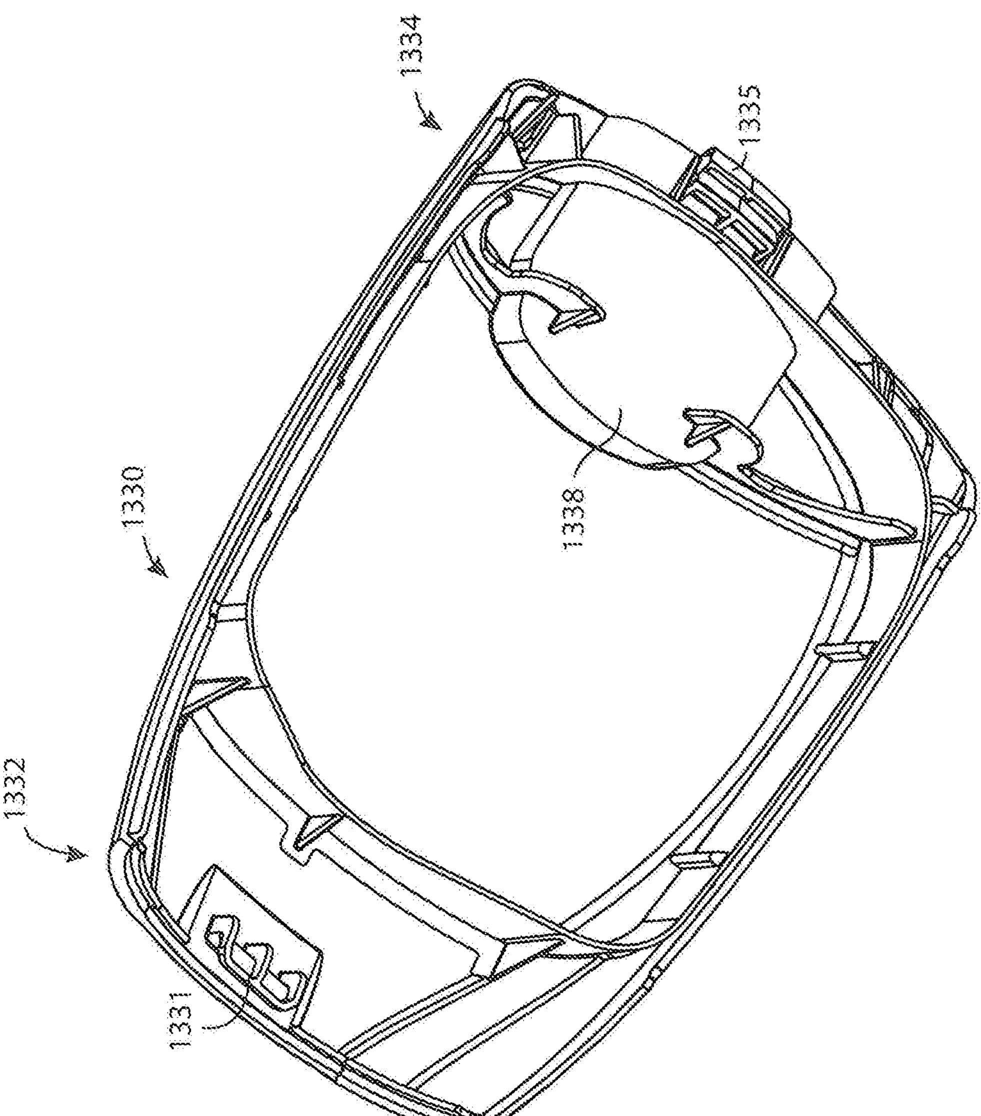


FIG. 18

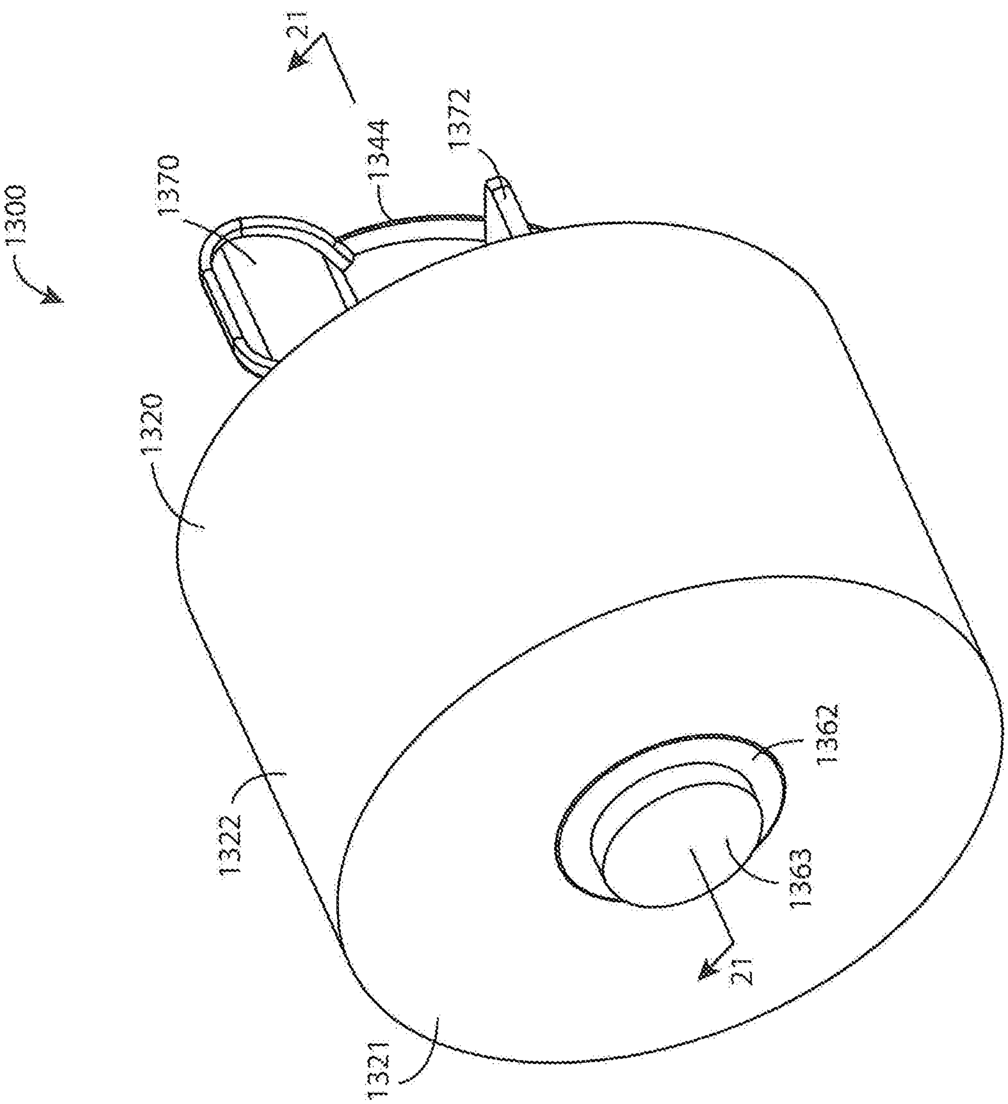


FIG. 19

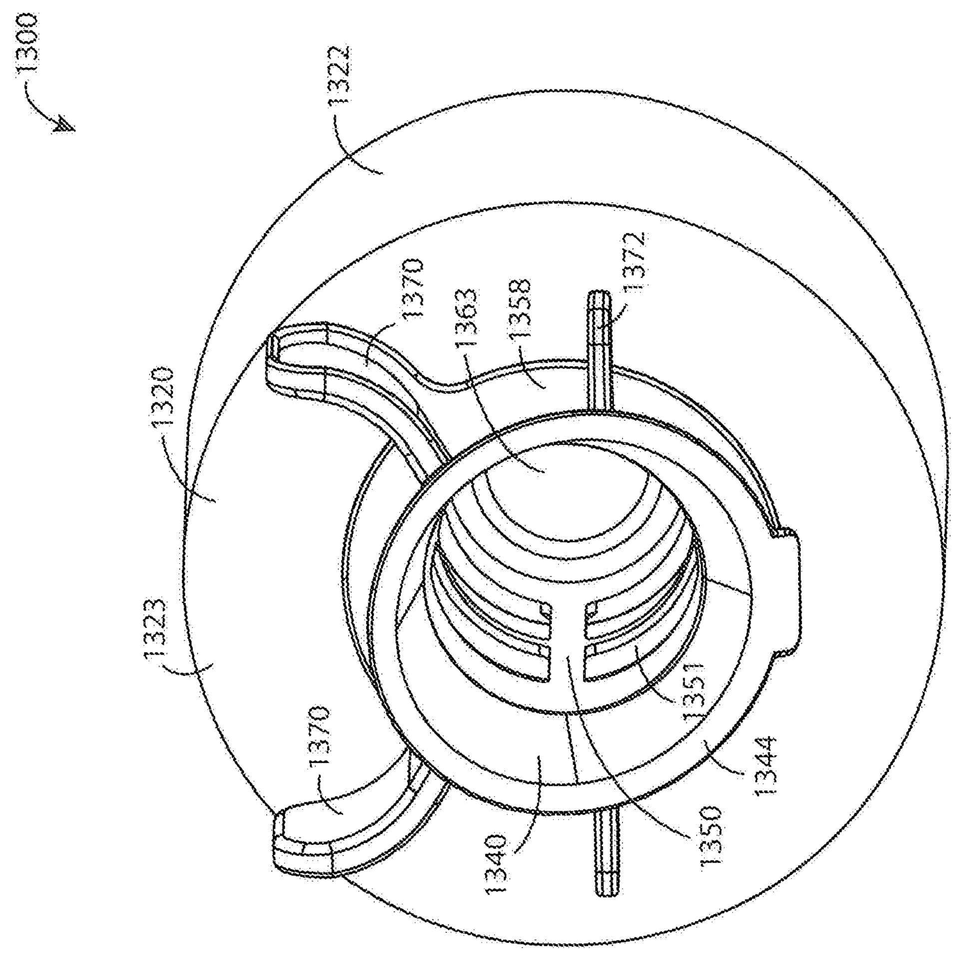

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FIG. 20

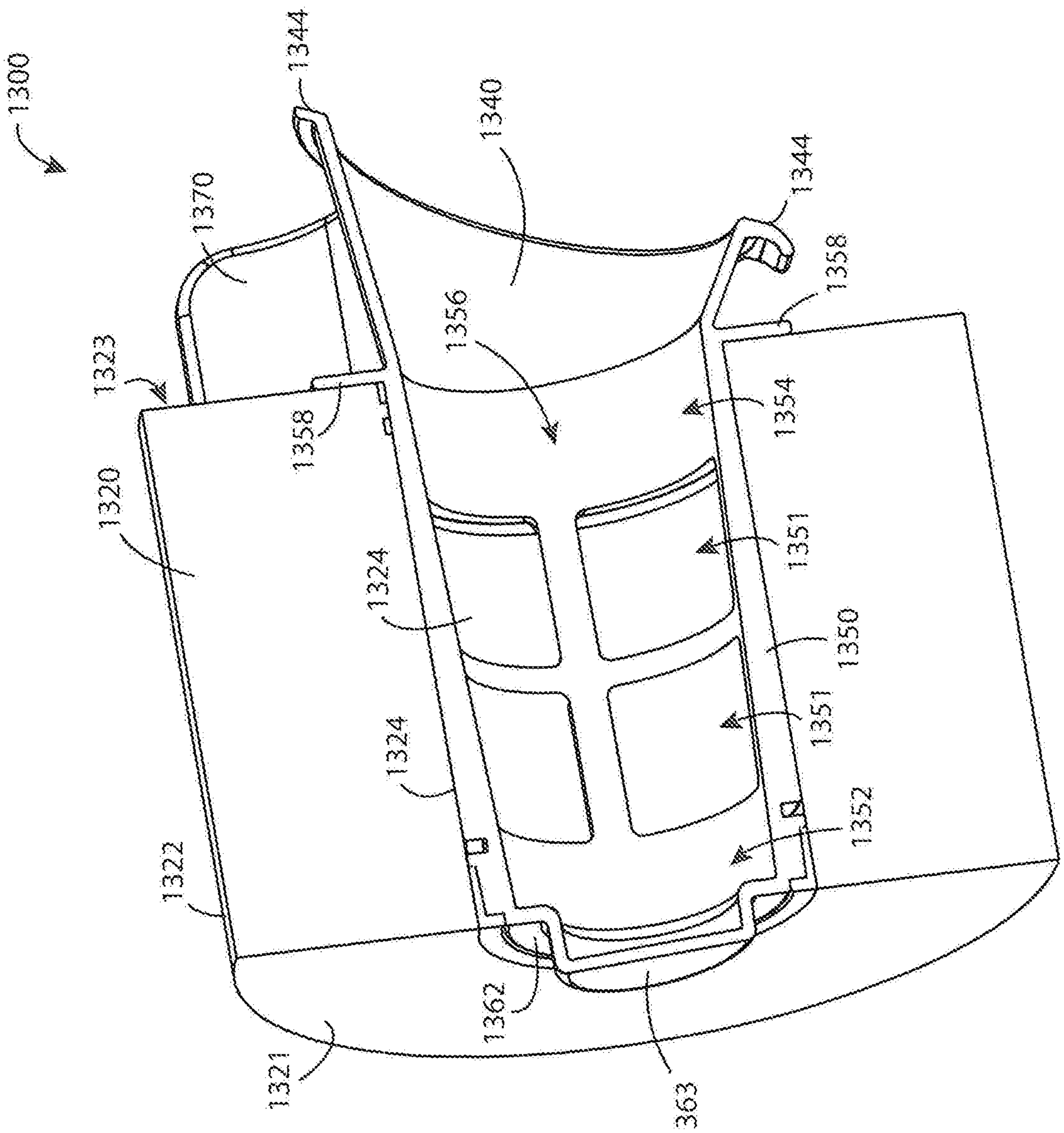
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FIG. 21

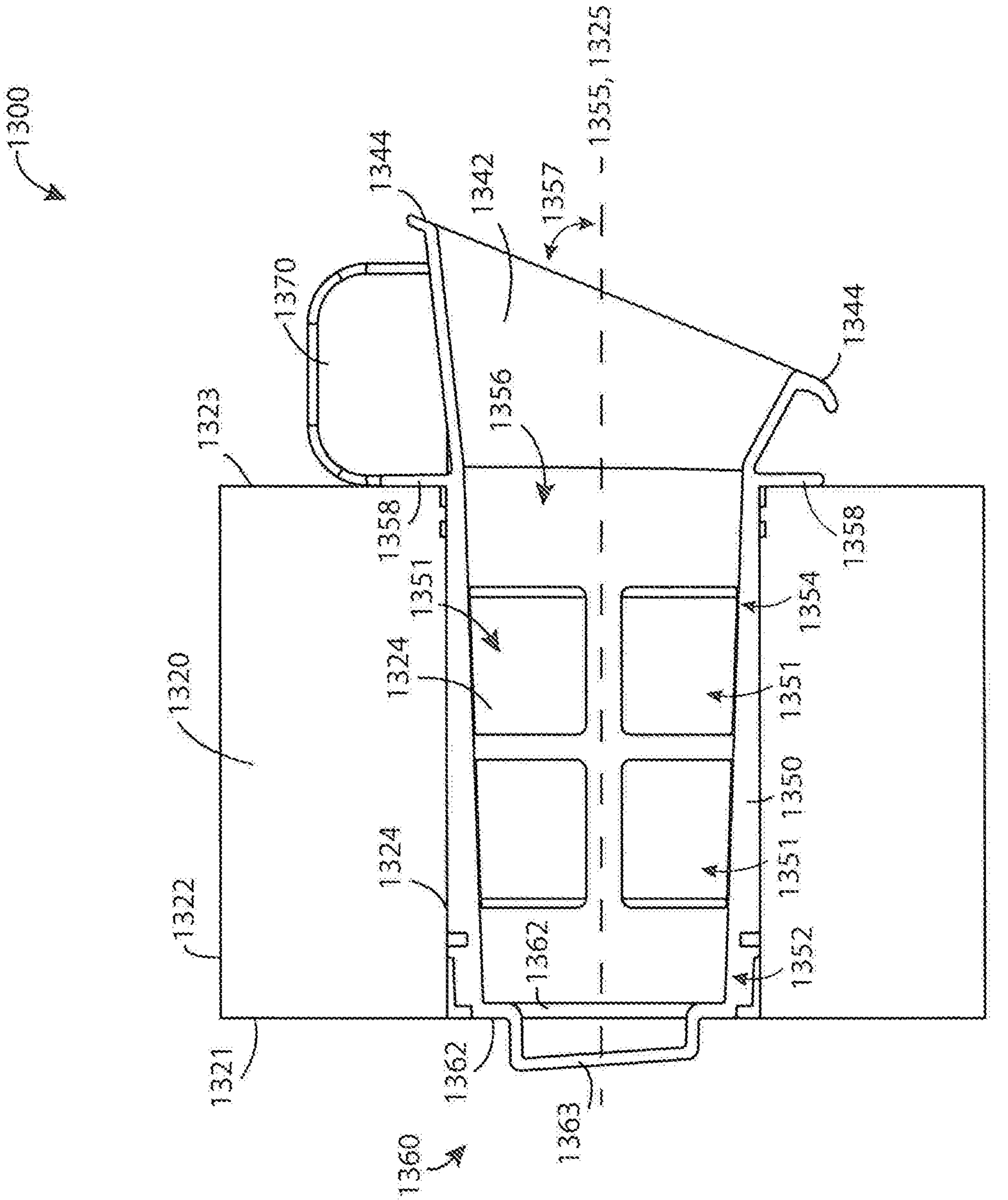

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FIG. 22

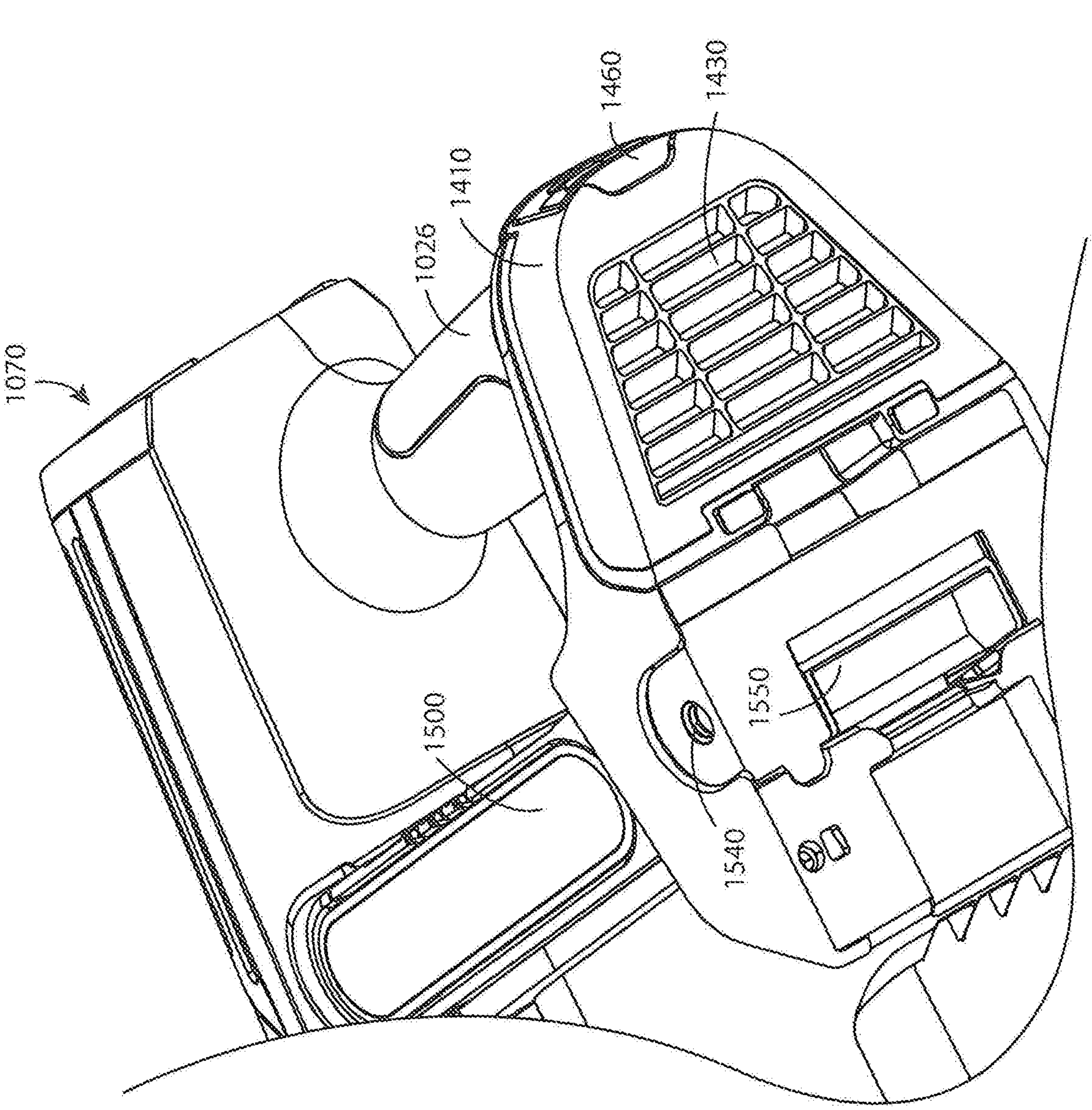


FIG. 23

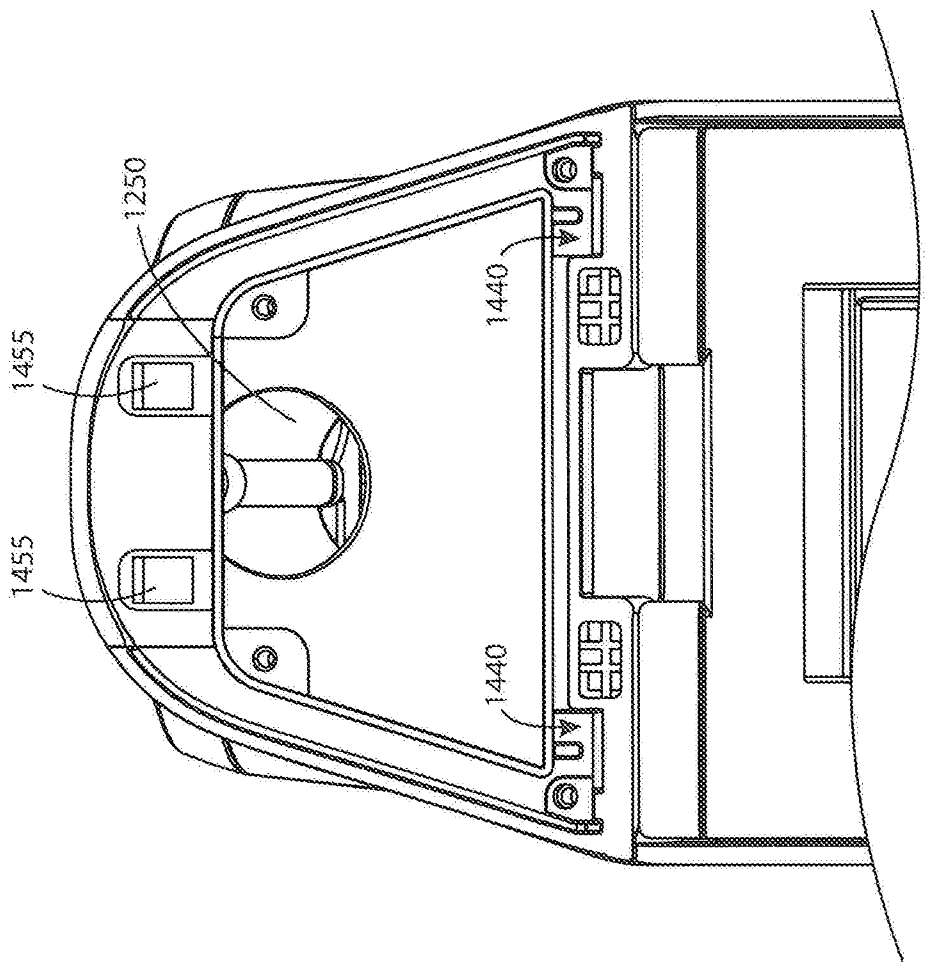
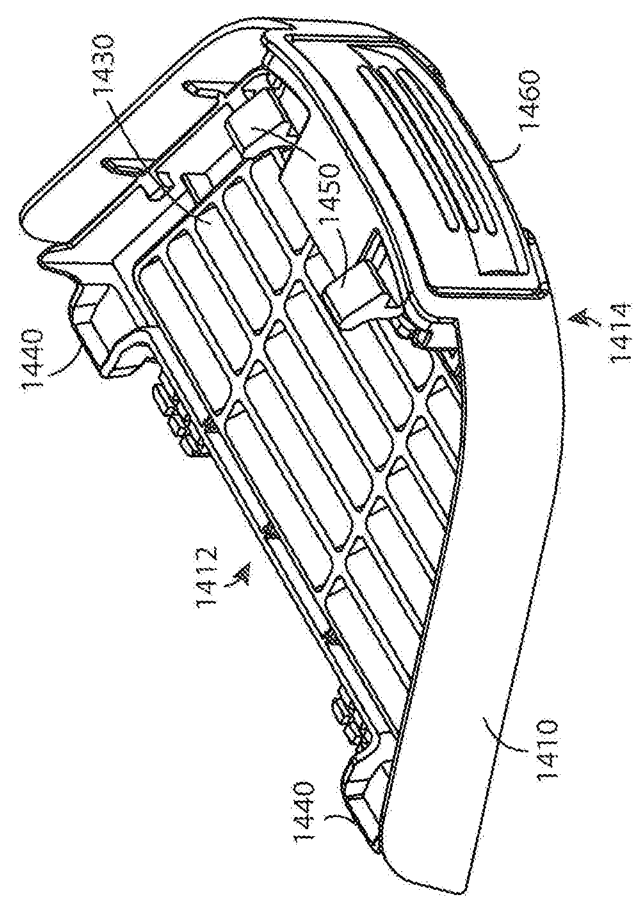


FIG. 24

FIG. 25



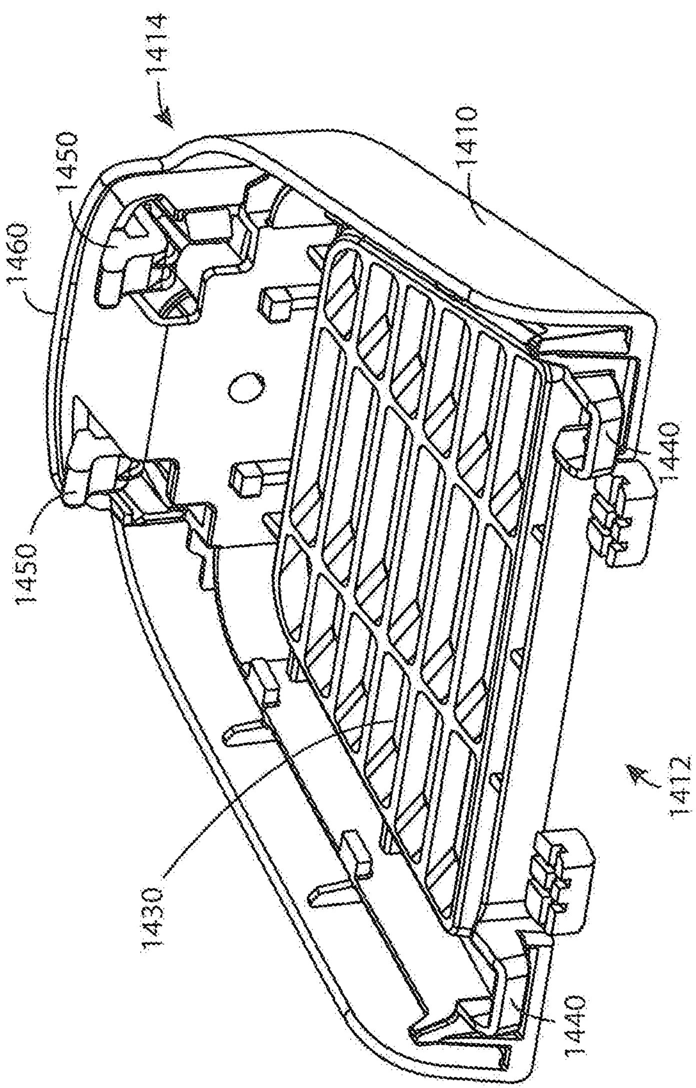


FIG. 26

FIG. 27

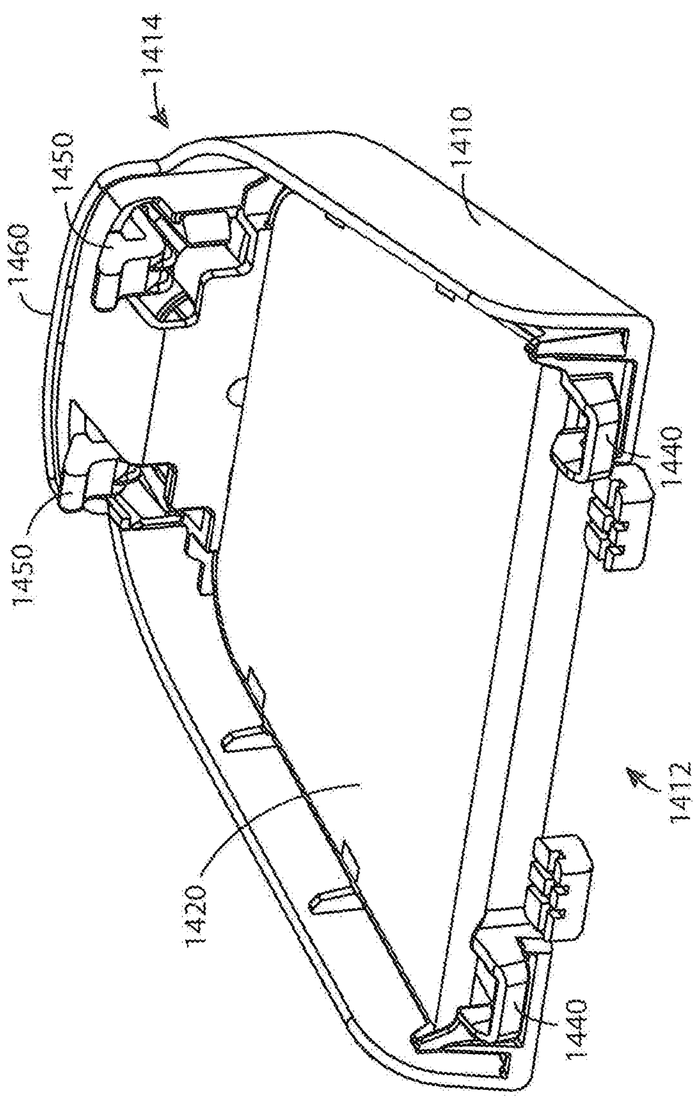
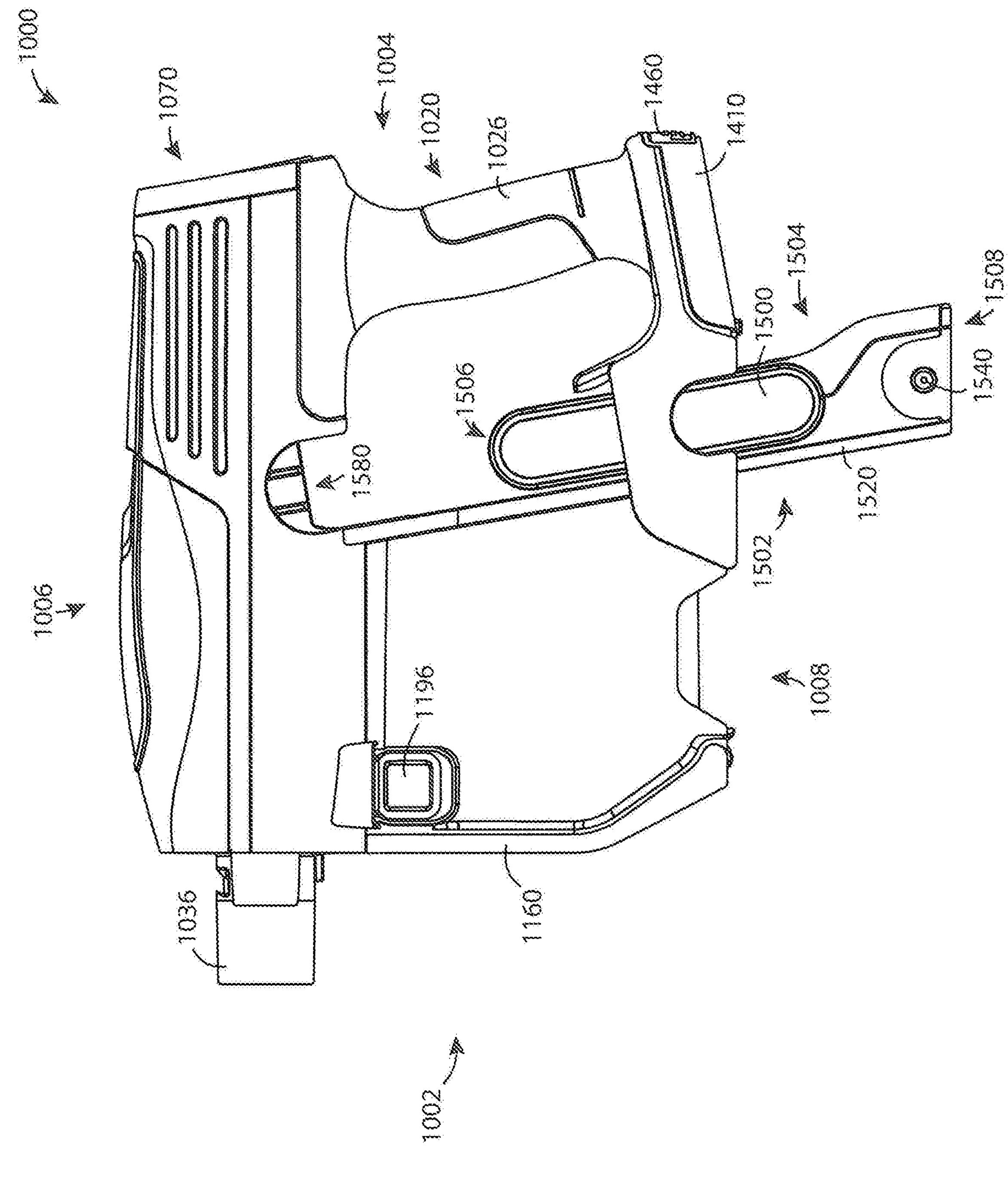


FIG. 28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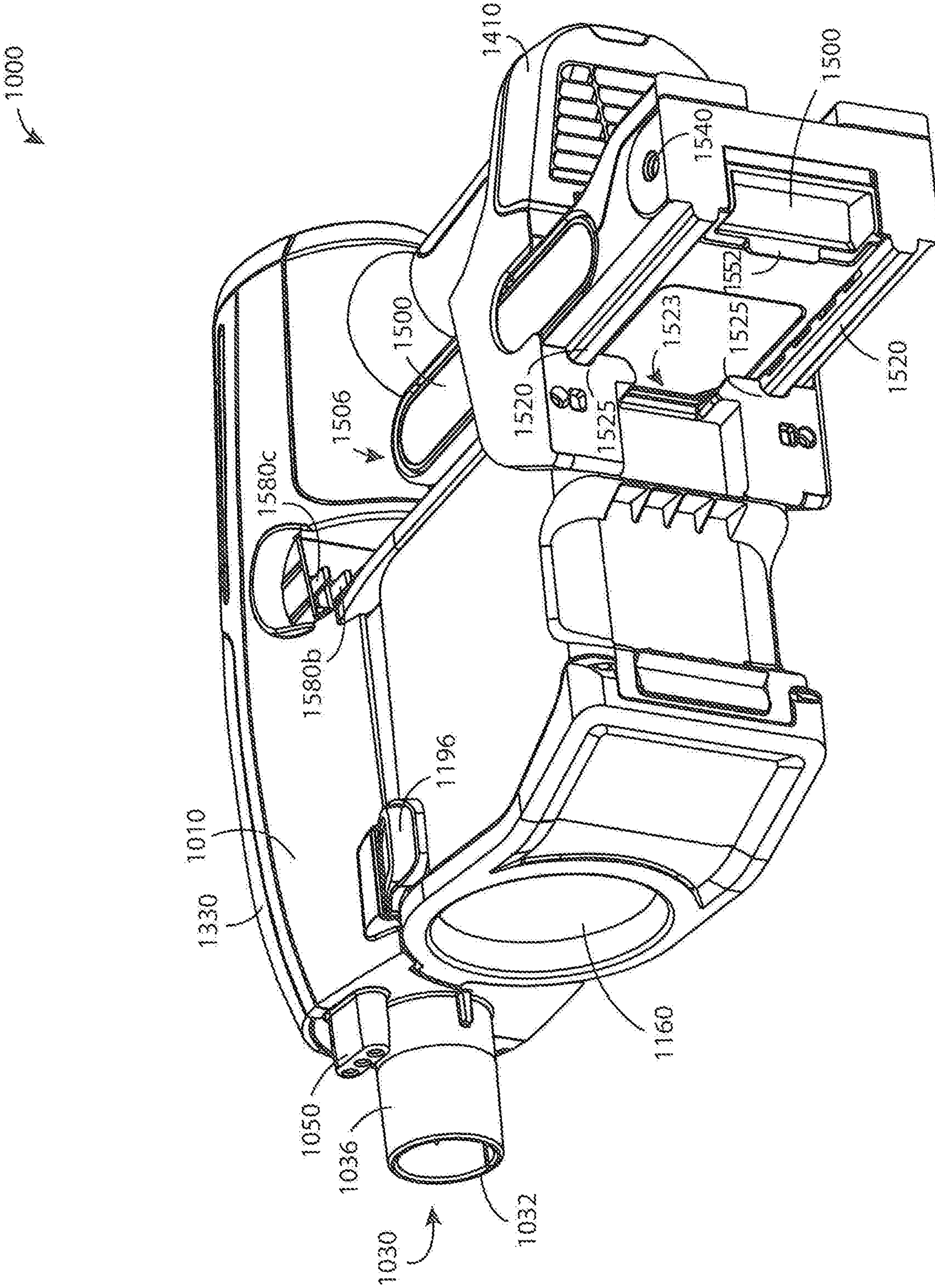
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FIG. 29

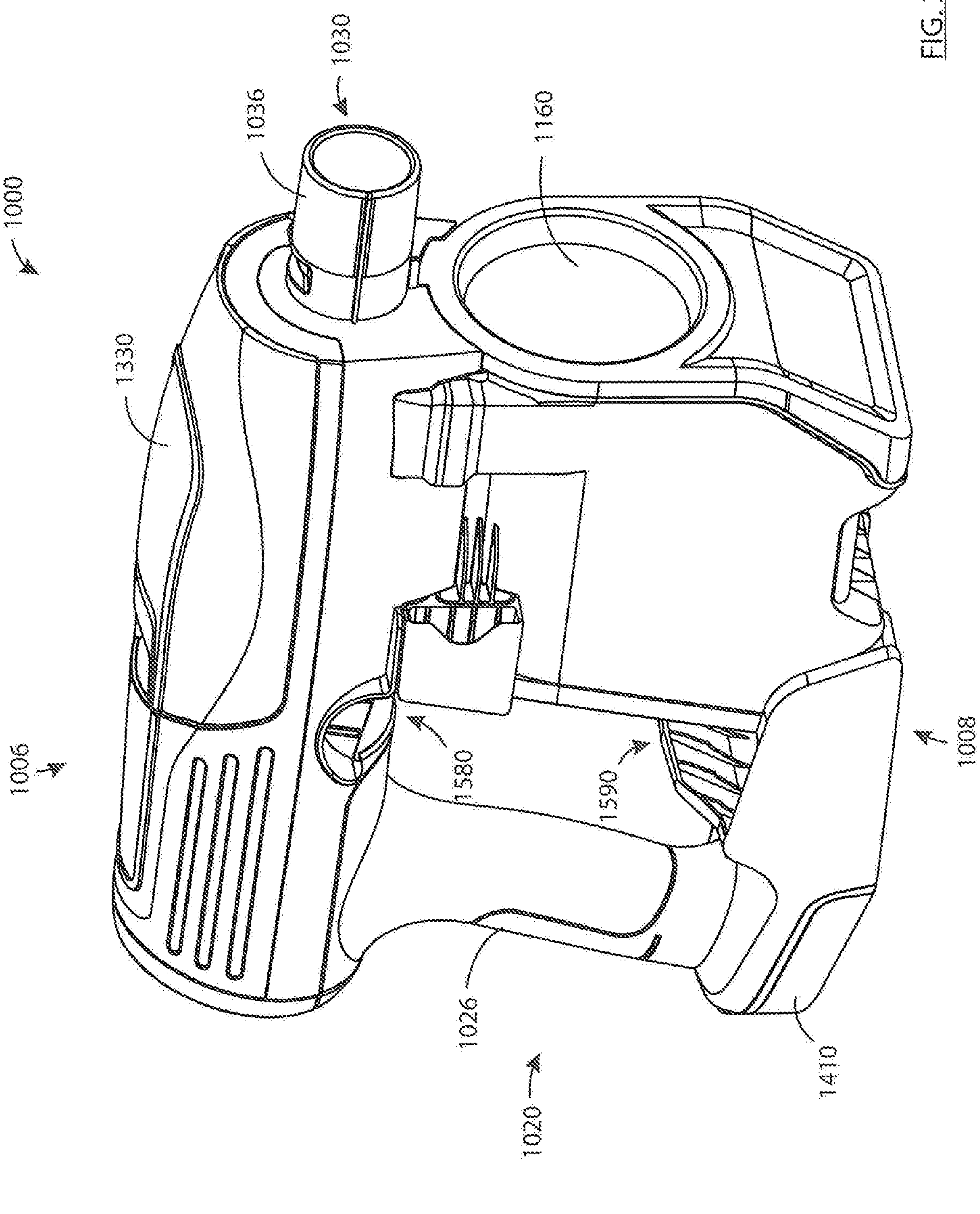

FIG. 30

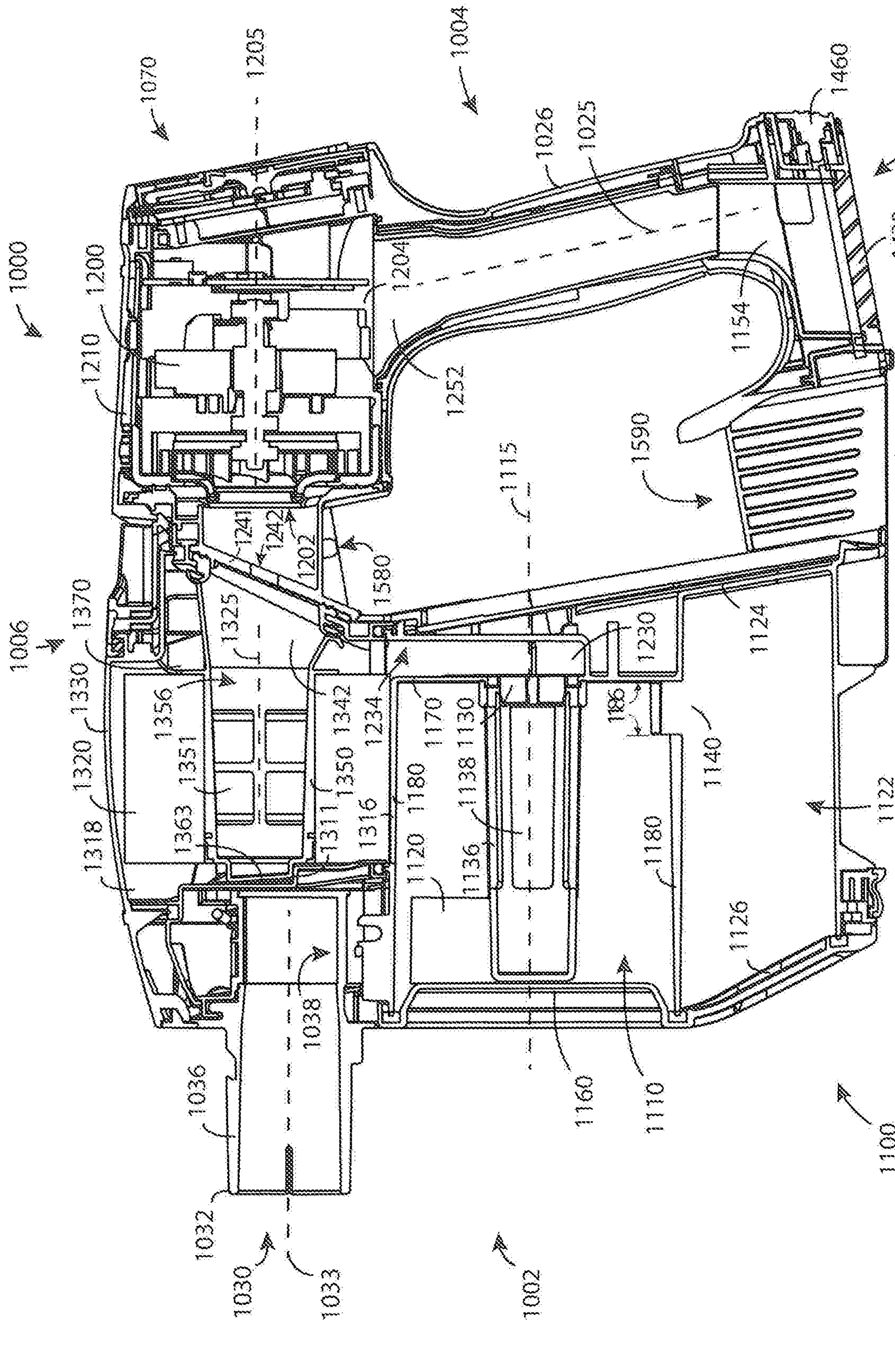
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FIG. 31

FIG. 32

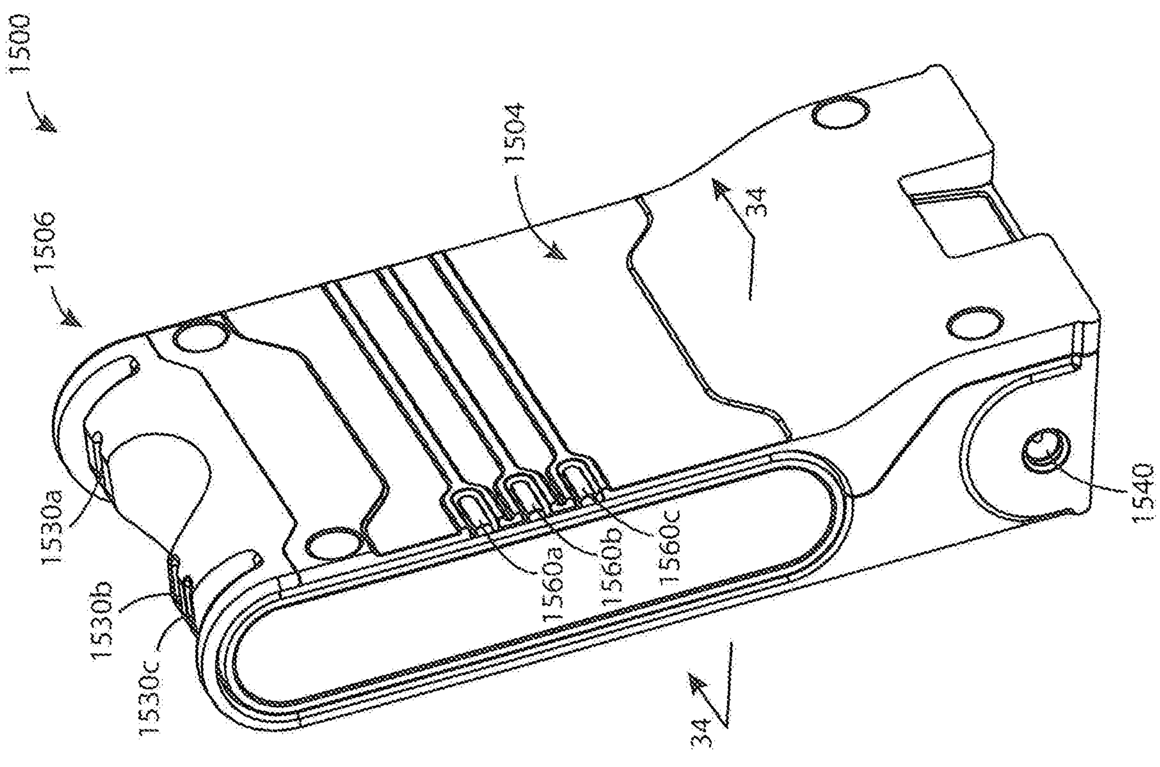
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FIG. 33

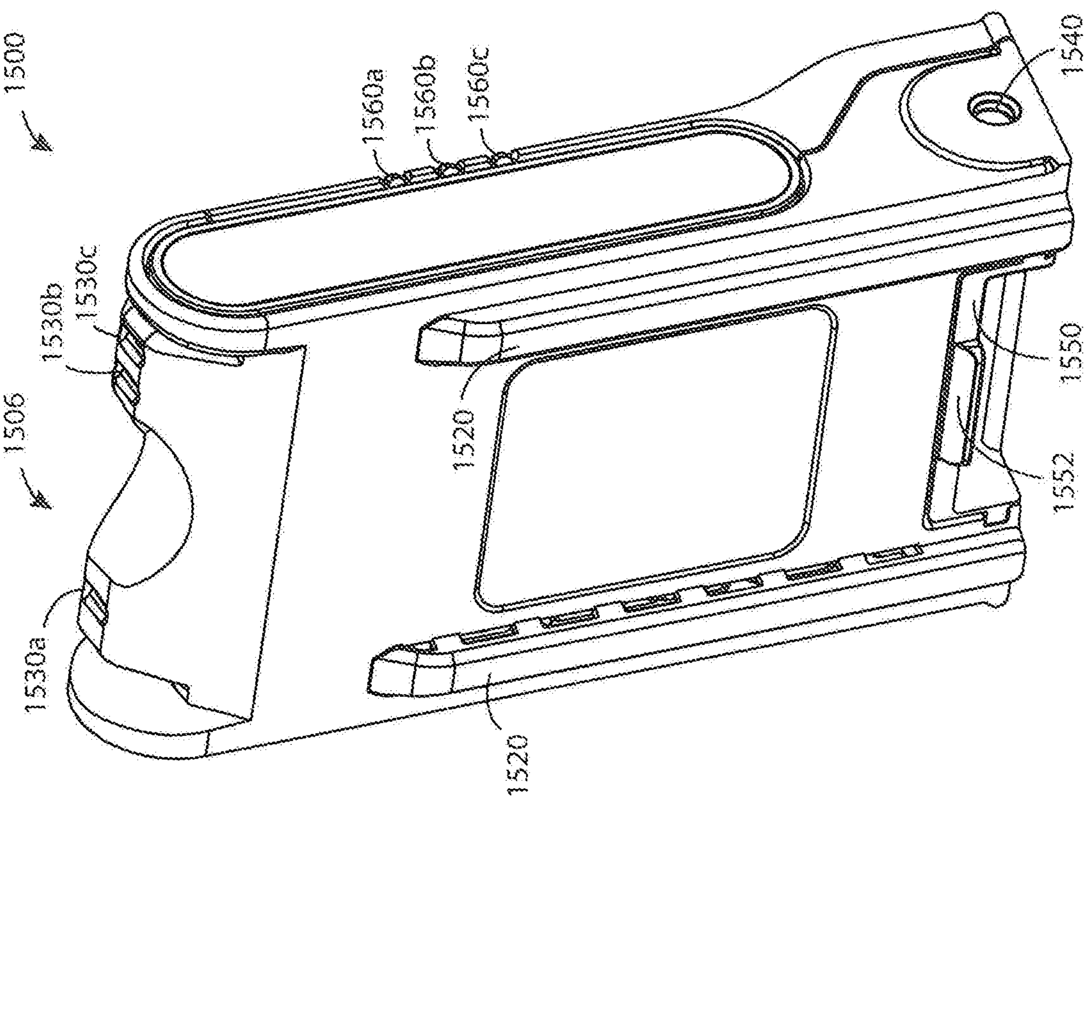
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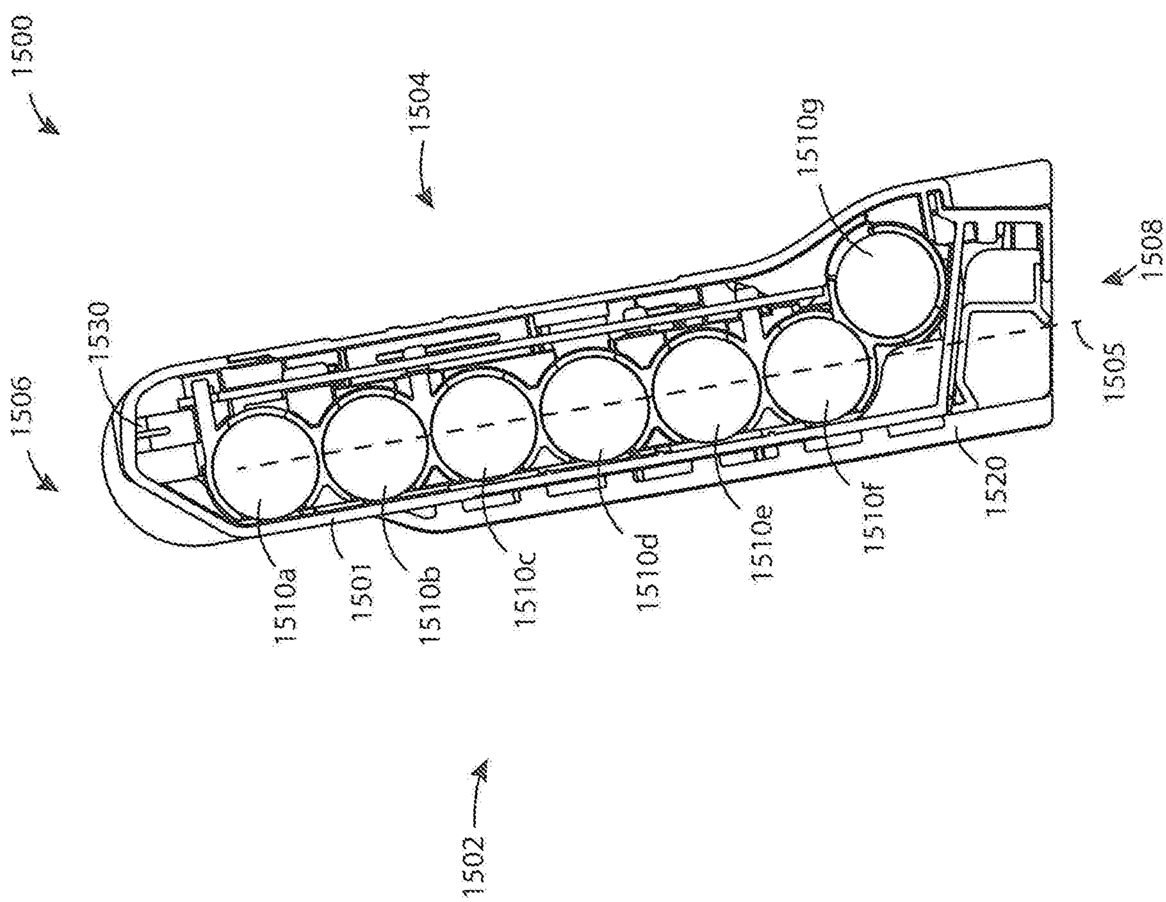
FIG. 34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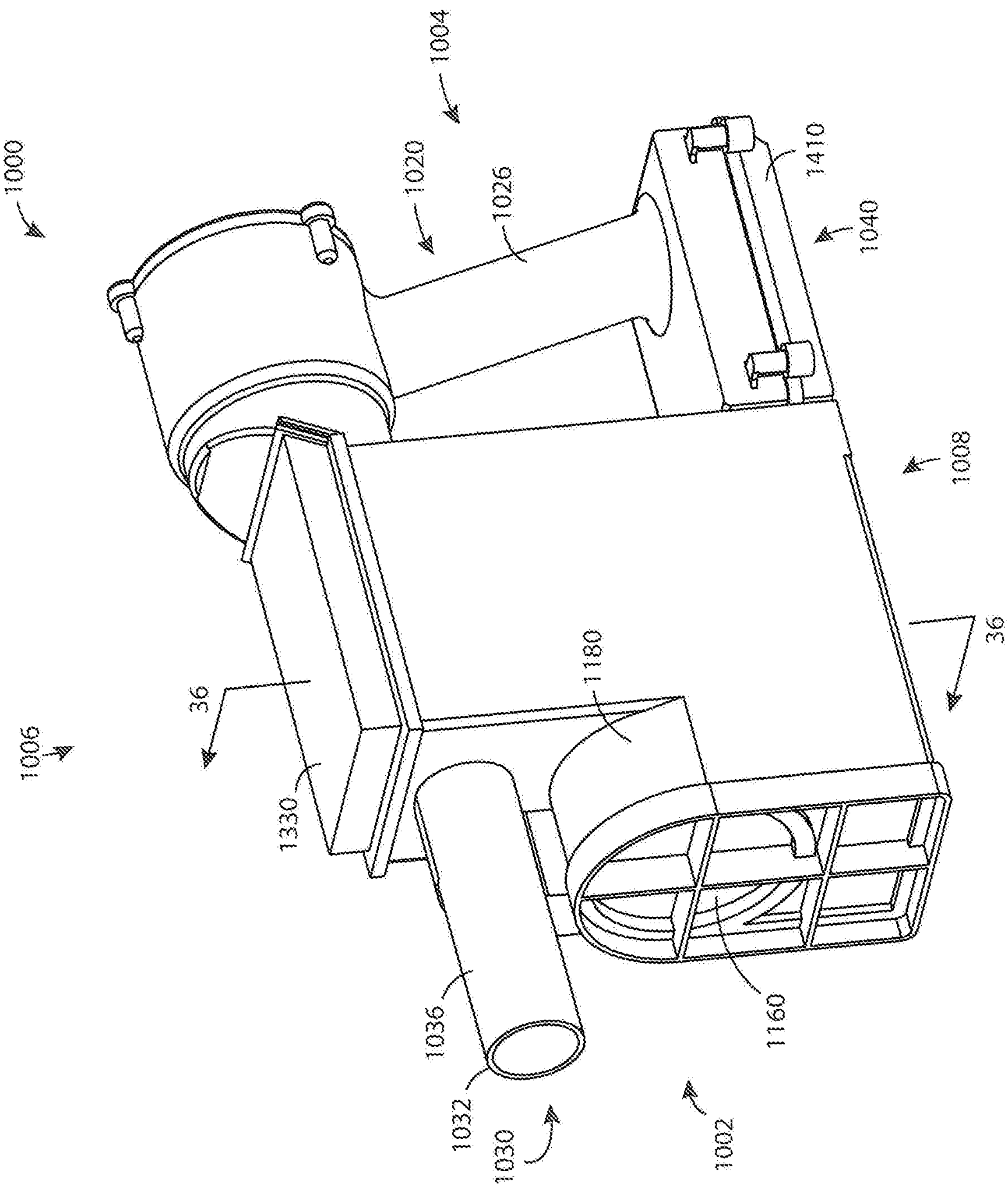
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FIG. 35

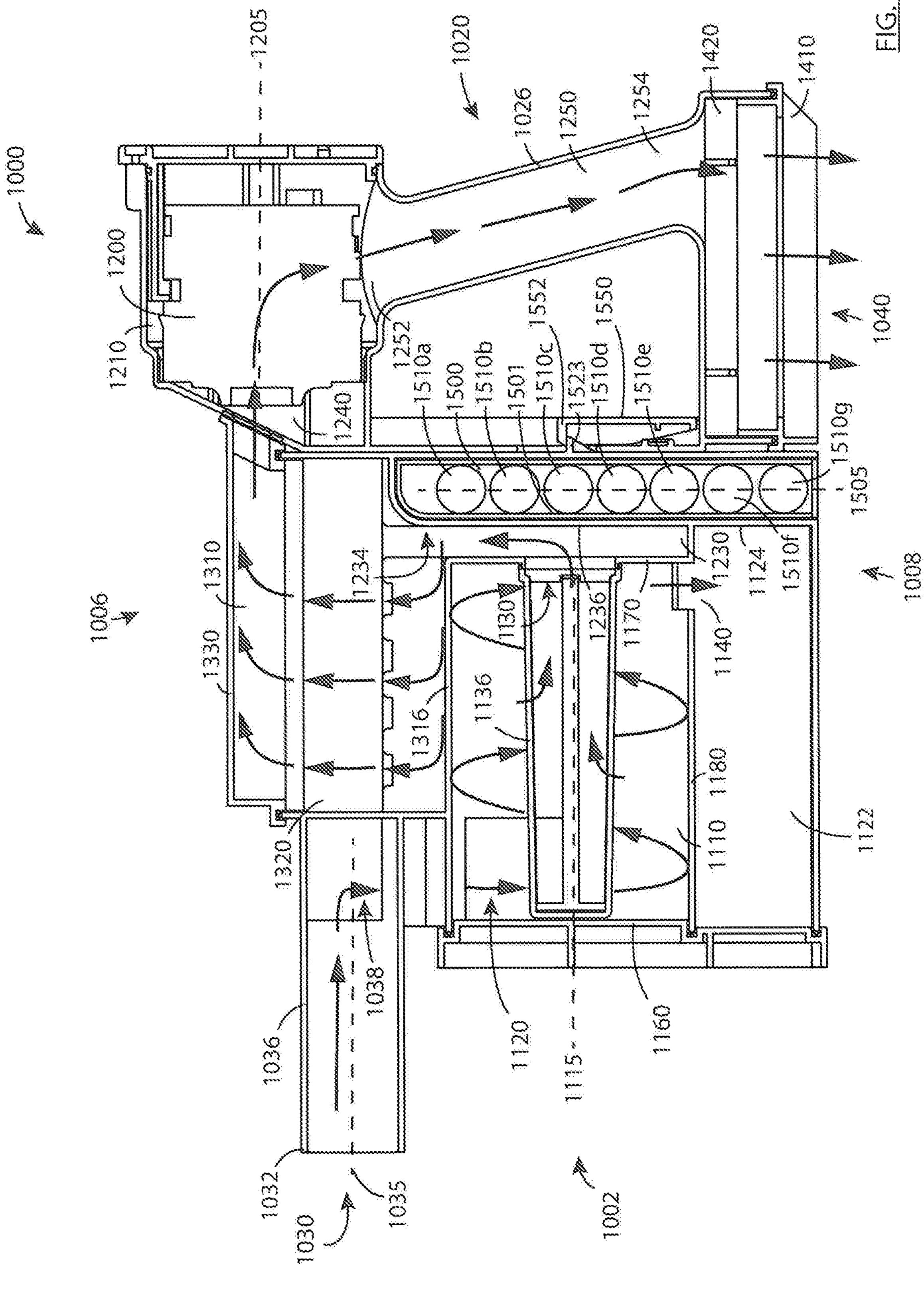
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FIG. 36

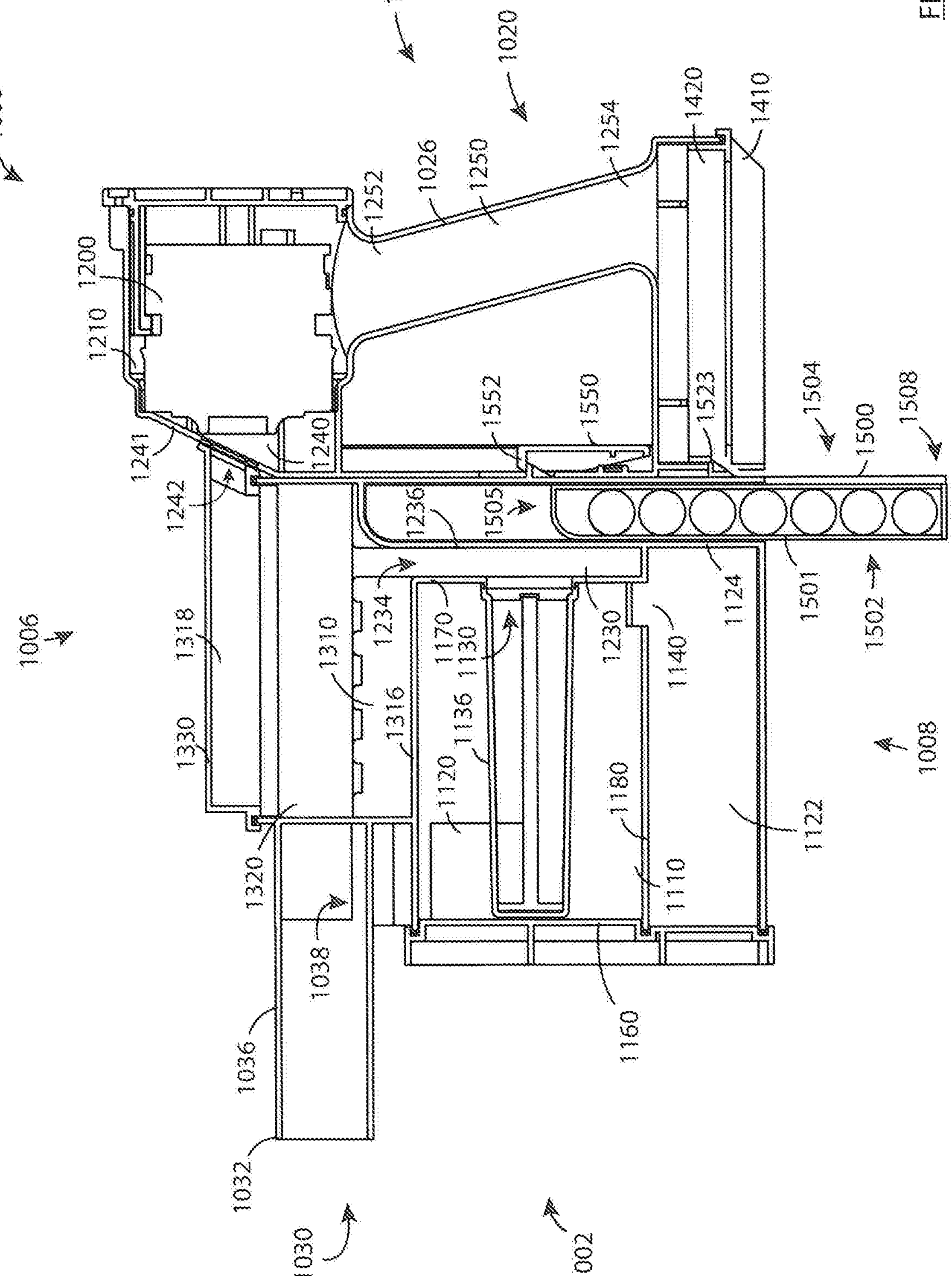
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FIG. 37

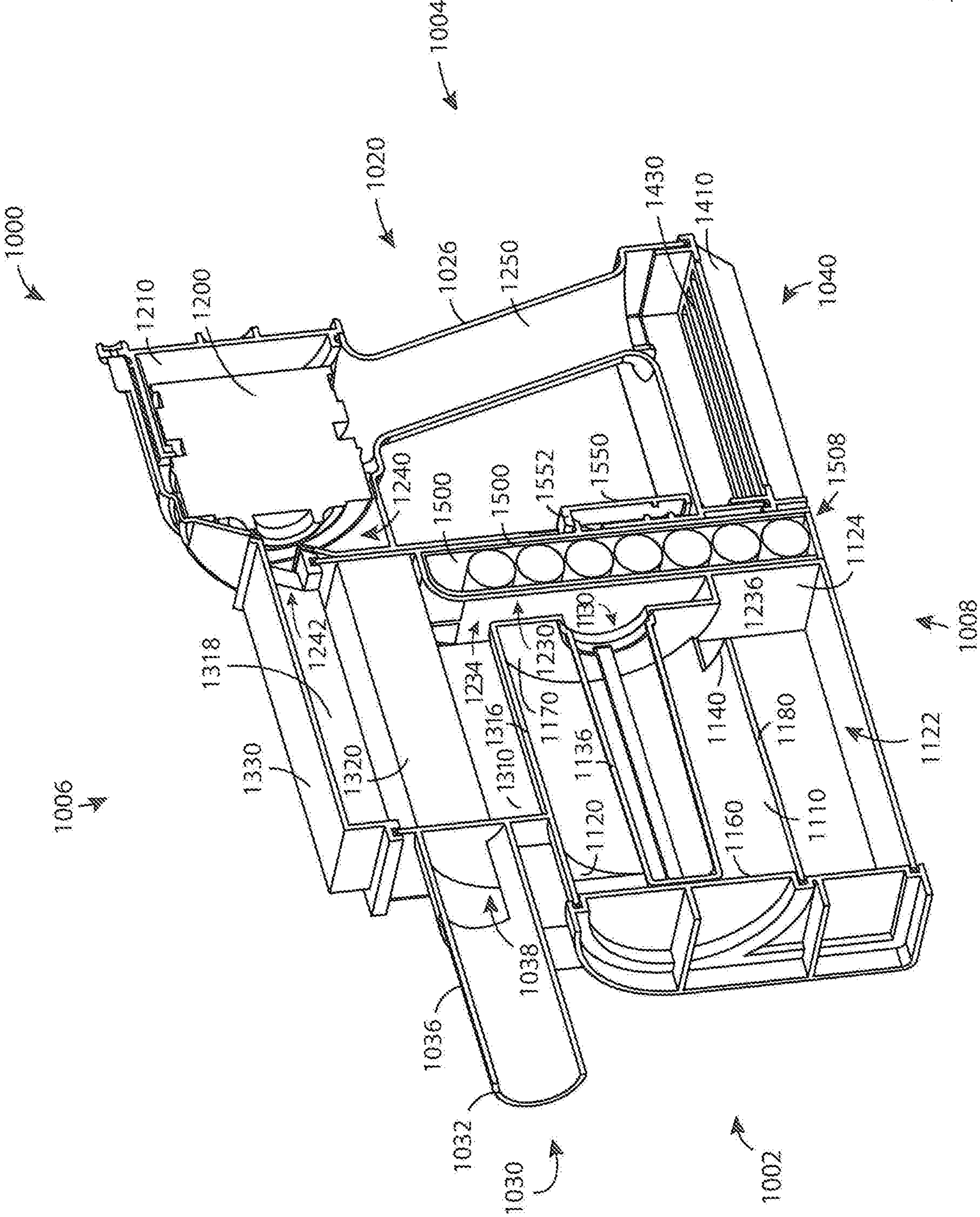
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FIG. 38

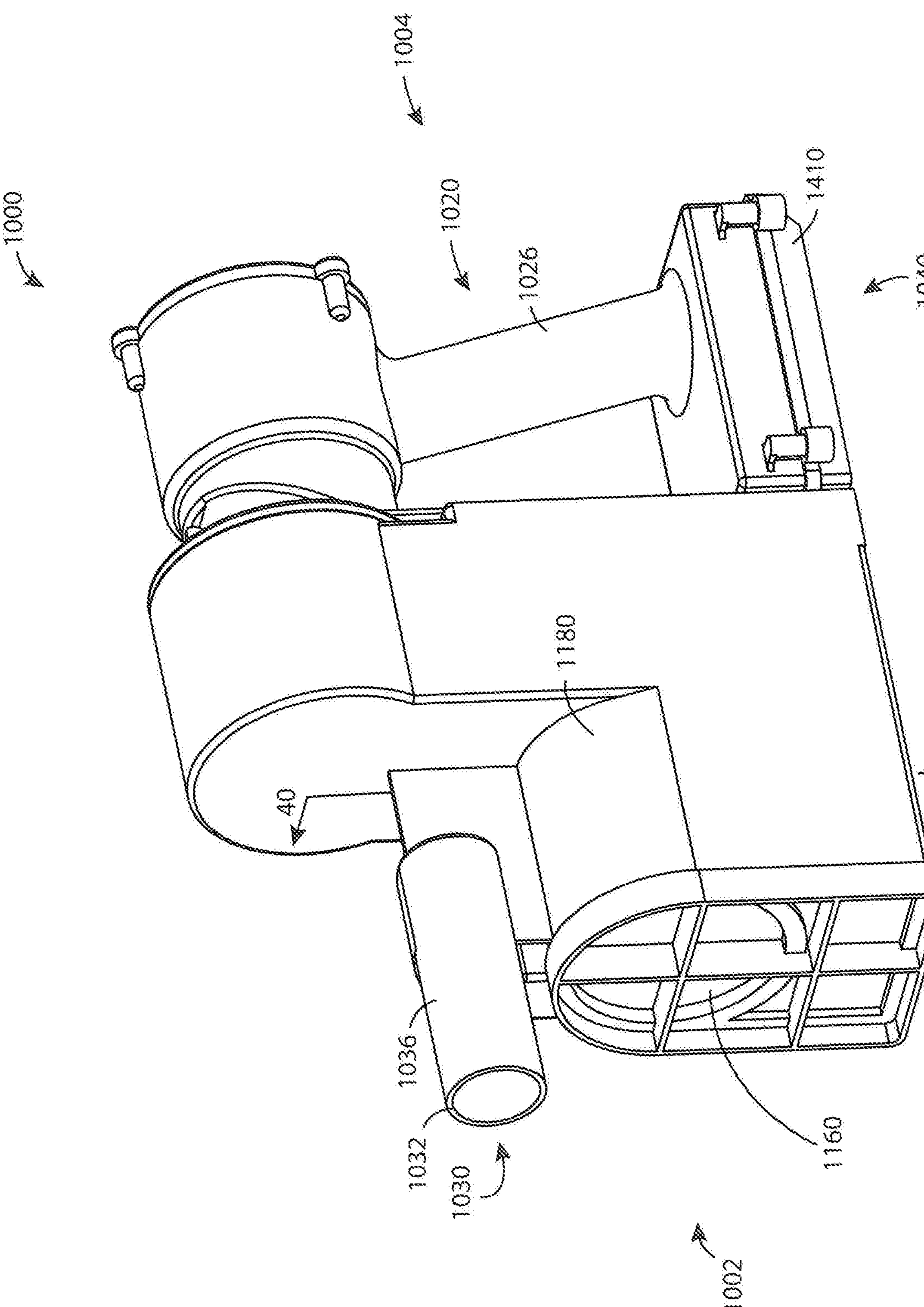
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FIG. 39

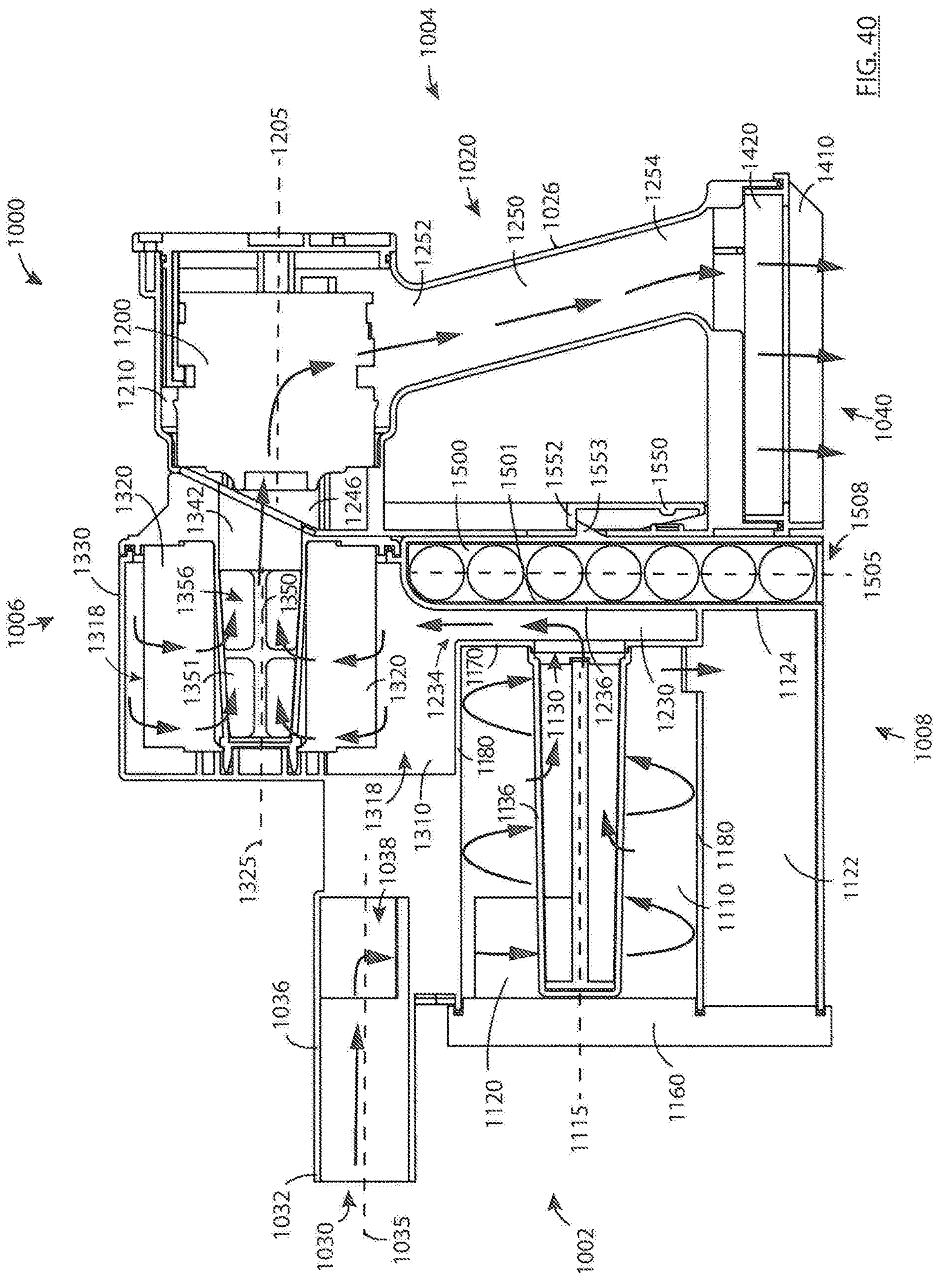
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FIG. 40

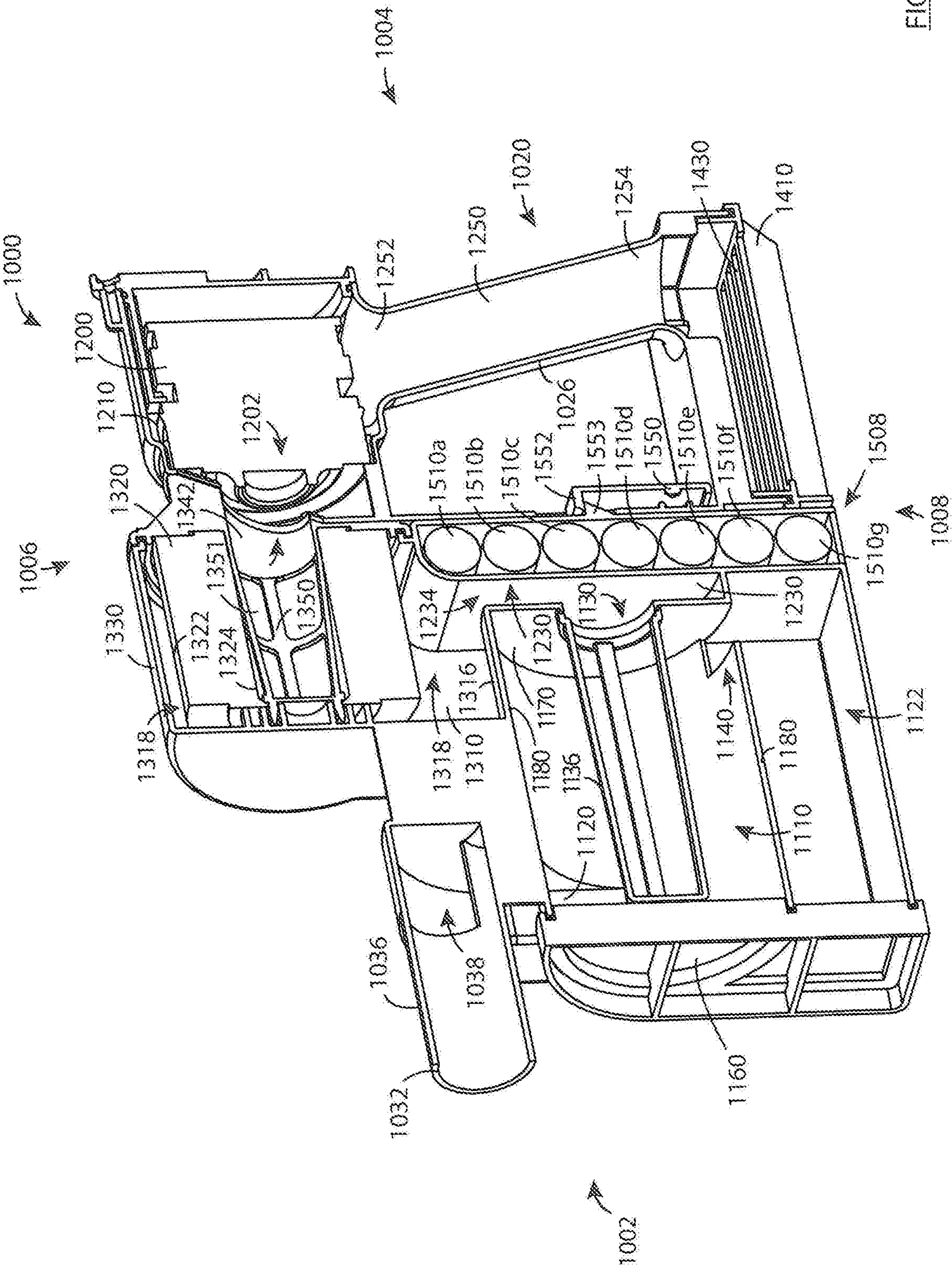
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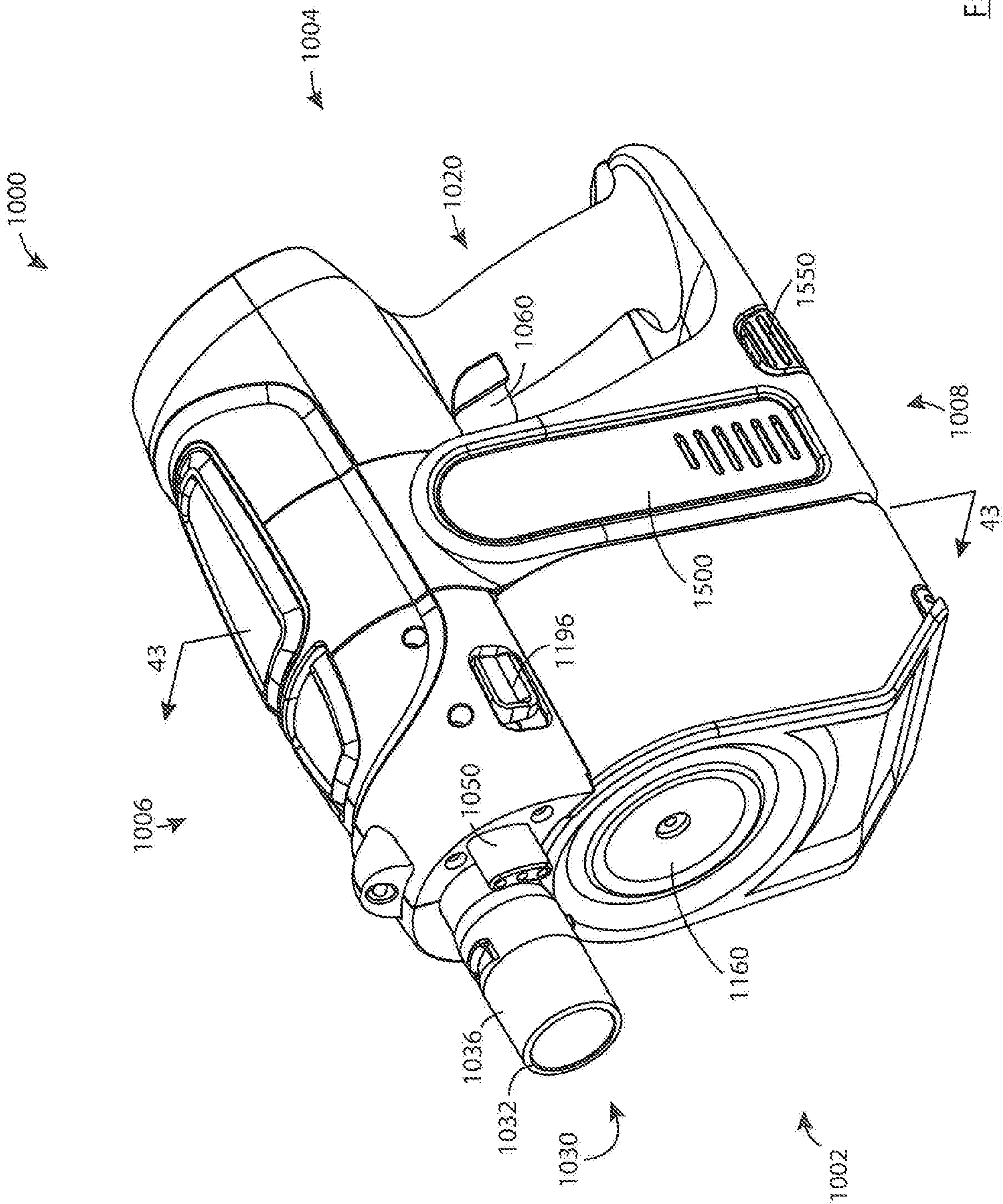
FIG. 41

FIG. 42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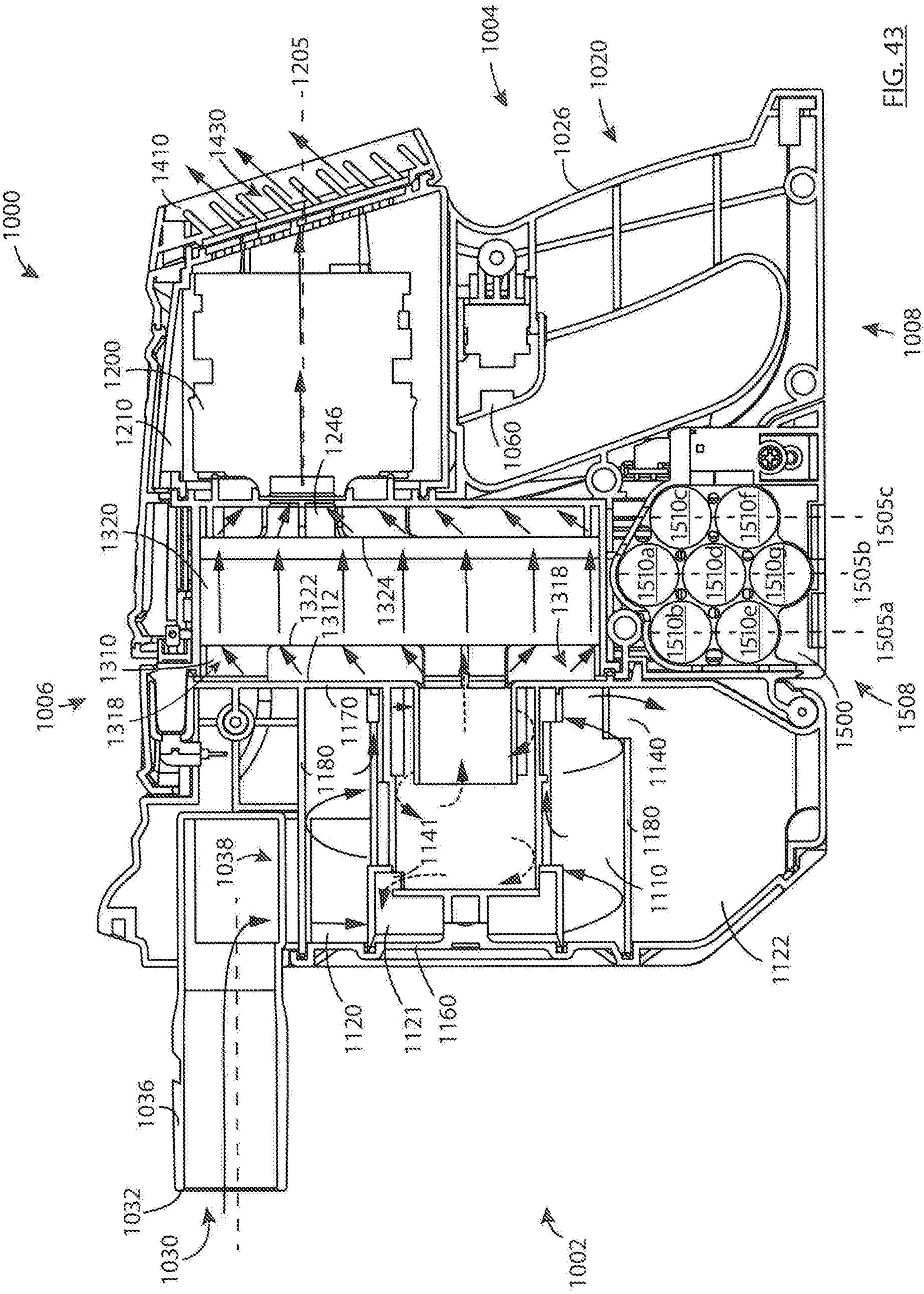
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FIG. 43

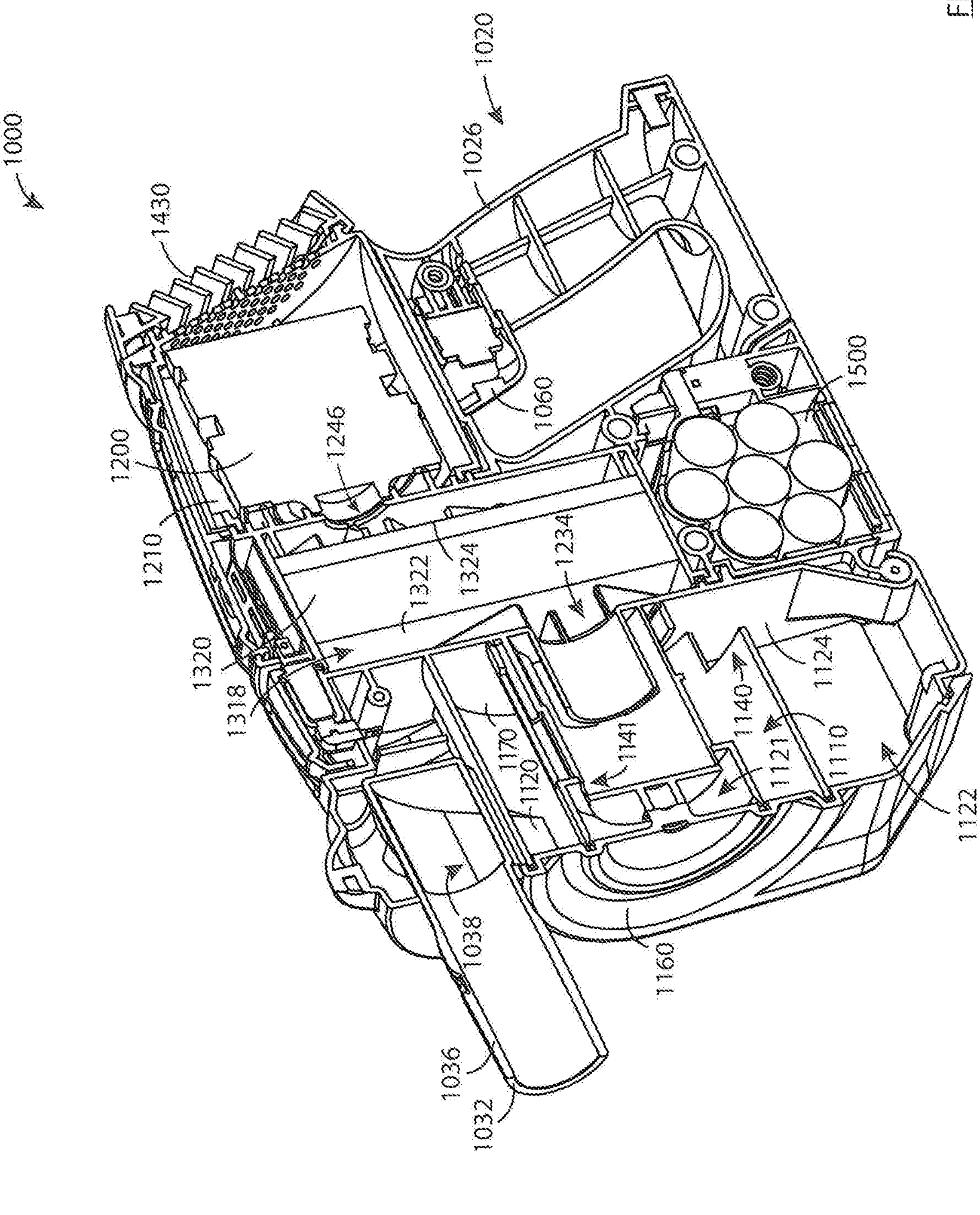
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FIG. 44

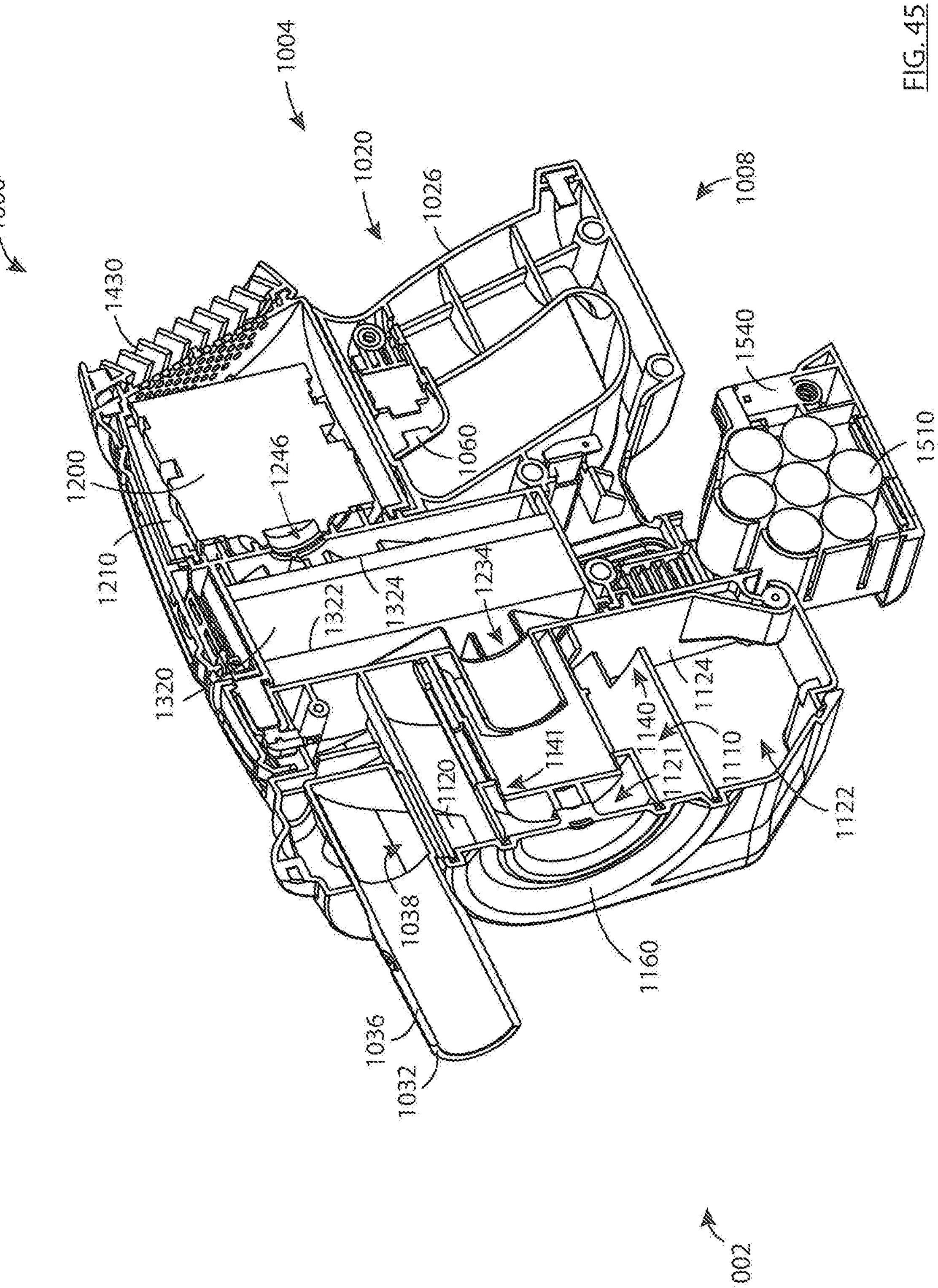
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FIG. 45

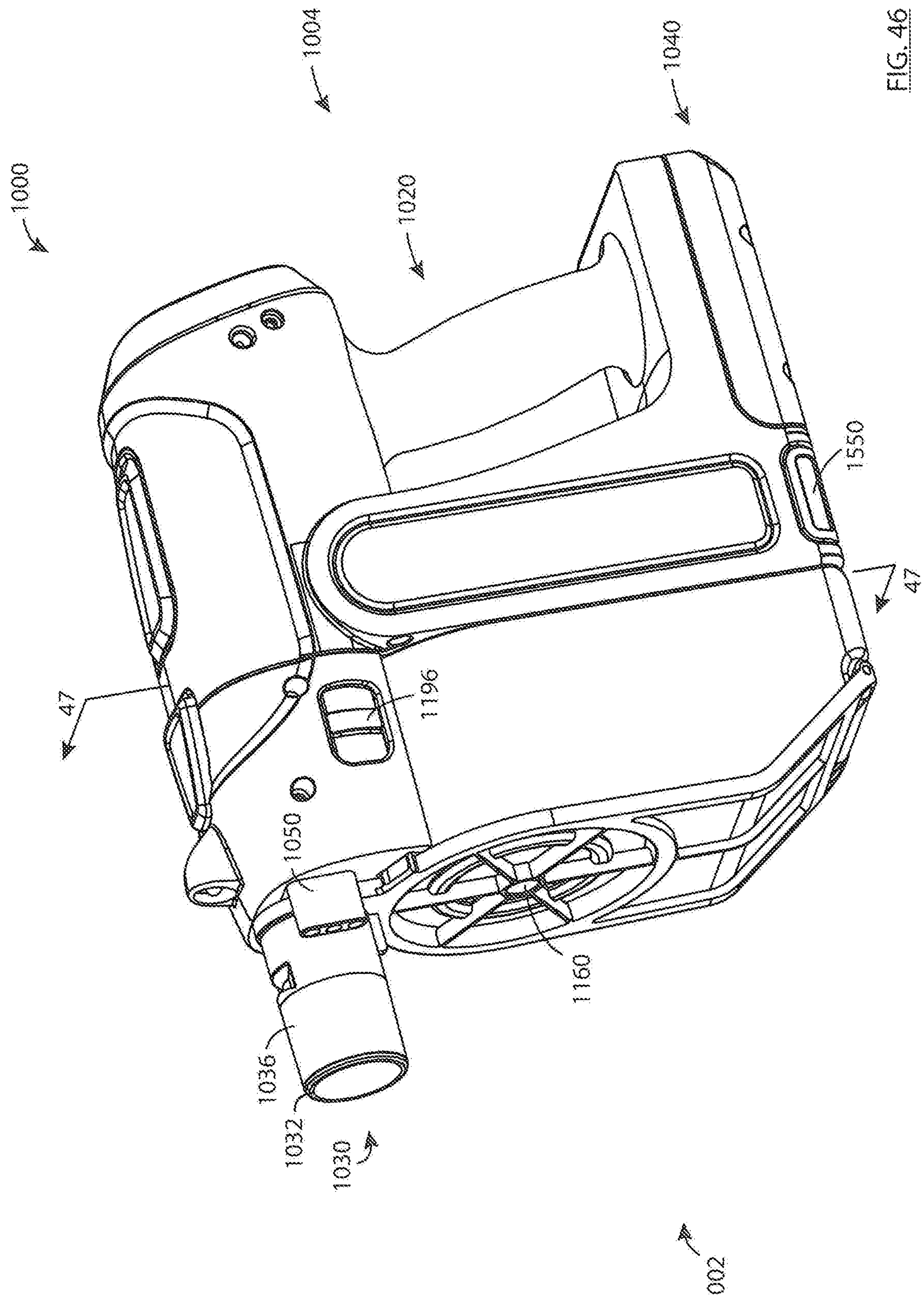
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FIG. 46

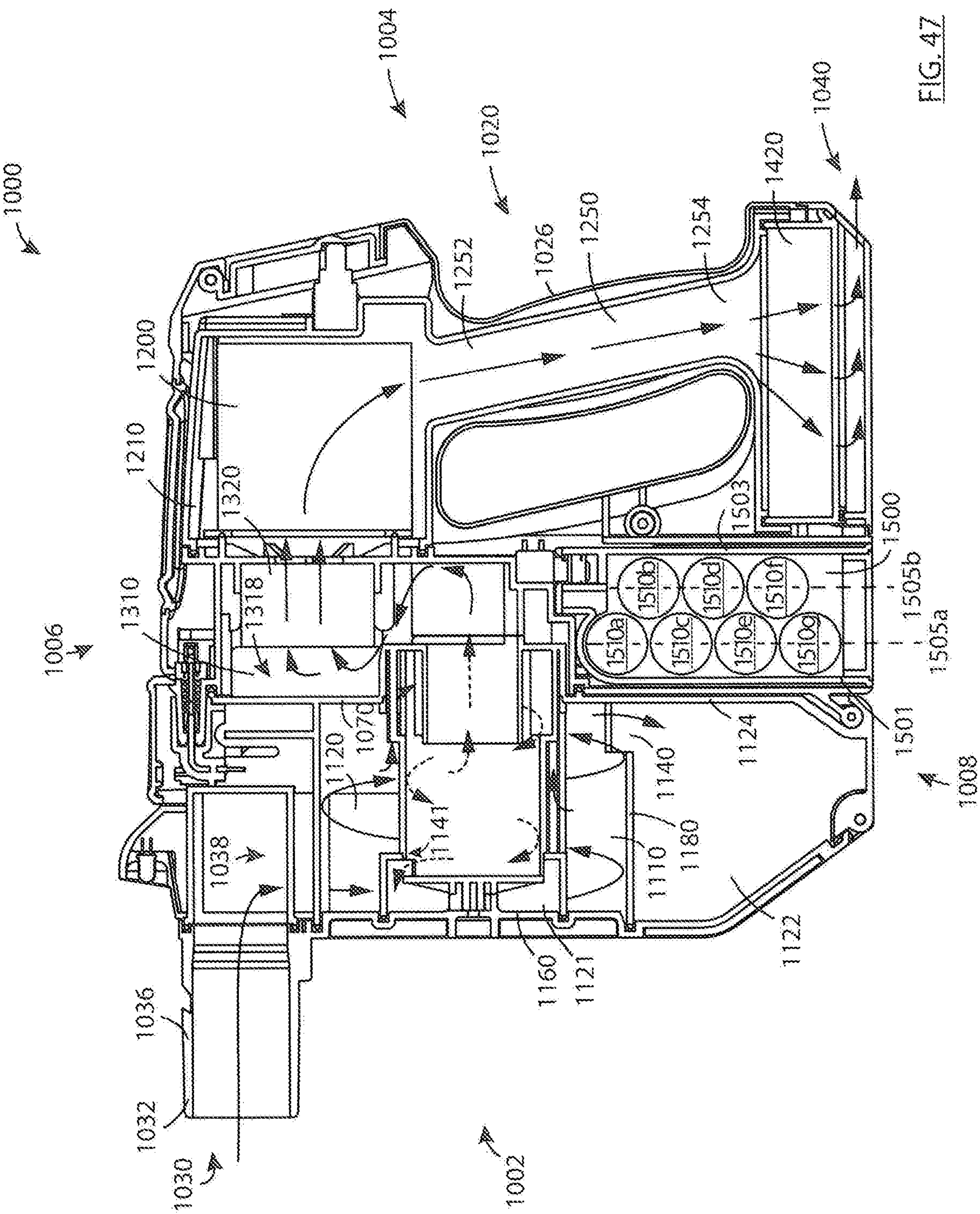
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FIG. 47

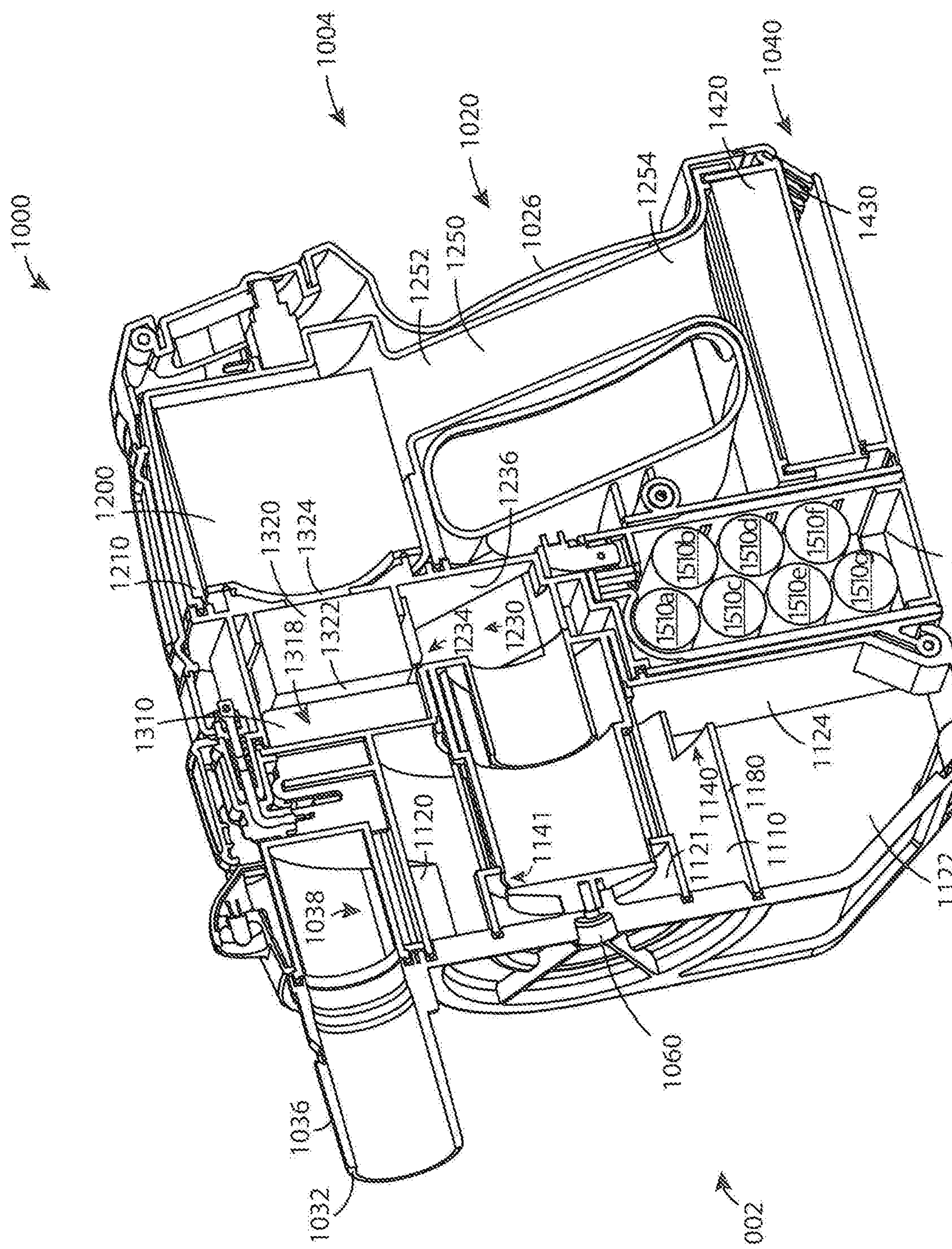
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FIG. 48

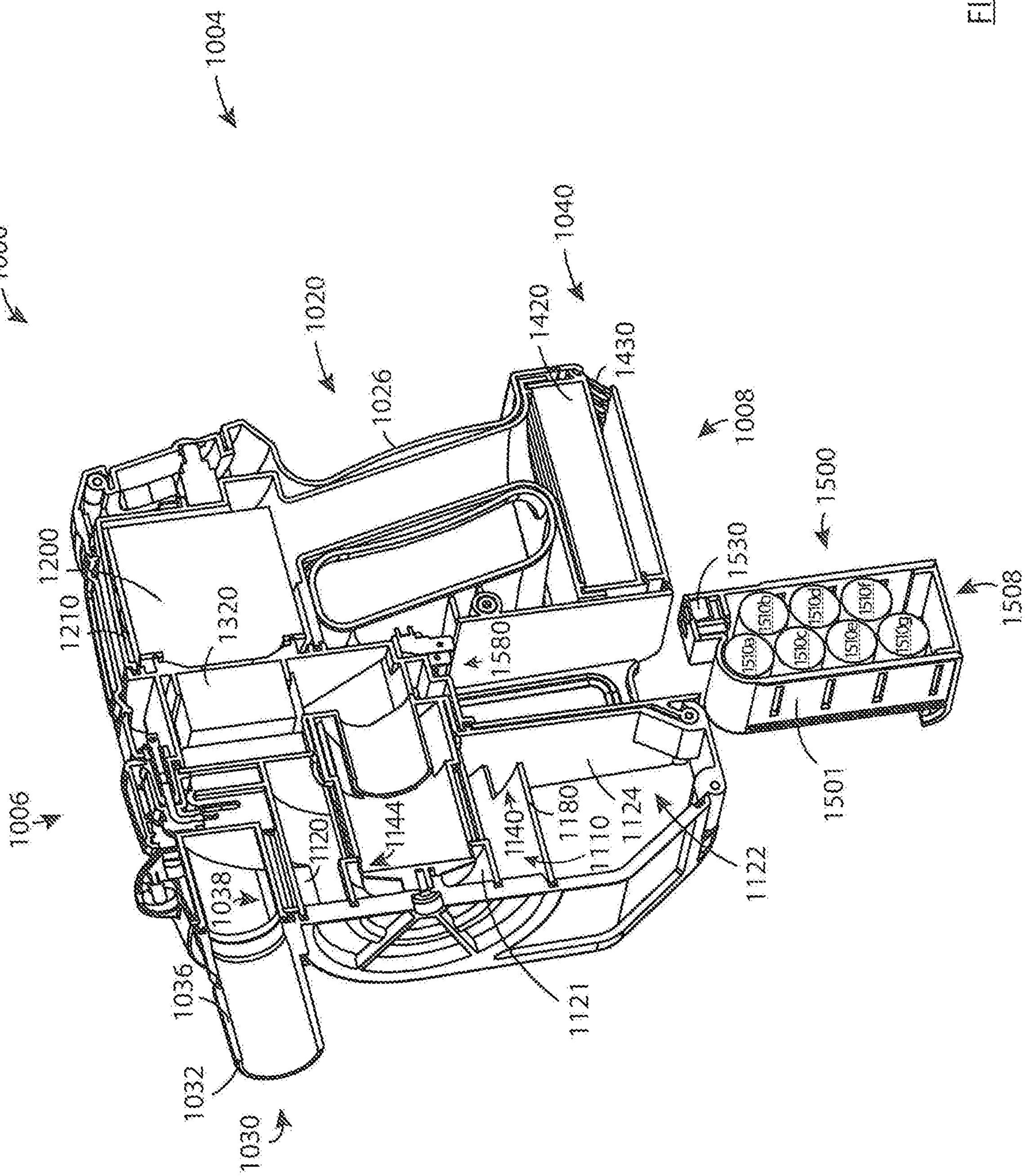
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FIG. 49

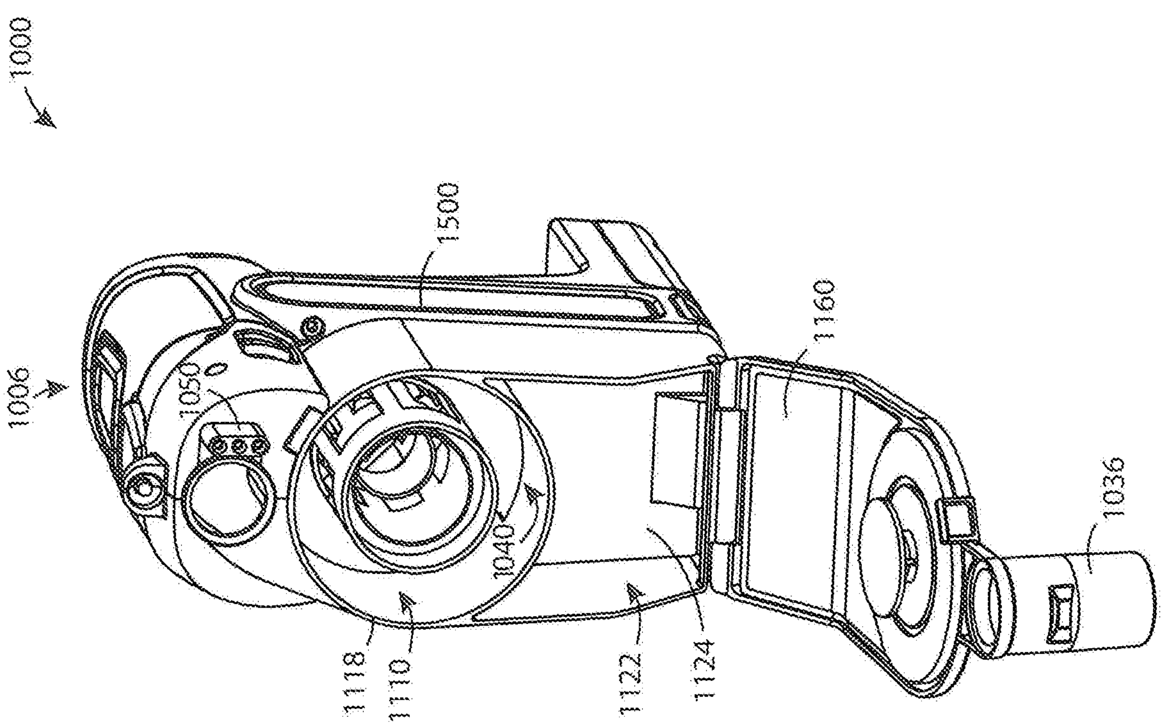

FIG. 50

HANDHELD SURFACE CLEANING APPARATUS

FIELD

This disclosure relates generally to surface cleaning apparatus. In a preferred embodiment, the surface cleaning apparatus comprises a portable surface cleaning apparatus, such as a hand vacuum cleaner.

INTRODUCTION

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

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

SUMMARY

The following introduction is provided to introduce the reader to the more detailed discussion to follow. The introduction is not intended to limit or define any claimed or as yet unclaimed invention. One or more inventions may reside in any combination or sub-combination of the elements or process steps disclosed in any part of this document including its claims and figures.

In accordance with one aspect of this disclosure, which may be used alone or in combination with any other aspect, a hand vacuum cleaner may be powered by an onboard energy source, such as a battery pack or other energy storage member. The energy storage member may include a chemical battery, such as a rechargeable battery. Some chemical batteries, such as lithium-ion batteries, may produce heat while being discharged (e.g. while supplying power to an electric motor). As disclosed herein, a hand vacuum cleaner may have an airflow path in which air exiting a cyclone chamber impinges on a wall of an energy storage chamber in which one or more energy storage devices are located. By directing relatively high-velocity airflow directly against a wall of such a chamber, cooling of an energy storage member (e.g. battery) located in the chamber may be promoted, particularly during discharge of the battery.

In accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

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

(b) a cyclone chamber positioned in the air flow path and having a cyclone air inlet, a cyclone air outlet, and a cyclone axis of rotation;

(c) a suction motor positioned in the air flow path upstream of the clean air outlet; and,

(d) at least one energy storage member positioned in an energy storage chamber having an energy storage chamber wall wherein the cyclone air outlet faces the energy storage chamber wall whereby air exiting the cyclone chamber impinges on the energy storage chamber wall.

In some embodiments, the cyclone axis of rotation may extend generally in a forward/rearward direction.

In some embodiments, the at least one energy storage member may comprise a plurality of energy storage members wherein at least some of the plurality of energy storage members are arranged one above another in a generally upwardly extending configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the energy storage members may be arranged one above another comprise longitudinally extending members each having a longitudinal axis which that extends laterally.

In some embodiments, the cyclone axis of rotation may intersect a volume defined by the generally upwardly extending configuration of energy storage members.

In some embodiments, the cyclone axis of rotation may extend generally in a forward/rearward direction.

In some embodiments, the at least one energy storage member may be removably receivable in the energy storage chamber.

In some embodiments, the at least one energy storage member may comprise a battery pack that is removably receivable in the energy storage chamber.

In some embodiments, the air flow path may comprise a portion that extends from the cyclone air outlet to the suction motor and is defined in part by the energy storage chamber wall.

In some embodiments, the portion of the air flow path may extend generally upwardly from the cyclone air outlet to the suction motor when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the suction motor may be positioned above the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the portion of the air flow path may extend generally downwardly from the cyclone air outlet to the suction motor when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the suction motor may be positioned below the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the hand vacuum cleaner may further comprise a handle having a hand grip portion that extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner wherein the handle is positioned rearward of the at least one energy storage member.

In some embodiments, the at least one energy storage member may comprise a plurality of energy storage members wherein at least some of the plurality of energy storage members are arranged one above another in a generally upwardly extending configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the hand vacuum cleaner may further comprise a finger gap positioned between the handle and the energy storage chamber.

In accordance with another aspect of this disclosure, which may be used alone or in combination with any other aspect, a hand vacuum cleaner may have a cyclone chamber, a suction motor, and pre-motor filter positioned downstream of the cyclone chamber and upstream of the suction motor. The pre-motor filter may be vertically spaced from the cyclone chamber, and air may travel generally rearwardly from the pre-motor filter to the suction motor. Promoting air to travel in this manner may help reduce or eliminate the need for additional bends or air flow direction changes between an air outlet of the pre-motor filter and the suction motor, thereby reducing backpressure and/or air flow losses through this portion of the hand vacuum cleaner due to a reduction in the number of bends in the air flow path.

In accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

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

(b) a cyclone assembly comprising a cyclone chamber positioned in the air flow path and having a cyclone air inlet, a cyclone air outlet, and a cyclone axis of rotation, wherein the cyclone axis of rotation extends generally in a forward/rearward direction;

(c) a pre-motor filter positioned downstream of the cyclone air outlet; and,

(d) a suction motor positioned in the air flow path downstream of the pre-motor filter and upstream of the clean air outlet and having a suction motor axis of rotation;

wherein the pre-motor filter is vertically spaced from the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner, and

wherein air travels generally rearwardly from the pre-motor filter to the suction motor.

In some embodiments, the pre-motor filter may be vertically spaced from the cyclone chamber when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the cyclone assembly may comprise a sidewall that extends generally parallel to the cyclone axis of rotation and the pre-motor filter may have an upstream surface that extends generally parallel to the sidewall of the cyclone assembly.

In some embodiments, the pre-motor filter may have a downstream surface that is opposed to the upstream surface, and air may exit the downstream surface in a generally vertical direction when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the pre-motor filter may at least partially overlie the cyclone chamber.

In some embodiments, the suction motor axis of rotation may be generally parallel to the cyclone axis of rotation.

In some embodiments, the suction motor may be positioned rearward of the cyclone chamber and the suction motor axis of rotation may be generally parallel to the cyclone axis of rotation.

In some embodiments, the pre-motor filter may comprise a generally cylindrical filter having a hollow interior wherein the suction motor has an inlet end that faces towards the hollow interior.

In some embodiments, the generally cylindrical filter may have an outer upstream surface and an inner downstream surface defining the hollow interior and the suction motor axis of rotation may intersect the hollow interior.

In some embodiments, the cyclone assembly may comprise a sidewall that extends generally parallel to the cyclone axis of rotation and the upstream surface of the pre-motor filter may extend generally parallel to the sidewall of the cyclone assembly.

In some embodiments, the pre-motor filter may at least partially overlie the cyclone chamber.

In some embodiments, the hand vacuum cleaner may further comprise a handle having a hand grip portion that extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner wherein the suction motor is located at an upper end of the handle.

In some embodiments, the suction motor may be positioned rearward of the cyclone chamber.

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

Also in accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

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

(b) a cyclone assembly comprising a cyclone chamber positioned in the air flow path and having a cyclone air inlet, a cyclone air outlet and a cyclone axis of rotation, wherein the cyclone axis of rotation extends generally in a forward/rearward direction;

(c) a generally cylindrical pre-motor filter positioned downstream of the cyclone air outlet and having a hollow interior; and,

(d) a suction motor positioned in the air flow path downstream of the pre-motor filter and upstream of the clean air outlet and having a suction motor axis of rotation that is generally parallel to the cyclone axis of rotation, wherein the suction motor has an inlet end that faces towards the hollow interior.

In some embodiments, the generally cylindrical filter may have an outer upstream surface and an inner downstream surface defining the hollow interior and the suction motor axis of rotation may intersect the hollow interior.

In some embodiments, the cyclone assembly may comprise a sidewall that extends generally parallel to the cyclone axis of rotation and the upstream surface of the pre-motor filter may extend generally parallel to the sidewall of the cyclone assembly.

In some embodiments, the pre-motor filter may at least partially overlie the cyclone chamber.

In accordance with another aspect of this disclosure, which may be used alone or in combination with any other aspect, it may be desirable for a hand vacuum cleaner to have a compact overall form, for example so it can be maneuvered around and/or between objects when being carried by a user while cleaning one or more surfaces. A compact form may also improve the ergonomics of the hand vacuum (e.g. the perceived balance or 'hand feel' when carried by a user). Typically, the suction motor and energy storage members (e.g. one or more batteries) may be among the heavier (if not the heaviest) individual components of the hand vacuum cleaner. While positioning the suction motor and energy storage members adjacent to each other may promote a compact design, such an arrangement may promote an undesirable concentration of mass relative to a handle of the hand vacuum cleaner. Positioning the suction motor at an upper end of a forwardly-inclined handle and rearward of at least some of the energy storage members, particularly when some or all of the energy storage members are forward of the handle, may help distribute the weight of the motor and batteries, and may affect the hand feel and/or perceived balance of the hand vacuum.

In accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

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

(b) a handle having a hand grip portion that extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner;

(c) a cyclone chamber positioned in the air flow path and having a cyclone air inlet, a cyclone air outlet, and a cyclone axis of rotation;

(d) at least one energy storage member positioned in an energy storage chamber; and,

(e) a suction motor positioned in the air flow path upstream of the clean air outlet, wherein the suction motor is located at an upper end of the handle and rearward of the at least one energy storage member when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

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

In some embodiments, the at least one energy storage member may comprise a plurality of energy storage members wherein at least some of the plurality of energy storage members may be arranged one above another in a generally upwardly extending configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner and the suction motor may be positioned rearward of at least some of the energy storage members when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the cyclone axis of rotation may intersect a volume defined by the generally upwardly extending configuration of energy storage members.

In some embodiments, the cyclone axis of rotation may extend generally in a forward/rearward direction.

In some embodiments, the at least one energy storage member may comprise a plurality of energy storage members wherein at least some of the plurality of energy storage members may be arranged one above another in a generally upwardly extending configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner and the suction motor may be positioned rearward of an upper end of the plurality of energy storage members when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the cyclone axis of rotation may extend generally in a forward/rearward direction.

In some embodiments, the suction motor may be positioned above the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the hand vacuum may further comprise a pre-motor filter positioned in the air flow path downstream of the cyclone chamber, the pre-motor filter comprising a generally cylindrical filter having a hollow interior wherein the suction motor has an inlet end that faces towards the hollow interior.

In some embodiments, the generally cylindrical filter may have an outer upstream surface and an inner downstream surface defining the hollow interior and the suction motor axis of rotation may intersect the hollow interior.

In some embodiments, the cyclone chamber may comprise a sidewall that extends generally parallel to the cyclone axis of rotation and the upstream surface of the pre-motor filter may extend generally parallel to the sidewall of the cyclone chamber.

In some embodiments, the pre-motor filter may at least partially overlie the cyclone chamber.

In some embodiments, the dirty air inlet may have a dirty air inlet axis that extends generally rearwardly and may be positioned above the cyclone chamber.

In some embodiments, the dirty air inlet axis may intersect a volume defined by a pre-motor filter housing.

In some embodiments, the dirty air inlet axis may intersect the suction motor.

In some embodiments, the hand vacuum may further comprise a pre-motor filter positioned in the air flow path downstream of the cyclone chamber, the pre-motor filter comprising a generally cylindrical filter having a hollow interior wherein the dirty air inlet has a dirty air inlet axis that extends generally rearwardly and intersects the hollow interior.

In some embodiments, the dirty air inlet axis may intersect the suction motor.

In accordance with another aspect of this disclosure, which may be used alone or in combination with any other aspect, a hand vacuum cleaner may have an energy storage member (e.g. a battery pack that includes one or more battery cells) that is inclined so that a portion of a dirt collection region may be located below a portion of the energy storage member. Providing at least some vertical overlap between an energy storage member and a dirt collection region may help provide a relatively larger dirt chamber capacity while helping to reduce the overall size of the hand vacuum. Also, as the energy storage members (e.g. one or more batteries) may typically be among the heavier individual components of the hand vacuum cleaner, such a configuration may help provide a compact overall design, while distributing the weight of the batteries to promote a desirable hand feel and/or perceived balance of the hand vacuum.

In accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

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

(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a dirt collection region, and a cyclone axis of rotation;

(c) a suction motor positioned in the air flow path upstream of the clean air outlet; and,

(d) a longitudinally extending battery pack wherein the battery pack extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner,

wherein a portion of the dirt collection region is located below a portion of the battery pack.

In some embodiments, the dirt collection region may have an upper portion and a lower portion when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner and the lower portion of the dirt collection region may be positioned rearwardly of the upper portion of the dirt collection region.

In some embodiments, a rear wall of the dirt collection chamber may be at a first angle to a vertical axis.

In some embodiments, the battery pack may be located in a battery pack chamber, the battery pack chamber having a front wall that is at a second angle to a vertical axis.

In some embodiments, the first and second angles may be about the same.

In some embodiments, the battery pack may extend generally linearly.

In some embodiments, the battery pack may be removably receivable in the hand vacuum cleaner.

In some embodiments, the battery pack may be removably receivable in the hand vacuum cleaner, a rear wall of the dirt collection chamber may be at a first angle to a vertical axis and the battery pack may have a front wall that is at a second angle to a vertical axis, wherein the first and second angles may be about the same.

In some embodiments, the dirt collection region may be at a lower end of the hand vacuum cleaner and the battery pack may be slidably insertable into the lower end of the hand vacuum cleaner.

Also in accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;
(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a dirt collection region, and a cyclone axis of rotation;
(c) a suction motor positioned in the air flow path upstream of the clean air outlet; and,
(d) a plurality of energy storage members arranged one above another in a generally upwardly extending configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner, the configuration having a forward side and a rearward side,

wherein a lower end of the forward side of the configuration of energy storage members is positioned rearward of an another portion of the forward side of the configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner, and,

wherein a portion of the dirt collection region is located below at least a portion of one of the energy storage members.

In some embodiments, the dirt collection region may have an upper portion and a lower portion when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner and the lower portion of the dirt collection region may be positioned rearwardly of the upper portion of the dirt collection region.

In some embodiments, a rear wall of the dirt collection chamber may be at a first angle to a vertical axis.

In some embodiments, the energy storage members may be located in an energy storage member chamber, and the energy storage member chamber may have a front wall that is at a second angle to a vertical axis.

In some embodiments, the first and second angles may be about the same.

In some embodiments, the configuration of energy storage members may extend generally linearly.

In some embodiments, the energy storage members may be removably receivable in the hand vacuum cleaner.

In some embodiments, the energy storage members may be removably receivable in the hand vacuum cleaner, a rear wall of the dirt collection chamber may be at a first angle to a vertical axis and the configuration of energy storage members may have a front side that is at a second angle to a vertical axis, wherein the first and second angles may be about the same.

In some embodiments, the dirt collection region may be at a lower end of the hand vacuum cleaner and the energy storage members may be slidably insertable into the lower end of the hand vacuum cleaner.

Also in accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;
(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a dirt collection region, and a cyclone axis of rotation;
(c) a suction motor positioned in the air flow path upstream of the clean air outlet; and,
(d) a power pack that extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner,

wherein the dirt collection region has a rear wall that extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner whereby at least a portion of the dirt collection region is below at least a portion of the power pack.

In some embodiments, the dirt collection region may be at a lower end of the hand vacuum cleaner and the rear wall of the dirt collection chamber may be located proximate a front side of the power pack.

In accordance with another aspect of this disclosure, which may be used alone or in combination with any other aspect, a hand vacuum cleaner may have an energy storage member (e.g. a battery pack that includes one or more battery cells) that is positioned rearward of a dirt collection region and at least partially underlies at least a portion of one or both of a cyclone chamber and a pre-motor filter. Providing at least some vertical overlap between an energy storage member and a cyclone chamber and/or a pre-motor filter may help to reduce the overall size (length front to back) of the hand vacuum and may therefore reduce the torque exerted on the hand of a user as the moment arm between the front of the hand vacuum cleaner and the handle may be reduced. Also, as the energy storage member (e.g. one or more batteries) may typically be among the heavier individual components of the hand vacuum cleaner, such a configuration may help provide a compact overall design without adversely affecting the hand feel and/or perceived balance of the hand vacuum.

In accordance with this broad aspect, there is provided hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;
(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a cyclone chamber, a dirt collection region, and a cyclone axis of rotation;
(c) a pre-motor filter downstream of the cyclone chamber;
(d) a suction motor positioned in the air flow path upstream of the clean air outlet; and,
(e) a battery pack wherein at least a portion of the battery pack is positioned rearward of the dirt collection region and at least a portion of the battery pack underlies at least a portion of one or both of the cyclone chamber and the pre-motor filter.

In some embodiments, the cyclone axis of rotation may extend generally in a forward/rearward direction.

In some embodiments, at least a portion of, or substantially all of or the entire battery pack may underlie at least a portion of the cyclone chamber, substantially all of the cyclone chamber or the entire cyclone chamber.

In some embodiments, at least a portion of, or substantially all of or the entire battery pack may underlie at least a portion of the pre-motor filter, substantially all of the pre-motor filter or the entire pre-motor filter.

In some embodiments, the battery pack may comprise at least a plurality of energy storage members wherein the energy storage members may be arranged in at least two columns in the forward/rearward direction.

In some embodiments, the dirt collection region may be at a lower end of the hand vacuum cleaner and the battery pack may be slidably insertable into the lower end of the hand vacuum cleaner.

In some embodiments, the hand vacuum may further comprise a handle and a finger gap positioned between the handle and the battery pack.

Also in accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;
(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a cyclone chamber, a dirt collection region, and a cyclone axis of rotation;
(c) a pre-motor filter downstream of the cyclone chamber;
(d) a suction motor positioned in the air flow path upstream of the clean air outlet; and,
(e) a plurality of energy storage members provided in a lower portion of the hand vacuum cleaner, wherein some of the energy storage members are arranged one above another and some are arranged one behind another and wherein at least some of the energy storage members underlie at least a portion of one or both of the cyclone chamber and the pre-motor filter.

In some embodiments, at least a portion of the energy storage members may be positioned rearward of the dirt collection region.

In some embodiments, the cyclone axis of rotation may extend generally in a forward/rearward direction.

In some embodiments, the at least a portion of, or substantially all of or all of the energy storage members may underlie at least a portion of the cyclone chamber, substantially all of the cyclone chamber or the entire cyclone chamber

In some embodiments, the at least a portion of, or substantially all of or all of the energy storage members may underlie at least a portion of the pre-motor filter, substantially all of the pre-motor filter or the entire pre-motor filter.

In some embodiments, the dirt collection region is at a lower end of the hand vacuum cleaner and the energy storage members are slidably insertable into the lower end of the hand vacuum cleaner.

In some embodiments, at least a portion of the energy storage members may be positioned rearward of the dirt collection region.

In some embodiments, the hand vacuum may further comprise a handle and a finger gap positioned between the handle and the energy storage members.

In accordance with another aspect of this disclosure, which may be used alone or in combination with any other aspect, a hand vacuum cleaner may have a cyclone chamber with a cyclone axis of rotation that extends in a forward/rearward direction, and a suction motor with a suction motor axis that also extends in a forward/rearward direction, where the suction motor is located at an upper end of a handle of the vacuum cleaner and the suction motor axis is vertically displaced from the cyclone axis of rotation. Such a configuration may have one or more advantages. For example, it may facilitate the reduction of conduit bends and/or air flow direction changes between a dirty air inlet and a clean air outlet, thereby reducing backpressure and/or air flow losses through this portion of the hand vacuum cleaner due to a reduction in the number of bends in the air flow path. Additionally, or alternatively, such a configuration may help provide a compact overall design of the hand vacuum cleaner without adversely affecting the hand feel and/or perceived balance of the hand vacuum.

In accordance with this broad aspect, there is provided a hand vacuum cleaner having a front end, a rear end, an upper end, a lower end, and first and second laterally spaced apart sides, and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet;
(b) a handle having a hand grip portion that extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner, the handle being positioned at the rear end of the hand vacuum cleaner;
(c) a cyclone chamber positioned in the air flow path and having a cyclone air inlet, a cyclone air outlet, and a cyclone axis of rotation that extends in a forward/rearward direction;
(d) a pre-motor filter positioned downstream of the cyclone chamber and upstream of the suction motor; and,
(e) a suction motor positioned in the air flow path upstream of the clean air outlet, wherein the suction motor has a suction motor axis of rotation that extends in a forward/rearward direction, wherein the suction motor is located at an upper end of the handle, and wherein the suction motor axis of rotation is vertically displaced from the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

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

In some embodiments, the cyclone axis of rotation may intersect the hand grip portion.

In some embodiments, the suction motor may be located rearward of the cyclone chamber.

In some embodiments, the suction motor may have an inlet that faces towards the pre-motor filter.

In some embodiments, the suction motor axis of rotation may intersect a volume defined by a pre-motor filter housing.

In some embodiments, the suction motor axis of rotation may extend through a central portion of a volume containing the pre-motor filter.

In some embodiments, the pre-motor filter may be positioned above the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the pre-motor filter may be positioned above the cyclone chamber when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In some embodiments, the cyclone axis of rotation may intersect the hand grip portion, the pre-motor filter may be positioned above the cyclone axis of rotation when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner, and the suction motor axis of rotation may extend through a pre-motor filter housing.

In some embodiments, the pre-motor filter may comprise a generally cylindrical filter having a hollow interior wherein the suction motor axis of rotation intersects the hollow interior.

In some embodiments, after exiting a downstream side of the pre-motor filter, air travels generally linearly to the suction motor.

In some embodiments, the pre-motor filter may comprise a generally cylindrical filter having a hollow interior wherein the dirty air inlet has a dirty air inlet axis that extends generally rearwardly and intersects the hollow interior.

In some embodiments, the dirty air inlet axis may intersect the suction motor.

In some embodiments, the cyclone axis of rotation may intersect the hand grip portion.

In some embodiments, the hand vacuum may further comprise a plurality of energy storage members wherein at least some of the plurality of energy storage members are arranged one above another in a generally upwardly extending configuration when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner, and the suction motor may be positioned rearward of at least some of the energy storage members when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner.

In accordance with another aspect of this disclosure, which may be used alone or in combination with any other aspect, a surface cleaning apparatus may have a removable pre-motor filter assembly having an outlet conduit wherein a terminal end of the outlet conduit extends at a first angle to a direction of air flow through the outlet conduit. An advantage of this design is that the terminal end of the outlet conduit may be positioned substantially flush against another air conduit having a similarly angled terminal end without requiring lateral movement of the outlet conduit towards other conduit. Accordingly, a filter assembly may be removed and inserted by moving the filter assembly substantially perpendicular to the direction of airflow exiting the filter assembly. Such an arrangement may, for example, facilitate the use of a gasket or other sealing member between the ends of the conduits to provide an improved seal between the conduits. Such an arrangement may also eliminate the need for a biasing or other retaining mechanism to exert a force on the filter assembly to maintain a seal between the conduits.

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

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

(b) an air treatment member positioned in the air flow path; and

(c) a removable pre-motor filter assembly positioned downstream of the air treatment member and upstream of a suction motor, the pre-motor filter assembly comprising a pre-motor filter and a filter support member, the filter support member having an outlet conduit wherein a terminal end of the outlet conduit extends at a first angle to a direction of air flow through the outlet conduit.

In some embodiments, the pre-motor filter may comprise a generally cylindrical filter having a hollow interior positioned about a body portion of the filter support member having an internal filter conduit, wherein the outlet conduit is in air flow communication with the hollow interior via the internal filter conduit.

In some embodiments, the outlet conduit may be aligned with the hollow interior.

In some embodiments, the body portion of the filter support member may include a porous portion located in the hollow interior and positioned between a downstream surface of the pre-motor filter and the internal filter conduit.

In some embodiments, the hollow interior may comprise a longitudinally extending passage having an outlet end from which the outlet conduit extends away and an opposed end wherein the opposed end is sealed.

In some embodiments, the opposed end may be sealed by a sealing member that extends into the hollow interior, the sealing member having a solid wall extending inwardly and located between a downstream surface of the pre-motor filter and the passage.

In some embodiments, the filter support member may have a body portion having an internal filter conduit that may extend into a hollow interior of the pre-motor filter, the body portion may have a solid wall extending inwardly and located between a downstream surface of the pre-motor filter and the internal filter conduit.

In some embodiments, the body portion of the filter support member may include a porous portion located in the hollow interior and positioned between a downstream surface of the pre-motor filter and the internal filter conduit and is upstream of the outlet conduit.

In some embodiments, the internal filter conduit may comprise a longitudinally extending passage having an outlet end from which the outlet conduit extends away and a second end, wherein the second end is sealed.

In some embodiments, the second end may be sealed by a sealing member that extends into the hollow interior, the sealing member having a solid wall extending inwardly and located between a downstream surface of the pre-motor filter and the internal filter conduit.

In some embodiments, the sealing member and the body portion define a continuous member extending through the hollow interior.

In some embodiments, the surface cleaning apparatus may further comprise a treated air conduit extending from the outlet conduit towards the suction motor, wherein an inlet end of the treated air conduit may also extend at about the first angle to a direction of air flow through the outlet conduit.

In some embodiments, the surface cleaning apparatus may further comprise a treated air conduit extending from the outlet conduit towards the suction motor, wherein an inlet end of the treated air conduit may also extend at a second angle to a direction of air flow through the outlet conduit and the terminal end of the outlet conduit may abut the inlet end of the treated air conduit when the filter assembly is positioned in the air flow path.

In some embodiments, the first and second angles may be about the same.

In some embodiments, the surface cleaning apparatus may further comprise a gasket provided at an interface of the terminal end of the outlet conduit and the inlet end of the treated air conduit.

In some embodiments, the filter assembly may be removable in a filter assembly removal direction that is at an angle to the direction of air flow through the outlet conduit.

In some embodiments, the filter assembly may be removable through an openable door and a side of the terminal end that is closest to the openable door may extend further in the direction of air flow though the outlet conduit than an opposed side of the terminal end that is further from the openable door.

In some embodiments, a side of the inlet end of the treated air conduit that is furthest from the openable door may extend further in the direction of air flow though the outlet conduit than an opposed side of the inlet end that is closest to the openable door.

It will be appreciated by a person skilled in the art that an apparatus or method disclosed herein may embody any one or more of the features contained herein and that the features may be used in any particular combination or sub-combination.

These and other aspects and features of various embodiments will be described in greater detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** is a top perspective view of a hand vacuum cleaner in accordance with one embodiment;

FIG. **2** is a bottom perspective view of the hand vacuum cleaner of FIG. **1**;

FIG. **3** is a side perspective view of the hand vacuum cleaner of FIG. **1**;

FIG. **4** is a rear perspective view of the hand vacuum cleaner of FIG. **1**;

FIG. **5** is a front end view of the hand vacuum cleaner of FIG. **1**;

FIG. **6** is a perspective view of the hand vacuum cleaner of FIG. **1**, with a front door or lid in an open position;

FIG. **7** is a front end view of the hand vacuum cleaner of FIG. **1**, with a front door or lid in an open position;

FIG. **8** is a perspective sectional view of the hand vacuum cleaner of FIG. **1**, taken along line **8-8** in FIG. **1**;

FIG. **9** is a perspective sectional view of the hand vacuum cleaner of FIG. **1**, taken along line **9-9** in FIG. **5**;

FIG. **10** is a cross-section view of the hand vacuum cleaner of FIG. **1**, taken along line **9-9** in FIG. **5**;

FIG. **11** is an enlarged view of the upper left portion of FIG. **10**;

FIG. **12** is an enlarged view of the upper left portion of FIG. **10**, with a pre-motor filter assembly removed;

FIG. **13** is an enlarged view of the upper left portion of FIG. **10**, with a pre-motor filter assembly and an openable door removed;

FIG. **14** is a top perspective view of the upper front portion of the hand vacuum cleaner of FIG. **1**, with an openable door removed to expose a pre-motor filter assembly;

FIG. **15** is a top perspective view of the upper front portion of the hand vacuum cleaner of FIG. **1**, with a pre-motor filter assembly and an openable door removed;

FIG. **16** is a top plan view of the upper front portion of the hand vacuum cleaner of FIG. **1**, with a pre-motor filter assembly and an openable door removed;

FIG. **17** is a top perspective view of the upper portion of the hand vacuum cleaner of FIG. **1**, with a pre-motor filter assembly and an openable door removed;

FIG. **18** is a bottom perspective view of an openable door of a pre-motor filter chamber of the hand vacuum cleaner of FIG. **1**;

FIG. **19** is a perspective view of a removable pre-motor filter assembly of the hand vacuum cleaner of FIG. **1**;

FIG. **20** is an end perspective view from the outlet end of the removable pre-motor filter assembly of the hand vacuum cleaner of FIG. **19**;

FIG. **21** is a perspective section view of the removable pre-motor filter assembly of the hand vacuum cleaner of FIG. **19**, taken along line **21-21** in FIG. **19**;

FIG. **22** is a cross section view of the removable pre-motor filter assembly of the hand vacuum cleaner of FIG. **19**, taken along line **21-21** in FIG. **19**;

FIG. **23** is a bottom perspective view of the lower rear portion of the hand vacuum cleaner of FIG. **1**;

FIG. **24** is a bottom perspective view of the lower rear portion of the hand vacuum cleaner of FIG. **1**, with a post-motor filter and a post-motor filter support removed;

FIG. **25** is a rear perspective view of a post-motor filter support of the hand vacuum cleaner of FIG. **1**;

FIG. **26** is a front perspective view of the post-motor filter support of FIG. **25**;

FIG. **27** is a front perspective view of the post-motor filter support of FIG. **26** and a post-motor filter;

FIG. **28** is a side view of the hand vacuum cleaner of FIG. **1**, with an energy storage member partially removed;

FIG. **29** is a bottom perspective view of the hand vacuum cleaner of FIG. **1**, with an energy storage member partially removed;

FIG. **30** is a side view of the hand vacuum cleaner of FIG. **1**, with an energy storage member removed;

FIG. **31** is a cross-section view of the hand vacuum cleaner of FIG. **1**, taken along line **9-9** in FIG. **5**, with an energy storage member removed;

FIG. **32** is a perspective view of an energy storage member of the hand vacuum cleaner of FIG. **1**;

FIG. **33** is a front perspective view of the energy storage member of FIG. **32**;

FIG. **34** is a cross-section view of the energy storage member of FIG. **32**, taken along line **34-34** in FIG. **32**;

FIG. **35** is a perspective view of a hand vacuum cleaner in accordance with another embodiment;

FIG. **36** is a cross-section view of the hand vacuum cleaner of FIG. **35**, taken along line **36-36** in FIG. **35**;

FIG. **37** is a cross-section view of the hand vacuum cleaner of FIG. **35**, taken along line **36-36** in FIG. **35**, with an energy storage member partially removed;

FIG. **38** is a perspective section view of the hand vacuum cleaner of FIG. **35**, taken along line **36-36** in FIG. **35**, with a post-motor filter removed;

FIG. **39** is a perspective view of a hand vacuum cleaner in accordance with another embodiment;

FIG. **40** is a cross-section view of the hand vacuum cleaner of FIG. **39**, taken along line **40-40** in FIG. **39**;

FIG. **41** is a perspective section view of the hand vacuum cleaner of FIG. **39**, taken along line **40-40** in FIG. **39**, with a post-motor filter removed;

FIG. **42** is a perspective view of a hand vacuum cleaner in accordance with another embodiment;

FIG. **43** is a cross-section view of the hand vacuum cleaner of FIG. **42**, taken along line **43-43** in FIG. **42**;

FIG. **44** is a perspective section view of the hand vacuum cleaner of FIG. **42**, taken along line **43-43** in FIG. **42**;

FIG. **45** is a perspective section view of the hand vacuum cleaner of FIG. **42**, taken along line **43-43** in FIG. **42**, with an energy storage member removed;

FIG. **46** is a perspective view of a hand vacuum cleaner in accordance with another embodiment;

FIG. **47** is a cross-section view of the hand vacuum cleaner of FIG. **46**, taken along line **47-47** in FIG. **46**;

FIG. **48** is a perspective section view of the hand vacuum cleaner of FIG. **46**, taken along line **47-47** in FIG. **46**;

FIG. **49** is a perspective section view of the hand vacuum cleaner of FIG. **46**, taken along line **47-47** in FIG. **46**, with an energy storage member removed; and

FIG. **50** is a perspective view of the hand vacuum cleaner of FIG. **46**, with a front door or lid in an open position;

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

DESCRIPTION OF EXAMPLE EMBODIMENTS

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

The terms “an embodiment,” “embodiment,” “embodiments,” “the embodiment,” “the embodiments,” “one or more embodiments,” “some embodiments,” 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”, 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”, or “directly fastened” where the parts are connected in physical contact with each other. None of the terms “coupled”, “connected”, “attached”, and “fastened” distinguish the manner in which two or more parts are joined together.

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

General Description of a Hand Vacuum Cleaner

Referring to FIGS. **1** to **34**, an exemplary embodiment of a surface cleaning apparatus is shown generally as **1000**. The following is a general discussion of this embodiment which provides a basis for understanding several of the features which are discussed herein. As discussed subsequently, each of the features may be used individually or in any particular combination or sub-combination in this or in other embodiments disclosed herein.

In the illustrated embodiment, the surface cleaning apparatus is 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, the handle and a clean air inlet may be rigidly coupled to each other (directly or indirectly) 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.

As exemplified in FIGS. **1** to **7**, surface cleaning apparatus **1000** includes a main body **1010** having a housing **1011** and a handle **1020**, an air treatment member **1100** connected to the main body **1010**, a dirty air inlet **1030**, a clean air outlet **1040**, and an air flow path extending between the dirty air inlet and the clean air outlet.

Surface cleaning apparatus **1000** has a front end **1002**, a rear end **1004**, an upper end or top **1006**, and a lower end or bottom **1008**. In the embodiment shown, dirty air inlet **1030** is at an upper portion of the front end **1102** and clean air outlet **1040** is at rearward portion of the lower end **1008**. It will be appreciated that the dirty air inlet **1030** and the clean air outlet **1040** may be provided in different locations.

A suction motor **1200** (see e.g. FIG. **10**) is provided to generate vacuum suction through the air flow path, and is positioned within a motor housing **1210**. In the illustrated embodiment, the suction motor is positioned downstream from the air treatment member, although it may be positioned upstream of the air treatment member (e.g., a dirty air motor) in alternative embodiments.

Air treatment member **1100** is configured to remove particles of dirt and other debris from the air flow and/or otherwise treat the air flow. In the illustrated example, air treatment member **1100** includes a cyclone assembly having a single cyclonic cleaning stage with a single cyclone chamber **1110** and a dirt collection region **1122** external to the cyclone chamber. The cyclone chamber **1110** and dirt collection region **1122** may be of any configuration suitable for separating dirt from an air stream and collecting the separated dirt, respectively.

The cyclone chamber **1110** may be oriented in any direction. For example, when surface cleaning apparatus **1000** is oriented with the upper end **1106** above the lower end **1108**, e.g. positioned generally parallel to a horizontal surface, a central axis or axis of rotation **1115** of the cyclone chamber **1110** may be oriented horizontally, as exemplified in FIG.

10. In alternative embodiments, the cyclone chamber may be oriented vertically, or at any angle between horizontal and vertical.

In alternative embodiments, the cyclone assembly may include two or more cyclonic cleaning stages arranged in series with each other. Each cyclonic cleaning stage may include one or more cyclone chambers (arranged in parallel or series with each other) and one or more dirt collection chambers, of any suitable configuration. The dirt collection chamber or chambers may be external to the cyclone chambers, or may be internal the cyclone chamber and configured as a dirt collection area or region within the cyclone chamber. For example, in the embodiments exemplified in FIGS. **42** to **45** and **46** to **50**, a second cyclonic cleaning stage is provided in series in what may be characterized as a 'nested' configuration. As exemplified in FIG. **43**, after traveling generally axially though the cyclone chamber **1110** from the front end wall **1160** toward the rear end wall **1170**, air exits cyclone chamber **1110** and enters a secondary cyclone chamber. A secondary dirt collection chamber **1121** is positioned exterior to the secondary cyclone chamber and is in communication with a dirt outlet **1141** to receive dirt and debris dis-entrained from a dirty air flow by the secondary cyclone chamber. In the embodiment exemplified in FIGS. **42** to **45**, air exiting the secondary cyclone chamber travels generally rearwardly and enters a pre-motor chamber **1318** via air inlet **1234**. In the embodiment exemplified in FIGS. **46** to **50**, the secondary cyclone air outlet faces a rear wall **1236** of the upflow duct or conduit **1230** that directs air upwardly towards a pre-motor filter **1320**. Alternatively, the air treatment member need not include a cyclonic cleaning stage, and can incorporate a bag, a porous physical filter media (such as foam or felt), or other air treating means.

As exemplified in FIG. **10**, hand vacuum cleaner **1000** may include a pre-motor filter housing **1310** provided in the air flow path downstream of the air treatment member **1100** and upstream of the suction motor **1200**. Pre-motor filter housing **1310** may be of any suitable construction, including any of those exemplified herein. A pre-motor filter **1320** is positioned within the pre-motor filter housing **1310**. Pre-motor filter **1320** may be formed from any suitable physical, porous filter media and having any suitable shape, including the examples disclosed herein with respect to a removable pre-motor filter assembly. For example, the pre-motor filter may be one or more of a foam filter, felt filter, HEPA filter, other physical filter media, electrostatic filter, and the like.

Optionally, the pre-motor filter housing **1310** may be openable (as described herein), and at least a portion of the sidewall **1316** (e.g. removable or otherwise openable door **1330**) and/or one of the end walls **1312** or **1314** may be removable, openable, or otherwise re-configurable to provide access to the interior of the pre-motor filter housing **1310**.

Positioning the pre-motor filter housing **1310** toward the top **1006** of the main body **1010** may help facilitate access to the pre-motor filter **1320** while the hand vacuum is resting on its base. For example, if the hand vacuum cleaner **1000** is rested upon a table or other such surface, an openable door **1330** of the pre-motor filter housing **1310** is provided at the upper end of the housing and is accessible to a user. A user could then open the pre-motor filter housing **1310** by removing or otherwise opening door **1330** while the hand vacuum **1000** rests on the table, to inspect or replace the pre-motor filter **1320**, without having to use one hand to grasp the handle **1020** or otherwise support the hand vacuum.

As exemplified, hand vacuum cleaner **1000** may also include a post-motor filter **1420** provided in the air flow path downstream of the suction motor **1200** and upstream of the clean air outlet **1040**. Post-motor filter **1420** may be formed from any suitable physical, porous filter media and having any suitable shape, including the examples disclosed herein. In alternative embodiments, the post-motor filter may be any suitable type of filter such as one or more of a foam filter, felt filter, HEPA filter, other physical filter media, electrostatic filter, and the like.

In the illustrated embodiment, the dirty air inlet **1030** of the hand vacuum cleaner **1000** is the inlet end **1032** of an inlet conduit **1036**. Optionally, inlet end **1032** of the conduit **1036** can be used as a nozzle to directly clean a surface. The air inlet conduit **1036** is, in this example, a generally linear hollow member that extends along an inlet conduit axis **1035** that is oriented in a longitudinal forward/backward direction and is generally horizontal when hand vacuum cleaner **1000** is oriented with the upper end **1006** above the lower end **1008**. Alternatively, or in addition to functioning as a nozzle, inlet conduit **1036** may be connected or 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 **1030** is positioned forward of the air treatment member **1100**, although this need not be the case. As exemplified, the dirty air inlet **1030** is positioned above the cyclone chamber. Optionally, the dirty air inlet **1030** may be provided at an alternate location, such as in the front end wall **1160**.

As exemplified in FIGS. **1**, **2**, **5**, **6**, and **7**, an optional accessory power coupler **1050** may be provided adjacent to the inlet conduit **1036**. Accessory power coupler **1050** includes a set of electrical connectors **1056** that can inter-engage with compatible electrical connectors on an accessory tool in order to provide an electrical connection between e.g. a power source of the hand vacuum and a motor or other electrical device of an accessory tool (e.g. a powered brush roller, a light source, and the like). While the illustrated accessory power coupler **1050** is a male connector (i.e. projecting outwardly from the main body **1010** of the hand vacuum cleaner **1000**), in alternative embodiments it may be a female connector (i.e. recessed inwardly) or any other shape suitable for cooperatively engaging with corresponding connectors on an accessory tool or other attachment. As exemplified, the accessory power coupler **1050** may be positioned laterally to one side of the inlet conduit **1036**. In other examples, the accessory power coupler **1050** may be located above or below the inlet conduit **1036**.

As exemplified, power may be supplied to the suction motor and other electrical components of the hand vacuum cleaner from an onboard energy storage member which may include, for example, one or more batteries or other energy storage device. In the illustrated embodiment, the hand vacuum cleaner **1000** includes a removable battery pack **1500** provided between the handle **1020** and the air treatment member **1100**. Battery pack **1500** is described in further detail herein. In alternative embodiments, a battery pack may not be provided and power may be supplied to the hand vacuum cleaner by an electrical cord connected to the hand vacuum cleaner (not shown) that can be connected to a standard wall electrical outlet.

Optionally, a forward surface of the handle **1020** and a rearward surface of the battery pack **1500** may cooperatively define a finger gap **1028** therebetween (see e.g. FIG. **10**). An advantage of this design is that the absence of an intervening portion of main housing **1010** between the handle and the energy storage member may facilitate a more compact overall size of hand vacuum **1000**.

As exemplified, a power switch **1060** may be provided to selectively control the operation of the suction motor (e.g. either on/off or variable power levels or both), for example by establishing a power connection between the batteries and the suction motor. The power switch may be provided in any suitable configuration and location, including a button, rotary switch, sliding switch, trigger-type actuator and the like. As illustrated in FIG. **4**, power switch **1060** is in the form of a button located toward upper end of the rear end **1004** of the hand vacuum cleaner, above a hand grip portion **1026** of the handle **1020**. In this position, a user may be able to access the button **1060** while holding the hand vacuum via the hand grip, e.g. with the thumb of the hand holding the handle, and/or with a digit of their other hand.

The power switch or an alternate controller may also be configured to control other aspects of the hand vacuum (brush motor on/off, etc.). Optionally, instead of being provided at an upper end of the handle, the power switch may be provided on the main body (such as on the motor housing or other suitable location).

As exemplified in FIG. **4**, an optional information display device **1070** may be provided to display one or more visual indications to a user. For example, the display device **1070** may provide a visual indication of: when suction motor is on; the current power level of the suction motor (if applicable); the current battery charge level; an estimated time until the battery charge will be depleted, and/or similar information. The display device **1070** may include one or more light sources (e.g. light emitting diodes (LEDs)), display screens (e.g. a liquid crystal, an LED screen, an organic light emitting diode (OLED) screen, and the like. The screen, and associated electronics, may be used to display status information of one or more electrical components of the hand vacuum cleaner.

In the illustrated embodiment, the information display device is in the form of a display screen **1070** that is provided at the upper end **1022** of the handle **1020**. A first display portion **1072** is configured to display an indication of whether the hand vacuum cleaner is in a floor cleaning mode or in a carpet cleaning mode (e.g. where power is being supplied to a brush roller of an accessory tool via electrical connectors **1056**), and a second portion **1074** is configured to display an indication of a power mode of the suction motor (e.g. a regular power mode, a higher power mode, and/or a higher power 'burst' mode).

Air Flow Path Through a Hand Vacuum Cleaner

The following is a description of different features of an air flow path through a hand vacuum cleaner. These features may be used by themselves in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein. For example, any of the airflow configurations described herein may be used with any of the pre-motor filter assemblies, relative positioning of the suction motor and energy storage members, inclined battery packs, battery pack configurations, airflow cooling configurations, and other features described herein.

As exemplified, the air treatment member **1100** of the hand vacuum cleaner **1000** may optionally be a single cyclonic cleaning stage with unidirectional air flow or a 'uniflow' cyclone chamber **1110** (i.e. where the cyclone air inlet and cyclone air outlet are at opposite ends of the cyclone chamber). Referring primarily to FIGS. **9** and **10**, hand vacuum cleaner **1000** includes a single cyclonic cleaning stage with a cyclone chamber **1110** that has a cyclone air inlet **1120** in fluid communication with the inlet conduit **1036**, a cyclone air outlet **1130**, and a dirt outlet **1140** that is in communication with a dirt collection chamber **1122**.

Optionally, the cyclone chamber **1110** may be generally horizontally oriented so that the cyclone air inlet **1120** is located toward the front end **1002** of the hand vacuum cleaner **1000**, and the cyclone air outlet **1130** is spaced rearwardly behind the cyclone air inlet **1120**, at a rear end **1114** of the cyclone chamber **1110**. From the cyclone air outlet **1130**, an upflow duct or conduit **1230** directs the airflow upwards to a pre-motor filter chamber **1310** that is vertically spaced from the cyclone chamber **1110**. After passing through the pre-motor filter **1320**, air may travel generally rearwardly from the pre-motor filter **1320** to an inlet end **1202** of the suction motor **1200**. An advantage of this arrangement is that, by promoting air to travel in this manner, the need for air flow direction changes between an air outlet of the pre-motor filter and the suction motor may be reduced or eliminated, thereby reducing backpressure and/or air flow losses through this portion of the hand vacuum cleaner. An additional, or alternative, advantage of providing a pre-motor filter chamber **1310** that is vertically spaced from the cyclone chamber **1110** is that the need for air flow direction changes between a cyclone air outlet and the suction motor may be reduced, thereby reducing backpressure and/or air flow losses through this portion of the hand vacuum cleaner. For example, any airflow in a forward direction may take place within the pre-motor filter chamber or header **1310**, as opposed to taking place in a (typically narrower) conduit that directs airflow in a direction opposite to the airflow through the dirty air inlet. An additional, or alternative, advantage of providing a pre-motor filter chamber **1310** that is vertically spaced from the cyclone chamber **1110**, and optionally above the cyclone chamber **1110**, is that the length (front to back) of the hand vacuum cleaner may be reduced, providing a more compact configuration.

FIGS. **1** to **34** exemplify one embodiment of a hand vacuum cleaner **1000** having a cyclone unit that includes a uniflow cyclone chamber **1110** and a dirt collection chamber **1122** that is positioned exterior to the cyclone chamber **1110** and is in communication with the dirt outlet **1140** to receive dirt and debris dis-entrained from a dirty air flow by the cyclone chamber **1110**. In the illustrated example, the cyclone air inlet **1120** and dirt outlet **1140** are positioned toward opposing ends of the cyclone chamber **1110**, and the cyclone air outlet **1130** is provided toward the same end as the dirt outlet **1140** (the rear end as illustrated). In this configuration, dirty air can enter at the front end of the cyclone chamber, while cleaner air and the separated dirt particles both exit the cyclone chamber at the opposing rear end.

In this embodiment, the cyclone chamber **1110** has a front end wall **1160** and an opposing rear end wall **1170** that is spaced apart from the front end wall along the cyclone axis **1115** about which air circulates within the cyclone chamber **1110** during operation of the hand vacuum cleaner. A cyclone chamber sidewall **1180** extends between the front and rear end walls **1160**, **1170**. In the illustrated example, when the hand vacuum is oriented with the upper end above the lower end, the cyclone axis **1115** is generally horizontal, and is closer to horizontal than vertical, e.g., ±20°, ±15°, ±10°, or ±5° from the horizontal. As exemplified, the cyclone axis **1115** is substantially parallel to, e.g. within ±20°, ±15°, ±10°, or ±5°, and vertically offset below the conduit axis **1035** of the air inlet conduit **1036**, and the cyclone chamber **1110** and dirt collection chamber **1122** are both below the inlet conduit axis **1035**. As illustrated in FIG. **10**, when the hand vacuum **1000** is horizontal (as illustrated), the pre-motor filter **1320** is vertically spaced from (e.g. above) the cyclone axis **1115**, and the suction motor

1200 is positioned rearward of the pre-motor filter **1320**, so that air travels generally rearwardly from the pre-motor filter to the suction motor.

In this embodiment, the cyclone air inlet **1120** is a tangential air inlet that, as exemplified, terminates at an aperture or port that is formed in cyclone sidewall **1180**, optionally an upper portion **1182** of the cyclone sidewall **1180**, adjacent the front end wall **1160**. Optionally, the cyclone air inlet **1120** may be provided at an alternate location, such as in the front end wall **1160**.

The cyclone air inlet **1120** is fluidly connected with the outlet end of the conduit **1036** via a corresponding air outlet aperture or port **1038** that may be provided in a lower portion of the air inlet conduit **1036**. The cyclone air inlet **1120** may have any suitable arrangement and/or configuration, and in the illustrated example is configured as a tangential air inlet that is directly connected to the air outlet aperture **1038**. Connecting the air inlet **1120** to the air outlet aperture **1038** in this manner may help reduce the need for additional conduits to fluidly connect the dirty air inlet **1030** to the cyclone chamber **1110**, and may reduce or eliminate the need for additional bends or air flow direction changes between the dirty air inlet **1030** and the cyclone chamber **1110**. Reducing the conduit length and number of bends may help reduce the backpressure and air flow losses within the air flow path.

Positioning the cyclone air inlet **1120** toward the front of the cyclone chamber **1110** may help facilitate a desired air flow configuration within the cyclone chamber **1110**. For example, in this configuration the cyclone chamber **1110** itself functions as part of the air flow path that conveys air rearwardly from the front **1002** of the hand vacuum **1000**, without the need for a separate fluid conduit.

In the illustrated example, cyclone air inlet **1120** is directly adjacent the front wall **1160**. Alternatively, cyclone air inlet **1120** may be axially spaced from the front end wall **1160**, and may be located at another location along the length of the cyclone chamber **1110**. Preferably, cyclone air inlet **1120** is provided in the front half of the cyclone chamber **1110** (i.e. forward of the axial mid-point of the cyclone chamber sidewall **1080**) in order to help reduce the distance between the dirty air inlet **1030** and the cyclone air inlet **1120**.

As shown in FIG. **10**, the cyclone air outlet **1130** is provided in the rear end wall **1170** of the cyclone chamber **1110**, and an axially extending vortex finder conduit **1136** extends from the rear end wall **1170** and is aligned with the cyclone air outlet **1130**. Optionally, a mesh screen (not shown) may be positioned over some or all of the inlet apertures **1138** of the vortex finder conduit **1136** to help inhibit lint, hair, and other such debris from entering the vortex finder conduit **1136**. Positioning the air outlet **1130** toward the rear end (and optionally in the rear end wall **1170**) may help facilitate the desired air flow through the cyclone chamber **1110**, such that air, while swirling, travels generally axially though the cyclone chamber **1110** from the front end wall **1160** toward the rear end wall **1170**.

Positioning the air outlet **1130** in the rear end wall **1170** of the cyclone chamber **1110** may also help facilitate the air flow connection between the cyclone chamber **1110** and other downstream components in the hand vacuum, such as the pre-motor filter housing **1310** and suction motor housing **1210** described herein. In the illustrated embodiment the air outlet **1130** is provided in the rear end wall **1170** and is connected to the pre-motor filter housing **1310** through an upflow duct or conduit **1230**. This may help simplify the air flow path and construction of the hand vacuum. Alternatively, the air flow path may include one or more additional conduits connected downstream from the cyclone air outlet.

In this arrangement, air travelling through the hand vacuum **1000** will travel generally rearwardly along the air inlet conduit **1036** (i.e. parallel to the conduit axis **1035** and then enter a tangential air inlet which essentially changes the direction of the air to travel generally downwardly through the cyclone air inlet **1120** (i.e. generally orthogonal to the cyclone axis **1115**). The air can then circulate within the cyclone chamber **1110**, and travel generally rearwardly toward the cyclone air outlet **1130**, and ultimately exit the cyclone chamber **1110** via the cyclone air outlet **1130** while travelling through the vortex finder conduit **1136** in a rearward direction (i.e. generally parallel to the cyclone axis **1115**). In this configuration, the air flow changes direction only once (and by only approximately 90° which may be accomplished by a tangential air inlet), between entering the dirty air inlet **1030** and exiting the cyclone air outlet **1130**.

The cyclone dirt outlet **1140** may be of any suitable configuration, and in the illustrated embodiment is a slot **1140** that is provided in the cyclone chamber side wall **1180**, toward the rear end wall **1170**. The slot **1140** may extend around at least a portion of the perimeter of the cyclone side wall **1180**, and may have any suitable length **1186** in the axial direction (see e.g. FIG. **10**). As exemplified, the slot may be provided only in a lower portion of the sidewall. Accordingly, when dirty air inlet **1030** faces downwardly during use, dirt will exit into an upper end of an external dirt collection chamber. Positioning the dirt collection chamber below the cyclone chamber, and not surrounding the cyclone chamber, reduces the width of the hand vacuum. While shown directly adjacent the rear end wall **1170**, such that the slot **1140** is partially bounded by the cyclone side wall **1180** and the rear end wall **1170**, the slot **1140** may be located at another location along the length of the cyclone side wall **1180**, and need not be directly adjacent the rear end wall **1170**. Alternatively, the dirt outlet **1140** may be provided toward the mid-point of the cyclone chamber sidewall **1180**, or may be provided toward the front end wall **1160**. While illustrated with a single dirt outlet **1140**, the cyclone chamber **1110** may include two or more dirt outlets that are in communication with the same dirt collection chamber, or optionally with different dirt collection chambers.

Preferably, at least a portion of the air treatment member may be openable for emptying. For example, at least one end, and optionally both ends of the dirt collection chamber **1122** may be openable for emptying. Optionally, at least one end, and optionally both ends of the cyclone chamber **1110** may also be openable for emptying.

Referring primarily to FIGS. **9** and **10**, the front end wall **1160** of the cyclone chamber **1110** and the front end wall **1126** of the dirt collection chamber **1122** are both provided by portions of an openable front door **1190** that covers the front end of the cyclone assembly. In this arrangement, opening the front door **1190** will concurrently open the front end walls **1160** and **1126** of the cyclone and dirt collection chambers **1110**, **1122**. In the illustrated example, a user may hold the hand vacuum **1000** via the handle **1020** with one hand and open the front door **1190** with the other hand. The front end wall **1160** of the cyclone chamber **1110** and the front end wall **1126** of the dirt collection chamber **1122** may be concurrently openable and may cover all of a substantial portion of the front end of the cyclone chamber and the dirt collection chamber. For example, the front end wall **1160** of the cyclone chamber **1110** and the front end wall **1126** of the dirt collection chamber **1122** may be a one piece assembly (i.e. they may be integrally formed).

The front door **1190** may be openably connected (e.g., pivotally openable or removably mounted) to the rest of the cyclone assembly using any suitable mechanism, including a hinge or other suitable device. Optionally, the front door **1190** may be secured in the closed position using any suitable type of locking mechanism, including a latch mechanism that may be released by a user. In the embodiment of FIGS. **1** to **34**, the front door **1190** may be opened by pivoting it about a hinge assembly **1192** from a closed position (e.g. as shown in FIG. **1**) to an open position (e.g. as shown in FIG. **6**). The front door **1190** may be secured in the closed position by a friction fit when connected as illustrated in FIG. **1**, and/or by an assembly door lock **1194** or other suitable locking mechanism. Preferably, the assembly door lock may include at least one release actuator **1196** so that a user may unlock the assembly door lock, e.g. by depressing the actuator. The actuator for opening/releasing the openable portion of the cyclone assembly may be provided on the cyclone assembly **1100** or on any other portion of the hand vacuum **1000** (such as the handle **1020**).

In the embodiments described herein, the surface cleaning apparatus includes a pre-motor filter housing **1310** positioned in the air flow path between the cyclone chamber and the suction motor. It will be appreciated that in some embodiments, the pre-motor filter may be of any configuration and the direction of air flow through the pre-motor filter **1320** may be any particular direction.

Referring primarily to FIGS. **9** and **10**, as exemplified, in some embodiments, the main body **1010** may be configured such that the suction motor housing **1210** is located rearward of the pre-motor filter housing **1310** and, preferably, axially aligned with the pre-motor filter housing **1310** such that air exiting the pre-motor filter may travel generally linearly to the suction motor. It will be appreciated that suction motor housing **1210** and pre-motor filter housing **1310** may be of any configuration

As exemplified herein, the pre-motor filter **1320** may be configured as a generally cylindrical foam filter with a hollow, open interior and is preferably part of a removable pre-motor filter assembly, as discussed elsewhere herein. The pre-motor filter **1320**, which may be a foam filter, extends longitudinally along a filter axis **1325**, which may be generally parallel with the suction motor axis of rotation and accordingly is exemplified as being generally horizontal in the illustrated embodiment. The interior, downstream surface of filter **1320** is in communication with the air outlet **1242** via an outlet conduit **1340** of the pre-motor filter assembly. An advantage of a cylindrical filter is that a relatively large upstream surface area may be provided in a small space. A further advantage of this configuration is that, if the suction motor housing **1210** is located rearward of, and generally axially aligned with, the pre-motor filter housing **1310**, air exiting the pre-motor filter may travel rearwardly through the hollow interior and then travel rearwardly to the suction motor.

In the illustrated example, the pre-motor filter housing **1310** is positioned such that the pre-motor filter **1320** is vertically spaced from and mostly, and optionally entirely, located above the cyclone axis **1115** and also above the cyclone chamber. Put another way, pre-motor filter **1320** mostly, and optionally entirely, overlies the cyclone chamber. In other embodiments, only a portion of the pre-motor filter may be above the cyclone axis **1115** and optionally also above the cyclone chamber.

Referring to FIG. **10**, in the illustrated example the pre-motor filter housing **1310** has forward and rear end walls **1312** and **1314**, and a chamber sidewall **1316** defining a pre-motor filter chamber or plenum **1318**. Optionally, the pre-motor filter is removable, such as proving a removable or otherwise openable door **1330**. Door **1330** may extend between forward and rear end walls **1312** and **1314**. The housing **1310** also has an air inlet **1234** that is connected downstream from the cyclone air outlet **1130** via upflow duct **1230**, and an air outlet **1242** positioned in the rear end wall **1314**. In the illustrated example, the housing air inlet **1234** is located toward the rear end of the housing **1310**. To travel from the air inlet **1234** to the air outlet **1242**, air passes through the pre-motor filter **1320** positioned within the chamber **1318**.

As the pre-motor filter **1320** is positioned above the cyclone air outlet, air travels upwardly to the pre-motor filter chamber **1318**. As exemplified herein, the pre-motor filter may be in the shape of a hollow cylinder which has a central axis that is generally parallel with the suction motor axis of rotation. An advantage of this configuration is that, after the air travels upwardly to the pre-motor filter chamber **1318**, in order to try to balance the forces in the pre-motor filter chamber **1318**, the air will tend to spread across the chamber. Therefore, without using a 90□ bend to direct the air to the front part of the pre-motor filter, a plenum is used to distribute the air across the upstream surface of the pre-motor filter. In accordance with this configuration, air travels to the filter housing **1310** in a generally upward direction, where it disperses in the pre-motor filter chamber **1318** and circulates around and through the outer, upstream surface of filter **1320**, and exits the housing air outlet **1242** in a generally rearward direction into the suction motor housing inlet end **1212**.

In the illustrated example, the suction motor **1200** is generally horizontally oriented, such that the suction motor axis of rotation **1205** is generally horizontal (e.g., ±20°, ±15°, ±10°, or ±5° from horizontal) when the hand vacuum cleaner is positioned with the upper end above the lower end (as illustrated in FIG. **10**). In this arrangement, the suction motor axis **1205** is generally parallel to the cyclone axis **1115** and the pre-motor filter axis **1325**.

In the example configuration illustrated in FIG. **10**, an inlet end **1202** of the suction motor **1200** faces towards a hollow interior of the pre-motor filter. In such a configuration, air may travel generally linearly from the pre-motor filter **1320** to the suction motor **1200**. An absence of air flow direction changes between an air outlet of the pre-motor filter and the suction motor may reduce backpressure and/or air flow losses through this portion of the hand vacuum cleaner.

Also, positioning the suction motor at an upper end of a handle of the vacuum cleaner with the suction motor axis vertically displaced from the cyclone axis of rotation may facilitate the reduction of air flow conduit bends and/or air flow direction changes between a dirty air inlet and a clean air outlet, thereby reducing backpressure and/or air flow losses through the hand vacuum cleaner. Additionally, or alternatively, such a configuration may help provide a compact overall design of the hand vacuum cleaner without adversely affecting the hand feel and/or perceived balance of the hand vacuum.

It will be appreciated that the air may exit the hand vacuum cleaner via a grill located in an upper portion of the main body (e.g., via an air outlet provided in the rear end of the main body or a sidewall adjacent the rear end). Alternately, air may exit through a lower portion of the main body. This may be achieved by conveying the air downwardly through the handle of the hand vacuum cleaner. Accordingly, as exemplified, at least a portion of the air flow path between the dirty air inlet **1030** and the clean air outlet **1040** may flow through the handle **1020**. This may help facilitate a variety of different air flow path configurations and clean air outlet **1040** locations. This may also allow at least some of the air being exhausted by the suction motor **1200** to flow over, and optionally help cool, operating components that are located in the handle. Examples of such components may include controllers, circuit boards, other internal electronics and the like. One example of such electronics can include a printed circuit board (PCB) provided to control optional information display device **1070** and/or power switch **1060**.

In the illustrated embodiment, a handle air flow passage **1250** has an inlet end **1252** that is located toward the top **1022** of the handle downstream from the suction motor **1200**, and an outlet end **1254** that is located toward the bottom **1024** of the handle. This may help channel the air through substantially the entire length of the hand grip portion **1026** of the handle **1020**.

As exemplified, the air exhausted from the suction motor **1200** is routed through the handle, and the clean air outlet **1040** is provided in the form of a plurality of slots **1430** that are formed in the lower end **1024** of the handle. Air entering the inlet end **1252** is directed through the handle **1020** and exits via the slots **1430**. In this example, the slots or grill **1430** are oriented such that air exiting the clear air outlet **1040** travels generally downwardly and rearwardly from the lower end **1024** of the handle **1020**. It will be appreciated that the clean air outlet may be of any design and may be located anywhere in the lower portion of the hand vacuum cleaner.

Optionally, one or more post-motor filters may be placed in the air flow path between the suction motor **1200** and the clean air outlet **1040**. The post-motor filter may be provided at the clean air outlet **1040**. The post motor filter may be in an openable housing. For example, as exemplified, the clean air outlet **1040** may be an openable grill. Further, the openable access panel may support the post-motor filter. For example, in the embodiment of FIGS. **1** to **34**, a post-motor filter **1420** is supported by a removable tray **1410** that covers the lower end of the post-motor filter housing **1400** and provides the clean air outlet **1040** in the form of a grill. The illustrated post-motor filter **1420** is a physical foam media filter, but optionally the post-motor filters may be any suitable type of filter and may include one or more of foam filters, felt filters, HEPA filters, other physical filter media, electrostatic filters, and the like.

With references to FIGS. **23**-**27**, removable tray **1410** includes a pair of rigid engaging projections **1440** provided on a front end **1412**, and a pair of movable engaging projections **1450** extending upwardly from a rear end **1414** and resiliently biased towards the rear end. To separate the tray from the main body **1010**, actuating (e.g. depressing) button **1460** results in forward movement of the movable engaging projections **1450**, resulting in their disengagement from corresponding recesses **1455** in the main body, allowing the rearward end **1414** of tray **1410** to be pivoted downwardly from handle **1020**. Once tray **1410** has been so pivoted, it may be translated rearwardly to remove engaging projections **1440** from corresponding recesses **1445** in the main body. To connect the tray **1410** to the main body **1010**, the process may be generally reversed. That is, projections **1440** may be inserted into recesses **1445**, and tray **1410** subsequently pivoted upwardly until engaging projections **1450** are secured in recesses **1455**. It will be appreciated that any other constructions may be used to removably secure tray **1410** in position on the main body.

While the figures exemplify positioning the pre-motor filter and suction motor vertically spaced above the cyclone axis, it will be appreciated that the pre-motor filter and suction motor vertically spaced below the cyclone axis.

Removable Pre-Motor Filter Assembly

The following is a description of different features of a removable pre-motor filter assembly for a surface cleaning apparatus. These features may be used by themselves in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein. For example, any of the pre-motor filter configurations described herein may be used with any of the air flow paths, relative positioning of the suction motor and energy storage members, inclined battery packs, battery pack configurations, airflow cooling configurations, and other features described herein.

In accordance with this feature, the outlet conduit of the filter assembly may be inclined at an angle to the removal direction of the pre-motor filter assembly with the upper (or outermost portion of the outlet conduit in the removal direction) extending further in the downstream direction than the lower (or innermost portion of the outlet conduit in the removal direction). The mating downstream conduit may be similarly oriented. An advantage of this configuration is that the downstream face of the pre-motor filter assembly (which may have a sealing gasket) may be placed on the upstream face of the downstream conduit (which may have a sealing gasket) instead of one face sliding across the other, which could damage one or both gaskets.

In accordance with this feature, as exemplified, the pre-motor filter **1320** of the hand vacuum cleaner **1000** is optionally part of a removable pre-motor filter assembly **1300**. FIGS. **19** to **22** exemplify one embodiment of a removable pre-motor filter assembly **1300** that includes a generally cylindrical filter **1320** supported by a filter support member **1340**. Filter support member **1340** has an outlet conduit **1342** for directing an air flow after it has passed through the filter **1320**. In use, air flows from an outer or upstream side **1322** of the filter **1320**, through the filter media and to an inner or downstream side **1324** of the filter **1320**, and to the outlet conduit **1342**.

Optionally, the outlet conduit **1342** generally faces an inlet end **1202** of suction motor **1200**. Therefore, as exemplified, the filter support member **1340** may be generally horizontally oriented so that the pre-motor filter axis **1325** extends in a generally forwards/rearwards direction (from front end **1321** to rear end **1323** of the pre-motor filter assembly) when the hand vacuum cleaner **1000** is oriented with the upper end above the lower end, and the outlet conduit **1342** faces generally rearwardly, and optionally directly faces an inlet end **1202** of suction motor **1200**. From the outlet conduit **1342**, a treated air conduit **1246** directs the airflow rearwards to an inlet end **1202** of suction motor **1200** that is horizontally spaced from the pre-motor filter **1320**.

As illustrated in FIGS. **19** to **22**, filter support member **1340** has a main body portion **1350** that is located in a hollow interior of the generally cylindrical filter **1320**. In the illustrated embodiment, an outer surface of main body portion **1350** is flush with a downstream or inner surface **1324** of filter **1320**, and the downstream surface **1324** is in air flow communication with an internal filter conduit **1356**. More specifically, in the illustrated example a plurality of apertures **1351** define a porous portion of the filter support member **1340** between a first end **1352** and a second end **1354** of the main body portion **1350**. It will be appreciated that more or fewer apertures may be provided in alternative embodiments. Accordingly, if filter **1320** is sealed to or seats securely on body portion **1350**, air will be inhibited from travelling between the outer surface of main body portion **1350** and the inner surface **1324** of filter **1320** to thereby bypass the filter media.

The outlet conduit **1342** extends from the second end **1354** of the main body portion **1350**. The second or opposed end **1352** of the main body portion **1350** may be sealed to or may seat securely on the second end **1354** of the main body portion **1350** to inhibit and preferably prevent air from exiting the internal filter conduit **1356** from the second end, so that substantially and preferably all of the air that exits the downstream side **1324** of the pre-motor filter **1320** is directed through outlet conduit **1342**.

In order to inhibit or prevent air exiting through the front end of the internal filter conduit **1356**, the front end of the main body portion **1350** may be closed. As exemplified, an end wall **1362** is provided to cap the opposed end **1352** of the main body portion **1350**. Optionally, end wall **1362** has an outwardly projecting portion **1363** to facilitate positioning the pre-motor filter assembly **1300** in a surface cleaning apparatus, as discussed further below.

Optionally, flanges or other sealing members may be provided at one or both ends of the main body portion **1350** to inhibit or prevent airflow from flowing between pre-motor filter **1320** and filter support member **1340** and to the internal filter conduit **1356**, e.g. effectively bypassing the pre-motor filter. In the illustrated example, a circumferential bypass flange **1358** is provided at the second end **1354** of the main body portion **1350**.

The pre-motor filter assembly may be seated in position in the pre-motor filter housing by any means known in the art. As exemplified, one or more alignment or seating members may be provided on one or both of the front and rear ends **1321**, **1323** of the pre-motor filter assembly.

In the illustrated example, a pair of alignment flanges **1370** extend from an axially longer (outermost) side of outlet conduit **1342**. Flanges **1370** may facilitate in the seating and/or alignment of pre-motor filter assembly **1300** within a pre-motor filter chamber. For example, in the illustrated example the flanges **1370** may be configured to act as camming surfaces with one or more projections from an internal surface of the openable door **1330** of the pre-motor filter chamber. As shown in FIG. **18**, openable door **1330** has an inwardly extending projection **1338** that has a width approximately equal to a radial distance between flanges **1370**. In this arrangement, as openable door **1330** is closed, projection **1338** is configured to come into contact with both flanges **1370**, thereby promoting a predetermined orientation of pre-motor filter assembly **1300** relative to the pre-motor filter housing **1310** as well as locating the outlet conduit to be aligned with the downstream air flow conduit.

Additionally, or alternatively, flanges **1370** may allow a user to grip and/or manipulate pre-motor filter assembly **1300** without having to come into contact with pre-motor filter **1320**, which may become dirty during use.

Optionally, one or more support projections may be provided on one or both ends of pre-motor filter assembly **1300**. In the illustrated example, a pair of support flanges **1372** extend from opposite lateral sides of outlet conduit **1342**. Flanges **1372** may facilitate the support and/or alignment of pre-motor filter assembly **1300** within a pre-motor filter chamber. For example, in the illustrated example the flanges **1372** may be configured to rest on corresponding support surfaces provided at the rearward end of the pre-motor filter chamber. As shown in FIGS. **15-17**, surfaces **1313** are formed in end wall **1344** of the pre-motor filter chamber **1310**. Also, a surface **1311** is formed in the opposing end wall **1312**. In this arrangement, as pre-motor filter assembly **1300** is lowered into the pre-motor filter chamber **1310**, surfaces **1313** are configured to come into contact with and support flanges **1372**, and surface **1311** is configured to come into contact with and support outwardly projecting portion **1363** of filter support member **1340**, thereby promoting a predetermined vertical position and/or angle of pre-motor filter assembly **1300** relative to the pre-motor filter housing **1310**.

In the illustrated embodiment, filter support member **1340** (including outlet conduit **1342**, main body portion **1350**, and end wall **1362**) is a one piece assembly (e.g. integrally formed). In alternative embodiments, filter support member **1340** may be constructed from two or more parts.

While in the illustrated example the pre-motor filter **1320** and the filter support member **1340** are co-axial, this may not be the case in alternative embodiments.

As illustrated in FIG. **22**, a downstream or terminal end **1344** of the outlet conduit **1342** is at an angle **1357** to a direction of air flow through the outlet conduit (e.g. generally parallel to a central pre-motor filter axis **1325** and/or a central filter support member axis **1355**). Outlet conduit **1342** mates with air conduit **1246**, which provides the air outlet **1242** from pre-motor filter chamber **1310**. As discussed subsequently, the inlet end of outlet conduit **1342** may be similarly angled.

An advantage of the terminal end of the outlet conduit being at an angle of to a direction through the outlet conduit is that the removable filter assembly may be positioned substantially flush against a downstream air conduit (e.g. a conduit that leads to a suction motor) having a similarly angled terminal end without requiring lateral movement of the outlet conduit towards other conduit. For example, the filter assembly may be moved in a direction substantially perpendicular to the direction of airflow (e.g., vertically upwardly in the orientation of FIG. **11**). Such an arrangement may, for example, facilitate the use of a gasket or other sealing member between the ends of the conduits to provide an improved seal between the conduits. For example, if the terminal end of the outlet conduit were perpendicular to a direction of airflow through the conduit, moving the filter assembly in a direction substantially perpendicular to the direction of airflow may shear or otherwise damage a flexible or otherwise deformable gasket (e.g. an elastomeric gasket or the like) provided at the end of the conduit to which the outlet conduit is to be aligned.

Alternatively, or additionally, such an arrangement may eliminate the need for a biasing or other retaining mechanism to exert a force on the filter assembly to maintain a seal between the conduits. For example, if the terminal end of the outlet conduit were perpendicular to a direction of airflow through the conduit, to avoid damaging a gasket or other sealing member between the conduit ends, at least the final motion to align the conduit ends may be in a direction parallel to a direction of airflow through the conduit. In such a situation, it may be necessary to maintain the application of an axial force to the pre-motor filter assembly in order to maintain an adequate seal.

As illustrated in FIGS. **11** to **17**, a terminal end **1241** of the treated air conduit **1246** may also be optionally provided at an angle **1257** (see FIG. **11**) to a direction of air flow through the treated air conduit **1246** that leads to the suction motor **1200**. In the illustrated example, the angle **1257** is about the same as the angle **1357** between the direction of air flow through the outlet conduit **1342** of the pre-motor filter assembly and the terminal end **1344** of the outlet conduit **1342**. This arrangement allows the outlet conduit **1342** and the treated air conduit **1246** to cooperatively define a generally linear air flow passage despite the angled terminal ends of the respective conduits.

Optionally, a gasket **1247** or other sealing member may be provided to help provide a substantially air tight seal between the terminal end **1344** of the outlet conduit **1342** and the terminal end **1241** of the treated air conduit **1246**. In the illustrated example, the gasket **1247** has a generally consistent axial length about its perimeter, e.g. to facilitate a seal between the ends **1344**, **1241** that are generally parallel to each other due to angles **1357**, **1257** being about the same. Alternatively, gasket **1247** may have a variable axial length about its perimeter, e.g. to facilitate a seal where angles **1357**, **1257** are different from each other (e.g. where ends **1344**, **1241** are not parallel.

Another advantage of the terminal end of the outlet conduit and the inlet end of conduit **1246** being at an angle to a direction through the outlet conduit is that the outlet face of the pre-motor filter assembly may be placed onto the inlet or upstream face of conduit **1246** during insertion of the pre-motor filter assembly. Further, when door **1330** is placed in the closed position, the engagement of inwardly extending projection **1338** and flanges **1370** may apply sufficient pressure to seal the end face and inhibit leakage out of the air flow conduits.

Another advantage of the terminal end of the outlet conduit being at an angle of to a direction through the outlet conduit is that the removable filter assembly may only be positionable within the surface cleaning apparatus in a single pre-determined orientation. In other words, a user may only be able to mount to the pre-motor filter assembly in a single orientation relative to the surface cleaning apparatus. This may prevent, for example, the pre-motor filter from being installed e.g. upside-down from its designed orientation, or otherwise mis-aligned. Accordingly, an asymmetric pre-motor filter media may be provided without the risk of a user improperly positioning the filter within a surface cleaning apparatus.

It will be appreciated that some of the embodiments disclosed herein may not use any of the features of the pre-motor filter assembly disclosed herein and that, in those embodiments, a pre-motor filter of any kind known in the art may be used, or a pre-motor filter may not be provided.

Inclined Battery Pack

The following is a description of different features of a hand vacuum cleaner with an inclined battery pack. These features may be used by themselves in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein. For example, any of the battery pack configurations described herein may be used with any of the air flow paths, pre-motor filter assemblies, relative positioning of the suction motor and energy storage members, battery pack configurations, airflow cooling configurations, and other features described herein.

In accordance with this feature, an upper end of the battery pack may be inclined in a forward direction. Accordingly, the lower end of the battery pack may extend further rearwardly. If the dirt collection region is located adjacent a forward face of the battery pack, then the dirt collection region may extend further rearwardly, thereby enabling a larger dirt collection region to be provided.

It will be appreciated that, in many embodiments, power may be supplied to the hand vacuum cleaner **1000** by an electrical cord connected to the hand vacuum (not shown) that can be connected to a standard wall electrical outlet. In such embodiments, the suction motor **1200** and other electronics may run on AC power supplied from a wall socket. In accordance with this feature, alternatively, or in addition to being powered by an electrical cord, the hand vacuum cleaner may include one or more onboard power sources. The power sources may be any suitable device, including, for example one or more batteries. Optionally, the batteries and battery packs may be rechargeable or may be replaceable, non-rechargeable batteries.

Battery pack **1500** may include any suitable number of cells **1510**, and may include, for example, lithium ion battery cells. Any number of cells may be used to create a power source having a desired voltage and current, and any type of battery may be used, including NiMH, alkaline, and the like. Battery pack **1500** may be of any known design and may be electrically connected to the hand vacuum cleaner by any means known in the art.

FIGS. **32** to **34** exemplify a battery pack **1500**. As exemplified, battery pack **1500** has an upper end **1506**, a lower end **1508**, a front face **1502**, and a rear face **1504**. In the illustrated example, battery pack **1500** is generally rectangular, but alternative embodiments may have any suitable shape.

In the illustrated examples, battery pack **1500** has a power coupling **1540** for supplying power (e.g. charging) the cells **1510**. Any suitable power coupling may be used, for example, a female coupling configured to receive a male coupling of an electrical cord that is connectable to a source of AC or DC power, such as a household power socket. Optionally, power coupling **1540** is accessible when the battery pack **1500** is electrically connected to hand vacuum cleaner **1000**. An advantage of such a configuration is that the battery pack may be charged without removing it from the hand vacuum cleaner **1000**. Another advantage is that it may allow for corded operation of hand vacuum cleaner **1000** when the power cells **1510** are substantially or completely discharged, as power may be supplied to the suction motor via power coupling **1540** instead of (or while) charging the cells **1510**.

Optionally, the battery pack **1500** may be removable from the rest of the hand vacuum using any mechanism known in the art. Referring to FIGS. **28** and **29**, the illustrated example battery pack **1500** is configured to be removable by sliding the battery pack downward through an aperture **1590** (see FIG. **31**) provided in the lower end **1008** of hand vacuum **1000**. Optionally, one or more guiding features may be provided on one or both of the hand vacuum **1000** and the battery pack **1500**. As illustrated in FIG. **33**, a pair of longitudinal ridges **1520** is provided on the front face **1502** of battery pack **1500**. Ridges **1520** are configured to be slidably received in corresponding grooves **1525** on an inner face of aperture **1590** (see FIG. **29**). Ridges **1520** and grooves **1525** thus cooperatively assist in aligning the battery pack as is it moved upwardly into and/or downwardly out of aperture **1590**.

In the illustrated embodiment, the upper end **1506** of the battery pack **1500** is provided with a plurality of electrical connectors **1530** that can inter-engage with compatible electrical connectors **1580** on the main body **1010** (see e.g. FIG. **29**). Engagement between the electrical connectors **1530** and **1580** can provide an electrical connection between the batteries **1510** and the suction motor **1200**, and optionally other electronics, such as display device **1070**. In this arrangement, removing the battery pack **1500** interrupts the supply of power to the suction motor **1200**, and the suction motor **1200** is not operable when the battery pack **1500** is detached. It will be appreciated that electrical connectors **1530** may be located elsewhere on the battery pack.

The battery pack **1500** can be secured to the rest of the main body **1010** using any suitable attachment mechanism, including mechanical latches, retention catches, or any other mechanism attachment structure capable of being released to disengage and remove the battery pack. Optionally, one or more actuators for releasing the attachment mechanism may be provided on the main body **1010** (and remain with the main body when the battery pack is removed), or alternatively may be provided on the battery pack **1500** such that the actuator is removable with the battery.

Referring to FIGS. **9** and **33**, in the illustrated example battery pack **1500** is configured to be releasably secured to hand vacuum **1000** using a single latch at the lower end **1506**. The latch can be released by pressing the release actuator that is provided in the form of button **1550**. Pressing rearwardly on the button **1550** results in a disengagement of a tab **1552** from a corresponding retaining surface **1523** provided proximate to and facing towards aperture **1590**. The button **1550** is mounted to the lower end **1506** of battery pack **1500**, and is removable with the battery pack.

Alternatively, a release actuator may be provided on the main body **1010** of the hand vacuum cleaner, and a corresponding retaining surface may be provided on the battery pack **1500**. For example, in the example illustrated in FIG. **36**, a retaining surface **1523** is provided on a rear face **1504** of battery pack **1500**, and is removable with the battery pack. A release actuator that is provided in the form of button **1550** is positioned on the main body **1010** of hand vacuum **1000**. Pressing forwardly on the button **1550** results in a pivoting and disengagement of a tab **1552** from retaining surface **1523**.

Optionally, the battery pack **1500** may be configured so that it can be connected to one or more other devices/apparatuses, in addition to the hand vacuum **1000**. For example, the same battery pack **1500** that is used with the hand vacuum could be connectable to another vacuum, power tool, cleaning device (such as a mop, steam cleaner, carpet extractor, etc.) or any other suitable device to power the other device(s) that the battery pack can be connected to.

Optionally, the battery pack **1500** may have one or more output devices to e.g. provide an indication of a status of the battery pack and/or of one or more of the individual battery cells **1510**. For example, one or more visual indicators such as LEDs and/or an audio output device such as a speaker may be provided. In the example illustrated in FIG. **32**, a number of LEDs **1560** are provided along an edge between a rear face **1504** and a side face of the battery pack **1500**. An advantage of positioning the output devices along an edge of the battery pack is that the indicators may be visible from a greater range of relative orientations than if they were positioned on a single face of the battery pack.

As illustrated in FIG. **4**, another advantage of positioning the LEDs **1560*a*-1560*c*** proximate a side edge of a rear face **1504** is that they may be more readily visible to a user holding the hand vacuum cleaner **1000** in front of them. Accordingly, a user may be able to see the LEDs **1560*a*-1560*c*** while using the hand vacuum without having to re-orient the hand vacuum cleaner from a typical in-use position.

As discussed above, battery pack **1500** may include any suitable number of individual battery cells **1510**. In example illustrated in FIG. **34**, battery pack **1500** contains 7 cells **1510*a*-1510*g***. Each cell **1510** is generally cylindrical, and the cells are arranged in a generally linear configuration (in a column) along the height of battery pack **1500**. More specifically, cells **1510*a*** to **1510*f*** are arranged with their central longitudinal axes positioned along a battery pack axis **1505** that in the illustrated example is parallel to a front wall **1501** of the battery pack **1500**, and cell **1510*g*** is positioned with its central longitudinal axis offset rearwardly from axis **1505**.

As shown in FIG. **10**, in the illustrated example battery pack **1500** extends upwardly and forwardly when the upper end of the hand vacuum cleaner is positioned above the lower end of the hand vacuum cleaner. For example, battery pack axis **1505** is at an angle **1507** to the horizontal when the inlet conduit axis **1035**, cyclone axis **1115**, filter axis **1325**, and/or suction motor axis **1205** is generally horizontally oriented. For example, battery pack axis **1505** may be generally parallel to a handle axis **1025** (see FIG. **31**).

Also, in the configuration shown in FIG. **10**, a portion **1123** of the dirt collection chamber **1122** adjacent the rear end wall **1124** of the chamber **1122** is located below a portion of the battery pack **1500**. An advantage of this design (i.e. providing at least some vertical overlap between an energy storage member and a dirt collection region) is that it may help provide a relatively larger dirt chamber capacity while helping to reduce the overall size of the hand vacuum **1000**.

In the illustrated example, the rear end wall **1124** of the dirt collection chamber **1122** is at an angle to the vertical. As shown, rear end wall **1124** is generally parallel to the front wall **1501** of the battery pack **1500** and to the battery pack axis **1505**, although in alternative embodiments they may not be parallel.

Also, when the inlet conduit axis **1035**, cyclone axis **1115**, filter axis **1325**, and/or suction motor axis **1205** is generally horizontally oriented, a lower end of the front face **1502** is positioned rearward of an upper portion of the front face **1502**.

It will be appreciated that the dirt collection region may be of various shapes which occupies some or all of the additional volume created by orienting the battery pack **1500** such that the lower end extends further rearwardly.

It will be appreciated that some of the embodiments disclosed herein may not use the inclined energy storage members as disclosed herein and that, in those embodiments, any suitable positioning of the energy storage members, if provided, may be used.

Positioning of Suction Motor and Energy Storage Member

The following is a description of different features of a hand vacuum cleaner with a suction motor positioned an upper end of a forwardly-inclined handle and rearward of at least some of the energy storage members. These features may be used by themselves in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein. For example, any of the relative positioning of the suction motor and energy storage members described herein may be used with any of the air flow paths, pre-motor filter assemblies, inclined battery packs, battery pack configurations, airflow cooling configurations, and other features described herein.

In accordance with this feature, the batteries and the suction motor may be positioned so as to reduce the torque experienced by a user operating the hand vacuum cleaner. For example, by positioning a suction motor positioned at or rearward of an upper end of a forwardly-inclined handle and rearward of at least some of the energy storage members, the weight of the suction motor may partially counterbalance the weight of the batteries.

As previously discussed, in some embodiments, batteries used to power the hand vacuum cleaner **1000** may be provided at a single location, for example as one large battery pack **1500** that may include any suitable number of cells **1510**, and may include, for example, lithium ion battery cells.

Optionally, a battery pack **1500** may be positioned such that some or all of the battery cells **1510** are positioned forward of a suction motor. In this configuration, the distribution of the weight of the battery pack **1500** and the weight of the suction motor **1200** may affect the hand feel and/or perceived balance of the hand vacuum **1000**.

In the example illustrated in FIG. **10**, suction motor **1200** is positioned rearward of cells **1510***a*, **1510***b*, **1510***c*, **1510***d*, and **1510***e* of battery pack **1500**. In the example illustrated in FIG. **43**, suction motor **1200** is positioned rearward of cells **1510***a*, **1510***b*, **1510***d*, **1510***e*, and **1510***g* of battery pack **1500**. In the examples illustrated in FIGS. **36**, **40**, and **47**, all of cells **1510***a*-**1510***f* are positioned forward of the suction motor **1200**.

Suction motor **1200** is preferably positioned at the upper end of a forwardly inclined handle **1020**, as shown in the illustrated embodiments, although it may alternatively be positioned rearward of the upper end of the handle or at the lower end or at a mid-point of a handle. Additionally, or alternatively, the handle **1020** may be generally vertical or may be rearwardly inclined.

Optionally, a battery pack **1500** may be positioned such that a volume defined by the battery cells **1510** is positioned such that an axis of rotation **1115** of a cyclone chamber **1110** may intersect such a volume when the battery pack is secured to the main body **1010**. For example, the cyclone chamber **1110** may be oriented horizontally, and the battery pack **1500** may be positioned rearward of the cyclone chamber. An advantage of such a configuration is that it may facilitate a more compact design of hand vacuum **1000**.

It will be appreciated that some of the embodiments disclosed herein may not use the relative positioning of the suction motor, handle, and energy storage members as disclosed herein and that, in those embodiments, any suitable design may be used.

Nested Energy Storage Members

The following is a description of different features of a hand vacuum cleaner having an energy storage member (e.g. a battery pack that includes one or more battery cells) that is positioned rearward of a dirt collection region and at least partially underlies at least a portion of one or both of a cyclone chamber and a pre-motor filter. These features may be used by themselves in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein. For example, any of the battery pack configurations described herein may be used with any of the air flow paths, pre-motor filter assemblies, relative positioning of the suction motor and energy storage members, inclined battery packs, airflow cooling configurations, and other features described herein.

In accordance with this feature, the some or all of a battery pack may be located beneath some or all of a cyclone chamber and/or a pre-motor filter. For example, the dirt collection region may be configured to enable the battery pack to nest or partially nest therein. Accordingly, the overall length of the hand vacuum cleaner (in the forward/rearward direction) may be reduced, thereby providing a more compact hand vacuum cleaner.

As previously discussed, in some embodiments, batteries used to power the hand vacuum cleaner **1000** may be provided at a single location, for example as one large battery pack **1500** that may include any suitable number of cells **1510**, and may include, for example, lithium ion battery cells.

Optionally, a battery pack **1500** may be positioned such that at least a portion of the battery pack **1500** is nested vertically spaced from a dirt collection region **1122**. For example, at least a portion of the battery pack **1500** may underlie at least a portion of one or both of a cyclone chamber **1110** and a pre-motor filter **1320**. In such a configuration, the overall size or length of the hand vacuum **1000** may be reduced.

For example, as illustrated in the embodiment of FIGS. **36** and **40**, as well as the embodiment of FIG. **43**, a battery pack **1500** is positioned rearward of a dirt collection region **1122**, and the entire battery pack **1500** is below a rearward portion of a pre-motor filter **1320**.

In the example illustrated in FIG. **47**, a battery pack **1500** is positioned rearward of a dirt collection region **1122**, and below a rearward portion of the cyclone chamber and below the pre-motor filter.

As discussed previously, battery pack **1500** may include any suitable number of individual battery cells, and the individual cells may be arranged in any suitable configuration. For example, some of the energy storage members (i.e. individual battery cells **1510**) may be arranged one above another and some may be arranged one behind another, e.g. within a single battery pack **1500**. For example, the energy storage members within a battery pack may be arranged in at least two columns in the forward/rearward direction. Accordingly, the battery pack may have a reduced height so as to assist in nesting the battery pack under a pre-motor filter and/or a cyclone chamber. An advantage of such configurations is that they may help provide a compact overall design without adversely affecting the hand feel and/or perceived balance of the hand vacuum.

As illustrated in FIG. **47**, cells **1510***a*-**1510***g* are arranged generally in two linear columns of cells. Specifically, cells **1510***a*, **1510***c*, **1510***e*, and **1510***g* are arranged in a first generally vertical column along a column axis **1505***a* that in the illustrated example is adjacent and generally parallel to a front wall **1501** of the battery pack **1500**, and cells **1510***b*, **1510***d*, and **1510***f* are arranged in a second generally vertical column along a column axis **1505***b* that in the illustrated example is adjacent and generally parallel to a rear wall **1503** of the battery pack **1500**.

As illustrated in FIG. **43**, cells **1510***a*-**1510***g* are arranged generally in three linear columns of cells. Specifically, cells **1510***b* and **1510***e* are arranged in a first generally vertical column along a column axis **1505***a* that in the illustrated example is adjacent and generally parallel to a front wall of the battery pack **1500**, cells **1510***a*, **1510***d*, and **1510***g* are arranged in a second generally vertical column along a column axis **1505***b* positioned rearward of and generally parallel to column axis **1505***a*, and cells **1510***c* and **1510***f* are arranged in a third generally vertical column along a column axis **1505***c* positioned rearward of and generally parallel to column axis **1505***b*.

It will be appreciated that some of the embodiments disclosed herein may not use the nested energy storage members as disclosed herein and that, in those embodiments, any suitable positioning of the energy storage members, if provided, may be used.

Airflow Cooling of an Energy Storage Chamber

The following is a description of different features of a hand vacuum cleaner having an airflow path in which air exiting a cyclone chamber impinges on a wall of an energy storage chamber. These features may be used by themselves in any surface cleaning apparatus or in any combination or sub-combination with any other feature or features described herein. For example, any of the airflow configurations described herein may be used with any of the air flow paths, pre-motor filter assemblies, relative positioning of the suction motor and energy storage members, inclined battery packs, battery pack configurations, and other features described herein.

Optionally, at least a portion of an air flow path between the dirty air inlet **1030** and the clean air outlet **1040** may be directed against a wall of an energy storage chamber. For example, a cyclone air outlet may face a wall of an energy storage chamber, whereby air exiting the cyclone chamber impinges on the energy storage chamber wall. In such a configuration, an airflow generated by suction motor **1200** flowing against and/or over such a wall may help cool one or more energy storage members positioned within the energy storage chamber. For example, energy storage members may include chemical batteries, such as lithium-ion batteries, that produce heat while being discharged (e.g. while supplying power to the hand vacuum **1000**). By directing a stream of air directly at, or at an angle to, a wall of a battery chamber, any boundary layer of air (which may act as an insulator) or laminar flow along a wall of a battery chamber is disrupted, thereby enabling enhanced cooling.

It will be appreciated that the battery pack may be provided in a chamber that receives a battery pack. Accordingly, there may be two walls between the impinging air stream and the batteries, i.e., a wall of the battery pack and a wall of the chamber in which the batter pack is received. Provided the walls contact each other or are adjacent, the impinging air stream will provide a cooling effect.

For example, in the examples illustrated in FIGS. **36** and **40**, cyclone air outlet **1130** faces a rear wall **1236** of the upflow duct or conduit **1230** that directs air upwardly towards a pre-motor filter **1320**. In these embodiments, rear wall **1236** is also a front wall of a recess in which battery pack **1500** is positioned. That is, rear wall **1236** is a wall of an energy storage chamber in which one or more energy storage members (e.g. individual cells **1510** and/or a battery pack **1500** containing a plurality of cells **1510**) are positioned.

It will be appreciated that some of the embodiments disclosed herein may not use the airflow cooling of an energy storage member as disclosed herein and that, in those embodiments, any suitable airflow design may be used.

As used herein, the wording "and/or" is intended to represent an inclusive-or. That is, "X and/or Y" is intended to mean X or Y or both, for example. As a further example, "X, Y, and/or Z" is intended to mean X or Y or Z or any combination thereof.

While the above description describes features of example 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. For example, the various characteristics which are described by means of the represented embodiments or examples may be selectively combined with each other. Accordingly, what has been described above is intended to be illustrative of the claimed concept and non-limiting. 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 a handle, a front end, a rear end, an upper end, a lower end and first and second laterally spaced apart sides and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet, the dirty air inlet is provided at the front end of the hand vacuum cleaner;

(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a cyclone chamber, a dirt collection region and a cyclone axis of rotation;

(c) a pre-motor filter downstream of the cyclone chamber;

(d) a suction motor positioned in the air flow path upstream of the clean air outlet, the suction motor is positioned in a suction motor housing; and,

(e) a battery pack comprising a first row of batteries wherein a longitudinal axis extends through the first row of batteries, the longitudinal axis intersects at least three batteries of the first row of batteries and is oriented generally vertically,

wherein, the first row of batteries is positioned exterior to the handle and exterior to the suction motor housing, and

wherein, at least a portion of the battery pack is positioned rearward of the dirt collection region and at least a portion of the battery pack is positioned directly underneath at least a portion of one or both of the cyclone assembly and the pre-motor filter.

2. The hand vacuum cleaner of claim **1** wherein the at least a portion of the battery pack is positioned directly underneath at least a portion of the cyclone chamber.

3. The hand vacuum cleaner of claim **1** wherein the at least a portion of the battery pack is positioned directly underneath at least a portion of the cyclone chamber.

4. The hand vacuum cleaner of claim **3** wherein the at least a portion of the battery pack is positioned directly underneath at least a portion of the pre-motor filter.

5. The hand vacuum cleaner of claim **1** wherein the at least a portion of the battery pack is positioned directly underneath at least a portion of the pre-motor filter.

6. The hand vacuum cleaner of claim **1** wherein substantially all of the battery pack is positioned directly underneath the pre-motor filter.

7. The hand vacuum cleaner of claim **1** wherein the battery pack comprises a second row of batteries and the second row of batteries is positioned adjacent the first row of batteries and has a second longitudinal axis that extends through the second row of batteries and the first and second longitudinal axis of the first and second rows of batteries extend in a common direction.

8. The hand vacuum cleaner of claim **1** wherein the dirty air inlet is provided in the upper end of the hand vacuum cleaner, the dirt collection region is at the lower end of the hand vacuum cleaner, and the battery pack is slidably insertable into the lower end of the hand vacuum cleaner.

9. A hand vacuum cleaner having a handle, a front end, a rear end, an upper end, a lower end and first and second laterally spaced apart sides and comprising:

(a) an air flow path extending from a dirty air inlet to a clean air outlet, wherein the dirty air inlet has a flow direction when the hand vacuum cleaner is in operation, and wherein the dirty air inlet is provided at the front end of the hand vacuum cleaner;

(b) a cyclone assembly positioned in the air flow path and having a cyclone assembly air inlet, a cyclone assembly air outlet, a cyclone chamber, a dirt collection region and a cyclone axis of rotation, the cyclone axis of rotation is oriented horizontally and is centrally positioned in the cyclone chamber;

(c) a pre-motor filter downstream of the cyclone chamber;

(d) a suction motor positioned in the air flow path upstream of the clean air outlet; and,

(e) a plurality of energy storage members wherein, the plurality of energy storage members are provided in a lower portion of the hand vacuum cleaner, wherein some of the energy storage members are arranged one above another and some are arranged one behind another and wherein at least some of the energy storage members are positioned directly underneath at least a portion of one or both of the cyclone assembly and the pre-motor filter.

10. The hand vacuum cleaner of claim **9** wherein at least a portion of the energy storage members is positioned rearward of the dirt collection region.

11. The hand vacuum cleaner of claim **9** wherein at least some of the energy storage members are positioned directly underneath at least a portion of the cyclone chamber.

12. The hand vacuum cleaner of claim **9** wherein at least some of the energy storage members are positioned directly underneath at least a portion of the cyclone chamber.

13. The hand vacuum cleaner of claim **12** wherein at least some of the energy storage members are positioned directly underneath at least a portion of the pre-motor filter.

14. The hand vacuum cleaner of claim **9** wherein at least some of the energy storage members are positioned directly underneath at least a portion of the pre-motor filter.

15. The hand vacuum cleaner of claim **9** wherein, the dirt collection region is at the lower end of the hand vacuum cleaner and the energy storage members are slidably insertable into the lower end of the hand vacuum cleaner.

16. The hand vacuum cleaner of claim **15** wherein at least a portion of the energy storage members is positioned rearward of the dirt collection region.

17. The hand vacuum cleaner of claim **15** wherein, at least a portion of the energy storage members is positioned rearward of the dirt collection region, and at least a portion of the energy storage members is positioned directly underneath at least a portion of one or both of the cyclone assembly and the pre-motor filter.

18. The hand vacuum cleaner of claim **9** wherein a finger gap is positioned between the handle and the energy storage members.

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