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(71) Demandeur/Applicant:
GBD CORP., CA

(72) Inventeur/Inventor:
CONRAD, WAYNE ERNEST, CA

(74) Agent: BERESKIN & PARR

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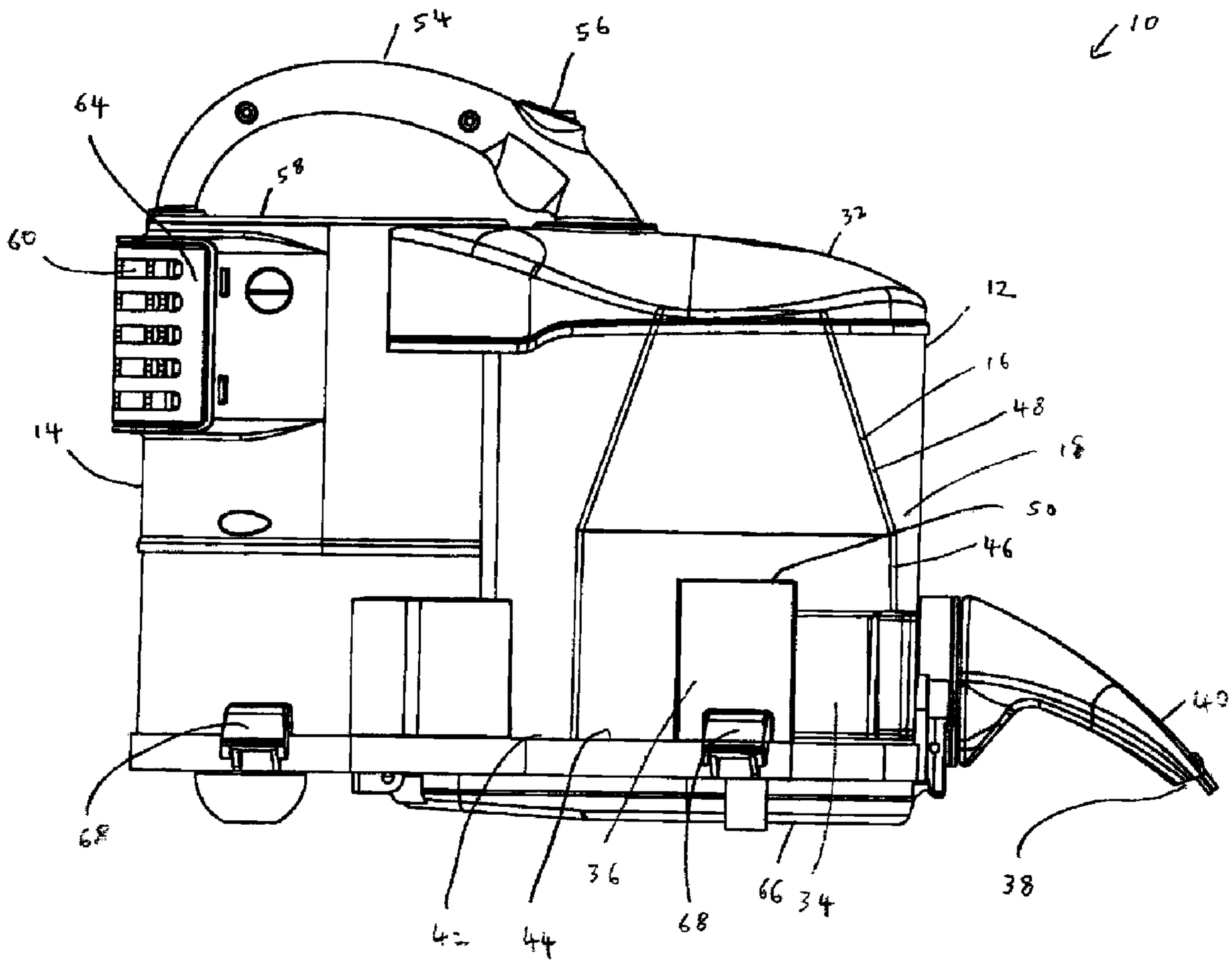

(57) Abrégé/Abstract:
Various different embodiments of a surface cleaning apparatus are disclosed.

ABSTRACT OF THE DISCLOSURE

Various different embodiments of a surface cleaning apparatus are disclosed.

TITLE: SURFACE CLEANING APPARATUS

FIELD

This application relates to surface cleaning apparatus, such as vacuum cleaners.

BACKGROUND

Various types of vacuum cleaners are known in the art. Currently, many of the vacuum cleaners, which are sold for residential applications, utilize at least one cyclone as part of the air filtration mechanism.

SUMMARY

In accordance with one embodiment of this invention, a surface cleaning apparatus is provided which includes a cyclone having a dirt outlet and an impingement surface positioned distal to the dirt outlet. The impingement surface is positioned from eight to thirty millimeters from the dirt outlet. Preferably, the dirt outlet is provided in a frustoconical portion of a cyclone and the impingement surface is provided in a dirt collection chamber. In a particularly preferred embodiment, the cyclone is inverted (i.e. the air inlet and the air outlet are provided in a lower portion of the cyclone) and the dirt outlet is provided in an upper portion of the cyclone. Accordingly, in such an embodiment, the impingement surface is positioned above the dirt outlet.

In accordance with such an embodiment, it is preferred that the dirt collection chamber surrounds at least a portion of, and preferably all of, the cyclone. The impingement surface may be a floor or lid of the dirt collection chamber or may be suspended therefrom.

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

(a) a dirty air inlet;

(b) a filtration apparatus comprising a cyclone downstream from the dirty air inlet, the cyclone having a lower air inlet, a lower air outlet and an upper dirt outlet;

(c) an impingement surface positioned above the upper dirt outlet and positioned from 8 mm to 30 mm from the upper dirt outlet;

(d) a dirt collection chamber in communication with the dirt upper dirt outlet;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

In one embodiment, the cyclone is frusto-conical.

In another embodiment the dirt collection chamber is positioned around at least a portion of the cyclone and the filtration apparatus comprises a lid positioned over the dirt collection chamber and the cyclone and the impingement surface comprises a portion of the lid.

In another embodiment the impingement surface comprises a plate positioned above the upper dirt outlet and spaced from a lid positioned above the plate. Preferably the plate, which may be of any design, is suspended from the lid.

In another embodiment the dirt collection chamber is positioned around at least a portion of the cyclone, the dirt collection chamber has a lower moveable dirt collection chamber floor, the cyclone has a lower moveable cyclone floor connected to the lower moveable dirt collection chamber floor, whereby both the cyclone floor and the dirt collection chamber floor are moveable concurrently such that the dirt collection chamber and the cyclone are concurrently emptied.

In another embodiment the dirt collection chamber floor and the cyclone floor comprise a pivoting bottom of the filtration apparatus.

In another embodiment the cyclone floor includes a vortex finder mounted thereto.

In another embodiment the surface cleaning apparatus further comprises a filtration member positioned beneath the vortex finder.

The surface cleaning apparatus of any of claims 8 and 9 wherein the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

In another embodiment the pivoting bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

In another embodiment the filtration member is moveably mounted in the filtration chamber.

In another embodiment the filtration member is moveably mounted to the access door.

In another embodiment the filtration member is removeably mounted to the access door.

In another embodiment the filtration member comprises screen.

In another embodiment the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

One advantage of this design is that the dirt separation efficiency of the cyclone is enhanced by positioning the impingement surface between eight and

thirteen millimeters from the dirt outlet. Preferably, the impingement surface is positioned 12 to 25 millimeters from the dirt outlet.

In accordance with another embodiment, the surface cleaning apparatus utilizes a filtration apparatus comprising at least one inverted cyclone wherein at least one anti-re-entrainment member is positioned on an outer surface of the cyclone. Accordingly, the cyclone may have a lower air inlet, a lower air outlet and upper dirt outlet. The anti-re-entrainment member may comprise at least one longitudinally extending rib provided on the outer surface of the cyclone and/or an annular ring provided on the outer surface of the cyclone. The rib and/or ring may be continuous or have discontinuities. Preferably, a plurality of ribs and/or rings are provided. In accordance with this embodiment, the outer surface of the cyclone having the anti-re-entrainment member is positioned in fluid communication with the dirt collection chamber and, preferably, is positioned within the dirt collection chamber. For example, the cyclone may be positioned, preferably centrally positioned, within a casing whereby the casing defines a dirt collection chamber surrounding the dirt outlet of the cyclone. An advantage of this design is that the dirt separation efficiency of the cyclone is enhanced by the provision of the anti-re-entrainment member on the outer surface of the cyclone.

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

(a) a dirty air inlet;

(b) a filtration apparatus comprising a cyclone downstream from the dirty air inlet, the cyclone having a lower air inlet, a lower air outlet, an upper dirt outlet and an outer surface;

(c) at least one anti-re-entrainment member positioned on the outer surface of the cyclone;

(d) a dirt collection chamber in communication with the dirt upper dirt outlet;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

In one embodiment the dirt collection chamber at least partially surrounds the cyclone and the anti-re-entrainment member is positioned in the dirt collection chamber.

In another embodiment the anti-re-entrainment member comprises at least one member extending outwardly from the outer surface.

In another embodiment the anti-re-entrainment member comprises at least one ring extending around the outer surface.

In another embodiment the at least one ring extends continuously around the outer surface.

In another embodiment the anti-re-entrainment member comprises at least one rib extending upwardly along the outer surface.

In another embodiment the anti-re-entrainment member comprises a plurality of ribs extending upwardly along, and spaced equidistantly around the outer surface.

In another embodiment the anti-re-entrainment member comprises at a plurality of ribs extending upwardly along, and spaced differing distances apart around the outer surface.

In another embodiment the cyclone is frustoconical.

In another embodiment the cyclone has a cylindrical lower section and a frustoconical upper section and the anti-re-entrainment member is provided at least on the cylindrical section.

In another embodiment the cyclone has a cylindrical lower section and a frustoconical upper section and the anti-re-entrainment member is provided at least on the frustoconical section.

In accordance with a further alternate embodiment of this invention, a surface cleaning apparatus includes a cyclone and a dirt collection chamber in communication with the dirt outlet of the cyclone. The cyclone is an inverted cyclone having a floor and an upper dirt outlet. A lower air inlet is provided and an air outlet is provided through the floor or a sidewall of the cyclone. In operation, air will enter through the air inlet and cyclone upwardly. Some of the dirt will exit upwardly through the dirt outlet. The air will then travel downwardly and exit the cyclone through the cyclone outlet. Some of the dirt will accumulate on the floor of the cyclone. The dirt collection chamber surrounds at least a portion of the cyclone and, preferably, all of the cyclone. The dirt collection chamber has a floor on which dirt entering the dirt collection chamber will accumulate. The floor of the cyclone and the floor of the dirt collection chamber concurrently open so that the dirt collected in the cyclone and the dirt collected in the dirt collection chamber are emptied concurrently. An advantage of this design is that fewer steps are required for a user to empty the dirt collection areas of the vacuum cleaner.

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

(a) a dirty air inlet;

(b) a filtration apparatus comprising a cyclone downstream from the dirty air inlet, the cyclone having a dirt outlet and a lower moveable cyclone floor;

(c) a dirt collection chamber in communication with the dirt outlet, positioned around at least a portion of the cyclone and having a lower moveable dirt collection chamber floor;

(d) the lower moveable dirt collection chamber floor is moveable concurrently with the lower moveable cyclone floor, whereby the dirt collection chamber and the cyclone are concurrently emptied when the dirt collection chamber floor and the cyclone floor are moved to an open position;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

In one embodiment the dirt collection chamber floor and the cyclone floor comprise a pivoting bottom of the filtration apparatus.

In another embodiment the cyclone floor includes a vortex finder mounted thereto.

In another embodiment the surface cleaning apparatus further comprises a filtration member positioned beneath the vortex finder.

In another embodiment the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

In another embodiment the pivoting bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

In another embodiment the filtration member is moveably mounted in the filtration chamber.

In another embodiment the filtration member is moveably mounted to the access door.

In another embodiment the filtration member is removeably mounted to the access door.

In another embodiment the filtration member comprises screen.

In another embodiment the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

In another embodiment the cyclone has a lower air inlet, a lower air outlet and the dirt outlet is in an upper portion of the cyclone.

In accordance with a further alternate embodiment of this invention, a surface cleaning apparatus comprises a filtration apparatus having a cyclone. The cyclone has an air inlet and an air outlet. A filtration member, which is preferably a screen, such as a mesh wire screen, is positioned exterior to the cyclone adjacent the cyclone air outlet. Accordingly, after the air exits the cyclone, the air passes through a filtration member. The filtration member may be accessed for cleaning by an access door, which is provided exterior to the cyclone (e.g. a door on an outer casing of the filtration apparatus).

In accordance with the prior art, a shroud or a screen may be provided interior of a cyclone (i.e. in the cyclone chamber). During use of the surface cleaning apparatus, elongate member such as hair and fibres may become adhered to the outer surface of the shroud or screen. Accordingly, in order to maintain the optimal cleaning efficiency of the vacuum cleaner, the shroud or screen must be cleaned from time to time. Either access must be provided to the interior of the cyclone to clean the shroud or screen, or, alternately, the shroud or screen must be removable. In accordance with this embodiment, a screen or other filtration member is positioned exterior to the cyclone. Accordingly, it is not necessary to remove a screen or shroud positioned within a cyclone chamber or to access the interior of the cyclone chamber in order to clean the filtration member.

In a particularly preferred embodiment, a cyclone chamber has no interior screen, shroud or filter covering the cyclone air outlet. Accordingly, no member

requiring cleaning is positioned inside the cyclone chamber or surrounding the cyclone outlet (e.g. surrounding the vortex finder).

In a particularly preferred embodiment, the cyclone comprises an inverted cyclone provided as part of the filtration apparatus. The filtration apparatus has a bottom surface on which the access door is provided. Accordingly, when the access door is opened, the filtration member may be accessed for cleaning. Preferably, the filtration member is mounted on the access door and may be movably mounted thereon or removably mounted thereto.

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

(a) a dirty air inlet;

(b) a filtration apparatus having a lower surface and comprising a cyclone downstream from the dirty air inlet, the cyclone having a dirt outlet and a cyclone floor;

(c) a dirt collection chamber in communication with the dirt upper dirt outlet and having a dirt collection chamber floor;

(d) an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

In one embodiment the filtration member is moveably mounted in the filtration chamber.

In another embodiment the filtration member is moveably mounted to the access door.

In another embodiment the filtration member is removeably mounted to the access door.

In another embodiment the filtration member comprises screen.

In another embodiment the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

In another embodiment the dirt collection chamber is positioned around at least a portion of the cyclone, the dirt collection chamber floor is moveable, the cyclone floor is moveable and is connected to the lower moveable dirt collection chamber floor and the lower surface comprises the cyclone floor and the dirt collection chamber floor, whereby both the cyclone floor and the dirt collection chamber floor are moveable concurrently such that the dirt collection chamber and the cyclone are concurrently emptied.

In another embodiment the dirt collection chamber floor and the cyclone floor comprise a pivoting bottom of the filtration apparatus.

In another embodiment the cyclone floor includes a vortex finder mounted thereto.

In another embodiment the surface cleaning apparatus further comprises a filtration member positioned beneath the vortex finder.

In another embodiment the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

In another embodiment the pivoting bottom is the lower surface.

In another embodiment at least a portion of the access door is transparent.

In another embodiment the cyclone has a lower air inlet, a lower air outlet and the dirt outlet is in an upper portion of the cyclone.

In accordance with another aspect of the invention, there is provided a surface cleaning apparatus comprising:

(a) a dirty air inlet;

(b) first and second housings positioned side by side, the first housing comprises at least one cyclone and the second housing comprises a filter;

(c) the second housing having a second housing bottom that is openable and the filter is visible when the second housing bottom is opened;

(d) a suction motor; and,

(e) a clean air outlet downstream from the suction motor.

In one embodiment the first housing has a first housing bottom that is openable.

In another embodiment the first housing bottom is connected to the second housing bottom whereby both the first housing bottom and the second housing bottom are moveable concurrently.

In another embodiment the first housing further comprises a dirt collection chamber positioned around at least a portion of the cyclone, the dirt collection chamber has a moveable dirt collection chamber floor, the cyclone has a lower moveable cyclone floor, whereby both the dirt collection chamber and the cyclone are concurrently emptied when the first housing bottom and the second housing bottom are opened concurrently.

In another embodiment the first housing bottom comprises the collection chamber floor and the cyclone floor.

In another embodiment the cyclone floor includes a vortex finder mounted thereto.

In another embodiment the surface cleaning apparatus further comprises a filtration member positioned beneath the vortex finder.

In another embodiment the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

The surface cleaning apparatus of claim 54 wherein the first housing bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

In another embodiment the filtration member is moveably mounted in the filtration chamber.

In another embodiment the filtration member is moveably mounted to the access door.

In another embodiment the filtration member is removeably mounted to the access door.

In another embodiment the filtration member comprises screen.

In another embodiment the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

In another embodiment the first housing bottom and the second housing bottom form part of an airflow passage from a cyclone outlet to an upstream side of the filter.

In another embodiment the first and second housings have a single pivoting bottom, the pivoting bottom comprising the first housing bottom and the second housing bottom and the pivoting bottom forms part of an air flow passage from a cyclone outlet to an upstream side of the filter.

In another embodiment the pivoting bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

In another embodiment the surface cleaning apparatus further comprises a mechanical filter-cleaning member.

In another embodiment the mechanical filter-cleaning member comprises a vibrator connected to the filter.

In another embodiment the vibrator is actuated when the second housing bottom is opened.

In another embodiment the mechanical filter-cleaning member comprises a wiper positioned on an upstream side of the filter.

In another embodiment the wiper is actuated when the second housing bottom is opened.

In another embodiment the mechanical filter-cleaning member is battery powered.

In another embodiment at least a portion of the airflow passage is transparent.

In accordance with a further embodiment of the instant invention, a surface cleaning apparatus has a bottom that is openable. When the bottom is opened, a filter is exposed. Preferably, the upstream surface of the filter is exposed. Accordingly, the surface of the filter which first encounters particulate

matter transported in a fluid flow stream is accessible when the bottom is opened. In accordance with this embodiment, the surface cleaning apparatus may be opened over a dirt receptacle (e.g. a garbage can). The dirt adhered to the upstream surface of the filter may then be removed by banging the surface cleaning apparatus against the garbage receptacle or by a user using their hand or other implement to tap or wipe the upstream surface of the filter.

While the filter may be removable, the upstream surface is exposed when the door is opened. If the filter is oriented to face downwardly, such as if the surface cleaning apparatus is held upright such as by a handle provided to use the surface cleaning apparatus, some dirt will fall out.

This embodiment is particularly preferred in combination with a bottom-emptying door for a cyclone and/or dirt collection chamber. In such an embodiment, the bottom that overlies the filter is preferably concurrently opened with the bottom-emptying door for a cyclone and/or dirt collection chamber. Accordingly, the filter will be cleaned when the cyclone and/or dirt collection chamber is emptied.

A mechanical member, such as a vibrator that may be battery operated may be provided to assist in removing dirt by agitating the filter.

Accordingly, an advantage of this design is that the filter is easier to clean as the dirt will tend to fall by gravity away from the filter when the bottom is opened.

In accordance with a further alternate embodiment of this invention, wire welding is used to manufacture an appliance, preferably a portion of a surface cleaning apparatus. More preferably, the portion comprises part of an airflow conduit. An advantage of using wire welding is that thinner walled material may be utilized. In particular, screw ports and reinforcing ribs surrounding the screw ports are not required. Accordingly, thinner, lighter plastic components may be utilized to manufacture a surface cleaning apparatus. In addition, the use of wire

welding can simplify securing parts together so as to create an airtight passage. It will be appreciated that leakage of air into a fluid flow passage may disrupt the cleaning efficiency of the surface cleaning apparatus. In addition, the wire-welded parts may be stronger as the wire welding may result in the part effectively forming a unibody construction.

In a particularly preferred embodiment, the electrically conductive wire that is utilized preferably extends continuously along the perimeter of a part to be secured to another part except for a gap. The gap is preferably less than 0.08 inches, more preferably less than 0.04 and, most preferably less than 0.02 inches. Plastic material positioned in the gap will be melted when a current is passed through the wire. Accordingly, a surface cleaning apparatus in accordance with this alternate embodiment includes at least two parts, which are secured together by wire welding.

In accordance with this aspect of the invention, there is provided a method of manufacturing a portion of a surface cleaning apparatus comprising:

(a) providing first and second portions constructed from a weldable material, the first portion having a first mating surface and second portion having a second mating surface;

(b) providing an electrically conductive wire along one of the mating surfaces;

(c) bringing the first and second mating surfaces together; and,

applying a current through the wire.

In one embodiment the step of providing an electrically conductive wire along one of the mating surfaces comprises positioning the wire around all of a perimeter of the one of the mating surface except for a gap.

In another embodiment the method further comprises providing a gap of up to 0.08 inches, preferably. up to 0.04 inches and, more preferably up to 0.02 inches.

In another embodiment the first and second portions define at least part of a fluid conduit and the method further comprises using the method to produce a fluid tight seal of the fluid conduit.

In another embodiment the first and second portions define two parts of a cyclone and the method further comprises using the method to produce a fluid tight seal of the cyclone.

In another embodiment the first and second portions define two parts of a dirt collection chamber and the method further comprises using the method to produce a fluid tight seal of the dirt collection chamber.

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

(a) a dirty air inlet;

(b) a filtration apparatus;

(c) a dirt collection chamber in communication with the dirt upper dirt outlet;

(d) a suction motor;

(e) a clean air outlet downstream from the suction motor; and,

(f) a fluid flow passage from the dirty air inlet to the clean air outlet and first and second portions define a portion of the fluid flow passage, the first and second portions are secured together by wire welding.

In one embodiment the first and second portions have an absence of screw ports securing the first and second portions together.

In another embodiment the first and second portions define two parts of a cyclone.

In another embodiment the first and second portions define two parts of a dirt collection chamber

In accordance with a further alternate embodiment of this invention, a surface cleaning apparatus uses a plurality of filtration members having varying filtration ability. In accordance with this embodiment, a surface cleaning apparatus utilizes a screen, a foam filter positioned downstream from the screen, a felt filter positioned downstream from the foam filter and a HEPA filter positioned downstream from the felt filter. Preferably, a shroud is provided for the air outlet of a cyclone chamber, if the vacuum cleaner utilizes a cyclone. The suction motor of the surface cleaning apparatus is preferably provided downstream from the HEPA filter, but may be upstream of the HEPA filter.

An advantage of this design is that filtration materials having a finer pore sizes are positioned downstream from a series of coarse filtration elements thereby extending the lifetime of the finer filter elements.

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

(a) a dirty air inlet, a clean air outlet downstream, a fluid flow passage extending from the dirty air inlet to the clean air outlet,

(b) a suction motor provided in the fluid flow passage;

(c) a filtration apparatus downstream from the dirty air inlet and comprising a cyclone having a cyclone outlet, the cyclone outlet having a shroud;

(d) a screen downstream from the vortex finder;

(e) a foam filter downstream from the screen;

(f) a felt filter downstream from the foam filter; and,

(g) a HEPA filter downstream from the felt filter.

In any embodiment the suction motor is downstream from the HEPA filter.

In any embodiment the suction motor is upstream from the HEPA filter.

In any embodiment the screen comprises an open wire mesh.

In any embodiment the shroud comprises an apertured end of the cyclone outlet.

It will be appreciated by those skilled in the art that any of these alternate embodiments may be used individually or in a single surface cleaning apparatus, as exemplified in a preferred embodiment described herein, or in any particular sub-combination. Accordingly, any two or more alternate embodiments may be used in a single surface cleaning apparatus. In addition, any of the optional features described herein may be used in combination with any alternate embodiment or sub-combination or combination of alternate embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other advantages of the instant invention will be more fully and completely understood in conjunction with the following description of the preferred embodiments of the invention in which:

Figure 1 is a side elevational view of a preferred embodiment of a vacuum cleaner in accordance with this design wherein the outer casing surrounding the cyclone and forming an outer wall of a dirt collection chamber is optionally transparent;

Figure 2 is a perspective view from the front and the right side of the vacuum cleaner of Figure 1;

Figure 3 is a cross-section along the line 3 – 3 in Figure 2;

Figure 4 is a schematic drawing of the vacuum cleaner of Figure 1 showing the airflow passage therethrough;

Figure 5 is a perspective view from the bottom of the vacuum cleaner of Figure 1 wherein the bottom of the first and second housings is open;

Figure 6 is a perspective view of the bottom of the vacuum cleaner of Figure 1 wherein the first and second housings are closed but an access door is open;

Figure 7 is a perspective view of the vacuum cleaner of Figure 1 with the lid removed showing the wire provided to permit the lid to be secured to the dirt collection chamber by wire welding;

Figure 8 is an enlargement of area A of Figure 7;

Figures 9A and 9B comprise a perspective view and a top plan view of a cyclone having a pair of equidistantly spaced ribs used as anti-re-entrainment members;

Figure 10A and 10B comprise a perspective view and a top plan view of a cyclone having four equidistantly spaced ribs used as anti-re-entrainment members;

Figures 11A and 11B comprise a perspective view and a top plan view of a cyclone having four unequidistantly spaced ribs used as anti-re-entrainment members;

Figures 12A and 12B comprise a perspective view and a side elevation view of a cyclone having a single annular ring provided on the outer surface of a cyclone for use as an anti-re-entrainment member;

Figures 13A and 13B comprise a perspective view and a side elevation view of a cyclone having two spaced apart annular rings provided on the outer surface of a cyclone for use as anti-re-entrainment members;

Figures 14A, 14B and14C comprise a perspective, top plan and side view, respectively, of a cyclone having a non-circular annular ring provided on the outer surface of the cyclone as an anti-re-entrainment member; and,

Figures 15A, 15B and 15C comprise a perspective, top plan and side view, respectively, of a cyclone having an elliptical ring positioned at an angle to the vertical as an anti-re-entrainment member on the outer surface of the cyclone.

DETAILED DESCRIPTION

The preferred embodiment set out in Figures 1 – 8 contains each of the alternate embodiments described in the summary of the invention. These have been described in a single preferred embodiment for convenience. However, each may be used individually or in combination with any one or more other alternate embodiments.

As shown in Figures 1 – 8, a surface cleaning apparatus comprises a vacuum cleaner 10. It will be appreciated that, surface cleaning apparatus may be a vacuum cleaner, a carpet extractor, a bare floor cleaner or the like. Preferably, as exemplified, the surface cleaning apparatus is hand held. However the surface cleaning apparatus may be configured as an upright vacuum cleaner, a stick vacuum cleaner, a canister vacuum cleaner, a back pack or shoulder strap vacuum cleaner or other configuration known in the art.

As exemplified, surface cleaning apparatus 10 has a first housing 12 and a second housing 14. As exemplified, first housing 12 comprises at least one cyclone 16 and a dirt collection chamber 18 and second housing 14 houses a plurality of filters which, preferably, in order comprise foam filter 20, felt filter 22

and HEPA filter 24 followed in the downstream direction by suction motor 26. It will be appreciated that only a single filter may be provided.

In accordance with a first embodiment of this invention, cyclone 16 has a dirt outlet 28 and an impingement surface 30 spaced from dirt outlet 28 in dirt collection chamber 18. As shown in Figure 3, impingement surface 30 is preferably spaced a distance D from outlet 28 wherein distance D is from 8 to 30 millimeters and, preferably from 12 to 25 millimeters. It will be appreciated that impingement member 30 may be mounted to lid 32 of dirt collection chamber 18. Alternately, impingement member may be mounted to a sidewall of dirt collection chamber 18 and/or cyclone 16.

As exemplified in Figure 3, cyclone 16 is an inverted cyclone. Accordingly, cyclone 16 has a lower air inlet 34 and a lower air outlet 36. Air inlet 34 is positioned downstream from dirty air inlet 38 of surface cleaning nozzle 40. Surface cleaning nozzle 40 may be any surface cleaning nozzle known in the art. Air inlet 34 of cyclone 16 may be in airflow communication with surface cleaning nozzle 40 in any manner known in the art. The exact structure of surface cleaning nozzle 40 and the communication passage between surface cleaning nozzle 40 and air inlet 34 will vary depending if the surface cleaning apparatus is an upright vacuum cleaner, canister vacuum cleaner or, as exemplified, a portable hand held vacuum cleaner. In operation, air will enter cyclone 16 through inlet 34 and travel upwardly, as exemplified in Figure 4. The air will then travel downwardly to exit cyclone 16 via outlet 34. As shown in Figure 4 by the hatched arrows, dirt will exit upwardly through outlet 28 and deposit on dirt collection chamber floor 42. In addition, some of the heavier particulate matter may not be entrained in the air stream and may be deposited on cyclone floor 34.

In an alternate embodiment, it will be appreciated that cyclone 16 need not be inverted. Cyclone 16 may be any cyclone with a dirt outlet provided that

impingement member or members are positioned spaced from the dirt outlet. The cyclone may accordingly be upright cyclone or a cyclone having a single direction of travel of the air.

As exemplified, cyclone 16 is a frustoconical cyclone having cylindrical portion 46 and frustoconical portion 48. Alternately, or in addition to the orientation of cyclone 16, it will be appreciated that cyclone 16 may be cylindrical, entirely frustoconical or any other shape known in the art.

As exemplified in Figure 3, outlet 36 of cyclone 16 comprises a vortex finder that extends inwardly into the cyclone chamber defined by cyclone 16. Outlet 36 preferably comprises a generally cylindrical passage having an inlet 50 and an outlet 52. It will be appreciated that, in an alternate embodiment any outlet known in the art for cyclones may be utilized. Further, inlet 50 may be covered by a screen, shroud or filter as in known in the art. In a particularly preferred embodiment, it is preferred that no screen, shroud or filter is provided.

As exemplified in Figures 1 – 8, vacuum cleaner 10 comprises a hand held vacuum cleaner. Accordingly, vacuum cleaner 10 may be provided with handle 54, which is affixed to lid 32 and lid 58 of second housing 14. Handle 54 may alternately be affixed to any other portion or portions of vacuum cleaner 10 as is known in the art. Optionally, as exemplified, on/off switch 56 may be provided on handle 54. On/off switch 56 may alternately be provided on any other portion of vacuum cleaner 10.

As exemplified in Figure 3, suction motor 26 is positioned in second housing 14, preferably with a suction fan provided below the electric motor. Clean air outlet 60 is provided downstream from suction motor 26. An optional post-motor filter may be provided downstream from suction motor 26, such as in post-motor filter housing 62, which may be accessible via post motor filter housing door 64, which could be pivotably mounted to second housing 14.

While the use of the impingement member is exemplified in a surface cleaning apparatus having side-by-side housings 12, 14, it will be appreciated that this design may be used in any vacuum cleaner configuration.

In accordance with an alternate preferred embodiment of this invention, dirt collection chamber 18 surrounds at least a portion of and, as exemplified, preferably all of cyclone 16. Accordingly, cyclone 16 may be positioned in dirt collection chamber 18 and, preferably, generally centrally therein. In accordance with this alternate preferred embodiment, vacuum cleaner 10 is configured such that the dirt collected on floor 44 of cyclone 16 is emptied at the same time as dirt collected on floor 42 of dirt collection chamber 18. Accordingly, floor 42 and floor 44 are both movable and connected to each other whereby both floor 42 and 44 are concurrently movable such that dirt collection chamber 18 and cyclone 16 are concurrently emptied.

As exemplified in Figure 5, floors 42 and 44 may comprise a pivoting bottom of first housing 12 and, alternately, of the filtration apparatus (e.g. housings 12 and 14 of this embodiment). Accordingly, as seen in Figure 5, when floors 42 and 44 are opened, both cyclone 16 and dirt collection chamber 18 may be emptied by holding vacuum cleaner 10 in the upright position (as shown in Figure 1). Accordingly, the dirt will fall out of collection chamber 16 and cyclone 16 and will fall downwardly off of floors 42 and 44.

As shown in Figure 5, housings 12 and 14 have a pivoting bottom 66, which is secured to each of housings 12 and 14 by a pivot 68. In the closed position exemplified in Figures 1 and 4, pivoting bottom 66 is secured in position by latch 70. Latch 70 has a button 72 which, when pressed, causes arm 74 to move outwardly thereby disengaging a flange provided on the bottom end of arm 74 from flange 76 provided on pivoting bottom 66. A gasket or other sealing member may be provided at the interface of housings 12 and 14 and pivoting bottom 66 to provide an air tight or fluid tight seal. It will be appreciated that

bottom 66 may be moveable in any other direction by any other means known in the art and may optionally be removable from housings 12, 14. Further, bottom 66 may be moveably secured in position by any other means known in the art and need not be connected to surface cleaning apparatus 10 for relative motion thereto.

As exemplified in Figure 5, outlet 36 is provided as part of floor 42, and is preferably integrally molded therewith. In an alternate embodiment, it will be appreciated that outlet 36 need not be removable from cyclone 16 with floor 42.

In an alternate embodiment, it will be appreciated that only floors 42 and 44 may be pivotably mounted to housing 12. In such an embodiment, foam filter 20 may remain sealed when cyclone 16 and dirt collection chamber 18 are emptied. In an alternate embodiment, a side-by-side of housings 12, 14 design as exemplified in Figure 1 need not be utilized. In such a case, floor 42 and floor 44 may comprise the entire floor of the filtration assembly.

If bottom 66 opens both housings 12 and 14, then it will be appreciated that dirt positioned on the upstream surface of filter 20 will be emptied when bottom 66 is opened.

In an alternate embodiment, a filtration member is provided adjacent outlet 36 and, preferably, in sealing engagement with outlet 52. Referring to Figure 3, filtration member 78 is positioned on rear surface 84 of floor 44 and overlies outlet 52. Accordingly, air that exits outlet 36 travels through filtration member 78. The air then travels through filtration chamber 80 and travels laterally to outlet 86, which is in air flow communication with headspace 88 below filter 20.

Preferably, filtration member 78 comprises a screen, such as an open mesh screen, e.g., a wire mesh screen or, alternately, a plastic mesh screen.

An access door 82 may be provided to permit access to filtration member 78 such that filtration member 78 may be cleaned. Access door may be any door that is movably mounted in overlying relationship to filtration chamber 80. As exemplified in Figure 6, access door 82 is pivotably mounted by pivot 90 to pivoting bottom 66. Access door 82 may be opened by utilizing a latch 70, which engages flange 92 provided on the front end of access door 82. A sealing gasket or other sealing member known in the art may be utilized to provide an air tight or fluid tight seal for filtration chamber 80. Any other securing member known in the art may be used. Further door 82 may be removable and need not be connected to surface cleaning apparatus 10 for relative motion thereto.

Preferably, filtration member 78 is mounted and, more preferably, movably mounted and, most preferably, removably mounted to access door 82. As shown in Figure 78, filtration member 78 is pivotably mounted to the inner surface of access door 82. Accordingly, when a user desires to clean filtration member 78, it may be pivoted in the direction shown by arrow A in Figure 6 to an open or cleaning position. It will be noticed that access door 82 may be opened independently of pivoting bottom 66. In an alternate embodiment, it will be appreciated that a pivoting bottom 66 need not be provided.

Preferably, at least a portion of and, more preferably, all of access door 82 is transparent. Accordingly, a user may lift the vacuum cleaner, invert the vacuum cleaner or tilt the vacuum cleaner on its side to view filtration member 78 and determine whether filtration 78 requires cleaning or, alternately, replacement.

As exemplified in Figure 3, vortex finder 36 is not surrounded by a screen or any shroud or filter. In accordance with a preferred embodiment, vortex finder 36 has no cover member (e.g. shroud, screen or the like). Accordingly, no filtration or screen member interior of cyclone 16 requires cleaning. Accordingly,

it will be appreciated that bottom 44 need not be openable to permit a screen or a shroud or filter associated with inlet end 50 of outlet 36 to be cleaned.

In accordance with an alternate preferred embodiment of this invention, a series of screening and filtration members are used in series downstream from the cyclone chamber of cyclone 16. In accordance with this preferred embodiment, the screening and filtration members comprise a screen 78, which is preferably positioned adjacent outlet 36, a foam filter 22 downstream from screen 78, a felt filter 22 downstream from foam 20 and a HEPA filter 24 downstream from felt filter 22. Preferably, all of these filters are positioned upstream from suction motor 26. Alternately, one or more of these filters may be positioned downstream from suction motor 26. In particular HEPA filter 24 may be downstream from suction motor 26. Accordingly, a plurality of screening and filtration members, each of which have a finer filtration capacity (e.g. smaller pores) are provided in series in the downstream direction. Optionally, a shroud (e.g. a perforated or apertured plastic cover) may be provided surrounding or overlying inlet 50 of outlet 36.

In accordance with another embodiment of this invention, as exemplified in Figures 9A – 15C, an inverted cyclone 16 may be provided with one or more anti-re-entrainment members provided on the outer surface of cyclone 16. Accordingly, the anti-re-entrainment member may comprise one or more ribs 94 provided on the outer surface of cyclone 16 and/or one or more annular rings 96 provided on the outer surface of cyclone 16. As shown in Figures 9A, ribs 94 are longitudinally extending (i.e. in the direction of the longitudinal axis of cyclone 16) and may be provided on the frustoconical portion 48 of cyclone 16 or, on the cylindrical portion 46 of cyclone 16 (not shown) or on both cylindrical portion 46 and frustoconical portion 48 of cyclone 16 (see Figures 10A and 10B). It will be appreciated that ribs 94 need not extend exactly perpendicular to the longitudinal axis of cyclone 16 but may be at an angle thereto. In addition, ribs

94 need not extend from bottom 98 to dirt outlet 28 but may extend for only a portion of the distance. In addition, ribs 94 need not be continuous, but they may have discontinuities. It will be appreciated that ribs 94 may be used on a cyclone having any known configuration, and on any part thereof.

As exemplified in Figures 9A, 9B, 10A and 10B, if a plurality of ribs are provided, they be spaced equidistantly apart (i.e. at equal angular displacement from each other). Alternately, as shown in Figures 11A and 11B, ribs 94 unevenly spaced around the outer surface of cyclone 16.

As exemplified in Figures 12A and 12B, only a single annular ring 96 may be provided. However, as shown in Figures 13A and 13B, a plurality of rings may be provided. Rings 96 may be provided on frustoconical portion 48, cylindrical portion 46 or both frustoconical portion 48 and cylindrical portion 46. It will be appreciated that rings 96 may be used on a cyclone having any known configuration, and on any part thereof.

As exemplified in Figure 14A – C, if a single annular ring is provided, it need not be provided at the top of cyclone 16 adjacent dirt outlet 28. In addition, as exemplified therein, annular ring 46 need not have an outer circular circumference. Instead, it may have a variety of shapes. For example, as shown in Figures 14A-C, the outer circumference of ring 96 is hexagonal. Alternately, as shown in Figures 15A-C, the outer circumference may be elliptical.

As exemplified in Figures 15A-C, ring 96 need not be provided in a plane that is perpendicular to the longitudinal axis of cyclone 16. Instead, as exemplified, ring 96 may be at an angle to the longitudinal axis 100 of cyclone 16.

As exemplified in Figures 7 and 8, in accordance with another embodiment, at least two parts of vacuum cleaner 10 may be assembled by wire welding. Accordingly, an electrically conductive wire 102 having terminal ends 104 and 106 is provided along a surface of a part of the vacuum cleaner (e.g.

top surface 108 of first housing 12). Preferably, wire 102 is provided in a groove provided in top surface 108. In accordance with such an embodiment, the top of wire 102 is preferably flush with top surface 108. Alternately, a portion of wire 102 may extend upwardly from top surface 108 and may be received in a groove in the part to be secured to top surface 108.

In order to secure the parts together (e.g. lid 32 and first housing 12), the parts may be brought into contact prior to or subsequent to terminals 104 and 106 connected to an electrical source (preferably DC) and an electrically current applied for a sufficient time to weld lid 32 and first housing 12 together. It will be appreciated that as electrical current is applied through wire 102, that the wire will heat up thereby melting the surrounding plastic. This permits a complete airtight or fluid tight seal to be formed between lid 32 and first housing 12.

In a preferred embodiment, ends 112 and 114 of wires do not meet but are separated by a gap 110. Preferably, this gap is less than 0.08 inches, more preferably less than 0.04 inches and, most preferably less than 0.02 inches. The advantage of providing a gap 110 is that excessive heating is not provided in that region. For example, if ends 112 and 114 abutted, additional heat would be provided adjacent ends 112 and 114 such that too much of the plastic in that region may melt to such an extent that the plastic may flow and insufficient plastic may be provided at a location to provide an air tight or fluid tight seal. Accordingly, ends 112 and 114 are preferably spaced apart a sufficient amount so that the plastic therebetween melts a sufficient amount to provide a full seal when current is provided through wire 102.

Subsequent to the wire welding operation, the portions of wire 102 that extend outwardly from the welded plastic may be bent or cut away. Preferably, the excess is cut away.

An advantage of using wire welding is that relatively thin walled plastics may be utilized. In particular, portions of a vacuum cleaner may be assembled

together without screws. If screws are utilized, then the plastic part is typically provided with one or more screw ports or one or more ports for receiving a screw (a screw receiving port). Due to localized stresses, which are associated with the use of screws, reinforcing ribs and/or thicker walls are provided in the vicinity of the screw port or screw receiving ports. These ribs and thicker walls increase the weight of the material and also may complicate construction of a vacuum cleaner. By using wire welding, reinforcing ribs are not required since, once welded, the parts effectively form a unibody construction (e.g. equivalent to being integrally molded).

In particular, it is preferred to use wire welding parts which, when assembled, define an airflow path or a portion thereof. The use of wire welding may be used to ensure a full airtight seal is provided, thereby avoiding air leaks into a vacuum cleaner (the portions of an air flow passage which are below atmospheric pressure), which may affect the performance of the cyclone.

It will be appreciated by those skilled in the art that any of the preferred embodiments may be used singly or in any particular combination or a sub-combination and that all of these are within the scope of the following claims. In addition, it will be appreciated by those skilled in the art that various modifications and additions may be made to any of these embodiments and all of those are within the scope of the following claims.

It will also be appreciated that the wire welding technique disclosed herein may be utilized for other household consumer appliances, such as power tools, garden tools, and the like.

In particular, it will be noted that the spacing of an impingement surface may be used alone or in combination with one or more of an anti-re-entrainment member, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, an access door to permit cleaning or replacement of a filtration member in a filtration chamber

downstream from a cyclone outlet, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a bottom door that opens to expose a filter and permit the filter to be cleaned, an embodiment wherein at least two parts are secured together by wire welding and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently may be used alone or in combination with one or more of the spacing of an impingement surface, an anti-re-entrainment member, an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a bottom door that opens to expose a filter and permit the filter to be cleaned, an embodiment wherein at least two parts are secured together by wire welding and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that an anti-re-entrainment member may be used alone or in combination with one or more of the spacing of an impingement surface, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a bottom door that opens to expose a filter and permit the filter to be cleaned, an embodiment wherein at least two parts are secured together by

wire welding and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet may be used alone or in combination with one or more of an anti-re-entrainment member, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, the spacing of an impingement surface, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a bottom door that opens to expose a filter and permit the filter to be cleaned, an embodiment wherein at least two parts are secured together by wire welding and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that a filter (preferably a screen) positioned downstream from a cyclone outlet, which is mounted in a housing which is transparent may be used alone or in combination with one or more of an anti-re-entrainment member, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet, the spacing of an impingement surface may be used, a bottom door that opens to expose a filter and permit the filter to be cleaned, an embodiment wherein at least two parts are secured together by wire welding and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that a bottom door that opens to expose a filter and permit the filter to be cleaned may be used alone or in combination with one or more of the spacing of an impingement surface, an anti-re-entrainment

member, an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, an embodiment wherein at least two parts are secured together by wire welding and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that an embodiment wherein at least two parts are secured together by wire welding may be used alone or in combination with one or more of the spacing of an impingement surface, an anti-re-entrainment member, an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, a bottom door that opens to expose a filter and permit the filter to be cleaned and the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner, or any particular combination or sub-combination thereof.

Alternately, it will be noted that the use of a screen, foam filter, felt filter and HEPA filter in series in a vacuum cleaner may be used alone or in combination with one or more of the spacing of an impingement surface, an anti-re-entrainment member, an access door to permit cleaning or replacement of a filtration member in a filtration chamber downstream from a cyclone outlet, a filter (preferably a screen) positioned downstream from a cyclone outlet which is mounted in a housing which is transparent, a configuration to allow a cyclone chamber and a surrounding dirt collection chamber to be emptied concurrently, a bottom door that opens to expose a filter and permit the filter to be cleaned

and an embodiment wherein at least two parts are secured together by wire welding, or any particular combination or sub-combination thereof

It will also be appreciated that any of the aforementioned embodiments may be used singly or in any particular combination or sub-combination of the remaining features listed above.

CLAIMS:

1. A surface cleaning apparatus comprising:
   (a) a dirty air inlet;
   (b) a filtration apparatus comprising a cyclone downstream from the dirty air inlet, the cyclone having a lower air inlet, a lower air outlet and an upper dirt outlet;
   (c) an impingement surface positioned above the upper dirt outlet and positioned from 8 mm to 30 mm from the upper dirt outlet;
   (d) a dirt collection chamber in communication with the dirt upper dirt outlet;
   (e) a suction motor; and,
   (f) a clean air outlet downstream from the suction motor.
2. The surface cleaning apparatus of claim 1 wherein the cyclone is frusto-conical.
3. The surface cleaning apparatus of any of claims 1 and 2 wherein the dirt collection chamber is positioned around at least a portion of the cyclone and the filtration apparatus comprises a lid positioned over the dirt collection chamber and the cyclone and the impingement surface comprises a portion of the lid.
4. The surface cleaning apparatus of any of claims 1-3 wherein the impingement surface comprises a plate positioned above the upper dirt outlet and spaced from a lid positioned above the plate.
5. The surface cleaning apparatus of claim 4 wherein the plate is suspended from the lid.
6. The surface cleaning apparatus of any of claims 1-5 wherein the dirt collection chamber is positioned around at least a portion of the cyclone, the dirt collection chamber has a lower moveable dirt collection chamber floor, the cyclone has a lower moveable cyclone floor connected to the lower moveable dirt collection chamber floor, whereby both the cyclone floor and

the dirt collection chamber floor are moveable concurrently such that the dirt collection chamber and the cyclone are concurrently emptied.

7. The surface cleaning apparatus of claim 6 wherein the dirt collection chamber floor and the cyclone floor comprise a pivoting bottom of the filtration apparatus.

8. The surface cleaning apparatus of claim 7 wherein the cyclone floor includes a vortex finder mounted thereto.

9. The surface cleaning apparatus of claim 8 further comprising a filtration member positioned beneath the vortex finder.

10. The surface cleaning apparatus of any of claims 8 and 9 wherein the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

11. The surface cleaning apparatus of any of claims 7-10 wherein the pivoting bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

12. The surface cleaning apparatus of claim 11 wherein the filtration member is moveably mounted in the filtration chamber.

13. The surface cleaning apparatus of claim 11 wherein the filtration member is moveably mounted to the access door.

14. The surface cleaning apparatus of claim 11 wherein the filtration member is removeably mounted to the access door.

15. The surface cleaning apparatus of any of claims 7-14 wherein the filtration member comprises screen.

16. The surface cleaning apparatus of claim 11 wherein the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

17. A surface cleaning apparatus comprising:

(a) a dirty air inlet;

(b) a filtration apparatus comprising a cyclone downstream from the dirty air inlet, the cyclone having a lower air inlet, a lower air outlet, an upper dirt outlet and an outer surface;

(c) at least one anti-re-entrainment member positioned on the outer surface of the cyclone;

(d) a dirt collection chamber in communication with the dirt upper dirt outlet;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

18. The surface cleaning apparatus of claim 17 wherein the dirt collection chamber at least partially surrounds the cyclone and the anti-re-entrainment member is positioned in the dirt collection chamber.

19. The surface cleaning apparatus of any of claims 17-18 wherein the anti-re-entrainment member comprises at least one member extending outwardly from the outer surface.

20. The surface cleaning apparatus of any of claims 17-18 wherein the anti-re-entrainment member comprises at least one ring extending around the outer surface.

21. The surface cleaning apparatus of any of claims 17-18 wherein the at least one ring extends continuously around the outer surface.

22. The surface cleaning apparatus of any of claims 17-18 wherein the anti-re-entrainment member comprises at least one rib extending upwardly along the outer surface.

23. The surface cleaning apparatus of claim 18 wherein the anti-re-entrainment member comprises a plurality of ribs extending upwardly along, and spaced equidistantly around the outer surface.

24. The surface cleaning apparatus of any of claims 17-18 wherein the anti-re-entrainment member comprises at a plurality of ribs extending upwardly along, and spaced differing distances apart around the outer surface.

25. The surface cleaning apparatus of any of claims 17-18 wherein the cyclone is frustoconical.

26. The surface cleaning apparatus of any of claims 17-18 wherein the cyclone has a cylindrical lower section and a frustoconical upper section and the anti-re-entrainment member is provided at least on the cylindrical section.

27. The surface cleaning apparatus of any of claims 17-18 wherein the cyclone has a cylindrical lower section and a frustoconical upper section and the anti-re-entrainment member is provided at least on the frustoconical section.

28. A surface cleaning apparatus comprising:

(a) a dirty air inlet;

(b) a filtration apparatus comprising a cyclone downstream from the dirty air inlet, the cyclone having a dirt outlet and a lower moveable cyclone floor;

(c) a dirt collection chamber in communication with the dirt outlet, positioned around at least a portion of the cyclone and having a lower moveable dirt collection chamber floor;

(d) the lower moveable dirt collection chamber floor is moveable concurrently with the lower moveable cyclone floor, whereby the dirt collection chamber and the cyclone are concurrently emptied when the dirt collection chamber floor and the cyclone floor are moved to an open position;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

29. The surface cleaning apparatus of claim 28 wherein the dirt collection chamber floor and the cyclone floor comprise a pivoting bottom of the filtration apparatus.

30. The surface cleaning apparatus of any of claims 28-29 wherein the cyclone floor includes a vortex finder mounted thereto.

31. The surface cleaning apparatus of claim 30 further comprising a filtration member positioned beneath the vortex finder.

32. The surface cleaning apparatus of claim 31 wherein the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

33. The surface cleaning apparatus of any of claims 29-32 wherein the pivoting bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

34. The surface cleaning apparatus of claim 33 wherein the filtration member is moveably mounted in the filtration chamber.

35. The surface cleaning apparatus of claim 33 wherein the filtration member is moveably mounted to the access door.

36. The surface cleaning apparatus of claim 33 wherein the filtration member is removeably mounted to the access door.

37. The surface cleaning apparatus of any of claims 33-36 wherein the filtration member comprises screen.

38. The surface cleaning apparatus of claim 33 wherein the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

39. The surface cleaning apparatus of any of claims 28-38 wherein the cyclone has a lower air inlet, a lower air outlet and the dirt outlet is in an upper portion of the cyclone.

40. A surface cleaning apparatus comprising:

(a) a dirty air inlet;

(b) a filtration apparatus having a lower surface and comprising a cyclone downstream from the dirty air inlet, the cyclone having a dirt outlet and a cyclone floor;

(c) a dirt collection chamber in communication with the dirt upper dirt outlet and having a dirt collection chamber floor;

(d) an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone;

(e) a suction motor; and,

(f) a clean air outlet downstream from the suction motor.

41. The surface cleaning apparatus of claim 40 wherein the filtration member is moveably mounted in the filtration chamber.

42. The surface cleaning apparatus of claim 40 wherein the filtration member is moveably mounted to the access door.

43. The surface cleaning apparatus of claim 40 wherein the filtration member is removeably mounted to the access door.

44. The surface cleaning apparatus of any of claims 40-43 wherein the filtration member comprises screen.

45. The surface cleaning apparatus of claim 40 wherein the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

46. The surface cleaning apparatus of any of claims 40-45 wherein the dirt collection chamber is positioned around at least a portion of the cyclone, the dirt collection chamber floor is moveable, the cyclone floor is moveable and is connected to the lower moveable dirt collection chamber floor and the lower surface comprises the cyclone floor and the dirt collection chamber floor, whereby both the cyclone floor and the dirt collection chamber floor are moveable concurrently such that the dirt collection chamber and the cyclone are concurrently emptied.

47. The surface cleaning apparatus of any of claims 40-46 wherein the dirt collection chamber floor and the cyclone floor comprise a pivoting bottom of the filtration apparatus.

48. The surface cleaning apparatus of claim 47 wherein the cyclone floor includes a vortex finder mounted thereto.

49. The surface cleaning apparatus of claim 48 further comprising a filtration member positioned beneath the vortex finder.

50. The surface cleaning apparatus of claim 49 wherein the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

51. The surface cleaning apparatus of any of claims 47-50 wherein the pivoting bottom is the lower surface.

52. The surface cleaning apparatus of any of claims 40-51 wherein at least a portion of the access door is transparent.

53. The surface cleaning apparatus of any of claims 40-51 wherein the cyclone has a lower air inlet, a lower air outlet and the dirt outlet is in an upper portion of the cyclone.

54. A surface cleaning apparatus comprising:

(a) a dirty air inlet;

(b) first and second housings positioned side by side, the first housing comprises at least one cyclone and the second housing comprises a filter;

(c) the second housing having a second housing bottom that is openable and the filter is visible when the second housing bottom is opened;

(d) a suction motor; and,

(e) a clean air outlet downstream from the suction motor.

55. The surface cleaning apparatus of claim 54 wherein the first housing has a first housing bottom that is openable.

56. The surface cleaning apparatus of claim 55 wherein the first housing bottom is connected to the second housing bottom whereby both the first housing bottom and the second housing bottom are moveable concurrently.

57. The surface cleaning apparatus of claim 56 wherein the first housing further comprises a dirt collection chamber positioned around at least a portion of

the cyclone, the dirt collection chamber has a moveable dirt collection chamber floor, the cyclone has a lower moveable cyclone floor, whereby both the dirt collection chamber and the cyclone are concurrently emptied when the first housing bottom and the second housing bottom are opened concurrently.

58. The surface cleaning apparatus of any of claims 56-57 wherein the first housing bottom comprises the collection chamber floor and the cyclone floor.

59. The surface cleaning apparatus of any of claims 56-58 wherein the cyclone floor includes a vortex finder mounted thereto.

60. The surface cleaning apparatus of any of claims 56-59 further comprising a filtration member positioned beneath the vortex finder.

61. The surface cleaning apparatus of claim 60 wherein the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

62. The surface cleaning apparatus of claim 54 wherein the first housing bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

63. The surface cleaning apparatus of claim 62 wherein the filtration member is moveably mounted in the filtration chamber.

64. The surface cleaning apparatus of claim 62 wherein the filtration member is moveably mounted to the access door.

65. The surface cleaning apparatus of claim 62 wherein the filtration member is removeably mounted to the access door.

66. The surface cleaning apparatus of any of claims 62-65 wherein the filtration member comprises screen.

67. The surface cleaning apparatus of claim 62 wherein the cyclone floor includes a vortex finder mounted thereto, the filtration member is positioned

beneath the vortex finder, the vortex finder has an inlet positioned inside the cyclone and the inlet is free of a surrounding shroud.

68. The surface cleaning apparatus of any of claims 54-67 wherein the first housing bottom and the second housing bottom form part of an air flow passage from a cyclone outlet to an upstream side of the filter.

69. The surface cleaning apparatus of any of claims 54-67 wherein the first and second housings have a single pivoting bottom, the pivoting bottom comprising the first housing bottom and the second housing bottom and the pivoting bottom forms part of an air flow passage from a cyclone outlet to an upstream side of the filter.

70. The surface cleaning apparatus of claim 69 wherein the pivoting bottom has a lower surface and an access door is provided on the lower surface, a filtration chamber is positioned between the lower surface and the access door and a filtration member is provided in the filtration chamber adjacent the lower air outlet of the cyclone.

71. The surface cleaning apparatus of any of claims 54-70 further comprising a mechanical filter-cleaning member.

72. The surface cleaning apparatus of claim 71 wherein the mechanical filter-cleaning member comprises a vibrator connected to the filter.

73. The surface cleaning apparatus of claim 72 wherein the vibrator is actuated when the second housing bottom is opened.

74. The surface cleaning apparatus of claim 71 wherein the mechanical filter-cleaning member comprises a wiper positioned on an upstream side of the filter.

75. The surface cleaning apparatus of claim 74 wherein the wiper is actuated when the second housing bottom is opened.

76. The surface cleaning apparatus of any of claims 71-75 wherein the mechanical filter-cleaning member is battery powered.

77. The surface cleaning apparatus of claim 69 or 70 wherein at least a portion of the air flow passage is transparent.

78. A method of manufacturing a portion of a surface cleaning apparatus comprising:

(a) providing first and second portions constructed from a weldable material, the first portion having a first mating surface and second portion having a second mating surface;

(b) providing an electrically conductive wire along one of the mating surfaces;

(c) bringing the first and second mating surfaces together; and,

(d) applying a current through the wire.

79. The method of claim 78 wherein the step of providing an electrically conductive wire along one of the mating surfaces comprises positioning the wire around all of a perimeter of the one of the mating surface except for a gap.

80. The method of claim 79 further comprising providing a gap of up to 0.08 inches.

81. The method of claim 79 further comprising providing a gap of up to 0.04 inches.

82. The method of claim 79 further comprising providing a gap of up to 0.02 inches.

83. The method of any of claims 78-82 wherein the first and second portions define at least part of a fluid conduit and the method further comprises using the method to produce a fluid tight seal of the fluid conduit.

84. The method of any of claims 78-82 wherein the first and second portions define two parts of a cyclone and the method further comprises using the method to produce a fluid tight seal of the cyclone.

85. The method of any of claims 78-82 wherein the first and second portions define two parts of a dirt collection chamber and the method further comprises using the method to produce a fluid tight seal of the dirt collection chamber.

86. A surface cleaning apparatus comprising:

(a) a dirty air inlet;

(b) a filtration apparatus;

(c) a dirt collection chamber in communication with the dirt upper dirt outlet;

(d) a suction motor;

(e) a clean air outlet downstream from the suction motor; and,

(f) a fluid flow passage from the dirty air inlet to the clean air outlet and first and second portions define a portion of the fluid flow passage, the first and second portions are secured together by wire welding.

87. The surface cleaning apparatus of claim 86 wherein the first and second portions have an absence of screw ports securing the first and second portions together.

88. The surface cleaning apparatus of claim 86 or 87 wherein the first and second portions define two parts of a cyclone.

89. The surface cleaning apparatus of claim 86 or 87 wherein the first and second portions define two parts of a dirt collection chamber.

90. A surface cleaning apparatus comprising:

(a) a dirty air inlet, a clean air outlet downstream, a fluid flow passage extending from the dirty air inlet to the clean air outlet,

(b) a suction motor provided in the fluid flow passage;

(c) a filtration apparatus downstream from the dirty air inlet and comprising a cyclone having a cyclone outlet, the cyclone outlet having a shroud;

(d) a screen downstream from the vortex finder;

(e) a foam filter downstream from the screen;

(f) a felt filter downstream from the foam filter; and,

(g) a HEPA filter downstream from the felt filter.

91. The surface cleaning apparatus of claim 90 wherein the suction motor is downstream from the HEPA filter.

92. The surface cleaning apparatus of claim 90 wherein the suction motor is upstream from the HEPA filter.

93. The surface cleaning apparatus of any of claims 90-92 wherein the screen comprises an open wire mesh.

94. The surface cleaning apparatus of any of claims 90-93 wherein the shroud comprises an apertured end of the cyclone outlet.

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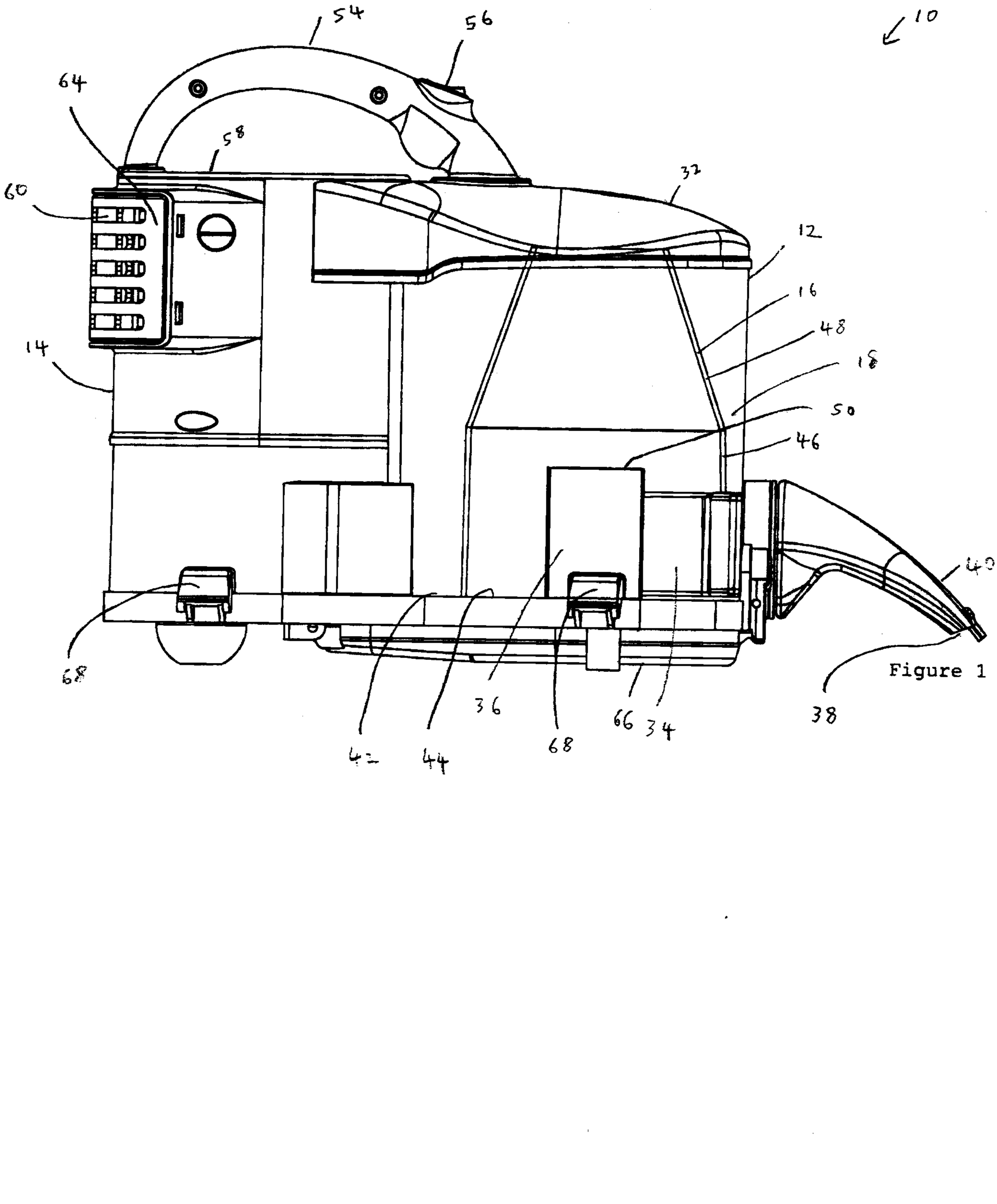

Figure 1

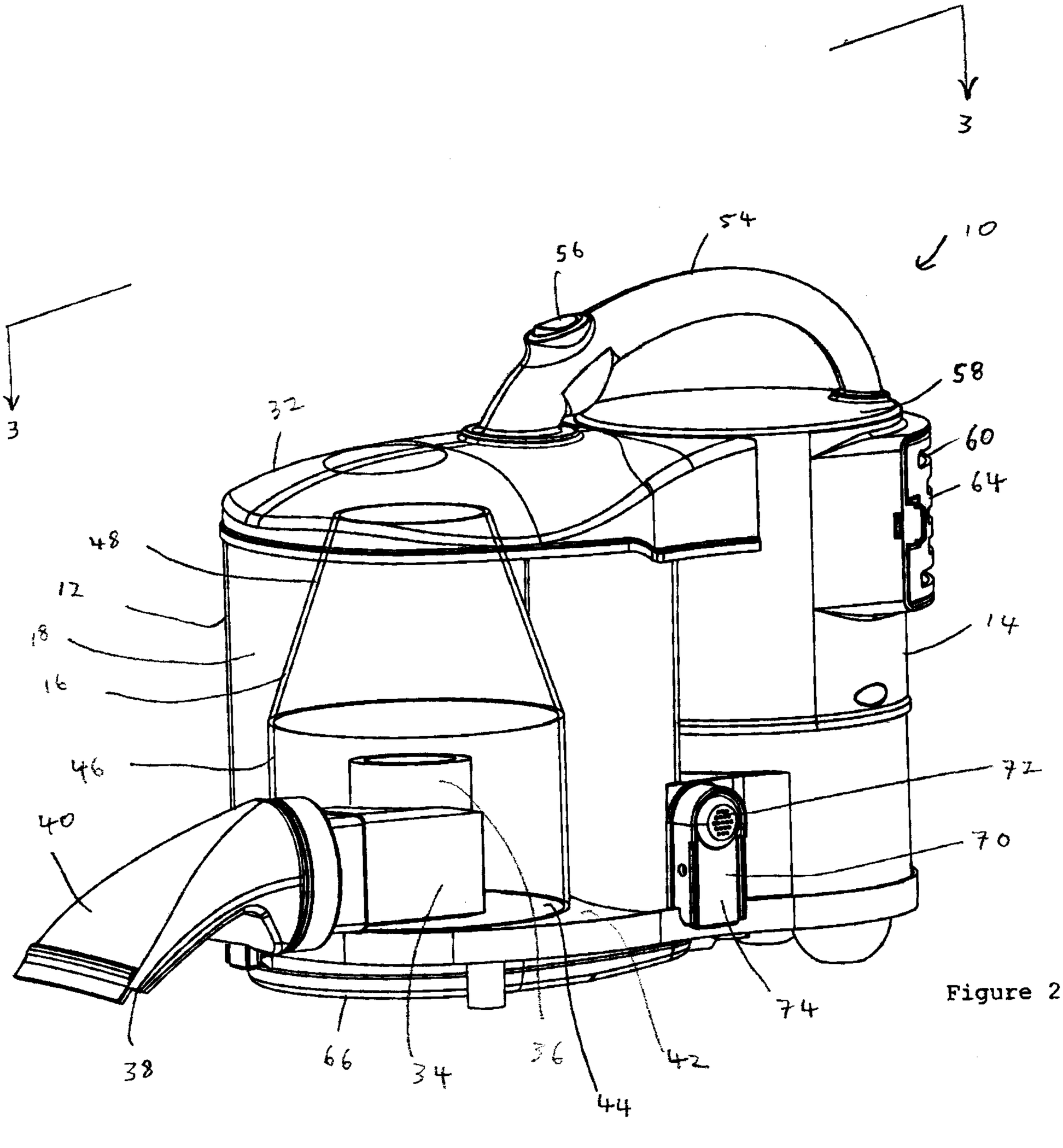

Figure 2

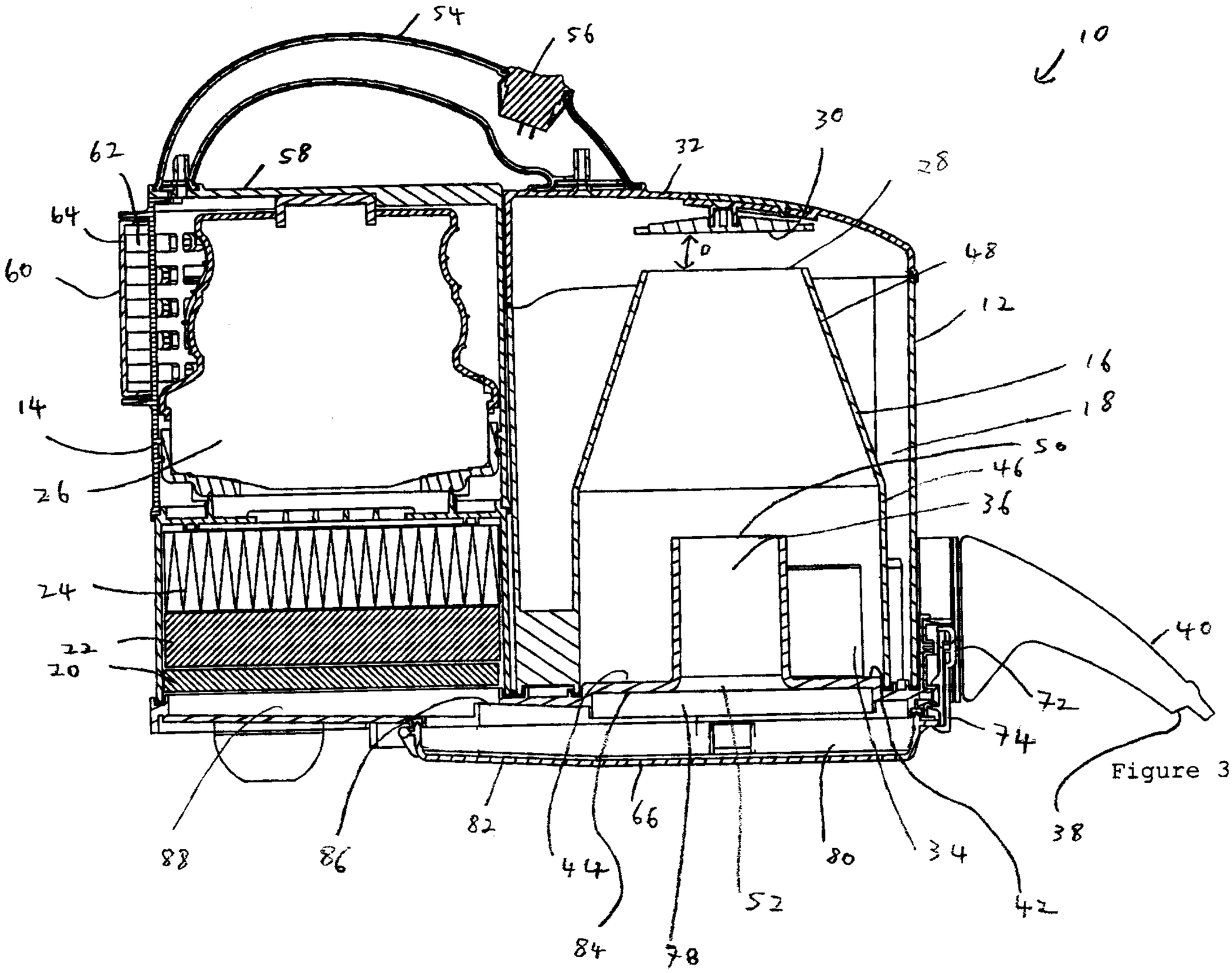
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Figure 3

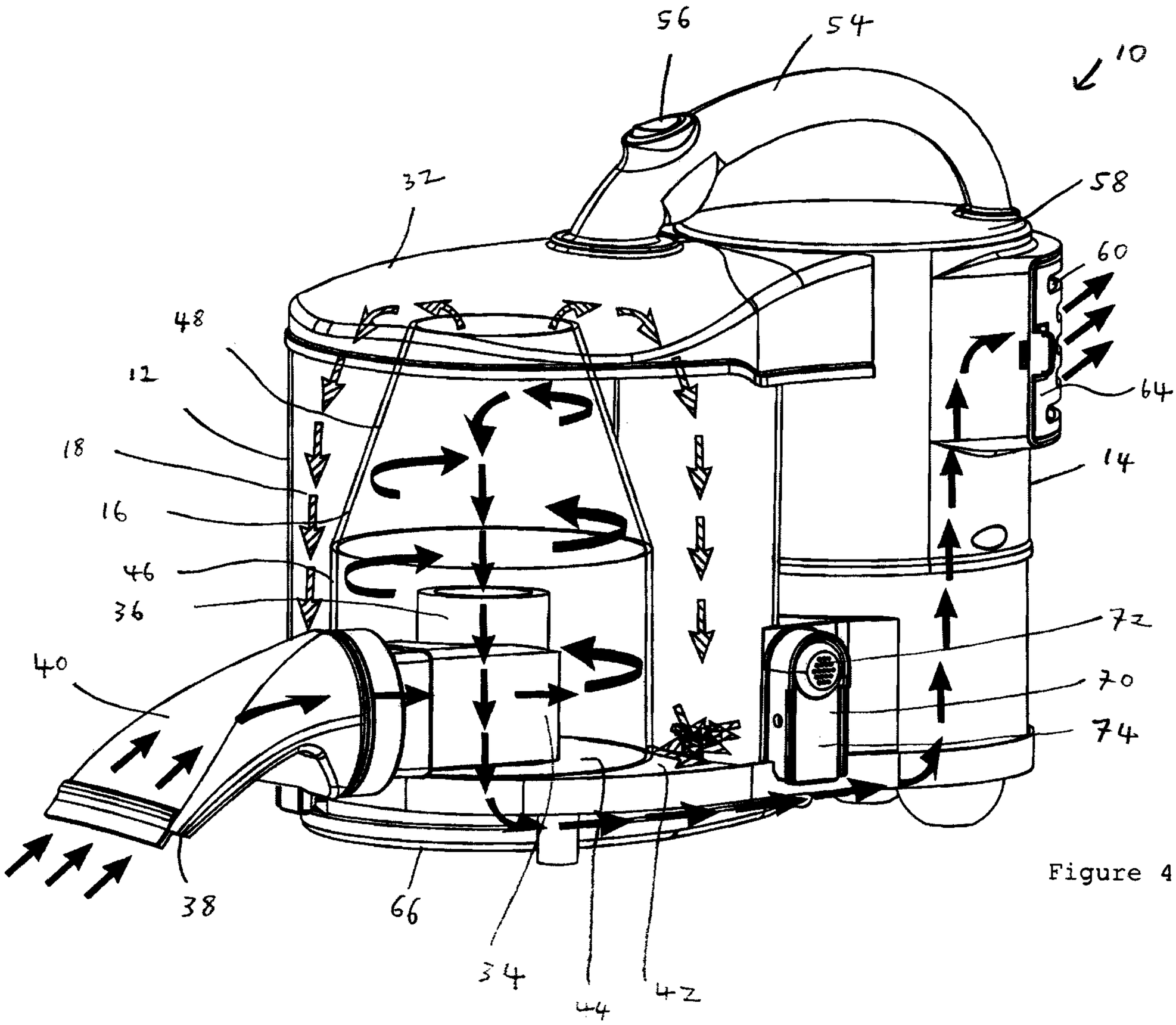


Figure 4

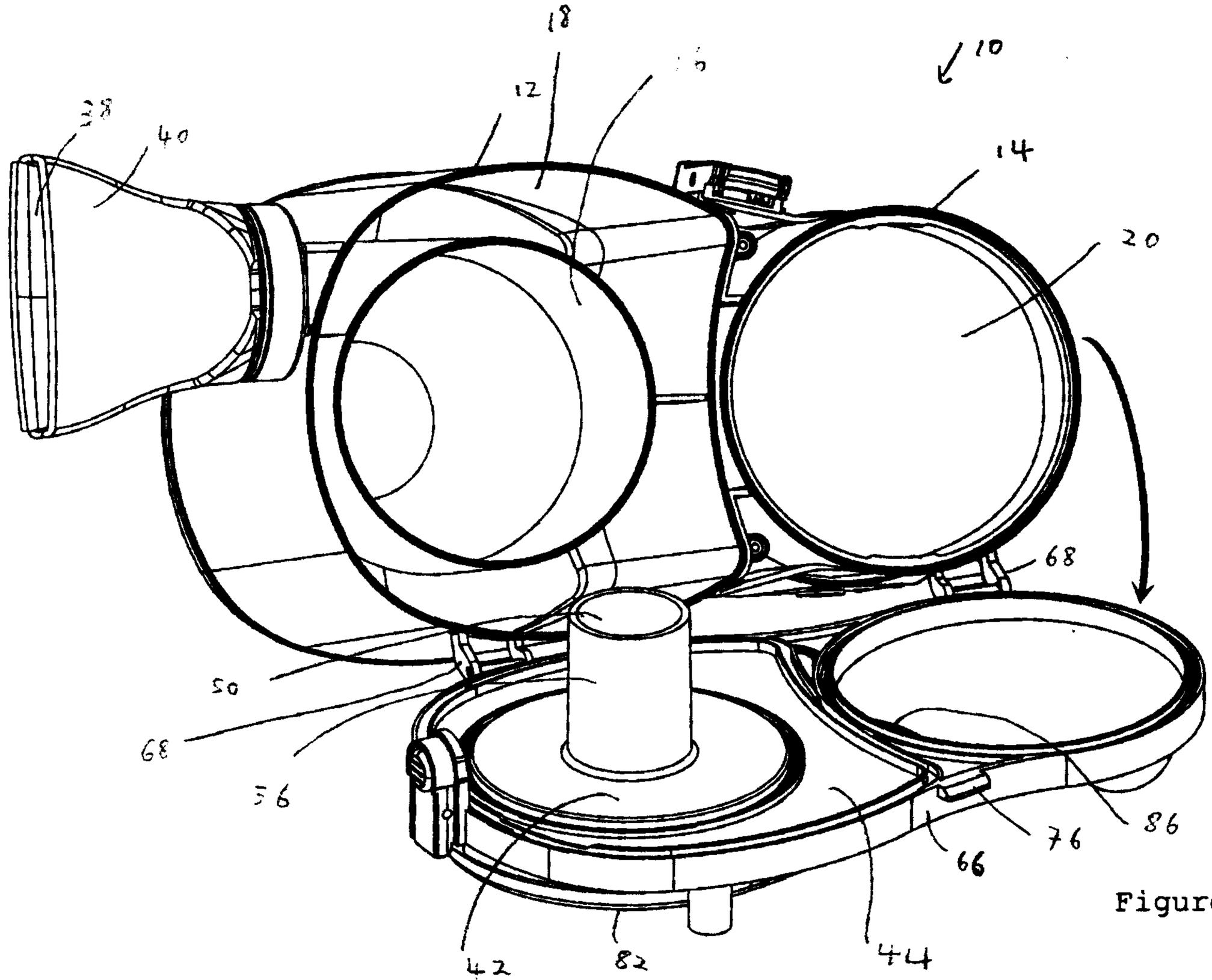


Figure 5

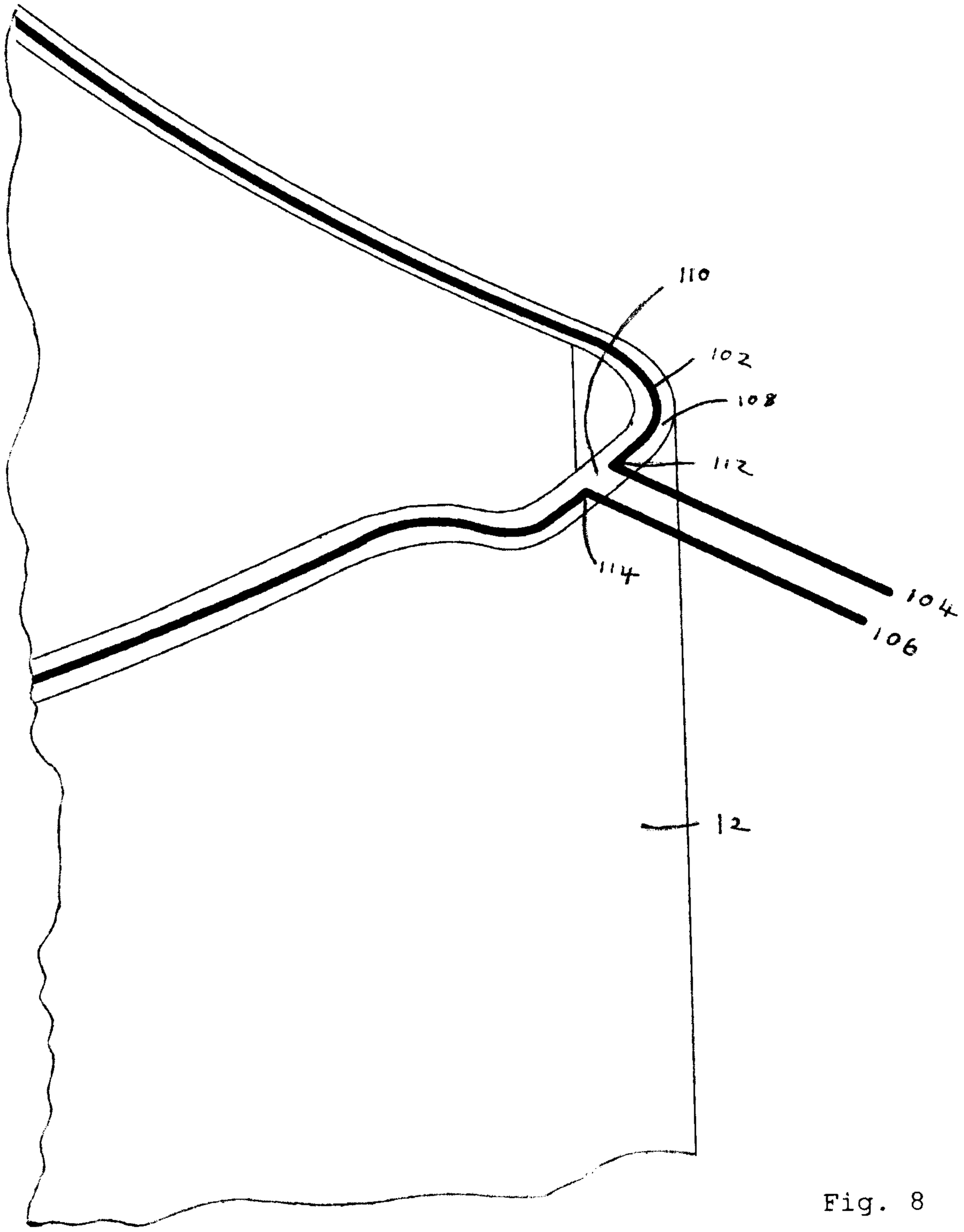


Fig. 8

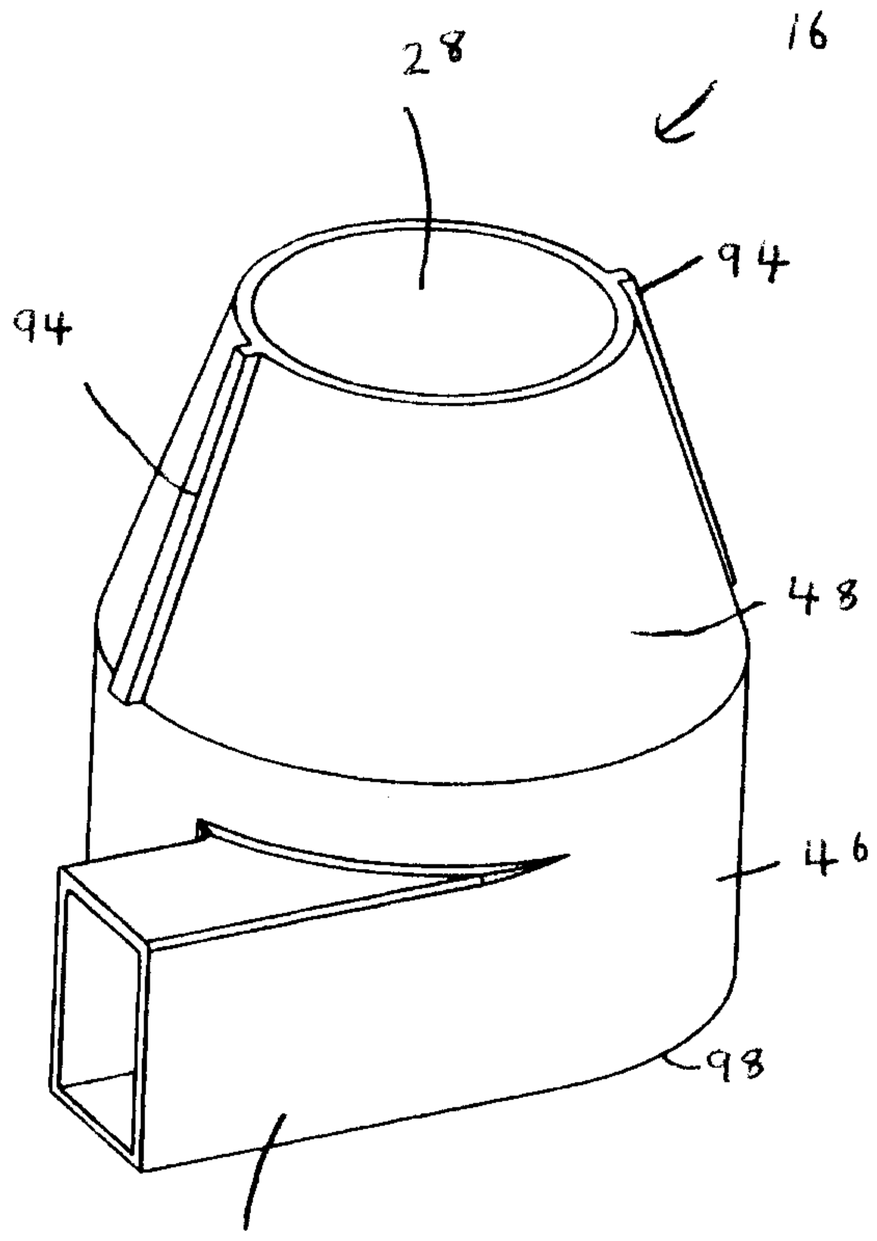


Fig 9A

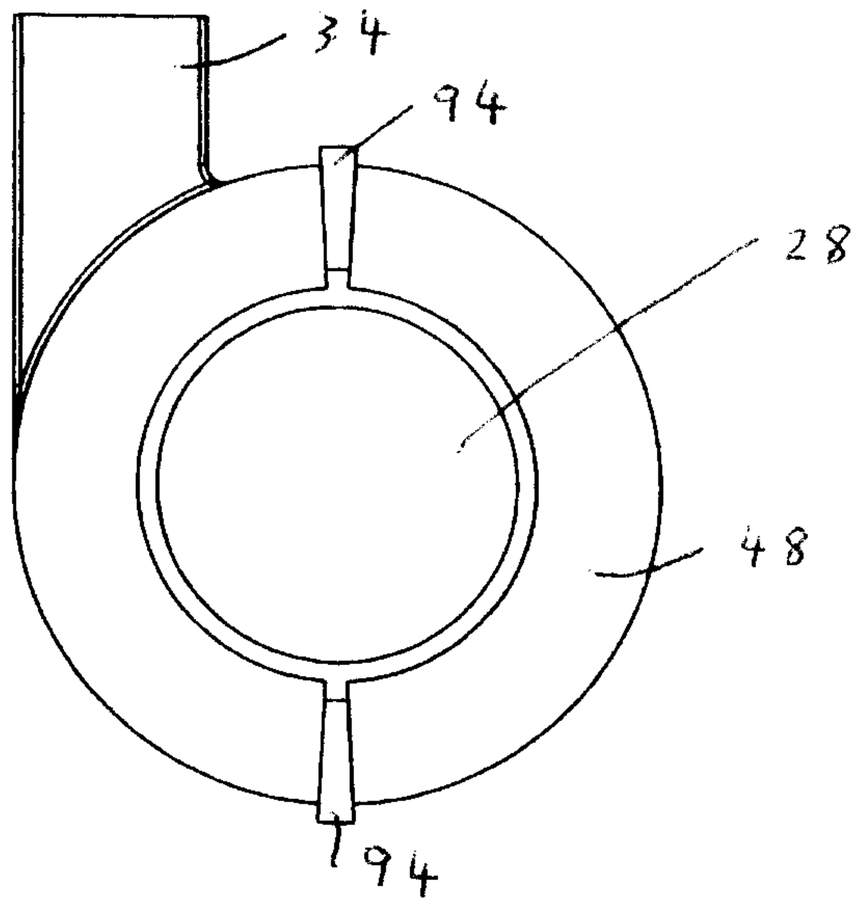


Fig 9B

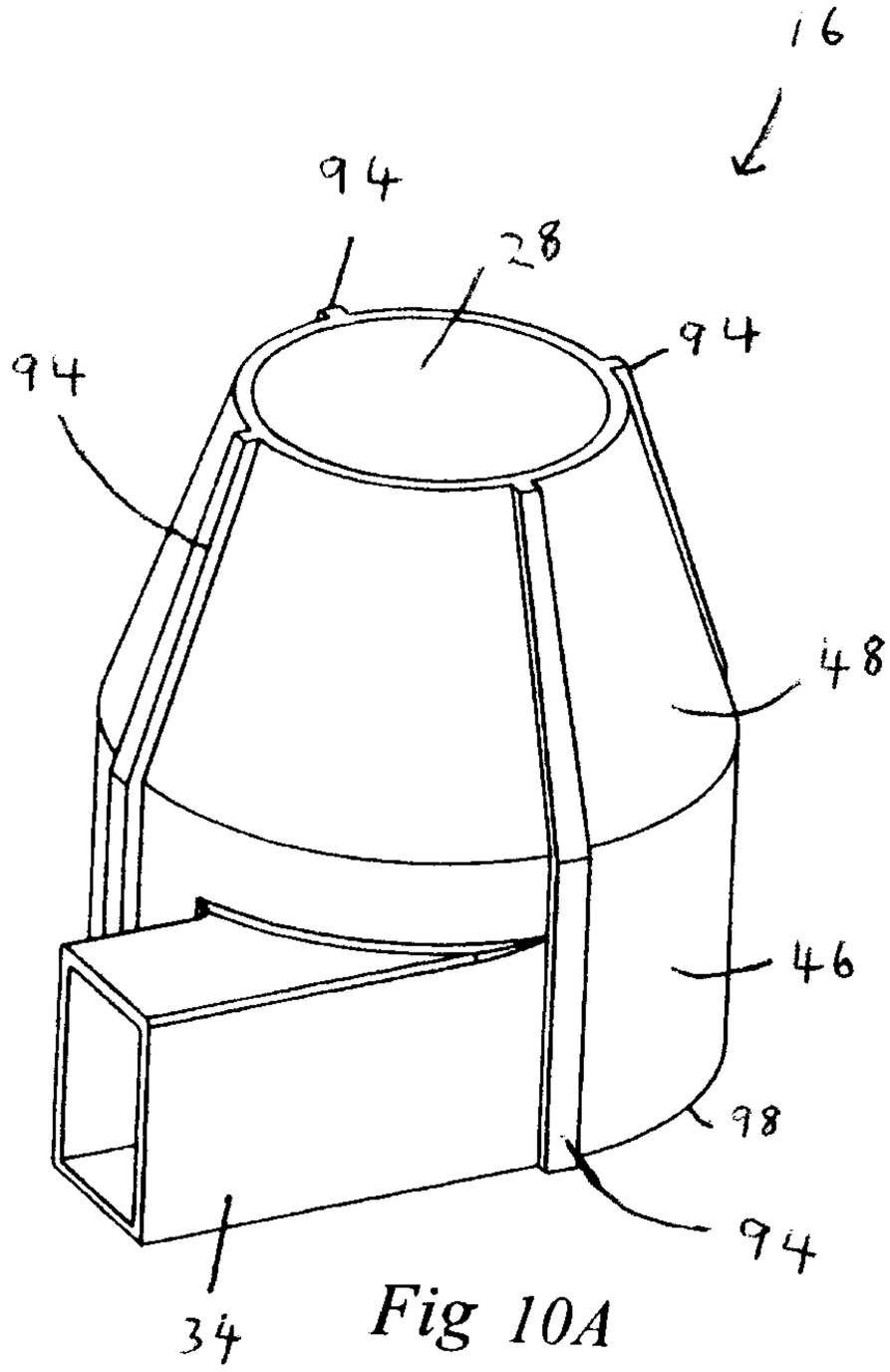


Fig 10A

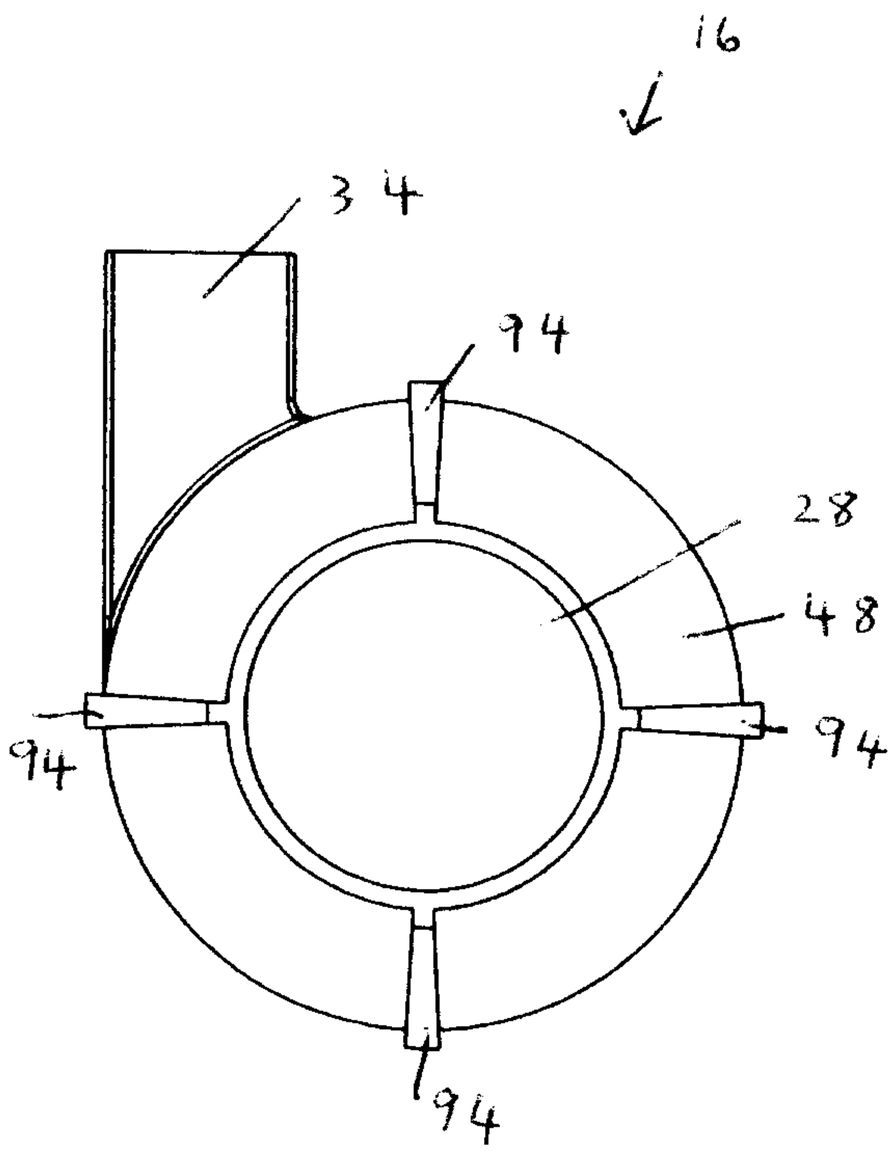


Fig 10B

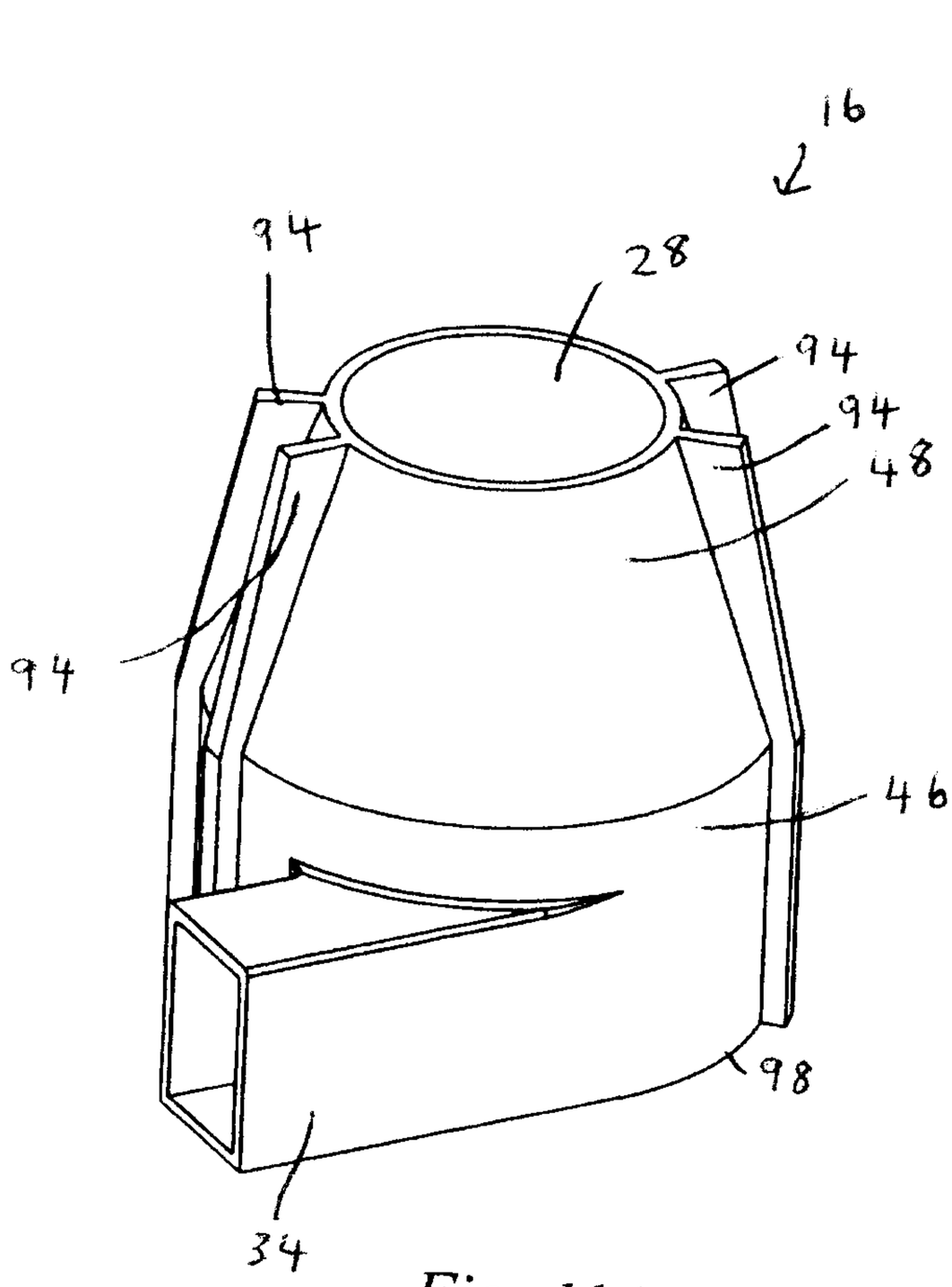


Fig 11A

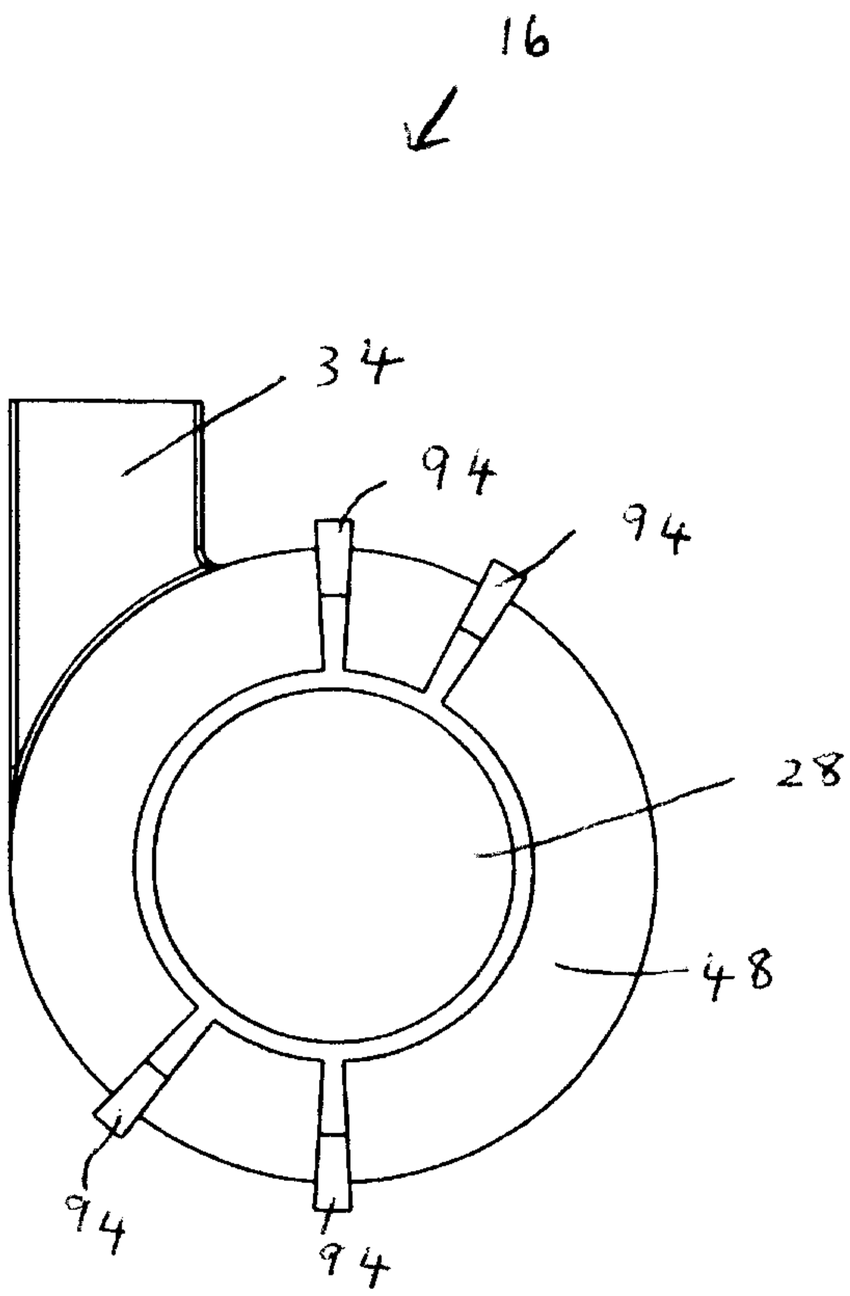


Fig 11B

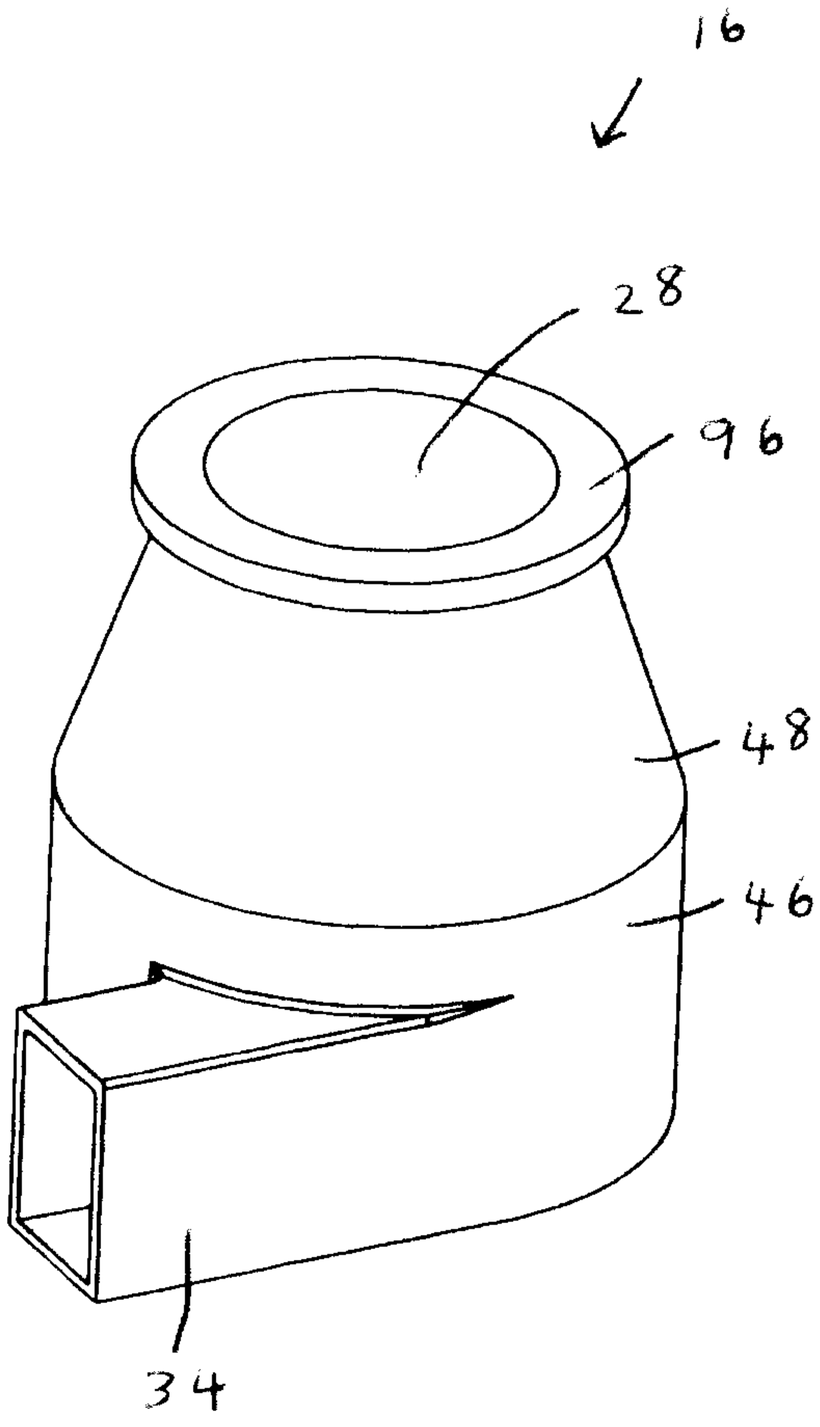


Fig 12A

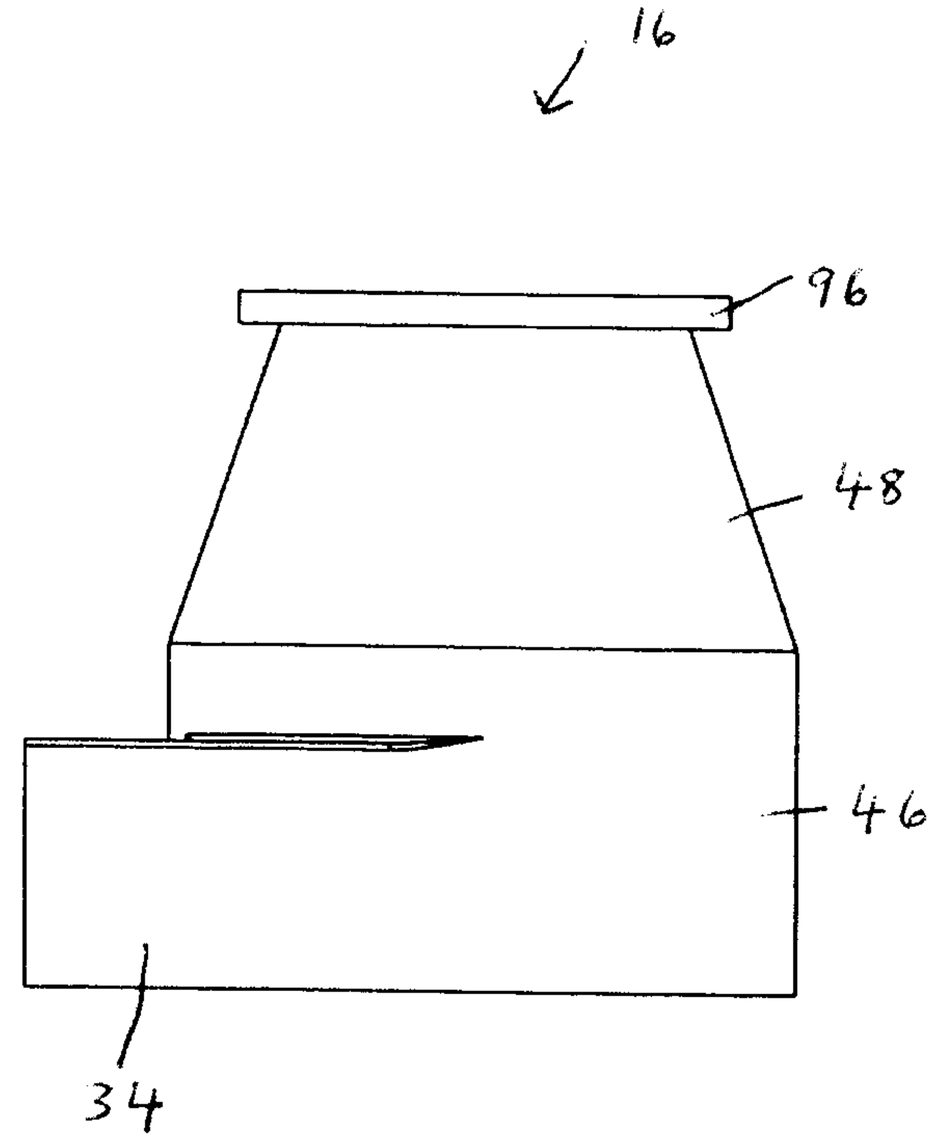


Fig 12B

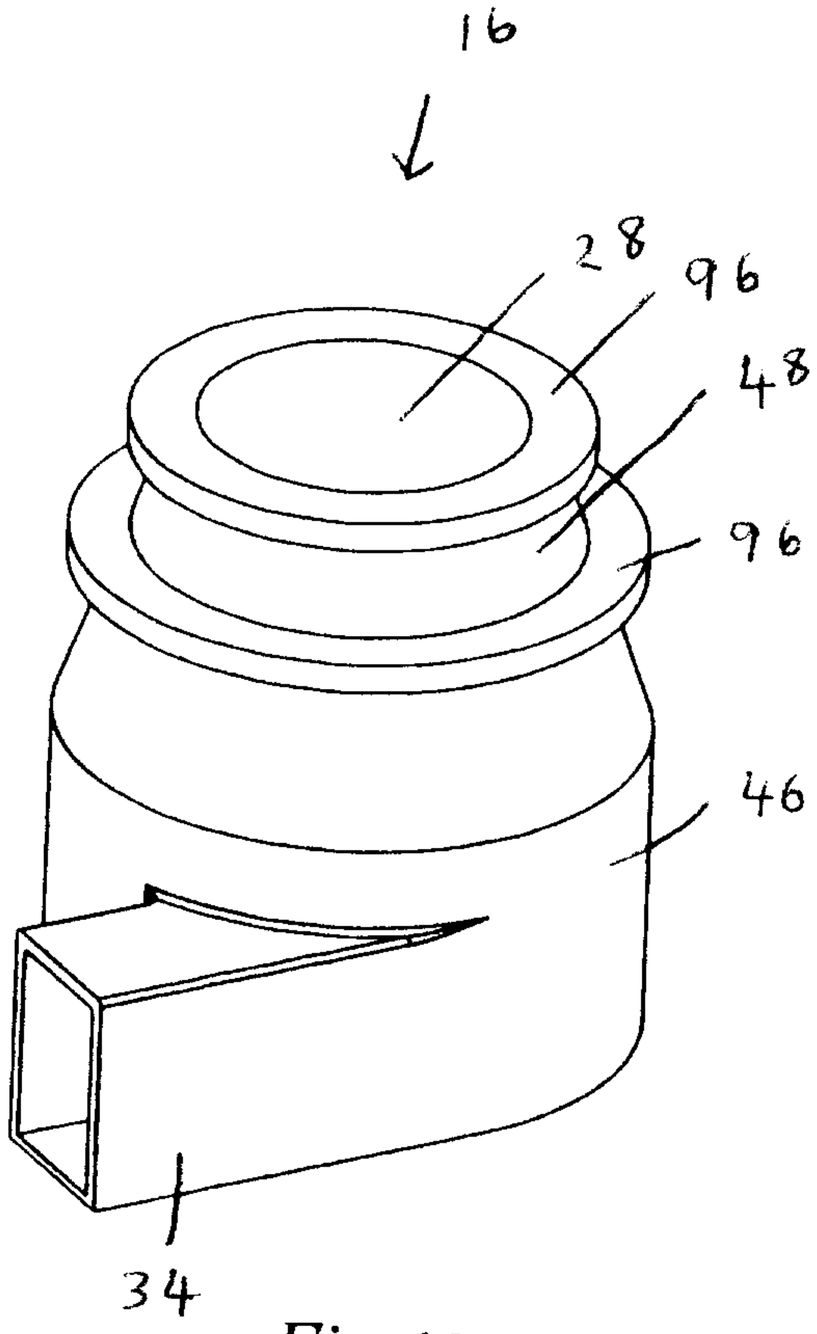


Fig 13A

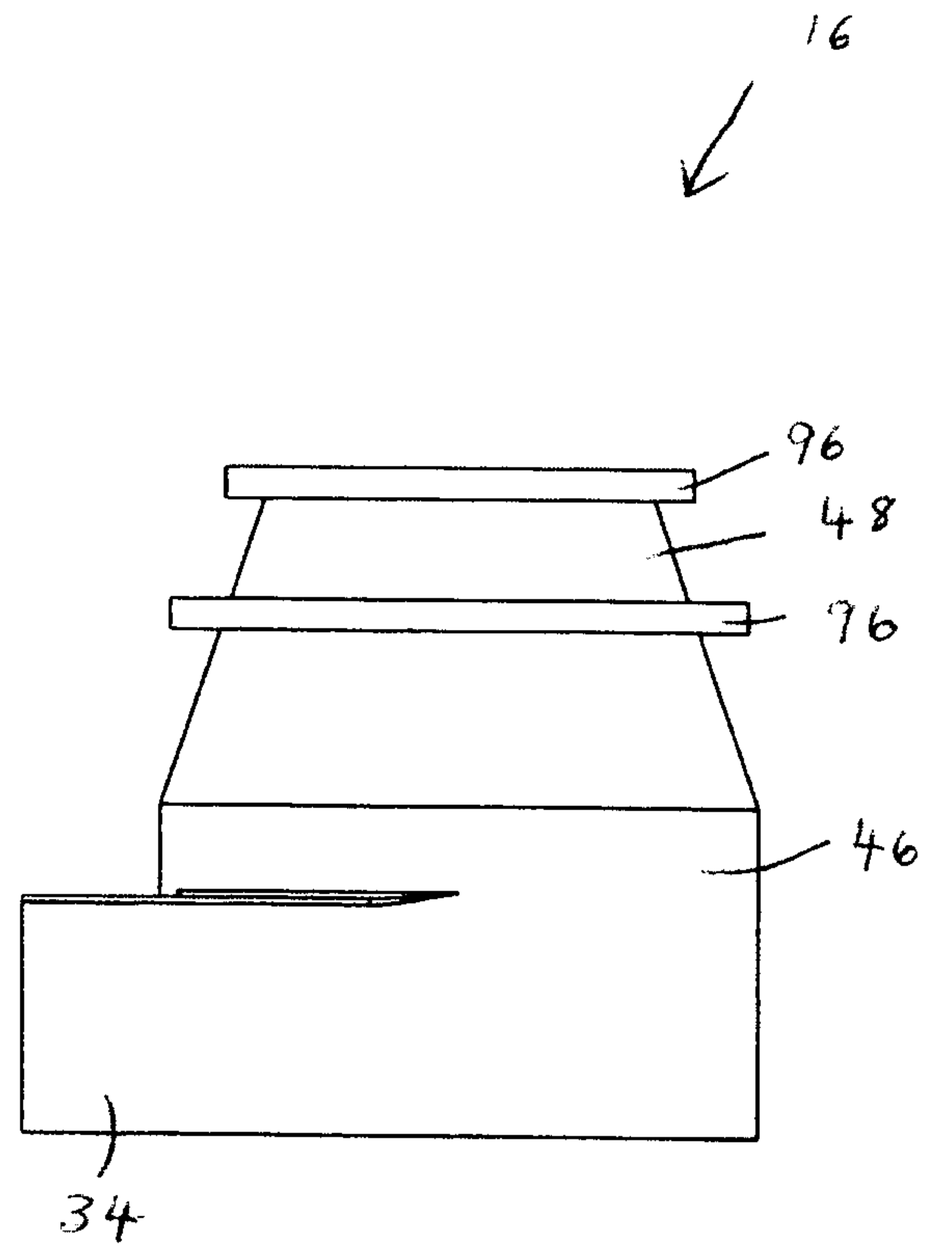


Fig 13B

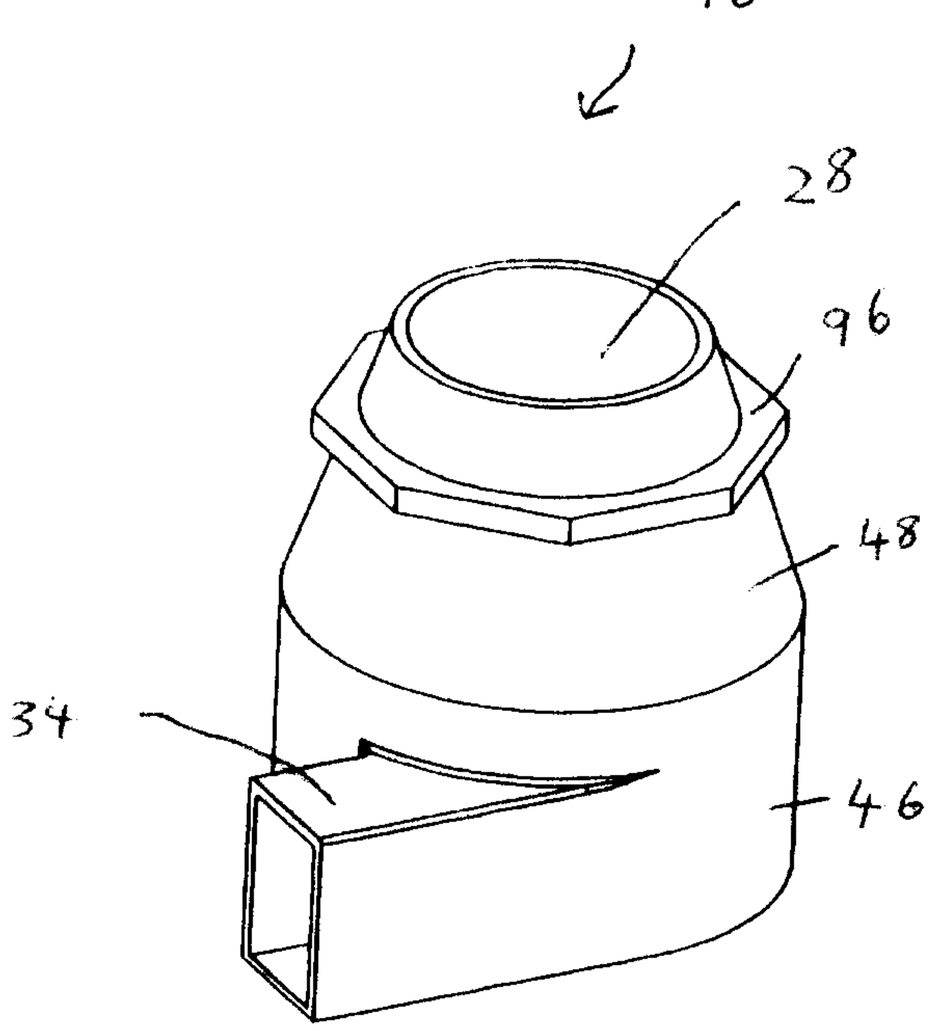


Fig 14A

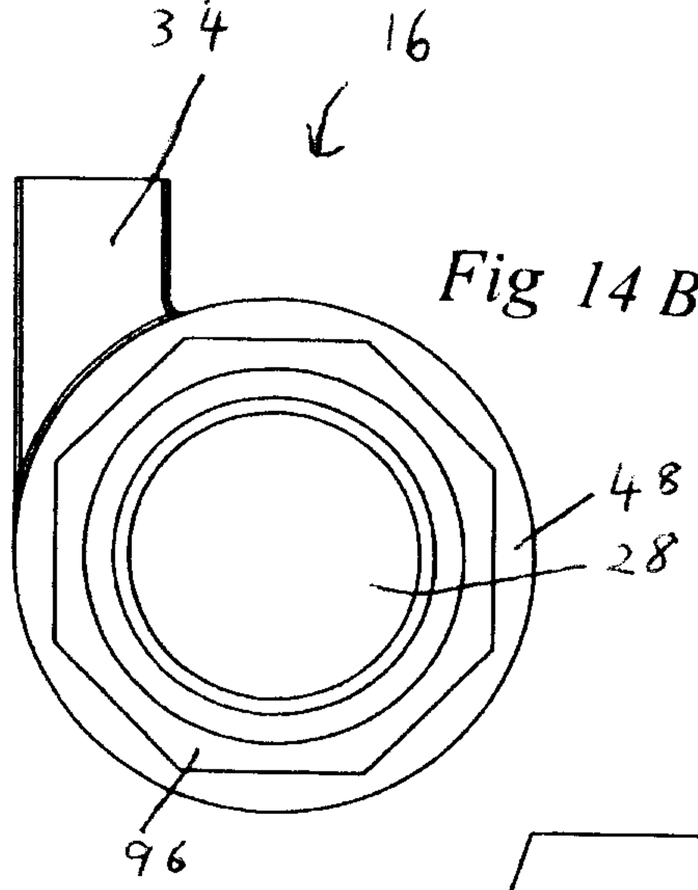


Fig 14B

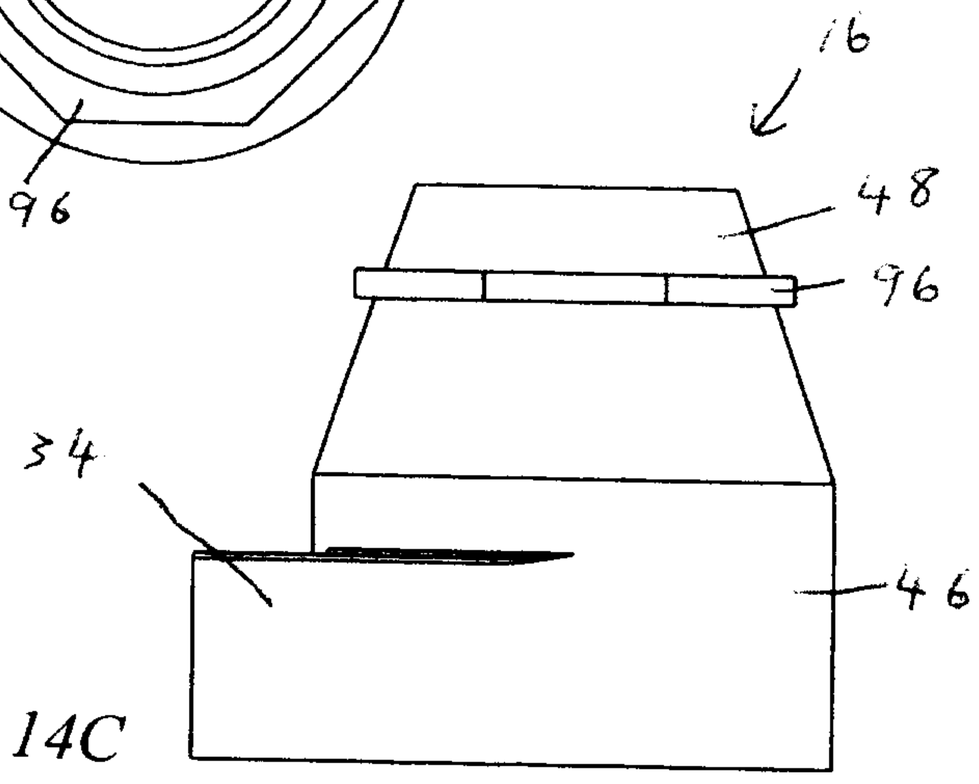


Fig 14C

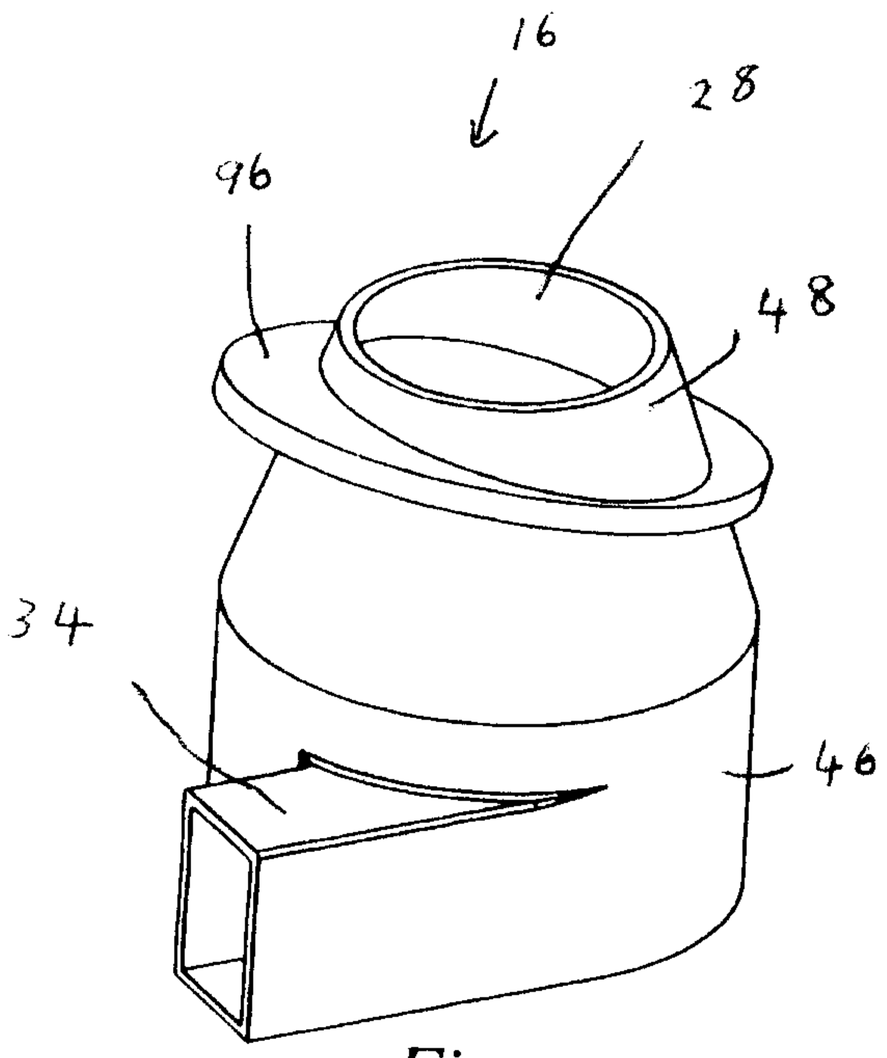


Fig 15A

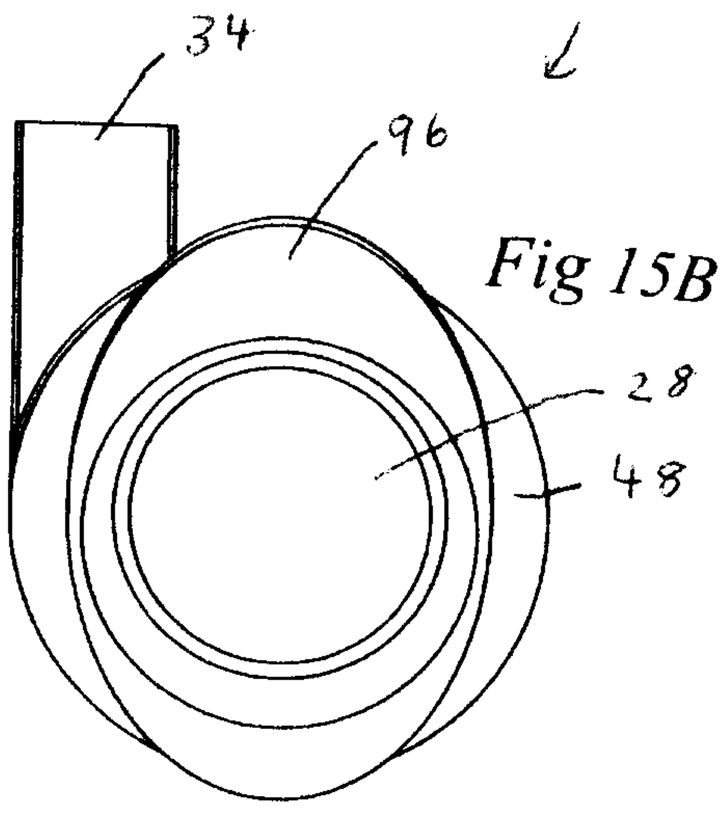


Fig 15B

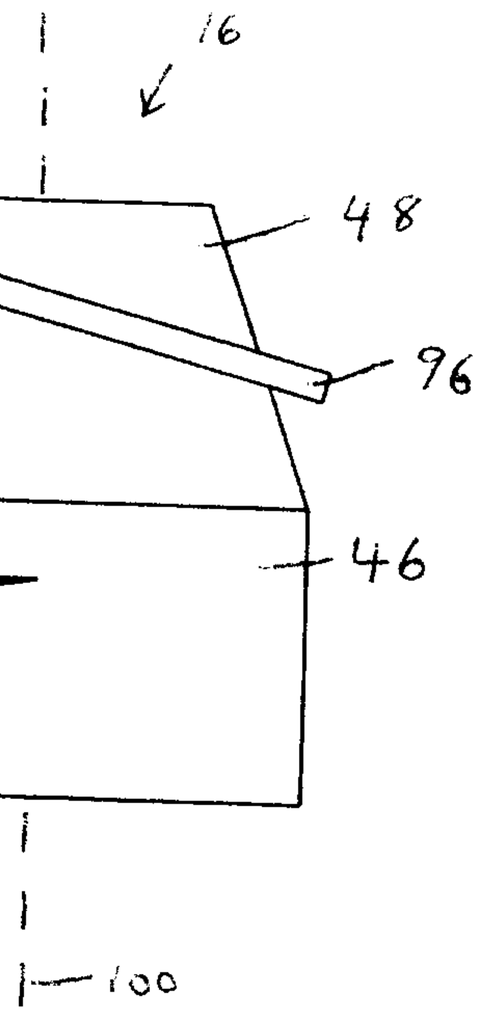
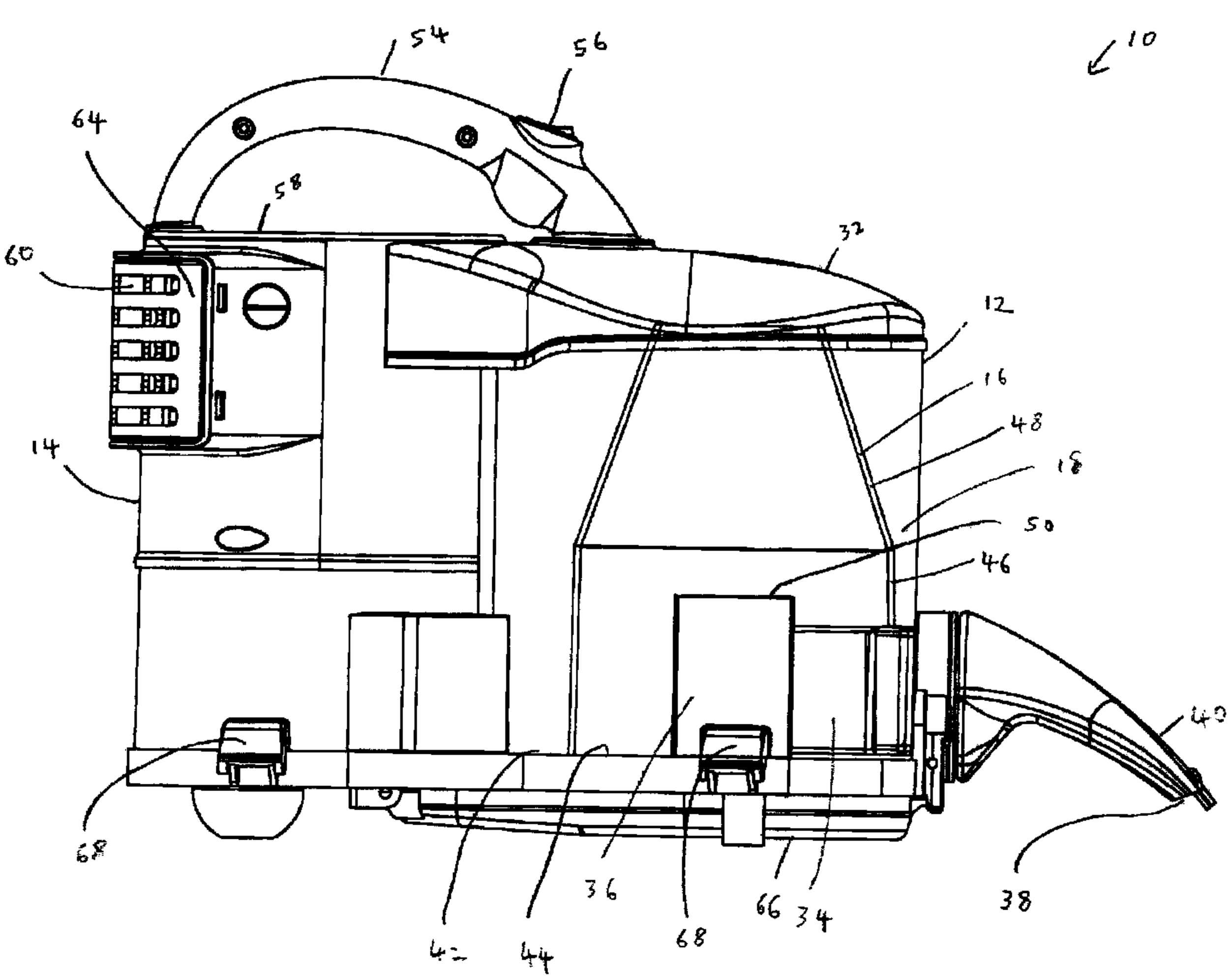


Fig 15C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