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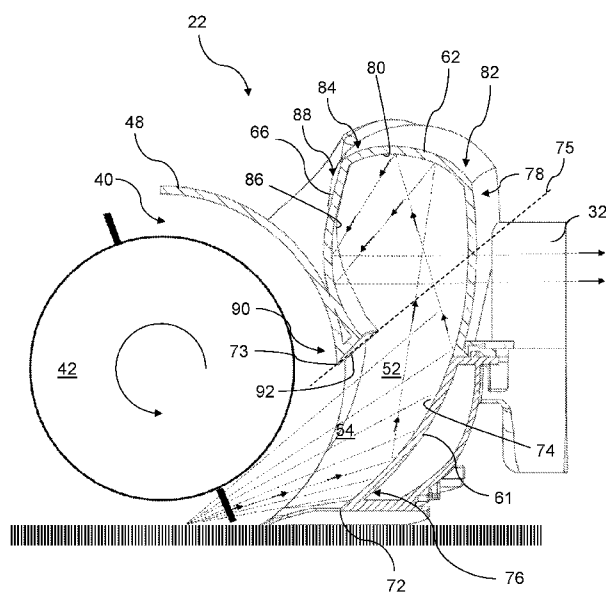
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SECTION B-B

FIG. 6b

(57) **Abstract:** This invention concerns a cleaner head 10 for a vacuum cleaning appliance (2) comprising a rotatable agitator assembly (42) and a main body (12) defining an agitator chamber (40) within which is supported the agitator assembly (42). The agitator chamber (40) comprises a suction opening (28) through which a portion of the agitator assembly (42) projects to engage a surface to be cleaned and an outlet (54) through which, in use, energised dirt particles leave the agitator chamber (40) to enter a rear section (22) of the main body (12) as the agitator assembly (42) sweeps them rearwardly from the surface. The rear section (22) comprises a plurality of deflection panels (50) defining a dust channel (52) extending between the outlet (54) of the agitator chamber (40) and an exhaust outlet (32) of the cleaner head (10) through which the energised dirt particles are drawn from the dust channel (52), and the plurality of deflection panels (50) comprise respective concave surfaces (74, 80, 86) configured to deflect the energised dirt particles from the outlet (54) of the agitator chamber (40) towards the exhaust outlet (32) through a series of sequential collisions.



CLEANER HEAD FOR A VACUUM CLEANING APPLIANCE

TECHNICAL FIELD

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The invention relates generally to vacuum cleaners, and particularly to a cleaner head or floor tool which forms part of a vacuum cleaner. The invention is concerned specifically with rotationally-driven agitators used in such cleaner heads, whether or not the cleaner head is permanently or removably fixed on a respective vacuum cleaner. The type of vacuum cleaner is immaterial to the invention, and so the invention may relate to so-called bagged or bagless vacuum cleaners.

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BACKGROUND

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A vacuum cleaning appliance or, more simply, 'vacuum cleaner', typically comprises a main body equipped with a suction source and a dust separator, wherein a cleaner head is connected to that dust separator usually by a separable coupling. The cleaner head has a suction opening with which it engages a surface to be cleaned and through which dirt-laden air is drawn into the vacuum cleaner towards the dust separator. The cleaner head performs a crucial role in the effectiveness of a vacuum cleaner in removing dirt from a surface, whether that surface is a hard floor covering such as wood or stone, or a soft floor covering such as carpet. Therefore, much effort is made by vacuum cleaner manufacturers to optimise cleaner head design to improve pick-up performance.

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Some cleaner heads are passive devices which rely on stationary elements such as so-called 'active edges' and bristle strips to dislodge dirt from floor coverings. These types of cleaner heads are relatively simple but generally their effectiveness at removing dirt from surfaces is limited. Often, they are recommended mainly for use on hard surfaces.

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Conventionally, the most effective cleaner heads incorporate some kind of powered brush bar or agitator. Examples are known in which the agitator is driven by a turbine which is actuated by the airflow through the cleaner head. Other known arrangements involve the use of an electric motor that is arranged to drive the agitator. In these known arrangements, it is usual for the motor to be

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coupled to the agitator by a suitable drive linkage such as a belt or gear mechanism, although it is also known for the motor to be housed within the agitator which provides a particularly space-efficient arrangement.

- 5 In either example, the powered agitator serves to wipe and beat the floor surface in order to improve the capability of the cleaner head to remove dirt from that surface. A common configuration is for the agitator to carry an array of bristles that extend radially outward from the surface of the agitator. The bristles are typically relatively stiff so that they engage the floor surface aggressively as the agitator rotates, thereby serving as a means to scrape and strike the floor
- 10 surface to loosen embedded particles. Other strips of material such as rubber and carbon fibre filaments may be used to provide complementary characteristics to the agitator. By way of example, US8782851 B2 describes an agitator that may be provided with a combination of relatively stiff bristles, carbon filaments and rubber strips.
- 15 A significant design challenge is to optimise the way in which air flows through the cleaner head, from where air enters its interior through the suction opening, to where air is discharged from an outlet towards the dust separator. It is known that air flow velocity is an important factor in pick-up performance since dirt particles are transported more effectively when the velocity of air moving through the tool is high. This is particularly true of high energy particles such as sand.
- 20 Being small and relatively heavy, such particles tend to be ejected from the floor surface and into the interior of the cleaner head at a high velocity where they tend to bounce around the cleaner head chaotically. High air flow speeds are needed to entrain the dirt particles in the air within the cleaner head and to transport those particles out of the cleaner head towards the dust collector. At low air flow speeds, however, there is a higher likelihood that these heavy particles will be
- 25 deposited back onto the floor covering. It will be appreciated, therefore, that maintaining good pick-up performance is challenging, particularly at low cleaner head air flow speeds.

Although high air flow speeds are achievable by equipping the vacuum cleaner with a powerful vacuum motor, this is generally undesirable as it means that the machine is less efficient, which

30 is a significant drawback in battery powered vacuum cleaners where energy efficiency has a direct effect on available runtime. So, it is desirable for a cleaner head to be effective at picking up even relatively heavy dirt particles from a floor surface without the need for high air flow speeds.

It is against this background that the invention has been devised.

SUMMARY OF THE INVENTION

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According to a first aspect of the invention, there is provided a cleaner head for a vacuum cleaning appliance, the cleaner head comprising: a rotatable agitator assembly; a main body defining an agitator chamber within which is supported the agitator assembly, the agitator chamber comprising a suction opening through which a portion of the agitator assembly projects to engage
10 a surface to be cleaned and an outlet through which, in use, energised dirt particles leave the agitator chamber to enter a rear section of the main body as the agitator assembly sweeps them rearwardly from the surface, wherein the rear section comprises a plurality of deflection panels defining a dust channel extending between the outlet of the agitator chamber and an exhaust outlet of the cleaner head through which the energised dirt particles are drawn from the dust
15 channel, and wherein the plurality of deflection panels comprise respective concave surfaces configured to deflect the energised dirt particles from the outlet of the agitator chamber towards the exhaust outlet through a series of sequential collisions. This way, the initial energy of the energised dirt particles entering the dust channel through the outlet of the agitator chamber is used to direct them towards the exhaust outlet using a series of sequential purposeful collisions
20 with the deflection panels, while avoiding any haphazard collisions, which could see them inadvertently retained within the dust channel and even returned to the floor surface. The collisions with the deflection panels dissipate the energy of the dirt particles and in doing so direct them to the exhaust outlet where suction is greatest and they are more inclined to become entrained within the air flow within the dust channel. Thus, the present invention not only improves
25 the pick-up performance of the cleaner head, but also provides for a reduced air flow rate through the dust channel, lowering the energy consumption of the vacuum cleaning appliance.

Preferably, the plurality of deflection panels comprises a first deflection panel and wherein the
30 outlet of the agitator chamber is defined by a lower edge of the first deflection panel.

Preferably, the first deflection panel comprises a first concave surface configured, in use, to deflect energised dirt particles from the outlet of the agitator chamber towards a second deflection panel of the plurality of deflection panels.

- 5 Preferably, the first concave surface curves rearwardly and upwardly from a lower end of the first deflection panel adjacent the outlet of the agitator chamber to an upper end of the first deflection panel.

- 10 Preferably, the second deflection panel comprises a second concave surface configured, in use, to deflect energised dirt particles deflected from the first concave surface towards a third deflection panel of the plurality of deflection panels.

- 15 Preferably, the second concave surface curves forwardly from a rear end of the second deflection panel adjacent the upper end of the first deflection panel to a forward end of the second deflection panel.

- 20 Preferably, the third deflection panel comprises a third concave surface configured, in use, to deflect energised dirt particles deflected from the second concave surface towards the exhaust outlet of the cleaner head.

- 25 Preferably, the third concave surface is configured, in use, to deflect energised dirt particles deflected from the second concave surface towards a focal point located on the longitudinal axis of the exhaust outlet. This arrangement avoids any deliberate interaction between the deflected dirt particles and side walls of the rear section, which could see them retained in the rear section or even returned to the agitator chamber.

- 30 Preferably, the third concave surface curves downwardly from an upper end of the third deflection panel adjacent the forward end of the second concave surface to a lower end of the third deflection panel.

Preferably, the rear section of the main body further comprises a semi-circular cylindrical panel defining the agitator chamber, and wherein a lower end of the semi-circular cylindrical panel

defines a plane above which the first concave surface terminates. This arrangement provides sufficient clearance for dirt particles energised by the agitator assembly to enter the dust channel through the outlet of the agitator chamber, thereby avoiding, or at least minimising, inadvertent collisions with the semi-circular cylindrical panel, which could see the dirt particles retained within the agitator chamber and eventually returned to the floor surface.

Preferably, the plane extends through at least part of the exhaust outlet. This arrangement ensures that any dirt particles that enter the dust channel, but do not strike the first concave surface, are instead steered directly to the exhaust outlet.

Preferably, the concave surfaces are angled towards the exhaust outlet such that an axially outer edge of each concave surface is positioned ahead of its axially inner edge with respect to the longitudinal axis of the exhaust outlet. This arrangement adds an axial component to the trajectory of the energised dirt particle to direct it axially inwards within the cleaner head.

Preferably, the first and second concave surfaces are configured to diverge from the third concave surface towards the exhaust outlet. This arrangement progressively widens the dust channel so as to avoid deliberate interaction between the deflected dirt particles and side walls of the dust channel, which could see them retained in the rear section of the housing or even returned to the agitator chamber.

According to a second aspect of the invention, there is provided a vacuum cleaning appliance comprising a cleaner head according to the first aspect.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a front perspective view of a vacuum cleaner comprising a cleaner head in accordance with an embodiment of the invention;

FIG. 2a is a front perspective view of the cleaner head of FIG. 1;

FIG. 2b is a rear perspective view of the cleaner head of FIG. 1;

FIG. 3 is a bottom view of the cleaner head of FIG. 1;

FIG. 4a is a front perspective view of a rear section the cleaner head of FIG. 1;

FIG. 4b is a rear perspective view of the rear section of the cleaner head of FIG. 1;

FIG. 5 is an upper plan view of the rear section of FIG. 4a and 4b;

FIG. 6a is a cross-sectional view of the rear section of FIG. 5 along section A-A;

FIG. 6b is a cross-sectional view of the rear section of FIG. 5 along section B-B;

FIG. 6c is a cross-sectional view of the rear section of FIG. 5 along section C-C; and,

FIG. 7 is a cross-sectional view in a horizontal plane of the cleaner head of FIG. 1.

In the drawings, like features are denoted by like reference signs.

SPECIFIC DESCRIPTION

Specific embodiments of the invention will now be described in which numerous features will be discussed in detail in order to provide a thorough understanding of the inventive concept as defined in the claims. However, it will be apparent to the skilled person that the invention may be put in to effect without the specific details and that in some instances, well known methods, techniques and structures have not been described in detail in order not to obscure the invention unnecessarily. Moreover, references in the following description to any terms having an implied orientation are not intended to be limiting, and refer only to the orientation of the features as shown in the accompanying drawings.

FIG. 1 shows a vacuum cleaning appliance or vacuum cleaner 2 comprising a dirt and dust separating unit 4, a motor-driven fan unit 6 and a cleaner head 10 in accordance with an embodiment of the invention. The vacuum cleaner 2 further comprises a wand 8 connecting the dirt and dust separating unit 4 and the cleaner head 10. The motor-driven fan unit 6 draws dirt-bearing air through the cleaner head 10, from a surface to be cleaned, to the dirt and dust separating unit 4, where dirt and dust particles are separated from the dirt-bearing air and the comparatively clean air is expelled from the vacuum cleaner 2. The dirt and dust separating unit 4 shown in this example is a cyclonic separating unit, but it will be understood by the skilled reader that the dirt and dust separating unit 4 is not material to the invention and that the cyclonic separating unit could be replaced with an alternative separating unit or a combination of different separating units. Similarly, the nature of the vacuum cleaner 2 is not material to the invention. The vacuum cleaner 2 shown in FIG. 1 is a cordless stick vacuum cleaner, but it will be understood that the cleaner head 10 disclosed herein may be used with other types of vacuum cleaners such as, for example, upright or cylinder vacuum cleaners.

With reference to FIG. 2a and 2b, the cleaner head 10 comprises a main body 12 rotatably attached to a coupling 14, which, in this example, is removably connectable to the wand 8. It will be apparent to the skilled reader, however, that the invention is also intended to cover cleaner heads that are configured to be permanently fixed to their respective vacuum cleaners. The main body 12 comprises a housing 16 which includes front, middle and rear sections 18, 20, 22 and a lower body plate section, or sole plate 24. The sole plate 24 defines a generally rectangular suction opening 28 through which, in use, dirt-bearing air is drawn into the cleaner head 10 from

a surface to be cleaned, such as a floor surface. The coupling 14 comprises a conduit, supported by a rolling assembly 30 for supporting the cleaner head 10 on the floor surface. The conduit comprises a forward portion connected to an exhaust outlet 32, formed in the rear section 22 of the housing 16, and a rearward portion, pivotably connected to the forward portion. The part of the coupling 14 defining the rearward portion of the conduit comprises a fixing arrangement 34 for connecting a free end 36 of the coupling 14 to the wand 8. A rigid curved hose arrangement is held within and extends between the forward and rearward portions of the conduit.

With reference to FIG. 3, two wheels 26 are mounted within recessed portions in the bottom surface of the sole plate 24 for supporting the cleaner head 10 on the floor surface. The wheels 26 are configured to support the sole plate 24 above the floor surface when the cleaner head 10 is located on a hard floor surface, and, when the cleaner head 10 is located on a carpeted floor surface, to sink into the pile of the carpet to enable the bottom surface of the sole plate 24 to engage the fibres of the carpet. The sole plate 24 may be moveable relative to the housing 16, allowing it to ride smoothly over the carpeted floor surface during cleaning.

The internal volume of the main body 12 comprises an agitator chamber 40, which is partially defined by the middle section 20 of the housing 16 and the sole plate 24. The cleaner head 10 further comprises an agitator assembly 42 comprising a generally cylindrical body 44 mounted within the agitator chamber 40 and which is rotatable about its longitudinal axis. The cylindrical body 44 houses an electric motor and a drive mechanism, which connects the agitator assembly 42 to the electric motor for driving the cylindrical body 44 about its longitudinal axis. Such drive arrangements are known, and so will not be explained in further detail. The agitator assembly 42 further comprises a plurality of agitators 46 outwardly extending from the outer radial surface of the cylindrical body 44. The agitators 46 may include one or more of a plurality of soft filaments, having tips that can flex relative to the cylindrical body 44 upon contact with the floor surface, stiff bristles or a strip of continuous material, and may be made of carbon fibre or nylon, to name two common material examples. The agitator assembly 42 is arranged so that the agitators 46 protrude through the suction opening 28 with its rotation to sweep dirt and dust particles, together with other debris (hereinafter, "dirt particles"), from both a hard floor surface and a carpeted surface into the agitator chamber 40. In this example, the electric motor and drive mechanism are arranged to rotate the agitator assembly 42 in such a direction that the agitators 46 sweep

over the floor surface rearwardly, from the front section 18 towards the rear section 22 of the housing 16. In this case, a large proportion of the dirt particles that have been energised by the rotation of the agitator assembly 42 is swept towards the rear of the agitator chamber 40.

5 With reference to FIG. 4a and 4b, in addition to the exhaust outlet 32, the rear section 22 of the housing 16 is removable from the main body 12 of the cleaner head 10 and comprises a generally semi-circular cylindrical panel 48, defining a rear section of the agitator chamber 40, together with a plurality of deflection panels, generally designated by 50. The plurality of deflection panels 50 define a dust channel 52 for receiving dirt particles that have been swept by the agitator assembly
10 42 towards the rear of the agitator chamber 40. The dust channel 52 extends between an outlet 54 of the agitator chamber 40, defined by the semi-circular cylindrical panel 48 and the plurality of deflection panels 50, and the exhaust outlet 32, establishing a fluid connection from the suction opening 28 to the exhaust outlet 32, which, in use, is subject to suction forces. The outlet 54 of the agitator chamber 40 horizontally extends substantially across the longitudinal width of the
15 agitator assembly 42

With reference to FIG. 5, in this example of the rear section 22 of the housing 16, the plurality of deflection panels 50 comprises nine discrete deflection panels 57, 58, 59, 60, 61, 62, 63, 64, 66 symmetrically arranged, in an arc-like fashion, about the longitudinal axis 56 of the exhaust outlet
20 32 (hereinafter, "the exhaust outlet axis 56") in order to deflect energised dirt particles through the dust channel 52 from the outlet 54 of the agitator chamber 40 to the exhaust outlet 32 through a series of sequential, directional collisions. Upon entering the dust channel 52, the initial energy of the dirt particles is, in the main, too high for the dirt particles to become immediately entrained within the air flow through the dust channel 52. Previously, this problem was addressed by
25 configuring the walls defining a dust channel to retain the dirt particles within the dust channel through a series of haphazard, directionless collisions, until the energy of the dirt particles has dissipated sufficiently, through impacts with the walls, to enable them to become entrained within the air flow through the dust channel. The present invention differs in that the initial energy of the dirt particles is used to direct them through the dust channel 52 towards the exhaust outlet 32
30 using a series of sequential purposeful collisions with the deflection panels 50. This not only improves the pick-up performance of the cleaner head 10, but also provides for a reduced air flow rate through the dust channel 52 and thus a lower energy consumption of the motor-driven fan

unit 6 of the vacuum cleaner 2. Eight of the deflection panels 57, 58, 59, 60, 61, 62, 63, 64 define a peripheral surface of the rear section 22 of the housing 16 (although only four of the deflection panels 58, 60, 62, 64 can be seen in FIG. 5), while the last of the deflection panel 66, which also cannot be seen in FIG. 5, is located adjacent the semi-circular cylindrical panel 48, within the internal volume of the rear section 22, generally opposite the other eight deflection panels 57, 58, 59, 60, 61, 62, 63, 64. In this example of the rear section 22 of the housing 16, the exhaust outlet 32 is centrally located in a traverse direction, which lends itself to the symmetrical arrangement of the deflection panels 50 about the exhaust outlet axis 56. The skilled reader will recognise, however, that this arrangement is not essential, and that the deflection panels 50 could be arranged about the exhaust outlet axis 56 asymmetrically provided that they still carry out the function of deflecting energised dirt particles from the outlet 54 of the agitator chamber 40 towards the exhaust outlet 32 through a series of sequential collisions within the dust channel 52. Moreover, it will also be recognised that locating the exhaust outlet 32 centrally on the rear section 22 is not an essential requirement of the invention.

FIG. 6a is a cross-sectional view the rear section 22 of the housing 16 through the section designated by A-A in FIG. 5 and includes the agitator assembly 42. Due to the symmetrical arrangement of the deflection panels 50 about the exhaust outlet axis 56, the structure of the rear section 22 of the housing 16 through the deflection panels 57, 58, 66 is similar to that shown in FIG. 6a. The rear section 22 of the housing 16 at this point comprises first, second and third deflection panels respectively defined by deflection panels 63, 64, 66. In the figure, deflection panels 63, 64 are shown in cross-section unlike deflection panel 66, which cannot be shown in cross-section at section A-A because of its orientation within the rear section 22 of the housing 16. A lower edge 72 of the first deflection panel 63 and a lower end 73 of the semi-circular cylindrical panel 48 define lower and upper boundaries of the outlet 54 of the agitator chamber 40 respectively. The lower edge 73 of the semi-circular cylindrical panel 48 defines a plane 75 extending through the cylindrical body 44 of the agitator assembly 42. This arrangement provides sufficient clearance for dirt particles energised by the agitator assembly 42, indicated by arrows 68, to enter the dust channel 52 through the outlet 54 of the agitator chamber 40, thereby avoiding, or at least minimising, inadvertent collisions with the semi-circular cylindrical panel 48, which could see the dirt particles retained within the agitator chamber 40 and eventually returned to the floor surface.

The first deflection panel 63 comprises a first concave surface 74, which is configured, in use, to deflect energised dirt particles from the outlet 54 of the agitator chamber 40 towards the second deflection panel 64. The first concave surface 74 curves, in the vertical direction, rearwardly and upwardly from a lower end 76 of the first deflection panel 63, adjacent the outlet 54 of the agitator chamber 40, to an upper end 78 of the first deflection panel 63, where it terminates above the plane 75 defined by the lower end 73 of the semi-circular cylindrical panel 48. Terminating the first concave surface 74 above the plane 75 defined by the lower edge 73 of the semi-circular cylindrical panel 48 ends makes certain that the large majority, if not all, of the energised dirt particles entering the dust channel 52 through the outlet 54 of the agitator chamber 40 first collide with the first concave surface 74, ensuring their deflection towards the second deflection panel 64. In the example shown, the first concave surface 74 extends from the lower edge 72 of the first deflection panel 63. However, it will be understood by the skilled reader that the first concave surface 74 alternatively may extend from a point near to the lower end 76 of the first deflection panel 63, provided that it maintains its function of deflecting energised dirt particles from the outlet 54 of the agitator chamber 40 towards the second deflection panel 64.

The second deflection panel 64 comprises a second concave surface 80 that is configured, in use, to deflect energised dirt particles deflected from the first concave surface 74 towards the deflection panel 66. The second concave surface 80 curves forwardly from a rear end 82 of the second deflection panel 64, adjacent the upper end 78 of the first deflection panel 63, to a forward end 84 of the second deflection panel 64. In the example shown, the second concave surface 80 extends between the rear and forward ends 82, 84 of the second deflection panel 64, and connects with the first concave surface 74 above the plane 75. This arrangement means that the energised dirt particles colliding with the first concave surface 74 at the upper end 78 of the first deflection panel 63 are deflected towards the second concave surface 80.

The third deflection panel 66 comprises a third concave surface 86, which opposes the second concave surface 80. The third concave surface 86 is configured, in use, to deflect energised dirt particles deflected from the second concave surface 80 towards the exhaust outlet 32 of the cleaner head 10. The third concave surface 86 curves downwardly from an upper end 88 of the third deflection panel 66, adjacent the forward end 84 of the second deflection panel 64, to a lower

end 90 of the third deflection panel 66. In the example shown, the third concave surface 86 extends between the upper and lower ends 88, 90 of the deflection panel 66. The lower end 90 of the third deflection panel 66 ends in the plane 75, providing clearance to the first concave surface 74 for the energised dirt particles entering the dust channel 52 through the outlet 54 of the agitator chamber 40. A straight panel section 92 extends, in the plane 75, between the lower end 90 of the third deflection panel 66 and the lower end 73 of the semi-circular cylindrical panel 48. The straight panel section 92 functions to direct any energising dirt particles colliding thereagainst towards the first concave surface 74, so that they can take on the correct trajectory through the dust channel 52 towards the exhaust outlet 32.

FIG. 6b is a cross-sectional view of the rear section 22 of the housing 16 through the section designated by B-B in FIG. 5. Similar to the arrangement shown in FIG. 6a, the rear section 22 of the housing 16 at this point comprises first, second and third deflection panels defining the dust channel 52. In this instance, the first, second and third deflection panels are respectively defined by deflection panels 61, 62, 66. A lower edge 72 of the first deflection panel 61 and the lower end 73 of the semi-circular cylindrical panel 48 define the lower and upper boundaries of the outlet 54 of the agitator chamber 40 respectively. The lower edge 73 of the semi-circular cylindrical panel 48 terminates in the plane 75.

The first deflection panel 61 comprises a first concave surface 74, which is configured, in use, to deflect energised dirt particles from the outlet 54 of the agitator chamber 40 towards the second deflection panel 62. The first concave surface 74 curves rearwardly and upwardly from a lower end 76 of the first deflection panel 61, adjacent the outlet 54 of the agitator chamber 40, to an upper end 78 of the first deflection panel 61, where it terminates above the plane 75. In the example shown, the first concave surface 74 extends from the lower edge 72 of the first deflection panel 61.

The second deflection panel 62 comprises a second concave surface 80 that is configured, in use, to deflect energised dirt particles deflected from the first concave surface 74 towards the third deflection panel 66. The second concave surface 80 curves forwardly from a rear end 82 of the second deflection panel 62, adjacent the upper end 78 of the first deflection panel 61, to a forward end 84 of the second deflection panel 62. Similar to the example shown in FIG. 6a, the

second concave surface 80 extends between the rear and forward ends 82, 84 of the second deflection panel 62, and connects with the first concave surface 74 above the plane 75.

5 The third deflection panel 66 comprises the third concave surface 86 opposing the second concave surface 80. The third concave surface 86 is configured, in use, to deflect energised dirt particles deflected from the second concave surface 80 towards the exhaust outlet 32 of the cleaner head 10. The third concave surface 86 curves downwardly from the upper end 88 of the third deflection panel 66, adjacent the forward end 84 of the second deflection panel 62, to the lower end 90 of the third deflection panel 66. In the example shown, the third concave surface 10 86 extends between the upper and lower ends 88, 90 of the third deflection panel 66. As with the arrangement shown in FIG. 6a, the lower end 90 of the third deflection panel 66 ends in the plane 75 defined by the lower end 73 of the semi-circular cylindrical panel 48. The straight panel section 92 extends, in the plane 75, between the lower end 90 of the third deflection panel 66 and the lower end 73 of the semi-circular cylindrical panel 48, and functions to direct any energising dirt 15 particles colliding thereagainst towards the first concave surface 74.

Again, because of the symmetrical arrangement of the deflection panels 50 about the exhaust outlet axis 56, the structure of the rear section 22 of the housing 16 through the deflection panels 59, 60, 66 is similar to that shown in FIG. 6b.

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FIG. 6c is a cross-sectional view the rear section 22 of the housing 16 along the exhaust outlet axis 56; that is, through the section designated by C-C in FIG. 5. Although there are structural differences when compared to the arrangements shown in the previous two figures, the rear section 22 of the housing 16 at this point nevertheless comprises first, second and third deflection 25 panels 61, 62, 66, defining the dust channel 52, wherein each deflection panel 61, 62, 66 comprises respective concave surfaces 74, 80, 86. As the exhaust outlet axis 56 sits where deflection panels 59, 60 connect with deflection panels 61, 62 either set of deflection panels 59, 60; 61, 62 may be considered to form the first and second deflection panels in FIG. 6c.

30 The arrangement shown in FIG. 6c functions substantially similar to the arrangements of the rear section 22 of the housing 16 shown in the previous two figures. That is, the first concave surface 74 is configured, in use, to deflect the dirt particles that collide against it towards the second

deflection panel 62. The first concave surface 74 curves rearwardly and upwardly from the lower end 76 of the first deflection panel 61, adjacent the outlet 54 of the agitator chamber 40, to the upper end 78 of the first deflection panel 61, where it terminates at the exhaust outlet 32. The second concave surface 80 is configured, in use, to deflect energised dirt particles deflected from the first concave surface 74 towards the third deflection panel 66. The second concave surface 80 curves forwardly from the rear end 82 of the second deflection panel 62, adjacent the exhaust outlet 32, to the forward end 84 of the second deflection panel 62. The third concave surface 86 opposes the exhaust outlet 32 and is configured, in use, to deflect energised dirt particles deflected from the second concave surface 80 thereto. The third concave surface 86 curves downwardly from the upper end 88 of the third deflection panel 66, adjacent the forward end 84 of the second deflection panel 62, to the lower end 90 of the third deflection panel 66. In the example shown, the third concave surface 86 extends between the upper and lower ends 88, 90 of the third deflection panel 66. The straight panel section 92 extends, in the plane 75, between the lower end 90 of the third deflection panel 66 and the lower end 73 of the semi-circular cylindrical panel 48, and functions to direct any energising dirt particles colliding thereagainst towards the first concave surface 74 or the exhaust outlet 32.

In the three examples described above, the rear section 22 of the housing 16 is configured such that, in the main, the energised dirt particles entering the dust channel 52 from the agitator chamber 40 first collide with the first concave surface 74. This collision directs them to the second concave surface 80, from which they are then deflected to the third concave surface 86. Finally, the collision with the third concave surface 86 directs them to the exhaust outlet 32. This trajectory is achieved by grouping a point on the first concave surface 74 with corresponding points on the second and third concave surfaces 80, 86, such that the majority of energised dirt particles striking a point on the first concave surface 74 will be directed to a corresponding points on the second and third concave surfaces 80, 86. The local curvatures of the first, second and third concave surfaces 74, 80, 86 at their respective points is such that an angle at which a dirt particle strikes the points relative to respective lines perpendicular to the points, equals an angle by which the dirt particle is deflected. This arrangement is analogous with the Law of Reflection, in which the angle of an incident ray equals the angle of the reflected ray.

Turning to FIG. 7, which is a cross-sectional view of the dust channel 52 in the horizontal plane, the first concave surfaces 74 are inclined such that their axially outer edges 94 are positioned ahead of their respective axially inner edges 96 with respect to the exhaust outlet axis 56. Although not shown in this figure, the second concave surfaces 80 of the deflection panels 58, 60, 62, 64 are similarly arranged with their axially outer edge positioned ahead of their axially inner edge with respect to the exhaust outlet axis 56. Similarly, the axially outer edges 98 of the third concave surface 86 are positioned, with respect to the exhaust outlet axis 56, ahead of its central point 99, which is located on the exhaust outlet axis 56. The first and second concave surfaces 74, 80, at each section of the dust channel 52, are inclined so as to diverge from the third concave surface 86 towards the exhaust outlet 32. This divergent arrangement between the first and second concave surfaces 74, 80 and the third concave surface 86 serves to widen sections of the dust channel 52, providing enough room for the energised dirt particles to reach the exhaust outlet 32 with no more than one collision against each of the concave surfaces 74, 80, 86. For example, in the trajectory defined by arrow 97, the energised dirt particle enters the dust channel 52 through the outlet 54 of the agitator chamber 40 in a direction substantially parallel to the exhaust outlet axis 56 and first collides with the first concave surface 74 at point I. The first concave surface 74 directs the energised dirt particle towards the second concave surface 80 and, due to its inclination, introduces an axial component to its trajectory to direct it away from its initial trajectory, axially inwards toward the exhaust outlet axis 56. The energised dirt particle collides with the second concave surface 80 at point II, from where it is directed to the third concave surface 86. The second concave surface 80 is inclined to add an additional axial component to the trajectory of the energised dirt particle further directing it axially inwards toward the exhaust outlet axis 56. The energised dirt particle collides with the third concave surface 86 at point III, which is configured to add yet a further axial component to its trajectory to direct it to the exhaust outlet 32.

As mentioned above, the present invention aims to use the initial energy of the energised dirt particles entering the dust channel 52 through the outlet 54 of the agitator chamber 40 to direct them towards the exhaust outlet 32 using a series of sequential purposeful collisions with the deflection panels 50, while avoiding any haphazard collisions, which, unless the dirt particles are entrained into the air flow through the dust channel 52, could see them inadvertently retained within the dust channel 52 and even returned to the floor surface. The collisions with the deflection

panels 50 dissipate the energy of the dirt particles, such that they are more inclined to become entrained within the air flow in the dust channel 52. Thus, the present invention not only improves the pick-up performance of the cleaner head 10, but also provides for a reduced air flow rate through the dust channel 52, lowering the energy consumption of the motor-driven fan unit 6 of the vacuum cleaner 2.

Many modifications may be made to the above examples without departing from the scope of the present invention as defined in the accompanying claims.

CLAIMS

1. A cleaner head (10) for a vacuum cleaning appliance (2), the cleaner head (10) comprising:

5 a rotatable agitator assembly (42);

a main body (12) defining an agitator chamber (40) within which is supported the agitator assembly (42), the agitator chamber (40) comprising a suction opening (28) through which a portion of the agitator assembly (42) projects to engage a surface to be cleaned and an outlet (54) through which, in use, energised dirt particles leave the agitator chamber (40) to enter a rear section (22) of the main body (12) as the agitator assembly (42) sweeps them rearwardly from the surface, wherein the rear section (22) comprises a plurality of deflection panels (50) defining a dust channel (52) extending between the outlet (54) of the agitator chamber (40) and an exhaust outlet (32) of the cleaner head (10) through which the energised dirt particles are drawn from the dust channel (52), and wherein the plurality of deflection panels (50) comprise respective concave surfaces (74, 80, 86) configured to deflect the energised dirt particles from the outlet (54) of the agitator chamber (40) towards the exhaust outlet (32) through a series of sequential collisions.

2. A cleaner head (10) according to claim 1, wherein the plurality of deflection panels (50) comprises a first deflection panel (63) and wherein the outlet (54) of the agitator chamber (40) is defined by a lower edge (72) of the first deflection panel (63).

3. A cleaner head (10) according to claim 2, wherein the first deflection panel (63) comprises a first concave surface (74) configured, in use, to deflect energised dirt particles from the outlet (54) of the agitator chamber (40) towards a second deflection panel (64) of the plurality of deflection panels (50).

4. A cleaner head (10) according to claim 3, wherein the first concave surface (74) curves rearwardly and upwardly from a lower end (76) of the first deflection panel (63) adjacent the outlet (54) of the agitator chamber (40) to an upper end (78) of the first deflection panel (63).

5. A cleaner head (10) according to any one of claim 3 or 4, wherein the second deflection panel (64) comprises a second concave surface (80) configured, in use, to deflect energised dirt

particles deflected from the first concave surface (74) towards a third deflection panel (66) of the plurality of deflection panels (50).

6. A cleaner head (10) according to claim 5, wherein the second concave surface (80) curves forwardly from a rear end (82) of the second deflection panel (64) adjacent the upper end (78) of the first deflection panel (63) to a forward end (84) of the second deflection panel (64).

7. A cleaner head (10) according to claim 5 or 6, wherein the third deflection panel (66) comprises a third concave surface (86) configured, in use, to deflect energised dirt particles deflected from the second concave surface (80) towards the exhaust outlet (32) of the cleaner head (10).

8. A cleaner head (10) according to claim 7, wherein the third concave surface (86) is configured, in use, to deflect energised dirt particles deflected from the second concave surface (80) towards a focal point located on the longitudinal axis (56) of the exhaust outlet (32).

9. A cleaner head (10) according to claim 7 or 8, wherein the third concave surface (86) curves downwardly from an upper end (88) of the third deflection panel (66) adjacent the forward end (84) of the second concave surface (80) to a lower end (90) of the third deflection panel (66).

10. A cleaner head (10) according to any one of claims 3 to 9, wherein the rear section (22) of the main body (12) further comprises a semi-circular cylindrical panel (48) defining the agitator chamber (40), and wherein a lower end (73) of the semi-circular cylindrical panel (48) defines a plane (75) above which the first concave surface (74) terminates.

11. A cleaner head (10) according to claim 10, wherein the plane (75) extends through the exhaust outlet (32).

12. A cleaner head (10) according to any one of claims 3 to 11, wherein the concave surfaces (74, 80, 86) are angled towards the exhaust outlet (32) such that an axially outer edge (94) of

each concave surface (74, 80, 86) is positioned ahead of its axially inner edge (96) with respect to the longitudinal axis (56) of the exhaust outlet (32).

13. A cleaner head (10) according to any one of claims 7 to 12, wherein the first and second
5 concave surfaces (74, 80) are configured to diverge from the third concave surface (86) towards the exhaust outlet (32).

14. A vacuum cleaning appliance (2) comprising a cleaner head (10) according to any preceding claim.

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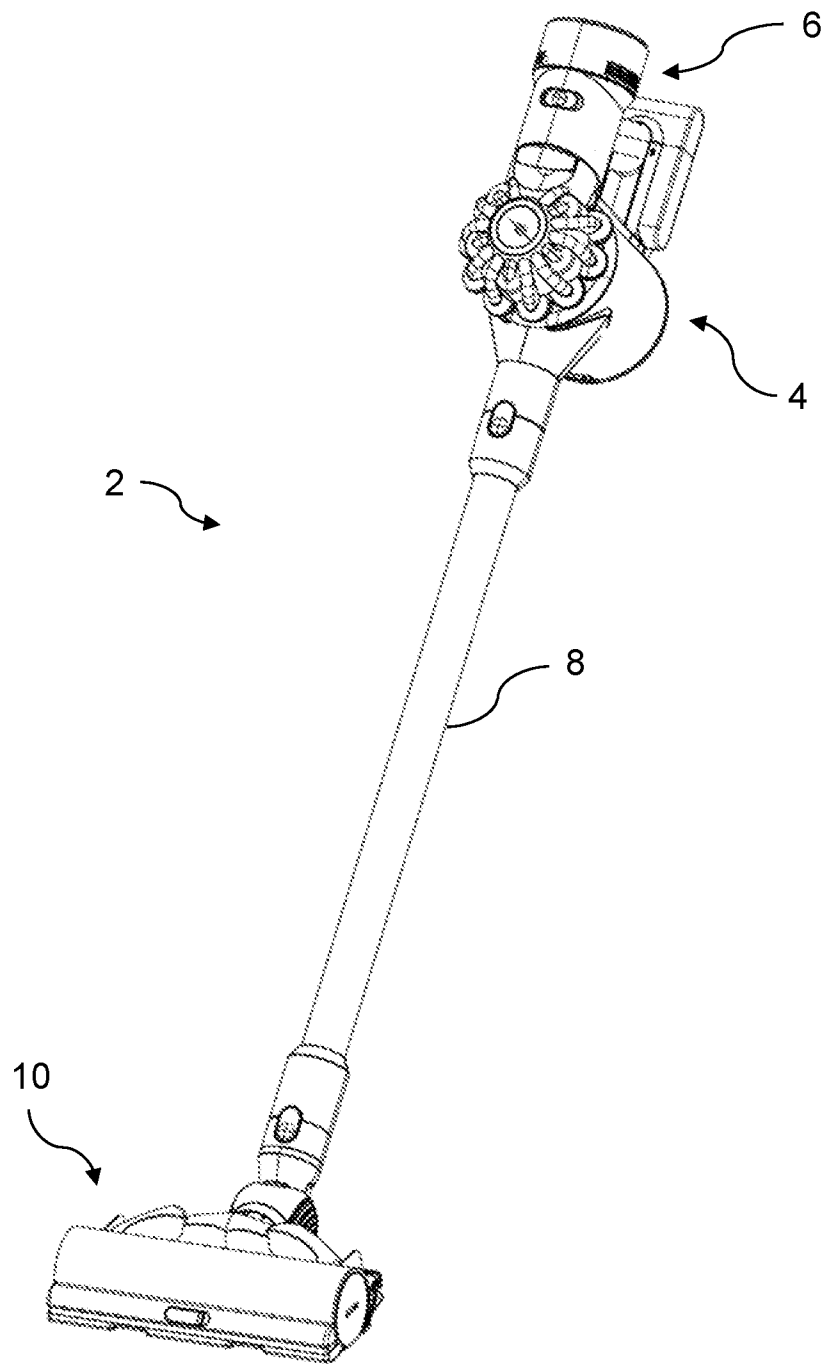


FIG. 1

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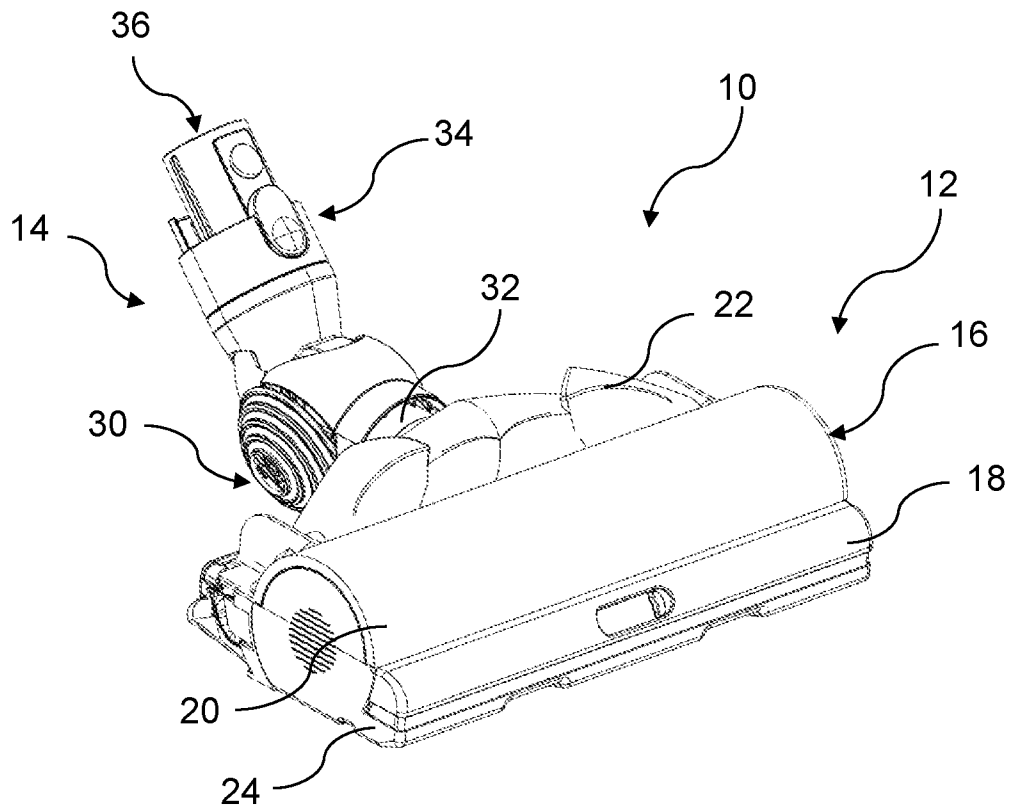


FIG. 2a

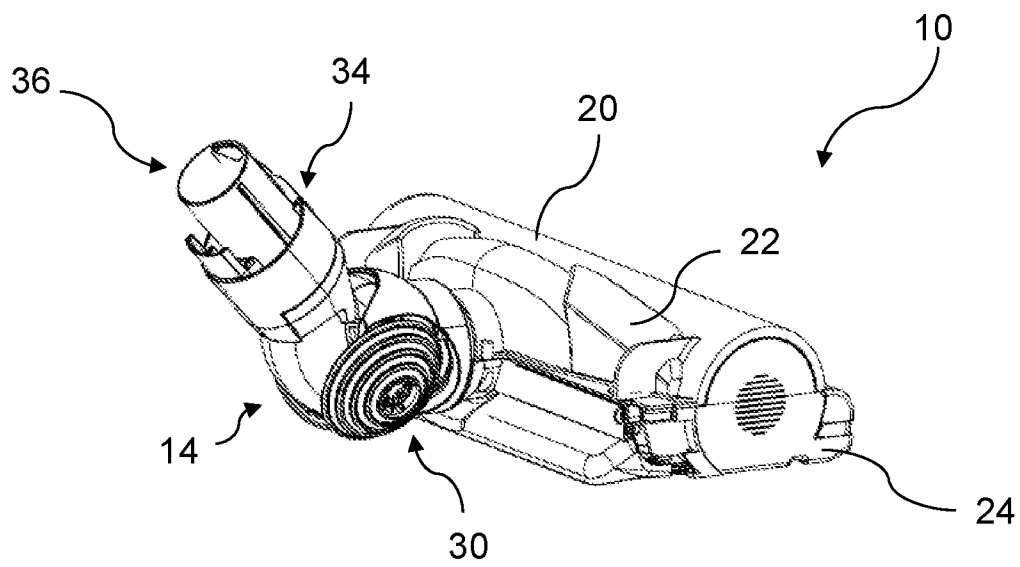


FIG. 2b

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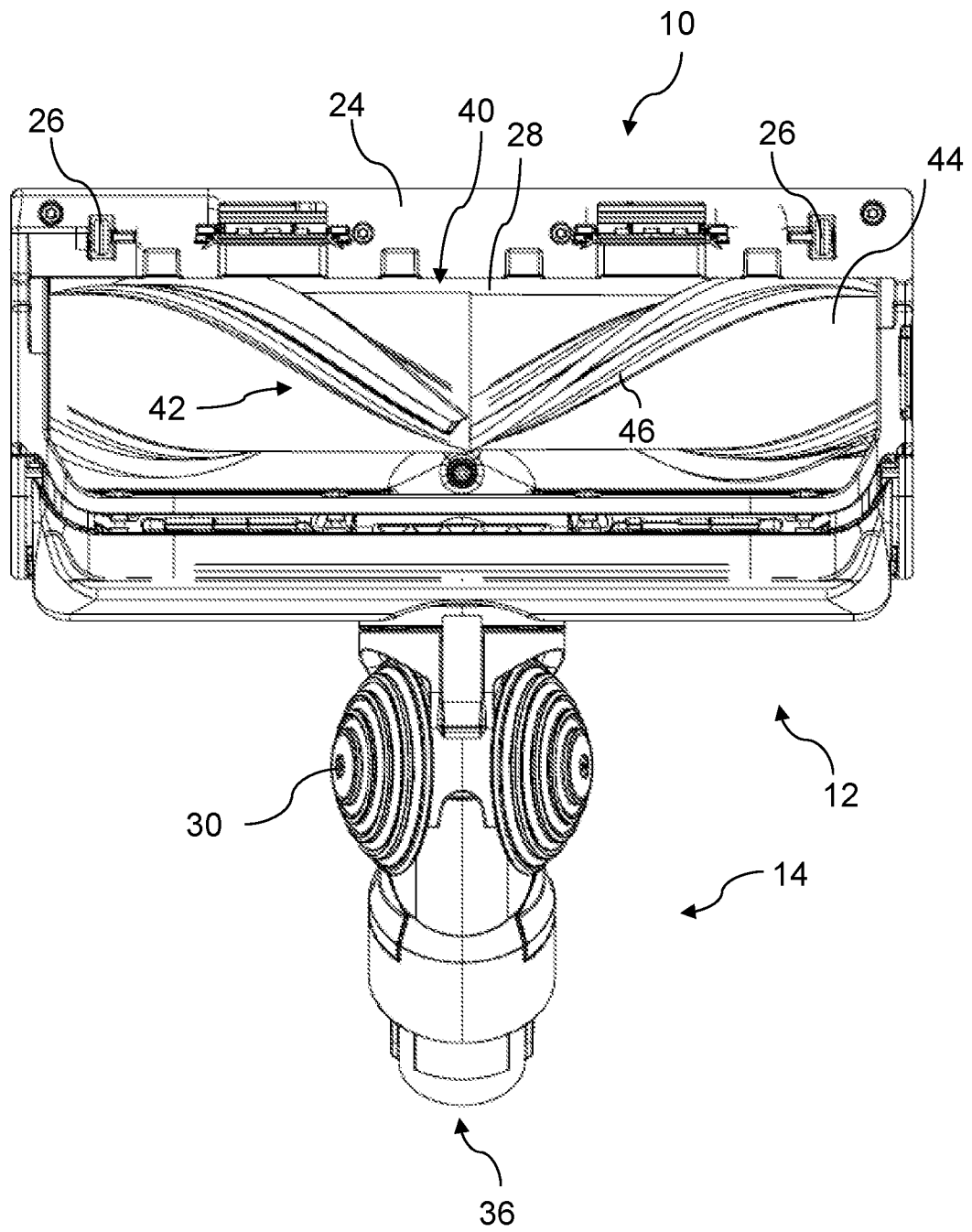


FIG. 3

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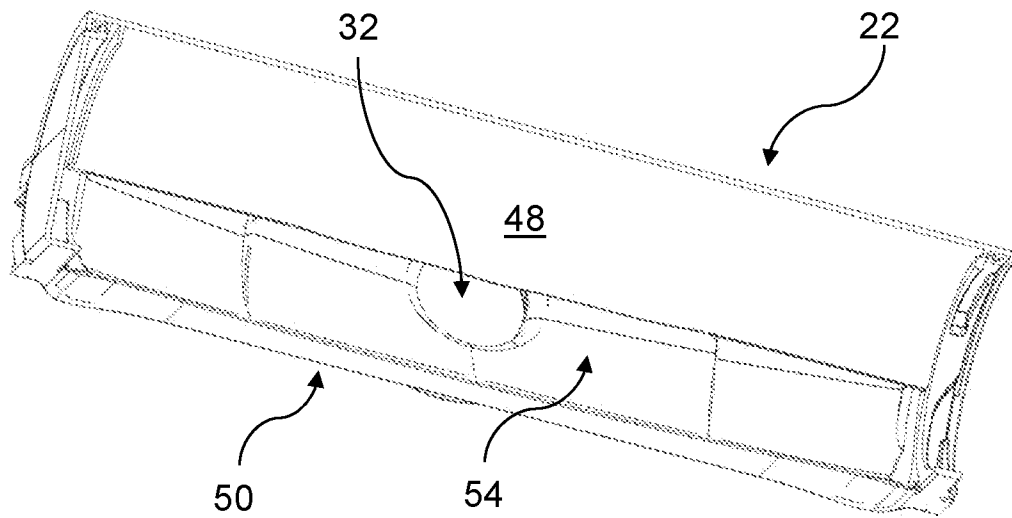


FIG. 4a

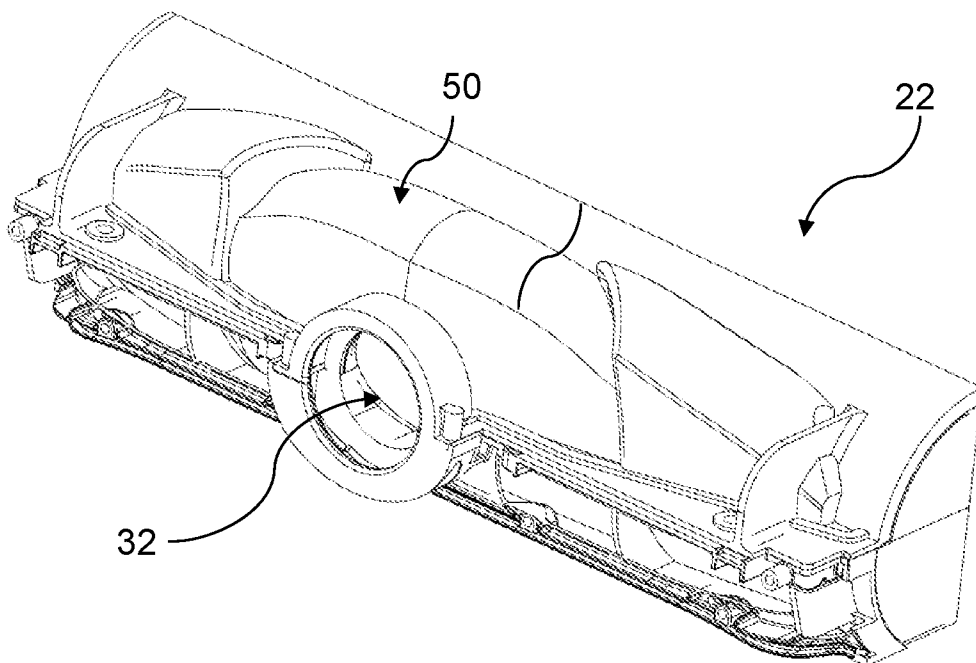


FIG. 4b

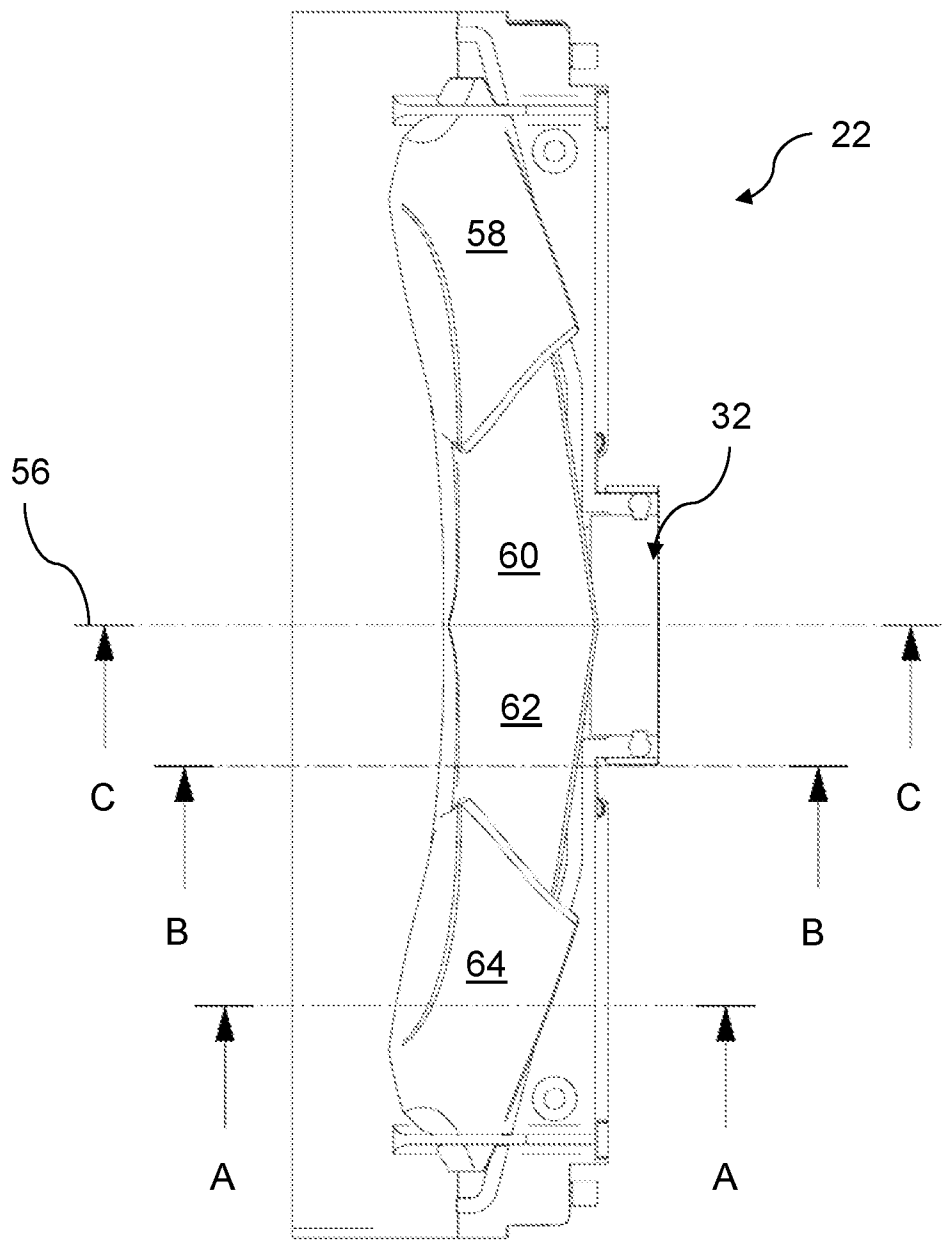
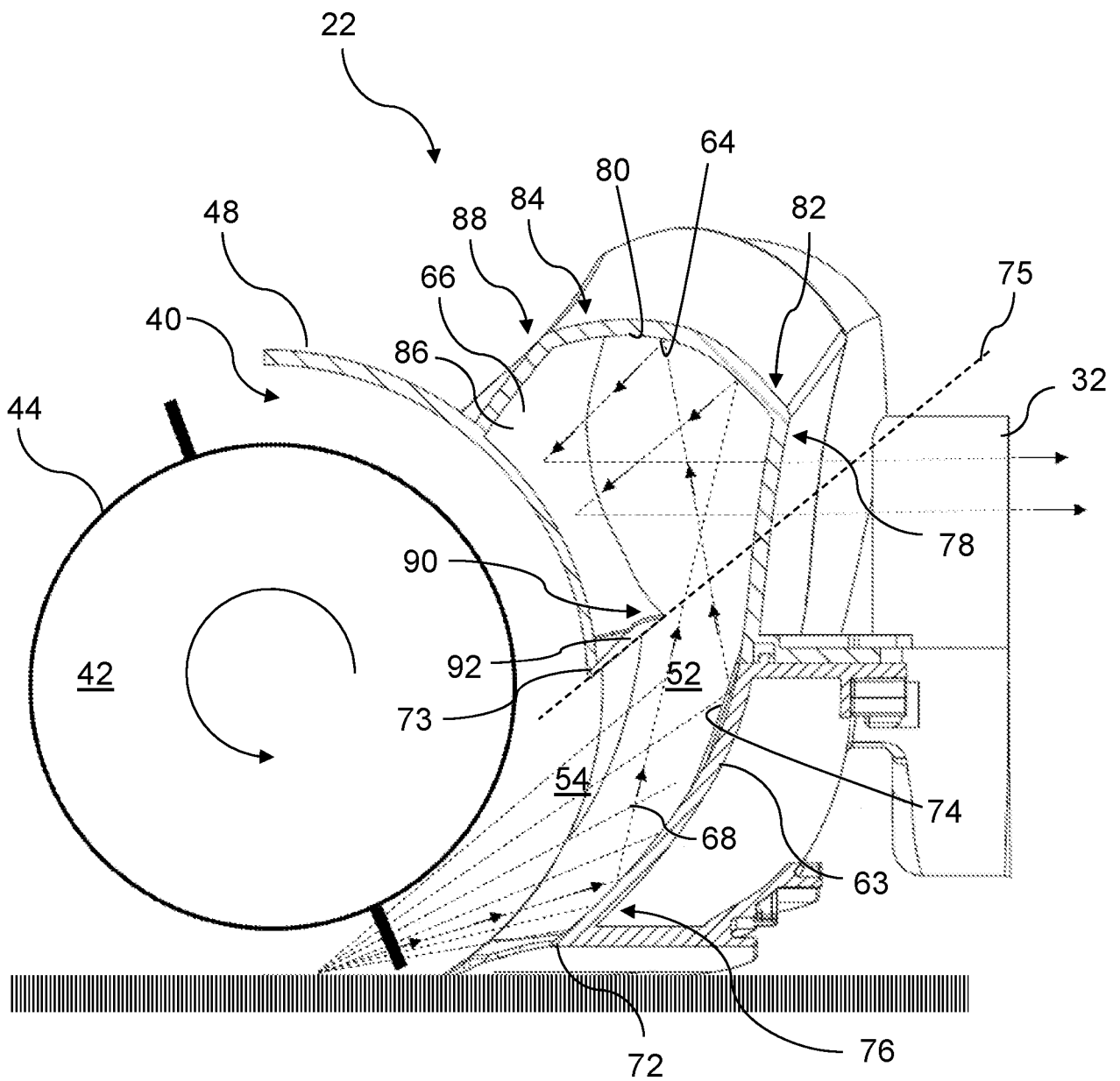


FIG. 5

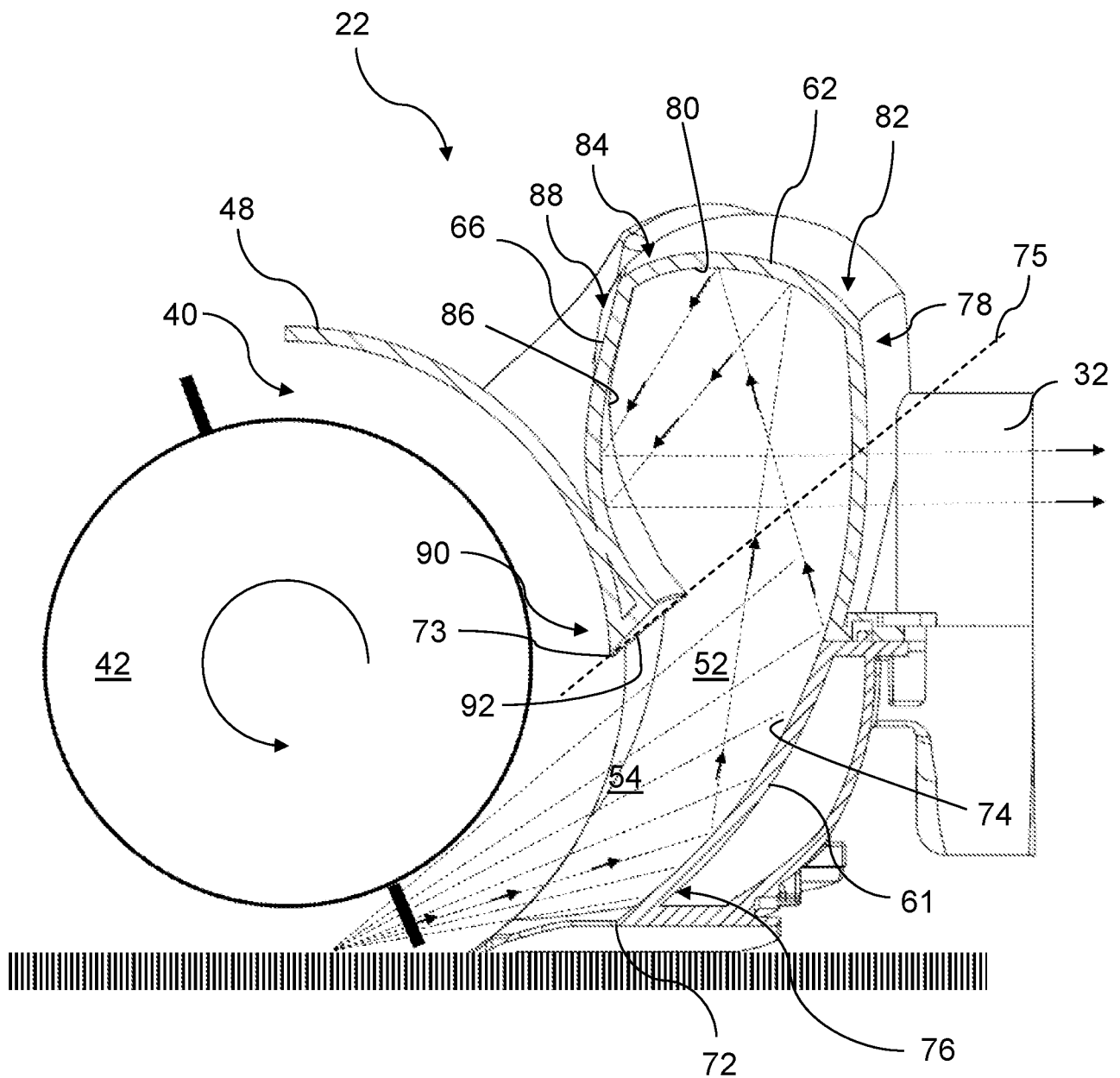
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SECTION A-A

FIG. 6a

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SECTION B-B

FIG. 6b

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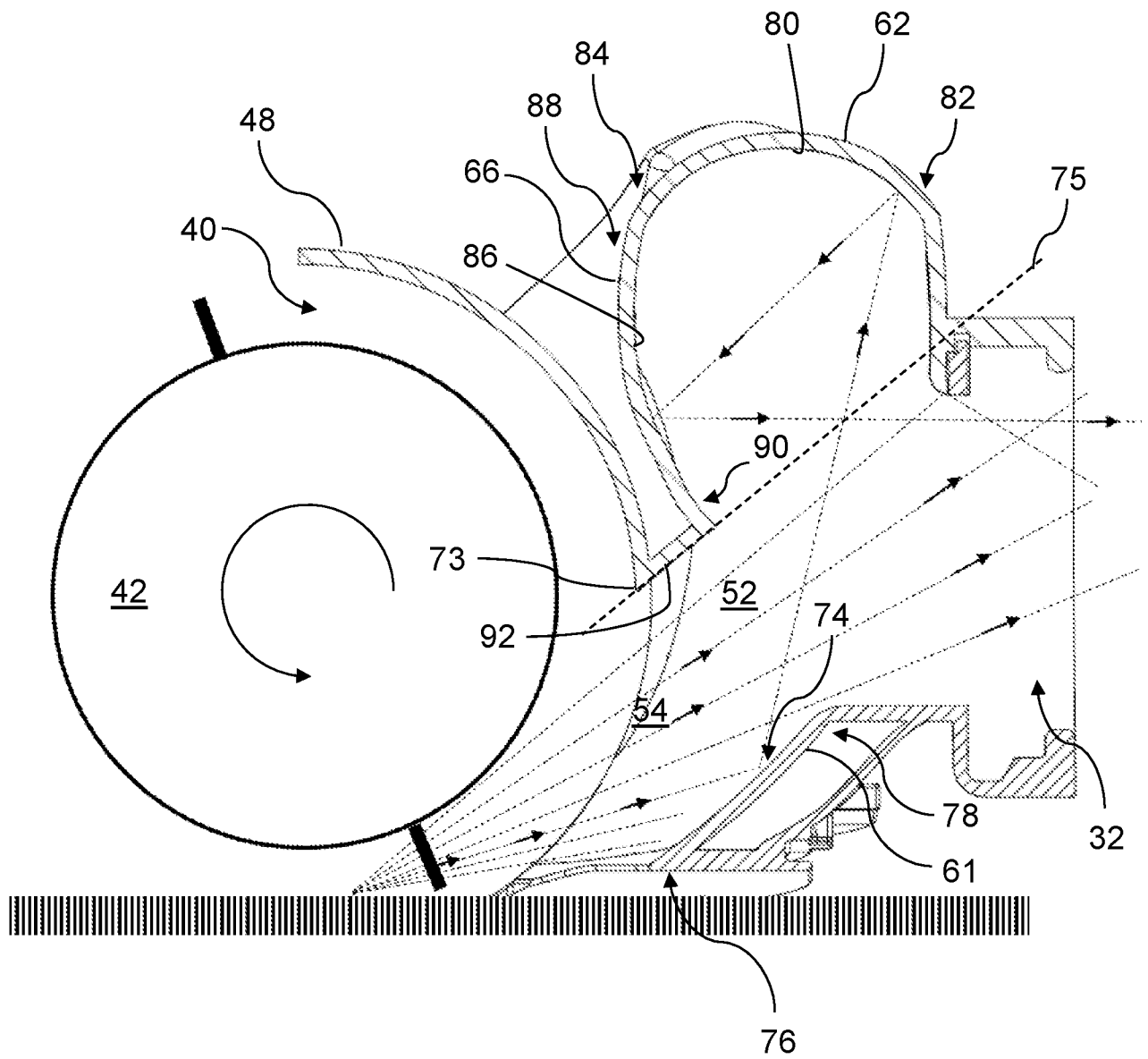


FIG. 6c

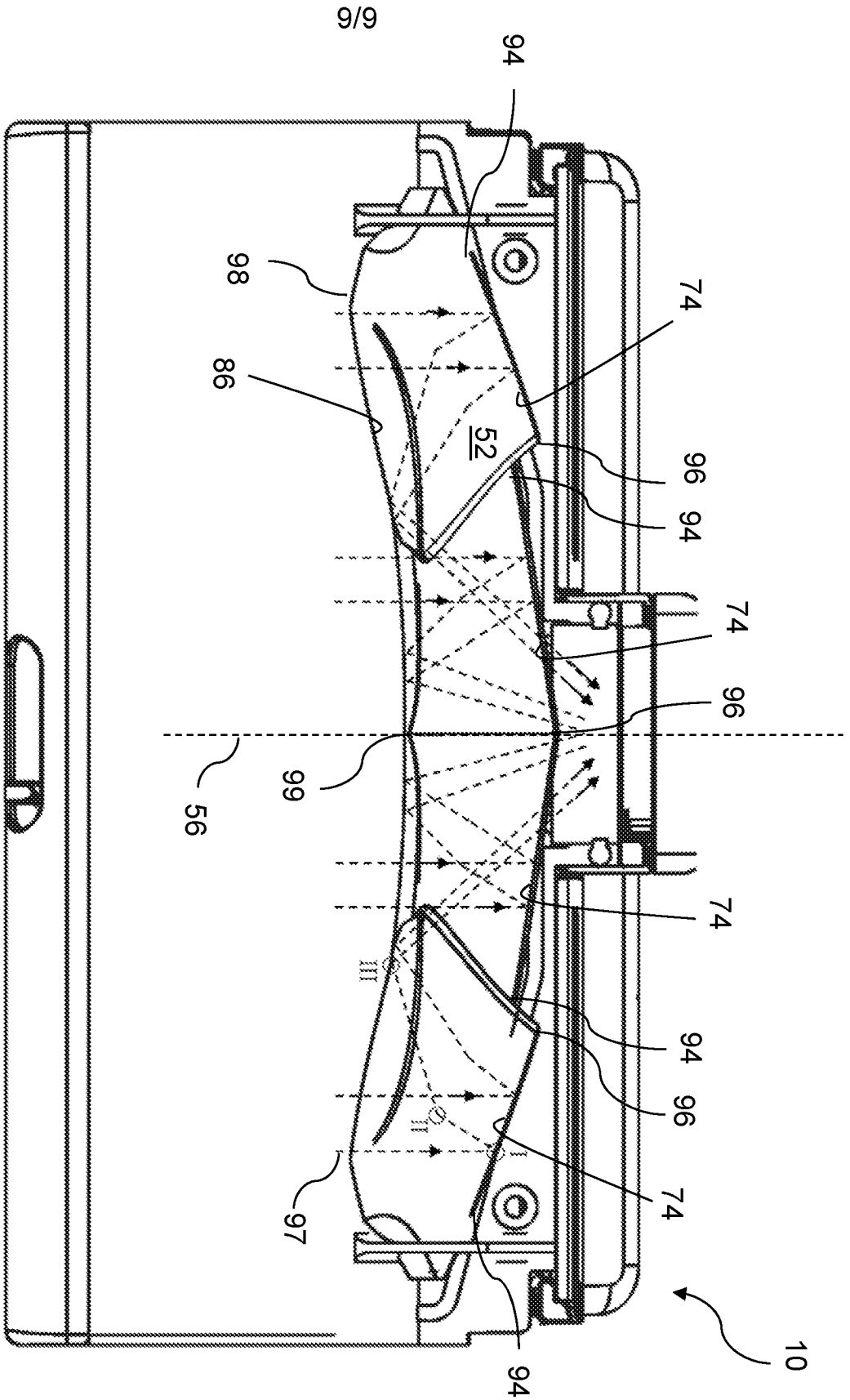


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2020/052299

A. CLASSIFICATION OF SUBJECT MATTER
INV. A47L9/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 592 987 A1 (DYSON TECHNOLOGY LTD [GB]) 22 May 2013 (2013-05-22)	1-9,
A	figures 11a-11f, 12	12-14
	-----	10,11
A	KR 2010 0088354 A (LG ELECTRONICS INC [KR]) 9 August 2010 (2010-08-09)	1-14
	figure 7	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 November 2020

Date of mailing of the international search report

03/12/2020

Name and mailing address of the ISA/

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Authorized officer

Eckenschwiller, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2020/052299

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