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IMPROVED SHROUD AND CLEANING APPARATUS
INCORPORATING AN IMPROVED SHROUD

The present invention relates to an improved shroud for a dual cyclonic cleaning apparatus. In particular, the present invention relates to a shroud which has a perforated section that is parallel with and spaced from the inside surface of the outer cyclone or container and which allows air to pass into a frusto-conically shaped inner cyclone without plugging the inlet openings to the inner cyclone within the apparatus.

Cyclonic vacuum cleaning apparatus are shown in our US Patents Nos. 4,573,236; 4,593,429; 4,571,772; 4,643,748; 4,826,515; 4,853,011 and 4,853,008. Our US Patent No. 4,853,008 describes dual cyclonic cleaning apparatus wherein a combined disc and shroud unit is mounted on the outside of the inner cyclone in order to retain dirt in the outer cyclone. The shroud has a perforated lower section adjacent and above the disc which is parallel to the conical outside surface of the cyclone. The perforated section acts as an air inlet to the inner cyclone while the disc retains large dirt particles and fibrous matter in the outer cyclone. The combined disc and shroud work well; however, there was a

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need for an improved design which would prevent the shroud perforations from being filled with dirt before the outer cyclone was full of separated dirt.

It is therefore an object of the present invention to provide improved cleaning apparatus wherein the shroud is designed to substantially reduce the tendency for dirt particles and fibrous matter to obstruct the shroud openings leading to the inner cyclone air inlet. Further, it is an object of the present invention to provide a combined disc and shroud which is easily mounted on the outside of the inner cyclone. Still further, it is an object of the present invention to provide an improved shroud which is simple and inexpensive to construct and easy to clean and which at the same time prevents escape of fibrous matter from the outer cyclone. These and other objects will become increasingly apparent to those skilled in the art and by reference to the drawings.

The invention provides shroud means for use in cleaning apparatus as set out in claim 1. The invention further provides cleaning apparatus as set out in claim 14. Further advantageous features of the invention are set out in the dependent claims.

It is unexpected that the perforated section could be arranged directly facing the parallel inside wall of the container and have a relatively close spacing of 0.6 inches to 1.4 inches (1.5 cm to 3.6 cm) with respect to



the inside wall and still be so effective in dirt separation. For upright vacuum cleaners as shown in Figures 1 and 2, the preferred diameter of the cylindrical section of the wall of the shroud and the diameter of the inside surface of the container is about 4.3 inches and 6.4 inches (10.9 and 16.3 cm), respectively. For tank type vacuum cleaners as shown in Figure 7, the diameter of the cylindrical section of the wall of the shroud and the diameter of the inside surface of the container is about 8.2 inches and 10.6 inches (20.8 cm and 26.9 cm), respectively.

It was found that as low a pressure drop as possible through the shroud is preferred. This means that a large number of openings, preferably round, should be provided in the perforated section of the shroud.

Embodiments of the invention will now be described with reference to the accompanying drawings, wherein:

Figure 1 is a left side perspective view of a preferred upright type vacuum cleaning appliance according to the present invention, particularly showing an outer cyclone surrounding the combined shroud and disc unit mounted on the outside of an inner cyclone;

Figure 2 is a partial front cross-sectional view along line 2-2 of Figure 1 showing the shroud and disc unit positioned between the inner cyclone and the outer cyclone;

Figure 2A is a partial front cross-sectional view

along a plane perpendicular to line 2-2 of Figure 1 showing the spring catch for removing the outer cyclone and receiver from the inner cyclone;

Figure 2B shows a first alternative version of the shroud and disc unit;

Figure 2C shows a second alternative version of the shroud;

Figure 3 is a plan cross-sectional view along line 3-3 of Figure 2 showing the dirty air inlet passage, the clean air exhaust passage and the intermediate handle mounted on the outside of the outer cyclone;

Figure 4 is a plan cross-sectional view along line 4-4 of Figure 2 showing the tangential air inlet into the inner cyclone;

Figure 5 is a plan cross-sectional view along line 5-5 of Figure 2 showing the perforated opening through the shroud member;

Figure 6 is an exploded perspective view showing the positioning of the inner cyclone inside the shroud and disc unit;

Figure 7 is a front cross-sectional view of preferred tank-type cleaning apparatus of the present invention and particularly showing an outer cyclone, an inner cyclone, a dirt collection receiver, and an inlet scroll and associated shroud for the inner cyclone;

Figure 8 is a plan cross-sectional view along line 7-7 of Figure 7 showing the inlet passage to the outer

cyclone with a spiral member for inlet into the inner cyclone;

Figure 8A is an alternative plan cross-sectional view similar to that shown in Figure 8 showing the inlet scroll having two spiral members rather than one;

Figure 9 is an isometric, exploded view of the inner cyclone, inlet scroll, and the ring with openings; and

Figure 10 is a graph showing area of opening versus pressure drop across a cylindrical section of the shroud and disc unit.

Figs 1 and 2 show an upright-type vacuum cleaning appliance 10 which is adapted for use in both the upright mode and the cylinder mode, the upright mode being illustrated. The functioning of the appliance 10 will now be described with reference to this upright mode. The cleaning appliance 10 includes a cleaning head 11 connected to a casing 12 which supports a motor fan unit (not shown) which is mounted behind conventional floor engaging brushes (not shown) and inside wheels (not shown). Exterior wheels 13 are mounted behind the casing 12.

An outer cyclone or container 15 is mounted on the casing 12. The outer cyclone 15 is preferably made of clear plastic so that a person can see the outer cyclone 15 fill with dirt. The outer cyclone 15 has a circular cross-section along a longitudinal axis a-a and is preferably cylindrical, or else it can be outwardly

tapering if space and dimensions permit. A skirt 16 is mounted on the outer cyclone 15 and extends to the casing 12. The outer cyclone 15 has a bottom wall formed by the frusto-conical section 40d of a receiver 40 that tapers downwardly and outwardly from the axis a-a, and a cylindrical inner surface 15a (Figure 3) which extends from the bottom wall 40d of the receiver 40. Supported on the outer cyclone 15 is a circular cross-sectioned airflow directing head 18 which is sealed to the upper edge of the outer cyclone 15 by means of a flexible inverted L-shaped seal 19 and an annular lip member 15c of the outer cyclone 15 (Figure 2). Positioned radially inwardly of the outer cyclone 15 and head 18 is an inner cyclone 20. The outer cyclone 15 and the inner cyclone 20 are preferably relatively long and slender along the longitudinal axis a-a.

The casing 12 is provided with a vertical extension 12a (Figure 3) which forms a rigid socket for slideably receiving the lower end of a tubular pipe or wand 21. The pipe 21 includes a grip 22. When the pipe 21 is fitted in the extension 12a, the hand grip 22 enables the appliance 10 to be used as an upright-type machine. In contrast, when the pipe 21 is slideably removed from the extension 12a, the pipe 21 is then used as a cleaner head at the end of a flexible hose (not shown) thus converting the appliance 10 into a cylinder type

machine. The conversion of the appliance 10 from one mode of operation to the other and vice versa is described more fully in our US Patent No. 4,377,882. Positioned adjacent the outside wall 15b of the outer cyclone 15 and mounting the outside wall 18a of the head 18 on opposed sides of pipe 21 are spaced apart dirty air inlet and clean air exhaust passages 27 and 28, respectively. The lower half of dirty air inlet passage 27 is formed by a rigid tube 29 adjacent the outside wall 15b of the outer cyclone 15, as shown in Figure 1. Tube 29 extends from a dirty air inlet passage (not shown) in casing 12 to a tube 30 mounted on the outside wall 18a of the head 18 which forms the upper half of dirty air inlet passage 27, (Figure 3). Tube 30 communicates through the upper part of the outside wall 18a of the head 18 through an inlet passage 31 so as to effect tangential entry and set up a swirling, cyclonic flow of air in a passage 32 of the head 18 leading to the outer cyclone 15.

As shown in Figure 2, depending from the circular upper plate 18b of head 18 is a conduit 18c which forms a clean air exhaust passage 33 from the inner cyclone 20. Exhaust passage 33 is in communication through head 18 with the upper half of the clean air exhaust passage 28 (Figure 3) which is formed by a tube 34 mounted on the outside wall 18a of the head 18. The lower part of tube 34 leads to a rigid lower exhaust tube (not shown)

which is mounted on the outside wall 15b of the outer cyclone 15. The lower exhaust tube (not shown) forms the lower half of the clean air exhaust outlet (not shown) in the casing 12 which cools the motor fan unit and exhausts at casing vents 12b below the skirt 16 as shown in Figure 1.

The inner cyclone 20 is a frusto-conical body, extending downwardly and tapering inwardly towards the axis a-a, and is connected to an inlet scroll 36. The inner cyclone 20 comprises an inner wall 20a leading to a cone opening 20b and an outer surface 20c of the inner wall 20a. The inlet scroll 36 comprises a horizontal web 37 (Figure 6) which extends from the upper edge 20d of the inner cyclone 20 to the inner surface 18d of the head 18. A sleeve 38 extends through the majority of the length of the inlet scroll 36 from the junction of the upper end surface 20d of the inner cyclone 20 and web 37 to the bottom side of plate 18b. A second horizontal web 39 extends from the upper end 38a of sleeve 38 to the junction where the inside wall 18d of head 18 meets plate 18b. A portion 38b (Figure 4) of sleeve 38 extends, in the form of a spiral, from the junction of the upper end surface 20d of the inner cyclone 20 and the web 37 to the inside wall 18d of the head 18 thereby competing the inlet scroll 36 and providing a tangential entry to the inner cyclone 20 in order to be capable of setting up a swirling cyclonic

flow of air.

The cone opening 20b of the inner cyclone 20 is connected to a dirt collecting receiver 40 for collecting dirt from the inner cyclone 20. The lower end of the outer surface 20c of the inner cyclone 20 engages a circular plate 40a which meets a frusto-conical member 40b that tapers downwardly and outwardly from the axis a-a. The lower edge of frusto-conical member 40b meets the upper edge of a short cylindrical member 40c of the receiver 40. Interposed between the inner cyclone 20 and the plate 40a of receiver 40 is a flexible annular sealing member 41. Depending from the bottom edge of the cylindrical member 40c is the frusto-conical section 40d which forms the bottom wall of the outer cyclone 15 and which extends downwardly and outwardly from the axis a-a to the inner surface 15a of outer cyclone 15 about 1.1 inches (2.7 cm) above the bottom wall 40e of receiver 40. The maximum diameter of the frusto-conical section 40d is preferably at least three times the diameter of the cone opening 20b, as described in US Patent No. 4,826,515.

Figure 2a shows an alternative preferred version of the connection between the cone opening 20b of the inner cyclone 20 and a receiver 140 which is similar to receiver 40. The receiver 140 has a frusto-conical section 140a secured directly to the cone opening 20b



through inverted U-shaped annular seal 141a. The frusto-conical section 140a tapers downwardly and outwardly from the axis b-b to an inner annular ring member 140b. A bottom plate 140c, circular in plan view, extends to and meets a first frusto-conical member 140d which tapers upwardly and outwardly from axis b-b. The upper edge of the first frusto-conical 140d meets a first cylindrical member 140e which extends to and meets a second frusto-conical member 140f. The second frusto-conical member 140f tapers upwardly and outwardly from the axis b-b to a second cylindrical member 140g. The second cylindrical member 140g seals against the inner surface 16a of skirt 16 through annular ring seal 141b. The receiver 140 is completed by annular ring seal 141c which is disposed between the inner annular ring member 140b and the second cylindrical member 140g thereby sealing the outer cyclone 15 from the receiver 140.

A combined shroud and disc unit 50 is mounted on the inner cyclone 20 intermediate the passage 32 leading to inlet scroll 36 and the cone opening 20b as particularly shown in Figure 2. The upper part of the unit 50 is tapered with wall 50a preferably parallel to the outer surface 20c of the inner cyclone 20 and forming passage 52. The wall 50a ends in a flange 50b which limits and encloses the inlet passage 32 to the inner cyclone 20. Cylindrical section 50c depends from the lower end of

wall 50a to an annular web 50d. A plurality of openings 50e (partially shown in Figure 5), located that are in and around the circumference of the cylindrical section 50c, serve as an outlet from the outer cyclone 15 to passage 51 leading to passage 52. Web 50d extends between the cylindrical section 50c and the outer surface 20c of the inner cyclone 20 where it meets conical member 50f leading to a cylindrical section 50g. Depending from the cylindrical section 50g is a disc 50h which can be conically shaped with a large downwardly tapered portion 50i facing the bottom wall 40d of the outer cyclone 15. The disc 50h can have a downward inclination forming an angle of between about $97\frac{1}{2}^{\circ}$ to 110° with the axis a-a or $7\frac{1}{2}^{\circ}$ to 20° with a line perpendicular to the axis a-a (not shown).

Figure 2B shows another version of the combined shroud and disc unit 150 that fits over the outer surface 20c of the inner cyclone 20, inside the head 18 and the outer cyclone 15, similar to the shroud and disc unit 50 shown in Figure 2. The upper part of the unit 150 is formed by a frusto-conical section 150a that tapers upwardly and outwardly from the axis e-e to a flange 150b. A cylindrical section 150c depends from the lower end of the frusto-conical section 150a to an annular web 150d. A plurality of openings 150e, located in and around the circumference of the cylindrical section 150c, serve as an outlet from the outer cyclone

15. Web 150d extends between the cylindrical member 150c toward the axis e-e and contacts the outer surface 20c of the inner cyclone 20. Web 150d meets a conical member 150f that together with web 150d forms a seal between the inner cyclone 20 and the lower end of the combined shroud and disc unit 150. Extending from the junction of the cylindrical member 150c and the web 150d is a disc 150h which can be conically shaped with a large downward inclination forming an angle of between about $97\frac{1}{2}^{\circ}$ to 110° with the axis e-e or $7\frac{1}{2}^{\circ}$ to 20° with a line perpendicular to the axis e-e. The disc 150h can also be perpendicular to the axis e-e (not shown).

Figure 2C shows still another version of the shroud unit 250 that fits over the outer surface 20c of the inner cyclone 20, inside of head 18 and the outer cyclone 15, similar to the shroud and disc unit 50 shown in Figure 2. The upper part of the unit 250 is formed by a frusto-conical section 250a that tapers upwardly and outwardly from the axis f-f to a flange 250b. A cylindrical section 250c depends from the lower end of the frusto-conical section 250a to an annular web 250d. A plurality of openings 250e located in and around the circumference of the section 250c, serve as an outlet from the outer cyclone 15. Web 250d extends between the cylindrical section 250c toward the axis f-f where it contacts the outer surface 20c of the inner cyclone 20

similar to web 150d of the shroud and disc unit shown in Figure 2B. Web 250d meets a conical member 250f that, together with web 250d, forms a seal between the inner cyclone 20 and the lower end of the combined shroud and disc unit 250. The shroud unit 250 does not have a disc to help to keep large dirt particles and fibrous matter in the outer cyclone 15 as is characteristic of the shroud and disc unit 50 in Figure 2 and the shroud and disc unit 150 in Figure 2B.

In operation of the preferred version of the upright-type vacuum cleaning apparatus 10 as shown in Figure 2, the fan unit in casing 12 pulls air into dirty air inlet passage 27 through tubes 29 and 30 and into inlet passage 31 leading to the outer cyclone 15. The air cyclones down and around the inner surface 15a and bottom wall 40d of outer cyclone 15, over the outside of walls 40c, 40b and 40a of the receiver 40 and up the outer surface 20c of the inner cyclone 20, then over the disc 50h, through openings 50e and up passages 51 and 52 defined by the shroud 50 and the outer surface 20c of the inner cyclone 20. The air then moves into passage 32 before entering the inlet scroll 36 leading to the inner cyclone 20 wherein the air cyclones down the inner wall 20a to the cone opening 20b before moving upward to the exhaust passage 33 formed by conduit 18c. The air finally moves to the clean air exhaust passage 28 defined by tube 34 and a lower exhaust tube (not shown)

adjacent the outside wall 15b of the outer cyclone 15 before being exhausted to the atmosphere or to the motor fan unit in the casing 12 to assist with cooling. The dirt collects on the bottom wall 40d of the outer cyclone 15 and on the bottom wall 40e of the receiver 40 as shown in Figure 2. Finer dirt collects primarily in the receiver 40.

It was surprising that the openings 50e in the cylindrical section 50c (Figure 2) could be positioned closely adjacent the inner surface 15a of the outer cyclone 15. During testing, it had been thought that the cylindrical section 50c should be as distant as possible from the dirt swirling around the inner surface 15a of the outer cyclone 15. It had been felt that a large distance between the cylindrical section 50c and the inner surface 15a of the outer cyclone 15 would make it less likely that dirt, fluff or fibrous material would become caught up in the airflow exiting the outer cyclone 15 through the openings 50e in cylindrical section 50c. However, with the cylindrical section 50c set as far away as possible from the inner surface 15a of the outer cyclone 15, fluff and fibrous material became trapped on the outer surface 50k of the cylindrical section 50c. Surprisingly, it was found that, by positioning the cylindrical section 50c closely adjacent the inner surface 15a of the outer cyclone, the outer surface 50k of the cylindrical section 50c did not

attract fibrous material and that dirt did not pass directly from the airflow circulating around the inner surface 15a of the outer cyclone 15 to the openings 50e in cylindrical member 50c. In fact, the outer surface 50k of the cylindrical member 50c was apparently being wiped clean by the airflow circulating around the inner surface 15a of the outer cyclone 15. With this construction, the dirt can accumulate to a relatively high level in the outer cyclone 15 (about level L) with good separation of the dirt.

As shown in Figure 2A, the outer cyclone 15 and receiver 40 (not shown) or receiver 140 are removable from the head 18 for emptying by releasing a spring catch 55 housed within the skirt 16. The catch 55 comprises a central spring arm member 55a that attaches at its proximal end 55b to the bottom surface 140h of the bottom plate 140c of the receiver 140 through mounting bracket 140i. The distal end 55c of the spring arm 55a is formed into a first inverted U-shaped member 55d. The spring arm 55a and a proximal leg 55e of the first inverted U-shaped member 55d form a U-shaped junction 55f that secures in a mating locking member 12c mounted on the casing 12. A distal leg 55g of the first inverted U-shaped member 55d acts as a finger grip that protrudes out from underneath the skirt 16 adjacent the casing 12. A second inverted U-shaped guide member 140j is mounted on the bottom surface 140h of the bottom

plate 140c of the receiver 140 spaced apart from mounting bracket 140i and adjacent the apex of the first inverted U-shaped member 55d. The second inverted U-shaped member 140j serves as a guide for an arrow tab 55h extending from the first inverted U-shaped member 55d of the catch 55 which helps to secure the receiver 140 and outer cyclone 15 to the head 18 and the inner cyclone 20 when the vacuum cleaning apparatus 10 is being used.

When the outer cyclone 15 and the receiver 140 become full of accumulated dirt, the operator raises the distal leg 55g of the first inverted U-shaped member 55d which releases the junction 55f of catch 55 from the locking member 12c and the arrow tab 55h from the second inverted U-shaped member 140j. The operator then pulls the outer cyclone 15, receiver 140 and skirt 16 away from the handle 21 (Figure 1) which causes the annular lip member 15c of the outer cyclone 15 to release from the head 18 at the flexible inverted L-shaped seal 19 and the receiver 140 to release from the inner cyclone 20 at the annular seal 141a, thereby exposing the rigid tube, the rigid lower exhaust tube (not shown) and the bottom part of the intermediate pipe 21. The outer cyclone 15 and the receiver 140 can then be emptied and replaced into the vacuum cleaning apparatus 10 by fitting annular lip member 15c of the outer cyclone inside the flexible inverted L-shaped seal 19 and by

fitting annular seal 141a around the cone opening 20b of the inner cyclone 20. The operator then pushes the outer cyclone 15 and receiver 140 towards the pipe 21 until the junction 55f of catch 55 locks into locking member 12c of casing 12 and arrow tab 55h secures into U-shaped member 140j.

Figure 7 shows a tank type vacuum cleaning apparatus 110, which comprises an outer cyclone 111 around an inner cyclone 112, a dirt collection receiver 113 and a motor driven fan unit 114. The inner and outer cyclones 111 and 112 have circular cross-sections with respect to a longitudinal axis c-c. The outer cyclone 111 has a base 111a and a cylindrical inner surface 111b which extends from the outer periphery of the base 111a. A circular cross-sectioned flange 111c extends radially outwardly from the upper end part of the outside wall 111d of the outer cyclone 111 and serves as one-half of a seal for the outer cyclone 111.

A removable cover 115 with hemispherical outer surface 115a fits over the top of the outer cyclone 111. The lower edge of the outer surface 115a of cover 115 has an annular rim 115b with a depending lip 115c which serves as a hand grip for removing the cover 115 from the outer cyclone 111. Extending inwardly from rim 115b toward the axis a-a is a horizontal support web 115d which meets the upper edge of a right-angled cross-sectioned protrusion 115e. An annular gasket 116

is mounted intermediate the protrusion 115e and the rim 115b on web 115d so as to be in contact with the circular cross-sectioned flange 111c. The gasket 116 serves to seal the cover 115 to the outer cyclone 111 while the apparatus 110 is in operation. The lower edge of the protrusion 115e meets the top edge of a frusto-conical section 115f which tapers radially inwardly and downwardly toward the axis c-c. An annular ring member 115g depends from the distal end of the conical section 115f and has openings 115h for bolts 117. Openings 115i are provided on the hemispherical outer surface 115a which serve as an exhaust port for the motor fan unit 114.

A cylindrical dirty air inlet passage 118 communicates through the upper part of the outside wall 111d of the outer cyclone 111. The end part 118a of the dirty air inlet passage 118, remote from the outer cyclone 111, is joined by a flexible tube (not shown) to a cleaner head (not shown) for contacting a dirty surface. Flanged section 118b of inlet passage 118, adjacent the outside wall 111d of the outer cyclone 111, has openings 119 for bolts 120 to secure the inlet passage 118 to the outside wall 111d of the outer cyclone 111. Inlet passage 118 leads to a dirty air inlet passage 121. As long as inlet passage 121 communicates through the upper part of the outside wall 111d of the outer cyclone 111 so as to make a tangential

entry and to set up a swirling, cyclonic flow of air in the outer cyclone 111, the exact position of the inlet passage 121 around the circumference of the outer cyclone 111 is not critical.

A plate 124, circular in plan view, with dependent tube 125 centered around the axis c-c is positioned above the inner cyclone 112. The dependent tube 125 extends downwardly along axis c-c from the plate 124 substantially coaxially with the inner cyclone 112. The motor driven fan unit 114 is located on the plate 124 and is arranged so as to draw air from the inner cyclone 112 through dependent tube 125. Extending from the top side 124a of the plate 124 is annular ring member 124b which is outside and adjacent the depending ring member 115g. Annular ring 124b has openings 126, centered on the axis d-d coinciding with the openings 115h in the depending ring member 115g, which enable bolts 117 to secure the cover 115 to the plate 124.

The inner cyclone 112 has a frusto-conical body extending radially downwardly and inwardly towards the axis c-c and a dependent inlet scroll 127. The inner cyclone 112 comprises a frusto-conical inner surface 112a leading to a cone opening 112b and an outside wall 112c. The inlet scroll 127 comprises the sleeve 123 which depends from the plate 124 to a horizontal annular web 128 (Figures 7 and 8). The web 128 extends between the upper end 112d of the frusto-conical body and the

lower end part of sleeve 123. A second dependent sleeve 129 extends between the cover 124 and the junction of the upper end 112d of the frusto-conical body and the web 128. The second sleeve 129 is located radially inwardly of the tubular sleeve 123 and through the majority of its length sleeve 129 extends from the upper end 112d of the frusto-conical body where the upper end 112d joins the inner periphery of the web 128. As shown in Figure 8, a portion 130 of the second sleeve 129 extends, in the form of a spiral, from the junction of the upper end 112d of the frusto-conical body and the web 128 to the tubular sleeve 123 thereby completing the inlet scroll 127 and providing a tangential entry to the inner cyclone 112 in order to be capable of setting up a swirling cyclonic flow of air.

Figure 8A shows another version of the inlet scroll 127 wherein two diametrically opposed sections 130a and 130b extend from the junction of the upper end 112d of the frusto-conical body and the web 128 to the tubular sleeve 123. In this manner, the inner cyclone 112 is provided with two opposed tangential entry points which are capable of setting up a swirling, cyclonic flow of air. It should be noted that the inlet scroll 127 can be completed by any number of sections 130 spiralling radially outwardly from the sleeve 129 to the tubular sleeve 123 as long as the sections 130 create at least one tangential entry point to the inner cyclone 112.

Depending from the scroll 127 and spaced from the outside wall 112c of the inner cyclone 112 is a shroud 131 which comprises a tubular ring 132 that depends from the junction of the tubular sleeve 123 and the web 128. The ring 132 of shroud 131 is totally perforated with a plurality of openings 133 (partially shown in Figure 9) that serve as an air outlet from the outer cyclone 11 to scroll 127 leading into the inner cyclone 112. The tubular ring 132 lies parallel to and spaced from the inner surface 111b of the outer cyclone 111. The shroud 131 is completed by a web 134 that extends between the lower end portion of ring 132 and the outside wall 112c of the inner cyclone 112, in particular a cylindrical support member 135 that depends from the outside wall 112c of the inner cyclone 112 and which, together with the upper surface 134a of the web 134, forms a right-angled closure from the outer cyclone 111 at an intermediate seal 136.

The dirt collection receiver 113 for the inner cyclone 112 comprises a cylindrical portion 113a which meets the upper edge of a frusto-conical section 113b extending downwardly and outwardly from the axis c-c to the base 111a of outer cyclone 111. Adjacent and radially inwardly of frusto-conical section 113b is an annular ring member 111e of the outer cyclone 111 which extends beyond the upper edge of frusto-conical section 113b adjacent the inside wall 113c of the receiver 113,

thus forming a seal between the receiver 113 and the outer cyclone 111. The cylindrical portion 113a lies intermediate the inner surface 111b of the outer cyclone 111 and the outside wall 112c of the inner cyclone 112 and is below the web 134 of the shroud 131. The receiver 113 is completed by a rubber seal 137 that extends from the top of the cylindrical portion 113a to the outside wall 112c of the inner cyclone 112 adjacent the web 134. In another embodiment (not shown), cylindrical portion 113a can meet and seal against the web 134 of the shroud 131.

The following are parameters for the preferred vacuum cleaner.

1. Number of Holes in Shroud

In the preferred version of the upright-type vacuum cleaning apparatus 10 as shown in Figure 2, and the preferred version of the tank-type vacuum cleaning apparatus 110 as shown in Figure 7, there should be approximately the number and size of openings or holes 50e in the cylindrical section 50c of the shroud and disc unit 50 and openings 133 in the tubular ring 132 of shroud 131 to position the pressure differential through the cylindrical section 50c and the pressure differential through the ring 132 of shroud 131 as far along from the pressure increase rise of the graph (Figure 10) as possible. It was found that, if there was a high differential pressure through the cylindrical

section 50c and through the ring 132 of shroud 131, large dirt particles that collect in the outer cyclones 15 and 111 when the dirt level in the outer cyclones 15 and 111 is below level L are pulled through the openings 50e in cylindrical section 50c and the openings 133 in the tubular ring 132 of shroud 131 where they will then enter the inner cyclones 20 and 112. The high differential pressure probably causes large particles and fluff to attach to and block the openings of 50e in the cylindrical section 50c of the shroud and disc unit 50 and the openings 133 in the tubular ring 132 of shroud 131. This result is undesirable because the large dirt particles will not separate out in the inner cyclones 20 and 112. Instead, the large dirt particles will be drawn through the exhaust passage 33 of the inner cyclone 20 and through the dependent tube 125 exhausting from the inner cyclone 112, where the large dirt particles will then be drawn into the motor fan units 14 and 114. This will damage the motor fan units 14 and 114 and can also result in dirt being expelled into the atmosphere.

The above discussion is also applicable for the pressure between the inside surface 150j and the outside surface 150k of the cylindrical section 150c (Figure 2B) and for the pressure between the inside surface 250j and the outside surface 250k of the cylindrical section 250c (Figure 2C).

The circumference of the cylindrical section 50c of shroud and disc unit 50 in Figure 2 was 13.6 inches (34.5 cm), the diameter was 4.3 inches (10.9 cm), and the height was 2.6 inches (6.6 cm). Where there were approximately 58 holes per row, a combination lying in the range of 32 to 38 rows of holes of 2.2 mm diameter was found to be best for the cylindrical section 50c of the shroud and disc unit 50 of the cleaning apparatus 10 shown in Figures 1 and 2. Also, the circumference of the ring 132 of the shroud 131 of the tank type vacuum cleaning apparatus 110 shown in Figure 7 was 15.5 inches (64.8 cm), the diameter was 8.2 inches (20.8 cm), and the height was 2.5 inches (6.4 cm). Where there were approximately 208 holes per row, a combination lying in the range of 34 to 38 rows of holes of 2.2 mm diameter was found to be best for the ring 132 of the shroud 131. A 2.2 mm diameter hole is sufficiently small to block the passage of particles of a greater size than would be successfully separated by the inner cyclone 20 of Figure 2 and the inner cyclone 112 of Figure 7.

It was believed that the greater the total area of holes 50e and 133 the less pressure there would be at each hole. This is beneficial because the cylindrical section 50c and the ring 132 of the shroud 131 would be better at not attracting fluff. Also, a lower pressure at each opening 50e of the upright type vacuum cleaning apparatus 10 and at each opening 133 of the ring 132 of



the shroud 131 of the tank type vacuum cleaning apparatus 110 would make it easier for fine dirt to gather at and maybe block rather than be drawn through the openings 50e and 133, thereby signalling to the operator that it is time to empty the respective vacuum cleaners 10 and 110.

2. Thickness of Material for the Shroud

It was found that better results were obtained when material at least 2 mm thick was used for the shrouds 50 and 131. Material 1 mm thick did not work as well. It was assumed that the thicker material causes a sharper change in direction for the clean air and therefore contributes to a better separation than is achieved by the thinner material.

3. Distance Between the Shroud and the Inner Surface of the Outer Cyclone

For the upright type vacuum cleaner 10 in Figures 1 and 2, the distance range between the cylindrical section 50c of the shroud and disc unit 50 and the inner surface 15a of the outer cyclone 15 is preferably from 0.59 inches to 1.18 inches (1.5 cm to 3.0 cm). For the tank type vacuum cleaning apparatus 110 in Figure 7, the distance range between the ring 132 of the shroud 131 and the inner surface 111b of the outer cyclone 111 is preferably from 0.75 inches to 1.26 inches (1.9 cm to 3.2 cm). However, if the distance between the cylindrical section 50c of the shroud and disc unit 50

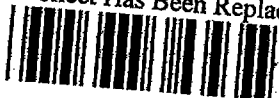
is too close, fluff will bridge between the disc 50b and the inner surface 15a of the outer cyclone 15.

Alternatively, if the distance is too great, fluff attaches to the cylindrical section 50c and blocks the openings 50e. The exact distance is dependent on the diameter of the outer cyclone and the inner cyclone of the respective vacuum cleaning apparatus 10 and 110.

It is intended that the foregoing description be only illustrative of the present invention and that the present invention be limited only to the hereinafter appended claims.

CLAIMS

1. Shroud means (50, 150, 250) for use in cleaning apparatus (10), the cleaning apparatus (10) including: a container (15) having a circular cross-section and comprising a bottom (40d) and a sidewall extending to and meeting the bottom (40d), the sidewall having an interior surface (15a), a dirty air inlet (27) which is oriented for supplying dirt laden air into the container (15) tangentially to the interior surface (15a) of the sidewall, and an air outlet from the container (15); a circular cross-sectioned cyclone (20) having a longitudinal axis and mounted inside the container (15), the cyclone (20) comprising a cyclone air inlet (36) at an upper end of the cyclone (20) in air communication with the air outlet of the container, an interior dirt rotational surface (20a) of frusto-conical shape for receiving an air flow from the air inlet (36) and for maintaining its velocity to a cone opening (20b) smaller in diameter than the diameter of the upper end of the cyclone (20), the air inlet (36) being oriented for supplying air tangentially to the interior dirt rotational surface (20a), an outer surface (20c) of frusto-conical shape, and a cyclone air outlet (33) communicating with the interior of the cyclone (20) adjacent the upper end of the cyclone (20); a dirt collecting receiver (40) extending from the the cone





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opening (20b); and means for generating an airflow which passes sequentially through the dirty air inlet (27), the container (15), the cyclone air inlet (36), the cyclone (20), the dirt receiver (40) and the cyclone air outlet (33), the airflow rotating around the frusto-conical interior surface (20a) of the cyclone (20) and depositing dirt in the receiver (40); the shroud means (50, 150, 250) being mountable on and around the outer surface (20c) of the cyclone (20) and, when in use, having opposed ends spaced in the direction of the longitudinal axis of the cyclone (20) and providing an air passageway from the container (15) to the air inlet (36) of the cyclone (20), one of the ends of the shroud means (50, 150, 250) being sealed against the outer surface (20c) of the cyclone (20), characterised in that a portion of the shroud (50, 150, 250) has a cylindrical perforated section (50c, 150c, 250c) having a large number of perforations (50e, 150e, 250e), the perforated section (50c, 150c, 250c) being spaced from the interior wall (15a) of the sidewall of container (15).

2. Shroud means as claimed in claim 1, wherein the end of the shroud means (50, 150, 250) which is sealed against the outer surface (20c) of the cyclone (20) comprises a web section (50d, 150d, 250d) which abuts directly against the outer surface (20c).

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3. Shroud means as claimed in claim 1 or 2, wherein the perforations (50e, 150e, 250e) through the perforated section (50c, 150c, 250c) are circular and are provided around a circumferential extent of the perforated section (50c, 150c, 250c) of the shroud means (50, 150, 250).

4. Shroud means as claimed in claim 3, wherein the circular perforations have a diameter of 2.2mm.

5. Shroud means as claimed in any one of the preceding claims, wherein, in use, the perforated section (50c, 150c, 250c) of the shroud means (50, 150, 250) is located between 0.59 inches and 1.38 inches (1.5 cm and 3.5 cm) from the inside wall (15a) of the container.

6. Shroud means as claimed in any one of the preceding claims, wherein the shroud means (50, 150, 250) has a flanged section (50b, 150b, 250b) above the cylindrical section (50c, 150c, 250c), the flanged section (50, 150, 250) being locatable around the longitudinal axis at an end of the cyclone (20) adjacent the air inlet (36) and in closely spaced relationship to the outside (20c) of the cyclone (20) so as to provide, in use, a chamber (32) leading to the air inlet (36).

7. Shroud means as claimed in any one of the preceding claims, wherein disc means (50h, 150h, 250h) are provided

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at a lower longitudinal extent of the shroud means (50, 150, 250), the disc means (50h, 150h, 250h) being locatable around the axis of the cyclone (20) with a space between the interior surface (15a) of the sidewall of the container (15) and the disc means (50h, 150h, 250h) for passage of air therebetween, such that, in use, the disc means (50h, 150h, 250h) aid in dirt removal in the container (15) by preventing some of the dirt from flowing to the air inlet (36) of the cyclone (20).

8. Shroud means as claimed in claim 8, wherein the shroud means (50, 150, 250) and the disc means (50h, 150h, 250h) form an integral unit slidable over the outer surface (20c) of the cyclone (20) such that the cone opening (20b) protrudes below and out of the unit.

9. Shroud means as claimed in claim 7 or 8 when dependent on claim 2, wherein a lower section (50f, 150f, 250f) of the shroud means (50, 150, 250) depending from a radius of the web section (50d, 150d, 250d) of the shroud means (50, 150, 250) supports the disc means (50h, 150h, 250h) and is locatable in sealed relationship with the outside wall (20c) of the cyclone (20) so that, in use, the airflow in the container (15) must travel over the disc means (50h, 150h, 250h) and past an outside surface of a lower section of the shroud means (50, 150, 250) before passing

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through the openings (50e, 150e, 250e) in the cylindrical section (50c, 150c, 250c) leading to the air inlet (36) of the cyclone (20).

10. Shroud means as claimed in any one of claims 7 to 9, wherein the disc means (50h, 150h, 250h) are circular in cross-section.

11. Shroud means as claimed in any one of claims 7 to 10, wherein the disc means (50h, 150h, 250h) have a conical shape around the shroud means (50, 150, 250) such that, in use, a larger portion of the conical shape faces towards the bottom (40d) of the container (15).

12. Shroud means as claimed in claim 11, wherein the conical shape, when viewed as a cross-section of the shroud means (50, 150, 250) and disc means (50h, 150h, 250h) through the longitudinal axis, is downwardly inclined at an angle of between $7\frac{1}{2}^{\circ}$ and 20° with respect to a line perpendicular to the longitudinal axis of the cyclone (20).

13. Shroud means as claimed in any one of claims 7 to 12, wherein, in use, the disc means (50h, 150h, 250h) are positioned at about one third of the distance between the cone opening (20b) and the air inlet (36) of the cyclone (20).

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14. Cleaning apparatus (10) including a container (15) having a circular cross-section and comprising a bottom (40d) and a sidewall extending to and meeting the bottom (40d), the sidewall having an interior surface (15a), a dirty air inlet (27) which is oriented for supplying dirt laden air into the container (15) tangentially to the interior surface (15a) of the sidewall and an air outlet from the container (15); a circular cross-sectioned cyclone (20) having a longitudinal axis and mounted inside the container (15), the cyclone comprising a cyclone air inlet at an upper end of the cyclone in air communication with the air outlet of the container, an interior dirt rotational surface (20a) of frusto-conical shape for receiving an airflow from the air inlet (36) and for maintaining its velocity to a cone opening (20b) smaller in diameter than the diameter of the upper end of the cyclone (20), the air inlet (36) being oriented for supplying air tangentially to the interior dirt rotational surface (20a), an outer surface (20c) of frusto-conical shape, and a cyclone air outlet (33) communicating with the interior of the cyclone (20) adjacent the upper end of the cyclone (20); a dirt collecting receiver (40) extending from the cone opening (20b); and means for generating an airflow which passes sequentially through the dirty air inlet (27), the container (15), the cyclone air inlet (36), the cyclone (20), the dirt receiver (40) and the cyclone air outlet

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(33), the airflow rotating around the frusto-conical interior surface (20a) of the cyclone (20) and depositing the dirt in the receiver (40); characterised in that the cleaning apparatus (10) further includes shroud means (50, 150, 250,) according to any one of the preceding claims.

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