Aug. 29, 1939. W. A. VAN BERKEL 2,171,248

VACUUM CLEANING APPARATUS

Filed Jan. 20, 1936 2 Sheets-Sheet 1

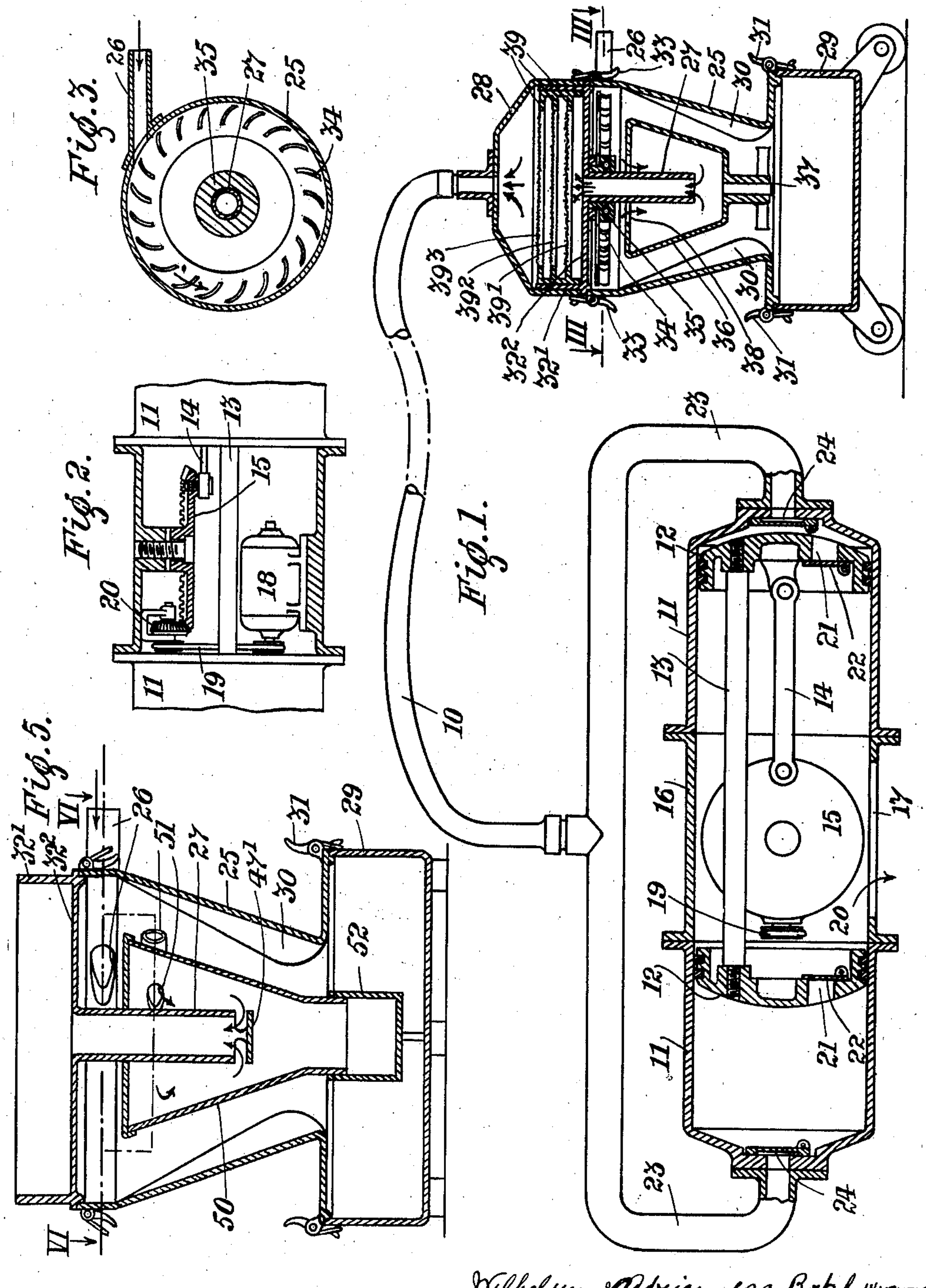

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Fig. 4.

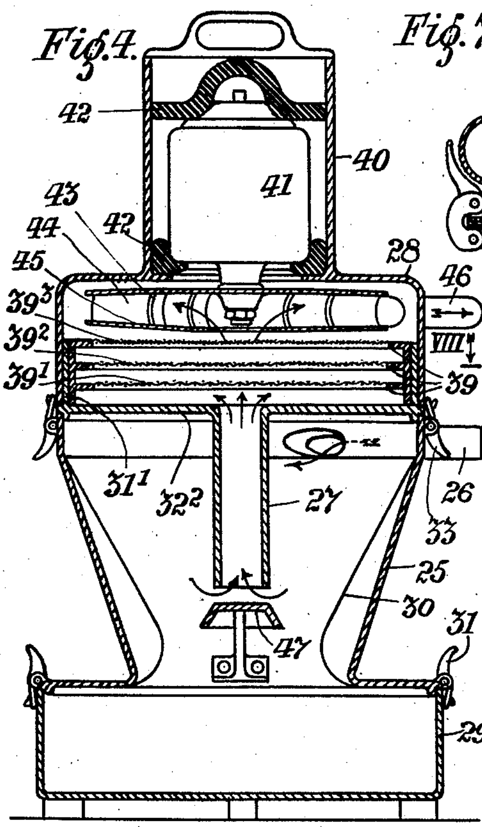


Fig. 7.

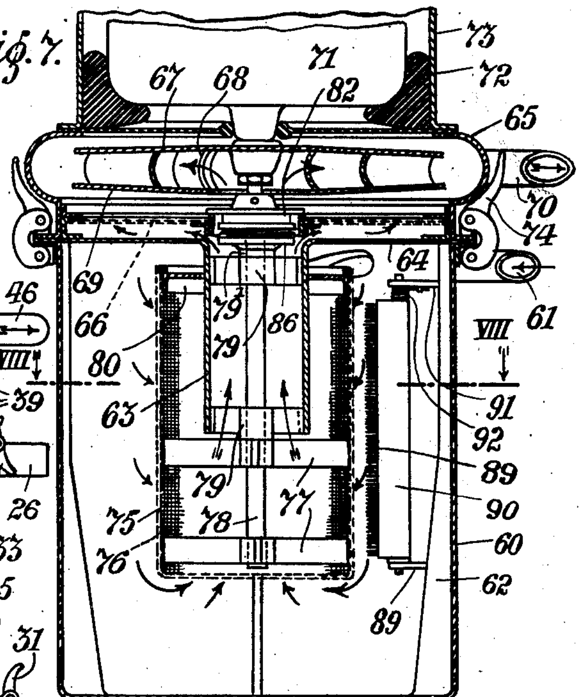


Fig. 8.

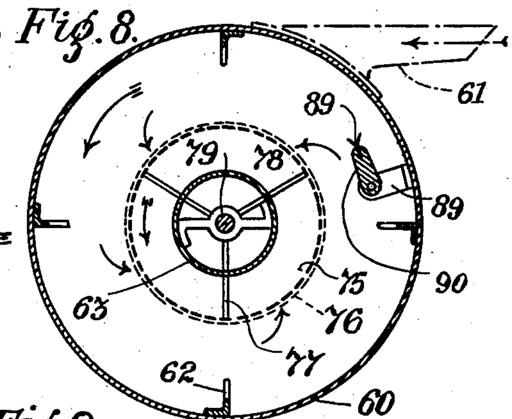


Fig. 6.

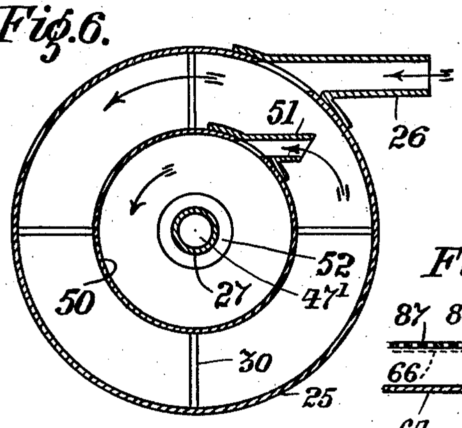
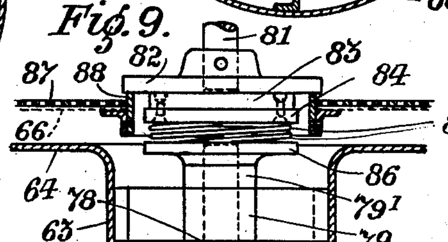


Fig. 9.



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VACUUM CLEANING APPARATUS

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4 Claims. (Cl. 183—83)

This invention relates to vacuum cleaning-apparatus having provision for separating dust from the air drawn through the apparatus.

One object of the invention is to provide in a vacuum cleaning-apparatus a dust-separator consisting of a housing entered by a suction-conduit and adapted to have a cyclone produced within it at a zone between the ends of said conduit by the suction draught, the walls of said housing being spaced from said conduit to provide for the passage of separated dust from said zone to a dust-collector.

Another object is to prevent as far as practicable the passage of dust into the suction end, or mouth of the suction conduit by surrounding the mouth by a hollow member having provision for passage of the air drawn through the apparatus, the arrangement being such that most of the dust entrained by the air in the cyclone is forced towards the wall of the housing, so that only a small proportion of such dust can be drawn into said hollow member. Such a hollow member may be a rotary or a stationary body; or, as an alternative to a hollow member, a stationary masking member such as a plate may be provided closely in front of the conduit mouth.

Another object is to improve the cyclone-separation effect by providing around the suction-conduit a turbine to be acted upon tangentially by the stream of dust-fouled air drawn tangentially into the dust-separator housing.

Another object is to make provision for secondary cyclone-separation, the second cyclone likewise being produced by the suction draught.

Another object is to provide the apparatus with a dust-separator housing which is formed with a wall that converges in the direction from the cyclone-separation zone towards the suction-conduit mouth, beyond which the housing has a dust-collector which may be detachably connected to it. In apparatus having provision for secondary cyclone-separation, an inner casing may be similarly formed and may likewise have its own dust-collector.

Another object is to improve the dust-collection effect by providing the walls of the housing internally with dust-trapping ribs or flanges extending transversely of the cyclone stream.

The construction of the air-discharging suction-generator employed would be determined according to the magnitude of suction required. For example, where a powerful suction action is required, apparatus according to the invention may have a suction-generator comprising a cylinder-and-piston pump unit operated by an electric motor. Where a less powerful suction effect is required, an electric-motor-driven fan may be employed.

The electric motor may have a resilient mounting consisting of rubber blocks or the like shaped to receive the motor ends.

The suction-conduit extending into the dust-separator housing communicates with the suction-generator, and communication preferably takes place through one or more than one removable filter, made for example of cloth or metal gauze and preferably of such a nature that, where there are more than one filter, successive filters are of progressively lower air-passing capacity e. g. of finer mesh).

Where a hollow member is provided to enclose the mouth of the suction conduit, said member may be a rotary filter drum composed mainly of perforated or open-mesh gauze material, preferably lined externally with filtering material. The action of such a rotary drum is to increase the cyclone effect and also to throw off any of the heavier particles which may contact with it. Such a drum may be motor-driven through the intermediary of a detachable slip and/or universal coupling, and a brush may be provided in the interior of the housing to sweep from the drum particles (and these would be mainly lighter particles) accumulating on its exterior. The arrangement may be such that the brush automatically adjusts itself under control of the cyclone action to sweep the drum only when the rotational speed thereof is below a predetermined limit; that is, during starting and stopping.

Different constructional embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 is a sectional elevation of a large-capacity vacuum cleaning-apparatus.

Fig. 2 is a fragmentary sectional plan of a portion of a pump unit constituting the suction-generator of said apparatus.

Fig. 3 is a section on the line III—III of Fig. 1.

Fig. 4 is a sectional elevation of a lower-capacity apparatus.

Fig. 5 is a sectional elevation of a modification of the apparatus according to Fig. 4, the modification involving provision for secondary cyclone-separation.

Fig. 6 is a section on the line VI—VI of Fig. 5.

Fig. 7 is a sectional elevation of another construction of vacuum cleaning-apparatus.

Fig. 8 is a section on the line VIII—VIII of Fig. 7.

Fig. 9 is a fragmentary sectional elevation drawn to a larger scale, of parts already included in Fig. 7.

Referring firstly to Figs. 1 to 3, the apparatus therein shown has a suction-generator which is structurally separate from the dust-separator, being connected thereto by flexible tubing 10.

The suction-generator comprises a two-piston-pump unit, including opposed cylinders 11 in which work two pistons 12 which are spaced apart and rigidly interconnected in tandem by a rod 13. One of the pistons is coupled by a connecting rod 14 to an electric-motor-driven crank-disc 15 which is housed in the space bounded by a casing 16 interconnecting the two cylinders, this space being permanently open to atmosphere through an opening 17. The electric motor 18 is secured to the interior of the casing 16 and drives the disc 15 through the intermediary of a pulley-drive 19 and a bevelled pinion 20 meshing with teeth on the disc. The pistons have air-inlet passages 21, with non-return flap-valves 22; and suction-conduits 23 connecting the cylinder ends to a connection with the aforesaid flexible piping 10 are likewise provided with non-return valves 24.

The dust-separator comprises mainly a housing 25, which is provided with an air-inlet 26 opening tangentially into the top of the housing; a suction-conduit 27 extending axially into the interior of the housing 25; a top-casing 28, to which the piping 10 is attached; and a dust-collector 29, which is formed as a wheeled structure. The necessary cyclone effect is produced around the suction conduit and at the level of the air inlet, but said effect continues with progressively diminishing force below said level and towards that of the mouth of the suction conduit. The housing 25 is constituted by a wall which converges in the direction from the cyclone-separation zone towards the dust-collector 29, said wall being provided internally with dust-trapping ribs 30 which extend transversely of the cyclone stream. These ribs deepen as they approach the dust-collector 29 so that they exercise little or no obstruction to air and dust swirling in the cyclone separation zone but exercise maximum dust-trapping action below said zone. The dust-collector 29 is attached by catches 31 to a flange formed at the bottom of the housing 25. The suction-conduit 27 is provided on top with and opens into a circular casing consisting of a wall 32^1 over which the casing 28 fits and a bottom plate 32^2 which is located in place between the housing 25 and the casing 28. The parts 28, 32^1 and 32^2 constitute a filter-compartment, and these parts are detachably connected to the housing 25 by means of catches 33.

With the object of improving the cyclone-separation effect, a turbine 34 is provided in the zone of separation. The turbine consists of blades mounted on a plate which has a ball-bearing or other anti-friction mounting on the suction-conduit 27, the blades being arranged in the path of air tangentially drawn into the interior of the housing through the inlet 26 (see Fig. 3). The turbine is rotated by the air, and its blades serve to assist separation of dust by striking incoming particles and projecting them tangentially outwards.

To prevent as far as practicable the passage of dust into the mouth of the suction-conduit 27, the mouth is enclosed in a hollow member 36, the bottom of which is supported by a boss 37 carried by spider supports on the housing 25. The member 36 is provided on top with an air-inlet opening 38 surrounding the conduit 27.

Within the filter-compartment, there are mounted a series of superposed frames 39 respectively provided with sheets 39^1 to 39^3 of filter material, which may be made of cloth or of metal gauze. The frames 39 are a neat sliding fit in the circular wall 32^1, so that they can be readily removed once the casing 28 is detached. As conventionally indicated, the further the filter material is from the suction conduit 27, the finer is its mesh; i. e. the lower is its air-passing capacity.

The arrangement is such that in normal use of the apparatus, a stream of dust-fouled air is drawn in through the usual nozzle and pipe (not shown) attached to the inlet 26, acts upon the turbine and becomes whirled in a cyclone or vortex within the housing 25. Hence, the dust is forced centrifugally towards the housing wall and strikes against the ribs 30, so that the dust falls downwards into the dust-collector 29, there being ample space for passage of the falling dust between said wall and the member 36. Air near the axis of the cyclone and therefore substantially freed from dust enters the hollow member 36 through the opening 38 and passes down to the mouth of the suction-conduit 27. The air is drawn up through this conduit and also through the filters 39^{1-3}, whence it passes by way of the tubing 10 to the pump-unit, which discharges the air in comparatively dust-free condition through the opening 17.

Whenever desired, the catches 31 can be disengaged and the housing 25 straightway removed from the dust-collector 29. Likewise, the catches 33 can be disengaged and the casing 28 removed, together with the filter-holding casing 32^1, 32^2 and its suction-tube 27.

The apparatus described with reference to Figs. 1 to 3 is of large capacity, being suitable for, say, hotels, restaurants, hospitals, theatres, etc. The apparatus illustrated in Fig. 4 is of smaller capacity, being suitable for ordinary domestic uses. In this apparatus, the suction generator and the dust-separator are embodied in one structure.

Referring to Fig. 4, the dust-separator housing 25 is again surmounted by a compartment containing filter frames 39 and filtering materials 39^1 to 39^3, but in this construction the casing 28 is surmounted by an additional casing 40 containing an electric motor 41, which has a resilient mounting consisting of annular rubber blocks 42 fitted within the casing 40 and shaped to receive the motor ends. The suction-generator consists of a fan mounted above the filters and within the casing 28, the fan consisting of a plate 43 secured to the motor-shaft, a plurality of small blades 44 secured to said plate, and another plate 45 secured to the blades and provided with an open centre through which air can pass between the plates 43, 45 and be discharged by the blades 44 through a tangentially arranged outlet 46 on the wall of the casing 28. The cyclone is obtained simply by arranging the air inlet 26 tangentially at the top of the housing 25. The suction-conduit 27 extends from its flanged plate 32^2 immediately below the lowermost filter 39^1 to the vicinity of a masking plate 47, which as shown is fixed to the housing 25.

The arrangement is such that dust-fouled air drawn into the apparatus by way of the inlet 26 whirls in a cyclone so that, as in the previous

construction, the dust is forced centrifugally towards the housing wall and falls into the dust-collector 29. The air, partly freed of dust, is drawn into the mouth of the suction-conduit 27, and the masking member 47 acts to prevent dust from being entrained with the air. Such dust as may be entrained by the air passing up the conduit 27 is filtered out by the series of filters 39^1 to 39^3, so that the air finally discharged through the outlet 46 by the fan is in a comparatively dust-free condition.

Fig. 5 shows a modification of the apparatus illustrated in Fig. 4, the modification consisting in the provision of means whereby secondary cyclone-separation is obtained. As shown, the suction-conduit 27 has secured to it a casing 50 (surrounding the mouth of the conduit) and adapted, like the outer housing 25, to have a cyclone produced within it. For this purpose, the inner casing 50 is provided with an air inlet 51 which is tangentially arranged near the top of the casing 50 at a level just below the primary cyclone separation zone within the outer housing 25. The inlets 26 and 51 are arranged distinctly out of alignment with one another so that air entering by the inlet 26 cannot pass direct to the air inlet 51, but must first of all take part in the primary cyclone. The inner casing 50 has a neat sliding connection with an auxiliary dust-collector 52 provided in the main dust-collector 29.

The bottom of the suction-conduit 27 is masked by a plate 47^1 which, as shown, forms part of the conduit itself.

The arrangement is such that air still fouled with dust is drawn from the primary cyclone through the tangential inlet 51, so that a second cyclone is set up within the inner casing 50. Accordingly, further cyclonic separation takes place and the separated dust falls into the auxiliary collector 52.

With reference now to the apparatus illustrated in Figs. 7 to 9, in this construction the dust-separator housing is of cylindrical form, the housing being provided with a tangentially arranged inlet 61 near its top and with vertical dust-trapping ribs 62. The suction-conduit 63 consists of a wide tube depending from a supporting plate 64. The housing 60 is surmounted by a casing 65 which houses a filter and a suction-generating fan. In the construction shown, there is only one sheet of filtering material 66, but if desired provision could be made for additional filters, and the filtering material is readily removable, like the material 39^1, 39^2, 39^3 according to Figs. 1 and 4. The fan consists of a pair of plates 67, 69 with a plurality of small blades 68 mounted between them, the lower plate 69 having an open centre. The casing 65 within which the fan works is provided with a tangentially arranged air outlet 70. The driving motor 71 is supported by annular rubber blocks 72 within a casing 73 which surmounts the compartment 65. Catches 74 serve to attach the interconnected casings 65 and 73, and also the suction-conduit-supporting plate 64 to the housing 60, the arrangement being such that withdrawal of the catches permits immediate separation of the parts mentioned from one another.

There is no separate dust-collector, the dust collecting in the bottom of the housing 60, the dimensions of which are such that an annular passage for falling dust is provided from the cyclone-separator zone at or near the top of the housing to the dust-collection zone at the bottom thereof.

The mouth of the suction-conduit 63 is enclosed in a hollow member, but in this construction the hollow member consists of a rotary drum 75 composed mainly of perforated or open-mesh gauze material, a bag 76 of filtering fabric being drawn over the drum. The drum is supported by spiders 77 which secure it to the lower portion of a shaft 78, this shaft being rotatably mounted in spider-supported bearings 79 in the interior of the suction-conduit 63. The top of the drum 76 consists of an annular closure plate 80 neatly surrounding the suction-conduit 63. The shaft 78 constitutes an extension of the motor-shaft 81, the two shafts being coupled together by a detachable universal slip coupling, consisting of the following parts: a flange 82 secured to the motor-shaft; a facing of rubber or the like on a plate 84; one or more torsion-and-compression springs 85 securing the plate 84 to a flange 86 at the top of the extension shaft 78. The arrangement is such that, when the detachable parts of the apparatus occupy their operative relationship, the facing 83 is pressed into frictional engagement with the flange 82 and accordingly driving power is transmitted from the shaft 81 to the drum 75. The upper bearing 79 would preferably be provided with a thrust-bearing 79^1 to take the weight of the drum and withstand the pressure of the springs 85.

The aforesaid filtering material 66 is supported by a perforated reinforcement plate 87 which also supports a sealing ring 88 serving to close the space between the filtering material and the flange 82. Accordingly, air drawn up the conduit 63 can only pass to the fan through the filtering material 66.

In the operation of the apparatus, the cyclone is set up, as in the previous constructions, mainly at or near the top of the dust-separator housing. Air is drawn through the perforated wall of the rotary drum 75, and most of the dust remaining after cyclone-separation is filtered out by the material 76. The air drawn up the suction-conduit 63 is again filtered by the material 66 before being discharged by the fan through the outlet 70, so that the discharged air is practically dust-free.

The apparatus includes a brush 89 for sweeping from the filtering fabric 76 any particles which accumulate thereon. The brush is supported by a member 90 which is journalled at its ends in bearings 91 fixed to the housing 60. A torsion spring 92 lightly urges the merger 90 to rotate and carry the brush 89 against the drum filter 76. During operation of the apparatus, when the cyclone is in full blast, the brush is blown away from the drum filter 76 in opposition to the spring action. When however the speed of the motor is low (as when stopping or starting) the spring 92 prevails and forces the brush to sweep the filter 76.

I claim:

1. In a vacuum-cleaning-apparatus of the type which is portable and adapted for domestic purposes, a dust separator comprising a housing, an inlet conduit tangentially arranged in said housing, an outlet conduit arranged inside said housing, a multi-blade dust deflector so mounted that it rotates in a plane with said inlet conduit and around said outlet conduit, the deflector throwing the heavier and lagging dust particles to the outer portion of the housing, a conical wall con-

stituting a lower part of said housing, an inner masking element the side of which is substantially parallel to said conical wall to form therewith an annular separation zone of approximately constant radial width, said masking element being arranged to mask said outlet conduit, and said conical wall and masking element limiting the separation zone beneath the deflector, vanes spaced around the inner periphery of the conical wall, the radial dimensions of said vanes increasing with the depth so that the cyclone separation action started in the upper portion of the housing and assisted by the tangential inlet conduit and the deflector is, as it continues into the lower separation zone, gradually diminished by the increasing depth of the vanes and corresponding decrease in the space wherein the air is free to rotate, and a removable collector into which the dust can slide down the gradually increasing channels formed by the vanes.

2. In a vacuum-cleaning-apparatus of the type which is portable and adapted for domestic purposes, a dust separator comprising a housing, an inlet conduit tangentially arranged in said housing, an outlet conduit arranged inside said housing, a conical wall constituting a lower part of said housing, an inner masking element arranged to mask said outlet conduit, and said conical wall and masking element limiting the lower portion of the separation zone, vanes spaced around the inner periphery of the conical wall, the radial dimensions of said vanes increasing with the depth so that the cyclone separation action started in the upper portion of the housing by the tangential inlet conduit is, as it continues into the lower separation zone, gradually diminished by the increasing depth of the vanes and decrease in the space wherein the air is free to rotate, and a removable collector into which the dust can slide down the gradually increasing channels formed by the vanes.

3. In a vacuum-cleaning-apparatus of the type which is portable and adapted for domestic purposes, a dust separator comprising a housing, an inlet conduit tangentially arranged in said housing, an outlet conduit arranged inside said housing, a conical wall constituting a lower part of said housing, an inner masking element the side of which is substantially parallel to said conical wall to form therewith an annular separation zone of approximately constant radial width, said masking element being arranged to mask said outlet conduit, and said conical wall and masking element limiting the lower portion of the separation zone, vanes spaced around the inner periphery of the conical wall, the radial dimensions of said vanes increasing with the depth so that the cyclone separation action started in the upper portion of the housing by the tangential inlet conduit is, as it continues into the lower separation zone, gradually diminished by the increasing depth of the vanes and corresponding decrease in the space wherein the air is free to rotate, and a removable collector into which the dust can slide down the gradually increasing channels formed by the vanes.

4. In a vacuum-cleaning-apparatus of the type which is portable and adapted for domestic purposes, a dust separator comprising a housing constituted by a wall, an inlet conduit tangentially arranged in said housing, an outlet conduit arranged inside said housing, an inner masking element the side of which is substantially parallel to said wall to form therewith an annular separation zone of approximately constant radial width, said masking element being arranged to mask said outlet conduit, and said wall and masking element limiting the lower portion of the separation zone, and vanes spaced around the inner periphery of the wall, the radial dimensions of said vanes increasing with the depth so that the cyclone separation action started in the upper portion of the housing by the tangential inlet conduit is, as it continues into the lower separation zone, gradually diminished by the increasing depth of the vanes and corresponding decrease in the space wherein the air is free to rotate.

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