A floor cleaning apparatus includes a body, a cyclonic dirt collection vessel and a suction generator. The cyclonic dirt collection vessel includes at least one non-concentric cyclone.
BAGLESS NON-CONCENTRIC CYCLONES FOR VACUUM CLEANERS

[0001] This document claims the benefit of U.S. Provisional Patent Application Ser. No. 61/530,107, filed on 1 Sep. 2011, the entire disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] This document relates to the floor care equipment field and, more particularly, to vacuum cleaners incorporating bagless non-concentric cyclones.

BACKGROUND

[0003] Canister and upright vacuum cleaners incorporating a reusable dirt cup and providing cyclonic cleaning action are well known in the art. Such cyclonic vacuum cleaners often include a main or primary cyclone having a cylindrical side wall, a tangentially directed inlet and an axially directed outlet. The axially directed outlet is covered by a shroud that provides for screening of relatively large particles of dirt and debris. The outlet of the primary cyclone is in fluid communication with a secondary cyclone assembly comprising a bank of secondary cyclones for cleaning any remaining relatively fine dirt and debris from the air stream. Examples of such a construction are disclosed in, for example, co-pending U.S. patent application Ser. No. 12/428,880 filed on 23 Apr. 2009, and U.S. Provisional Patent Application Ser. No. 61/411,659 filed on 9 Nov. 2010, the full disclosures of which are incorporated herein by reference.

[0004] As should be appreciated, the bank of secondary cyclones comprises a group of individual, separate cyclones that are provided in parallel. Each secondary cyclone includes a cylindrical sidewall and an axially directed outlet. The axis of each secondary cyclone extends parallel to the axis of the primary cyclone with the secondary cyclones radially arrayed around an extension of the axis of the primary cyclone. While this structural arrangement performs very well it is somewhat bulky and there is a waste of space between the secondary cyclones.

[0005] The present vacuum cleaner addresses this shortcoming by providing non-concentric secondary cyclones that may be more tightly bunched together while still efficiently performing their fine particle separation function. Advantageously, this eliminates wasted space and allows a more compact construction with additional room for other vacuum features and the presentation of a slim and more aesthetically pleasing appearance.

SUMMARY

[0006] A floor cleaning apparatus is provided comprising a body, a cyclonic dirt collection vessel carried on the body and a suction generator carried on the body. The cyclonic dirt collection vessel includes at least one non-concentric cyclone. The at least one non-concentric cyclone includes a tangentially directed dirty air inlet, an axially directed clean air outlet and a dirt particle discharge outlet. A first centerline of the clean air outlet and a second centerline of the dirt particle discharge outlet form an included angle of between about 8 and about 14 degrees. In one particularly useful embodiment the included angle is about 10.9 degrees.

[0007] More specifically describing the apparatus, the at least one non-concentric cyclone includes a first tubular side wall section, a second tubular side wall section and a curved transition side wall section connecting the first and second tubular side wall sections. The first tubular side wall section includes a tangentially directed dirty air inlet and an axially directed clean air outlet. The second tubular side wall section includes a dirt particle discharge outlet.

[0008] In one particularly useful embodiment, multiple non-concentric cyclones are radially arrayed around a central axis. The first tubular sections of the radially arrayed multiple non-concentric cyclones extend parallel to one another while the second tubular sections of the radially arrayed multiple non-concentric cyclones extend toward the central axis.

[0009] In yet another embodiment the cyclonic dirt collection vessel includes a primary cyclone having a primary cyclone chamber with a primary tangentially directed inlet and a primary axially directed outlet. In this embodiment the multiple non-concentric cyclones form a secondary cyclone assembly provided downstream from the primary cyclone where the primary cyclone axially directed outlet is connected to the tangentially directed dirty air inlets of the multiple non-concentric cyclones.

[0010] In the following description there is shown and described preferred embodiments of the apparatus. As it will be realized, the apparatus is capable of still other different embodiments and its several details are capable of modification in various, obvious aspects. Accordingly, the drawings and descriptions will be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings incorporated herein and forming a part of the specification, illustrate several aspects of the present invention and together with the description serve to explain certain principles of the invention. In the drawings:

[0012] FIG. 1 is a front elevational and partially broken away view of a vacuum cleaner;

[0013] FIG. 2 is a rear elevational view of the vacuum cleaner illustrated in FIG. 1;

[0014] FIG. 3 is a detailed longitudinal cross sectional view of the dirt collection assembly or vessel of the vacuum cleaner;

[0015] FIGS. 4a-4c are respective transverse cross sectional views taken along lines A-A, B-B, C-C of FIG. 3; and

[0016] FIGS. 5a and 5b are detailed longitudinal cross sectional views of one of the non concentric cyclones of the dirt collection assembly illustrated in FIGS. 3 and 4a-4c.

[0017] Reference will now be made in detail to the present preferred embodiment of the vacuum cleaner, examples of which are illustrated in the accompanying drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Reference is now made to FIGS. 1 and 2 illustrating the floor care apparatus of the present invention in the form of an upright vacuum cleaner 10. The upright vacuum cleaner 10 has a body 12 comprising a nozzle assembly 14 and a handle assembly 16. As is known in the art, the nozzle assembly 14 and handle assembly 16 are pivotally connected together. Further, the nozzle assembly 14 includes an agitator cavity or a suction inlet 18. A rotary agitator 20 is mounted on the nozzle assembly 14 in the agitator cavity 18. The rotary
agitator 20 may be equipped with bristles, tufts, wipers or other projecting cleaning structures (not shown) in a manner known in the art.

The handle assembly 16 includes a control stalk 22 by which the operator may control the movement of the vacuum cleaner 10 during the cleaning operation. A control switch 24 allows the operator to turn the vacuum cleaner on and off. Wheels 26 and rollers 27 provided on the body 12 allow the vacuum cleaner 10 to be moved smoothly across the floor. Both a suction generator 28, such as a fan and motor assembly, and a dirt collection assembly or vessel 30 are carried on the body 12. In the illustrated embodiment the nozzle assembly 14 includes an internal compartment 32 for receiving the suction generator 28 and the handle assembly 16 includes an opening 34 for receiving and holding the dirt collection assembly 30. Conduits 36, including flexible hoses, connect the suction inlet 18 with the dirt collection assembly 30. Conduits 38, including flexible hoses, connect the dirt collection assembly 30 with the suction generator 28.

During vacuum cleaner operation, the operator manipulates the vacuum cleaner using the control stalk 22. Specifically, the operator pivots the handle assembly 16 relative to the nozzle assembly 14 so that the control stalk 22 moves from the storage position illustrated in FIGS. 1 and 2 to an oblique, operating position. The operator is then able to move the vacuum cleaner 10 smoothly across the floor being cleaned as the handle assembly 16 freely pivots relative to the nozzle assembly 14.

Reference is now made to FIGS. 3, 4a, 4b, 5a and 5b illustrating in detail the dirt collection assembly or vessel 30. The dirt collection assembly 30 includes a primary cyclone 42 having a cylindrical outer wall 44 and a primary cyclone chamber 45. A tangentially directed inlet 46 is provided in the cylindrical outer wall 44. The primary cyclone 42 also includes an axially directed outlet 48 covered by a filter shroud 50 including a plurality of air flow apertures 52. As will be apparent from this description, the shroud 50 functions to screen relatively large or coarse dirt and debris from the air stream as it passes through the vacuum cleaner 10.

The dirt collection assembly 30 also includes a secondary cyclone assembly 54 comprising multiple non-concentric cyclones 56 that are provided in parallel downstream from the primary cyclone 42. Each of the multiple non-concentric cyclones 56 includes a first tubular sidewall section 58, a second tubular sidewall section 60 and a curved transition sidewall section 62 connecting the first and second tubular sidewall sections. In one possible embodiment illustrated in FIG. 5a, the transition section 62 is angled. In another possible embodiment, the transition section is curved and the curve of the wall 63 extends into a second tubular sidewall section 60.

The first tubular sidewall section 58 includes a tangentially directed dirty air inlet 64 and an axially directed clean air outlet 66. Each of the second tubular sidewall sections 60 includes a dirt particle discharge outlet 68 which is provided in communication with and discharges fine particles into a fine particle dirt collection chamber 70 formed by the element 72 so as to be concentrically positioned within the primary cyclone chamber 45.

As best illustrated in FIG. 5a, a first centerline C1 of the clean air outlet 66 of each cyclone 56 and a second centerline C2 of the dirt particle discharge outlet 68 and second tubular sidewall section 60 of each cyclone 56 form an included angle of between about 8 and about 14 degrees and most typically about 10.9 degrees. Further, as best illustrated in FIG. 4a, the first centerlines C1 of the non-concentric cyclones 56 at the axial outlet 66 are all spaced a distance D1 from the central axis CA where D1 is between about 11.0 and about 7.0 centimeters. Typically the distance D1 is about 9.0 centimeters. Further, the second centerlines C2 at the dirt particle discharge outlets 68 of the multiple non-concentric cyclones 56 are all spaced a distance D2 from the central axis CA where D2 < D1 and is typically between about 10.0 and about 6.0 centimeters and most typically about 7.5 centimeters. Advantageously, such a construction and geometry allows the cyclones 56 to be tightly bunched together while still efficiently performing fine particle separation and discharge of fine particles through the element 72 concentrically through the filter shroud 50 into the fine particle dirt collection chamber 70. As a result, the dirt collection assembly 30 may be constructed with a smaller overall diameter. The reduced diameter of the dirt collection assembly 30 eliminates otherwise wasted space between the secondary cyclones and allows additional room for other vacuum cleaner features as well as the presentation of a slim and more aesthetically pleasing appearance.

During operation of the vacuum cleaner 10, the rotary agitator 20 functions to sweep dirt and debris from the nap of an underlying carpet to be cleaned. That dirt and debris is entrained in an air stream being drawn into the suction inlet 18 by the suction generator 28. That air stream entrained with dirt and debris passes serially through the conduits 36 and the tangentially directed dirty air inlet 46 into the primary cyclone chamber 45. There relatively large particles are collected while relatively clean air passes through the air flow apertures 52 of the filter shroud 50 and along the axially directed outlet 48 of the primary cyclone 42 to the tangentially directed dirty air inlets 64 of the cyclones 56 of the secondary cyclone assembly 54. The cyclones 56 function to remove relatively fine dirt particles from the air stream. Those fine dirt particles pass through the dirt particle discharge outlets 68 and drop through the element 72 into the fine particle dirt collection chamber 70. Simultaneously, clean air passes through the axially directed clean air outlets 66 into the manifold 76, which may or may not contain a filter, before being discharged through the outlet 78 and along the conduits 38 to the suction generator 28. The air stream then reenters the motor of the suction generator 28 so as to provide cooling before passing through a final filter (not shown) and the exhaust port 40 back into the environment.

During operation the primary cyclone chamber 45 gradually fills with dirt and debris. As the level of dirt and debris rises toward the filter shroud 50 and tangentially directed inlet 64, it is necessary to empty the dirt collection assembly 30. In order to do this, the dirt collection assembly 30 is removed from the handle assembly 16 and the bottom wall 80 is opened so that dirt and debris drop from both the primary cyclone chamber 45 and fine particle dirt collection chamber 70 into an underlying garbage can. The bottom wall 80 is then closed and the dirt collection assembly 30 is reattached to the handle assembly 16.

The foregoing description of the preferred embodiments of the present invention have been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments were chosen and described to provide the best illustration of the principles
of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally and equitably entitled. The drawings and preferred embodiments do not and are not intended to limit the ordinary meaning of the claims in their fair and broad interpretation in any way.

What is claimed:

1. A floor cleaning apparatus, comprising:
   a body;
   a cyclonic dirt collection vessel carried on said body; and
   a suction generator carried on said body;
   said cyclonic dirt collection vessel including at least one
   non-concentric cyclone.

2. The apparatus of claim 1, wherein said at least one
   non-concentric cyclone includes a tangentially directed dirty
   air inlet, an axially directed clean air outlet and a dirt particle
   discharge outlet, a first centerline of said clean air outlet and
   a second centerline of said dirt particle discharge outlet form-
   ing an included angle of between about 8 and about 14
degrees.

3. The apparatus of claim 1, wherein said at least one
   non-concentric cyclone includes a tangentially directed dirty
   air inlet, an axially directed clean air outlet and a dirt particle
   discharge outlet, a first centerline of said clean air outlet and
   a second centerline of said dirt particle discharge outlet form-
   ing an included angle of about 10.9 degrees.

4. The apparatus of claim 1, wherein said at least one
   non-concentric cyclone includes a first tubular sidewall section,
   a second tubular sidewall section and a curved transition
   sidewall section connecting said first and second tubular side-
   wall sections.

5. The apparatus of claim 4, wherein said first tubular
   sidewall section includes a tangentially directed dirty air inlet
   and an axially directed clean air outlet.

6. The apparatus of claim 5, wherein said second tubular
   sidewall section includes a dirt particle discharge outlet.

7. The apparatus of claim 6, including multiple non-con-
   centric cyclones radially arrayed around a central axis.

8. The apparatus of claim 7, wherein said first tubular
   sections of said radially arrayed multiple non-concentric
   cyclones extend parallel to one another.

9. The apparatus of claim 8, wherein said second tubular
   sections of said radially arrayed multiple non-concentric
   cyclones extend toward said central axis.

10. The apparatus of claim 9, wherein each axially directed
    clean air outlet of each of said multiple non-concentric
    cyclones includes a first centerline and each particle dis-
    charge outlet of each of said multiple non-concentric
    cyclones includes a second centerline.

11. The apparatus of claim 10, wherein said first and sec-
    ond centerlines of each of said multiple non-concentric
    cyclones forms an included angle of between about 8 and
    about 14 degrees.

12. The apparatus of claim 11, wherein said first centerlines
    of said multiple non-concentric cyclones are all spaced a
    distance D1 from said central axis.

13. The apparatus of claim 12, wherein said distance D1 is
    between about 11.0 and about 7.0 centimeters.

14. The apparatus of claim 13, wherein said second cen-
    terlines at said dirt particle discharge outlets of said multiple
    non-concentric cyclones are all spaced a distance D2 from
    said central axis where D2 < D1.

15. The apparatus of claim 14, wherein said distance D2 is
    between about 10.0 and about 6.0 centimeters.

16. The apparatus of claim 7, wherein said cyclonic dirt
    collection vessel includes a primary cyclone having a primary
    cyclone chamber with a primary tangentially directed inlet
    and a primary axially directed outlet.

17. The apparatus of claim 16, wherein said multiple non-
    concentric cyclones form a secondary cyclone assembly pro-
    vided downstream from said primary cyclone where said
    primary axially directed outlet is connected to said tangen-
    tially directed dirty air inlets of said multiple non-concentric
    cyclones.

18. The apparatus of claim 17, wherein said cyclonic dirt
    collection vessel includes a fine particle dirt collection cham-
    ber, said particle discharge outlets of said multiple non-con-
    centric cyclones discharging fine dirt particles into said fine
    particle dirt collection chamber.

19. The apparatus of claim 18, wherein said fine particle
    dirt collection chamber is concentrically positioned within
    said primary cyclone chamber.

20. The apparatus of claim 19, further including a filter
    shroud covering said primary axially directed outlet.