



(22) Date de dépôt/Filing Date: 2001/01/11

(41) Mise à la disp. pub./Open to Public Insp.: 2001/07/14

(30) Priorité/Priority: 2000/01/14 (09/482,907) US

(51) Cl.Int.⁷/Int.Cl.⁷ A47L 9/16

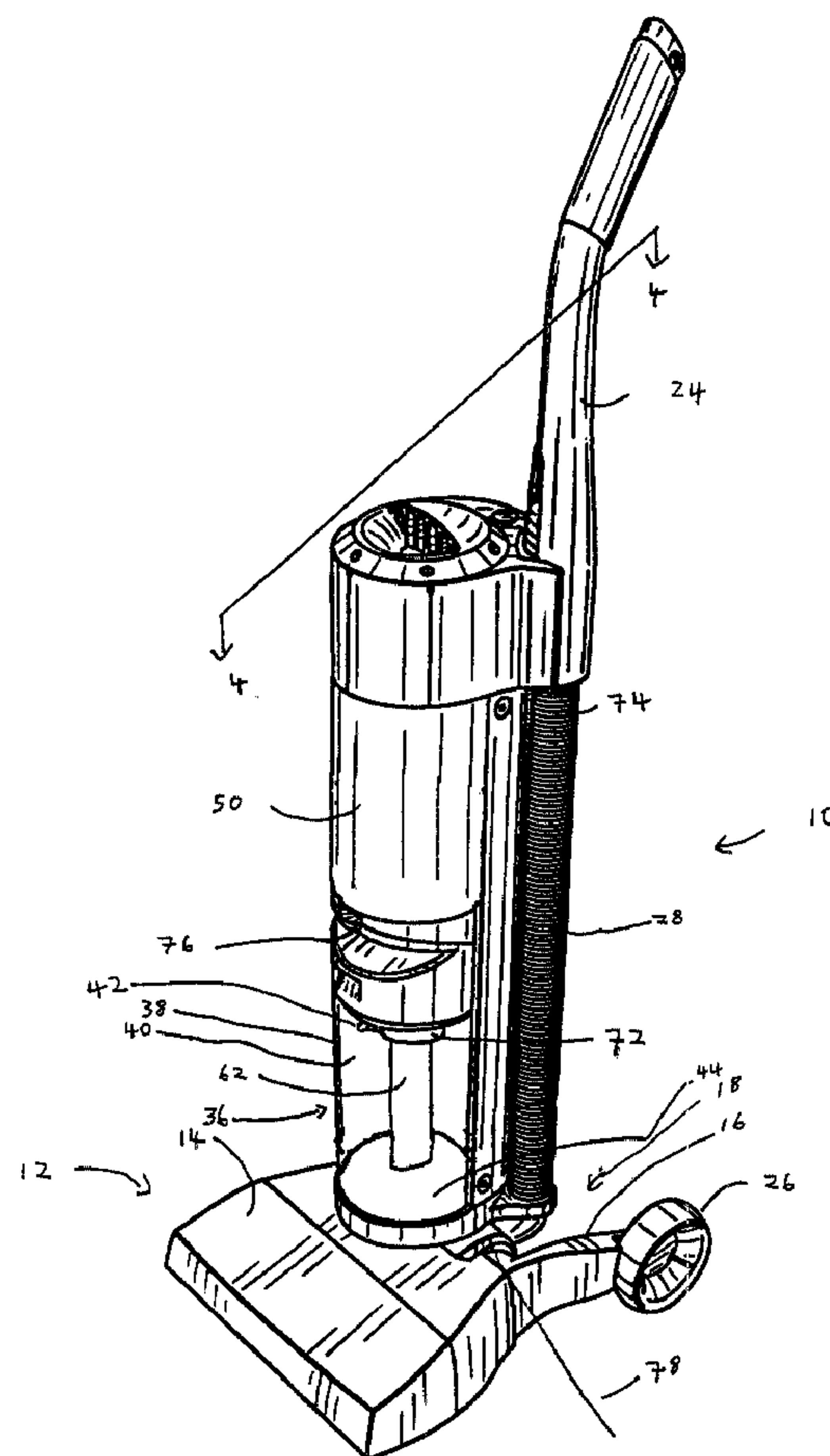
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(54) Titre : ASPIRATEUR

(54) Title: VACUUM CLEANER



(57) Abrégé/Abstract:

A vacuum cleaner comprises a housing having a clean air outlet, a cleaning member having a dirty air inlet, an air flow path extending from the dirty air inlet to the clean air outlet, a primary filtration stage comprising at least one cyclone particle separator

(57) Abrégé(suite)/Abstract(continued):

positioned in the air flow path downstream from the dirty air inlet, the air flow path including the primary filtration stage having an operational back pressure from 2 - to 12 kpa when the air flow path is not blocked, and a motor and fan assembly having an air flow rate sufficient to transport the dirt in an air stream to the primary filtration stage and to cause cyclonic separation in the cyclone particle separator of particulates suspended within the air stream over the normal operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.

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ABSTRACT OF THE DISCLOSURE

A vacuum cleaner comprises a housing having a clean air outlet, a cleaning member having a dirty air inlet, an air flow path extending from the dirty air inlet to the clean air outlet, a primary filtration stage comprising at least one cyclone particle separator positioned in the air flow path downstream from the dirty air inlet, the air flow path including the primary filtration stage having an operational back pressure from 2 - to 12 kpa when the air flow path is not blocked, and a motor and fan assembly having an air flow rate sufficient to transport the dirt in an air stream to the primary filtration stage and to cause cyclonic separation in the cyclone particle separator of particulates suspended within the air stream over the normal operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.

Title: VACUUM CLEANER**FIELD OF THE INVENTION**

5 The present invention relates generally to full size vacuum cleaners. In one particular embodiment, the invention relates to a bagless vacuum cleaner such as those which use cyclonic separation.

BACKGROUND OF THE INVENTION

10 Over the past century, vacuum cleaners have evolved from simple combinations comprising a suction fan as the motive force, a filter bag as the dirt catcher media and a hose and floor nozzle to conduct dirt from the floor or furniture into the filter bag. In early models, the suction fan would draw air from the floor nozzle through a cloth or paper filter bag. The cloth or filter bag had pores or air holes smaller than much of the dirt and debris thereby capturing the dirt and debris within the filter bag while permitting the air which transported the dirt to the filter bag to exit the bag. The main physical characteristic of this type of system is that as cloth or paper filter bag fills with dust, dirt, hair, fibres and other debris, the pressure drop across the filter bag dramatically increases. This is due to the pores becoming blocked or at least partially blocked as the bag is filled. Therefore, the suction fan must be designed to continue to deliver significant air flow as the back pressure against which it operates dramatically increases.

25 A fan can either be optimized in terms of energy efficiency to operate effectively under high flow low back pressure conditions or effectively under high flow high back pressure conditions. The design conditions imposed by the use of filter bag media has caused fans for vacuum cleaners to be optimized to produce high flow conditions under high back pressure conditions.

30 In the 1980's and 1990's, vacuum cleaners using cyclonic cleaning action began to be designed and manufactured. These include vacuum cleaners which use a plurality of cyclones (eg. two or three

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cyclones) as the main filtration means. Others use a single cyclone in combination with other filter media which can become blocked with the passage of dirt there through. Even with vacuum cleaners which utilized solely or primarily cyclonic cleaning action, the fan has been designed to produce a high flow under high back pressure conditions. Thus, the energy required to operate the vacuum cleaner is significant.

Starting in the 1980's, designs were developed for full size upright vacuum cleaners (as opposed to hand held portable vacuum cleaners). Examples of these are United States Patent Nos.

4, 173,809; 5,014,388; 5,020,186; 5,084,934; and 5,115,538. A disadvantage with existing vacuum cleaner designs (both those which use filter bag media as well as cyclonic separators) is that they require large amounts of power as a consequence of the high flow, high back pressure operating characteristics of the vacuum cleaner. Despite the apparent advantages of a cordless vacuum cleaner, to date, the designs for battery operated vacuum cleaners have not provided a product having a sufficient operating life while, at the same time, being of a sufficient weight to be attractive to consumers and also cost competitive.

SUMMARY OF THE INVENTION

Surprisingly, it has been found that full size cyclonic vacuum cleaners do not require a motor and fan assembly that are capable of operating under high back pressure conditions and produce a high seal suction to provide good cleaning efficiency. In particular, a full size upright vacuum cleaner (eg. weighing about 15 to 20 pounds) and having a dirt collection capacity of a standard upright vacuum cleaner and having a continuous operating life of 30 to 45 minutes or more, may be prepared using a cyclonic separation means as the sole or primary filtration stage wherein the motor is preferably positioned downstream from the cyclone and is designed to operate efficiently under high flow, low back pressure conditions.

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According to the instant invention, cyclonic vacuum cleaners employ motors that are designed for use at high air flow rates (preferably 30 - 80 cfm or more) and a low back pressure (preferably 2 - 8 kpa). Such motors may weigh as little as 500 g yet still provide sufficient motive power to produce a high air flow rate (eg. 30 - 50 cfm) through the vacuum cleaner. Despite the weight of the motor and fan assembly, the motor and fan assembly are still sufficiently powerful to also power an air driven turbine which is drivingly connected (eg. by a fan belt) to a rotatably mounted brush in the cleaning head of the vacuum cleaner.

An advantage of the instant invention is that the motor runs substantially cooler (eg. the exhaust air may be at a temperature of about 45°C or less compared with, eg., 65°C). Accordingly, the motor is less likely to overheat.

A further advantage of this motor design is that, due to the lower operating temperature, the overall durability of the vacuum cleaner may be improved. For example, the motor shroud, the motor mount and the air flow path downstream of the motor are typically made from plastic. The long term durability of plastic components is predicated upon the operating temperatures to which they are exposed. Lowering the operating temperature will increase the operating life of these components. Further, by operating at lower temperatures, different plastics may be used for these components and/or these components may be of a thinner wall construction while still maintaining comparable durability.

This invention may be used with upright vacuum cleaners, canister vacuum cleaners, back pack vacuum cleaners or related applications which preferably employ at least one cyclone separator but do not include a traditional porous bag as the filter medium. It will be appreciated that the vacuum cleaner may also use a supplemental filter medium which does not have a large change in back pressure during normal operation (eg. the difference in the back

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pressure between when the supplemental filter member is clean and newly installed and when the supplemental filter member requires cleaning or replacement may vary by about 2 - 4 kpa). Examples of such supplemental filter medium are HEPA filters and electrostatic filters.

In accordance with the instant invention, there is provided a bagless vacuum cleaner comprising a housing having a clean air outlet; a cleaning member having a dirty air inlet; an air flow path extending from the dirty air inlet to the clean air outlet; a primary filtration stage comprising at least one cyclone particle separator positioned in the air flow path downstream from the dirty air inlet, the air flow path including the primary filtration stage having an operational back pressure from 2 - to 12 kpa when the air flow path is not blocked; and, a motor and fan assembly having an air flow rate sufficient to transport the dirt in an air stream to the primary filtration stage and to cause cyclonic separation in the cyclone particle separator of particulates suspended within the air stream over the normal operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.

In one embodiment, the vacuum cleaner further comprises a battery for powering the vacuum cleaner.

The air flow rate is preferably from 30 to 80 cfm and, more preferably, from 40 to 50 cfm. The back pressure is preferably from 2 to 8 kpa.

In another embodiment, the motor and fan assembly is positioned in the air flow path downstream from the cyclone air outlet.

In another embodiment, the motor and fan assembly has a combined efficiency of at least 33% based on the conversion of electrical input to the motor and fan assembly to air watts over the normal operational back pressure of the air flow path.

In another embodiment, the motor and fan assembly has a combined efficiency of at least 50% based on the conversion of

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electrical input to the motor and fan assembly to air watts over a back pressure of the air flow path from 2 to 10 kpa.

5 In accordance with the instant invention, there is also provided a vacuum cleaner comprising a housing having a clean air outlet; a cleaning member having a dirty air inlet; an air flow path extending from the dirty air inlet to the clean air outlet and including a primary filtration stage; and, a motor and fan assembly mounted in the housing and positioned in the air flow path, the motor and fan assembly constructed to provide a high air flow rate and overcome a
10 low back pressure over the normal operational back pressure of the air flow path.

In one embodiment, the primary filtration stage includes a cyclone and the motor and fan assembly have an air flow rate sufficient to entrain dirt entering the dirty air inlet and to cause cyclonic
15 separation in the cyclone particle separator of particulates suspended within the fluid stream over the normal operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.

In accordance with the instant invention, there is also provided a vacuum cleaner comprising dirty air inlet means; clean air
20 outlet means; an air flow path extending from the dirty air inlet means to the clean air outlet means; filtration means comprising cyclonic separation means positioned in the air flow path downstream from the dirty air inlet means, the cyclonic separation means having cyclonic air inlet means and cyclonic air outlet means; and, motor and fan means
25 positioned in the air flow path, the motor and fan means constructed to provide a high air flow rate and overcome a low back pressure over the normal operational back pressure of the air flow path through the filtration means.

30 In one embodiment, the cyclonic separation means has a back pressure from 3 to 6 kpa.

BRIEF DESCRIPTION OF THE DRAWINGS

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For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made by way of example to the accompanying drawings which show an embodiment of the present invention, in which:

5 Figure 1 is a perspective view of an upright cyclonic vacuum cleaner;

 Figure 2 is a front elevational view of the vacuum cleaner of Figure 1;

10 Figure 3 is a side elevational view of the vacuum cleaner of Figure 1; and,

 Figure 4 is a cross-section along line 4 - 4 in Figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

15 While the vacuum cleaner of the instant invention may be of any variety known in the art, the following description is based on a full size upright vacuum cleaner.

20 As shown in the Figures, upright cyclonic vacuum 10 has a floor cleaning head 12 and an upper body portion 30. Upper body portion 30 is preferably pivotally mounted to cleaning head 12 such as by a ball joint so as to pivot rearwardly along axis 78. Accordingly, upper body portion 30 may be positionable in an upright storage position as shown in Figure 1 wherein upper body portion 30 extends generally vertically upwardly from cleaning head 12 when in the above the floor cleaning mode. Upper body portion 30 may be lockingly positioned in this place by a locking means as is known in the art. When the locking means is released, upper body portion 30 may be pivoted rearwardly to the floor cleaning mode.

25 Typically cleaning head 12 is provided at the lower end of upper body portion 30 of vacuum cleaner 10. It will be appreciated that cleaning head 12 and upper body portion 30 may be of any design
30 known in the art.

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As shown in the Figures, cleaning head 12 may comprise a forward portion 14 and two rear portions 16 extending rearwardly from the forward portion 14. Rear portions 16 are spaced apart and define a space 18 there between. Cleaning head 12 has a dirty air inlet 20 which is positioned in forward portion 14 and, preferably, adjacent the front end of forward portion 21 (see Figure 4). Preferably, cleaning head 12 also comprises a transversely extending, floor-contacting rotating brush member 22 which is mounted for rotation in cleaning head 12. Brush member 22 may be powered by an air driven turbine positioned in the air flow stream of by an electrically powered motor. A handle 24 and rear wheels 26 may be provided to facilitate movement of vacuum cleaner 10 for cleaning a floor and the like. Cleaning head 12 may also incorporate a forward set of wheels (not shown) as is known in the art. Preferably, cleaning head 12 includes battery means 80 (eg. one or more individual batteries) for powering fan and motor 32.

If the vacuum cleaner is convertible for above the floor cleaning, handle 24 may be hollow and be connected to a flexible hose 28 for connecting handle 24 in air flow communication with the dirt filtration means in upper body portion 30.

Upper body portion 30 incorporates the filtration means for removing entrained dirt from the dirty air which is introduced into the vacuum cleaner, via, for example, dirty air inlet 20. Upper body portion 30 has motor and fan assembly 32 provided therein to draw the air through vacuum cleaner 10. Preferably, as shown in Figure 4, motor and fan assembly 32 is positioned downstream from the filtration means or at least preferably downstream from the primary filtration means. For example, a secondary filtration means (such as a HEPA filter or an electrostatic filter) may be positioned upstream from motor and fan assembly 32. It will be appreciated that, depending upon the construction of vacuum cleaner 10, the filtration means and

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motor and fan assembly 32 may be placed at any desired locations in the vacuum cleaner.

Motor and fan assembly 32 is constructed to provide a high air flow rate and overcome a low back pressure over the normal operational back pressure of the air flow path, i.e. when the air flow path is not blocked. Motor and fan assembly 32 may have an air flow rate during normal operation of from 30 to 80 cfm, preferably from 30 to 60 cfm and more preferably from 40 to 50 cfm. Such a motor and fan assembly 32 may have overcome a back pressure of from 2 to 12 kpa, preferably from 2 to 10 kpa, more preferably from 2 to 8 kpa and most preferably from 3 to 6 kpa. In a particularly preferred embodiment, the motor and fan assembly produces is selected to overcome a back pressure in the air flow path (including at least the primary filtration means) of 2 to 8 kpa at an air flow rate of 30 to 60 cfm.

The efficiency of a motor and fan assembly includes the efficiency of the motor itself at converting the electrical input to the motor to rotational movement of a shaft to which the fan is attached and the efficiency of the motor at converting the rotation of the fan to movement of the air (i.e. air watts). This combined efficiency of the motor and fan assembly is preferably greater than 33%, more preferably greater than 50% and most preferably greater than 75%.

The filtration means of the vacuum cleaner uses members that have a substantially fixed open passage there through when the vacuum cleaner is in use. Thus, as dirt is removed from the air stream passing through the filtration means, the size of the air flow path remains generally constant and there is not a large increase in back pressure over the filter means as entrained dirt is removed from the air stream passing through the vacuum cleaner and collected in the filter means. The increase in back pressure is preferably 10 kpa or less, more preferably 8 kpa or less and most preferably 4 kpa or less. The increase in back pressure is based on the back pressure when the filter

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means is new or has just been emptied and the back pressure when the filter means is full. Preferably, the filtration means, or at least the primary filtration means, comprises one or more cyclone separators.

5 The pressure drop (i.e. back pressure) across a cyclone separator during normal operation remains substantially constant (eg. the pressure drop may be 4 - 6 kpa). This occurs since a cyclone separator has an air flow passage there through (i.e. the cyclone air inlet, the cyclone chamber in which the cyclonic filtration occurs and the cyclone air outlet) which in normal operation is of a constant fixed
10 size. "Normal" operation means that the air flow path through the vacuum cleaner is not blocked by large objects, eg. objects large enough to block a portion of the air flow path to the cyclone, the cyclone air inlet or the cyclone air outlet do not enter the air stream of the vacuum cleaner or that a sufficient amount of separated dirt does
15 not accumulate in the cyclone chamber so as to prevent efficient cyclonic separation therein. This is in contrast with standard filter bags which are used with vacuum cleaners that have small pores therein (eg. about 10 μ) that become blocked with small dirt particles.

The vacuum cleaner may include two or more dirt
20 separation stages provided that each stage does not have an air flow path that will become blocked as air to be filtered passes there through during normal operation of the vacuum cleaner. For example, the primary filtration means of the vacuum cleaner may be a cyclone separator and the secondary stage filtration means may comprise a
25 HEPA filter or a electrostatic precipitator. If a HEPA filter is used, it will typically be positioned downstream from the motor and fan assembly so as to remove carbon dust that is produced by the motor. The pressure drop over a HEPA filter may be only about 4 kpa even when the HEPA filter is full and requires replacement or washing. Thus the
30 total back pressure across the filtration means may be about 4 - 6 kpa if the filtration means is a single cyclone separator. If the filtration means is a cyclone separator combined with a HEPA filter or the like, then the

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total back pressure across the filtration means may be less than about 10 kpa, preferably less than 8 kpa and most preferably less than about 6 kpa even when the HEPA filter is full. Accordingly, the motor and fan are selected to have an optimum flow performance in terms of flow and suction to match the normal suction and flow of the filtration means.

A cyclone separator 36 which may be used in conjunction with this invention is shown in the Figures in which cyclone separator 36 is the primary filtration means. Cyclone separator 36 may be positioned in the lower portion of upper body portion 30. Cyclone separator 36 may comprise any type of dirt separation cyclone known in the art, e.g. cylindrical or frusto-conical, and may comprise a single cyclone or multiple cyclones (either in series and/or in parallel). Preferably, cyclone separator 36 comprises a single cyclone. Cyclone separator 36 comprises cyclone bin 38 defining a cyclone chamber 86 having an inner wall 40 defining a dirt rotation surface and an air inlet 42, typically at upper end 48 thereof,. Air inlet 42 is adapted for providing an air flow tangentially to an inner wall 40 of bin 38. Bin 38 also has a dirt collection surface or bottom 44 and a clean air outlet 46. Upper end 48 of bin 38 is sealed, such as by its engagement with the housing of upper body portion 30 from which it is removably attached (eg. by means of handle 76) so as to enable bin 38 to be emptied.

If the vacuum cleaner is used in the upright vacuum cleaner mode, the air flow path through vacuum cleaner 10 commences with an air supply conduit 54 provided in cleaner head 14 having an upstream portion 56 in flow communication with dirty air intake 20 and a downstream portion 58 adjacent valve 60. Valve 60 may be an on-off rotatable valve which is provided in cleaning head 14 for connecting dirty air inlet 20 in air flow communication with cyclone separator 36 when the vacuum cleaner is used in the floor cleaning mode (i.e. the handle is rotated rearwardly). Cyclone separator 36 has a central air feed tube 62 having an upstream portion 64 in air flow

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communication with valve 60 and a downstream portion 66 in air flow communication with curved passageway 68. Curved passageway 68 is curved upwardly and outwardly from downstream portion 66 to cyclone air inlet 42.

5 Centrally located in upper end 48 of bin 38 is a clean air outlet 46 for permitting withdrawal of air from bin 38. From clean air outlet 46, the air flow may proceed to vacuum fan motor assembly 32 or to a second stage of filtration, such as a second cyclone or other filtration means (eg. an electrostatic precipitator). From the second
10 stage of filtration, the cleaned air may be in air flow communication with vacuum fan motor 32.

As shown in Figure 4, motor and fan assembly 32 is provided at the upper end of the housing of upper body portion 30 downstream from clean air outlet 46. If required, a supplemental
15 filtration means may be provided in cavity 50 (eg. a second stage cyclone or an electrostatic precipitator). Further, a secondary filtration stage, eg. a HEPA filter, may be positioned downstream from motor and fan assembly 32 in cavity 52.

If vacuum cleaner 10 is used in the above the floor
20 cleaning mode, then dirty air will travel to central feed tube 62 via hose 28 and transverse passage 70. Any valving arrangement known in the art may be used to connect hose 28 in air flow communication with cyclone separator 36 when vacuum cleaner 10 is used in the above the floor cleaning mode and to isolate distal end 74 of hose 28 from
25 cyclone separator 36 when the vacuum cleaner is used in the floor cleaning mode (eg. a valve may be provided at distal end 74 of hose 28). Hose 28 may be connected to any vacuum nozzle means as is known in the art.

In operation, the vacuum fan motor 32 is activated to
30 induce an air flow through vacuum cleaner 10. The air flow causes a partial vacuum to form at dirty air inlet 20. Air, and entrained dirt, is drawn into upstream portion 56, with the aid of brush member 22. The

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dirty air flow moves upwardly to dirty air inlet 42 and is introduced tangentially to bin 38. The airflow is then accelerated around inner wall 40, and proceeds generally downwardly along and around inner wall 40 until it reaches a position towards bottom 44 of bin 38, at which point the air flow travels upwardly through the central portion of cyclone bin 38.

Bin 38 may incorporate a wall which is a cylindrical sleeve 72 extending downwardly from outlet 46 to assist in preventing the cleaned air travelling upwardly to outlet 46 from mixing with the dirty air which is introduced into bin 38 via inlet 32.

While the above description constitutes the preferred embodiment, it will be appreciated that the present invention is susceptible to modification and change without departing from the fair meaning of the proper scope of the accompanying claims.

It will be appreciated that additional dirt separation stages may be incorporated into the vacuum cleaner. For example, an open mesh screen to prevent elongate material such as hair and the like from travelling downstream may be positioned between the cyclonic separation stage and motor and fan assembly 32. The cooled air may then exit the vacuum cleaner or may pass through a further filtration stage positioned upstream of motor and fan assembly 32.

It will be appreciated that motor and fan assembly 32 may be positioned at any stage in the air flow path through vacuum cleaner 10 provided a sufficient amount of dirt has been removed from the air so as not to damage or unduly damage motor and fan assembly 32.

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We Claim:

1. A bagless vacuum cleaner comprising:
 - (a) a housing having a clean air outlet;
 - (b) a cleaning member having a dirty air inlet;
 - 5 (c) an air flow path extending from the dirty air inlet to the clean air outlet;
 - (d) a primary filtration stage comprising at least one cyclone particle separator positioned in the air flow path downstream from the dirty air inlet, the air flow path including the primary filtration stage having an operational back pressure from 2 - to 12 kpa when the air flow path is not blocked; and,
 - 10 (e) a motor and fan assembly having an air flow rate sufficient to transport the dirt in an air stream to the primary filtration stage and to cause cyclonic separation in the cyclone particle separator of particulates suspended within the air stream over the normal operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.
 - 15
- 20 2. The vacuum cleaner as claimed in claim 1 further comprising a battery for powering the vacuum cleaner.
3. The vacuum cleaner as claimed in claim 1 wherein the air flow rate is from 30 to 80 cfm.
4. The vacuum cleaner as claimed in claim 1 wherein the air flow rate is from 40 to 50 cfm.
- 25 5. The vacuum cleaner as claimed in claim 3 wherein the back pressure is from 2 to 8 kpa.

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6. The vacuum cleaner as claimed in claim 2 wherein the motor and fan assembly is positioned in the air flow path downstream from the cyclone air outlet.

5 7. The vacuum cleaner as claimed in claim 1 wherein the motor and fan assembly has a combined efficiency of at least 33% based on the conversion of electrical input to the motor and fan assembly to air watts over the normal operational back pressure of the air flow path.

10 8. The vacuum cleaner as claimed in claim 1 wherein the motor and fan assembly has a combined efficiency of at least 50% based on the conversion of electrical input to the motor and fan assembly to air watts over a back pressure of the air flow path from 2 to 10 kpa.

15 9. The vacuum cleaner as claimed in claim 1 wherein the motor and fan assembly has a combined efficiency of at least 75% based on the conversion of electrical input to the motor and fan assembly to air watts over the normal operational back pressure of the air flow path.

20 10. A vacuum cleaner comprising:
(a) a housing having a clean air outlet;
(b) a cleaning member having a dirty air inlet;
(c) an air flow path extending from the dirty air inlet to the clean air outlet and including a primary filtration stage; and,
25 (d) a motor and fan assembly mounted in the housing and positioned in the air flow path, the motor and fan assembly constructed to provide a high air flow rate and

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overcome a low back pressure over the normal operational back pressure of the air flow path.

11. The vacuum cleaner as claimed in claim 10 wherein the motor and fan assembly having a combined efficiency of more than 50% over the entire operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.

12. The vacuum cleaner as claimed in claim 10 wherein the primary filtration stage includes a cyclone and the motor and fan assembly have an air flow rate sufficient to entrain dirt entering the dirty air inlet and to cause cyclonic separation in the cyclone particle separator of particulates suspended within the fluid stream over the normal operational range of back pressure of the vacuum cleaner when the air flow path is not blocked.

13. The vacuum cleaner as claimed in claim 10 wherein the air flow rate is from 30 to 80 cfm.

14. The vacuum cleaner as claimed in claim 12 wherein the back pressure the motor and fan means overcome is from 2 to 10 kpa.

15. The vacuum cleaner as claimed in claim 10 further comprising a battery for powering the vacuum cleaner.

20 16. A vacuum cleaner comprising:
(a) dirty air inlet means;
(b) clean air outlet means;
(c) an air flow path extending from the dirty air inlet means to the clean air outlet means;
25 (d) filtration means comprising cyclonic separation means positioned in the air flow path downstream from the dirty air inlet means, the cyclonic separation means

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having cyclonic air inlet means and cyclonic air outlet means; and,

(e) motor and fan means positioned in the air flow path, the motor and fan means constructed to provide a high air flow rate and overcome a low back pressure over the normal operational back pressure of the air flow path through the filtration means.

17. The vacuum cleaner as claimed in claim 16 wherein the air flow rate is from 30 to 80 cfm.

18. The vacuum cleaner as claimed in claim 16 wherein the air flow rate is from 30 to 60 cfm.

19. The vacuum cleaner as claimed in claim 17 wherein the back pressure the motor and fan means overcome is from 2 to 12 kpa.

20. The vacuum cleaner as claimed in claim 18 wherein the back pressure the motor and fan means overcome is from 2 to 8 kpa.

21. The vacuum cleaner as claimed in claim 16 wherein the cyclonic separation means has a back pressure from 3 to 6 kpa.

22. The vacuum cleaner as claimed in claim 16 further comprising a battery for powering the vacuum cleaner.

23. The vacuum cleaner as claimed in claim 16 wherein the motor and fan means has a combined efficiency of at least 33% based on the conversion of electrical input to the motor and fan means to air watts over the normal operational back pressure of the air flow path.

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24. The vacuum cleaner as claimed in claim 16 wherein the motor and fan means has a combined efficiency of at least 50% based on the conversion of electrical input to the motor and fan means to air watts over the normal operational back pressure of the air flow path.

5 25. The vacuum cleaner as claimed in claim 16 wherein the motor and fan means has a combined efficiency of at least 75% based on the conversion of electrical input to the motor and fan means to air watts over the normal operational back pressure of the air flow path.

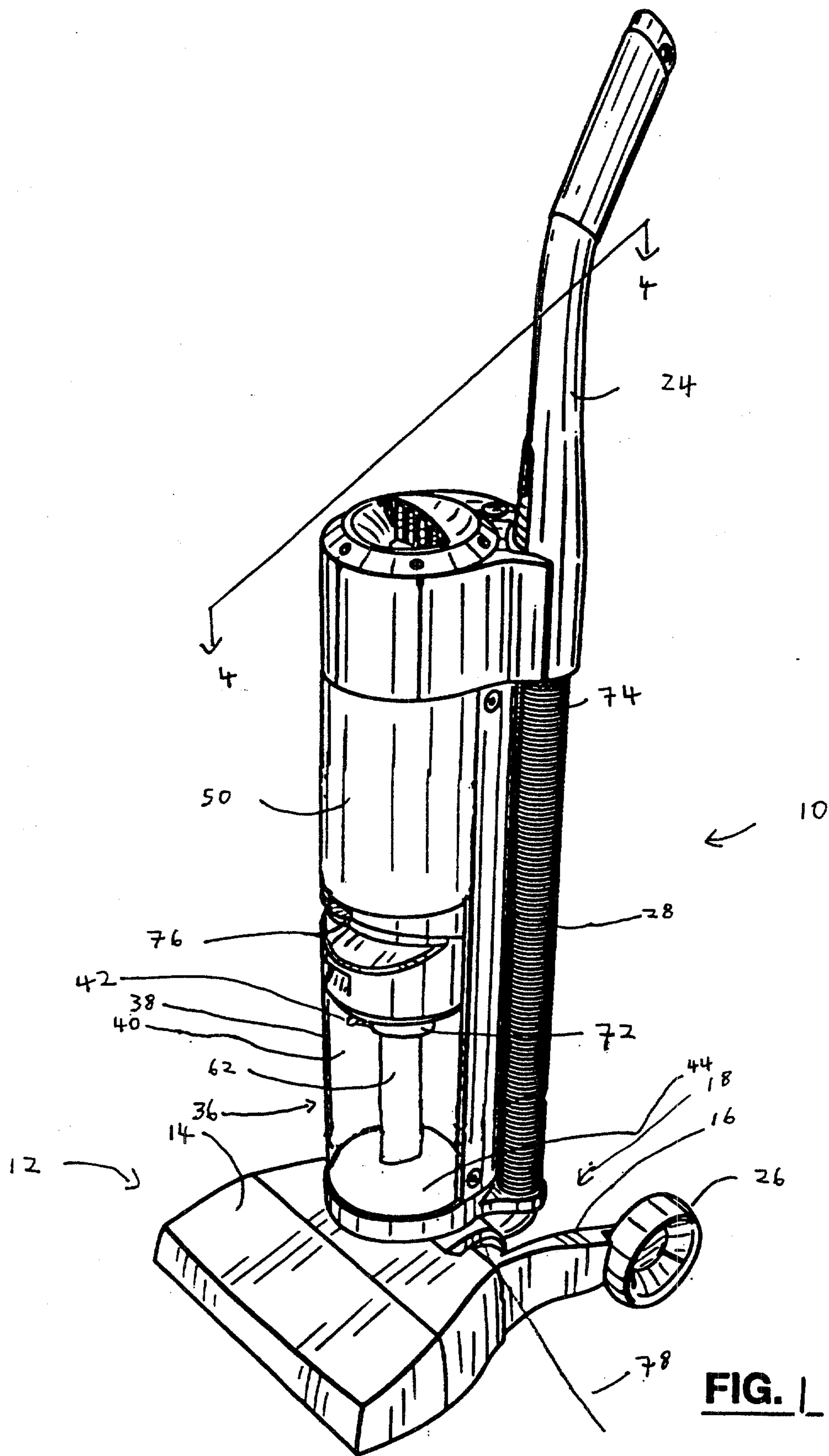
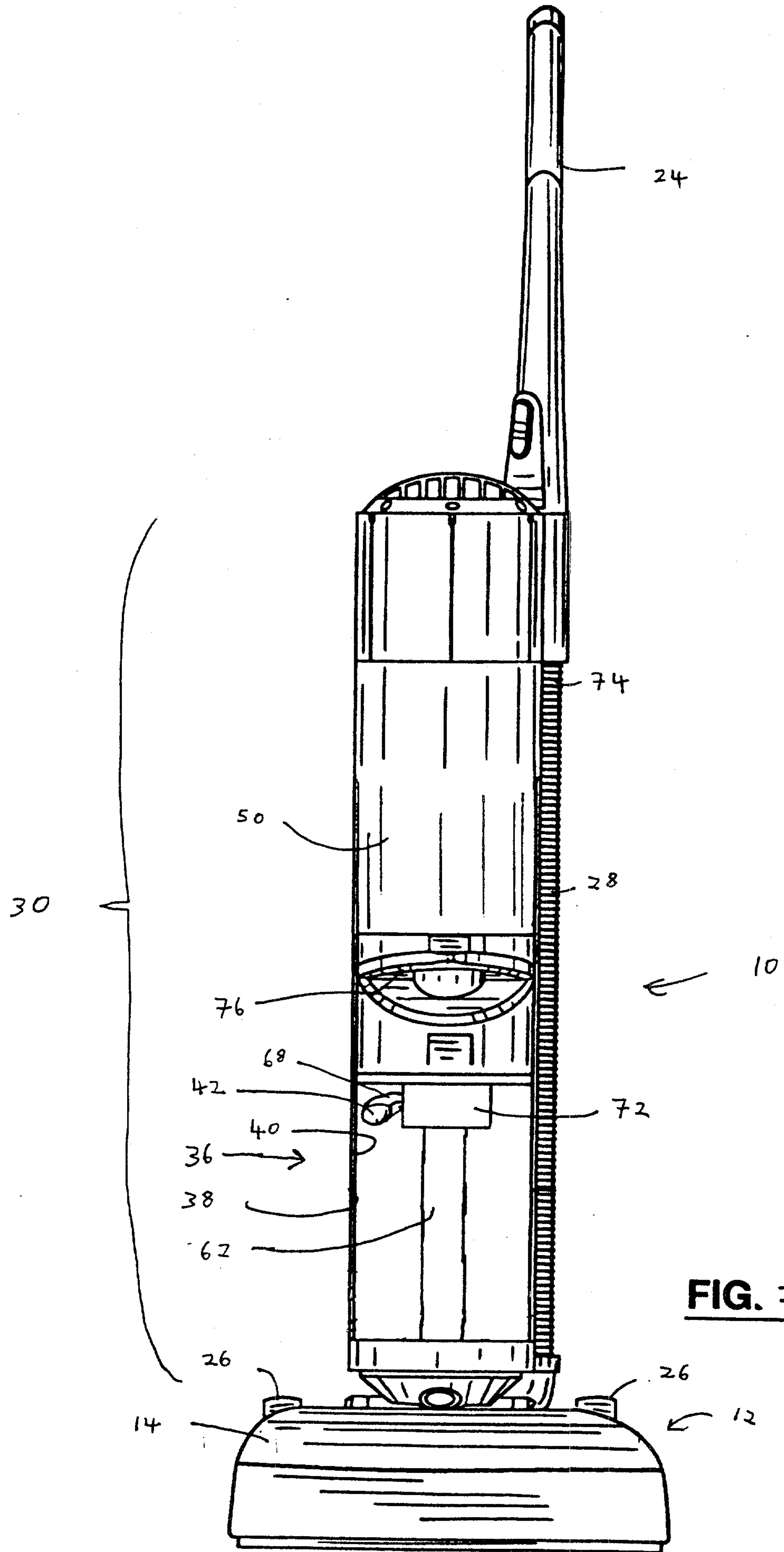
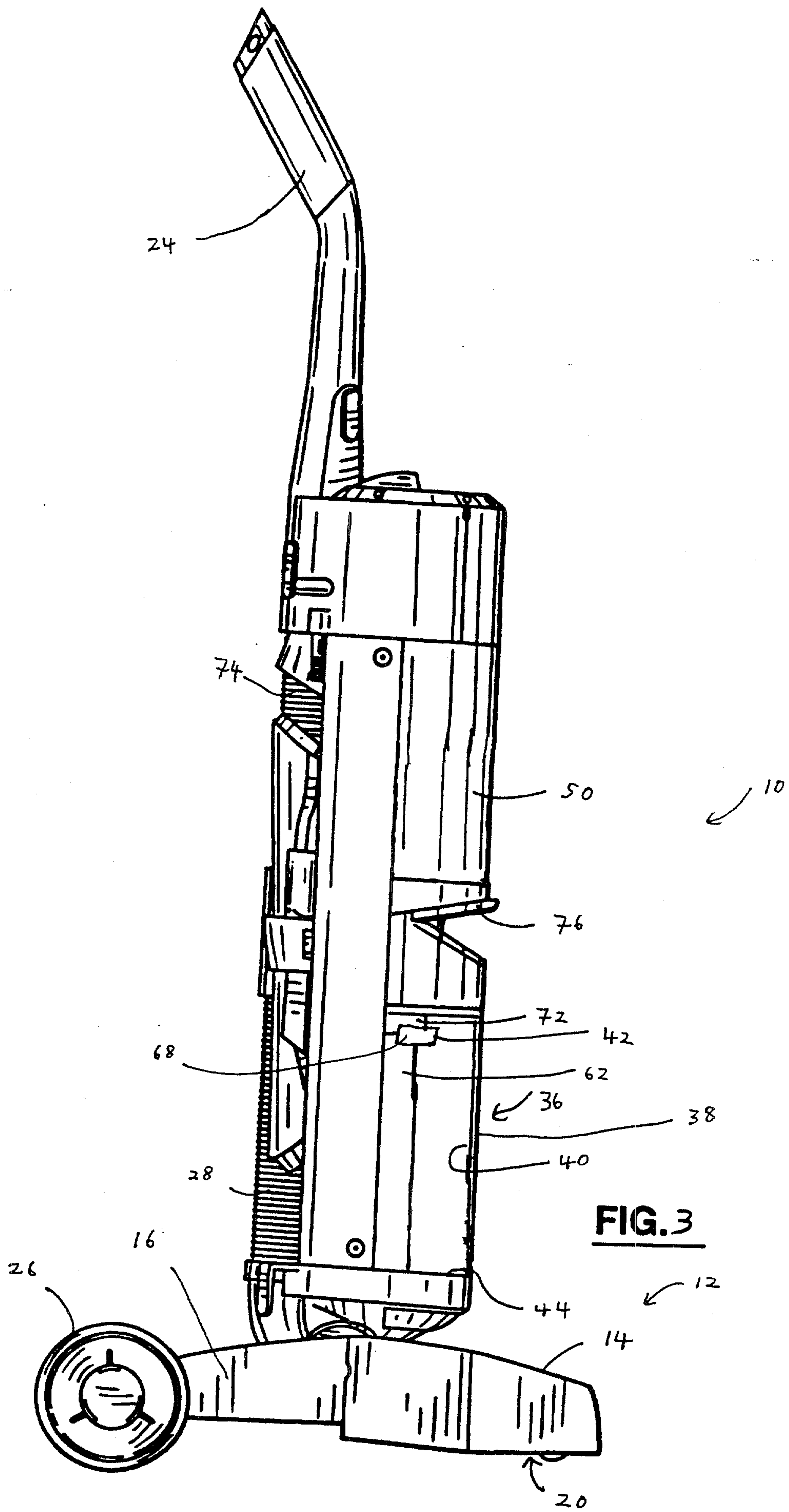


FIG. 1





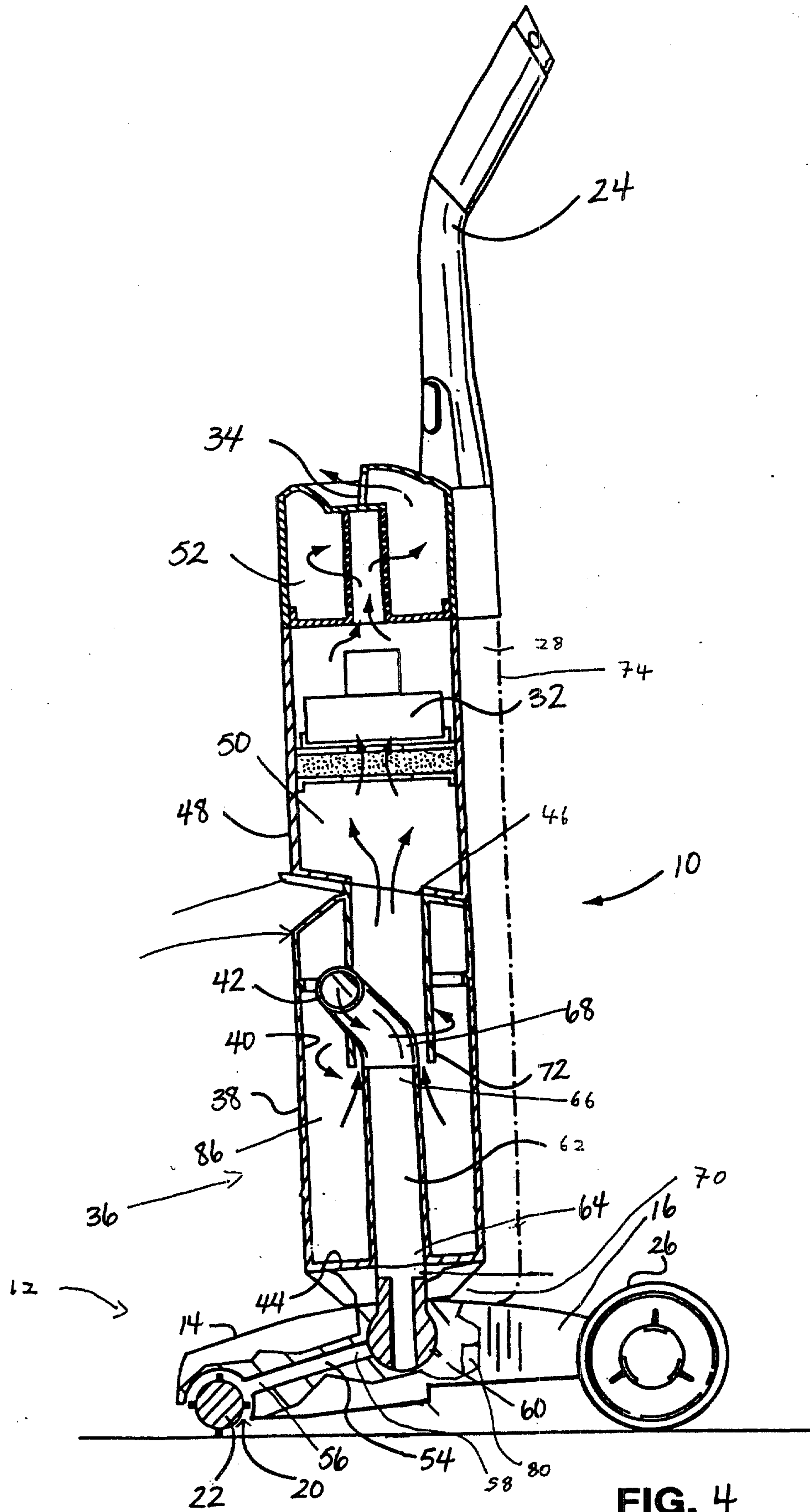


FIG. 4

