July 15, 1969 MASAYUKI KUWAHARA 3,454,978

ELECTRIC CLEANER OF DOUBLE JET STREAM

Filed July 31, 1967 2 Sheets-Sheet 1

Fig. 1.

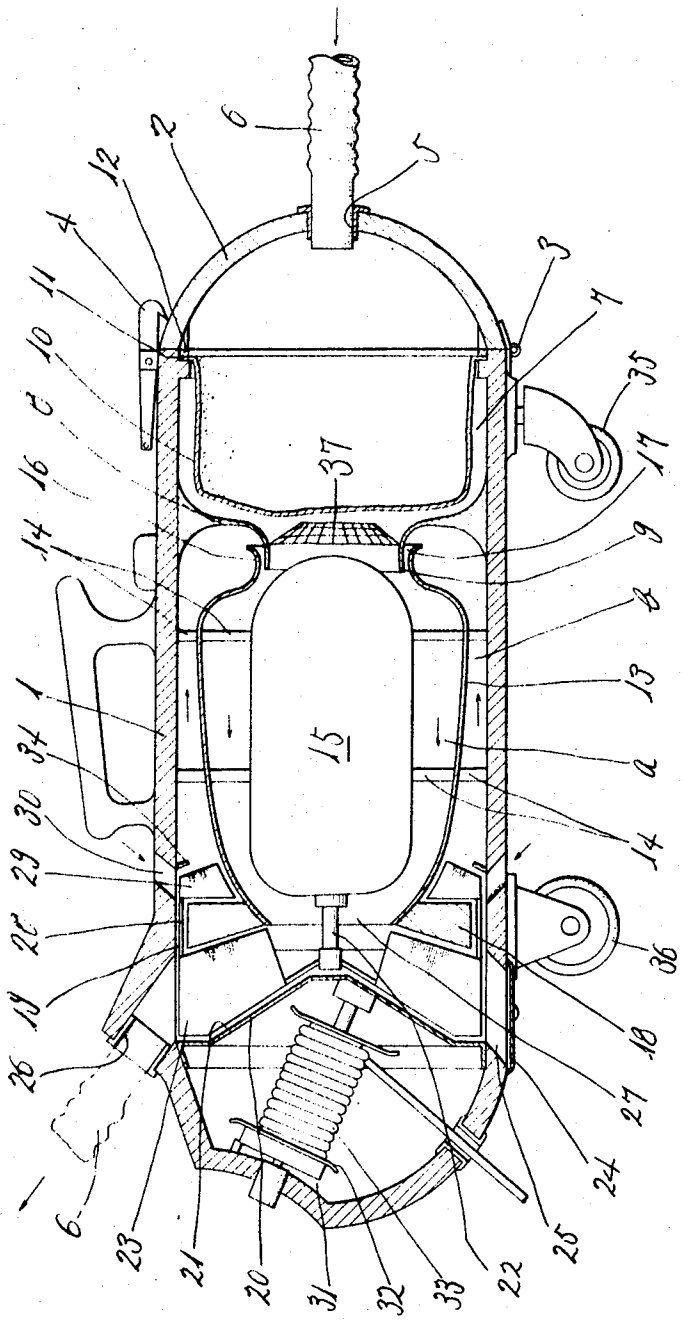

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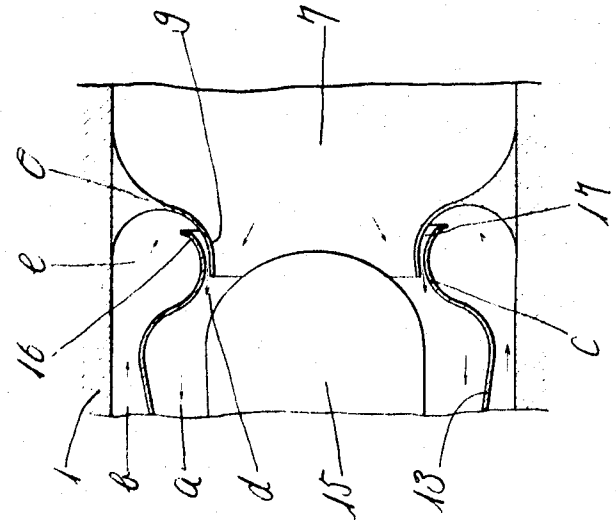
Fig. 2.



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United States Patent Office 3,454,978
Patented July 15, 1969

3,454,978

ELECTRIC CLEANER OF DOUBLE JET STREAM

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Filed July 31, 1967, Ser. No. 657,196
Claims priority, application Japan, Oct. 21, 1966, 41/69,558
Int. Cl. A47l 5/00, 9/00, 11/00
U.S. Cl. 15—327 8 Claims

ABSTRACT OF THE DISCLOSURE

An electric cleaner which is provided with double annular passages one of which will produce the Venturi effect outside the spout of the dust collecting chamber and having an annular nozzle whose opening spout is within said passage, high pressure air being forced at high speed from the said annular nozzle into the annular passage by means of the compressing fan, the said annular passage being exhausted by means of the exhaust fan, the suction power being thus increased by means of intensifying air suction inside the dust collecting chamber taking advantage of a double function of the suction responsive to a Venturi effect as well as the suction of the exhaust fan.

The prior art electric cleaners of the most traditional type generally use a system whereby both the suction and the exhaust are effected by means of the fan disposed within a single fan box provided adjacent the dust collecting chamber, so that air pressure inside the fan box falls with the r.p.m.'s of the fan, decreasing the efficiency of the fan.

Moreover, when a more powerful motor is employed for the purpose of increasing the sucking effect and the fan is rotated at super-high speed, the fan will be in a state extreme racing when in rarefied air and there will arise a marginal exfoliative strata of current on the surface adjacent the exhaust spout of the fan, thus causing an excessive current and then air percussion waves. Accordingly, merely increasing torque in itself not only reduces the efficiency of the fan substantially but also causes an irregular current inside the exhaust tube thereby preventing a smooth exhaust.

This necessarily results in overheating of the motor, an increased rate of occurrence of disorders, greater noise and many other disadvantages.

A principal object of this invention is to obtain a cleaner of high efficiency characterized by removing all the above-mentioned disadvantages.

In the present invention, an annular passage, which has a Venturi-shaped vertical section adapted to produce the Venturi effect, is formed around the outside of the spout of the dust collecting chamber housed in the body, an annular nozzle formed on the inner periphery of the said spout opening its mouth inside the said annular passage, a tubular partition disposed on the outside of the annular passage so as to provide an air passage both on the inside and the outside thereof respectively. The inner air passage is equipped with an exhaust fan and a drive motor with which to exhaust the dust collecting chamber as well as said inner air passage. The outer passage is provided with an air compressing fan and an air compressing chamber which leads to the above-mentioned annular passage and annular nozzle, whereby the air sucked in by the air compressing fan and compressed in the compressing chamber is blown into the annular passage through the annular nozzle, and the dust sucking or intake power inside the dust collecting chamber is thus increased by means of the double function of the Venturi effect and the sucking effect of the exhaust fan.

The attached illustrative drawings and the explanation thereof will clarify the particulars of this invention.

FIG. 1 is a longitudinal cross section of the cleaner of this invention with certain parts shown in elevation.

FIG. 2 is an enlarged, fragmentary longitudinal cross section of the essential part of the cleaner of this invention.

In the figures the numeral 1 designates the tubular main body, the opening at the forward end thereof being provided with a lid 2 which freely openable by means of a hinge 3 and catch 4.

When the forward opening of the main body 1 is closed, the construction is such that the lid 2 will cover the opening in a perfectly airtight manner, being locked by the lid catch 4.

The lid 2 is provided with an inlet hole 5, a dust sucking hose 6 adapted to be removably connected to the said dust sucking hole.

Inside the main body 1 a dust collecting chamber 7 is formed adjacent the inside of the lid 2. The said dust collecting chamber 7 is divided from the center of the main body 1 by means of a partition 8 having an annular spout portion 9 with a dust filter 37 being formed at the center of the said partition 8. A dust collecting bag 10 is inserted into the dust sucking chamber 7, the external protruding edge 11 of the bag being clamped between the rim of the front opening of the main body 1 and the peripheral edge of the lid 2. Accordingly, the bag 10 can be removed from inside the dust collecting chamber 7 when the lid 2 is opened. A circular rubber packing 12 is conventionally fixed between the lid 2 and the bag's external protruding edge 11.

At the center of the main body 1 a tubular partition 13 is concentrically fixed within the main body 1 by means of a stay or brace 14.

Inside the partition 13 is provided a motor 15, which is also disposed concentrically with the main body 1, and both the motor 15 and the partition 13 are connected together by the stay 14, too.

A tubular inner air passage *a* is formed between the motor 15 and the partition 13, while a tubular outer air passage *b* is formed on the outside of the partition 13.

The front end of the above-mentioned tubular partition 13, that is, on the side of the lid 2, is constricted to form an opening tube 16 having an arc-shaped cross section, expanding toward both inside and outside. Adjacent the outside or forward path thereof there is formed a compressing chamber *e* which communicates with the front end of the outermost air passage *b*, said spout 9 projecting toward the rear of the partition 8 and having an outwardly flaring or tapering shape expanding toward the outer or front end, an annular nozzle 17 equipped with a constricted circular mouth *c* being formed between the spout portion 9 and the opening tube 16.

The front end of the motor 15, being shaped hemispherically, projects inside the spout 9, and defines therewith an annular passage *d* (FIG. 2) which has a Venturi-shaped longitudinal section between the motor 15 and the opening tube 16.

On the external periphery at the rear end of the tubular partition 13 is fixed an annular radially extended partition 18, which helps to form an annular space 19 between the outer periphery thereof and the inside of the main body 1. A fan box 21 is formed between the partition 18 and a conical partition 20 fixed at the rear end inside the main body 1, within which box a suction or exhaust fan 23 is fixed on the axial drive shaft 22 of the above-mentioned motor 15 to be freely rotatable therein.

The peripheral wall of the main body 1 which forms the outside of the fan box 21 is provided with a first outlet or spout 25 which has a freely openable sliding cover or

lid 24 and a second outlet or spout 26 to which the hose 6 is also selectively attachable only when necessary.

The fan 23 is shaped to facilitate sucking air from inside the passage *a* and drawing it rearwardly through an outlet hole 27 at the center of the fan box responsive to the operation of the fan 23 and to thereby discharge or exhaust the air outside through said outlets 25 and 26.

Into the above-mentioned space 19 a plurality of connecting pieces project forward from the external periphery of the fan 23, the front ends of the said connecting pieces 28 being projecting inside the rear end of the passage *b* and fixed to the external periphery of an air compressing fan 29 which freely rotates with said exhaust fan 23 but inside the rear end of the passage *b*.

The main body 1 is provided with a plurality of suction holes 30 facing the external periphery of the compressor fan 29, whereby outside air is drawn into the passage *b*. In other words, the fan 29 is formed in a shape to facilitate drawing in the outside air through the suction holes 30 and forcing the air into and along the passage *b* and compressing it forwardly during operation of the said fans.

The rear part of the above-mentioned partition 20 is utilized to form part of a cord housing box 31, which is equipped with a cord reeling drum 32 on which is stored the power supply cord 33.

It is necessary to make the above-mentioned space 19 as small as possible and preferably of a labyrinth formation or the like, so as to minimize the air leakage and prevent an increase of resistance during the fan operation.

On the internal periphery of the main body 1 located ahead of the exterior periphery of the fan 29 there is provided a radially inwardly protruding edge or annular baffle 34 which acts to help the air sucked through the suction holes 30 to flow into the passage *b* with ease. Furthermore, the front part of the tubular partition 13, the partition 8 and the like must have sections which curve as smoothly as possible so as to minimize the resistance arising with the flow of air.

The main body 1 is equipped underneath with a front wheel 35 to a swinging type and a pair of rear wheels.

In operation of the above-mentioned embodiment, when the forward opening of the main body 1 is closed, the hose 6 is inserted into the dust sucking hole 5 of the lid 2 which is retained by means of the lid catch 4. The sliding cover 24 of the spout 25 is opened and the fans 23, 29 are revolved along with the shaft 22 by starting the motor 15, whereupon the fan 23 sucks the air inside the passage *a* rearwardly through the suction hole 27 and exhausts the air through the spouts 25 and 26, with the result that the air inside the dust collecting chamber 7 is sucked out into the passage *a* through the spout 9 and directed toward the spouts 25, 26 by the fan 23 as mentioned above.

The air drawn in by way of the suction hole 30 responsive to rotation of the fan 29 is transferred along the passage *b* in the arrow-indicated direction by the fan 29, where it continues until it changes course by and achieves higher pressure while being compressed within the compressing chamber *e*, whereupon it is rapidly expelled rearwardly through the annular passage *d* from the spout *c* of the annular nozzle 17.

As is clear from the drawings, the nozzle 17 is progressively more constricted in the rearward direction as it nears the spout *c*, as a result of which the air gathers speed while passing this part and spurts out of the spout *c* at higher speed. The air thus spurting from the spout *c* travels at high speed toward the passage *a* along the passage *d*, because the spout *c* faces the Venturi-shaped annular passage *d* formed by the motor 15 and the opening tube 16.

When the air travels at high speed through the Venturi-shaped annular passage *d* as mentioned above, these arises the Venturi effect remarkable reducing the ambient or local air pressure and consequently strongly drawing the air inside the dust collecting chamber 7.

When the air, having traveled along the passage *d* at high speed, reaches the portion where the cross-sectional dimension is large, it commences to lose its speed and is sent to the spouts 25, 26 by the fan 23.

Additionally, if the hose 6 is fixed to the spout 26 as indicated by the dotted lines in FIG. 1 and the motor 15 is operated with the aperture 25 closed by means of the sliding cover 24, the air is forced from the other or front end of the hose 6, so that by this arrangement it is convenient to blow off the dust.

By utilizing the present inventive structure it is possible to obtain far greater suction than that achieved by electric cleaners of the traditional type.

As stated at the beginning, although the efficiency of the fan is substantially reduced as a result of the air inside the fan box becoming extremely thin in case of the traditional cleaners, the cleaner of this invention is so designed that the air is sucked from outside by the compressing fan 29, compressed into high pressure air inside the compressing chamber *e* and then blown into the inner air passage *a* through the nozzle 17, as a result of which the air inside the passage *a* and the fan box 21 does not become rarefied even when the air inside the passage *a* is so powerfully exhausted by means of the exhaust fan 23, thereby enabling the fan 23 to work with higher efficiency.

A more precise explanation will be given here with reference to the actual use. When, for instance, a comparatively large and heavy solid body is sucked against the front end of the dust collecting hose 6 and the opening is narrowed as a result, the air inside the hose 6 and the dust collecting chamber 7 is rapidly drawn in and exhausted through the inner air passage *a* by means of the suction fan 23, with the result that the air density inside the passage *a* becomes considerably rarefied and the frontal resistance of the fan 23 to the air is reduced, thus increasing the r.p.m.'s of the motor 15.

However, this condition is offset by the present invention in that with the increase of the motor r.p.m.'s, the r.p.m.'s of the compressing fan 29 integrated with the suction fan 23 is also increased and accordingly the quantity of the air sucked from outside through the suction intake hole 30 is increased, too.

Then the air is sent through the outer air passage *b* to the air compressing chamber *e*, where it is compressed into high pressure air and sent to the annular nozzle 17, from which it is spurted in a jet stream through the annular spout *c* and then into the Venturi-shaped annular passage *d*.

Consequently, the Venturi effect is remarkably strengthened, making the air suction inside the spout 9 strong enough, so that more and more intensified vacuum is produced at the bottom of the dust collecting bag 10, strongly sucking the residual air inside the dust collecting chamber 7, with the result that the suction of the hose 6 is remarkably increased. In other words, the cleaner of this invention can display increased suction when it draws in comparatively large solids which are the heaviest and have the greatest air resistance among the dusts.

As already pointed out, in case of all the cleaners of the traditional type rarefied air inside the suction fan box is the greatest cause of reduced vacuum, a result of which precludes such cleaners from picking up comparatively heavy solids. Furthermore, it has been difficult in prior art machines to collect almost invisibly minute dust by means of minimizing the filtering holes of the dust collecting bag by the use of thick and dense material, but in this invention a satisfactory sucking effect is obtainable even when a dust collecting bag for the above-mentioned infinitesimal dust is used.

Therefore, the cleaner of this invention is quite hygienic, for it is free from the risk of soiling the air by spurting almost invisible dust from the exhaust hole while cleaning the room.

In this invention, as explained above, although the air adjacent the spout 9 may become conspicuously rarefied, the air inside the fan box 21 does not become very rare-

fied, so that the fan **23** works with constant efficiency. Accordingly, it is not necessary to utilize any excessively high speed fan **23**, hence less noise.

A potential question may arise as to whether or not the effect of vacuum suction will be reduced if air is blown into the passage *a* from the nozzle **17**, as mentioned above. However, the vacuum sucking effect can be heightened simply by intensifying the vacuum at the bottom of the dust collecting bag **10**, and in this invention the vacuum adjacent the spout **9** facing the bottom of the dust collecting bag **10** is increased to a maximum, so that a vacuum of far higher degree is obtainable at the bottom of the dust collecting bag **10** than any of the cleaners of the traditional type.

Furthermore, in this invention the motor **15** is located inside the inner air passage *a*, while on the outside of the motor **15** passes comparatively dense air which is a combination of the air from the nozzle **17** and the air from the spout **9**, so that the motor cooling effect is great enough. This fact, together with the advantage of not requiring an exceptionally high speed motor **15** serves to preclude overheating of the motor **15** and remarkably reduces the wear thereof.

Since both the exhaust fan **23** and the air compressing fan **29** are driven by a single motor **15**, the mechanism is quite simple despite the fact that two sets of fans are used. Moreover, the required output being smaller, a lighter and more economical motor can be employed.

I claim:

1. An electrically operated vacuum cleaner having a dual jet stream or air flow system comprising in combination:

(a) an elongated hollow casing (**1**) having a forward inlet (**5**) end and a rearward discharge end, said forward inlet (**5**) adapted to receive a dust collecting tube means (**6**);

(b) a first generally transverse radial wall member (**8**) spaced from said forward end defining a dust collecting chamber (**7**) with said casing, said wall having a central opening defined by a rearwardly projecting annular wall constituting a spout (**9**) disposed coaxially with the axis of the cleaner;

(c) dust bag means and filter means disposed within said dust chamber;

(d) an electric drive motor (**15**) of cylindrical shape having a generally hemispherically curved end portion mounted coaxially within said cleaner and rearward of said dust collecting chamber, said motor end portion projecting slightly within the aforesaid spout (**9**) and defining therebetween an annular space air passage, the other end of said motor having an axial drive shaft (**22**) projecting rearwardly therefrom and having rotary fan means (**23**+) attached thereto for drawing air through said cleaner from the inlet end thereof and exhausting it out the rearward portion thereof;

(e) an elongated tubular partition (**13**) fixedly disposed within the cleaner housing and in spaced relation therefrom and from said electric motor which it encloses, said partition thereby forming annular inner (*a*) and outer (*b*) air passages with respect to said annular partition (**13**), said partition having a smoothly curved forward constricted end terminating in an annular opening tube (**16**) having an arcuate radial cross-section and disposed concentrically with and in radially outwardly spaced relation to the aforesaid spout (**9**) and to said hemispherical motor and thereby forming a dual jet stream air flow during motor operation, said partition having its other end terminating in radially spaced relation to the opposite end of said drive motor and forming a rearward axial air discharge passage (**27**) communicating with said rotary fan means and through which air is drawn responsive to rotation of said fan to draw air from the filtered dust collecting chamber (**7**) passing via said inner air passage (*a*) of paragraph (e) around and to ventilate said motor (**15**) and discharging said air through rearwardly directed circumferentially spaced apertures (**25**) (**26**) in said casing adjacent to said exhaust fan;

(f) a second generally transverse partition (**18**) disposed rearwardly in said casing (**1**) and projecting radially between said rearward portion of said tubular partition (**13**) and said outer casing, and substantially separating the inner (*a*) and outer (*b*) air passages; and

(g) said outer casing (**1**) having air inlet apertures (**30**) formed forwardly of said second transverse partition (**18**) communicating with said outer annular air passage (*b*) whereby during operation of the vacuum cleaner, air is also drawn in through said latter apertures (**30**) forwardly in said outer passage (*b*) and in jet stream form through the annular spacing (**17**) between said tube (**16**) and spout (**9**), whereupon it joins with the jet stream action of air passing from the dust collecting chamber (**7**) rearwardly through spout (**9**) between said adjacent hemispherical motor end and thence rearwardly through said inner air passage (*a*) whereupon it is discharged rearwardly as aforesaid.

2. A vacuum cleaner as defined in claim **1** wherein the rotary fan means of paragraph (d) include a principal exhaust fan (**23**) and a secondary compressor fan (**29**) spaced forwardly thereof, means interconnecting said fans for integral rotation by said one drive motor, said secondary fan disposed forwardly adjacent of said second transverse partition (**18**) near the air inlet apertures (**30**) so as to more positively draw in outside air and force it forwardly in outer passage (*b*) as aforesaid.

3. A vacuum cleaner, as defined in claim **1**, wherein said first transverse partition (**8**) includes a radially outward reversely curved portion and said latter curved portion and said annular partition (**13**) at the forward end thereof are of generally complemental formation thereby defining and forming an air compressing chamber (*e*) between said outer passage (*b*) and said tube (**16**) and spout (**9**) portions.

4. A vacuum cleaner as defined in claim **3** wherein the double jet system of paragraph (e) in base claim **1** includes a double Venturi formation, one of which is formed between the constricted arcuate in cross section shaped opening tube (**16**) and the spaced hemispherical end portion of motor (**15**); and the second Venturi formed by the annular space (**17**) between spout (**9**) and the generally concentric, overlapping tube (**16**), said tube and spout being of such a construction and relation that space (**17**) is greater at the forward end and progressively reduces or constricts toward the rearward direction.

5. A vacuum cleaner as defined in claim **1** further including an electric cord storage means and a compartment in the rearward portion of said cleaner housing.

6. A vacuum cleaner as defined in claim **1** further including movable cover means in association with some of the rearwardly directed housing apertures (**25**) as recited in the latter part of paragraph (e), and at least one of the other apertures (**26**) is adapted to receive the end of a dust hose (**6**).

7. A vacuum cleaner including a housing having a forward inlet and a rearward outlet or exhaust, rotor means for inducing flow of air therethrough, first patirtion means forming a dust collecting chamber having an outlet communicating with both the forward inlet and the rearward exhaust outlet; a single electric drive motor having a hemispherical shaped end and disposed coaxially within said housing and operably connected with said rotor; second partition means including an elongated tubular partition disposed coaxially within said housing in radially spaced relation both from said housing and said drive motor; said latter partition thereby defining inner and outer annular air passages; said housing including

supplemental outside air inlet means in communication with said outer annular air passage, said inner and outer annular passages being in communication with one another only at the forward portion thereof; said first and second partition means including means formed relative to each other and to said hemispherical end of the motor to constitute a dual Venturi effect air flow responsive to operation of said rotor means.

8. A vacuum cleaner as defined in claim 7 wherein the rotor means include a first exhaust rotor inducing a suction flow of air through the cleaner, and a second air compressing rotor, means connecting said second rotor with said first rotor for integral rotation by said single motor, said second rotor disposed in said outer annular air passage and adapted to draw in air through said supplemental air inlet means and to compress it and force it by Venturi effect into said inner annular air passage.

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ROBERT W. MICHELL, Primary Examiner

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