Sept. 6, 1960 A. G. BODINE, JR 2,951,257

VACUUM CLEANER WITH PULSATING SUCTION

Filed June 23, 1953 2 Sheets-Sheet 1

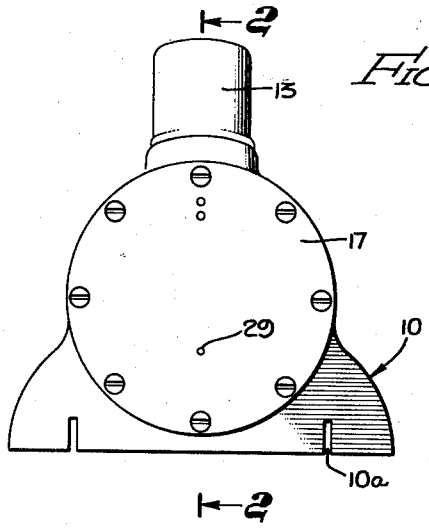


FIG. 1.

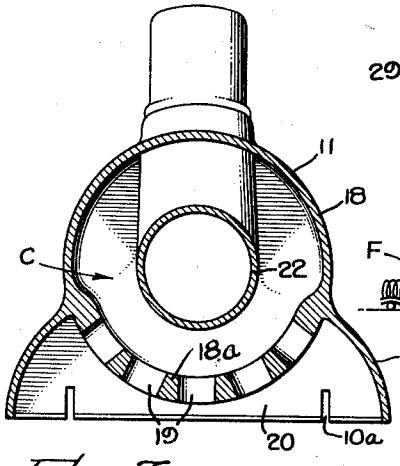


FIG. 3.

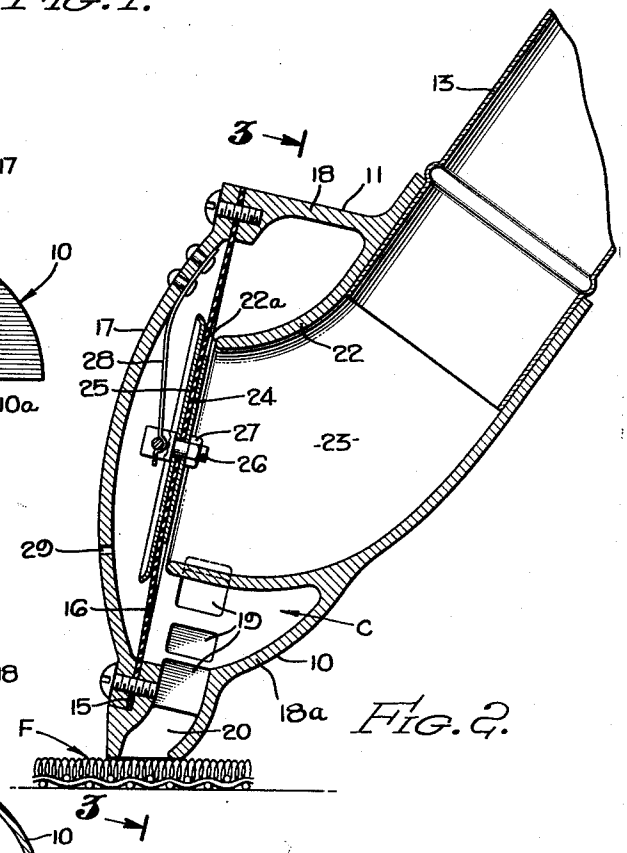


FIG. 2.

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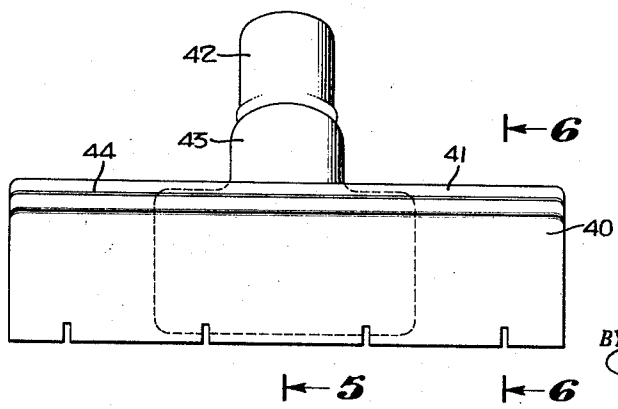


FIG. 4.

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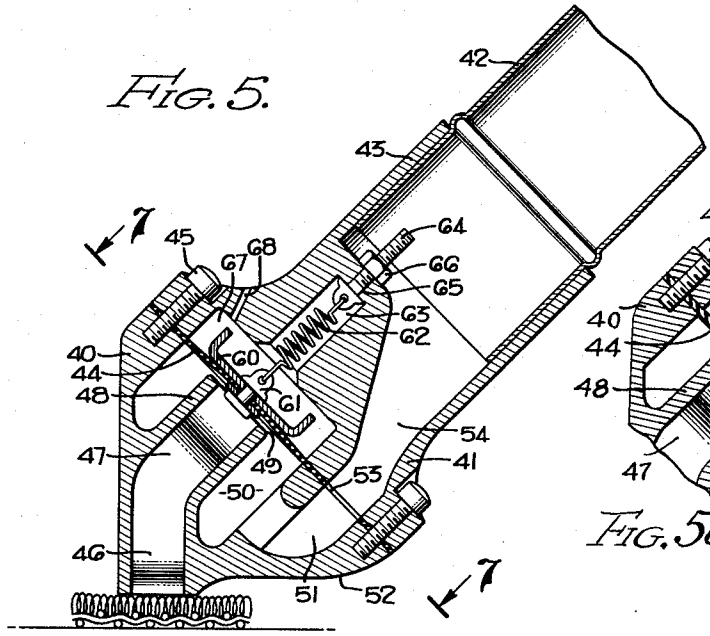
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Sept. 6, 1960 A. G. BODINE, JR 2,951,257

VACUUM CLEANER WITH PULSATING SUCTION

Filed June 23, 1953 2 Sheets-Sheet 2

FIG. 5.



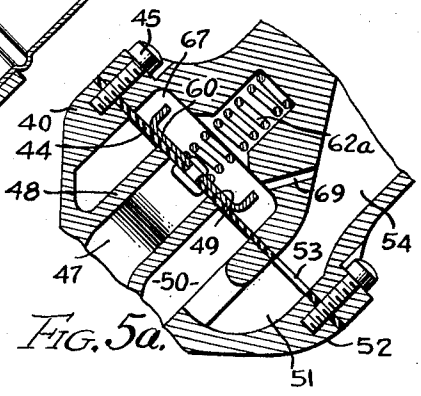


FIG. 5a.

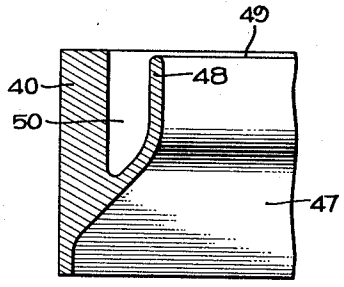


FIG. 8.

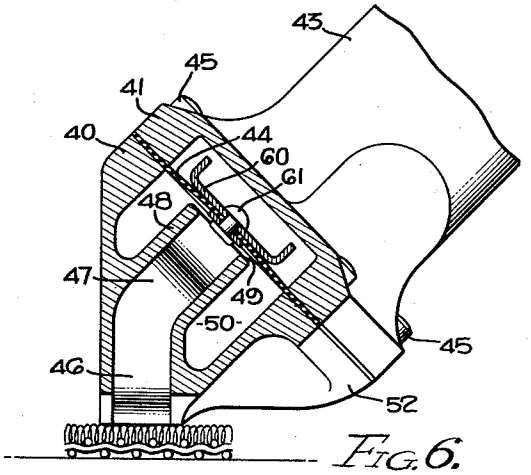


FIG. 6.

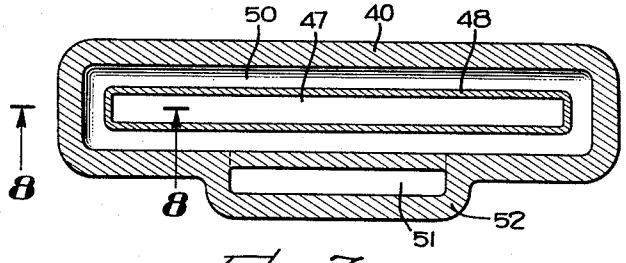


FIG. 7.

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2,951,257

VACUUM CLEANER WITH PULSATING SUCTION

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Filed June 23, 1953, Ser. No. 363,516

16 Claims. (Cl. 15—404)

This invention relates generally to suction cleaners for rugs and the like, and more particularly to suction cleaners of a novel type employing a pulsating suction air flow which greatly assists in removing dirt from the rug.

A pulsating type of suction air flow, particularly one having a frequency of many cycles per second, is especially efficacious for fabric and rug cleaning, because of the dirt loosening action inherent in the resulting vibratory motion of the fabric. However, while the fabric is vigorously vibrated, the cleaning action is of gentle nature in the respect that frictional abrasion is minimized.

It is accordingly a broad object of the invention to provide a suction cleaner characterized by pulsating suction with high frequency action at the nozzle.

Further objects of the invention relate to the provision of a pulsating suction cleaner which is simple, lightweight and easily adapted to existing designs of conventional suction cleaners.

In accordance with the invention, a suction nozzle is provided, and connected thereto is a conduit leading to a source of suction, i.e., a suction motor. A vibratory diaphragm is provided, and controls the communication between the suction line and the nozzle. In operation, the suction developed in the suction line first moves the diaphragm to shut off this communication. Air then leaks with a quick surge into the nozzle through the fabric of the rug, and as atmospheric pressure is thus built up at the diaphragm, it suddenly moves to permit the charge of atmospheric air then present in the nozzle to pass to the suction line. Suction is then again developed in the nozzle, closing the diaphragm, and so on in automatically sustained repetition. Thus is created the desired pulsating suction, which vigorously vibrates the fabric of the rug, loosening its dirt, and greatly expediting the cleaning action.

The invention will be more fully understood from the following detailed description of present illustrative embodiments thereof, reference being had to the accompanying drawings, in which:

Figure 1 is a front elevational view of a suction cleaner in accordance with the invention;

Figure 2 is a vertical medial section taken on line 2—2 of Figure 1;

Figure 3 is a section taken on line 3—3 of Figure 2;

Figure 4 is a front elevational view of second embodiment of the invention;

Figure 5 is a section taken on line 5—5 of Figure 4;

Fig. 5*a* is a view similar to Fig. 5 showing a modification;

Figure 6 is a section taken on lines 6—6 of Figure 4;

Figure 7 is a section taken on line 7—7 of Figure 5; and

Figure 8 is a section taken on line 8—8 of Figure 7.

Referring now to Figs. 1 to 3 of the drawings, the suction cleaner is shown to have nozzle **10**, formed on the lower portion of housing **11**, and tubular wand **13**. The nozzle **10** is laterally extended, in the general

fashion conventional in suction cleaners, and has a generally rectangular orifice **20**. Slots **10***a* provide auxiliary orifices, and may be provided in certain cases. This nozzle **10** is integral with housing **11**, which is of generally circular cross section, and has at the front an annular shoulder or seat **15** to receive circular diaphragm **16** and cover **17**. The housing includes a peripheral wall **18**, which includes a lower portion **18***a* extending across the nozzle and formed with ports **19** furnishing unrestricted communication between the nozzle orifice **20** and the remainder of the housing cavity.

Integral with housing **18** is a tubular member **22** having an open end defining an annular seat **22***a*, this tubular member being located within the housing in concentric relation to the flexible diaphragm **16**, and with its seat **22***a* closely adjacent the latter. This tubular member **22**, which defines an air passage or chamber **23**, is integrally joined to the walls of the housing **11** and forms the back thereof, as shown. Its rearward end extends upwardly and rearwardly at a suitable angle and has fitted thereto the conventional tubular wand **13**.

The diaphragm **16** may be composed of various materials, but I prefer a conventional neoprene impregnated diaphragm fabric of cotton or nylon, typically .015" thick. The center of this diaphragm is clamped between discs **24** and **25**, and the assembly is fastened by a screw **26** and nut **27**, as shown. Engaged de-mountably with the head of this screw **26** is a leaf spring **28**, riveted to cover **17**, and arranged to exert a normal biasing force on the diaphragm in a direction to unseat it from the seat **22***a* on the end of tube **22**. The normal position of the diaphragm is unseated from tube **22**, as shown in Fig. 2. The space inside the cover **17** is vented to atmosphere by means of vent hole **29**.

The space inside the nozzle together with the interior housing space outside of tube **22** forms a "fill-and-drain" or "capacitance" chamber C. The space or chamber **23** inside the tube **22** is understood to be connected to the vacuum line and suction motor, not shown.

Operation is as follows: nozzle **10** is applied to the fabric or rug F that is to be cleaned, as in Fig. 2. The fabric, which is of course air-porous, nevertheless very substantially constricts the orifice. With the orifice thus constricted, suction is communicated from the vacuum line through tube **22** and past the unseated diaphragm to chamber C and nozzle orifice **20**. Vacuum thus acts on the entire area of the side of the diaphragm facing the tube **22**, while atmospheric pressure communicates with the opposite side thereof. The differential of total pressures then overcomes the biasing spring **28**, and the diaphragm moves to the right to seat and form a seal against the seat **22***a* of tube **22**. This cuts the vacuum line off from chamber C, and atmospheric pressure builds up therein by virtue of air flow through the fabric F into the nozzle. If the fabric is such as too much constricts the orifice, the auxiliary orifices **10***a* may be used, and this provision increases the rate at which the chamber C can be filled. When atmospheric pressure is thus approached or attained in chamber C, the pressures on the two sides of the diaphragm outside the seat **22***a* are neutralized. The spring **28** is made strong enough that it then overcomes the differential of forces acting on the diaphragm area inside the seat **22***a*, so that the diaphragm then moves off **22***a* toward the left, and the charge of atmospheric air accumulated in chamber C is then sucked quickly into the tube **22**. Vacuum is thus again developed in chamber C (owing to the restricted inflow by reason of the presence of the fabric over the nozzle orifice), whence the cycle is repeated.

This cycle recurs rapidly, with a periodicity determined by a number of factors, among which are the suction developed in the vacuum line, the relative diaphragm

areas inside and outside the seat 22*a*, the mass of the diaphragm 16 and the strength of spring 28, the volume of chamber C, and the degree of constriction of the nozzle orifice by the fabric F, which last may vary both with the porosity characteristic of the fabric and the pressure with which the nozzle is pressed down on the fabric.

In general, the portion of the cycle devoted to build-up of atmospheric pressure in C by "leakage" through the fabric F into nozzle 10 may be large relative to the portion of the cycle devoted to suction of the air charge from C past the diaphragm into tube 22. The diaphragm thus snaps open and back closed with great rapidity, and remains closed momentarily between opening and closing movements. Its opening and closing excursion is facilitated by "tuning" it and its spring 28 to a frequency which is at least as high or higher than the frequency at which the system operates. This is accomplished by use of a very light diaphragm and a spring of substantial stiffness. Such a tuned diaphragm will not tend to lag or be sluggish in its response to the periodic influences which cause its described movements.

It is possible to use an elastic metal diaphragm, and to omit the biasing spring, in which case, of course, the diaphragm is positioned at a slight spacing from the seat 22*a*. A metal diaphragm, however, is in general undesirable because of its necessary mass and consequent sluggishness and lack of adaptability to high frequency tuning.

Attention is directed to the fact that the diaphragm normally stands open, in the position illustrated in Fig. 2; and if the cleaner nozzle is not restricted, as by being pressed down onto a rug, suction sufficient to move the diaphragm to closed position will not be developed in the chamber C. Under these conditions the diaphragm will not vibrate, and the cleaner will not emit noise owing to diaphragm vibration. In the actual operation of rug cleaning, the vibration of the diaphragm is capable of causing noise; but under these conditions, the suction nozzle is pressed down onto the rug, and the noise is muffled.

The effect of the described pulsating suction applied to the rug is to produce a strong dirt loosening and cleaning action. The fabric is vibrated bodily, and in addition, fibers, strands and threads are vibrated individually, or relatively to one another. The result is a rapid "working" of the fabric, occurring at many cycles per second, which rapidly frees both loose and caked dirt, and the cleaning action is not only greatly accelerated, but made much more thorough than has heretofore been possible.

A modification is shown in Figs. 4–7, wherein the housing comprises a laterally extended nozzle casting designated at 40, and a back housing casting 41, a tubular wand 42 being joined to tubular extension 43 of casting 41. The two parts 40 and 41 have inclined meeting planes, between which is clamped flexible diaphragm 44, and cap screws 45 serve to secure the parts together.

Nozzle 40 has extended rectangular intake orifice 46, which opens to passage or chamber 47 extending first upwardly and then, on an incline, upwardly and rearwardly to the plane of diaphragm 44, the inclined portion of the passage being bounded by a flat nozzle tube member 48 terminating in seat 49 presented in opposition to the diaphragm.

A suction chamber 50 surrounds the tube member 48, and a somewhat elongated passage 51 formed in a central enlargement 52 on the lower side of the nozzle casting extends from the lower side of chamber 50 through a port 53 in the diaphragm to a passage 54 in housing part 41. The passage 54 communicates with the interior of the tubular extension 43, and therefore with the tubular wand 42.

The diaphragm 44 is braced throughout the major portion of its length by a flanged plate 60, fastened to the diaphragm as by rivets 61, and to the center of these rivets is connected one end of a biasing spring 62, lodged in a cavity 63 in the housing part 41, the other end of the spring being connected to the head of a screw 64 passing through bore 65 and set in adjusted position by means of nut 66. In the present example, the spring 62 is a tension spring, and biases the diaphragm to take a normal position slightly separated from the seat 49, as shown. The side of the diaphragm 40 on the opposite side from seat 49 is exposed to atmospheric pressure in chamber 67, which communicates with outside atmosphere by way of vent 68.

Operation is equivalent to that of the earlier described embodiment. Suction developed by the motor connected to the wand is communicated via passages 54 and 51 to the area of the diaphragm 44 outside of the seat 49. The diaphragm being at this time separated from said seat by the bias exerted by spring 62, this suction is also communicated to the passage or chamber 47. If the nozzle is not applied to a rug or the like, the suction so developed in the system is readily satisfied by atmospheric air entering through the nozzle orifice, and the diaphragm 44 remains in its illustrated unseated position. Upon application of the nozzle to a rug, however, the nozzle orifice is very materially constricted, so that the pressure within chambers 47 and 50 is materially lowered. This causes the diaphragm to move to the left, seating against seat 49, and so sealing off the chamber 47 against the suction in the line. Thereupon, atmospheric air leaks into the chamber 47 through the fabric of the rug, and as atmospheric pressure is attained or approached in the chamber 47, the pressures on the two sides of the diaphragm inside the seat 49 are substantially neutralized, and the spring 62 moves the diaphragm back off its seat against the negative pressure then acting only on the diaphragm area outside the seat 49.

The air charge accumulated within the chamber 47 is then rapidly sucked into chamber 50 and thence evacuated via passages 51 and 54. Negative pressure then being effective over the entirety of the diaphragm 44, the diaphragm then moves instantly back onto the seat 49, and the cycle is repeated over and over, at a frequency depending upon such factors as described in connection with the first described embodiment of the invention.

Fig. 5*a* shows a modification of Fig. 5, according to which atmospheric vent 68 is omitted, and a vent 69 is provided between chamber 67 and suction passage 54, the vent 69 communicating suction to chamber 67, and thus functioning to provide a force tending to move the diaphragm off its seat. This unseating force is partially offset by compression spring 62*a* such that the suction which can be developed in chambers 47 and 50 will be capable of overcoming the net unseating force effective on the diaphragm. When the machine is stopped, or in its static condition, of course, the spring 62*a* causes the diaphragm to move onto its seat. When the machine is started, the diaphragm is separated from its seat by the suction communicated thereto within chamber 67 via vent 69, the negative force owing to suction vent 69 being larger than the partially offsetting force of spring 62*a*, thus affording a small net dynamic bias which unseats the diaphragm. Suction is then communicated to both chambers 50 and 47, but, with nozzle 46 unrestricted, the pressure does not thereby drop to a material extent, and the diaphragm remains unseated. Upon application of the nozzle to a rug, the pressure in said chambers is materially lowered, until the suction therewithin acts on the diaphragm to overcome the unseating bias, whereupon the diaphragm is moved onto its seat. This permits the pressure at 47 to increase (by leakage of air through the rug into the nozzle), until the biasing force on the diaphragm again becomes dominant and moves the diaphragm off its seat. Suction is then communicated from chamber 50 past seat 49 to chamber 47, reducing the pressure in the latter sufficiently to overcome the net unseating bias on the diaphragm, and the diaphragm again closes, and so on.

It will be understood that the embodiments of my invention here shown are for illustrative purposes only, and that various changes in design, structure and arrangement may be made without departing from the spirit and scope of the appended claims.

I claim:

1. In a suction cleaner, the combination of: a housing containing a chamber, a flexible vibratory diaphragm peripherally supported in said chamber and dividing the same into two parts, fixed wall means in said chamber dividing one of said chamber parts into two compartments exposed to a common side of said diaphragm and including a diaphragm valve seat between said compartments facing said diaphragm and adapted in coaction with the vibrating diaphragm alternately to form an air seal and an air suction passage between said compartments, a nozzle applicable to a rug or the like communicating with one of said compartments, a suction pipe communicating with the other of said compartments, and means for urging said diaphragm to move away from said seat, said diaphragm being movable onto said seat in opposition to said last mentioned means in response to suction developed in said compartments when said nozzle is applied to a rug or the like, and being movable away from said seat by said means upon resulting increase in pressure in the compartment which is in communication with said nozzle.

2. In a suction cleaner, the combination of: a housing containing a chamber, a flexible vibratory diaphragm peripherally supported in said chamber and dividing the same into two parts, fixed wall means in said chamber dividing one of said chamber parts into two compartments exposed to a common side of said diaphragm and including a diaphragm valve seat between said compartments facing said diaphragm and adapted in coaction with the vibrating diaphragm alternately to form an air seal and an air suction passage between said compartments, a nozzle applicable to a rug or the like communicating with one of said compartments, a suction pipe communicating with the other of said compartments, and means biasing said diaphragm to yieldingly occupy normally a position separated from said diaphragm seat, said diaphragm being movable onto said seat in opposition to said biasing means in response to suction developed in said chambers when said nozzle is applied to a rug or the like, and being movable away from said seat by said biasing means upon resulting increase in pressure in the compartment which is in communication with said nozzle.

3. The subject matter of claim 2 wherein said diaphragm urging means includes a spring acting to separate said diaphragm from said seat.

4. The subject matter of claim 2 wherein said diaphragm urging means includes a spring acting to separate said diaphragm from said seat, and wherein the housing chamber part on the side of said diaphragm opposite to said common side is vented to atmosphere.

5. In a suction cleaner, the combination of: a housing having a suction nozzle formed with an intake orifice adapted to be applied to and to be substantially constricted by a rug or the like, a chamber in said housing in communication with said orifice, a flexible diaphragm peripherally supported in said housing, having an inner wall surface defining a boundary of said chamber, a suction tube having an open end formed with a diaphragm seat positioned closely adjacent but normally spaced from said inner surface of said diaphragm, said suction tube being adapted for connection to a suction source, and means biasing said diaphragm to stand normally but yieldingly in a position slightly spaced from said diaphragm seat, said diaphragm being movable onto said seat in response to suction developed in said suction tube and chamber when said nozzle orifice is applied to a rug or the like.

6. The subject matter of claim 5, wherein the biasing means comprises a spring arranged to yieldingly oppose movement of said diaphragm onto said seat.

7. In a suction cleaner, the combination of: a housing formed at the bottom with a suction nozzle having an intake orifice adapted to be substantially constricted by a rug or the like, a chamber in said housing above and in constant communication with said nozzle orifice, said housing having a front wall formed with an opening into said chamber, a flexible diaphragm mounted in said front wall over said opening, whereby the inner surface of said diaphragm forms a bounding surface of said chamber, and a suction tube in said housing having an open ended portion within said chamber formed at its extremity with a bounding seat positioned closely adjacent but normally separated slightly from said diaphragm, and a spring biasing means normally but yieldingly holding said diaphragm in said normal position of separation from said seat, said spring biasing means permitting said diaphragm to move onto said seat upon development of suction in said suction tube and said chamber when said nozzle orifice is applied to a rug or the like.

8. In a suction cleaner, the combination of: a housing formed at the bottom with a suction nozzle having an intake orifice adapted to be substantially constricted by a rug or the like, a chamber in said housing above and in constant communication with said nozzle orifice said housing having a front wall formed with an opening into said chamber, a flexible diaphragm mounted in said front wall over said opening, whereby the inner surface of said diaphragm forms a bounding surface of said chamber, and a suction tube in said housing having an open ended portion within said chamber formed at its extremity with a bounding seat positioned closely adjacent but normally separated slightly from said diaphragm, a cap vented to atmosphere mounted on said front wall of said housing over said diaphragm, and a spring biasing means normally but yielding holding said diaphragm in said normal position of separation from said seat, said spring biasing means permitting said diaphragm to move onto said seat upon development of suction in said suction tube and said chamber when said nozzle orifice is applied to a rug or the like.

9. The subject matter of claim 2, in which said one of said compartments is in the form of a tube inside the other of said compartments, and communicates at one of its ends with said nozzle, and wherein said diaphragm valve seat terminates and is formed around the other end of said tube.

10. The subject matter of claim 9, wherein the biasing means comprises a spring arranged to yieldingly oppose movement of said diaphragm onto said seat.

11. The subject matter of claim 10, including also a vent exposing the side of said diaphragm away from said seat to atmospheric pressure.

12. In a suction cleaner, the combination of: a hollow housing, a flexible diaphragm peripherally supported across the interior of said housing, fixed wall means in said hollow housing dividing the interior space of said housing at one side of said diaphragm into two compartments defined at one side by different portions of a common side of said diaphragm and including a diaphragm valve seat between said compartments facing said diaphragm and adapted in coaction with the vibrating diaphragm alternately to form an air seal and an air suction passage between said compartments, a nozzle applicable to a rug or the like communicating with one of said compartments, a suction pipe communicating with the other of said compartments, and means supporting said flexible vibratory diaphragm from said housing in a normal position slightly spaced from said valve seat, in such manner that said diaphragm deflects cyclically into sealing engagement with said seat in response to suction developed in said compartments when said nozzle is applied to a rug or the like, and resumes said normal position upon increase in pressure in said compartment which is in communication with said nozzle.

13. In a suction cleaner, the combination of: a hollow

housing, a flexible diaphragm peripherally supported across the interior of said housing, fixed wall means in said hollow housing dividing the interior space of said housing at one side of said diaphragm into two compartments defined at one side by different portions of a common side of said diaphragm and including a diaphragm valve seat between said compartments facing said diaphragm and adapted in coaction with the vibrating diaphragm alternately to form an air seal and an air suction passage between said compartments, a nozzle applicable to a rug or the like communicating with one of said compartments, a suction pipe communicating with the other of said compartments, and means for urging said diaphragm to move away from said seat, said diaphragm being movable onto said seat in opposition to said last-mentioned means in response to suction developed in said compartments when said nozzle is applied to a rug or the like, and being movable away from said seat by said means upon resulting increase in pressure in the compartment which is in communication with said nozzle.

14. In a suction cleaner, the combination of: a housing containing a chamber, a flexible vibratory diaphragm peripherally supported in said chamber and dividing the same into two parts, fixed wall means in said chamber dividing one of said chamber parts into two compartments exposed to a common side of said diaphragm and including a diaphragm valve seat between said compartments facing said diaphragm and adapted in coaction with the vibrating diaphragm alternately to form an air seal and an air suction passage between said compartments, a nozzle applicable to a rug or the like communicating with one of said compartments, a suction pipe communicating with the other of said compartments, and an air suction passage communicating the other of said chamber parts to said suction pipe, whereby a suction is developed in said other chamber part and acts on the side of said diaphragm opposite to said common side whereby to yieldingly bias said diaphragm away from said seat during operation of the cleaner, the diaphragm being movable cyclically onto said seat in opposition to said bias in response to suction developed in said compartments when said nozzle is applied to a rug or the like, and being movable away from said seat by said suction bias upon resulting increase in pressure in the compartment which is in communication with said nozzle.

15. The subject matter of claim 14, including a spring acting on said diaphragm in a direction to counteract a portion of said suction bias.

16. In a suction cleaner, the combination of: a hollow housing, a flexible resilient diaphragm peripherally supported across the interior of said housing, fixed wall means in said hollow housing dividing the interior space of said housing at one side of said diaphragm into two compartments defined at one side by different portions of a common side of said diaphragm and including a diaphragm valve seat between said compartments facing said diaphragm and adapted in coaction with the vibrating diaphragm alternately to form an air seal and an air suction passage between said compartments, a nozzle applicable to a rug or the like communicating with one of said compartments, and a suction pipe communicating with the other of said compartments, said flexible resilient diaphragm being so-mounted as normally to assume a positon off said seat, and being resiliently deflectable onto said seat in response to suction developed in said compartments when said nozzle is applied to a rug or the like, and being movable away from said seat by its internal restoring stresses upon resulting increase in pressure in the compartment which is in communication with said nozzle.

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