Aug. 4, 1970 K. ZENKNER 3,522,994

VACUUM CLEANER

Filed May 20, 1968 3 Sheets-Sheet 1

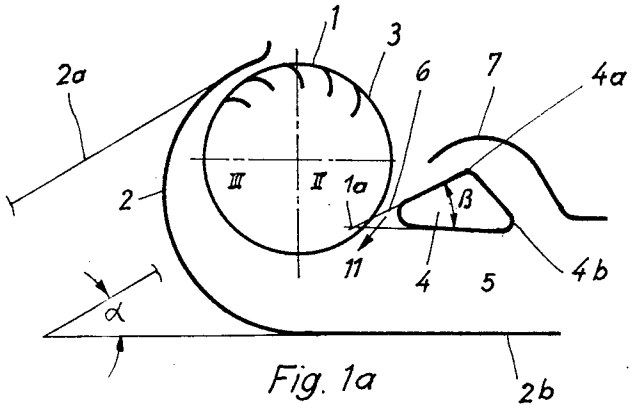


Fig. 1a

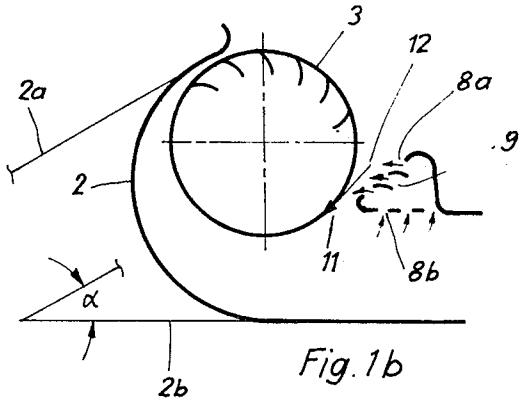


Fig. 1b

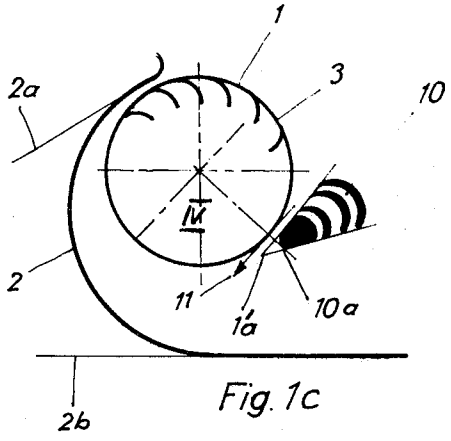


Fig. 1c

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VACUUM CLEANER

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$$\psi_{st} = \frac{\Delta p_{st}}{\varrho/2 \cdot u_2^2}$$

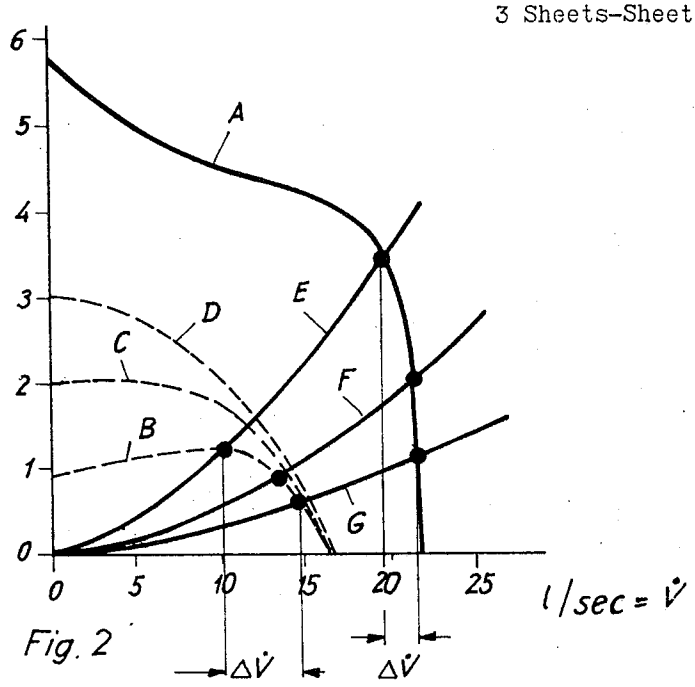


Fig. 2

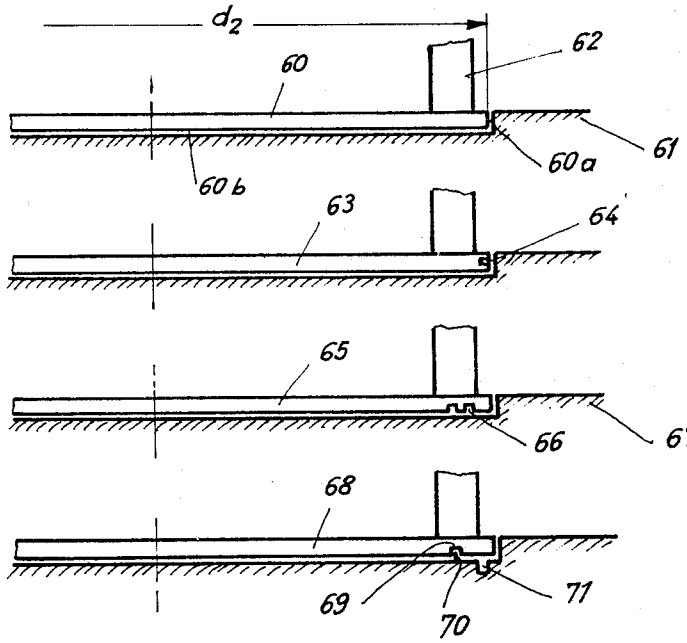


Fig. 4a

Fig. 4b

Fig. 4c

Fig. 4d

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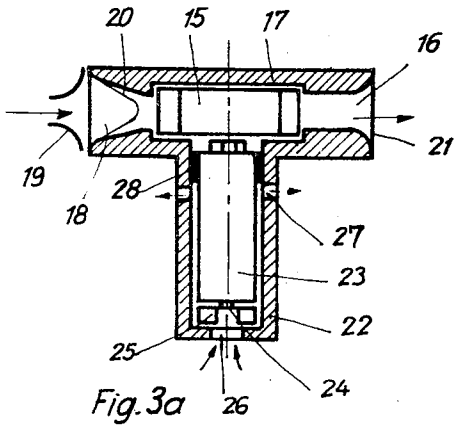


Fig. 3a

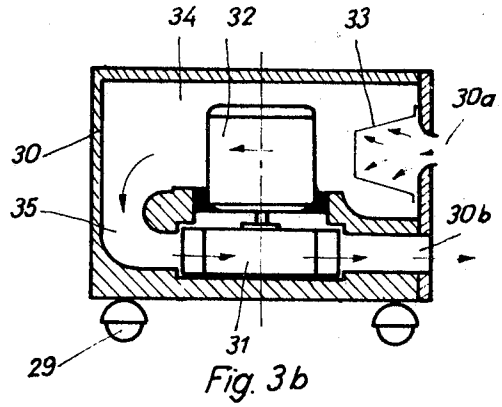


Fig. 3b

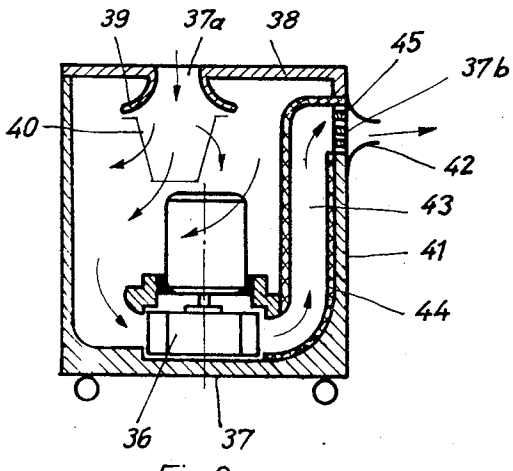


Fig. 3c

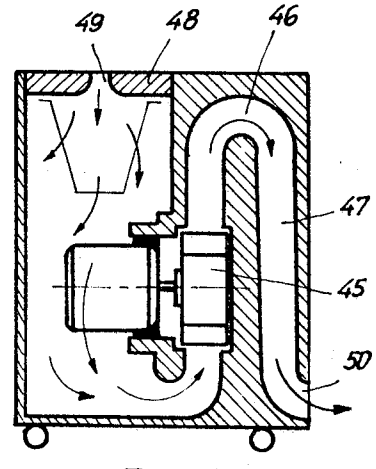


Fig. 3d

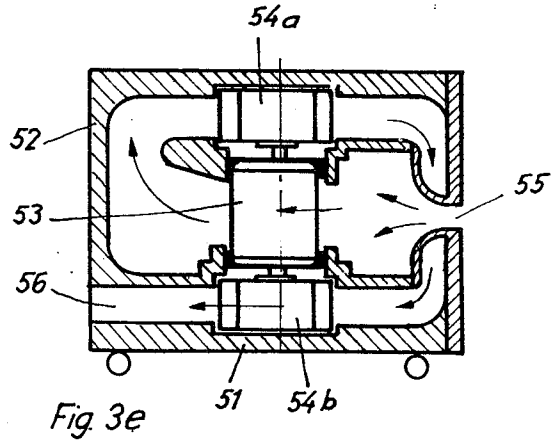


Fig. 3e

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VACUUM CLEANER

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Claims priority, application Germany, May 18, 1967, 1,628,428
The portion of the term of the patent subsequent to Aug. 27, 1985, has been disclaimed
Int. Cl. F04b 17/08; F04d 39/00
U.S. Cl. 415—53 17 Claims

ABSTRACT OF THE DISCLOSURE

A vacuum cleaner has a casing in which is mounted a blower for feeding air to an outlet duct. The ends of the rotor are closed by end plates. A wall section starting adjacent the periphery of the rotor and diverging therefrom extends around the outside of the rotor for approximately 180°. The tangents to the beginning and end points of this wall section form an angle of less than 90°. A wedge-shaped section of wall positioned on the side of the rotor opposite the first wall section has associated with it an arrangement for producing a return of part of the flow to the rotor periphery. The planes of the walls of the wedge-shaped section on the pressure and suction sides meet in a point close to the periphery of the rotor.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a vacuum cleaner having a blower with a so-called cross-flow rotor driven by a motor, the rotor being disposed in a flow-channel portion of the vacuum housing, acting as an air conduit, between a suction aperture with its dust filter and an outlet aperture, hereinafter and in the claims referred to as a "vacuum cleaner of the type aforesaid."

The prior art

The basic condition for an efficiently and reliably operating vacuum cleaner, and one which always forms a problem, is to produce a very high pressure with a constant feed rate and the minimum possible space utilisation, with the feed rate at high pressures as low as possible in relation to pressure. This is especially true because the surfaces being cleaned may have very different properties, so that, for instance, a velour carpet, a sisal carpet or a smooth floor may require very considerably differing pressures. With known vacuum cleaners of the type aforesaid, these high pressures can only be provided by putting several blower stages in sequence, assuming one does not wish to use a large diameter blower which would have the disadvantage of not meeting a further basic requirement in vacuum cleaner design, that is, use of the minimum possible space, quite apart from the need for large forces and dimensions. But multi-stage arrangements are complicated and expensive in construction, which should also be avoided.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a vacuum cleaner without the above disadvantages and whose blower can produce a very high pressure at constant volumes, without the necessity for a multi-stage arrangement and without taking up excessive room.

The present invention is a vacuum cleaner of the type aforesaid in which the rotor is held at its two axial end faces between closed or solid wall sections or end plates and in which directly adjacent to the rotor periphery is a section of wall, serving as an air feed conduit, which seen in the flow direction, bellies out from the rotor inlet and becomes of spiral form, and acts as a guide plate, the tangent to the beginning of this wall section acting as a guide plate making an angle below 90° with the tangent to the end of this wall section, the radii from the rotor centre point to the tangent contact points enclosing an angle of about 180°, a wedge-shaped section of the wall serving as an air feed conduit being located immediately adjacent to the rotor and functioning as a turbulence tongue, said section lying substantially diametrically opposite to the wall section acting as a guide plate, and separating the pressure side from the suction side, the wall-section on the suction side forming with the rotor periphery a gap broadening in the direction of rotation and with its pressure side enclosing an acute angle, the wedge-shaped wall section functioning as a turbulence tongue helping to form a channel for returning part of the flow to the rotor periphery, the width of the cross-flow rotor measured axially being several times less than its diameter.

The device provided by the invention has the advantage that with constant volumes a pressure factor up to a value of about 10 can be achieved, which compares favourably with large diameter drum rotors which are commonly stated to have the highest achievable pressure value, a ψst of 2.5–2.8. The new blower device produces a highly stable characteristic line of constant and regular inclination, whereby extremely high ψst values can be reached. The single-stage blower arrangement is fully adequate, the space taken up is as low as possible.

Since performance can also be reduced by excessive marginal influences, so that the non-dimensional characteristic line may unavoidably sink even at high Reynolds numbers, according to a further aspect of the invention a vacuum cleaner of the type aforesaid has the end plates of the cross-flow rotor set in a recess in the vacuum cleaner housing, so that between the plates and the adjacent face of the corresponding housing side wall there is a gap in the radial direction of less than 1%, and in the axial direction of less than 1.5%, of the rotor diameter. With this arrangement a change in counter-pressure only involves a slight volume change. The high end peaks of the rotor characteristic line—conventional blowers have nothing comparable—provide an ideal method of avoiding clogging in the vacuum cleaning suction lines.

As already mentioned, the static pressure which can be achieved is a multiple of that for similarly sized conventional blowers. The flow from the blower wheel into the housing is such that there is no jump in level on entering the rotor.

BRIEF DESCRIPTION OF THE DRAWING

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGS. 1*a*, 1*b*, 1*c* are three different embodiments of a blower for use with the new vacuum cleaner provided by the invention, purely diagrammatically, in side view;

FIG. 2 is a diagram showing the characteristic lines of various vacuum cleaner rotors for comparison;

FIGS. 3*a*-3*e* are various ways of incorporating the new blower in a vacuum cleaner as provided by the invention, each in side view and vertical section;

FIGS. 4*a*–4*d* are details of further variations of the inventive concept, in side view and vertical section.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In a vacuum cleaner of the type aforesaid, its blower is formed in special manner. Referring firstly to FIGS. 1*a* to 1*c* a rotor is held between closed or solid wall sections or end plates at its two axial end faces. Immediately adjacent to the periphery of the rotor **1** is

a wall-section **2** functioning as a guide-plate which, as seen from the flow direction bellies away from the rotor behind an inlet **3** and thus adopts a spiral shape. The arrangement here is such that guide-plate or wall-section **2** corresponding to a rotor periphery covers an outer sector angle of 180°, and a tangent **2***a* to the start of the wall-section **2** forms an angle appreciably below 90° with tangent **2***b* to the end of the wall-section. Immediately adjacent to the rotor **1** is a wall-section **4** acting as a so-called "turbulence tongue," of wedge shape and separating a pressure side **5** from a suction side **3** which is disposed in general diametrically opposite the wall-section guide-plate **2**. The suction-side wall **4***a* of this wall-section **4** forms, with the rotor periphery, a gap **6** broadening out in the direction of rotation, while, with the pressure-side wall, it encloses an acute angle of, for example, 20–60°. Thus this wedge-shaped wall-section **4** forming a turbulence tongue helps to form a channel for returning part of the flow to the rotor periphery. In the FIG. 1*a* embodiment the wall **7** is used with the wedge-shaped wall-section **4** for this purpose, while in the FIG. 1*b* embodiment the wall-section is formed as a hollow body with apertures **8***a* on the suction-side part of the wall and apertures **8***b* on the pressure side, so that the medium can return from the pressure-side to the suction-side following arrows **9**. In the FIG. 1*c* embodiment the wedge-shaped wall-section is pierced by channels **10** open at both ends to return the medium to the suction side. In all these cases the arrangement is such that the stream of returned medium is directed generally tangentially to the rotor periphery, as indicated by arrows **11** in FIGS. 1*a*, 1*b*, 1*c*. The wedge-shaped turbulence tongue is so disposed relative to the rotor that a point **1***a*, where the imaginary extensions of the two wall portions intersect, lies in the second half, taken clockwise, of the quadrant II (FIG. 1*a*) adjacent to the turbulence tongue, or in the immediately adjacent area of the succeeding quadrant III. FIG. 1*c* shows that this point **1***'a* can also lie in quadrant IV based on the radius to the tip **10***a* of the wedge-shaped turbulence tongue. The arrangement is also such that the width of the cross-flow rotor measured in the axial direction is several times less than its diameter.

The return channel can taper from the pressure side to the suction side, and the arrangement may also be such that the wall sections and parts helping to form the return channel form in combination a wedge-shaped body.

FIG. 2 shows for comparison purposes the characteristic line A of a novel vacuum cleaner with the blower provided by the invention, the line B for a single-stage radial blower with rearwardly directed blades and lines C and D for radial blowers of two-stage and three-stage construction respectively. Curves E, F, G, correspond to the so-called "operating characteristic" for a velour carpet, a sisal carpet and a smooth floor respectively. The graph clearly shows the technical air feed advantages of a single-stage high stability cross-flow blower when compared even with a three-stage radial blower. The manufacturing cost of a single-stage cross-flow blower is naturally appreciably less than for the multi-stage radial blower. A further advantage provided by the invention is that the blower can be axially expanded as desired, which increases air throughput linearly. This cannot be achieved with radial blowers, for instance, since the circular air-inlet cross-section must be larger than the cylindrical air passage cross-section in that case.

FIGS. 3*a* to 3*e* show embodiments of vacuum cleaners made in accordance with the invention. The cross-flow blower **15** in FIG. 3*a*, axially narrow relative to its diameter, is mounted in a flow channel **16** of a vacuum cleaner housing portion **17** forming a transverse channel, and at the left-hand end of the channel **16** is an inlet aperture **18** with a carpet nozzle **19** and dust-bag **20**, while the right-hand end has an outlet aperture **21**, preferably of large area, so that the air can flow out freely and relatively quietly. The vacuum cleaner housing portion **22**, forming the longitudinal part and also the handle, contains an electric drive motor **23**, of narrow construction, having its axle connected to the rotor of the cross-flow blower **15**. An axle **24** projecting from the motor housing on the other side carries a fan-wheel **25** for cooling the motor. The housing portion **22** has an air inlet aperture **26** and an outlet aperture **27** to permit access of air to the motor **23**, which is resiliently affixed to the vacuum cleaner housing by a rubber ring **28** or the like.

With the vacuum cleaners in FIGS. 3*b*–3*d* the drive motor is cooled not by a separate fan-wheel as in the FIG. 3*a* arrangement, but directly by the air sucked in by the cross-flow blower. The vacuum cleaner housing **30** in FIG. 3*b*, standing on the floor with feet **29**, again has a narrow cross-flow blower **31** disposed in the flow channel and with its rotor connected to the axle of a flexibly mounted drive motor **32**. Here the cross-flow blower **31** with drive motor **32** is disposed normally to the base of the housing **30**. Inlet aperture **30***a* is on the right-hand side of the housing **30**, and an outlet aperture **30***b* is directly below the inlet aperture **30***a*. The air sucked in passes through a dust-bag **33** in a housing cavity **34** whereinto motor **32** projects. In this manner the air flowing into cavity **34** also surrounds the motor housing, thus cooling the motor. From the cavity **34** the sucked-in air passes through a channel base **35** to the cross-flow blower **31**, and thence through outlet aperture **30***b* into the atmosphere again.

With the vacuum cleaner arrangement in FIG. 3*c* the axis of a resiliently mounted motor/blower unit is again normal to the base of a housing **37**, but in this case, an inlet aperture **37***a* is provided in the top horizontal surface or wall **38** of housing **37**. Adjacent to this top inlet aperture is an internal funnel-shaped expanded portion **39** carrying a dust-bag **40**. In the upper part of a right-hand side wall **41** of the cleaner housing is an outlet aperture **37***b* with an external tubular extension **42**. The walls of a channel **43** extending between the cross-flow rotor and the outlet aperture are clad with sound-absorbing material as shown at **44**. The outlet aperture is also provided with a grating **45**.

With the vacuum cleaner of FIG. 3*d* a motor/blower unit **45** is disposed horizontally in the cleaner housing. Here an inlet aperture is at the top left, **49**, and an outlet aperture at bottom right, **50**, in the vacuum cleaner housing. A bend **46** in a flow channel **47** causes a deflection of the air stream.

The motor/blower unit **53**, arranged normal to base **51** of a housing **52** of the vacuum cleaner in FIG. 3*e*, has two cross-flow blowers **54***a*, **54***b*, the extended drive motor axles being connected to both. At the centre of the right side of the housing is an inlet aperture **55**, with an outlet aperture **56** on the bottom left. Since the motor carries a blower on both sides, it is resiliently mounted at both its sides. The two blowers are arranged in sequence in the flow channel. The path of the sucked-in air is shown by arrows in the drawing.

FIGS. 4*a*–4*d* show examples of the infinitely variable entry of air into the rotor of a vacuum cleaner blower provided by the invention, and for the sealing between rotor and cleaner housing, only the corner of a rotor and the corresponding part of the housing being shown in each case. FIG. 4*a* shows a narrow smooth gap between a rotor end-plate **60** and a housing **61**, both radially at **60***a* and axially at **60***b*. The rotor end plate **60** projects radially beyond the blower blade **62**, leaving the concentric gap **60***a* to the housing **61** which is less than 1% of the blower diameter d_2. In FIG. 4*b* the edge of end-plate **63** has a groove **64**. In the arrangement of FIG. 4*c* the blower end-plate has grooves **66** on the side opposite housing **67** or the flat side. With the FIG. 4*d* arrangement, the end plate **68** also has grooves **69** whose

sealing effect is increased in this case by lips **70** projecting into the grooves. In this case two grooves **71** are provided in the side of the housing opposite the end plate. With all these embodiments the arrangement is also such that there is a flush transition from the housing surface to the inside of the end plate, that is, these two adjacent areas are contained in one plane.

The arrangement may, with advantage, have the vacuum cleaner housing itself form the air feed.

Although my invention has been illustrated and described with reference to the preferred embodiments thereof, I wish to have it understood that it is in no way limited to the details of such embodiments, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. A vacuum cleaner of the type aforesaid having closed end plates, a rotor held at its axial end faces between said end plates, and having directly adjacent to the rotor periphery a first section of wall, serving as an air feed conduit, which, seen in the flow direction, bellies out from the rotor inlet and becomes of spiral form and acts as a guide plate, the tangent to the beginning of said first wall section making an angle below 90° with the tangent to the end of said first wall section, the radii from the rotor center point to the tangent contact points enclosing an angle of about 180°, a second wedge-shaped section of wall serving as an air feed conduit located immediately adjacent to the rotor and functioning as a turbulence tongue, said section lying substantially diametrically opposite to the first wall section and separating the pressure side from the suction side, the face of the second wall section on the suction side forming with the rotor periphery a gap broadening in the direction of rotation and with the face of the second wall section on its pressure side enclosing an acute angle, and means associated with the wedge-shaped wall section to form a channel for returning part of the flow to the rotor periphery, the width of the cross-flow rotor measured axially being several times less than its diameter.

2. A vacuum cleaner as claimed in claim **1**, in which the face of the suction side wall section of the wedge-shaped wall portion encloses an angle of 20–60° with the face of the pressure side wall section thereof, while the point whereat the planes of these two walls intersect lies immediately adjacent the rotor periphery.

3. A vacuum cleaner as claimed in claim **2**, in which the point whereat the planes of the two wall sections intersect lies in the approximate area of the second half, viewed clockwise, of the quadrant of the rotor opposite the turbulence tongue.

4. A vacuum cleaner as claimed in claim **2**, in which the point whereat the planes of the two wall sections intersect lies in the area of the quadrant based on the radius from the center of the rotor to the tip of the wedge-shaped turbulence tongue.

5. A vacuum cleaner as claimed in claim **1**, in which the return feed channel forming means includes means to return part of the feed in a direction substantially tangential to the rotor periphery.

6. A vacuum cleaner as claimed in claim **1**, in which the suction-side wall section of the second wall portion has first apertures forming outlet apertures for the return feed channel, while the pressure side wall section of the turbulence tongue has second apertures forming inlets for the return feed channel, and in which the second wall section is a hollow body, said first and second apertures and said hollow body constituting said channel forming means.

7. A vacuum cleaner as claimed in claim **1** in which the wedge-shaped wall section is penetrated by channels open at both ends, constituting said channel forming means.

8. A vacuum cleaner as claimed in claim **1** in which the return feed channel forming means comprises the wedge-shaped wall section and a separate adjacently disposed guide plate.

9. A vacuum cleaner as claimed in claim **1**, in which the return feed channel tapers from the pressure side to the suction side.

10. A vacuum cleaner as claimed in claim **9**, in which the wall sections and parts forming the return feed channel constitute in combination a wedge-shaped body.

11. A vacuum cleaner as claimed in claim **1**, having means to deflect the air through at least 90° during its path between the inlet and outlet apertures.

12. A vacuum cleaner as claimed in claim **1**, in which the rotor has end plates so mounted in a depression in the cleaner housing, the space between the end plates and the adjacent surface of the housing side wall being less than 1% of the rotor diameter in the radial direction, and of less than 1.5% of the rotor diameter in the axial direction.

13. A vacuum cleaner as claimed in claim **12**, in which the rotor end plates are mounted in the housing depression with a flush transition between the housing surface and the inner side of the end plate.

14. A vacuum cleaner as claimed in claim **13**, in which the edge and/or flat surfaces of the rotor end plate have grooves forming a labyrinthine seal on the side opposite the corresponding housing depression.

15. A vacuum cleaner as claimed in claim **13**, in which the depression in the housing has grooves forming a labyrinthine seal at the side facing the end plate.

16. A vacuum cleaner is claimed in claim **15** in which a rib on one part projects into the grooves formed on the opposite part.

17. A vacuum cleaner as claimed in claim **1** in which the rotor has end plates and the cleaner housing has depressions therein opposite the end plates, the end plates being positioned in the housing depressions with a flush transition between the housing surface and the inner sides of the end plates and the surfaces of the wall portions of the housing around the depressions lying in the same plane as the inner sides of the end plates.

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U.S. Cl. X.R.

15—375; 230—132, 133, 232; 415—172; 417—371