(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 475 028 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.11.2004 Bulletin 2004/46

(51) Int Cl.[7]: **A47L 9/18**

(21) Application number: **04002891.2**

(22) Date of filing: **10.02.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: **07.05.2003 IT MI20030920**

(71) Applicant: **GISOWATT S.P.A. Industria Elettrodomestici**
21055 Gorla Minore (Varese) (IT)

(72) Inventor: **Sozzi, Validio**
20155 Gorla Minore (VA) (IT)

(74) Representative: **Coloberti, Luigi**
Via E. de Amicis No. 25
20123 Milano (IT)

(54) Liquid bath vacuum cleaner with dynamic separator

(57) The liquid bath vacuum cleaner comprises a suction fan assembly (16) and a dynamic separator (21) extending into an air wirling chamber (22). The separator (21) comprises a basket-like cylindrical body provided with a plurality of slots (34) for the passage of the air, and peripheral fins (21). Each fin has a wide flat front surface (SF2), rearwardly slanted in a direction opposite to the rotation of the separator (21), for ejecting the particles of dust (P) towards the wirling chamber (22), into the liquid bath.

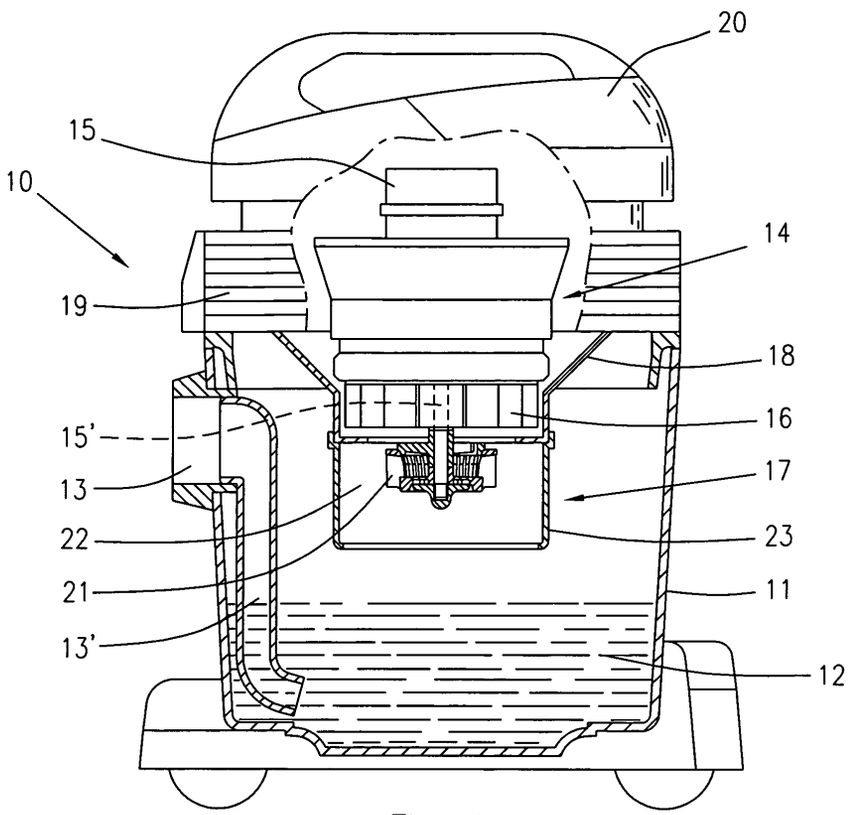

Fig. 1

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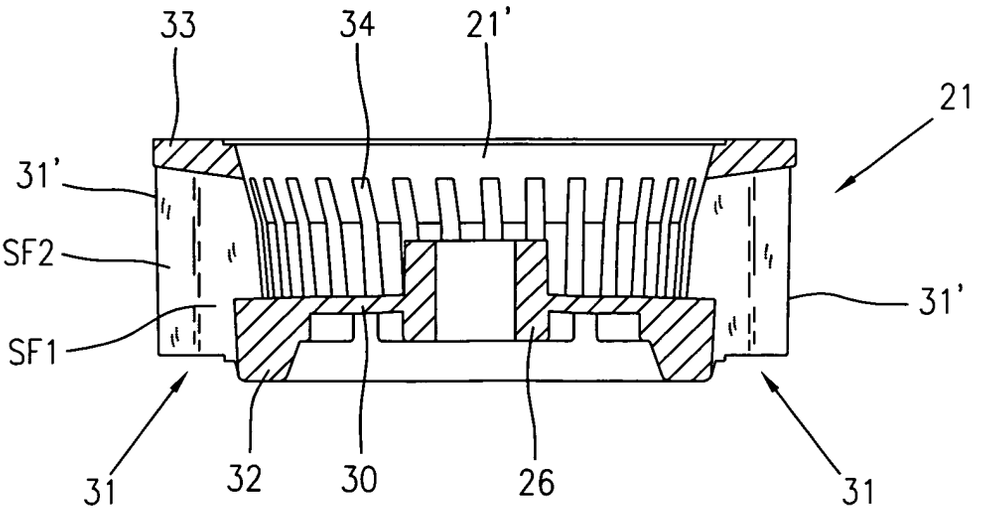

Fig. 6

Description

BACKGROUND OF THE INVENTION

[0001] This invention refers to improvements in dirt and dust filtering and separating systems for vacuum cleaners of the liquid bath type, and more in particular relates to a compact and highly efficient liquid both vacuum cleaner provided with liquid and air stream separator of dynamic type, according to claim 1.

STATE OF THE ART

[0002] Vacuum cleaners of various types are widely used in different residential environments for cleaning purposes or for other similar uses.

[0003] In particular, the so-called "liquid bath" vacuum cleaners are known, in which the stream of sucked air, which is laden with dust and particles of dirt, is first made to pass through a liquid bath at the bottom of a water pan assembly, in which a large amount of the dust and particles of dirt are trapped before the air stream is returned towards the outside environment.

[0004] An important advantage of this type of filtering system consists in the elimination of a large amount of the dust and particles of dirt, without the need to use mechanical filters and to replace them from time to time, but simply by changing the dirty water in the filtering bath.

[0005] Although liquid bath vacuum cleaners have proved to be extremely efficient, a moderate percentage of fine dust and particles is nevertheless able to pass through the liquid bath and be conveyed by the air stream towards the outside environment.

[0006] Consequently, in liquid bath vacuum cleaners of the aforementioned kind, in order to trap the largest possible percentage of dust and fine particles entrained by the flow of intake air, use is made of rotary separators operatively connected to the driving shaft of a fan.

[0007] Examples of liquid bath vacuum cleaners having a rotary separator, are in EP-A-0.053.508, US-A-4.693.734, GB-A-2.372.200 and EP-A-1.219.223.

[0008] In particular, in EP-A-0.053.508 and GB-A-2.372.200 use is made of dust separators in the form of a rotating disk positioned close to the air intake fan; the use of simple rotating disks however has proved to be somewhat inefficient and unable to remove a large percentage of dust and fine particles.

[0009] US-A-4.693.734 illustrates a liquid bath vacuum cleaner comprising a rotary type separator which freely extends downwards, directly into the water pan for the liquid bath below. The separator is substantially in the form of a cup-shaped element whose peripheral wall is provided with a plurality of blades for directing the air inside the water pan assembly. A complicated path makes it possible to separate an air flow for cooling the motor, from the cleaned air stream which is made to return to the outside environment.

[0010] This vacuum cleaner, in addition to the complexity of the filtering system for the intake and circulation of the air stream, also seems to be incapable of efficient separation of the dust and fine particles, as a result of the simple cup conformation of the separator and its disposition within the water pan.

[0011] Lastly, EP-A-1.219.223 which constitutes the prior art closest to this invention, illustrates a liquid bath vacuum cleaner provided with a rotary type separator which extends into a dust separation chamber having a peripheral wall open towards the bottom and towards the liquid bath below.

[0012] Although this solution in some ways has proved to be advantageous, in that a sort of air wirling is created in the dust separation chamber, which by effect of the centrifugal force increases the efficacy of the separation of the dust and particles of dirt from the stream of intake air, in practice it has revealed a number of drawbacks due to the specific disposition and conformation of the separator.

[0013] In fact, because of the truncated cone shape of the separator and the helicoidal development of the fins defining the inlet apertures for the passage of the air, as well as the extremely limited surface area of the same fins, it was not possible to achieve high percentages of separation of the dust and fine particles, which were partly entrained by the air stream again towards the outside.

[0014] Moreover, the truncated cone conformation and the helicoidal shape of the fins and the apertures for the air passage, due to the different circumferential speeds along the rotational axis of the separator, gave rise to a differentiated separation degrees, in the longitudinal direction of the separator, and accumulation of dust on the fins causing unbalanced working conditions for the separator and of the air intake fan; unbalanced conditions for the separator and the air intake fan in turn gave rise to greater wear and noise. This phenomenon was also increased by the fact that in order to compensate for the limited number of fins, and the limited dimensions of the separator, the latter had to be made to rotate at a high speed, for example ranging from 20,000 to 30,000 revolutions (rpm) in order to maintain a sufficient air flow intake.

[0015] The truncated cone shape of the separator and the helicoidal form of the fins constituted a further cause of

unbalancing, because of the complexity and the use of movable parts in the manufacturing mould, it was not possible to achieve a constant and even distribution of the plastic material during moulding.

OBJECTS OF THE INVENTION

[0016] It is consequently necessary to search for new solutions, whereby it is possible to obtain a greater filtering degree of dust and micro-dust in liquid bath vacuum cleaners provided with a dynamic type separator.

[0017] The main object of this invention is therefore to provide an innovative and improved liquid bath vacuum cleaner having a water filter provided with a dynamic separator, which is capable of obviating the existing problems in liquid bath vacuum cleaners provided with a rotary separator of conventional type.

[0018] In particular, one object of this invention is to provide a liquid bath vacuum cleaner provided with a dynamic separator, whereby it is possible to increase the separation of the liquid and gaseous streams and the micro-dust filtering efficacy, by means of a combined action between a swirling effect inside a chamber, and energetic impingiment action exerted directly by the separator in relation to its particular shape and design.

[0019] A still further scope of this invention is to provide a liquid bath vacuum cleaner provided with a dynamic dust separator having a homogeneous and dynamically balanced structure, the separation efficacy of which remains substantially unchanged over the entire axial length.

[0020] A still further object of this invention is to provide a liquid bath vacuum cleaner provided with a dynamic separator of extremely limited dimensions, while maintaining a high filtering efficiency over time.

BRIEF DESCRIPTION OF THE INVENTION

[0021] The aforementioned objects can be achieved by means of a liquid bath vacuum cleaner according to claim 1.

[0022] More precisely, according to a first aspect of this invention, a liquid bath vacuum cleaner has been provided, comprising:

a pan assembly defining a cavity for containing a liquid bath;
air inlet means enabling ingress of a sucked air stream into the liquid bath of the vacuum cleaner;
a cover for the pan, said cover having aoutlet apertures for the egression of cleaned air sream; and
a fan and separator assembly downwardly protruding from the cover into the pan cavity, said dust separator having a hollow body provided with air flow apertures and a plurality of peripheral fins for impinging and throwing dust and dirt particles into the liquid bath characterised in that the dust impinging fins of the separator comprise longitudinally extending and differently slanted front and back flat surfaces;
said front and back flat surfaces being rearwardly oriented in respect to a rotational direction of the separator, and arranged to provide inwardly converging air pathes for the cleaned air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] These and further features of a liquid bath vacuum cleaner provided with a rotary separator according to this invention, will be more clearly evident from the following description, with reference to the example of the accompanying drawings, in which:

Fig. 1 shows a sectional view of a liquid bath vacuum cleaner, according to the invention;
Fig. 2 shows an enlarged detail of the separator of fig. 1;
Fig. 3 shows a top view of an adapter ring;
Fig. 4 shows a perspective view of the separator;
Fig. 5 shows a front view of the separator of fig. 4;
Fig. 6 shows a cross-sectional view along the line 6-6 of fig. 5;
Fig. 7 shows a bottom view of the separator along the line 7-7 of fig. 5;
Fig. 8 shows an enlarged detail of fig. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0024] With reference to fig. 1, a description will now be given of the general features of a liquid bath vacuum cleaner comprising a dynamic separator according to this invention.

[0025] The vacuum cleaner, indicated as a whole by reference 10, comprises a water pan assembly 11 on the bottom of which a liquid bath 12, for example water, provide a prefiltering action of a sucked air stream, for removing a large part of dirt and dust particles entrained by the air flow, which are retained into the liquid bath 12.

[0026] The pan 11 is also provided with an air inlet means comprising a socket 13 to which a pipe 13'is connected for conveying into the water bath the flow of intake air; the pipe 13' extends downwards and into the liquid bath 12 on the bottom of the pan 11.

[0027] The vacuum cleaner 10 also comprises a fan assembly 14 including an electric motor 15 and a fan 16 supported by a shaft 15' of the drive motor; a rotary separator 17 for the dust particles that have not been retained by the liquid bath 12, is provided in a position below the fan 16.

[0028] A cover 20 and a cone-shaped element 18 close the pan 11 from above, removably supporting the separator and fan assembly 14, 17.

[0029] The assembly provided by the cone-shaped element 18, the housing 19 for the fan assembly, and the cover 20 can be removed to gain access to the inside of the pan 11, whenever the water bath 12 has to be renewed.

[0030] As shown in fig. 1 and in the enlarged detail in fig. 2, the dust separator 17 is disposed immediately beneath the fan 16 to rotate with the same. The separator 17 comprises a cylindrical basket-like body 21 appropriately secured to the lower end of the motor shaft 15' to rotate with the fan 16 and for conveying the sucked air stream from the pan cavity, towards the fan 16 and air emission apertures of the housing 19.

[0031] The separator device 17 in the example shown, preferably is disposed into a bottom open air-wirling chamber 22 delimited by a peripheral wall 23 coaxially arranged to the separator 21.

[0032] The wirling chamber 22 is open towards the bottom, facing the liquid bath 12 below.

[0033] In the wirling chamber 22, the wirling motion of the air stream caused by the rapid rotational movement of the separator 21, generates high centrifugal forces which project the drops of liquid and the particles of dirt and dust entrained by the flow of air, against the peripheral wall 23 from where they fall downwards into the liquid bath 12 below.

[0034] As shown in the enlarged detail in fig. 2, the separator 21 is secured to the shaft 15' of the motor by disposing between the separator 21 and the fan 16, an adapter ring 24 capable of maintaining the separator 21 in a perfectly centred position with respect to the driving shaft 15'.

[0035] The adapter ring 24 is provided at the bottom with a conical edge 24' which adapts perfectly against a conical surface 21' on the peripheral wall, inside the separator 21.

[0036] The separator 21 and the adapter ring 24 are provided with a central hub 25, respectively 26, fitted onto the shaft 15' of the motor, to which they are secured by screwing a cap nut 27 onto the lower threaded end of the shaft 15'.

[0037] With reference to the figures from 4 to 8, a more detailed description will now be given of the features of the rotary separator according to this invention.

[0038] As shown in fig. 4, the body of the separator 21 is in the form of a basket having a bottom wall 30 provided with the hub 26, and a peripheral wall from which a plurality of peripheral fins 31 extends outwards; the fins are spaced apart from one another and each fin 31 is delimited by flat lateral surfaces rearwardly oriented with respect to the rotational direction W of the separator, as explained further on. The fins 31 extend lengthwise parallely to the rotational axis of the separator 21, and crosswise to the aforesaid axis for a substantial width, towards an outer edge 31'.

[0039] In particular, as shown in the figures 5 and 6, the fins 31 extend longitudinally between a lower ring 32 and an upper flange 33, substantially over the entire height of the separator 21.

[0040] Between adjacent fins 31, on the internal wall of the separator, narrow slits 34 are consequently created for passage of the air flow, which extend from the lower ring 32 to the upper flange 33.

[0041] Although the dimensions of the inner and outer diameters of the separator, the number and dimensions of the fins, and the dimensions of the slots 34 for passage of the air may vary in relation to the specific requirements and design of the vacuum cleaner onto which the separator must be fitted, in order to limit the overall dimensions of the separator without substantially reducing its efficacy, it is preferable to maintain the dimensions and the number of fins within pre-established values; for example, the number of the fins 31 may range from 30 to 40, with a maximum external diameter of the separator defined by the outer edges 31' of the fins 31, ranging for example from 50 to 70 millimetres.

[0042] Correspondingly, the height of the rotor may vary between 20 and 30 millimetres with a maximum rotor diameter/height ratio ranging from 1.6 to 3.5, preferably from 2 to 2.5.

[0043] As mentioned previously, the efficiency of the separator according to this invention derives from the wirling effect that is generated in the chamber 22 of the separator, combined with the impingiment effect exerted directly on the drops of water and on the particles of dust and dirt by the particular conformation of the fins 31 during the rotation of the separator.

[0044] This can be more clearly explained with reference to figures 7 and 8 of the accompanying drawings which show a view from below of the separator, and an enlarged detail on which several typical parameters have been indicated.

[0045] In fig. 7, reference W has been again used to indicate the direction of rotation of the separator, with respect to which the side of each fin facing said direction of rotation will be indicated as "front side", while the opposite side will be indicated as "back side"; in the aforementioned figure 7, the same reference numbers as the previous figures have been used to indicate similar parts of the separator.

[0046] As can be seen from figures 7 and 8, each fin 31 is rearwardly oriented (considering the forward direction of

rotation W), with respect to a radial reference plane R passing for example through a point C disposed on a diameter D1 relating to the attachment area of each fin 31 with the lower ring 32, in figure 8; it is not excluded that the reference plane R may be otherwise defined.

[0047] According to a particular feature of this invention, the fins 31 of the separator are delimited by flat surfaces, SF1, SF2 on the front side, both oriented in a direction opposite to the rotational direction W of the separator; the surfaces SF1 and SF2 are differently slanted with respect to the related reference plane R.

[0048] More precisely, as indicated in figure 8 for the lower fin 31C, each fin is delimited on the rear side by a flat surface SP which extends from the ring 32, substantially as far as the outer edge of the fin itself.

[0049] On the front side each fin is in turn delimited by a first flat surface SF1 which extends from the internal wall of the separator, and by a second flat surface SF2 which, from the surface SF1 extends substantially as far as its outer edge.

[0050] The flat surfaces SP, SF1 and SF2 which delimit each fin 31, extend over the entire height of the separator along planes substantially parallel to the rotational axis of the separator; for the purposes of this description, the term "substantially parallel" is understood to mean a plane oriented in the direction of the rotational axis of the separator, forming with the latter a small draft angle of one degree or slightly more, normally necessary for demolding the separator from the cavity of a manufacturing mould.

[0051] The working of the separator 21 is described hereunder again with reference to fig. 8 which shows an enlarged detail of three fins 31A, 31B, 31C.

[0052] As mentioned previously, and as shown by way of example for the fin 31C in fig. 8, each fin of the separator is delimited on the back side by a flat surface SP, while on the front side the fin is delimited by a first internal flat surface SF1, extending between the internal diameter D1 and an intermediate diameter D2 of the separator, while it is delimited towards the outside by a second flat surface SF2 extending between the intermediate diameter D2 and the outer diameter D3 defined by the outer edges of the fins.

[0053] The two front surfaces SF1 and SF2 are merging in correspondence with the intermediate diameter D2 where the fins 31 present a maximum thickness S, measured in a circumferential direction. For the purposes to improve the efficacy of the separator, in addition to the more slanted disposition of the external front surface SF2 of each fin 31, it is advisable for such surface to extend widthwise for a substantial length; merely by way of example, the width of the portion SF2 of the front surface, can be defined by the ratio D3/D2 between the outer and intermediate diameters of the separator, ranging from 1.2 to 2.0.

[0054] As shown for the fin 31C in fig. 8, all the fins of the separator extend for a substantial length L, measured parallel to the back surface SP, between the internal diameter D1 and the external diameter D3.

[0055] In order to achieve a satisfactory ratio between the efficacy and minimum overall dimensions of the separator, the optimal ranges for the individual parameters of the separator have to be defined by means of calculations and experimental tests; in particular indicating by:

H = length of the fins measured parallel to the axis of the separator;
L = width of the fins measured parallel to the back side;
S = maximum thickness of the fins, as previously referred to;
D1 = internal diameter of the fins in correspondence with the attachment point C with the lower ring;
D2 = intermediate diameter connecting the front surfaces SF1 and SF2;
D3 = maximum diameter defined by the external edges of the fins;
N = number of fins of the separator;
α = angle between the back surface SP of the fin and the reference plane R;
$\beta 1$ = angle between the front surface SF1 and the reference plane R;
$\beta 2$ = angle between the front surface SF2 and the reference plane R;
γ = angle between the front surface SF2 of a fin, and the back surface SP of a fin immediately after.

[0056] Bearing in mind the previous definitions, the various parameters of the separator and the range of variation are indicated in the following tables:

TABLE 1

H mm	L mm	S mm	D1 mm	D2 Mm	D3 mm	D3/D2 mm	D3/D4 mm
18-30	10-20	2-5	15-25	40-60	50-70	1,2-2,0	1,6-3,5

TABLE 2

N	α°	β1°	β2°	γ°
30-40	20-28	20-28	30-40	18-30

[0057] During several tests it was noted that the high efficiency of the separator can be mainly attributed to the presence of the flat front surfaces SF1 and SF2 of the individual fins, and to their inclination in the rear direction as previously mentioned, which determine a wide angular aperture between adjacent fins, as well as to the substantial extension of the external front surface SF2, referred to the length L of the fin and to the maximum diameter D3 of the separator. Between adjacent fins a convergent air flow path is therefore provided for the cleaned air.

[0058] The same figure 8 shows the operating mode of the separator according to the invention.

[0059] From said figure, it can be seen that when a particle P1 of dust or dirt that has not been retained by the liquid bath 12, or a water drop entrained by the flow of air is impinging on the flat surface SF2 of the front side of a fin 31, because of the rear inclination of such surface, and because of the high rotational speed of the separator, which causes centrifugal forces, it will impinge and tend to slide outwards on the surface SF2, towards the peripheral edge 31' of the fin 31, and then ejected into the wirling chamber 22, where it will be subjected to a further centrifugal action of the swirling air created in the aforesaid chamber, impinging against the wall 23, and then falling dawn into the liquid bath 12 below.

[0060] The above also applies for a generic particle P2 which at a given moment moves along a path lying between the opposite surfaces of the two adjacent fins 31A and 31C.

[0061] In fact, due to the flat conformation and the inclination of the front surface SF2 of the fins, when the particle P2 entrained by the air will be in the position indicated by reference P2', it will still impinge on the flat front surface SF2 of the fin 31A which in the meantime has moved to the position indicated by the phantom line; the particle P2 will consequently also be ejected outwards and subjected to the wirling action of air generated within the chamber 22 of the separator.

[0062] From what has been described and shown in the examples of the accompanying drawings, it will be clear that a liquid bath vacuum cleaner has been provided comprising a dynamic separator for the particles of dust and dirt which, thanks to its particular conformation of the peripheral fins, offers considerably improved separation efficacy, that is unlikely to be achieved with other types of separators.

[0063] It is understood however that what has been described and shown with reference to the accompanying drawings, has been given purely by way of example in order to illustrate the general features of a liquid bath vacuum cleaner and of the dynamic separating device according to this invention.

[0064] Consequently, other modifications or changes may be made, both with regard to the shape and features of the entire vacuum cleaner, and with regard to the features of the separator, without thereby deviating from the scope of the accompanying claims.

Claims

1. A liquid bath vacuum cleaner (10) of the type comprising:

- a pan assembly (11) defining a cavity for containing a liquid bath (12);
- air inlet means (13, 13') enabling ingress of a sucked air stream into the liquid bath (12) of the vacuum cleaner (10);
- a cover (19, 20) for the pan (11), said cover (19, 20) having outlet apertures for the egression of a cleaned air stream; and
- a fan dust separator assembly (14, 21) downwardly protruding from the cover (19, 20) into the pan cavity (11), said dust separator (21) having a hollow body provided with air flow apertures (34) and a plurality of peripheral fins (31) for impinging and throwing dust and dirt particles (P) into the liquid bath (12) **characterised in that** the dust impinging fins (31) of the separator (21) comprise longitudinally extending and differently slanted front and back flat surfaces (SF1, SF2, SP);

said front and back flat surfaces (SF1, SF2, SP) being rearwardly oriented in respect to a rotational direction of the separator, and arranged to provide inwardly converging air pathes for the cleaned air.

2. A liquid bath vacuum cleaner according to claim 1, **characterised in that** the separator (21) comprises a bottom ring (32), an upper annular flange (33) and a plurality of peripheral fins (31) angularly spaced apart and parallely

extending from said bottom ring (32) and upper annular flange (33).

3. A liquid bath vacuum cleaner according to claim 1, **characterised in that** the separator (21) is disposed inside an air wirling chamber (22) downwardly opening towards the liquid bath (12).

4. A liquid bath vacuum cleaner according to claim 1, **characterised in that** the separator (21) comprises a basket-like cylindrical body having a rotational axis and an inner wall (21') provided with a plurality of longitudinal slits (34) parallely arranged to the rotational axis of the separator (21), and a plurality of peripheral fins (31) which extend from the sides of said slots (34).

5. A liquid bath vacuum cleaner according to claim 1, **characterised in that** the front side of each fin (31) comprises a first inner flat surface (SF1) and lying in a first plane rearwardly oriented forming a first angle (β1) with a radial reference plane (R), and a second outer flat surface (SF2), lying in a second rearwardly oriented plane forming, with the reference plane (R), a second angle (β2) wider than the angle (β1) of the first outer surface (SF1).

6. A liquid bath vacuum cleaner according to claim, **characterised in that** the external surface (SF1) at the front side of each fin (31) and the surface the back side of an adjacent fin (31), are lying in planes forming an angle ranging from 18° to 30°.

7. A liquid bath vacuum cleaner according to claim 1, in which the separator (21) comprises a plurality of fins 21 extending up to an external diameter (D3), and having a height H, in the longitudinal direction of the body of the separator **characterised in that** the ratio between the external diameter (D3) and the height (H) of the fins (31) is comprised between 1.6 and 3.5.

8. A liquid bath vacuum cleaner according to claim 7, **characterised in that** the height (H) of the fins (31) is comprised in a range between 18 and 30 mm, whilst the outer diameter (D3) is comprised in a range between 50 and 70 mm.

9. A liquid bath vacuum cleaner according to claim 1, in which the fins (31) extend between an inner diameter (D1) and an outer diameter (D3) of the separator (21), and in which said first (SF1) and second (SF2) flat front surfaces of each fin (21) are merging in correspondence with an intermediate diameter (D2), **characterised in that** the ratio between the outer diameter (D3) and the intermediate diameter (D2) of the fins (31) is ranging between 1.2 and 2.0.

10. A liquid bath vacuum cleaner according to claim 9, **characterised in that** the outer diameter (D3) of the fins (31) ranges from 50 to 70 mm, whilst the intermediate diameter (D2) ranges from 40 to 60 mm.

11. A liquid bath vacuum cleaner according to claim 5, **characterised in that** the outer surface (SF2) at the front side of each fin (31), lies in a plane forming, with the reference plane (R), an angle ranging from 30° to 40°.

12. A liquid bath vacuum cleaner according to claim 5, **characterised in that** said inner surface (SF1) at the front side and the back surface (SP) of each fin (31), lie in planes forming an angle ranging from 20° to 28° with the reference plane (R).

13. A liquid bath vacuum cleaner as claimed in claim 1, **characterised in that** the number of the fins of the separator ranges from 30 to 40.

14. A liquid bath vacuum cleaner according to claim 1, in which the separator (21) comprises an inner cylindrical wall (21'), **characterised by** comprising an adapter ring (24) disposed between the separator (21) and the fan (16), said adapter ring (24) and said internal cylindrical wall (21') of the separator (21), having conical matching surfaces.

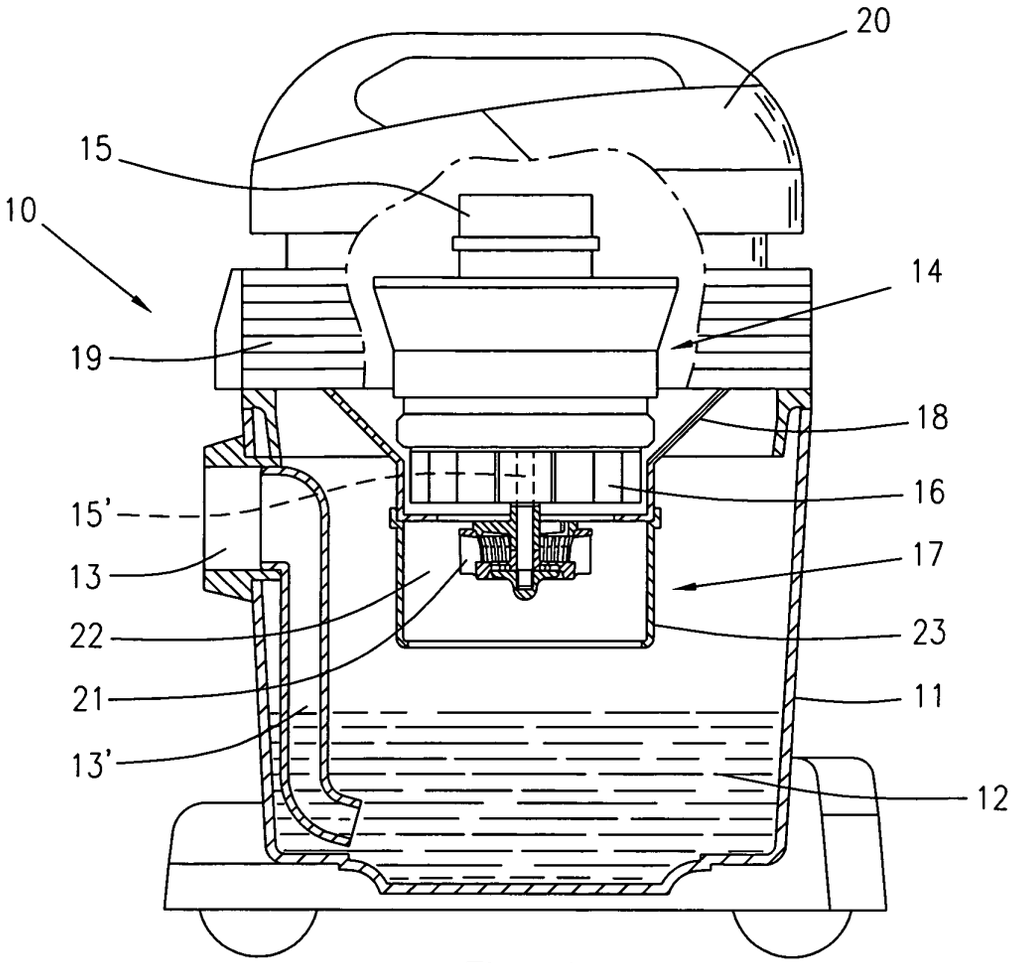

Fig. 1

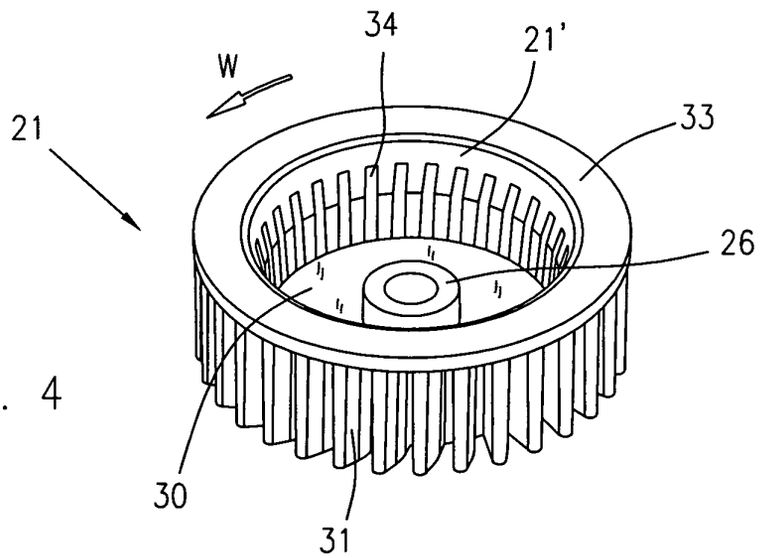

Fig. 4

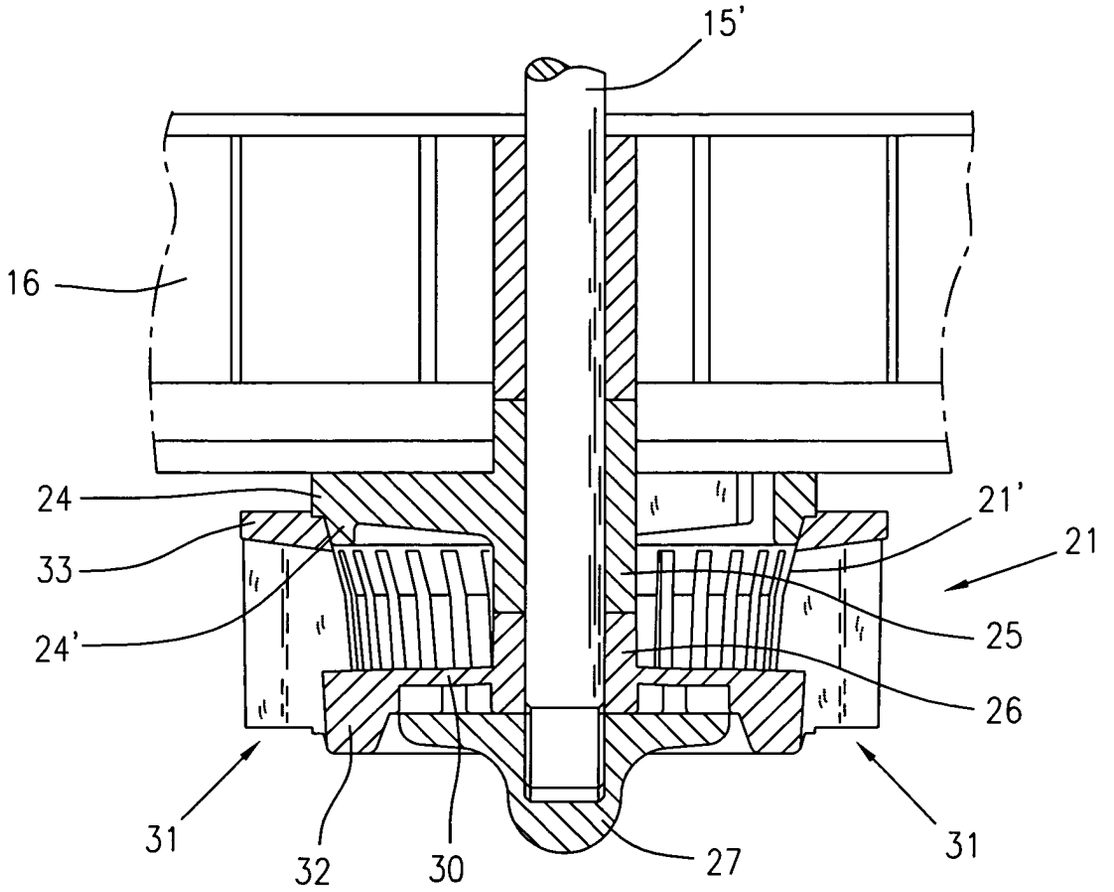

Fig. 2

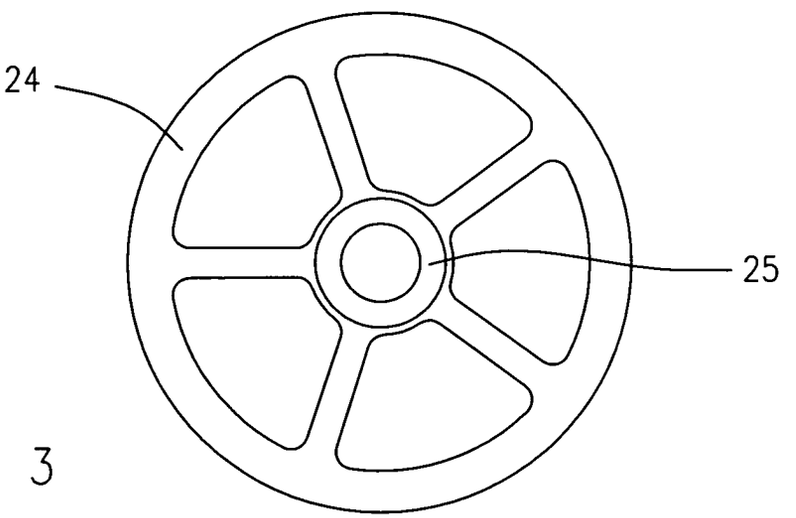

Fig. 3

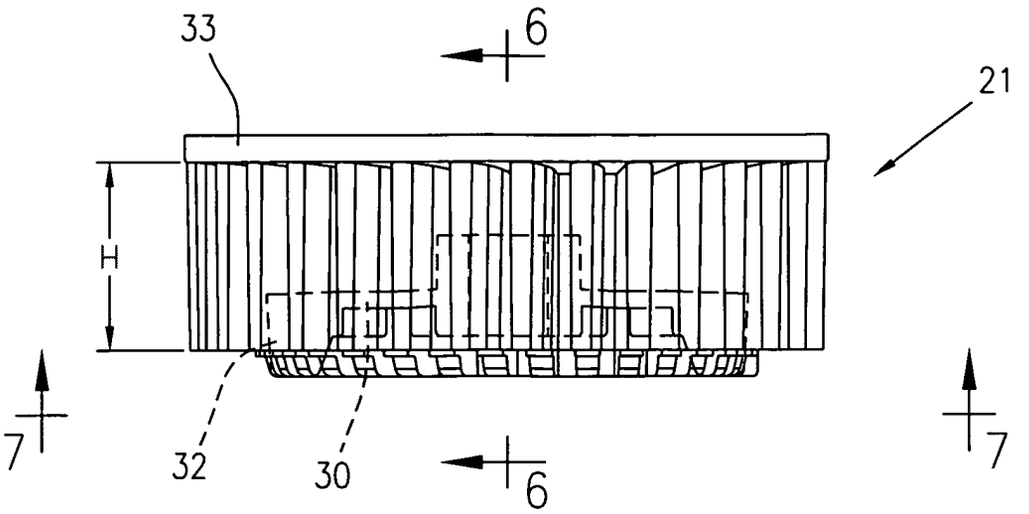

Fig. 5

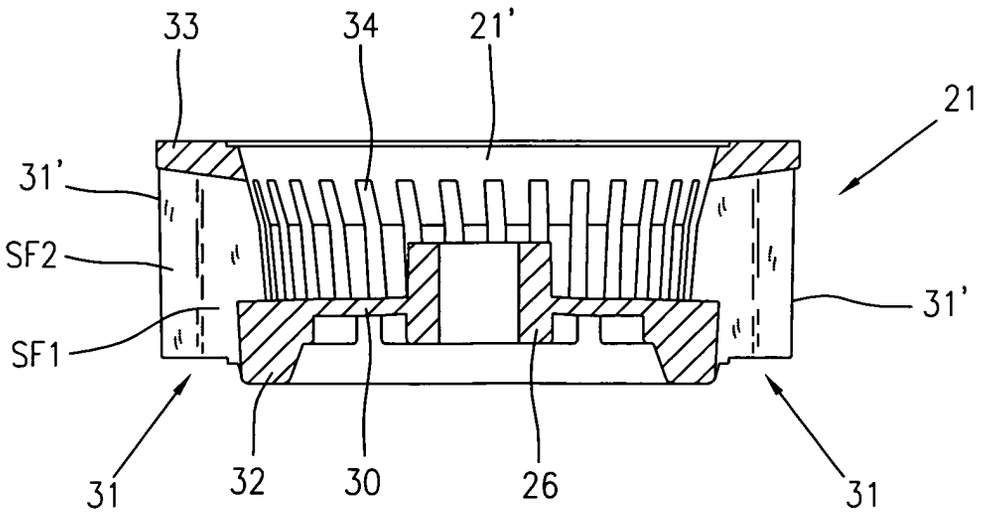

Fig. 6

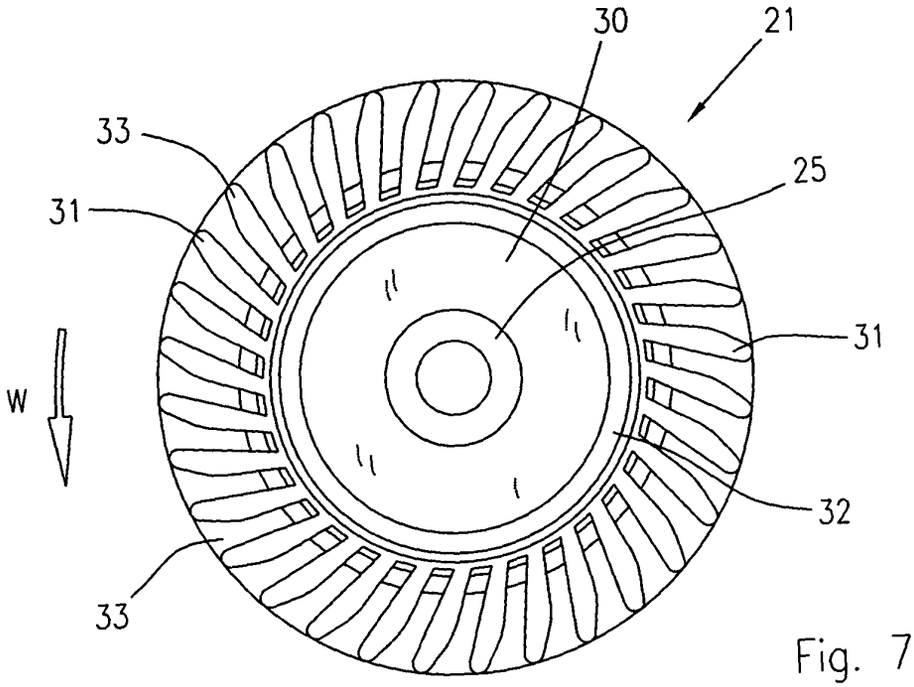
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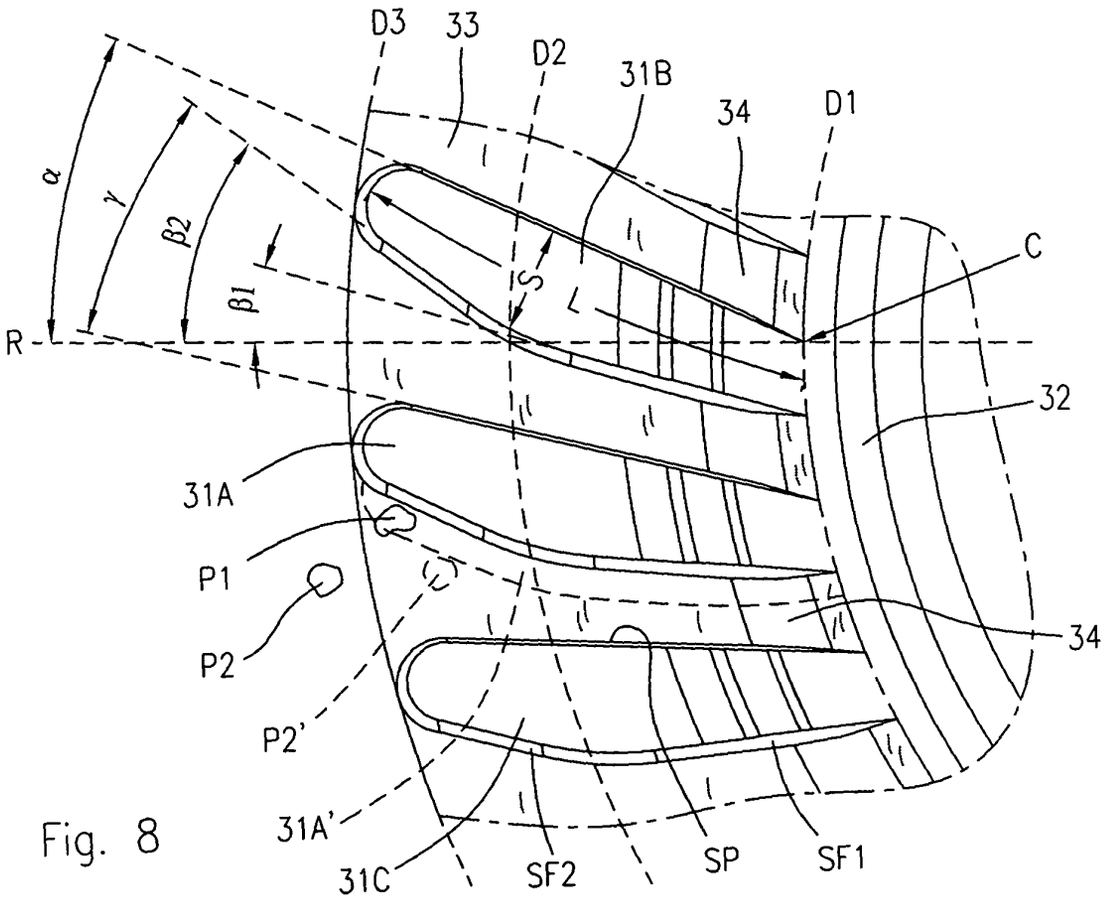
Fig. 7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P2
34
P2'
31A'
31C
SF2
SP
SF1

Fig. 8