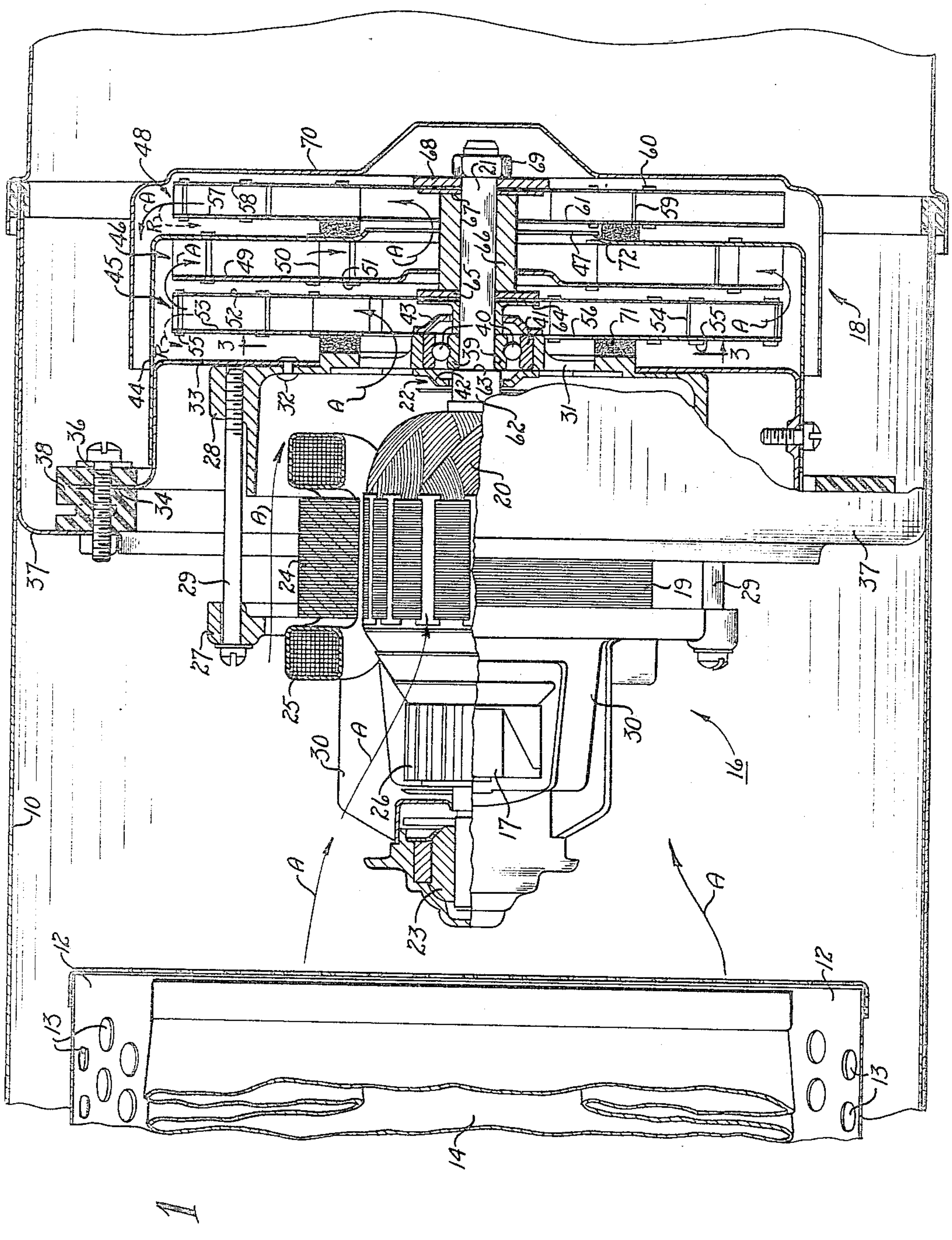

Fig. 1

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CENTRIFUGAL FAN HAVING SUBSTANTIALLY REDUCED INTERNAL AIR RECIRCULATION

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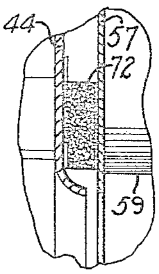

Fig. 2

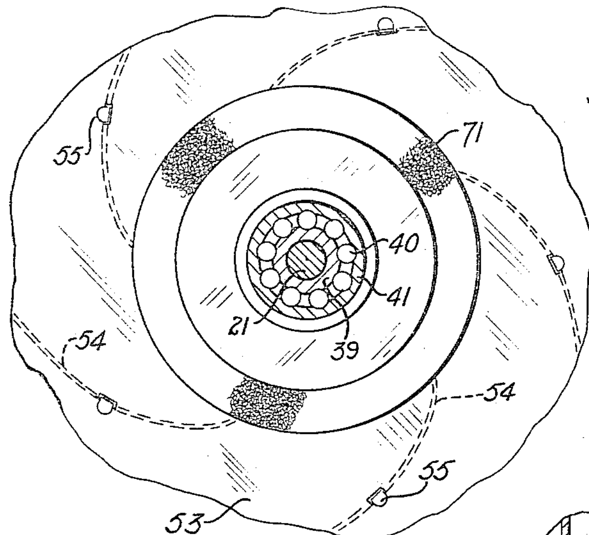

Fig. 3

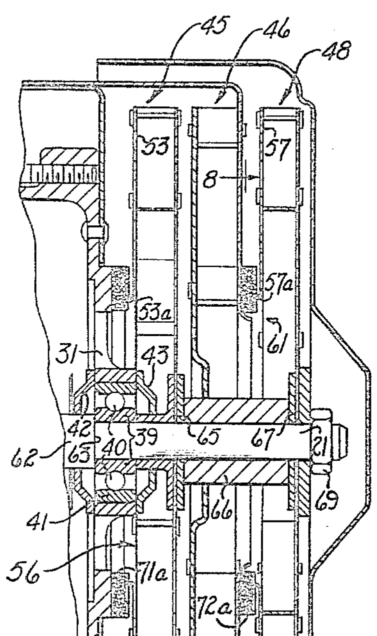

Fig. 6

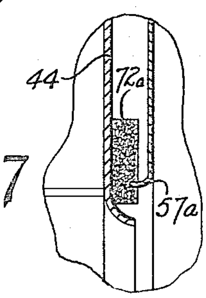

Fig. 7

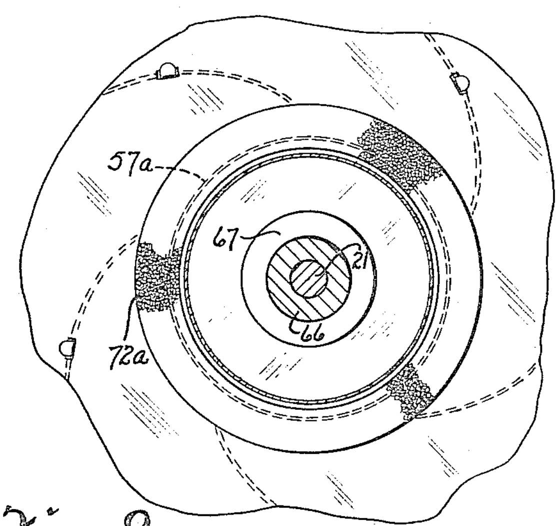

Fig. 8

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CENTRIFUGAL FAN HAVING SUBSTANTIALLY REDUCED INTERNAL AIR RECIRCULATION

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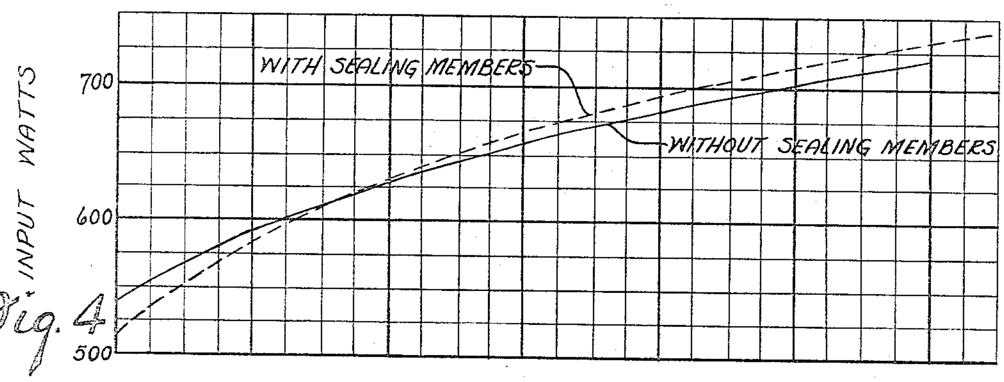

Fig. 4

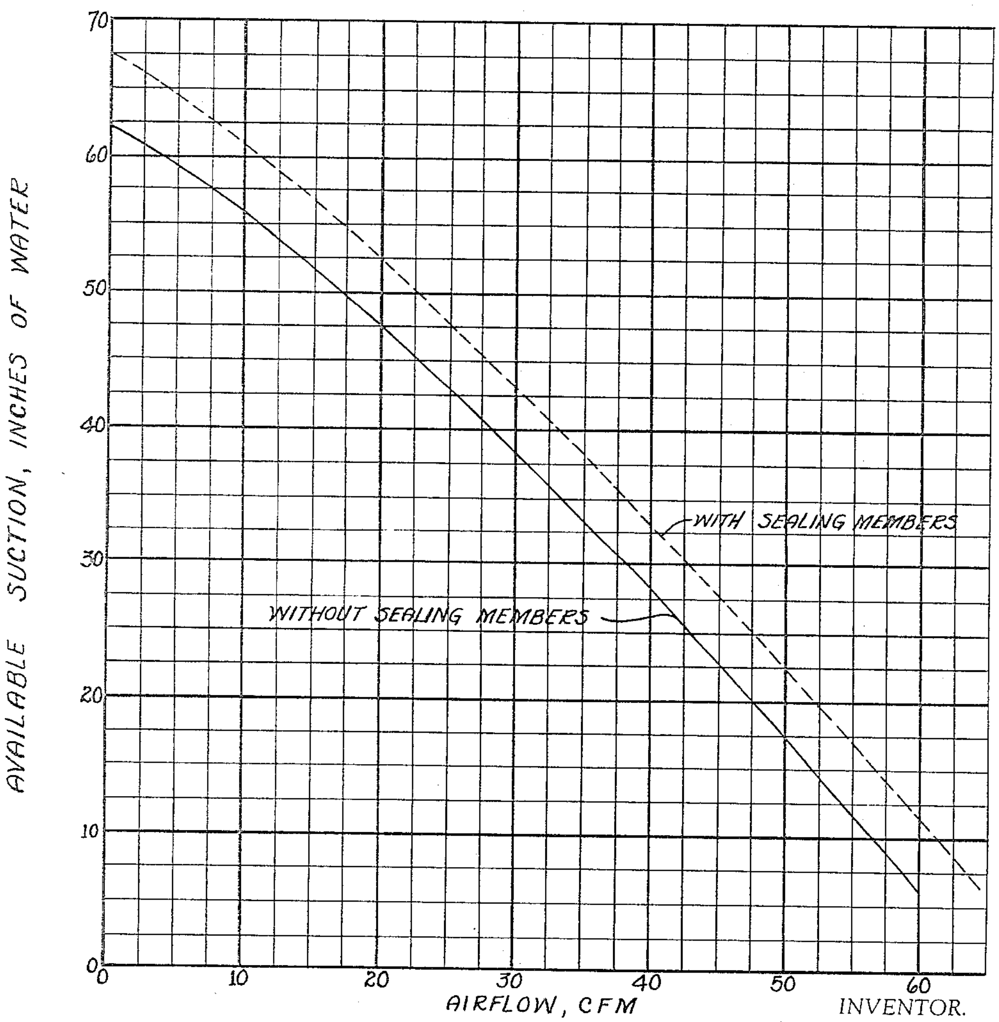

Fig. 5

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United States Patent Office

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CENTRIFUGAL FAN HAVING SUBSTANTIALLY REDUCED INTERNAL AIR RECIRCULATION

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4 Claims. (Cl. 230—130)

My invention pertains to centrifugal fans or blowers of the kind used in tank-type vacuum cleaners and my main object is to eliminate, or substantially reduce, the internal recirculating air currents within the fan unit in order to increase the suction produced by the fan unit over its entire airflow range.

The impeller wheels of the aforementioned centrifugal fans are customarily of lightweight low-inertia construction. Typically, such impeller wheels are comprised of a pair of axially spaced thin circular discs which are interconnected by thin spiral-like vanes situated between the two discs. Both the discs and the vanes are made of a thin gauge sheet metal or the like. One of the discs has an inlet opening at the center thereof through which air enters the rotating impeller wheel and is moved outward between the vanes until it is discharged at the periphery of the wheel.

Part of the air discharged from the wheel's periphery recirculates radially inward between the outer face of the disc with the central opening and a stationary wall or bulkhead, which wall or bulkhead may form part of the fan housing or a stationary interstage airguide. Eventually the recirculating air reenters the disc's central opening and the aforementioned recirculation activity is repeated.

In order to reduce the clearance between the apertured discs of the impeller wheels and the stationary bulkheads adjacent thereto for the purpose of reducing the amount of recirculating air attempts have been made to machine, form and assemble the stationary and rotating elements of the fan to very close tolerances. While such attempts are somewhat successful with relatively heavier and thicker gauge metals, it is very costly to do so. However, such close machining, forming and assembling processes have not proved satisfactory with the lightweight thin gauge materials used in vacuum cleaner fan units. Such thin gauge materials do not hold their close dimensions very well, especially when they rotate at high speeds.

Therefore, in accordance with my invention I incorporate sealing members in a centrifugal fan to seal the air recirculation paths betwen the centrifugal impeller wheels and the stationary walls or bulkheads of the fan. The sealing members are made of a rigid, low density, cellular material which is readily friable so that but a relatively small force is required to wear away a surface portion of the material. One face of each such sealing member is fastened to the surface of a stationary bulkhead which has an air inlet or air outlet opening therethrough and the sealing member closely surrounds this opening. The opposite face of the sealing member is initially assembled in interference contact with the face of a thin centrally apertured disc which forms part of a centrifugal impeller wheel. The sealing member closely surround the disc's central aperture, which aperture is axially aligned with the opening in the stationary bulkhead. After about the first revolution or so of the impeller wheel the apertured disc wears away just enough of the material on the face of the sealing member to allow the wheel to thereafter rotate freely without contact between the disc and the face of the sealing member. Thus, the disc's abrasion against the surface of the sealing member causes a minimal clearance distance to obtain between the sealing member and the disc with the result that the air recirculation is substantially reduced.

Because of the aforesaid easily friable nature of the material forming the sealing member the thin centrally apertured disc of the impeller wheel meets little resistance as it wears away a portion of such material and hence no distortion of the thin gauge members forming the impeller wheel occurs.

Furthermore, by locating the aforesaid sealing members as close as possible to the center of the apertured disc of the rotary impeller wheel, the sealing members are subjected to relative low circumferential speeds of the rotary disc and hence there is eliminated the danger of shearing the entire sealing member from the wall of the stationary bulkhead during the initial rotation of the impeller wheel while the material of the seal is being worn away by the disc of the wheel.

Other objects and advantages of my invention will be apparent from the following description considered in connection with the accompanying drawings which form part of the specification and of which:

FIG. 1 is a longitudinal cross-section showing part of the tank unit of a vacuum cleaner in which there is mounted a motor and a centrifugal fan which embodies a first form of my invention;

FIG. 2 is an enlarged view of part of the fan shown in FIG. 1 and illustrates a section of a sealing member arranged in the centrifugal fan between a stationary bulkhead and a rotary impeller wheel;

FIG. 3 is a cross-sectional view taken along the lines 3—3 of FIG. 1;

FIG. 4 is a graph showing the relationship between input power and airflow for a fan having sealing members according to my invention and for a like fan not having the aforesaid sealing members;

FIG. 5 is a graph showing the relationship between available suction and airflow for a fan having sealing members according to my invention and for a like fan not incorporating the aforesaid sealing members;

FIG. 6 is a part of a longitudinal cross-section of a fan according to another embodiment of my invention;

FIG. 7 is an enlarged view of part of the fan shown at FIG. 6 showing a section of a sealing member mounted in the fan between a stationary bulkhead and a rotating centrifugal impeller wheel; and,

FIG. 8 is a cross-sectional view taken along the lines 8—8 of FIG. 6.

In FIG. 1 a centrifugal fan 18 according to a first embodiment of my invention is shown mounted within a body 10 of a tank-type or canister-type vacuum cleaner together with an electric motor 16 which rotates the fan. A dust bag compartment 12 having a plurality of holes 13 therethrough is also mounted within the tank 10 and a dust separator, such as a disposable paper dust bag 14 is situated in the compartment 12. The motor 16 and fan 18 are located downstream of the dust bag 14 so that filtered airstreams, indicated by the arrows A, emanating from the dust bag can pass over the motor 16 to cool it before the airstreams A enter the fan 18.

The motor 16 may be a conventional series wound universal motor including a wound armature 20, or rotor, including an armature shaft 21 which is journaled for rotation in the two bearing members 22 and 23. Surrounding the armature 20 is a laminated stator 19 which includes two opposing pole pieces 24. A field winding 25 encompasses each pole piece 24. One end of the armature 20 is provided with a commutator 26 which is electrically energized through a pair of carbon brush units, one of which is shown at 17. The motor 16 also includes two stationary frame members 27 and 28 which when coupled together by means of bolts 29 support the stator 19 and armature 20. The frame member 27 includes ribs 30 between which there are defined openings so that the airstreams A can pass over the various parts of the motor to cool it. As indicated, the airstreams A pass over the armature 20, stator 19 and the field windings 25. In addition, the frame member 27 serves as a support for the bearing member 23 and for the brush units 17. The frame member 28 has a generally cylindrical shape and is open at one end. The other end thereof is partly closed; i.e., partly closed at the end nearest the bearing member 22. At the partly closed end of the frame member 28 there are formed a number of spokes 31, or rib members and between these adjacent spokes 31, spaces are provided so that air streams A can pass through into the fan unit 18 as shown in FIG. 1. Frame members 27 and 28 may be fashioned from aluminum or the like; for example, cast aluminum is one of a number of materials which are suitable.

Fastened by means of rivets 32 to the outside surface of the frame member 28 at the partly closed end thereof is a cylindrical cup-like wall member 33 which may also be fashioned from aluminum. At one end of this member 33 there is formed an outwardly turned annular flange 34 and in about three or four places on this flange there are provided holes through which bolts, such as the bolt 36, may pass for the purpose of fastening the wall member 33 to a generally cylindrical member having a radial bulkhead 37, which member is fastened by spot welding to the tank 10. An annular rubber gasket 38 is also provided to form an airtight seal and to dampen vibrations. In the center of the partly closed end of the frame member 28 there is a circular hole within which an outer bearing race 41, bearing balls 40 and an inner bearing race 39 which comprise the bearing 22 are situated. The armature shaft 21 passes through a hole provided in the center of the inner bearing race 39. Secured to the frame member 28 by means of screws (not shown) are the two centrally apertured stationary bearing cups 42 and 43. As shown, the diameter of the central aperture of these cups 42 and 43 is sufficiently large so that these end cups will not interfere with rotation of the armature shaft 21 nor with any of the other elements, hereinafter identified, which rotate together with the armature shaft 21. The spaces between the two bearing races 39 and 41 and between the two end cups 42 and 43 are filled with a suitable lubricant; e.g., grease.

Fitted over the outside surface of the wall member 33 and fastened thereto is cup-like fan housing member 44. This member 44 which may be formed from sheet aluminum or the like extends for a substantial distance in an axial direction beyond the end of the wall member 33. Within the space defined between the end of wall member 33 and the interior of the fan housing 44 there is located a first stage centrifugal impeller 45 and an interstage stationary diffuser 46.

At one end of the fan housing wall member 44 there is provided an opening 47 through which airstreams A can flow into a second stage or final stage centrifugal impeller 48. Within the fan housing member 44 and arranged parallel to an inside surface thereof there is a centrally apertured circular disc 49. Between the fan housing member 44 and the disc 49 there is situated a plurality of spaced apart vanes 50. The vanes 50 are radially arranged in the space between the housing 44 and the disc 49 and each vane is of a spiral-like configuration lengthwise. Each vane 50 has projecting ears 51. These ears 51 extend through accommodating holes in the housing 44 and in the disc 49 and are bent over onto the outside surfaces of the housing and disc 44 and 49 respectively. To ensure a positive interconnection between the wall 44, the vanes 50 and the disc 49, the bent over ears 51 may be spot welded to the wall 44 and the disc 49. As may be seen in FIG. 1 the central aperture in the disc 49 has a diameter just large enough to permit the armature shaft 21 and the other elements coupled therewith to rotate freely without interference with the disc 49.

The first stage centrifugal impeller 45 is located between the wall member 33 and the stationary diffuser 46 as shown in FIG. 1. The impeller 45 is comprised of two spaced apart circular discs 52 and 53 and radially arranged spiral-like vanes 54 connected therebetween. These vanes 54 are regularly spaced apart and each vane 54 includes a plurality of ears 55, which protrudes through accommodating holes in the discs 52 and 53. These ears 55 are bent over and spot welded to the outside surfaces of the discs. As indicated, the disc 53 has a large diameter central aperture 56 in alignment with the openings between the spokes 31 which admits airstreams A into the impeller 45.

The second or last stage impeller 48 is comprised of two spaced apart circular discs 57 and 58 and radially arranged spiral-like vanes 59 connected therebetween. These vanes 59 are regularly spaced apart between the discs and each vane includes a plurality of ears 60 which protrude through accommodating holes in the discs 57 and 58 and are bent over and spot welded to the outside surfaces of these discs. As shown the disc 57 has a large diameter central aperture 61 in alignment with opening 47 to admit airstreams A into the final stage impeller 48.

The armature shaft 21 has an enlarged section 62 having a diameter greater than the remainder of the shaft 21. At juncture of the enlarged section 62 and the smaller diameter portion of the armature shaft there is defined the annular shoulder 63 against which one end of the inner bearing race 39 is in contact encompassing the shaft 21. Situated next to the opposite end of the bearing race 39 is a flanged cylindrical body 64. One end of this body 64 is in contact with the opposite end of the bearing race 39 and the flange portion of the body 64 is in contact with the face of the disc 52. In contact with the opposite face of the disc 52 there is the centrally apertured washer 65 which encompasses the armature shaft 21. Next to the washer 65 and in contact therewith is a centrally apertured cylindrical body 66 which also encompasses the armature shaft 21. Situated between the opposite end of the cylindrical body 66 and the face of the disc 58 is another centrally apertured washer 67 which also encompasses the shaft 21. In contact with the opposite face of disc 58 is another centrally apertured washer 68 which also encompasses the armature shaft 21. The end of the armature shaft 21 is externally threaded and it receives an internally threaded nut 69 which is tightened so as to bear with considerable force against the face of the washer 68. The force exerted by nut 69 is transmitted to the annular shoulder 63 through the washer 68, disc 58, washer 67, cylindrical body 66, washer 65, flanged body 64 and the inner bearing race 39. Thus all of the aforementioned parts between the shoulder 63 and the nut 69 and including the nut 69 rotate together with the armature shaft 21 due to the high pressure contact therebetween. Also since the discs 52 and 57 are rigidly secured to the discs 53 and 58 respectively, through the vanes 54 and 59, in the manner hereinbefore set forth, the first and second stage impellers 45 and 48 defined by these vanes and discs rotate together with the armature shaft 21.

A cup-like fan housing 70 is fastened, by means not shown, to the fan housing 44 and these housing members 44 and 70 are maintained in spaced relation relative to one another as shown in FIG. 1. The space between the housing members 70 and 44 includes an elongated annular space and this is the space through which airflow exhausting from the last stage impeller 48 diffuses, thereby converting some of the velocity energy of the exhausting air into pressure energy.

Between the stationary bulkhead defined by the wall member 33 and the frame member 28 which is fastened thereto and the disc 53 of the first stage impeller 45 there is located an annular sealing member 71. Another annular sealing member 72 is located between the outside of the fan housing 44 and the disc 57 of the last stage impeller 48. The sealing members 71 and 72 are formed from a rigid, low density, cellular material which is readily friable when subjected to small force. One suitable material, among others, is rigid foamed polystyrene; e.g., Styrofoam 22 made by the Dow Chemical Company. The foamed polystyrene may be of the closed cell or the open cell type. However, if the open cell type is used, it is preferable that the pores be of relatively small size. The annular sealing members of rigid foamed polystyrene may have a pressure sensitive adhesive applied to one face thereof. The face of the sealing member **71** having the adhesive thereon is applied to the surface of the stationary frame member **28** so that the sealing member encompasses the openings in the member **28** which are defined between the ribs or spokes **31**. The sealing member **71** also encompasses the opening **56** which is provided in disc **53** of the first stage impeller **45**. Similarly, that face of the sealing member **72** which has the adhesive thereon is applied to the surface of the stationary wall **44** so that the sealing member encompasses the opening **47** in the fan housing member **44**. The sealing member **72** will also encompass the opening **61** which is provided in the disc **57** of the final stage impeller **48**.

If the sealing member **71** were not provided, a portion R of the airstream A exhausting from the first stage impeller **45** would tend, as shown in FIG. 1, to recirculate between the outside surface of disc **53** and the wall **33** and reenter the first stage impeller **45** through the opening **56**. Similarly, without the sealing member **72** a portion R of the airstream A exhausting from the final stage impeller **48** would tend to recirculate between the housing member **44** and the outside surface of the disc **57** and reenter the final stage impeller **48** through the opening **61**. Thus the annular sealing members **71** and **72** seal off the air recirculation paths.

In assembling the fan **18**, the annular sealing members **71** and **72** which have been bonded by pressure to the support member **28** and fan housing member **44**, respectively, are initially in an interference fit relationship with the discs **53** and **57**, respectively, of the first and second stage impellers. After about a revolution or so of these impellers the first time the motor is started the outside faces of the discs **53** and **57** will wear away a minimal amount of the rigid but friable polystyrene foam and the amount of material so worn away is just sufficient to permit these impellers to rotate without further interfering with the sealing members.

Tests were made to determine the effect of employing sealing members, such as **71** and **72**, in a vacuum cleaner fan unit, such as the fan unit shown in FIG. 1. One motor-fan unit without seals was tested and it was compared with a like motor-fan unit which had the seals **71** and **72** incorporated therein. As shown in FIG. 5, the fan unit having the sealing members **71** and **72** produced higher suction over its entire airflow range as compared to a like motor-fan unit not having sealing members. FIG. 4 shows that the difference in input power over the entire airflow range of the fan having seals was relatively insignificant as compared with the fan not having seals.

In FIGS. 6, 7 and 8 there is shown a second embodiment of my invention. The fan unit shown in these figures, is essentially the same as that shown in FIG. 1, with the exception that at that portion of the discs **53** and **57** of the first and last stage impeller wheels **45** and **48** there are formed sharp circular edges **53*a*** and **57*a***, respectively. These edge portions are turned in a generally axially direction and normal of the plane of the discs **53** and **57** as shown. The very small areas sharp circular edges **53*a***, and **57*a*** are initially in interference contact with the faces of the sealing members **71*a*** and **72*a***. After about a revolution or so of the impeller wheels **45** and **48** there is worn away a somewhat annular groove in these sealing members and this annular groove is just sufficient to permit further rotation of the impellers without interference with the sealing members. Very little drag on the impeller wheels occurs in wearing away or displacing the material from the sealing members because of the small contact area between the sharp circular edges and the sealing members and this lasts for but an instant.

While more than one embodiment of my invention has been described and illustrated, this has been done for the purpose of illustration only and the scope of my invention is to be determined from the appended claims.

What I claim is:

1. Apparatus comprising a centrifugal fan of light weight low inertia construction having a first impeller, said first impeller comprising a pair of spaced sheet metal discs interconnected by a plurality of sheet metal vanes situated therebetween, a central air inlet in one of said discs, said one disc having an axially projecting edge extending in a direction away from the other of said pair of discs, a stationary fan housing having a wall portion, said wall portion having an opening therein substantially coaxial with said central air inlet of said one disc; the improvement comprising an annular sealing member consisting of a rigid low density friable cellular material, and means for adhering said sealing member to said wall portion between said housing and said impeller, the aperture of said sealing member having an inside diameter less than the outside diameter of said opening in said disc and being coaxial with both said wall portion opening and said disc opening, said sealing member having initially an interference fit with said edge whereby said edge abrades said friable material for unobstructed rotation of said impeller wheel after a number of revolutions of said impeller in use.

2. Apparatus according to claim **1** with the addition of a second centrifugal impeller coaxial with said first impeller and axially spaced therefrom, means for defining an interstage stationary sheet metal diffuser beween said first and second impellers, a central opening in said diffuser means, said diffuser means directing air from the periphery of said first impeller radially inwardly to the central opening therein, said second impeller having a pair of spaced sheet metal discs interconnected by a plurality of sheet metal vanes situated herebetween, one disc of said second impeller having an inlet opening coaxial with the central opening of said diffuser means for receiving the radially inwardly directed air from the first impeller, a second annular sealing member consisting of said rigid low density friable cellular material and means for adhering said second sealing members to a wall of said diffuser means, said one disc of said second impeller having an axially projecting edge extending in the direction of said second sealing member and initially engaging said second sealing member in an interference fit.

3. Apparatus according to claim **2** wherein both said sealing members consist of foamed polystyrene.

4. Apparatus according to claim **2** wherein a pressure sensitive adhesive adheres both said sealing members to the associated stationary walls.

References Cited by the Examiner

UNITED STATES PATENTS

918,894	4/1909	Noe	230—117
2,021,298	11/1935	Forsberg	230—117
2,245,760	6/1941	Clements	230—117
2,668,068	2/1954	Bredemeier	277—96
2,963,307	12/1960	Bobo	253—77.3

FOREIGN PATENTS

536,916	5/1941	Great Britain
563,727	8/1944	Great Britain.
852,887	11/1960	Great Britain.

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