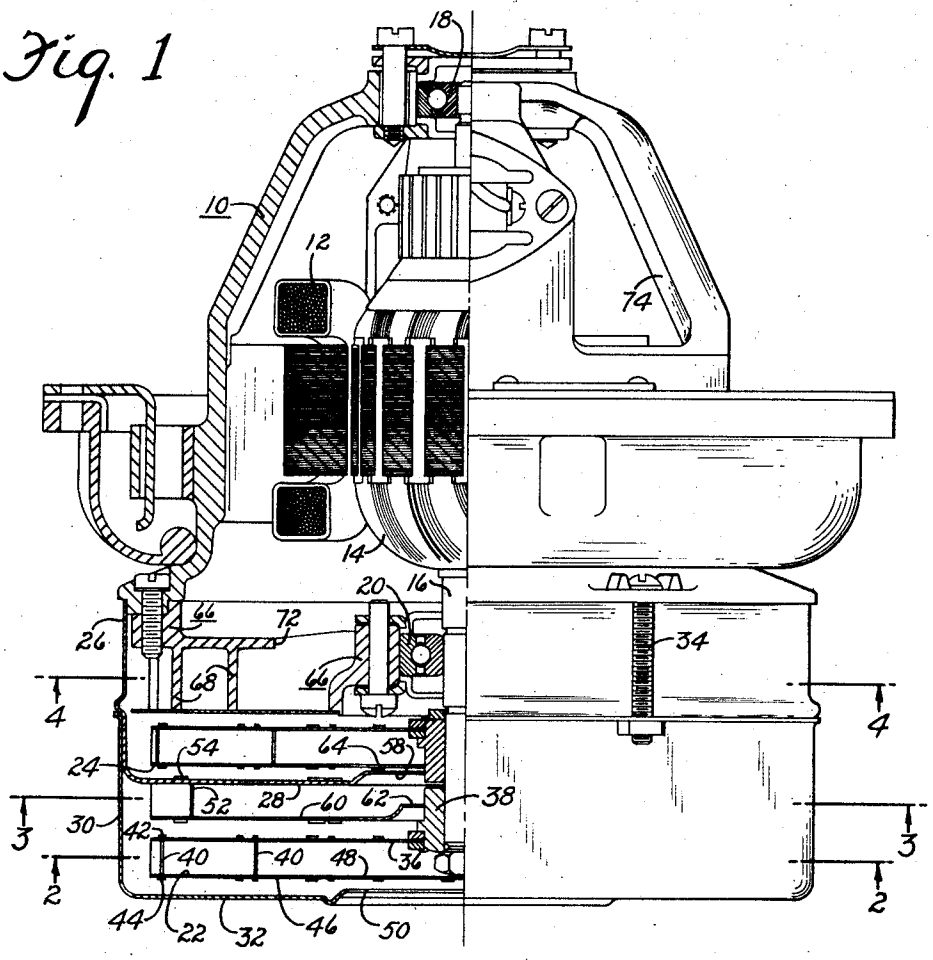
Dec. 1, 1959 F. L. GALIULO ET AL 2,915,237

CENTRIFUGAL BLOWERS

Filed June 13, 1956 2 Sheets-Sheet 1

Fig. 1



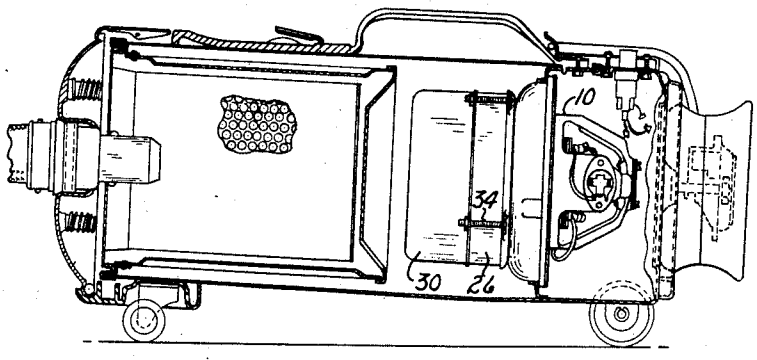


Fig. 5

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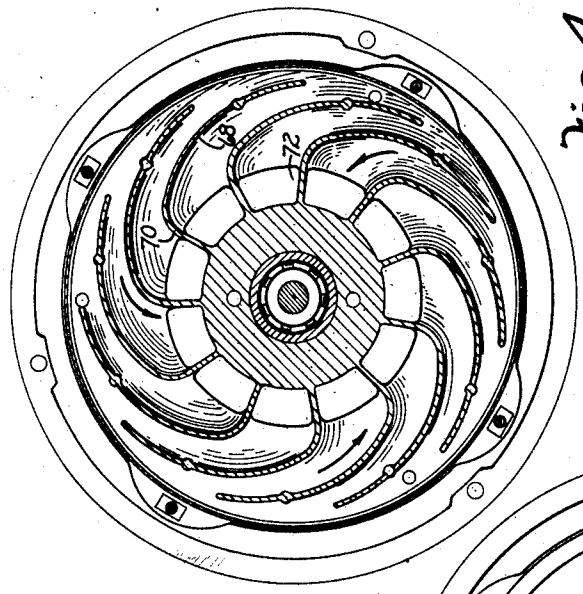
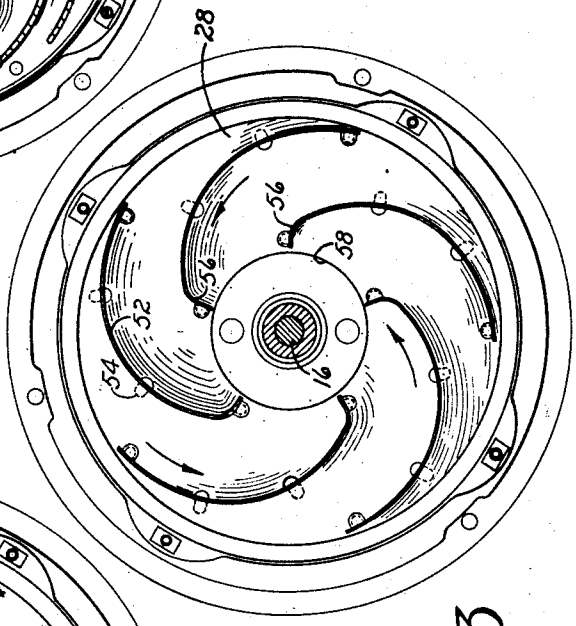


Fig. 4



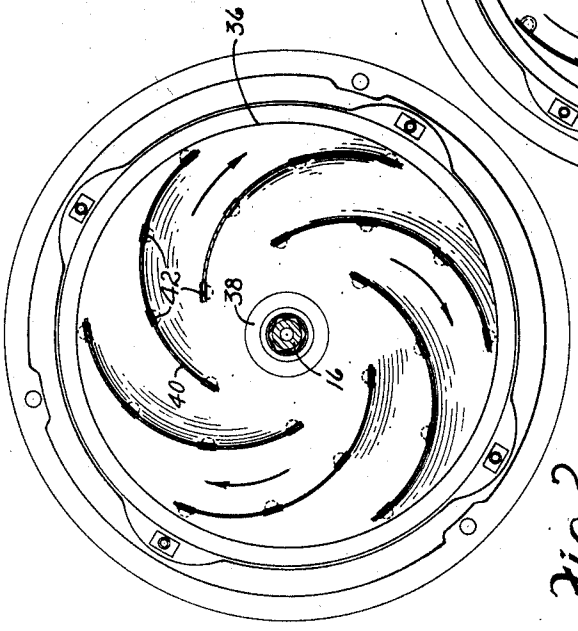


Fig. 3

Fig. 2

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CENTRIFUGAL BLOWERS

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Application June 13, 1956, Serial No. 591,058

5 Claims. (Cl. 230—117)

Our invention relates to centrifugal blowers and more particularly to multi-stage blowers of the turbine type, such as are employed in tank type vacuum cleaners. In a blower of this type it is necessary to direct the air discharged from the outlet of the first stage to the inlet of the next stage. Moreover, in so doing it is also desirable to transform the velocity head of the air as discharged to pressure head before admitting it to the next stage. In order to accomplish this, stationary interstage blading is used which provides passages of increasing cross-sectional area, thus permitting a reduction in the velocity of the air passing therethrough. Inasmuch as the air is discharged at the periphery of the first stage impeller and must be directed radially inwardly so as to enter the centrally located inlet of the second stage impeller, straight blades or vanes for the interstage blading would result in a decrease in the cross-sectional area of the passageways therebetween. However, by using suitable spiral blading, the desired diffusion may be obtained.

Heretofore, diffusion blading of this type has been successfully employed in guiding the air discharged from the rotor of a single stage blower to atmosphere, but when this same spiral blading was used as interstage blading, the efficiency of the blower was surprisingly low.

We have discovered that the efficiency may be significantly improved if each vane of the interstage blading, instead of having a smooth spiral profile, is made with a bend to a substantially radial profile near its inner end immediately adjacent to the inlet of the subsequent stage.

We have also determined that if the air discharged from the last stage of the blower is to be directed to flow in an axial direction close to the axis of rotation of the blower, as is the case when it is introduced into the housing of an electric motor driving the blower for the purpose of cooling the motor, it is advantageous to use the same type of vanes as just described in connection with the interstage blading.

Further objects and advantages of our invention will be apparent from the following description considered in connection with the accompanying drawings which form a part of this specification and of which;

Fig. 1 is a cross-sectional view of a two-stage centrifugal blower embodying the present invention and an electric motor for driving the blower;

Fig. 2 is a cross-sectional view through the first stage impeller and is taken on the line 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view through the interstage blading and is taken on the line 3—3 of Fig. 1;

Fig. 4 is a cross-sectional view through the discharge blading and is taken on the line 4—4 of Fig. 1, and

Fig. 5 is a view partially in cross-section and on a reduced scale of the blower according to the present invention installed in a vacuum cleaner.

Referring to the drawings, reference character **10** designates generally the housing or frame of an electric motor having a stationary field winding **12** and an armature winding **14** mounted on an armature shaft **16** rotatably

supported in the frame **10** by means of bearings **18** and **20**. Armature shaft **16** extends through bearing **20** and has secured thereto a first stage impeller **22** and a second stage impeller **24**. The second stage impeller is mounted within a housing having a cylindrical wall portion **26** and a transverse wall portion **28**. The first stage impeller **22** is also mounted within a housing having a cylindrical wall portion **30** and a transverse wall portion **32**. The two housings are held together and to the motor frame **10** by means of tiebolts **34**, one of which is shown in Fig. 1.

The impellers **22** and **24** may be substantially identical and hence only the first stage impeller **22**, which is also shown in Fig. 2, will be described in detail. It consists of a disc **36** mounted on a hub **38** which is fixed to the armature shaft **16**. Secured to the forward face of the disc **36** is a plurality of spiral vanes **40**. Each vane may be provided with a plurality of ears **42** which extend through appropriately located slots formed in the disc **36** and are bent over on the rear side of the disc. The opposite edges of the vanes are formed with similar ears **44** which extend through slots formed in a disc **46** which is provided with an inlet opening **48**. Thus, the discs **36** and **46** are secured together by means of the vanes **40** and this assemblage constitutes the impeller which rotates with the armature shaft. The transverse wall **32** of the first stage housing is formed with an inlet opening **50** substantially in line with the inlet opening **48** in the forward disc **46** of the impeller.

Secured to the outer surface of the transverse wall **28** of the second stage housing so as to be located within the first stage housing is a plurality of vanes **52** shown more particularly in Fig. 3. As here shown, each vane is provided with a plurality of ears **54** which extend through correspondingly located slots in the wall **28** and are bent over against the inner face of the wall. While the greater extent of each vane **52** has a smooth spiral profile, it will be noted that the inner end is bent inwardly, as is indicated at **56** in Fig. 3, so as to have a substantially radial profile immediately adjacent a central opening **58** formed in the wall **28**.

The forward edges of the vanes **52** carry a disc member **60** which is formed with a central opening **62** the periphery of which is disposed close to the hub **38** and the disc **60** is disposed close to the disc **36** of the first stage impeller. Inasmuch as the vanes **52** are mounted on the stationary wall **28** of the second stage housing, these vanes and the disc **60** are stationary and constitute the interstage blading for guiding the air discharged from the periphery of the first stage to the inlet **64** of the second stage impeller **24**. As above stated, this impeller is similar in all respects to the first stage impeller **22**.

The discharge blading from the second stage is formed on the member **66** which constitutes the front bearing bracket of the motor frame **10**. As is shown particularly in Fig. 4, a plurality of vanes **68** are formed on the outer forward face of the member **66**, and inasmuch as this member is usually a casting, it is convenient to cast the vanes **68** integral therewith. As is the case with the interstage blading **52**, these vanes have a spiral profile throughout the greater part of their length which changes to a substantially radial profile **70** immediately adjacent to openings **72** formed in the member **66**. These openings lead to the interior of the motor so that the air entering therethrough may pass in contact with and cool both the field windings **12** and the armature windings **14** before being discharged through openings **74** formed in the rear of the motor frame **10**.

In operation, the armature of the motor is caused to rotate in a counterclockwise direction, as viewed in Fig. 2, thus causing both the impellers **22** and **24** to rotate in this direction. Rotation of impeller **22** causes air

to be drawn in through the inlet **50** in the wall **32** of the housing and through the inlet **48** in the disc **46** of the impeller. This air is acted upon by the rotating blades **40** and is discharged at the outer periphery where it has a high velocity head. This rotating air passes between the outer ends of the fixed vanes **52** of the interstage blading and flows in the direction of the arrows shown in Fig. 3 inwardly towards the center. In order to pass from the channels formed between the blades **52** into the inlet **64** of the second stage impeller, it is necessary that the air change its direction of flow from radial to axial and we have found that this is greatly facilitated by the provision of the substantially radial profile **56** of the vanes.

During its passage through the interstage blading, due to the increasing cross-sectional area of the passages between the vanes, part of the velocity head of the air is converted to pressure head and consequently it enters the second stage at a higher pressure than it had at the exit from the first stage. The second stage impeller forces the air outwardly, as previously described in connection with the first stage, and the air discharged at the periphery of the second stage again has a high velocity head. This air passes between the curved vanes **68** of the discharge blading and is guided thereby in a generally radially inward direction. Inasmuch as the channels between the vanes **68** increase in cross-sectional area, some of the velocity head of the air is converted to pressure head during its passage therethrough. This air is caused to change direction to flow through the opening **72** and is aided in this change of direction by the change in profile of the vanes. This air then flows in a generally axial direction through the motor housing where it serves to cool the motor before being discharged through the opening **74**.

The improvement in efficiency of a blower unit of this nature may be expressed in terms of air horsepower, and in order to determine the improvement produced by the present invention a motor fan unit strictly in accordance with the foregoing disclosure, hereinafter designated unit I, was tested to determine its air horsepower, which was then compared with a similar value obtained by testing the same unit except that the vanes **52** of the interstage blading as shown in Fig. 3 had been replaced by vanes having a smooth spiral profile throughout their entire lengths, terminating at the periphery of the central opening **58**, hereinafter designated unit II.

The formula for determining air horsepower is

$$\text{A.H.P.}=\frac{W\cdot H}{550}$$

where W is rate of flow of the air in pounds per second, and H is the pressure or head of the air in feet. If flow is measured in cubic feet per minute and pressure in inches of water, which are more convenient to measure, the formula becomes

$$\text{A.H.P.}=\frac{q\cdot h}{6356}$$

where q represents the flow and h the pressure.

The above-mentioned units I and II were tested in a vacuum cleaner of the type shown in Fig. 5, each unit being tested with inlet orifices of two different diameters, with the results as shown in the following table.

Unit	Inlet Orifice, inches	h	q	A.H.P.	Motor Input, Watts
I	1⅜	5.95	60.5	.0565	580
II	1⅜	5.60	58.7	.0517	580
I	⅝	37.80	30.90	.184	540
II	⅝	36.90	30.55	.177	540

In this table the A.H.P. was derived in each case by the use of the above formula, using the values for h and q obtained from the tests. The increase in efficiency of unit I over unit II is obtained by dividing the A.H.P. of one by that of the other. Thus, at 1⅜" orifice,

$$\frac{.0565}{.0517}=1.09$$

or an increase of 9%. At ⅝" orifice,

$$\frac{.184}{.177}=1.04$$

an increase in efficiency of 4%. It will be noted that the greater the air flow, the more the present invention improves the efficiency. Thus, at 1⅜" orifice the flow is about twice that at ⅝" orifice, and the increase in efficiency is somewhat more than doubled.

While we have shown one more or less specific embodiment of our invention, this has been done for the purpose of illustration only, and the scope of our invention is not to be limited thereby, but is to be determined from the appended claims.

What we claim is:

1. In a centrifugal blower, a housing, an impeller rotatably disposed therein and provided with blading for discharging air at the periphery thereof, said housing having an axially located outlet opening disposed radially inwardly from said periphery, and stationary vanes in said housing between said periphery and said outlet opening, each of said vanes having a spiral profile from the outer end through a major portion of its length and changing abruptly to a substantially radial profile which extends a minor portion of its length adjacent to the inner end thereof, every tangent to said major portion of each vane being disposed at an angle to a line extending radially from the axis of said impeller through the point of tangency.

2. In a centrifugal blower, a housing, an impeller rotatably disposed therein and provided with blading for discharging air at the periphery thereof, said housing having an axially located outlet opening disposed radially inwardly from said periphery, and stationary vanes in said housing between said periphery and said outlet opening, defining channels the cross-sectional areas of which increase towards said opening, each of said vanes having a spiral profile from the outer end through a major portion of its length and changing abruptly to a substantially radial profile which extends a minor portion of its length adjacent to the inner end thereof, every tangent to said major portion of each vane being disposed at an angle to a line extending radially from the axis of said impeller through the point of tangency.

3. In a centrifugal blower, a first stage housing, a first stage impeller rotatably disposed therein and provided with blading for discharging air at the periphery thereof, a second stage housing, a centrally located opening establishing communication between the interiors of said housings, a second stage impeller rotatably disposed in said second stage housing and having a central inlet in axial alignment with said opening, and stationary vanes in said first stage housing between said periphery and said opening, each of said vanes having a spiral profile from the outer end through a major portion of its length and changing abruptly to a substantially radial profile which extends a minor portion of its length adjacent to the inner end thereof, every tangent to said major portion of each vane being disposed at an angle to a line extending radially from the axis of said impeller through the point of tangency.

4. In a centrifugal blower, a first stage housing, a first stage impeller rotatably disposed therein and provided with blading for discharging air at the periphery thereof, a second stage housing, a centrally located opening establishing communication between the interiors of said housings, a second stage impeller rotatably disposed in said second stage housing and having a central inlet in axial alignment with said opening and provided with blading for discharging air at the periphery thereof, said second

stage housing having an axially located outlet opening, and stationary vanes in each of said housings between the peripheries of the impellers and the respective openings, each of said vanes having a spiral profile from the outer end through a major portion of its length and changing abruptly to a substantially radial profile which extends a minor portion of its length adjacent to the inner end thereof, every tangent to said major portion of each vane being disposed at an angle to a line extending radially from the axis of said impeller through the point of tangency.

5. In an electric motor driven centrifugal blower, a motor frame, an armature shaft rotatably mounted in said frame, motor windings within said frame including an armature winding on said shaft, a second stage blower housing secured to said frame, a first stage blower housing secured to said second stage housing, a centrally located opening establishing communication between the interiors of said housings, and an axially located opening establishing communication between the interiors of said second stage housing and said motor frame, said armature shaft extending into both of said housings, a first stage impeller mounted on said shaft in said first

stage housing, a second stage impeller mounted on said shaft in said second stage housing, each of said impellers being provided with blading for taking in air at the center and discharging it at the periphery, and stationary vanes in each of said housings between the peripheries of the impellers and the respective centrally located openings, each of said vanes having a spiral profile from the outer end through a major portion of its length and changing abruptly to a substantially radial profile which extends a minor portion of its length adjacent to the inner end thereof, every tangent to said major portion of each vane being disposed at an angle to a line extending radially from the axis of said impeller through the point of tangency.

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