Jan. 12, 1965 W. H. WENTLING ETAL 3,165,258

BLOWER

Filed April 4, 1963

FIG-1

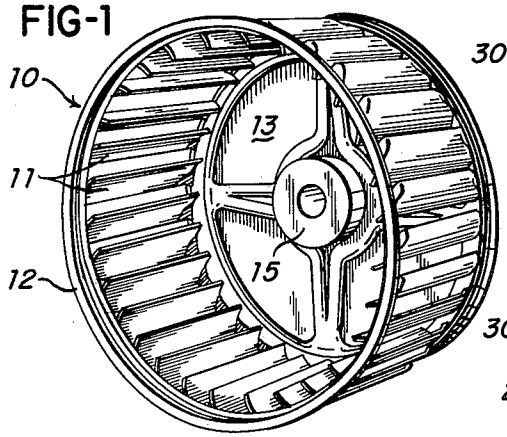


FIG-2

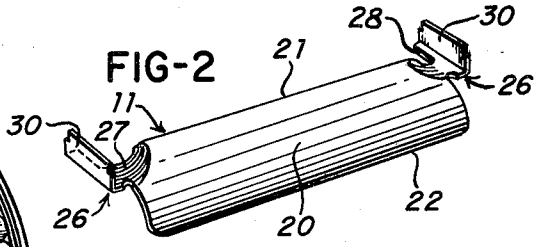


FIG-3

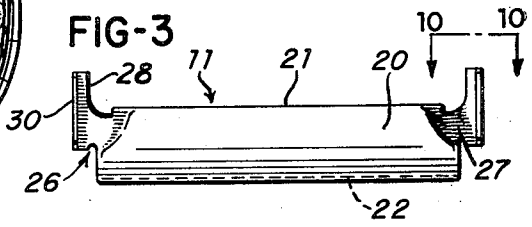


FIG-4

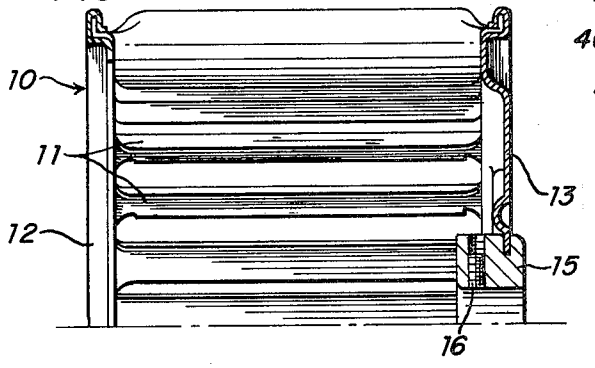


FIG-5

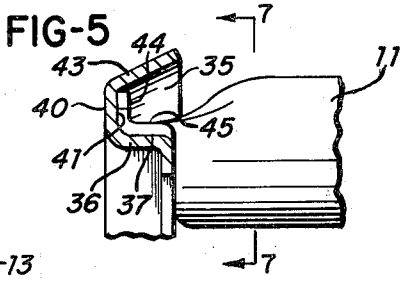


FIG-6

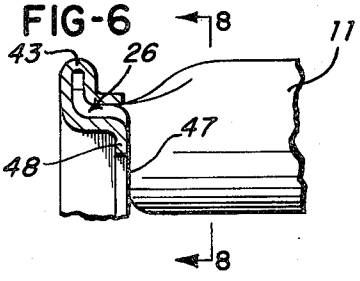


FIG-7

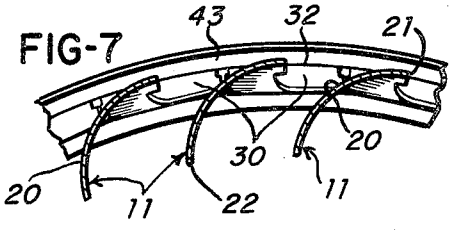


FIG-8

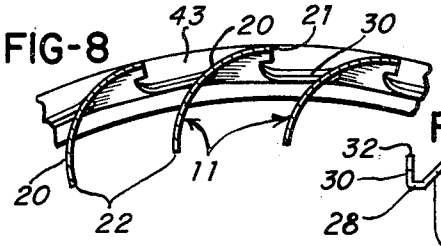


FIG-9

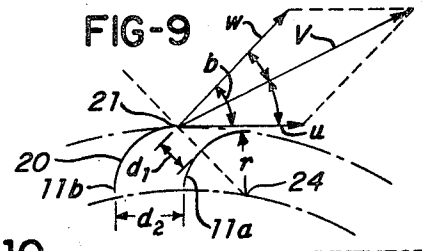
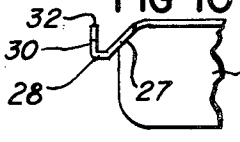


FIG-10



INVENTORS
WILLIAM H. WENTLING,
BY DONALD D. KINSWORTHY &
WILLIAM P. POWELL

Marechal, Biebel, French & Bugg
ATTORNEYS

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3,165,258

BLOWER

William H. Wentling, Donald D. Kinsworthy, and William P. Powell, Dayton, Ohio, assignors to The Lau Blower Company, Dayton, Ohio, a corporation of Ohio

Filed Apr. 4, 1963, Ser. No. 270,582
4 Claims. (Cl. 230—134)

This invention relates to centrifugal blower wheels, and particularly to fabricated blower wheels which have forwardly curved blades.

Two of the more prevalent expedients utilized for the construction of blower wheels are the single blade sheet type wherein the blades are cut in an integral sheet which is then formed into a wheel, and the individual blade type wherein a plurality of separate blades is secured between a pair of end rings. The latter type is much more acceptable from the standpoint of performance in that the blades can be spaced around the periphery of the wheel to achieve higher efficiency, whereas in the blade sheet type wheel, the spacing between the blades is usually fixed so that this type of wheel is not satisfactory for use where high performance is desired.

The use of individually fabricated blades often limits the curvature of the blade surface so that the leading edges of the blades are not tangential to the blower wheel and there are large energy losses due to the impacting of the air on the trailing edges of the blades. Without a tangential blade tip, the outlet velocity from the wheel is much less thus decreasing the velocity pressure produced thereby. The individual blade type blower wheel also suffers from the disadvantage that the end rings have an outer diameter larger than the outer diameter of the blades. Thus a nine-inch blower wheel does not have a nine-inch outside diameter at the blade tips, and this loss in the diameter decreases the efficiency of the wheel since the centrifugal force exerted by such a blower wheel is proportional to the blade diameter thereof.

Another important consideration in the design of this type of wheel is that the blades must be secured to the end ring and back plate so that they are rigidly supported against any substantial flexure as a result of high speed rotation of the wheel. This connection between the blades and end ring also must not restrict the flow of air through the open end of the wheel, and furthermore must permit the most desirable blade configuration and mounting angle.

Accordingly, it is an object of this invention to provide an improved blower wheel having individual blades of optimum configuration and circumferential spacing for improved efficiency thereof, and particularly to provide a blower wheel having an outer blade diameter substantially equal to the outer diameter of the end ring and back plate.

Another object of this invention is to provide a fabricated centrifugal blower wheel having individual blades secured at one end to an end ring in such a manner that the flow of air into the blower wheel is not impeded and a substantially rigid connection is provided capable of withstanding the centrifugal forces exerted thereon by high speed rotation of the blower wheel.

A further object of this invention is to provide a blower wheel of the aforesaid type having individual blades which are easily manufactured and have an optimum configuration for providing maximum capacity to the blower assembly, and further to provide a blower wheel of the above type which can be inexpensively fabricated from numerous types of materials.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

FIG. 1 is a perspective view of the blower wheel looking through the inlet end thereof;

FIG. 2 is a perspective view of one of the individual blades utilized in the blower wheel shown in FIG. 1;

FIG. 3 is a top view of the individual blade of FIG. 2;

FIG. 4 is a sectional view taken on a radial plane through the blower wheel shown in FIG. 1;

FIG. 5 is an enlarged fragmentary view illustrating the end ring before the spinning operation;

FIG. 6 is a view similar to FIG. 5 showing the end ring after the spinning operation;

FIG. 7 is a sectional view taken essentially along the line 7—7 of FIG. 5;

FIG. 8 is another sectional view taken essentially along the line 8—8 of FIG. 6;

FIG. 9 is a schematic diagram of the forces generated by the individual blades; and

FIG. 10 is a fragmentary view of the flange portion of the blade taken along the view line 10—10 of FIG. 3.

Referring to the drawings wherein a preferred embodiment of the invention is shown, FIG. 1 shows a centrifugal blower wheel **10** including a plurality of parallel blades **11** which form the circumferential sides of the blower wheel and are held securely in position by the end ring **12** and back plate **13**. A hub **15** is secured to the back plate **13** for mounting the blower wheel on a drive shaft in the usual manner, and the screw **16** (FIG. 4) in the hub **15** is utilized to lock the blower wheel **10** to the drive shaft. The blades **11** are preferably formed and the blower wheel **10** fabricated in accordance with the process and apparatus disclosed in the copending U.S. application of William H. Wentling and William P. Powell, for Centrifugal Fan, Serial No. 215,988, filed August 9, 1962, and assigned to the assignee of this invention.

Each blade **11** is constructed of a relatively thin sheet metal, such as steel or aluminum, and includes a blade surface **20** (FIG. 2) having leading and trailing edges **21** and **22** with the blade surface **20** being arcuately formed about a radius *r* having a center at **24**, as shown in FIG. 9. The blade surface **20** preferably extends through slightly more than 90° to provide maximum surface area while permitting the production of the blade **10** by suitable die stamping or apparatus, such as shown in the aforesaid copending application, which limits the degree of deformation to that which permits the blade to be stripped from the die. Moreover, this full blade surface **20** makes it possible for the leading edge **21** to be in a tangential plane whereas the trailing edge **22** extends inwardly generally in a radial direction.

Identical extensions **26** project longitudinally from each end of each blade **11** adjacent the leading portion of the blade surface **20** for use in securing the blades **11** to the end ring **12** and back plate **13**. Each of the extensions includes a tapered section **27** having an axially extending shoulder **28** at its outer end from the outer edge of which the upturned flange **30** projects in a plane parallel to the leading edge **21** of the particular blade under consideration. The edge **32** of each shoulder **30** also lies radially inwardly of the wheel from the leading blade edges **21** so that the outer diameter of the end ring **12** and back plate **13** will be substantially equal to the outer diameter of the blower wheel at the blades.

As seen in FIG. 3, one-half of the flange **30** and shoulder **28** project forwardly of the leading edge **21** for mounting the leading edge **21** of the blade **11** tangentially of the wheel. This arrangement makes possible production of the blades by stamping from an elongated strip of metal as described in the aforesaid copending application. That is, in order to provide leading and trailing edges

21 and 22 which are nearly perpendicular to each other, the leading edge must be horizontal in the die and therefore parallel to the flange 30.

The end ring 12 and back plate 13, as seen in FIGS. 5 and 6, have identical outer peripheral constructions which include a groove 35 for receiving the extensions 26 for each blade 11. The grooves 35 are defined by an inner suppport wall 36 which supports the lower surface 37 of the shoulder 28, a radial side wall 40 which engages the outermost side wall 41 of the flanges 30, and the upper deformable wall 43 which is spun over the inner side 44 of the flange 30 and the top surface 45 of the shoulder 28. The side edge 47 of the blade surface is compressed against the radially inwardly extending lip 48 during the spinning operation thus giving the finished wheel additional resistance to twisting and similar deformation which results from unusual stresses. Thus the end ring 12 and back plate 13 rigidly lock the blades 11 in position against movement in any direction, with the deformed wall 43 (FIG. 5) providing effective resistance to the radially acting centrifugal forces which act on the blades 11 when the blower wheel 10 is rotated at high speed.

While the extensions 26 fit snugly within the grooves 35 before the spinning operation, only the opposite ends of the upper edge 32 of each flange 30 contact the deformable wall 43, as seen in FIG. 7. The only point on this top edge 32 which is parallel to a tangent of the adjacent portion of the wall 43 is a point midway between the opposite ends of the edge 32. Thus, since the leading edge 21 of the blades 11 is parallel to the top edge 32 of the flange 30, to position the leading edge 21 tangentially of the blower wheel 10, the leading edge 21 must be in the same radial plane as the midpoint of the flange 30. The important feature required to achieve a tangential leading edge regardless of the relative position of the surface 20 and the extension 26, is that the leading edge 21 and the center 24 of the radius of curvature lie in the same radial plane.

The centrifugal blower wheel 10 imparts velocity to the air as a result of two forces, that is, the centrifugal force caused by rotation of the air and rotary force caused by contact between the air and the blades. As shown in FIG. 9, these forces can be broken into the exit velocity w which leaves the wheel perpendicularly to the outlet area between any two blades and the tangential velocity u which leaves the wheel tangentially. The outlet area lies in a plane extending through the center of blade 11a and through the leading edge 21 of the adjacent trailing blade 11b, and has a width d_1 and length equal to the blade length. The outlet velocity V of the air is the total of the exit and tangential velocities which must have their directions, as well as their numerical values, added. In order to achieve the largest possible outlet velocity V, the angle b between the exit and tangential velocities w and u must be as low as possible.

Referring to FIG. 9, it is seen that the outlet velocity V leaving the outlet area between the blades 11a and 11b is

$$V=u+w \tag{1}$$

where

V is the outlet air velocity vector,
u is the tangential speed vector at the leading edge of the blade 11b, and
w is the exit velocity of this blade.

However,

$$w=u_1\times C \tag{2}$$

where

u_1 is blower wheel speed at the inside diameter of the blade, and C is a blade conversion constant equal to d_2/d_1.

Therefore,

$$V=u+u_1\cdot d_2/d_1 \tag{3}$$

where

d_1 is the spacing of the blades at their outlet, and d_2 is the blade spacing at their inlet.

Thus, within certain limits, if u and d_2 are as large as possible, and d_1 is held to a minimum, the resulting velocity will be high.

As indicated above, the direction of the outlet w is perpendicular to the outlet area between two adjacent blades, or perpendicular to a line between the center of the radius of curvature of the blade adjacent the previous blade under consideration. Within limits the smaller the value of d_1, the smaller the angle b so that the vector u and w will produce a large value of velocity V.

The theoretical total velocity pressure delivered is

$$P=\left(\frac{V}{1096.5}\right)^2 pK \tag{4}$$

where

P is the theoretical total velocity pressure,
V is the air velocity leaving the wheel, and
p is air density, and
K is a constant equal to

$$\frac{l\times n}{r\times 60}$$

1096.5 is a conversion constant. See Fan Engineering, by Buffalo Forge Co., Buffalo, N.Y., 5th ed. 1949, pages 98 and 99 for derivation.

where

l is the surface width of the blade,
r is the blade radius, and
n is the number of blades in the blower wheel

so that the outlet velocity V and the number of blades n have the greatest influence on the pressure P since l and r are proportional.

Consequently it is seen that the blade edge 21 is tangential and thus creates a relatively low angle b between the tangential velocity vector u and the exit velocity vector w. The full blade surface 20 permits a low value of d_1 and the high value d_2 which results in a higher total velocity V than previously known. This factor is an important consideration in determining the velocity pressure developed by the blower wheel.

Moreover, the full blade surface 20 substantially reduces the impact force between the air and the blade since, as the air is moved radially outwardly from the center of the wheel, the smoothly curved blade surface 20 gradually changes its direction from radial to that of the outlet velocity V. If the blade 11 had a smaller surface area on the innermost portion thereof, there would be a substantial increase in the energy dissipated by the impact of the radially moving air with the portion of the blade adjacent the trailing edge 22. The invention has provided a tangential blade edge 21 as well as a generally radial trailing blade edge 22 to reduce the aforesaid losses due to impact by providing a substantially ninety degrees of blade surface 20. By way of example, the production embodiment of the invention has ninety-two degrees of blade surface.

The invention has thus provided an improved centrifugal blower wheel which is capable of highly efficient operation wherein a maximum air velocity is generated thereby with minimum impact losses due to contact between the air and the blades. The leading edges 21 of the blades 11 determine the outer diameter of the blower wheel since the end ring 12 and back plate 13 have outer diameters which are substantially equal to the outer diameter measured at the blades 11. In addition, the end ring rigidly supports the adjacent end of the blades without adversely effecting the air flow into the blower wheel.

The invention has been illustrated in connection with a single inlet blower wheel 10 but it should be appreciated that the invention is readily adapted for use in a double inlet wheel where the blades 10 are longer, an end ring is used in lieu of the back plate 13, and a suitable center disk is provided for supporting the blades on a drive shaft. Moreover, a double inlet blower wheel can be produced by placing two of the single inlet wheels 10 together with their back plates held rigidly by a single hub or the like.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A centrifugal blower wheel comprising, a plurality of parallel separate blades circumferentially arranged to form a wheel having a predetermined outer diameter, each said blade having a smoothly curved blade surface with a predetermined radius, said blade surface having a free inner trailing edge portion and an outer leading edge portion in a direction of rotation of the wheel, said leading portion terminating in a leading edge which is substantially tangent to the wheel periphery, an integral extension on each end of each said blade projecting axially outward of said blade from said outer edge portion only and substantially forward thereof in the direction of rotation of the wheel so that the end of said blades adjacent said trailing inner edge portions are free for axial flow of air into the wheel thereby increasing the inner intake area of said wheel, said outer edge portion of said blade and said extension having a tapered portion in the area of their juncture for positioning the outermost portion of said extension radially inward of the wheel from said leading edges, said extension including a rectangular flange on said outermost portion thereof which projects perpendicularly therefrom radially outward of the wheel, said flange having upper and lower edges which are parallel to each other and to a plane extending tangentially of said wheel through said leading edge of said blade surface, and a continuous retaining ring at each end of the wheel having a groove concentric with the wheel for receiving and enclosing said flanges to position the center of curvature of said blade surface and the midpoint of said flanges attached thereto in a common radial plane with said leading edge of said blade surface so that said leading edges lie substantially tangential of the wheel, said rings having a radial inner portion which supports the radial innermost surface of said extension and lies radially outward of said free inner trailing edge portions of said blade, and an integral radial outer portion on said rings which surrounds said flange and has an outer diameter substantially equal to said predetermined diameter for locking said blades together.

2. A centrifugal blower wheel comprising, a plurality of parallel separate blades circumferentially arranged to form a wheel having a predetermined outer diameter, each said blade having a smoothly curved blade surface with a predetermined radius, said blade surface having a free inner trailing edge portion and an outer leading edge portion in a direction of rotation of the wheel, said leading portion terminating in a leading edge which is substantially tangent to the wheel periphery, an integral extension on each end of each said blade projecting axially outward of said blade from said outer edge portion only and substantially forward thereof in the direction of rotation of the wheel so that the end of said blades adjacent said trailing inner edge portions are free for axial flow of air into the wheel thereby increasing the inner intake area of said wheel, said outer edge portion of said blade and said extension having a tapered portion in the area of their juncture and slightly radially depressed relative to said leading edge portion of said blade for positioning the outermost portion of said extension radially inward of the wheel from said leading edges, said extension including a rectangular flange on said outermost portion thereof which projects perpendicularly therefrom radially outward of the wheel, said flange having upper and lower edges which are parallel to each other and to a plane extending tangentially of said wheel through said leading edge of said blade surface, and a continuous retaining ring at each end of the wheel having a groove concentric with the wheel for receiving and enclosing said flanges to position the center of curvature of said blade surface and the midpoint of said flanges attached thereto in a common radial plane with said leading edge of said blade surface so that said leading edges lie substantially tangential of the wheel, said rings having a radial inner portion which supports the radial innermost surface of said extension and lies radially outward of said free inner trailing edge portions of said blade, and an integral radial outer portion on said rings which surrounds said flange and has an outer diameter substantially equal to said predetermined diameter for locking said blades together.

3. A blower wheel as defined in claim 2 wherein at least one of said continuous retaining rings is part of an end plate adapted to have a hub secured thereto for mounting the wheel for rotation.

4. A blower wheel as defined in claim 2 wherein said radial inner portion of said retaining rings include a radially inward extending lip in engagement with the adjacent end of said blade surface for adding rigidity to the wheel, and at least one of said lips defining an inlet opening to the wheel free from obstruction by any portion of said extension.

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