

Dec. 28, 1954

J. R. AULT ET AL
AXIAL FLOW FAN

2,698,128

Filed Dec. 28, 1948

4 Sheets-Sheet 1

Fig. 1.

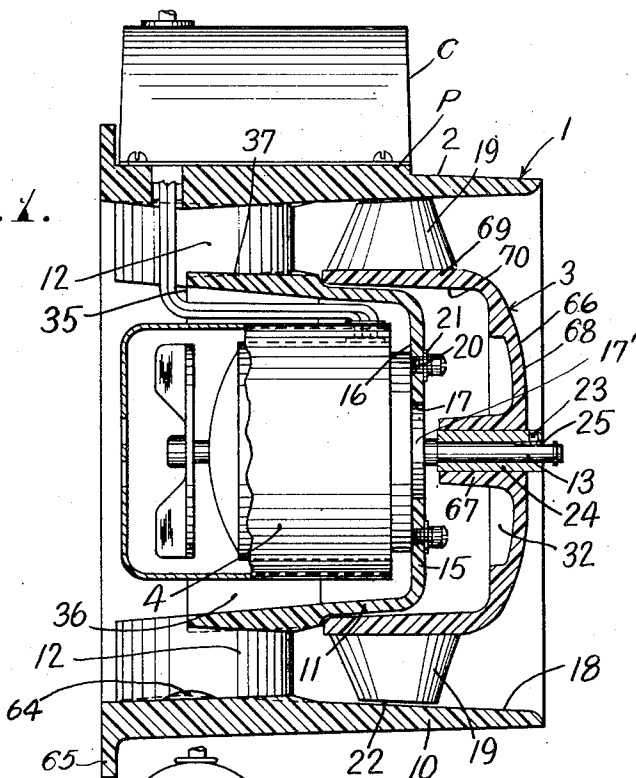
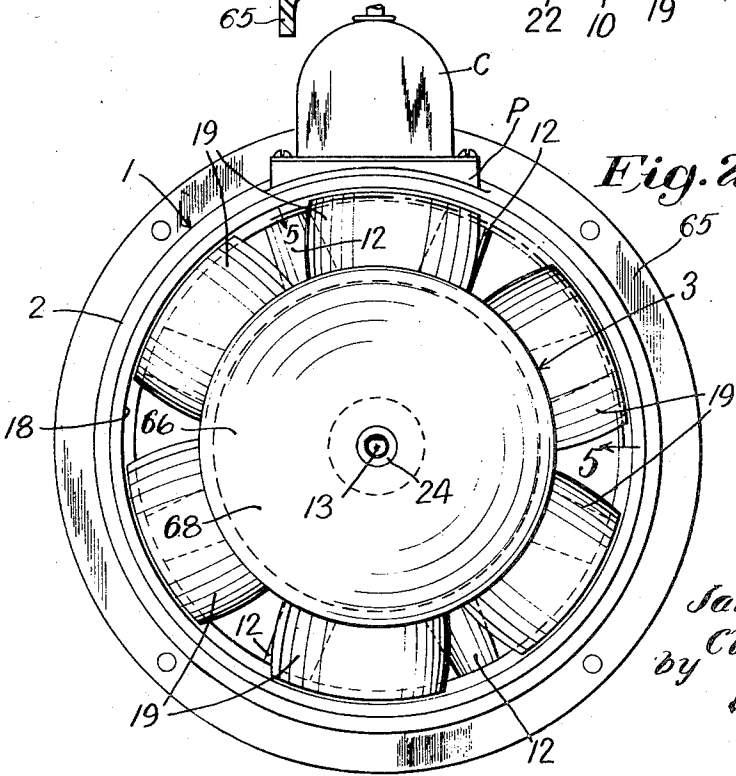


Fig. 2.



Inventors:
James R. Ault,
Chester P. Jenkins
by Paul A. Maxon,
attorney.

Dec. 28, 1954

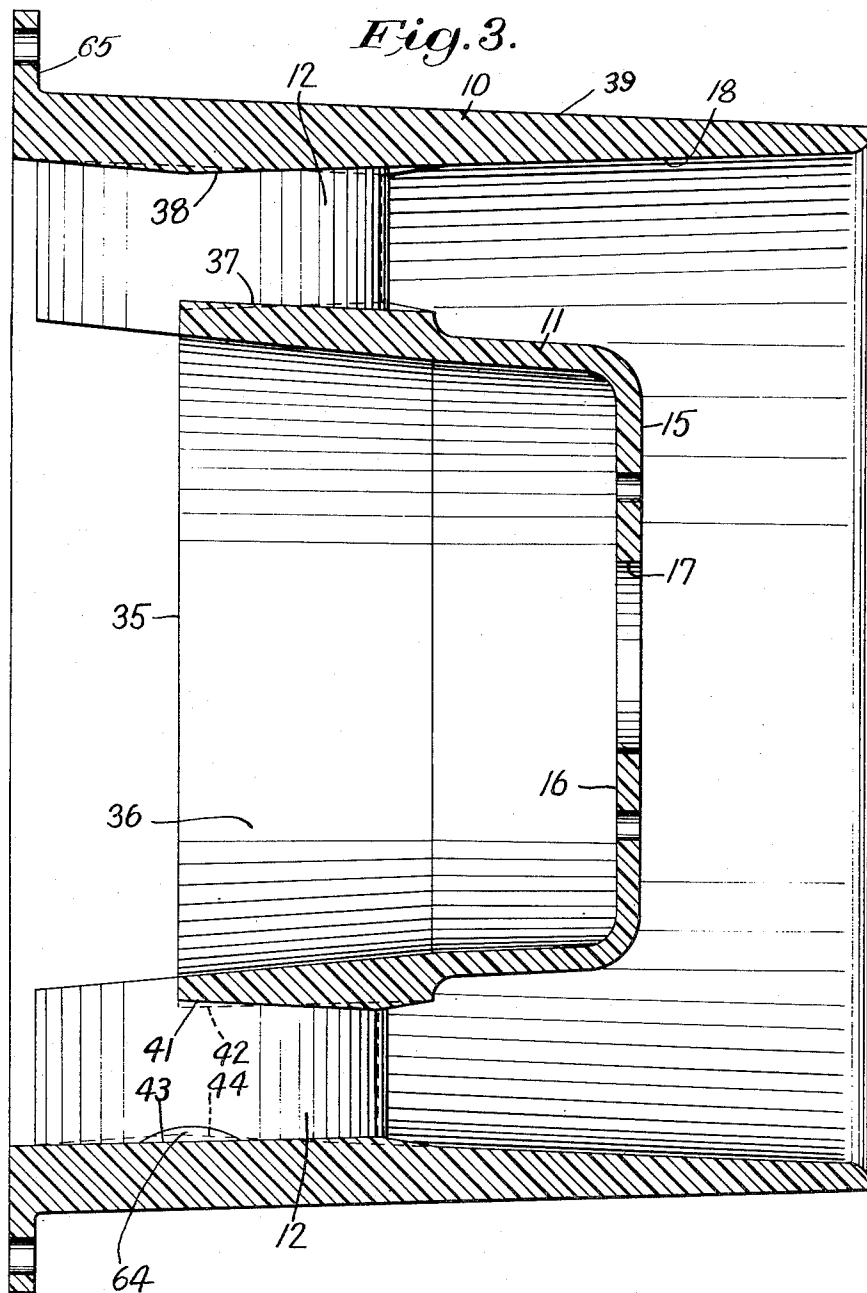
J. R. AULT ET AL

2,698,128

AXIAL FLOW FAN

Filed Dec. 28, 1948

4 Sheets-Sheet 2



Inventors:
James R. Ault.
by Chester P. Jenkins.
Paul A. Maxon.
Attorney.

Dec. 28, 1954

J. R. AULT ET AL

2,698,128

AXIAL FLOW FAN

Filed Dec. 28, 1948

4 Sheets-Sheet 3

Fig. 4.

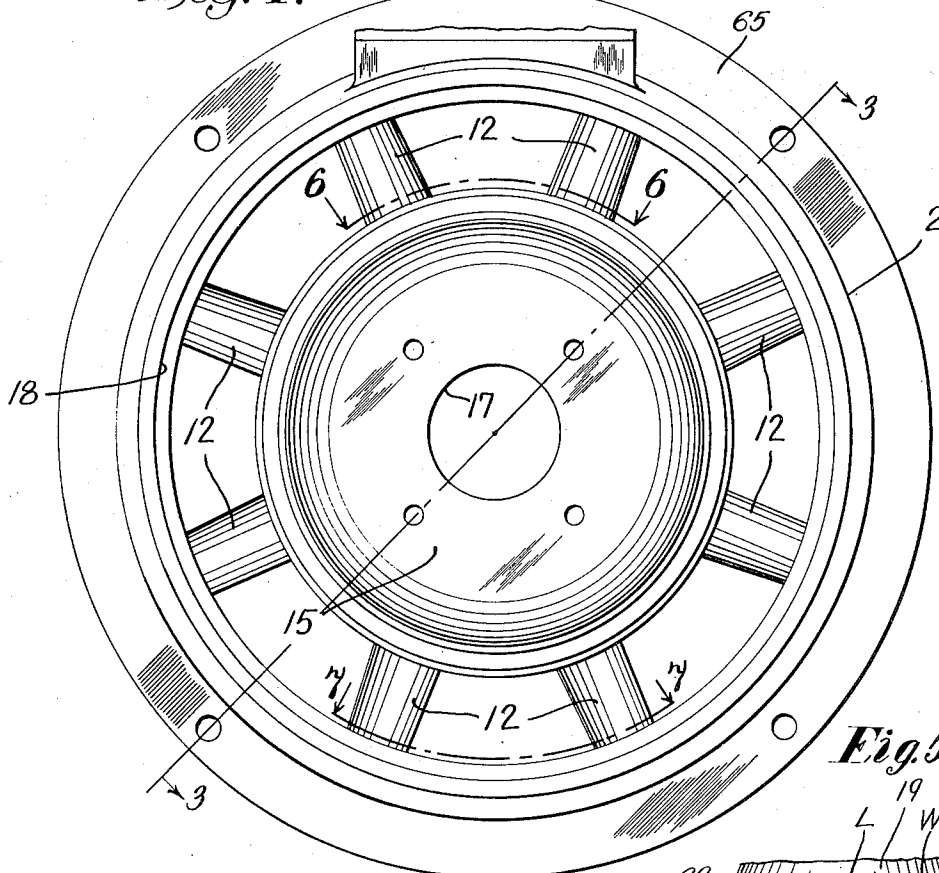


Fig. 5A.

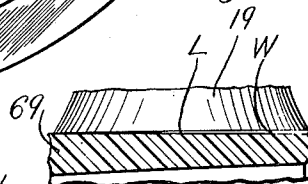
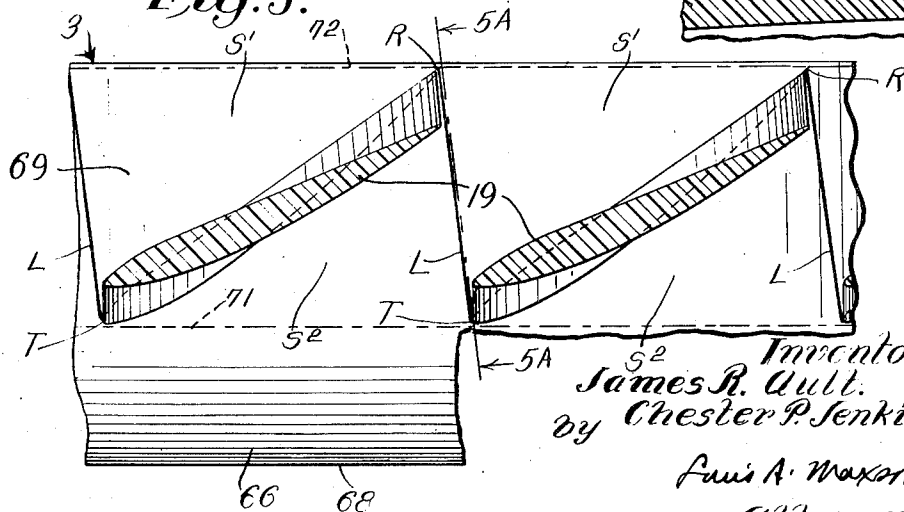


Fig. 5.



Inventors:
James R. Ault.
by Chester P. Jenkins.
Paul A. Maxam.
Attorney.

Dec. 28, 1954

J. R. AULT ET AL

2,698,128

AXIAL FLOW FAN

Filed Dec. 28, 1948

4 Sheets-Sheet 4

Fig. 6.

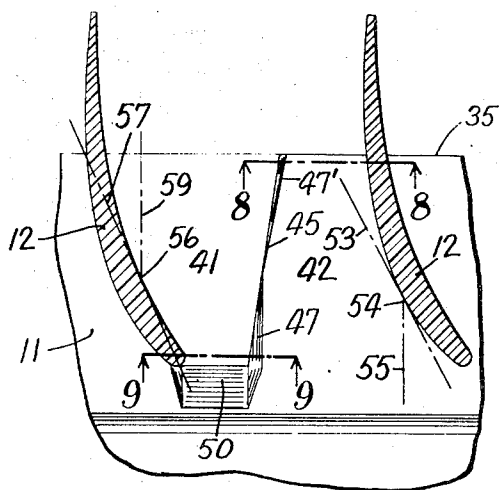


Fig. 7.

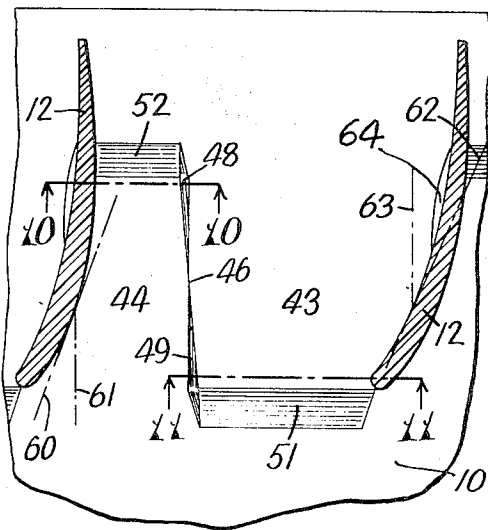


Fig. 8.

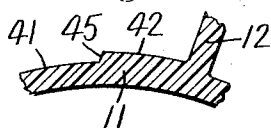


Fig. 9.

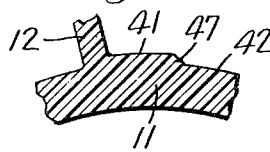


Fig. 11.

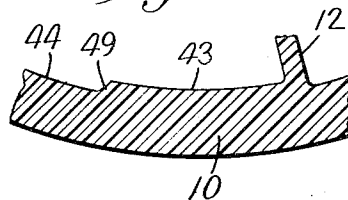
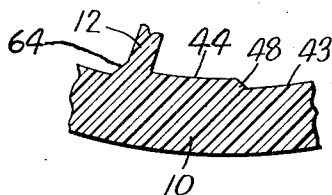


Fig. 10.



Inventors:
James R. Ault.
by Chester P. Jenkins.
Louis A. Maxson.
Attorney.

1

2,698,128

AXIAL FLOW FAN

James R. Ault and Chester P. Jenkins, New Philadelphia, Ohio, assignors to Joy Manufacturing Company, Pittsburgh, Pa., a corporation of Pennsylvania

Application December 28, 1948, Serial No. 67,738

14 Claims. (Cl. 230—117)

Our invention relates to axial flow fans, and more particularly, from different aspects thereof, to the fan and motor housings of such fans, to the fan members proper thereof, and to the complete fan units.

Fan and motor housings which are employed with fan driving motors mounted in and supported by them and with fans rotating in fan chambers formed within such housings, when built up of component parts welded or otherwise connected together upon assembly, are found to be subject to distortion, due to the presence of internal strains resulting from their mode of construction, and it is accordingly desirable to cast in one piece metallic fan and motor housings, because otherwise the close blade-tip clearances necessary for efficient operation will not be maintained, and contact of the blade tips with the inner wall of the fan chamber may ultimately take place; and, whether or not that occurs, there may be distortion, with increased tip clearance at some points and reduced clearance at others, with resultant loss of efficiency. When, as is desirable from the standpoint of weight, to mention only one possibly cogent factor, the fan and motor housings are to be made of plastics—e. g. thermo-plastic materials, a virtual necessity for mono-bloc construction is encountered.

Whether the fan member and/or the fan and motor housing—principal constituent elements of axial flow fans aside from the fan driving motors—are to be cast in one piece or molded in one piece, it is essential for economy of construction that they shall be capable of having the mold or die parts in which they are cast, formed or molded, separable from each other without injury to themselves or to the fan elements, and to that end the fan elements will desirably be constructed so that they may be formed between or within mold or like parts from which they can be removed without breakage. Where there are vanes—and the same is true of blades—which have curved surfaces which, at both sides of a point of tangency to a line parallel to the axis of the element with which said blades or vanes are integral, diverge from such a line, the problem of mono-bloc construction is greatly increased, if molds or dies which are not to be destroyed in the process of fan manufacture are to be used.

Another consideration of importance connected with our invention is the provision of an arrangement of fan elements which by relative axial adjustment of such elements enables the same parts to be adapted to meet different load conditions.

It is an object of our invention to provide an improved axial flow fan structure of which the cooperating fan member and fan and motor housing may be cast or molded by the use of molds or dies which will be uninjured in their separation and in the removal from them (or vice versa) of the parts they are employed to produce. It is another object of our invention to provide an improved mono-bloc fan member. It is a further object of our invention to provide an improved mono-bloc fan and motor housing. It is yet a further object of our invention to provide an improved mono-bloc fan and motor housing capable of production by molding or casting in dies which may be used many times. It is still another object of our invention to provide an improved fan and motor housing including vanes having surfaces which curve away, at both sides of their point of contact with a line parallel to the axis of the housing, from such a line and which are so arranged that they may be formed in simple separable molds or dies. It is still another object of our invention to provide an improved fan and motor hous-

2

ing having a motor casing spaced by curved flow-directing blades from an outer casing or fairing element, and in which the circumferentially extending surfaces at the points where such vanes join the outer wall of the fan and motor housing and join the peripheral wall of the motor casing proper shall be made up of surface portions adjacent the vane surfaces so disposed that they shall slope in one direction, longitudinally of the housing, from concave vane surfaces, and in the other direction, longitudinally of the housing, from the convex surfaces. It is still another object of the invention to provide an improved axial flow fan construction in which by the relative adjustment of a fan member to a fan casing-providing member the same elements may be caused to satisfy different load conditions. Other objects and advantages of the invention will hereinafter more fully appear.

In the accompanying drawings in which one illustrative embodiment of our invention in each of its aspects has been shown,

Fig. 1 is an approximately central vertical section through an axial flow fan in which the illustrative embodiment of the invention is incorporated.

Fig. 2 is an end elevational view of the fan of Fig. 1, viewed from the right, that is, from the fan end thereof.

Fig. 3 is a central longitudinal section on an enlarged scale and on a plane including the axis thereof, through a fan and motor housing, the section being taken on the plane of the line 3—3 of Fig. 4.

Fig. 4 is an end view, from the right hand end of Figs. 1 and 3, and on a scale smaller than that of Fig. 3, but larger than that of Fig. 1, of the fan and motor housing of Fig. 3, parts shown in Fig. 1 being omitted.

Fig. 5 is an enlarged fragmentary sectional view—or, perhaps better put, a developed view—on the curved section line 5—5 of Fig. 2, showing a detail of fan blade construction.

Fig. 5A is a detail sectional developed view on the plane of the line 5A—5A of Fig. 5.

Fig. 6 is a section on the curved section line 6—6 of Fig. 4 through certain stationary vanes, and showing the outer periphery of the cup-shaped receptacle later described.

Fig. 7 is a view on the curved section line 7—7 of Fig. 4, through a pair of flow directing vanes, and showing a portion of the inner surface of the outer casing wall of the fan and motor housing.

Fig. 8 is a fragmentary transverse section on the plane of the line 8—8 of Fig. 6.

Fig. 9 is a fragmentary transverse section on the plane of the section line 9—9 of Fig. 6.

Fig. 10 is a fragmentary transverse section on the plane of the line 10—10 of Fig. 7.

Fig. 11 is a fragmentary cross section on the plane of the line 11—11 of Fig. 7.

Referring to the drawings, it will be observed that an axial flow fan generally designated 1 includes a fan and motor housing 2, a fan member 3, and a driving motor 4. The fan and motor housing 2 is of mono-bloc construction and includes an outer annular wall 10 and a centrally disposed cup-shaped hub portion or receptacle 11 connected to the outer annular wall by a plurality of vanes 12. The cup-shaped hub portion or receptacle 11 is arranged to receive a cylindrical shaft-supporting means, herein the motor 4, and the motor has a shaft 13 which supports and drives the fan member 3 within the outer annular wall 10. The cup-shaped hub portion 11 has an inwardly directed annular wall portion 15 which has a plane inner surface 16 and which has at 17 a circular opening coaxial with an inner surface 18 formed within the wall 10 and surrounding the fan blades 19 of the fan 3. The end of the motor 4 abuts against the end surface 16, and the motor is held against the wall portion 15 by screws and washers 20, 21. The motor has a peripheral surface of revolution 17' snugly fitting within the opening 17 and coaxial with the motor shaft 13. The mounting of the motor is thus such that the axis of the motor shaft 13 is perfectly central within the surface 18, so that the tip clearance indicated at 22 between the fan blades 19 and the internal surface 18 may be maintained at a very low value. In actual construction the tip clearance may be as low as a few thou-

sandths of an inch, and the tip clearance may be readily varied, noting that the wall 18 conforms to a portion of the surface of a cone of which the base lies to the right of the fan and motor housing, in terms of Fig. 1, and that the outer ends of the fan blades 19 also conform to the surface of such a cone, merely by shifting the fan 3 along the motor shaft, as may be done by releasing a holding screw 23 which is threadedly carried by a desirably externally knurled steel insert 24 about which the fan element 3 is molded, the screw 23 engaging a flat 25 formed on one side of the shaft 13.

The provision of a conical (or frusto-conical) shape for the fan chamber, and the shaping of the tips of the fan blades so that they lie in a conical (or frusto-conical) surface of the same cone angle as the fan chamber, permits variation of the clearance between the blade tips and the surrounding fan chamber wall, while the clearance will be the same, in any particular adjustment, at all points along the lengths of the blades. A very close tip clearance, secured by moving the fan inwardly (rearwardly) in the fan chamber, until the minimum safe running clearance exists, is desirable for a system in which the volume and pressure characteristics are relatively constant, as the maximum volume and pressure will then be delivered by the fan and its maximum efficiency will be obtained. If the fan is to be used in a system having changing volume and pressure characteristics, it may be adapted to such a use by moving the fan outwardly (forwardly) in the fan chamber and increasing the tip clearance. The fan will then operate at relatively high efficiency over a greater range than is possible where minimum tip clearance was provided, though the maximum volume and pressure with this adjustment will not be as good as can be obtained with minimum tip clearance.

Reverting to the structure of the fan and motor housing 2, it will simplify the understanding of the details of construction now to be given with respect to this element if it be considered as having a first annular portion and a second annular portion or, otherwise stated and in reverse order, a forward end and a rearward end, the terms "forward end" and "second annular portion" being used to designate that end within which the fan rotates, and the terms "rearward end" and "first annular portion" employed to indicate the opposite end of the fan and motor housing. It has been noted that the fan and motor housing comprises an outer annular wall 10 and a hub portion, or perhaps more aptly stated, a centrally disposed cup-shaped receptacle 11 which constitutes a support for the motor. It has further been noted that there are a plurality of stationary vanes 12 which support the cup-shaped receptacle or support 11 substantially concentrically within the outer wall 10. These vanes connect the first annular portion or rearward end of the fan and motor housing 2 to the support. The rearward ends of these vanes 12 extend beyond the rearward end of the receptacle 11. It has been noted that the receptacle or hub portion 11 is in the form of a body open at its rearward end 35, and having at its forward end an inwardly directed annular wall or abutment 15. The chamber 36 within the hub or cup-shaped receptacle decreases in diameter, from its rearward end to its forward end, more sharply to a point slightly forward of the forward ends of the vanes 12, and then more gradually. The cup-shaped receptacle 11 has on its outer surface, between its rearward end and a circle passing through the points of junction of the forward ends of the vanes with the periphery of the cup-shaped receptacle a zone 37 of substantial width. Forward of such zone 37 the outer periphery of the cup-shaped receptacle includes only surfaces tapering toward the forward end of said receptacle or hub portion. The inner surface of the outer annular wall 10 has a zone 38 between a plane including the rearward edge of the receptacle and a circle passing through the points of junction of the forward ends of the stationary vanes 12 with the outer wall 10, forwardly of which zone the inner surface of the outer wall—the portion thereof designated 18, i. e. the portion between said circle and the forward end of the wall, includes only surfaces which taper toward the rearward end of the fan and motor housing. The outer surface 39 of the outer wall 10 tapers toward the forward end of the housing oppositely to the inner surface. Back of the rearward end of the zone 38 the inner surface of the wall 10 conforms to a frustum of a cone whose larger

end is to the rear of the fan and motor housing. The zones 37 and 38 are sub-divided by the vanes 12 and each has between each pair of vanes its surface made up principally of two surfaces sloping oppositely longitudinally of the housing, the oppositely sloping surfaces on the hub or receptacle 11 being designated 41 and 42, and the oppositely sloping surfaces on the housing wall 10 being designated 43 and 44. The oppositely sloping surfaces 41 and 42 are essentially portions of the frustums of cones, the larger end of one of which is to the rear of the housing and the larger end of the other of which is forward of the housing, the surfaces 42 constituting or conforming to portions of the frustum of a cone whose larger end is rearward of the housing and the surfaces 41 constituting or conforming to portions of a surface of the frustum of a cone whose larger end is forward of the housing. The oppositely sloping surfaces 43 and 44 of the zone 38 on the interior of the annular wall 10 conform substantially to portions of the frustums of cones the larger end of one of which is to the rear of the housing and the larger end of the other of which is forward of the housing. Surfaces 43 conform to the surface of a frustum of a cone whose larger end is to the rear of the housing, specifically to the surface of the frustum mentioned a few lines above. The surfaces 44 conform to the surfaces of a frustum of a cone whose larger end is forward of the housing. This frustum is the one to which the surface 18 conforms. The adjacent edges of the oppositely sloping surfaces 41, 42 and of the oppositely sloping surfaces 43, 44 terminate in mutually oblique lines, respectively numbered 45 and 46, and oblique fills, as at 47, 47', 48 and 49, are made along said lines where air flow would be substantially adversely affected in the absence of such fills. Ramplike portions are provided at the forward end of the surfaces 41 and 43, as at 50 and 51 and a ramplike sloping fill 52 is provided at the rearward end of the surfaces 44. Rearwardly of this fill lies a surface portion which is a portion of the surface 43. Each stationary vane 12 has its side surfaces so curved that a line drawn parallel to the axis of the housing from any point in such a side surface, in the direction of removal of a mold which forms such side surface, will not pass through the vane. Thus, referring to Fig. 6, a mold forming the surface 42 and the left side of the blade 12 at the right of that figure would be moved downwardly relative to the fan and motor casing to effect their separation, and from the point of tangency of a line 53 to the vane at 54 a line 55 can be drawn downwardly, in parallelism with the axis of the fan and motor casing, without passing through the blade, and the divergence between the line 55 and the portion of the line 53 below the point 54 in Fig. 6, will make it clear that the mold can be withdrawn without difficulty.

Again, a mold that would form the surface 41 and the right side of the blade 12 at the left in Fig. 6 would be withdrawn upwardly of Fig. 6, and a line 59 can be drawn upwardly, parallel to the axis of the fan and motor casing, from the point of tangency 56 of a line 57 with the surface of the vane, without passing through the vane, and the upward divergence of the lines 59 and 57 clearly indicates the ready removability of the mold.

Turning next to Fig. 7, it will be noted that the mold which forms the surface 44 and the right hand side of the left hand vane 12 is downwardly removable, and that the line 61 may be drawn downwardly in parallelism with the axis of the fan and motor housing from the point of tangency of a line 60 with the surface of the vane, and not pass through the vane, and the downward divergence of lines 60 and 61 clearly shows the ready removability of the mold from the casing.

Finally, the mold that forms the surface 43 and the concave side of the right hand vane shown in Fig. 7 is removed upwardly, and the divergence between the line 63, drawn upwardly parallel to the axis of the fan and motor housing, from the point of tangency of the line 62 with the curve of the left hand side of the right hand vane 12, shows the ready removability of the mold that forms the surface 43 and concave side of the right hand vane.

It is to be understood that references to movement of mold to casing are to explain relative directions of separative movement, and do not exclude removal of the casing from the molds instead of vice versa. In order to enable cleaner separation between the housing and

5

the die or mold fills at sharp corners may be provided as at 64.

Before considering further the structure of the fan member 3, it may be noted that the fan and motor housing 10 may desirably be tapered exteriorly towards its forward end and may also desirably have a mounting flange as at 65. The casing or housing 10 may also have a pad P formed thereon for the mounting of a connector box or the like C. In order to facilitate molding, the plane of pad P to which box C is fastened preferably slopes slightly toward the motor axis at the forward end.

We may now advert further to the structure of the fan member 3. This may be noted to comprise a rotor body portion 66 which includes a hub portion 67 in which the steel insert 24 is mounted, a radially extending wall 68, and an annular portion 69 supporting the blades 19. The hub portion 67 and the inner wall 70 of the portion 69 are each so formed that a corelike element forming the inner wall of the mold for the fan proper may be readily withdrawn.

The external periphery of the annular portion 69, at the portions thereof from which the blades 19 project is specially formed to facilitate removal of the fan from the mold in which it is formed. Let it be imagined that this annular portion is surrounded by two concentric circles, one, indicated in broken lines at 71 in Fig. 5, at the leading edges of the blades, and the other, indicated in broken lines at 72 in the same figure, at the receding edges of the fan blades. Circle 71 will be slightly larger in diameter than circle 72. In other words the external diameter of portion 69 is slightly larger just forward of the blades 19 than just to the rear of them. The surface between the circles 71 and 72 is broken up into sections respectively principally forward of the blades and principally rearward of the blades. Because the blades do not overlap each other as shown, but are slightly spaced circumferentially of the rotor, the surfaces may be more sharply defined as follows: From a point adjacent the forward tip T of each blade, let a line L be drawn to a point adjacent the receding edge R of the blade next ahead. Now, there will be seen to be two series of areas—the one, S¹, made up of areas at least principally to the rear of the fan blades and the other, S², made up of areas at least principally ahead of the fan blades. Now with respect to the areas S¹, these areas will conform to a frustum of a cone coaxial with said fan (with its axis in the same line with the fan axis) and the elements of the surfaces of said areas will all be elements of such a frustum and all will slope rearwardly. On the other hand, the elements of the surfaces of the areas S² ahead of the blades will each correspond to the elements of a frustum of a cone having its axis in the same line with the rotor axis and having its larger end to the rear of the rotor. This will mean that an element extending rearwardly of the fan from the point near the leading edge T of a blade slopes rearwardly inwardly towards the axis of the fan, while an element extending forwardly from the point near the receding edge R of the next blade ahead slopes forwardly and inwardly, that the forward ends of the two elements are in a common circle 71 struck from the axis of the fan rotor, and that extending between the points is a surface W having edges diverging from the point near the forward end of the first blade to the point near the receding edge of the preceding blade. Thus there will be readily possible a molded structure separable from its mold by draft in opposite directions. The narrow circular surfaces forward of the first circle 71 and rearward of the second circle 72 correspond to the adjacent frusto-conical surfaces and form extensions thereof. The first mentioned of these narrow circular surfaces merges into the rounded nose of the fan. Fig. 5A is provided to show the surface W.

Evidently, now the portions of the blades 19 and of the surfaces around their roots are so formed that two mold elements, one forming the rearward surfaces of the blades and the peripheral surface areas S¹ behind them, and the other shaping the forward surfaces of the blades and the surfaces S² ahead of them may be readily separable after the fan is molded. To lighten the fan construction the radial wall portion thereof is recessed annularly as at 32, and it will be apparent that the portion of the rearward mold element which fills this recess during casting or molding of the fan will be freely withdrawable from the recess because of the shape of the walls thereof.

6

It will be noted that the motor 4 constitutes a cylindrical means having a rotating driving shaft therein with a fan mounted thereon, and that the motor is thus illustrative of fan driving means which may not have their motor means coaxial with the fan and motor housing.

It should be further noted that each of the vanes 12 has an entry nose portion at its forward end, a trailing edge portion at its rearward end and an intermediate curved portion, and that the entry nose portion is disposed at an angle to the axis of the housing while the trailing portion is directed substantially axially to the housing, and that the zone 38 has the portions of its surface between the vanes which lie adjacent to them slope longitudinally toward the axis of the housing in one direction from the concave portions of said vanes and longitudinally toward the axis of the housing in the other direction from the convex portions of the vanes.

It may be noted that book-type dies could be used, in which case the outer surface 39 would not need to be tapered.

The invention described herein may be injection molded if desired, or it may be made by filling a mold with plastic in powder form, after which the mold may be heated under pressure to a temperature high enough to fuse the powdered plastic. A still further alternative would be die casting, if the parts were made of metal.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In an axial flow fan structure comprising cylindrical means having a rotating driving shaft therein with a fan mounted thereon, said fan having outwardly extending blades whose end surfaces lie in a frusto-conical surface, said cylindrical means supporting the shaft and having a casing with an end portion through which said shaft extends, said casing having an external surface of revolution substantially concentric with said shaft, the improvement of a housing for the cylindrical means and the fan, said housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal frusto-conical surface surrounding the fan and having its end of smaller diameter nearer said first annular portion, said support having first and second angularly related surfaces, said first angularly related surface constituting an internal surface of revolution substantially concentric both to said shaft and to said internal frusto-conical surface, said first angularly related surface closely receiving said external surface of revolution of the said casing and substantially concentrically aligning said external surface of revolution of the casing and the shaft with the said internal frusto-conical surface, whereby a substantially constant tip clearance is maintained between the fan blades and said frusto-conical surface, said second angularly related surface constituting transversely disposed abutment means against which the end portion of said casing longitudinally abuts and through which said shaft extends, and fastening means fastening the said casing to the abutment means for holding the said casing and shaft against longitudinal movement.

2. In an axial flow fan structure comprising cylindrical means having a rotating driving shaft therein with a fan mounted thereon and having outwardly extending blades whose end surfaces lie in a frusto-conical surface, said cylindrical means supporting the shaft and having a casing with an end portion through which said shaft extends, said casing having an external surface of revolution substantially concentric with said shaft, the improvement of a housing for the cylindrical means and the fan, said housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality

of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal frusto-conical surface surrounding the fan and of like cone angle with said first mentioned frusto-conical surface and having its end of smaller diameter nearer said first annular portion, said support having first and second angularly related surfaces, said first angularly related surface constituting an internal surface of revolution substantially concentric both to said shaft and to said internal frusto-conical surface, said first angularly related surface closely receiving said external surface of revolution of the said casing and substantially concentrically aligning said external surface of revolution of the casing and the shaft with the said internal frusto-conical surface, whereby a substantially constant tip clearance is maintained between the fan blades and said frusto-conical surface, said second angularly related surface constituting transversely disposed abutment means against which the end portion of said casing longitudinally abuts and through which said shaft extends, and fastening means fastening the said casing to the abutment means for holding the said casing and shaft against longitudinal movement.

3. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, and said first annular portion having the internal surface thereof between the connections of said vanes therewith comprised principally of oppositely sloping portions conforming to frusto-conical surfaces of mutually opposite taper but with their axes in the same line with the axis of said outer fan chamber wall.

4. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal frusto-conical surface forming the outer wall of a fan chamber, and said first annular portion having the internal surface thereof between the connections of said vanes therewith comprised principally of oppositely sloping portions conforming to frusto-conical surfaces of mutually opposite taper but with their axes in the same line with the axis of said outer fan chamber wall, certain of said portions constituting extensions of said first mentioned frusto-conical surface.

5. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal frusto-conical surface forming the outer wall of a fan chamber, and said first annular portion having the internal surface thereof between the connections of said vanes therewith comprised principally of oppositely sloping portions conforming to frusto-conical surfaces of mutually opposite taper but with their axes in the same line with the axis of said outer fan chamber wall, certain of said portions constituting extensions of said first mentioned frusto-conical surface and there being ramp portions adjacent the ends of smaller radius of said oppositely sloping portions.

6. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal frusto-conical surface forming the outer wall of a fan chamber, and said first annular portion having the internal surface thereof between the connections

of said vanes therewith comprised principally of oppositely sloping portions conforming to frusto-conical surfaces of mutually opposite taper but with their axes in the same line with the axis of said outer fan chamber wall, certain of said portions constituting extensions of said first mentioned frusto-conical surface and there being ramp portions adjacent the ends of smaller radius of said oppositely sloping portions and one of the portions between each pair of vanes extending for a portion of its length for the full width of the space between such pair.

7. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, and said centrally disposed support having the exterior periphery thereof in the zone of the connections thereto of said vanes comprised of oppositely sloping sections conforming to frusto-conical surfaces whose axes are in the same line with the axis of said outer fan chamber wall and whose larger ends are at the opposite ends of said vanes.

8. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, and said centrally disposed support having the exterior periphery thereof in the zone of the connections thereto of said vanes comprised of oppositely sloping sections conforming to frusto-conical surfaces whose axes are in the same line with the axis of said outer fan chamber wall and whose larger ends are at the opposite ends of said vanes, one of said oppositely sloping sections having a ramp at its end of larger diameter.

9. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, each of said vanes having a leading and a rearward end, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, and said centrally disposed support having the exterior periphery thereof in the zone of the connections thereto of said vanes comprised of oppositely sloping sections conforming to frusto-conical surfaces whose axes are in the same line with the axis of said outer fan chamber wall and whose larger ends are at the opposite ends of said vanes, said oppositely sloping sections being of less length than said vanes and extending from points adjacent the leading ends of said vanes only to points short of the rearward ends of said vanes.

10. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support and a plurality of vanes for connecting said support to said outer annular wall, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, said first annular portion having the internal surface thereof between the connections of said vanes therewith comprised principally of oppositely sloping portions conforming to frusto-conical surfaces of mutually opposite taper but with their axes in the same line with the axis of said outer fan chamber wall, and said centrally disposed support having the exterior periphery thereof in the zone of the connections thereto of said vanes comprised of oppositely sloping sections conforming to frusto-conical surfaces of mutually op-

posite taper but with their axes in the same line with the axis of said outer fan chamber wall.

11. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support, and a plurality of vanes for connecting said support to said outer annular wall, each of said vanes having an entry nose portion, a trailing edge portion, and an intermediate curved portion therebetween, whereby said vanes have concave and convex portions, said entry nose portion being disposed at an angle to the axis of said housing and said trailing portion being directed substantially axially of said housing, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, and said first annular portion having the portions of its surface between said vanes which lie adjacent to them slope longitudinally towards the axis of the housing in one direction from the concave portions of said vanes and longitudinally towards the axis of the housing in the other direction from the convex portions of the vanes.

12. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support, and a plurality of vanes for connecting said support to said outer annular wall, each of said vanes having an entry nose portion, a trailing edge portion, and an intermediate curved portion therebetween, whereby said vanes have concave and convex portions, said entry nose portion being disposed at an angle to the axis of said housing and said trailing portion being directed substantially axially of said housing, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, and said centrally disposed support having the exterior periphery thereof in the zone of the connections thereto of said vanes so formed that the portions of said periphery which are adjacent to the vanes slope longitudinally toward the axis of the housing in one direction from the concave portions of the vanes and longitudinally toward the axis of the housing in the other direction from the convex portions of the vanes.

13. In an axial flow fan, a fan and motor housing comprising a mono-bloc structure having an outer annular wall, a centrally disposed motor support, and a plurality of vanes for connecting said support to said outer annular wall, each of said vanes having an entry nose portion, a trailing edge portion, and an intermediate curved portion therebetween, whereby said vanes have concave and convex portions, said entry nose portion being disposed at an angle to the axis of said housing and said trailing portion being directed substantially axially of said housing, said outer annular wall having a first and a second annular portion, said plurality of vanes connecting said centrally disposed support to said first annular portion, said second annular portion having an internal surface of revolution forming the outer wall of a fan chamber, said first annular portion having the portions of its surface between said vanes which lie adjacent to the latter slope longitudinally towards the axis of the housing in one direction from the concave portions of said vanes and longitudinally towards the axis of the housing in the other direction from the convex portions of the vanes, and said centrally disposed support having the exterior periphery thereof in the zone of the connections thereto of said vanes so formed that the portions of said periphery which are adjacent to the vanes slope longitudinally toward the axis of the housing in one direction from the concave portions of the vanes and longitudinally toward the axis of the housing in the other direction from the convex portions of the vanes.

14. A mono-bloc fan and motor housing having a for-

ward end and a rearward end and comprising an outer annular wall, a centrally disposed cup-shaped receptacle, and a plurality of stationary vanes supporting the cup-shaped receptacle substantially concentrically within the outer wall, said cup-shaped receptacle comprising a body open at its rearward end and having at its forward end an inwardly directed annular abutment and having a chamber decreasing in diameter from its rearward end to the forward end thereof, said cup-shaped receptacle having on the outer surface thereof, between the rearward end thereof and a circle passing through the points of junction of the forward ends of said vanes with the periphery of said cup-shaped receptacle a zone of substantial width, the outer periphery of said cup-shaped receptacle including, forwardly of such zone, only surfaces tapering towards the forward end thereof, and the inner surface of said outer annular wall having a zone between a plane including the rearward edge of said receptacle and a circle passing through the points of junction of the forward ends of said stationary vanes with said outer wall, the inner surface of said outer wall, between said circle and the forward end of said wall, including only surfaces which taper towards the rearward end of said fan and motor housing, and said zones each having the surfaces thereof subdivided by said vanes and each having between each pair of vanes its surface made up principally of two surfaces sloping oppositely longitudinally of said housing, said oppositely sloping surfaces on said receptacle being essentially portions of the frusta of cones the larger end of one of which is to the rear of said housing and the larger end of the other of which is forward of said housing, and the oppositely sloping surfaces of said zone on the inner surface of the outer annular wall conforming substantially to portions of the frusta of cones the larger end of one of which is to the rear of said housing and the larger end of the other of which is forward of said housing, the adjacent edges of said oppositely sloping surfaces in each zone terminating in mutually oblique lines and there being oblique fills at points along said lines where air flow would be substantially affected in the absence of such fills, and said stationary vanes being so curved that at no point in either lateral surface thereof in adjacency to the inner surface of said outer annular wall does the angle between a straight line tangent to such lateral surface and a straight line parallel to the axis of said housing, which angle has its sides lying in a plane perpendicular to a radial line extending from the point of tangency to the axis of said housing, have its apex towards the larger end of the truncated cone to which that one of said oppositely sloping surfaces in said second zone which is adjacent to such lateral surface conforms.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,502,062	Schmidt	July 22, 1924
2,111,817	Sherman	Mar. 22, 1938
2,153,604	Wheller	Apr. 11, 1939
2,163,706	Sayers	June 27, 1939
2,190,945	Guth	Feb. 20, 1940
2,307,283	Loneragan	Jan. 5, 1943
2,311,896	Criqui	Feb. 23, 1943
2,390,879	Hagen	Dec. 11, 1945
2,397,171	Troller et al.	Mar. 26, 1946
2,421,888	Jackson	June 10, 1947
2,427,032	Troller et al.	Sept. 9, 1947
2,460,902	Odor	Feb. 8, 1949
2,488,945	Troller	Nov. 22, 1949
2,489,692	Whittle	Nov. 29, 1949
2,540,968	Thomas	Feb. 6, 1951
2,552,118	Sawyer	May 8, 1951

FOREIGN PATENTS

Number	Country	Date
305	Australia	Jan. 20, 1931