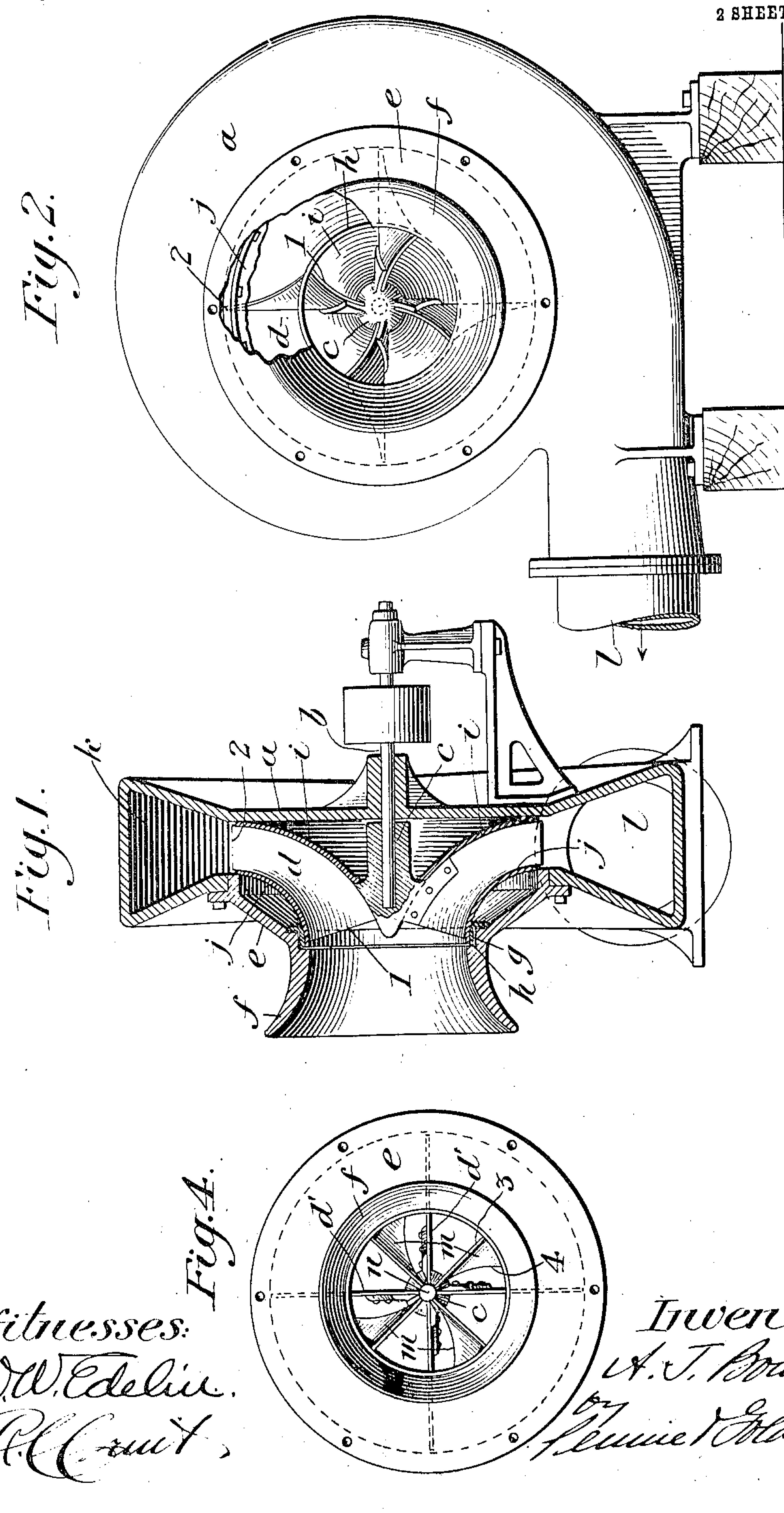
A. J. BOWIE, Jr.

CENTRIFUGAL FAN.

APPLICATION FILED JUNE 3, 1905.

909,863. Patented Jan. 19, 1909.

2 SHEETS—SHEET 1.



Witnesses:
D. W. Edelin.
R. C. Grant

Inventor:
A. J. Bowie Jr.,
by Pennie & Goldsborough,
Attys

A. J. BOWIE, Jr.
CENTRIFUGAL FAN.
APPLICATION FILED JUNE 3, 1905.

909,863. Patented Jan. 19, 1909.

2 SHEETS—SHEET 2.

Fig. 3.

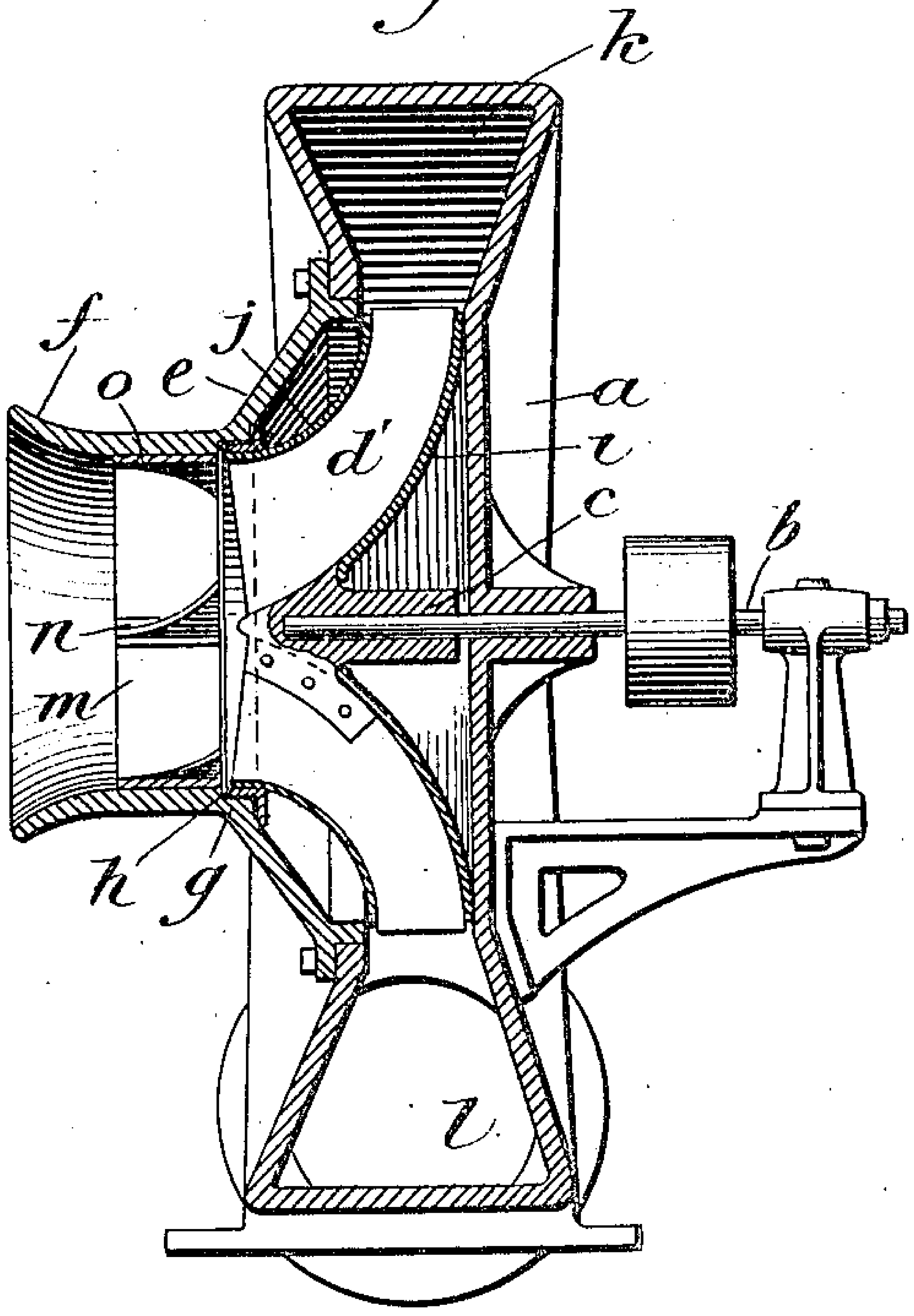


Fig. 5.

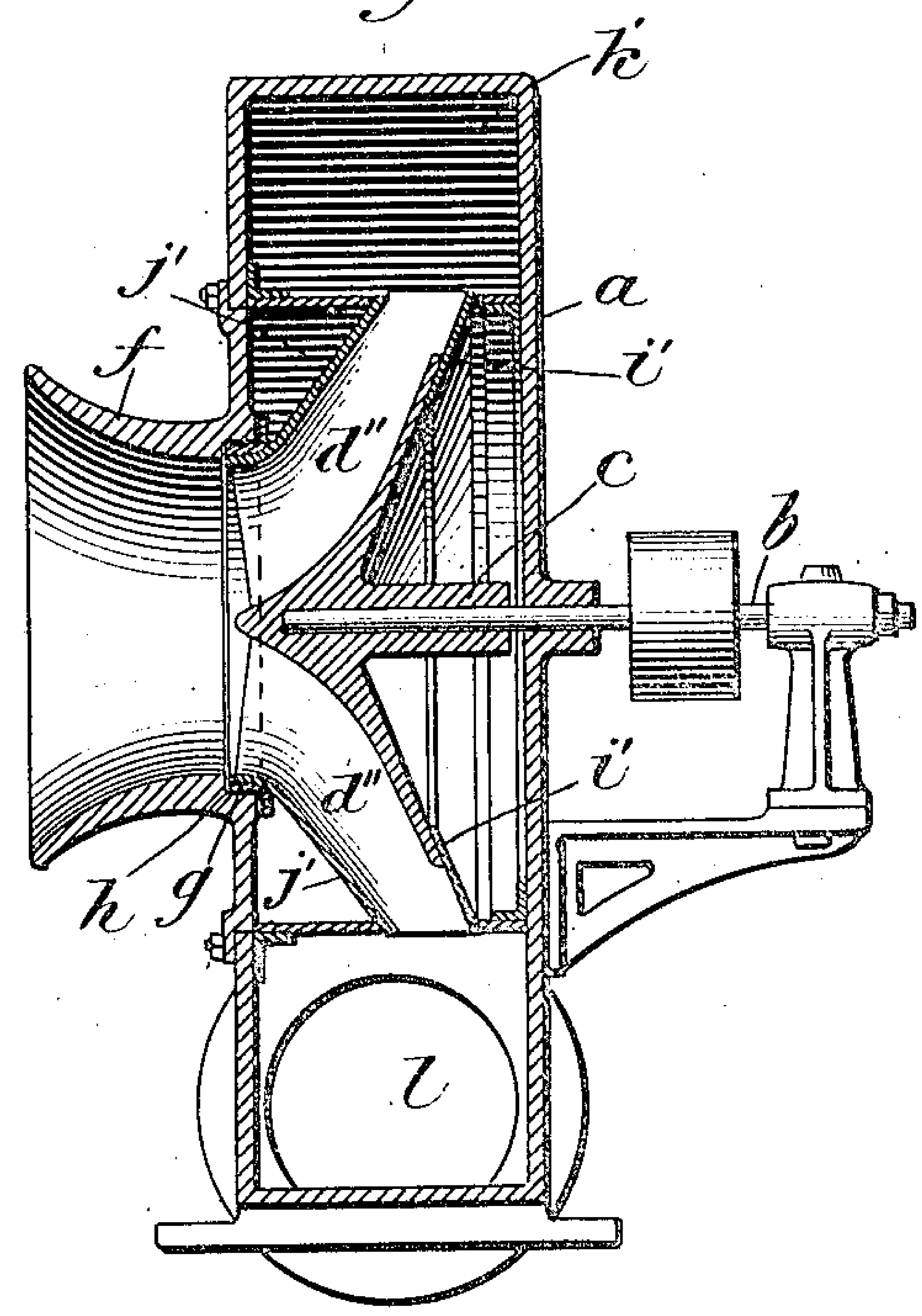


Fig. 6.

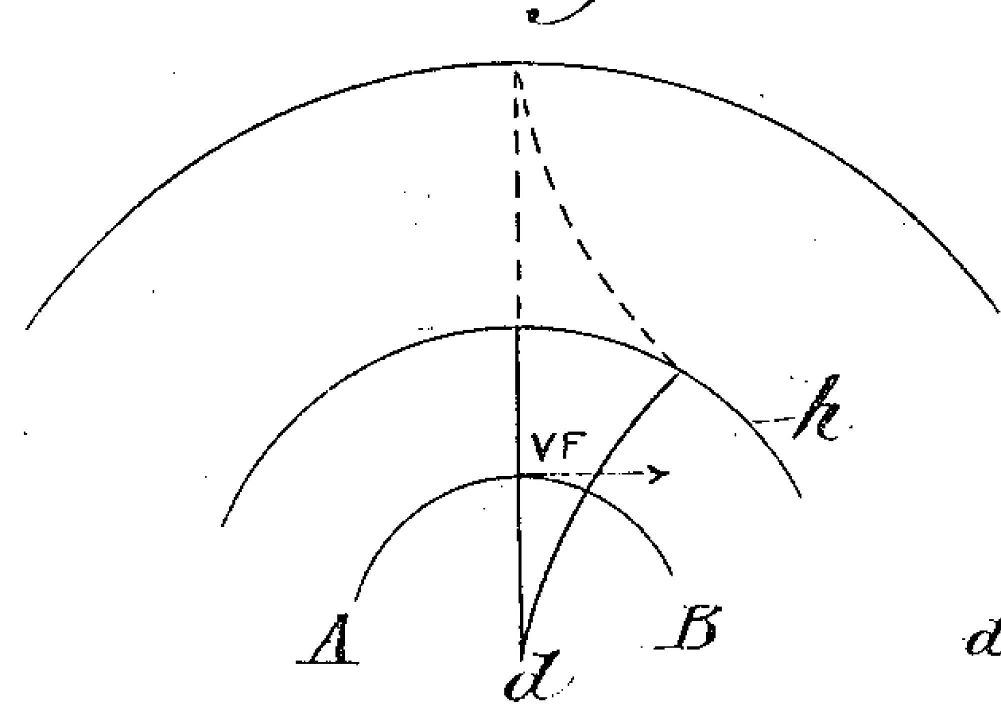


Fig. 8.

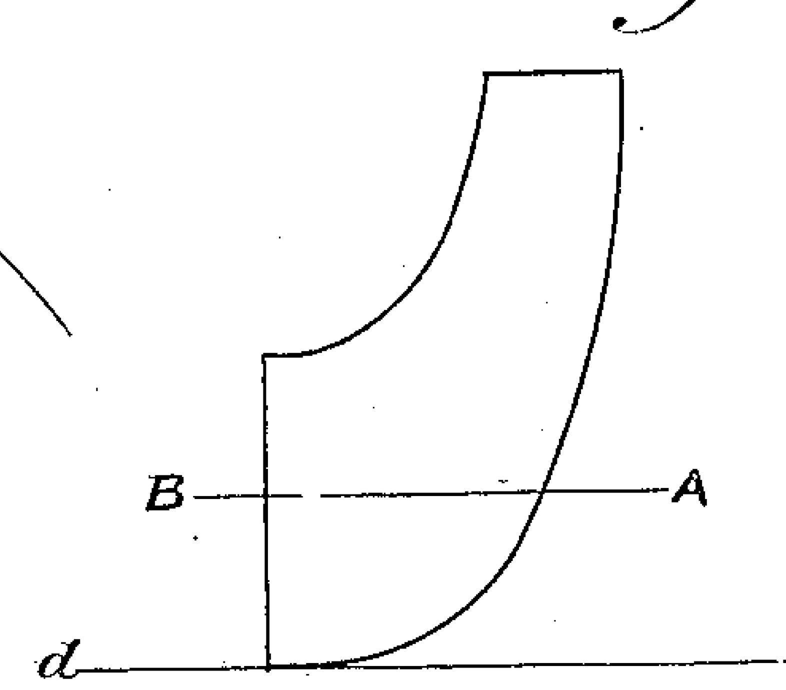
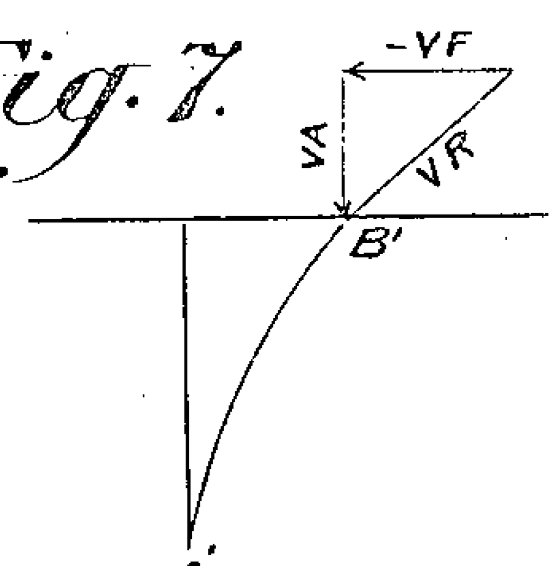


Fig. 7.



Witnesses:
D. W. Edelin.
R. C. Craig

Inventor:
A. J. Bowie Jr.,
by [signature]
Attys.

UNITED STATES PATENT OFFICE.

AUGUSTUS J. BOWIE, JR., OF WASHINGTON, DISTRICT OF COLUMBIA.

CENTRIFUGAL FAN.

No. 909,863. Specification of Letters Patent. Patented Jan. 19, 1909.

Application filed June 3, 1905. Serial No. 263,567.

To all whom it may concern:

Be it known that I, Augustus J. Bowie, Jr., a citizen of the United States, residing at Washington, District of Columbia, have invented certain new and useful Improvements in Centrifugal Fans; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The invention has reference to centrifugal fans or blowers, and has for its object to provide a machine of the character described, having its parts so constructed and arranged as to avoid back slippage of air, to subpress eddy currents within the casing, and to eliminate shock between the entering air and the vanes; whereby the air is caused to circulate rapidly through the machine without loss of energy due to abrupt change of direction of flow, or to violent impact with the moving parts of the machine, so that the mechanical efficiency of the machine is materially increased.

In the accompanying drawings; Figure 1 is a vertical transverse section of a centrifugal fan embodying the features of my invention; Fig. 2 is a side elevation thereof, certain portions being broken away in order to more clearly indicate the relative arrangement of the interior parts; Fig. 3 is a view corresponding to that in Fig. 1, illustrating a modified form of the invention; Fig. 4 is a side elevation of the machine shown in Fig. 3, the volute casing, however, being omitted; Fig. 5 is a vertical transverse section of another modification, illustrating a suitable form of casing and of runner and blades which may be employed in fans of large size with sheet iron casings. Figs. 6, 7 and 8 are diagrams illustrative of the mode of constructing the suction or intake ends of the blades of the fan.

Considered generally, the apparatus comprises a casing *a*, into which projects power shaft *b*, having on its inner end a hub *c*, to which is bolted or otherwise attached a series of blades, designated by reference letters *d*, *d'*, and *d''*, respectively, in the several modifications. The casing *a* is constructed of the usual volute form, with a constantly increasing section from the cut-off lip to the discharge. The centrally disposed inlet is provided with a flaring or bell shaped mouth *f* to avoid loss of head in the entering air. This flaring intake *f* may, of course, be located on the casing, or, if a suction pipe is used, at the inlet end of said pipe. In Figs. 1, 2, 3 and 4 of the drawing, the bell shaped intake *f* is formed as part of an annular casting *e*, which is bolted to the front of the casing *a*. In order to avoid back slippage of air at the intake, if the fan is of the closed runner type, a ring *h*, secured to the suction end of the runner, engages a groove *g* in the inner face of intake *f*, the ring and the groove being accurately turned to provide a close fit having just sufficient clearance laterally and circumferentially to permit the ring to turn freely, without allowing reverse air currents to blow back into the bell *f*.

In Figs. 1 and 2, which illustrate a preferred construction employed in fans with cast iron casings, the vanes are inclosed by conical or conoidal walls *i*, *j* at front and back, which walls are attached to the vanes and form the lateral surfaces of the runner, being so constructed as to suppress eddy currents within the runner and to effect a gradual change in the direction of flow of the air from the suction entrance to the discharge end of the runner; that is to say, to gradually change the direction of the current of air, moving axially of the fan at the entrance, to a substantially radial movement thereof at the point of discharge from the vanes of the runner. The relation and arrangement of the lateral walls *i*, *j*, with respect to the gradually tapering blades of the runner are such that the change of velocity of the air across a section substantially normal to the surface of said walls, is gradual and practically uniform from the suction entrance to the discharge from the runner, so that, generally considered, the radial discharge velocity of the air from the runner is somewhat less than the initial or entrance velocity of the air thereto. The effect of this arrangement of the blades and the inclosing walls therefor, is to avoid the eddy current loss due to unequal radial surface distribution of air, occasioned by the comparatively low radial velocity of discharge from the runners in fans as heretofore constructed and at the same time to avoid the loss due to too high a radial velocity, caused by increasing the radial velocity of discharge over the axial velocity at entrance to the runner. By observing these conditions, I have found, for example, that as compared with standard fans or blowers, my fan will deliver more air, although the width of the face of the blades at their outlet end is less than half that of said standard fans. This effect may perhaps be explained by the consideration that in a fan in which the velocity of discharge is considerably greater than the velocity of intake the air, instead of passing in a continuous body directly through the runners without eddy currents, is allowed, by reason of the shape of the runner, to expand greatly and furthermore to eddy and return upon itself, thus giving rise to efficiency losses. In a fan in which the velocity of discharge is greater than the velocity of intake a compression of the air within the runner and a useless change in the velocity substantially exists, which also gives rise to efficiency losses. In my improved fan the point of greatest velocity is at the initial portion of the runner and from there the air expands gradually and uniformly throughout the length of the runner and throughout the body of the volute casing, expansion being slight and entirely gradual so that no eddy currents are set up and at the same time no useless compression or change of velocity takes place.

In centrifugal fans, as heretofore constructed, a comparatively large loss of efficiency is due to the sudden impact of the entering air upon the blades or runners, as the entire energy of the repeated blows between the fan blades and the incoming air is wasted. The present invention contemplates the provision of specially formed blades or vanes to take in air without shock, whereby this element of loss is eliminated, and the efficiency of the fan is correspondingly increased. This highly important feature of the invention is effected by constructing each blade so that it shall have a propeller shape, viz. a constant pitch at the induction end, which gradually curves in the direction of rotation toward a position substantially parallel of the axis of the shaft at the discharge end of the blade. Considering both speed and capacity of the fan, therefore, the important point to be observed is to give the entrance line of the vanes proper propeller shape, and to curve the remaining portions of the vanes gradually, until they are substantially parallel to the axis of rotation along their peripheral edges, so that the air will be passed smoothly and gently into engagement with the vanes at the suction end, and gradually changed or diverted in its direction of flow until it is discharged radially into the volute casing. The initial portion of the blade or vane, to meet the conditions hereinbefore referred to, is generated or produced in the following manner.

Referring to Figs. 6, 7 and 8, let A, B, indicate a cylinder, concentric with the shaft of the fan, intersecting the vane between the center of the shaft *b* and the ring *h;* Fig. 6 showing the parts in end elevation; Fig. 7 being the development of said cylinder showing the line A′, B′ of intersection of the cylinder and the vane, B′ being a point in the suction edge of the blade or vane; and Fig. 8 being a radial projection of the blade or vane. Let VA indicate the velocity and direction of the entering air, and VF the peripheral velocity of the vane at the line of intersection of the cylinder A B therewith, and VR the resultant of VA and —VF, then by making the inclination or curvature of the edge of the vane at B′ tangent to the resultant of VA and —VF, the air entering and engaging the vane at point B′ will not be subject to shock or impact blow, but will be advanced along the surface of the vane without resistance. As VF varies with the distance of point B′ from the axis, it is evident that the inclination or curvature of the initial portion of the blade must also vary, to meet the necessary condition that it shall be tangent to the resultant of the velocity of the entering air current and the circumferential velocity of the edge of the vane at every point in the latter taken negatively. In other words, the blades or vanes shall have an initial curvature along their suction ends such that the tangent to the line of intersection of a vane and a cylinder concentric with the axis, will be along the resultant of the velocity of the entering air current, considered as one component, and the circumferential velocity of any particular point of the suction end in question taken negatively, considered as the other component. As the values of VA and VF are known, or may be readily determined, it is evident that the proper initial curvature of the suction ends of the vanes may be accurately calculated, and the curve plotted therefrom, or said curve may be graphically determined by representing the velocities VA and VK as in Fig. 7, determining the resultant VR thereof for varying distances from the axis of the fan, and constructing a curve which shall be tangent to these resultants, which curve will be coincident with the edge or suction end of the blade.

As heretofore referred to, the portions of the blades or vanes succeeding the initial or suction ends thereof, are then gradually curved so that they tend to or practically do become parallel with the axis of the fan at their discharge ends. These features of construction are clearly illustrated in Figs. 1 and 2, in which 1 indicates the suction edge of the blades or vanes, so curved, in accordance with the rule hereinbefore enunciated, that the entering air engages the suction edges of the blades without shock, and the succeeding portions of said blades are gradually curved until their discharge ends or edges 2 are substantially parallel with the axis of the fan, and the discharge of the air therefrom is in a substantially radial direction. If desired, however, in addition to the initial curvature of the vanes, they may be bent gradually either forward or backward with reference to the direction of rotation, as may best subserve the conditions under which the fan is to be operated.

In centrifugal fans, as heretofore constructed, considerable energy has been lost, by reason of eddy currents, formed in the receiving chamber for the air discharged from the fan. In order to overcome this difficulty, which, as above noted, is inherent in smaller fans, I construct the volute casing *a* with outwardly inclined or flaring sides, which are closed by the curved cover, so that the air leaving the peripheral edges of the fan blades or vanes is discharged into a chamber constantly increasing in width by reason of the flared sides, and in depth by reason of the volute form of the casing.

It has been demonstrated, by tests, that fans having the characteristic structure and relative arrangement hereinbefore described, take in air with practically no loss of head, due to the flaring bell mouth *f*, lose no air by back slippage, and are materially steadied in their rotation by reason of the ring *h* snugly fitting the groove *g* in the end of the bell *f*, eliminate eddy currents within the casing and produce a gradual change of the direction of the air currents through the gradually curved lateral walls *i* and *j*, and also produce an increased efficiency by virtue of the velocity of the radial discharge from the vanes being less than the velocity at the suction or intake, avoid eddy current losses in the volute because of the gradually increasing cross sectional area of the volute chamber, and, lastly, take in air without shock and transmit it along the channels between the blades with practically no loss of energy by reason of the particular shape or curvature of the initial portion of said blades, and the gradually curved surfaces of said blades toward parallelism with the axis of the fan.

For constructive reasons, it may be found advisable at times to form the blades or vanes without the initial curvature at the suction or entrance end thereof, but to preserve all of the other characteristic features of the fan, as hereinbefore described. Under such conditions, means should be provided to deliver the air from the suction bell *f* to the surfaces of the vanes or blades without shock or impact blow, or, in other words, to deliver the inflowing current to the blades, so that the air will be received by the latter and conveyed to the substantially radial discharge end thereof without loss due to shock or sudden change of direction. Such a construction is illustrated in Figs. 3 and 4, in which the fan proper has the essential characteristics of that hereinbefore described, except that the blades or vanes *d′* are located in substantially radial planes. Within the throat of the bell *f*, however, there is located a series of stationary guide vanes *m*, each having one edge attached to a central axis *n*, and the opposite edge attached to an inclosing ring *o* fitted closely within the bell. These vanes *m* have their front edge substantially normal to the axis *n*, but are given a twist or curvature both longitudinally and transversely, so that the inner edge next to the suction end of the blades *d′* has an inclination or curvature similar to the edge *l* of the blades *d* in Figs. 1 and 2, whereby the tangential component of the air velocity leaving the vanes *m* and entering upon the vanes or runners *d′*, is just equal, at all points of the rotation, to the velocity of rotation of the corresponding points of the vanes or runners *d′*. It will thus be apparent that the air currents taken in by this type of fan, will be given the necessary direction and the requisite velocity to be taken up by the vanes or runners *d′* without shock or impact blow.

In the larger types of fans, it is found preferable, for constructive reasons, to modify the character of the discharge chamber or volute, and also of the runner, as illustrated in Fig. 5, in which construction, however, the other essential characteristics of the fan illustrated in Figs. 1 and 2, are preserved. It will be noted that this fan has the flaring bell mouth *f*, the initially curved blades *d″* being constructed and arranged to take the air without shock and discharge the same in a substantially radial direction into the chamber *k′* of the volute. The blades or runners *h′* are inclosed by lateral walls *i′* and *j′*, attached to and rotating therewith, the wall *i′* being formed partly by the extended conical walls of the hub and partly by a peripheral ring. The volute *k′* is made of substantially rectangular cross section, as shown in Fig. 5, increasing gradually toward the ultimate discharge *l*.

To avoid eddy currents, the peripheral edges of the runner enter the discharge chamber *k′* so as practically to close the receiving chamber from the rest of the casing.

Although the centrifugal fans herein before described, are of the closed runner type, it is to be understood that the invention is not limited thereto, as its main characteristic advantages may be realized in open runner fans in which the lateral walls *i*, *j*, are fixed to the casing, and the blades revolve within said walls, with small running clearance.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is:—

1. In a centrifugal fan, the combination of an inclosing casing provided with an air

inlet or suction opening, and a series of rotary blades whose suction ends have an initial curvature such that the line of intersection of a vane and a cylinder concentric with the axis has, at the point where the line of intersection cuts the edge of the fan blade, a tangent which coincides in direction with the resultant of the velocity of the entering air current, considered as one component, and the circumferential velocity of that point in the edge of the fan blade taken negatively, considered as the other component, substantially as described.

2. In a centrifugal fan, the combination of an inclosing casing provided with an air inlet or suction opening, and a series of rotary blades whose suction ends have an initial curvature such that the line of intersection of a vane and a cylinder concentric with the axis has, at the point where the line of intersection cuts the edge of the fan blade, a tangent which coincides in direction with the resultant of the velocity of the entering air current, considered as one component, and the circumferential velocity of that point in the edge of the fan blade taken negatively, considered as the other component, the blades being further gradually curved beyond the point of initial curvature until their discharge ends merge into planes substantially parallel to the axis, substantially as described.

3. In a centrifugal fan, the combination of an inclosing casing provided with an air inlet or suction opening, and a series of rotary blades whose suction ends have an initial curvature such that the line of intersection of a vane and a cylinder concentric with the axis has, at the point where the line of intersection cuts the edge of the fan blade, a tangent which coincides in direction with the resultant of the velocity of the entering air current, considered as one component, and the circumferential velocity of that point in the edge of the fan blade taken negatively, considered as the other component, the blades being further gradually curved beyond the point of initial curvature until their discharge ends merge into planes substantially parallel to the axis and also radial to said axis, substantially as described.

4. In a centrifugal fan, the combination of an inclosing casing provided with an air inlet or suction opening, a series of rotary blades operating in the casing, and confining lateral surfaces for said blades, all so constructed and arranged as to form passages from the point of intake to the point of discharge from the blades in which passages the cross-sectional area normal to the axis of the passage gradually and uniformly increases from the point of intake to the point of discharge to such an extent that the velocity of discharge is only slightly less than the velocity of intake whereby unequal radial distribution and eddy current losses are avoided, substantially as described.

5. In a centrifugal fan, the combination of an inclosing casing provided with an air inlet or suction opening, a series of rotary blades operating in the casing, and confining lateral surfaces for said blades, all so constructed and arranged as to form passages from the point of intake to the point of discharge from the blades in which passages the cross-sectional area normal to the axis of the passage gradually and uniformly increases from the point of intake to the point of discharge to such an extent that the velocity of discharge in only slightly less than the velocity of intake, whereby unequal radial distribution and eddy current losses are avoided, the said lateral surfaces being gradually curved to effect a gradual change in the direction of flow of the air, substantially as described.

6. In a centrifugal fan, the combination of an inclosing casing provided with an air inlet or suction opening, a series of rotary blades operating in the casing, and confining lateral surfaces for such blades, all so constructed and arranged as to form passages from the point of intake to the point of discharge from the blades in which passages the cross-sectional area normal to the axis of the passage gradually and uniformly increases from the point of intake to the point of discharge, to such an extent that the velocity of discharge is only slightly less than the velocity of intake, in combination with an outer portion of the casing constituting a receiving chamber and having a gradually increasing cross-sectional area from the discharge edges of the blades to the outer wall of the casing; substantially as described.

7. In a centrifugal fan, the combination of an inclosing casing provided with an air inlet or suction opening, a series of rotary blades operating in the casing, and confining lateral surfaces for such blades, all so constructed and arranged as to form passages from the point of intake to the point of discharge from the blades in which passages the cross-sectional area normal to the axis of the passage gradually and uniformly increases from the point of intake to the point of discharge, to such an extent that the velocity of discharge is only slightly less than the velocity of intake, in combination with an outer volute portion of the casing constituting a receiving chamber and having a gradually increasing cross-sectional area from the discharge edge of the blades to the outer wall of the casing; substantially as described.

8. In a centrifugal fan, the combination with an inclosing casing provided with an air inlet or suction opening, of air passages

communicating with the suction opening and formed in part by a series of rotary blades, the initial portions of said passages having a curvature such that if a line be drawn from any point on the line of intersection of the initial portion of a fan blade with a cylinder concentric with the axis and equal in amount and direction to the circumferential velocity of that point in the fan blade, then the line closing the triangle thus formed will coincide in direction and amount with the velocity of the entering air, substantially as described.

9. In a centrifugal fan, the combination with an inclosing casing provided with an air inlet or suction opening, of air passages communicating with the suction opening and extending through the inclosing casing and formed in part by a series of rotary blades whose suction ends have an initial curvature such that the line of intersection of a vane and a cylinder concentric with the axis has, at the point where the line of intersection cuts the edge of the fan blade, a tangent which coincides in direction with the resultant of the velocity of the air current entering upon the blades from the initial portions of the passages considered as one component and the circumferential velocity of that point in the fan blade taken negatively, considered as the other component, substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

AUGUSTUS J. BOWIE, Jr.

Witnesses:

JOHN C. PENNIE,

J. E. HUTCHINSON, Jr.