A. A. CRIQUI.

CENTRIFUGAL FAN.

APPLICATION FILED AUG. 3, 1914.

1,240,949.

Patented Sept. 25, 1917.

3 SHEETS—SHEET 1.

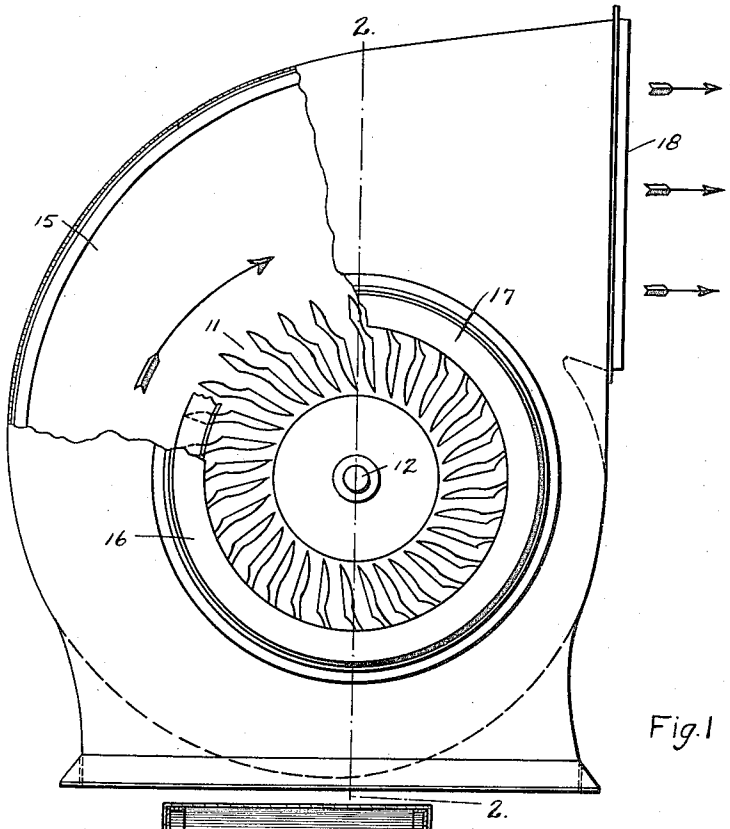


Fig. 1

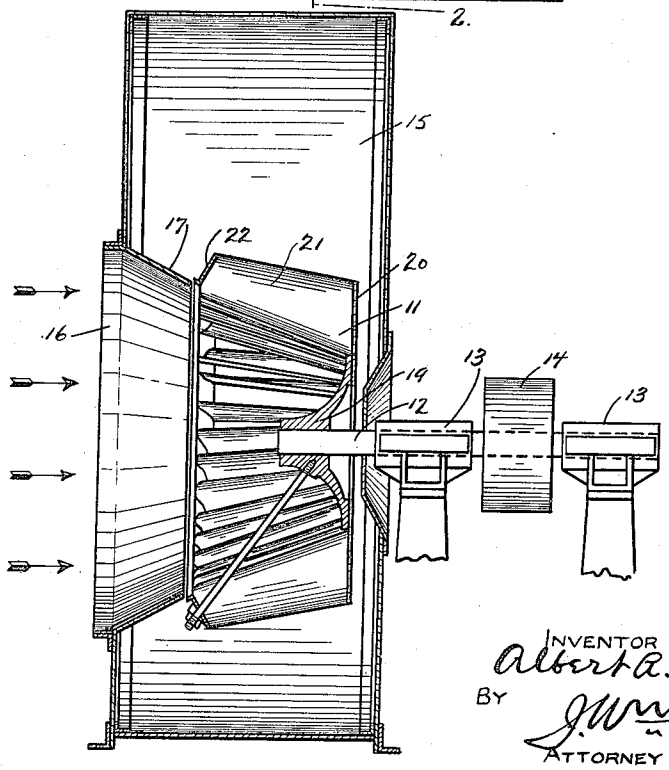


Fig. 2

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3 SHEETS—SHEET 2.

Fig. 3.

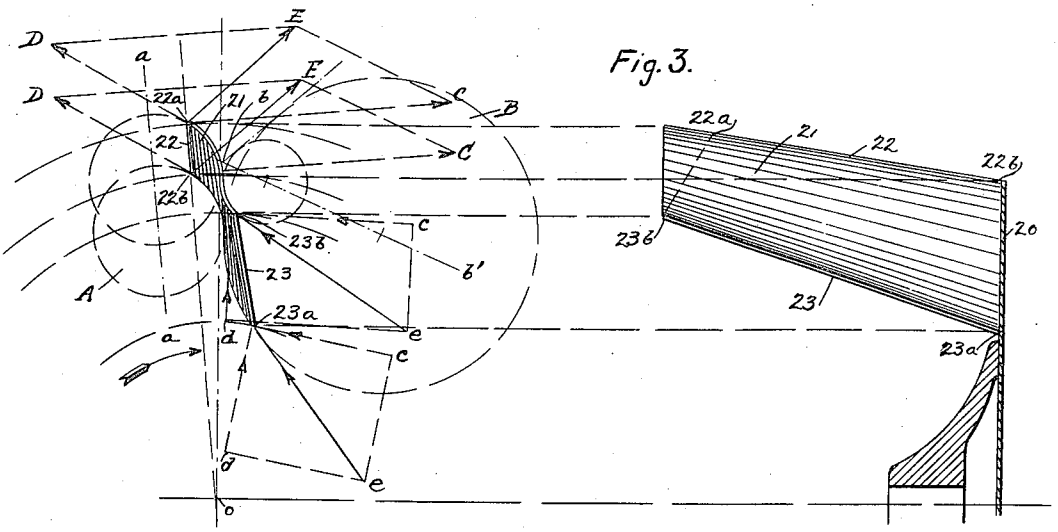


Fig. 4.

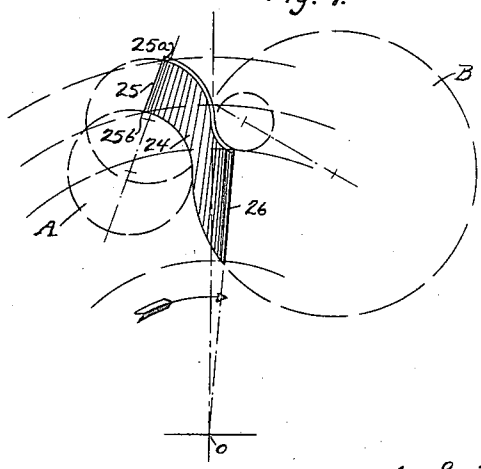


Fig. 5.

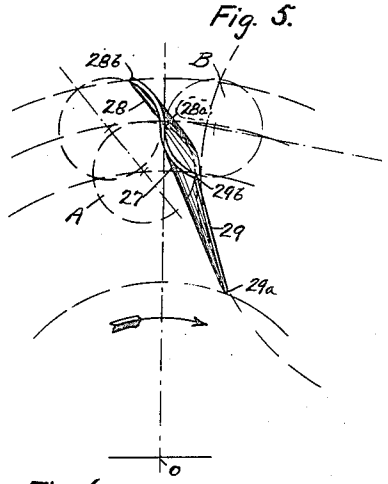
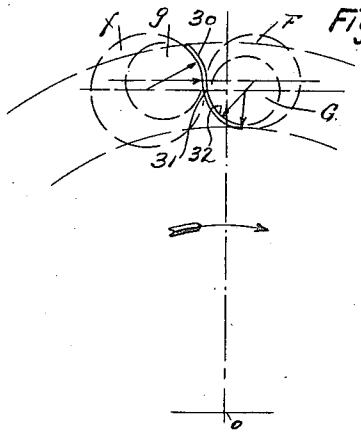


Fig. 6.



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3 SHEETS—SHEET 3.

Fig. 7.

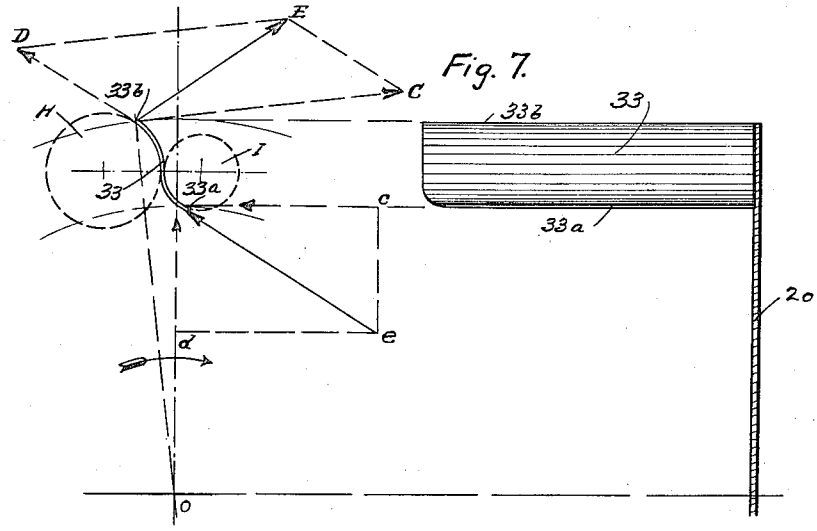


Fig. 10.

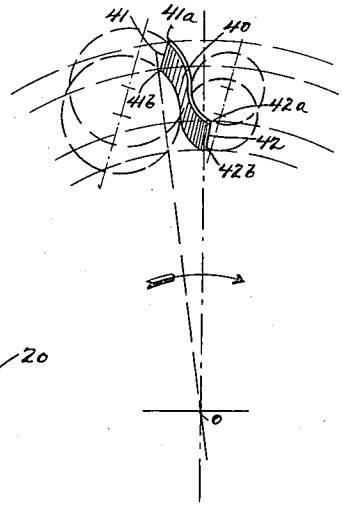


Fig. 8.

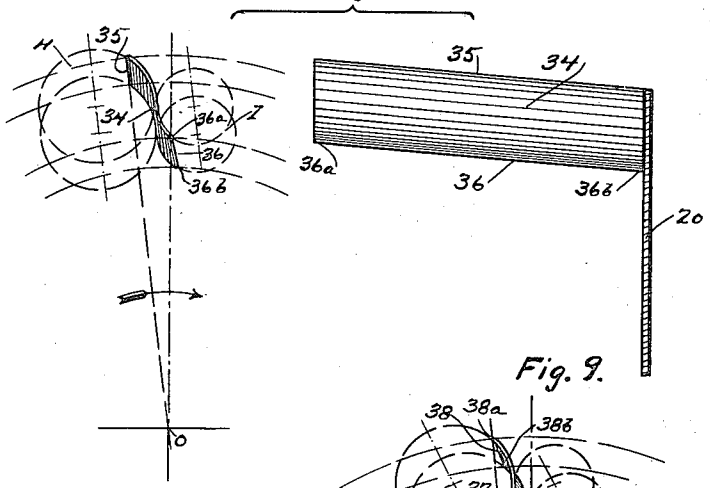
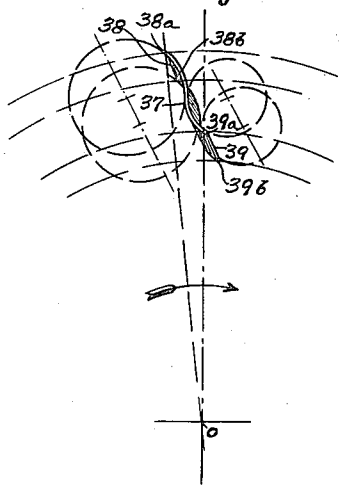


Fig. 9.



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CENTRIFUGAL FAN.

1,240,949. Specification of Letters Patent. Patented Sept. 25, 1917.

Application filed August 3, 1914. Serial No. 854,671.

To all whom it may concern:

Be it known that I, ALBERT A. CRIQUI, a citizen of the United States of America, and a resident of the city of Buffalo, county of Erie, and State of New York, have invented certain new and useful Improvements in Centrifugal Fans, of which the following is a full, clear, and exact description.

My invention relates generally to a multi-blade centrifugal fan of the type in which a large number of blades are arranged in an annular series around a central space, open at one side for the entrance of the air which is drawn in through the central opening and forced outwardly through the spaces between the blades by centrifugal force.

My invention relates particularly to improvements in the formation of the blades, which form part of the wheel of the centrifugal fan.

As is well known to those skilled in the art, fans of this type are generally constructed to deliver air under pressure at a comparatively slow speed of rotation. In places where direct-connected fans, of this type, are installed and a low pressure of air is desired, it is necessary to run the fan wheel at a slow speed and a large frame motor is therefore required in order that the slow speed may be obtained. This is because of the fact that in most fan constructions, inventors have sought to produce fans in which the velocity of the air leaving the wheel would be greater than the peripheral velocity of the wheel.

The general object of my invention has been, therefore, to provide a fan having a wheel with blades in which the velocity of the air leaving the wheel shall be less than the velocity of the periphery of the wheel, thereby producing a low resultant static pressure at a comparatively high speed of rotation.

Another object has been to provide a fan wheel having blades so formed that the friction of the air passing through the blades shall be greatly minimized, and thus produce a fan having maximum efficiency.

Another object has been to provide a blade which shall equalize the discharge of the air along the entire length of the same, and also one which shall pick up the air at a minimum loss by shock or impact with the entering air.

Another object has been to provide blades, the surfaces of which shall be formed from the surfaces of a cylinder and a cone, the surfaces of two cylinders, or solids having irregularly curved peripheries, each of the surfaces of the solids forming the blades having an element included in a plane tangent to both of their surfaces.

Throughout this description I use the term air, as applied to my fan, but obviously the same may be used for gases or other fluids, and it is not intended to restrict this application to the use of air.

The above objects and advantages have been accomplished by the device shown in the accompanying drawings, forming a part of this specification. In the drawings, like characters of reference indicate like parts throughout the several views, of which:

Figure 1 is a side elevation of a complete fan with a portion of the casing thereof broken away.

Fig. 2 is a sectional elevation of the same, and is taken on line 2—2 of Fig. 1.

Fig. 3 is an end and side elevation of a complete blade formed from the surfaces of a cylinder and a cone, and shows diagrammatically the manner in which the blade is developed, as well as means for ascertaining the comparative pressures and velocities developed at each corner of the blade. In this figure the blade is shown as having its tip coplanar with the axis of the wheel and its heel non-coplanar therewith.

Fig. 4 is an end elevation of a slightly modified form of blade where the tip of the same is non-coplanar with the axis of the wheel, and the heel is coplanar with said axis.

Fig. 5 is an end elevation of a modified form of blade where the tip and heel are both non-coplanar with the axis of the wheel.

Fig. 6 is an end elevation of a form of blade for a wheel having its entrance end of substantially the same diameter as the diameter of its disk end, the surface of which is formed about the surfaces of two solids each having irregularly curved or elliptical surfaces.

Fig. 7 is an end and side elevation of a

form of blade for a wheel having its entrance end of substantially the same diameter as the diameter of its disk end, the surfaces of which are formed from two cylinders; this view shows diagrammatically the manner in which the blade is developed, and also a means of ascertaining the comparative pressures and velocities of the air at the heel and tip of the blade.

Fig. 8 is an end and side elevation of a modified form of the blade shown in Fig. 7, and is designed for a tapered faced wheel. The blade shown in this figure has its tip coplanar with the axis of the wheel, and its heel non-coplanar therewith.

Fig. 9 is a modified form of blade formed from two cylindrical surfaces, and has its heel and tip both non-coplanar with the axis of the wheel. In this blade the end of the tip farthest from the inlet precedes the end of the tip nearest to the inlet.

Fig 10 is an end elevation of a modified form of the blade shown in Fig. 9, where the tip and the heel are both non-coplanar, but where the end of the heel nearest to the inlet precedes the end farthest from the inlet.

Referring to the drawings, and more particularly to Figs. 1 and 2, 11 is the wheel of my fan, which is mounted upon a shaft 12, rotatably carried in suitable bearings 13. In these drawings, for convenience of illustration, I have shown the shaft 12 provided with a pulley 14 by which the wheel of the fan may be driven, but obviously the fan may be direct connected to an electric motor or other suitable direct connected means for furnishing motive power to the fan.

15 is a snail-shaped casing which incloses the wheel 11 and is provided with an inlet opening or eye 16, in which is secured an inlet cone 17, which directs the air from the exterior atmosphere into the central part of the wheel 11. The casing 15 is also provided with a tangential discharge opening 18. The wheel 11 of my fan comprises a central hub 19, which is securely attached to the inner end of the shaft 12. This hub carries an annular disk 20, to which the inner ends of the blades 21 are secured. These blades extend laterally and have secured at their outer ends an annular ring 22, said ring being arranged adjacent to the inlet cone 17.

As is well known, in ordinary fan constructions, the entering air has a tendency to rush to the end farthest from the entrance and be discharged from that point of the wheel, thus greatly increasing the discharge at the disk end of the wheel. In order to overcome this disadvantage and to produce a uniform discharge of air along the entire tip of the blade, I have made the wheel 11, in all the forms shown (except that shown in Figs. 6 and 7), conical in shape with the larger diameter of the wheel at the entrance end. I preferably make the blades narrower at the entrance end than at the disk end. Owing to the difference of diameter in the wheel, the peripheral velocities of the tips of the blades will be greater at the entrance end than at the disk end of the wheel, and thus tend to force a greater amount of air through the blades at the entrance end, which will thereby substantially equalize the velocity of the air leaving the tips of the blades. The blades of my fan are each formed from the surfaces of two solids, each of which has an element included in a plane tangent to both of their surfaces and arranged so that the concave surface of each is presented to the air at the heel of the blade, and the convex surface is presented to the air as it leaves the tip of the blade. To suit different requirements, these blades may have their tips and heels coplanar or non-coplanar with the axis of the wheel and may have the entrance end of the tip or heel precede or follow the disk end thereof. In Fig. 2, I have shown the smaller outside diameter of the wheel at the disk end and the larger outside diameter at the entrance end of the wheel, but a reverse arrangement might advantageously be employed, in which case in order to take care of the inequalities of the air discharge along the edge of the blade, I change the curvature of the blade along the tip and thus change the angle at which the air leaves the same. The curvature of the blade along the tip is changed so that the surface at the tip does not lie in a plane which contains an element of the surface of either of the solids from which it is formed.

Referring now more particularly to Figs. 3, 4 and 5, it will be seen that the blades in these figures are each formed from a portion of the surfaces of a cylinder and a truncated cone, the upper convex surface being formed from the cylinder, and the lower concave surface being formed from the truncated cone. Obviously this arrangement might be reversed so that the upper surface could be formed from a truncated cone, and the lower surface from a cylinder and advantageous results be thus attained. For clearness, I will describe the formation of the blades shown in Fig. 3, it being obvious that the blades shown in Figs. 4 and 5 are formed in substantially the same manner. In this figure A is the cylinder and B the truncated cone, from which the blade 21 is formed. It will be seen that these surfaces contact along one circumferential line, thus having one element in common. The axis of the cylinder A is represented by the line *a*—*a*, which in this form of blade, is parallel to the tip of the blade, which tip is coplanar with the axis of the wheel. The cone B has its apex represented at *b* and its axis by the line *b*—*b'*. It will be seen from these figures that the cone and

cylinder are so arranged with relation to each other that when the blade is wrapped around their surfaces, a smooth, forward and backward curve is produced. The tip 22 of the blade, shown in Fig. 3, is coplanar with the axis *o* of the wheel, and the heel 23 is non-coplanar with the axis. The end 22*a* of the tip of the blade is farther from the axis of the wheel in a radial direction than the end 22*b*, and the end 23*a* of the heel of the blade is nearer the axis of the wheel than the end 23*b*. For clearness of diagrammatical illustration, the blade shown at the righthand side of Fig. 3 has its forward end extended out with its face parallel to the disk 20, it being understood that this blade is cut off at an angle which is indicated by the broken line extending from the ends 22*a* to 23*b* of the blade. While in this figure I have shown the surface of the blade as being formed from a cone and cylinder and having one element in common with both cylinder and cone, it should be understood that the blade, cone and cylinder surfaces may also be advantageously formed with a uniting surface which is tangent to both said cone and said cylinder. In other words instead of having two curved surfaces meeting and joining each other, they may be formed with a flat and preferably radially disposed surface lying in a plane common to both curved surfaces and disposed between and joining the same.

While I have shown in this figure the surface of the blade as being formed from a cone and a cylinder, obviously the blade surface could be advantageously formed from a cone and an eliptical surface.

In Fig. 3 is also shown, in a diagrammatical manner, a means of ascertaining the comparative pressures and velocities at the different points of the blade, the broken line 23*a*—*c* represents the lineal velocity of the end 23*a* of the heel of the blade, and the broken line 23*a*—*d* represents the radial velocity of the air passing through the blade at the end 23*a*. The resultant velocity is indicated by the full line 23*a*—*e*. The lineal velocity of the blade at the end 23*b* of the heel is indicated by the broken line 23*b*—*c*, and the radial velocity of the air passing through the blade at this end is indicated by the broken line 23*b*—*d*. The resultant velocity of the air at the end 23*b* of the heel is represented by the full line 23*b*—*e*. The lineal velocity of the end 22*a* of the tip of the blade is represented by the broken line 22*a*—C, which line is tangent to the periphery of the wheel at the end 22*a*. The blade at this end is curved backwardly, and the air leaves the blade at a tangent to the outer curved surface of the same, which is represented by the broken line 22*a*—D. The resultant velocity of the air leaving the end 22*a* of the tip of the blade is indicated by the full line 22*a*—E. The lineal velocity of the air leaving the end 22*b* of the tip is indicated by the broken tangential line 22*b*—C, and the line 22*b*—D represents the tangential line of discharge of the air as it leaves the end of the tip of the blade. The resultant velocity of the air at the end 22*b* of the tip is indicated by the full line 22*b*—E. It will be understood that the radial velocity of the air leaving the tip of the blade is indicated by the distance between the line indicating the lineal velocity of the tip of the blade and the line of the parallelogram, which is parallel therewith. It will thus be seen that the resultant velocity of the air leaving the tip of the blade is far less than the lineal velocity of the tip of the blade, thus giving a low velocity pressure at a high speed of revolution.

A snail-shaped casing is used in connection with the wheel, by means of which a portion of the velocity pressure of the air leaving the wheel is converted into static pressure. And my wheel, in connection with its casing, will produce a lower static pressure than a wheel having forward, curved or straight blades in connection with its casing, when both wheels are running at the same peripheral velocity.

In Fig. 4 is shown a blade of the same type as that shown in Fig. 3, except that the cylinder A is set at such an angle that the blade 24 has its tip 25 non-coplanar with the axis *o* of the wheel, the end 25*a* preceding the end 25*b* of the same. The heel 26 of this blade is coplanar with the axis *o* of the wheel.

In Fig. 5, the blade has its cylindrical convex surface formed from the surface of the cylinder A, which, in this form, is inclined at an angle to the axis *o* of the wheel, and is opposite to the inclination of the axis of the cylinder A in Fig. 4. The tip 28 in this blade is non-coplanar with the axis *o* and has its end 28*a* preceding the end 28^b. The heel 29 of the blade in this figure is also non-coplanar with the axis *o* of the wheel and its end 29*a* precedes the end 29^b.

In Fig. 6, I show a form of blade, each surface of which is formed from a solid having an irregular or elliptical curved surface, or from two or more cylinders having different diameters. The convex surface 30 of the blade 31, in this figure, is formed at its outer end, from the larger cylinder *f* and as its surface approaches the center of the blade, or the point where the concave and convex surfaces meet, it is formed from the smaller cylinder *g*, the surface of which is tangent to the surface of the cylinder *f*. The concave surface 32 of this blade is developed near its center by the larger cylinder F, and the surface thereof near its heel is formed by the smaller cylinder G, the sur-

faces of these two cylinders being tangent to each other. It will thus be seen that the blade 31 in this figure has a forward and backward surface formed in an irregularly curved or elliptical shape. The blade here shown is for a wheel having its entrance end of substantially the same diameter as the diameter of its disk end, but obviously the same curved surfaces may be provided on a blade for a conical shaped wheel, and the surfaces instead of being formed from two cylinders may be formed from two cones.

Referring now to Figs. 7 to 9, it will be seen that the blades there shown are each formed from two cylinders. Fig. 7 shows a blade having a wheel having its entrance end of substantially the same diameter as the diameter of its disk end, while Figs. 8 to 10, inclusive, show blades mounted on wheels which have their disk ends smaller in diameter than their entrance ends. In these figures are shown diagrammatically the manner in which the blades are formed from the surfaces of two cylinders. In Fig. 7, I also show diagrammatically the manner in which the comparative pressures and velocities at the different points of the blade are ascertained.

The blade 33, shown in Fig. 7, has its convex surface formed by the surface of the large cylinder H, and the concave or heel portion of the blade formed by the small cylinder I. The lineal velocity of the heel 33*a* of the blade is represented by the broken line 33*a*—*c*, and the radial velocity of the air passing through the wheel at the heel is represented by the broken line 33*a*—*d*. The resultant velocity of the air through the blade at the heel is represented by the tangential full line 33*a*—*e*. The lineal velocity of the air at the tip 33*b* of the blade is indicated by the broken line 33*b*—C, which is tangent to the periphery of the wheel, and the radial velocity of the air through the blade at the tip is indicated by the tangential broken line 33*b*—D. The resultant velocity of the air at this point of the blade is represented by the full line 33*b*—E.

The blade 34, shown in Fig. 8, has its surface formed from a cylinder H, whose axis is parallel with the axis of the wheel, and a cylinder I whose axis is inclined at an angle to the axis of the wheel, thus making the tip 35 of this blade coplanar with the axis and the heel 36 thereof non-coplanar with the axis. The end 36*a* of the heel of the blade, which is near the inlet, is preceded by the end 36*b* which is farthest from the inlet.

In Fig. 9, the blade 37 is formed from the surfaces of two cylinders, each of which has its axis inclined at an angle with the axis of the wheel, but parallel to each other. The axes of the cylinders in this form of blade are so inclined that the tip and heel of the blade are both non-coplanar with the axis of the wheel. The inclination of the axes in this form of blade is such that the tip 38 has its inlet 38*a* preceded by the disk end 38*b*. The heel 39 has its inlet end 39*a* also preceded by the disk end 39*b*. The blade 40, shown in Fig. 10, is formed from cylinders having their axes parallel to each other, but inclined at an angle to the axis of the wheel, which angle is opposite to the angle of inclination of the cylinder shown in Fig. 9. In this figure, both the heel and tip are non-coplanar with the axis of the wheel. The tip of this blade 41 has its inlet end 41*a* preceding the disk end 41*b*, and the heel 42 thereof has its inlet end 42*a* also preceding the disk end 42*b*.

While I have shown and described my invention as applied to a fan having a single wheel and a single inlet opening, it is obvious that it may be applied to fans having a double opening, or to fans where two wheels are provided, each with an inlet opening. Moreover, instead of having each blade formed of two curved surfaces meeting and joining each other, they may be formed with a flat and preferably radially disposed surface lying in a plane common to both curved surfaces and disposed between and joining the same. These and other modifications of the details herein shown and described may be made without departing from the spirit of my invention or the scope of the appended claims.

Having thus described my invention, what I claim is:

1. A centrifugal fan having a wheel provided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof.

2. A centrifugal fan having a wheel provided with a plurality of blades, the surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, and each of said blades having an element included in a plane tangent to its surface.

3. A centrifugal fan having a wheel provided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, and each of said blades being arranged with its tip edge substantially coplanar with the axis of the wheel.

4. A centrifugal fan having a wheel pro-

vided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, and each of said blades having a forward and a backward curve.

5. A centrifugal fan having a wheel provided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, each of said blades having a forward and backward curve, and the surface of each of said blades, which is presented to the air, being concave at its heel and convex at its tip.

6. A centrifugal fan having a wheel provided with a plurality of blades, the surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, and the heel of each blade being substantially non-coplanar with the axis of said wheel.

7. A centrifugal fan having a wheel provided with a plurality of blades, the surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, each of said blades being arranged with its tip edge substantially coplanar with the axis of the wheel, and the heel of each blade being substantially non-coplanar with the axis of said wheel.

8. A centrifugal fan having a wheel provided with a plurality of blades, the surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, and the disk end of said wheel being smaller in diameter than the entrance end.

9. A centrifugal fan having a wheel provided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, and the disk end of said wheel being smaller in diameter than the entrance end.

10. A centrifugal fan having a wheel provided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, the disk end of said wheel being smaller in diameter than the entrance end, and each of said blades being arranged with its tip edge substantially coplanar with the axis of the wheel.

11. A centrifugal fan having a wheel provided with a plurality of blades, the entire surface of each of said blades being formed from a portion of the surfaces of two solids having curved surfaces, each successive part of the surface of each of said blades progressively receding from the heel to the tip thereof, the disk end of said wheel being smaller in diameter than the entrance end, and each of said blades having a forward and a backward curve.

12. A centrifugal fan having a wheel provided with a plurality of blades, a part of the surface of each of said blades being formed from the surface of a cone, and a part of the surface of each of said blades being formed from the surface of a cylinder.

13. A centrifugal fan having a wheel provided with a plurality of blades, a part of the surface of each of said blades being formed from the surface of a cone, and a part of the surface of each of said blades being formed from the surface of a cylinder, each of said blades having a forward and a backward curve.

In testimony whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

ALBERT A. CRIQUI.

Witnesses:
JOHN F. MURRY,
J. WM. ELLIS.