April 3, 1962 A. A. ATALLA 3,028,072

AIR IMPELLING FAN AND ASSOCIATED PART

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FIG. 1

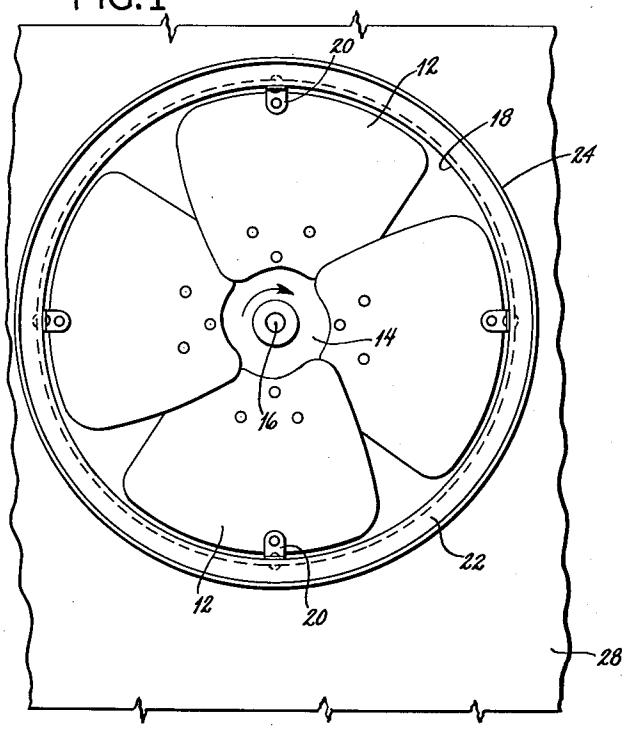


FIG. 2

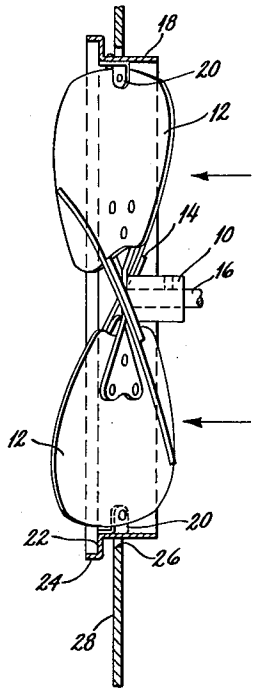
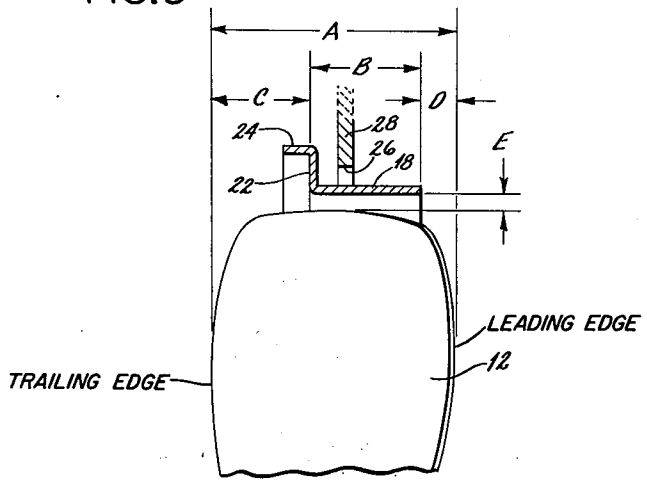


FIG. 3



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FIG.4 FIG.5 FIG.7 FIG.8 FIG.9

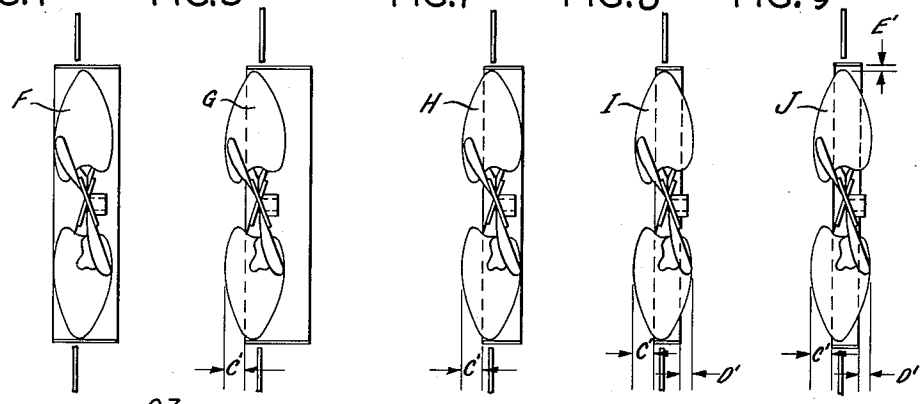


FIG. 6

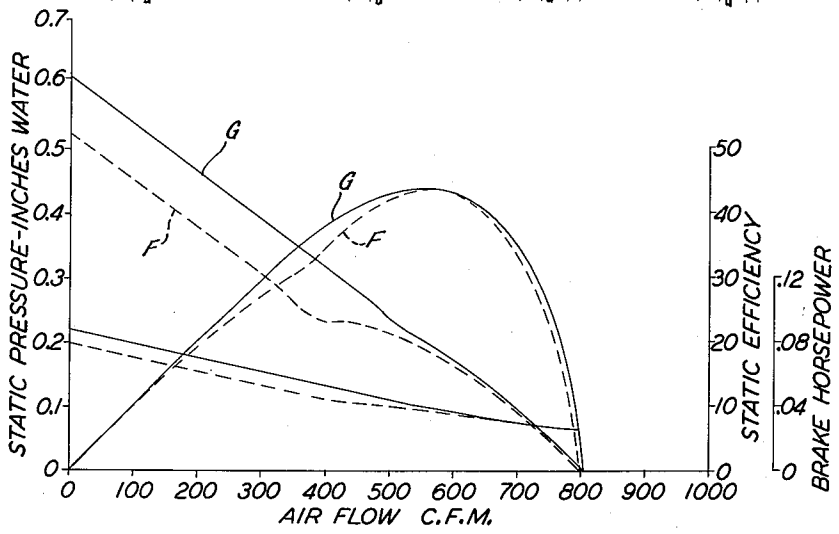
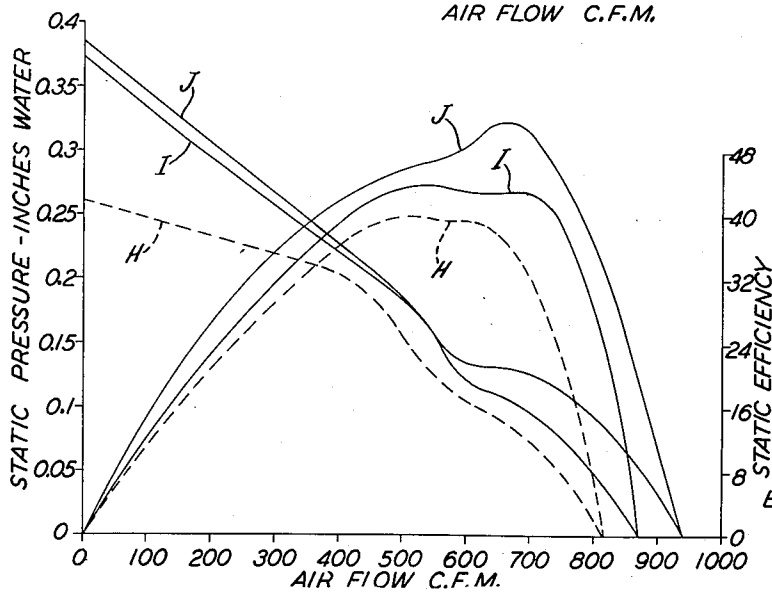


FIG.10



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3,028,072

AIR IMPELLING FAN AND ASSOCIATED PART

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8 Claims. (Cl. 230—241)

The invention relates to a rotary air impelling fan and its general object is to provide a fan having superior operating characteristics. The object is attained in part by providing the fan with a rotating orifice ring connected with the tips of the fan blades, said ring having specific relationships with the blades as hereinafter fully set forth. The object of the invention is further attained in part by combining the fan and its rotating orifice ring with a wall having a stationary orifice within which the rotating orifice ring of the fan is located.

The drawings show a preferred embodiment of the invention and such embodiment will be described, but it will be understood that various changes may be made from the construction disclosed, and that the drawings and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Of the drawings:

FIG. 1 is a front view of a fan embodying the invention together with an associated chamber wall having an orifice therein.

FIG. 2 is a side view of the fan shown in FIG. 1 with the chamber wall shown in vertical central section.

FIG. 3 is an enlarged schematic view similar to the upper portion of FIG. 2.

FIGS. 4 and 5 are schematic views showing differing relationships between the fan blades and the rotating orifice ring.

FIG. 6 is a graph showing various values dependent on the relationships shown in FIGS. 4 and 5.

FIGS. 7, 8 and 9 are schematic views similar to FIGS. 4 and 5 and showing other differing relationships between the fan blades and the rotating orifice ring.

FIG. 10 is a graph similar to FIG. 6 and showing various values dependent on the relationships shown in FIGS. 7, 8 and 9.

In accordance with the invention, a fan is provided which is rotatable about a central longitudinal axis and is adapted for impelling air in a forward direction, and as shown, the forward direction is toward the left as indicated by the arrows in FIG. 2. The fan includes a rotatable central hub **10** and a plurality of similar generally radial blades **12, 12** which are uniformly spaced circumaxially. As shown, there are four blades but the invention is not so limited. The several blades **12, 12** are secured to the hub **10** at uniform pitch angles and they are preferably so secured by means of a spider **14**. The hub **10** is secured to a driving shaft **16** which may be the end portion of the shaft of an electric motor, not shown. The motor is suitably supported in a fixed position, and the motor shaft **16** and the fan axis are shown as being horizontal, but this is not essential. The blades **12, 12** are sharply pitched and, as shown, they are pitched for clockwise rotation as viewed from the front. The pitch angles of the blades are such that they have a substantial projected axial depth as indicated at A in FIG. 3.

A ring **18** is provided which surrounds the blades **12, 12** and is secured to the tips thereof for rotation therewith. The ring **18** provides a rotating orifice and said ring is shown as being connected with the blades by means of sheet metal angle members **20, 20** each of which has one leg riveted or otherwise connected to a blade and has the other leg riveted or otherwise connected to the ring. Said ring **18** has an inner face conforming to a surface of revolution concentric with said central axis. While the invention is not necessarily so limited, said inner face of the orifice ring is preferably cylindrical. Said ring **18** is preferably relatively thin in the radial direction.

The ring **18** has a depth in the axial direction that is at least 35% of the projected axial depth of the blades **12, 12** and said ring is so located that the trailing edges of the blades project forwardly therefrom to a substantial extent and preferably is further so located that the leading edges of the blades project rearwardly therefrom to a substantial extent which is ordinarily smaller than the extent of forward projection of the trailing edges. The inner radius of the ring **18** is preferably somewhat greater than the radius of the fan at the tips of the blades.

Preferably, but not necessarily, a slinger ring **22** is connected with the orifice ring **18** and extends radially outwardly therefrom. The slinger ring **22** is preferably located adjacent the front or pressure side of the fan and at the forward edge of said orifice ring **18**. An annular forwardly projecting cylindrical flange **24** may be provided on the slinger portion **22**. The two rings **18** and **22** and the flange **24** may be integral with each other and they are so shown.

A fan and rotating orifice embodying the invention can advantageously be used in a stationary sharp edged orifice **26** in a thin wall such as **28** which may be the wall of a chamber, the air pressure at the left or front of the wall being greater than that at the right or rear thereof. The ring **18** is within the orifice **26** and the orifice is sufficiently larger than the ring to provide a reasonable clearance but the exact amount of clearance is not critical. As shown, the wall **28** is spaced slightly forwardly from the midway plane of the ring **18** but this spacing is not critical.

The relationship of the orifice ring **18** to the blades **12, 12** is indicated in FIG. 3. A represents the total projected axial depth of the blades; B represents the depth of the orifice ring **18** in the axial direction; C represents the extent by which the trailing edges of the blades project forwardly from the orifice ring; D represents the extent by which the leading edges of the blades project rearwardly from the orifice ring; and E represents the radial spacing between the inner face of the orifice ring and the tips of the blades.

The axial depth B of the orifice ring is at least 35% of the projected blade depth A and it is preferably within the range of 35% to 55% of said blade depth. The extent C of forward projection of the blades is within the range of 5% to 50% of the projected blade depth A and the optimum extent of such projection is on the order of 32%. The extent D of rearward projection of the blades, when provided, is within the range of 5% to 15% of the projected blade depth A and the optimum extent of projection is about 15%. The spacing E between the tips of the blades and the inner face of the orifice ring is within the range of 2% to 6% of the diameter of the fan and the optimum spacing is about 4%.

In general, the rotating orifice ring by reason of its substantial depth in the axial direction and by reason of the resultant shrouding on the fan blade tips serves to reduce tip leakage losses. The orifice ring further serves to produce a flow barrier in a localized area and in planes perpendicular to the axis of rotation. These planes extend radially from the rotating ring and recirculation around the blade tips is substantially reduced.

The relationship of parts which enables the trailing edges of the blades to project forwardly from the orifice ring to a substantial extent constitutes a very important

feature of the invention. FIG. 4 is a schematic showing of a fan F having a rotating orifice ring of such width and so located that neither the trailing edges nor the leading edges of the blades project beyond the said ring. The inner face of the ring 18 has the same radius as the tips of the blades, and there is no spacing between the tips of the blades and the orifice ring. FIG. 5 is a view similar to FIG. 4, but showing a fan G wherein the orifice ring is of such width and so located that the trailing edges of the blades project forwardly from the ring to an extent C' which is about 32% of the projected blade depth.

FIG. 6 is a graph sheet having various curves thereon which indicate test results obtained by operating the fan F and the fan G under the same test conditions. Referring particularly to the static pressure curves in FIG. 6, it will be observed that with the fan F not having the forward projection of the trailing edges of the blades, the static pressure does not increase proportionately to the decrease in air flow. This condition is undesirable and often referred to as "stall recession." However, with the fan G having the trailing edges projecting forwardly, the static pressure increases more nearly proportionately to the decrease in air flow. It will also be observed that the curves representing brake horsepower and static efficiency show more favorable operating conditions for fan G than for fan F.

The relationship of parts which enables the leading edges of the blades to project rearwardly from the orifice ring to a substantial extent constitutes another important feature of the invention, but it may be less important than the forward projection of the trailing edges. FIG. 7 is a schematic showing of a fan H having a rotating orifice ring of such width and so located that the trailing edges of the blades project forwardly to the same extent C' as in the fan G shown in FIG. 5, but further of such width and so located that the leading edges of the blades do not project rearwardly. It will be observed that there is no spacing between the tips of the blades and the orifice ring. FIG. 8 is a view similar to FIG. 7 and showing a fan I having a rotating orifice ring differing in width and position from that of the fan H in that the orifice ring is narrower so that the leading edges of the blades project rearwardly to an extent D'. The extent of projection is shown as being about 15%.

FIG. 10 is a graph sheet having various curves thereon which indicate test results obtained by operating the fan H and the fan I under the same test conditions. It will be evident that the test conditions represented by FIG. 10 are not the same as those represented by FIG. 6, but this is unimportant for purposes of comparison between the fans H and I. Referring particularly to the static pressure curves in FIG. 10, it will be observed that the static pressure is substantially increased as the result of the described blade projection. It will further be observed that the static efficiency has been increased.

FIG. 9 is a schematic showing of a fan J having a rotating orifice ring. Fan J is exactly like fan I except that the orifice ring is spaced outwardly to an extent E' from the tips of the blades. The spacing E' is shown as being about 4% of the diameter of the fan. Referring again to FIG. 10 and comparing the curves for fans I and J, it will be observed that the outward spacing of the orifice ring has increased the static pressure and has also increased the static efficiency.

The invention claimed is:

1. In a fan rotatable about a central longitudinal axis and adapted for impelling air in a forward direction, the combination of a rotatable central hub, a plurality of similar generally radial blades uniformly spaced circumaxially and secured to the hub at uniform fixed pitch angles which provide a substantial projected axial depth, a thin wall provided with a stationary orifice therein, and an orifice ring surrounding said blades and secured to the tips thereof for rotation therewith which ring has an inner face conforming to a surface of revolution concentric with said central axis, said orifice ring being positioned within said stationary orifice and being of slightly less diameter than the said stationary orifice and having a depth in the axial direction that is at least 35% of said projected axial depth of the blades and said ring being so located that the trailing edge of the blades project forwardly therefrom to an extent which is approximately 32% of said projected axial blade depth.

2. A fan as set forth in claim 1, wherein said orifice ring is so located that the leading edges of the blades project rearwardly therefrom to a substantial extent.

3. A fan as set forth in claim 2, wherein the extent of rearward projection of said leading edges of the blades is within the range of 5% to 15% of the projected blade depth.

4. A fan as set forth in claim 1, wherein said depth of said orifice ring in the axial direction is within the range of 35% to 55% of the projected axial blade depth, and wherein the extent of rearward projection of said leading edges of the blades is within the range of 5% to 15% of the projected blade depth.

5. A fan as set forth in claim 1, wherein the inner face of said orifice ring is spaced from the tips of said blades by a distance within the range of 2% to 5% of the diameter of the blades.

6. A fan as set forth in claim 1, wherein the inner face of said orifice ring is cylindrical.

7. A fan as set forth in claim 1, wherein a rotatable slinger ring is provided which is secured to said orifice ring and extends outwardly therefrom.

8. A fan as set forth in claim 7, wherein the inner face of said orifice ring is cylindrical, and wherein the slinger ring is secured to said orifice ring at the front edge thereof and at the rear side of said wall.

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