United States Patent

Pratinidhi

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[45] **Feb. 1, 1972**

[54] **FLEXIBLE-BLADED FAN WITH EXTENDED BLADE STRUCTURE**

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[21] Appl. No.: **86,750**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 18,855, Mar. 12, 1970, abandoned.

[52] **U.S. Cl.** **416/132,** 416/237, 416/240

[51] **Int. Cl.** **F04d 29/38**

[58] **Field of Search** 416/132, 240, 237

[56] **References Cited**

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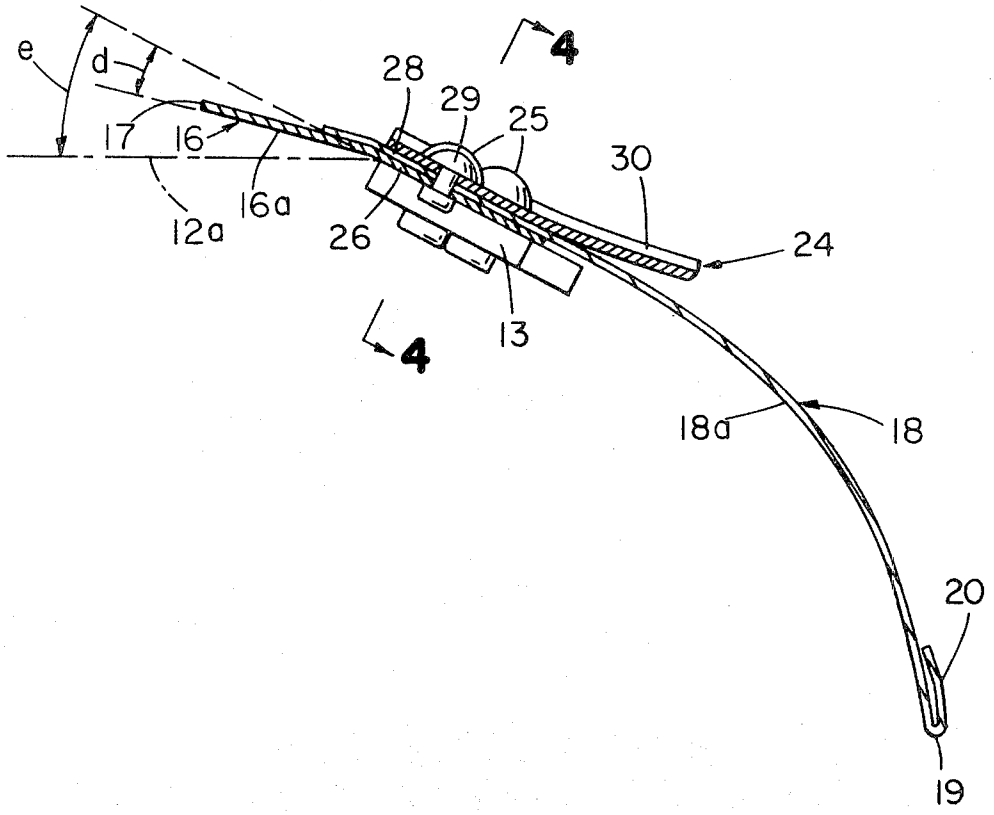
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Primary Examiner—Everette A. Powell, Jr.
Attorney—W. R. Hulbert

[57] **ABSTRACT**

A fan having a hub, a plurality of arms each extending radially outwardly of the hub and at an acute angle to the rotational plane of the fan, and blade structures, one secured to each arm, each blade structure having a flexible, resilient trailing airfoil portion, comprising the major portion of the blade structure, which decambers as rotational speed increases, and a less flexible leading airfoil portion comprising a slat extending forward of the respective arm and disposed at an angle thereto lying within the above specified acute angle, with the trailing and leading portions mutually constructed to have the leading and trailing edges of the blade define therebetween a chord disposed at a predetermined chord angle to the rotational plane of the fan.

12 Claims, 5 Drawing Figures



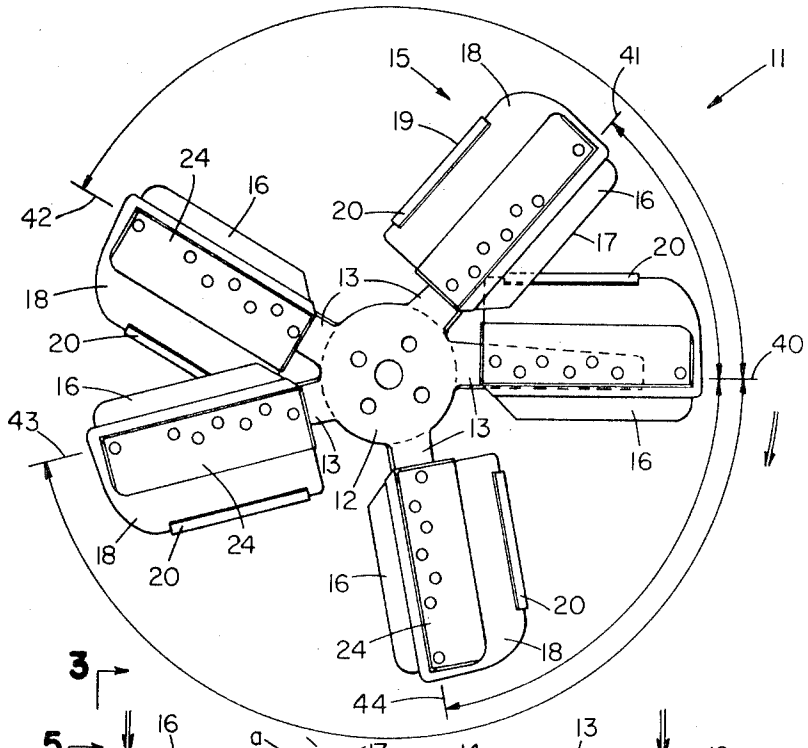


FIG 1

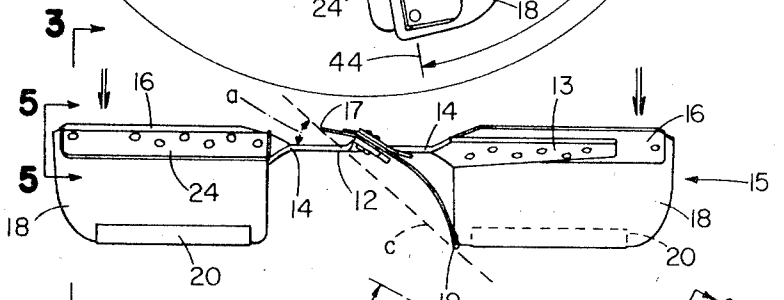


FIG 2

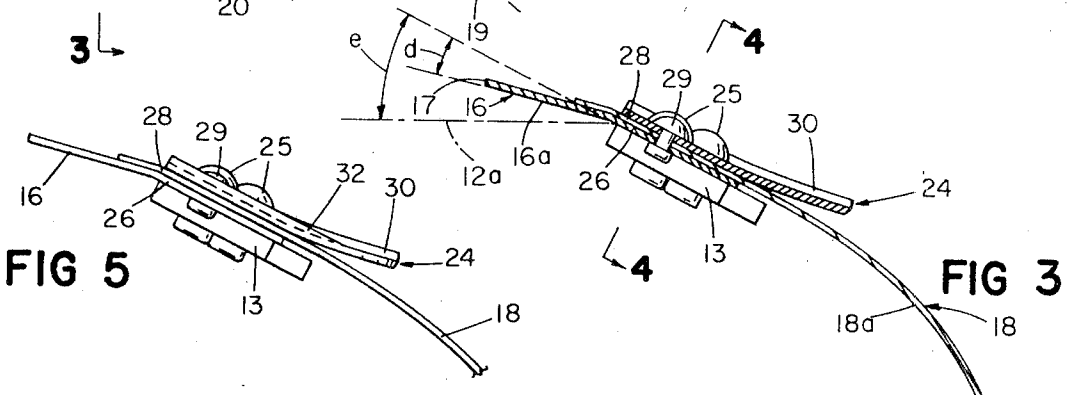
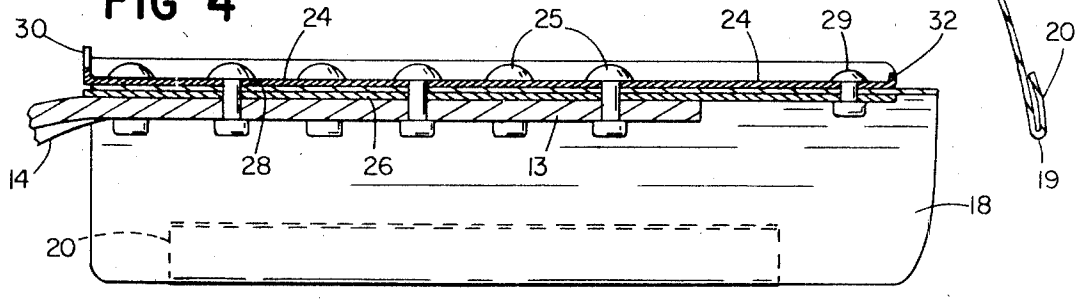


FIG 5

FIG 3

FIG 4



FLEXIBLE-BLADED FAN WITH EXTENDED BLADE STRUCTURE

This application is a continuation-in-part of my copending U.S. application, Ser. No. 18,855, filed Mar. 12, 1970, now abandoned.

This invention relates to fans having flexible blades which decamber as rotational speed increases.

The principal object of this invention is to increase the pumping, and hence the cooling capacities of flexible bladed fans without increasing the number of blades or substantially altering the space requirements for the fan. Other objects are to provide improved cooling capacity in such fans without increasing fan vibration, noise, weight, or size to unacceptable levels, and while maintaining the advantages of flexible blades.

The invention features, in a fan having a hub, a plurality of arms extending radially outwardly of the hub, and blade structures secured to these arms, the blade structures each comprising a flexible, resilient trailing portion, defining an air foil surface terminating in the trailing edge of the blade structure, which decambers as rotational speed increases, the improvement wherein each arm is disposed at an acute angle to the rotational plane of said fan, and wherein each blade structure also comprises a leading portion, less flexible than the trailing portion, extending forward of the arm to which it is secured, and effectively disposed at an angle thereto lying within the aforementioned acute angle, each leading portion comprising a slat defining an extended airfoil surface terminating in the leading edge of its corresponding blade structure, the trailing portion comprising the major portion of the blade structure and the leading edge of the leading portion and trailing edge of the trailing portion defining between them a chord disposed at a predetermined chord angle to the rotational plane of the fan.

In a preferred embodiment, the chord angle (with the blade structure in an unbiased condition) is between about 25° and 35°, most preferably about 32°, and the chord lies in a plane defined by the substantially parallel leading and trailing edges of the fan; the respective leading portion is effectively disposed at an angle (preferably less than about 20°, most preferably about 15°) to the arm, the leading and trailing edges are located on opposite sides of the rotational plane of the hub; the leading portion is composed of a more rigid material than the trailing portion; and the blade structure comprises separate trailing and leading members, including the trailing and leading portions, respectively, which are arranged to overlap and are secured between a separate reinforcing cap and the arm, with the trailing member, between the cap and the overlapping portion of the leading member, extending somewhat forward of the arm but still behind the leading member and the reinforcing cap secured to the blade structure at a point radially outward of the arm.

Other objects, features and advantages will be apparent to one skilled in the art from the following description of a preferred embodiment of the invention, taken together with the attached drawings thereof, in which:

FIG. 1 is a plan view of the upstream side of an engine-cooling fan embodying the present invention;

FIG. 2 is a side elevational view of the fan of FIG. 1;

FIG. 3 is an enlarged sectional view of an arm and blade structure of the fan taken along the line 3—3 of FIG. 2;

FIG. 4 is a sectional view of an arm and blade structure of the fan taken along the line 4—4 of FIG. 3; and,

FIG. 5 is an enlarged partial view similar to FIG. 3 taken along the line 5—5 of FIG. 3.

There is shown in the figures generally at 11 an engine-cooling fan adapted for use on a motor vehicle. The fan has a central planar hub 12, with asymmetrically disposed arms 13 extending therefrom. As best shown in FIGS. 2 and 4, each arm has a twisted section 14 joining it to the hub so that the plane of each arm is at an acute angle *e* (FIG. 3) to the plane 12*a* of the hub 12.

A blade structure 15 is secured to the upstream side of each arm 13, and has an air-moving or airfoil surface formed, as illustrated, on two separate pieces, a leading member 16 and a trailing member 18. The leading blade member 16, here constructed as a separate slat formed of a relatively rigid steel (SAE 950, prepainted, 0.024 inch thick), defines an extended air-moving or airfoil surface 16*a*, terminating in the leading blade edge 17. The curved trailing blade member 18 is formed of a resilient, more flexible steel (AISI 301 stainless steel, 0.018 inch thick), and defines an air-moving or airfoil surface 18*a*, terminating in the trailing blade edge 19, which is substantially parallel to leading edge 17. The trailing member 18, extending rearwardly from arm 13 a greater distance than the forward extension of leading member 16, forms the major portion of the blade structure.

Provided at the trailing edge of each trailing blade member 18 is a weight 20. As illustrated the weight 20 is an integral portion of blade member 18 folded upon itself at the trailing edge so as to engage the convex side of the blade member and has a mass of about 15 percent of the total mass of the blade member 18. Such weights are fully described in my copending U.S. Pat. application Ser. No. 857,849, filed Sept. 15, 1969, entitled "Fan with Weighted Flexible Blades."

As shown in greater detail in FIGS. 3 and 4, each blade member 16, 18 overlies the arm 13 to which it is mounted on the upstream side of the arm, and is secured to the arm by a reinforcing cap 24, which overlies the convex side of the blade member 18, and rivets 25. The flat portion 26 of leading member 16 is overlapped by the flat portion 28 of trailing member 18, and the flat portion 26, 28 are secured between reinforcing cap 24 and The upstream side of arm 13 by the rivets 25 therethrough. The reinforcing cap also is radially coextensive with the leading member 16 which lies against arm 13, and is secured to the members 16, 18, past the end of arm 13 by the rivet 29 to reduce flutter of the blade members 16, 18. The trailing portion of trailing member 18 is curved through the plane of arm 13 toward the downstream side of the fan, convexly, as viewed in FIG. 1, away from the plane of hub 12, whereas the leading portion of leading member 16 is bent toward the plane of hub 12. The angle *a* of the chord plane *c* (FIG. 2) between the leading edge 17 and the trailing edge 19 with the rotational plane of the fan (which, in the illustrated embodiment, is also the plane 12*a* of hub 12) is about 32° as illustrated and preferably between about 25° and about 35°, when, as in the illustrated embodiment, the fan is idle and the trailing member 18 is not otherwise biased or supported between the arm 13 and the trailing edge 19. To provide this chord angle, the airfoil surface 16*a* is effectively disposed at an angle *d* to the arm 13, which is within the acute angle *e* of the arm 13 to the plane 12*a* (FIG. 3) of hub 12. As illustrated, the angle *d* is about 15° (preferably less than about 200°). Although as shown, a separate, a separate slat 16 is provided to form this leading airfoil surface, other portions of the fan structure, such as the trailing member 18 or even the reinforcing cap 24 should be extended forward to form the slat.

The reinforcing cap 24 is also bent away from the plane of arm 13 at its trailing edge (FIG. 3) and has reinforcing lips 30 and 32 which are integrally formed by turning up the edges of cap 24 (about one-eighth inch) extending along its inner and outer edges, respectively, to render the reinforcing cap (0.048 inch SAE 950A steel) both strong and light weight.

The arms 13 are arranged for balance of the fan, and the arcuate distances between the reference lines 40, 41, 42, 43, 44 (drawn radially of hub 12 and parallel to the edges 17, 19) are as follows:

40–41:48° 30′
40–42:150° 30′
40–44:80°
40–43:165°

In operation, as the fan rotates clockwise, in the direction indicated by the arrow in FIG. 1, air is moved from upstream to downstream as indicated by the arrows in FIG. 2, by the airfoil surfaces 16*a* and 18*a*. As fan speed increases, air pressure and centrifugal force cause only the trailing blade members 18 to decamber—in general, to move toward the plane of hub 12. The addition of the leading airfoil surfaces 16*a* permit a five-

bladed fan, as shown, to move as much air as a seven-bladed fan without any increase in noise, or any substantial increase in size or weight. Furthermore, as illustrated, the more corrodible trailing blade member **18** is protected by being secured between a prepainted cap **24** and a prepainted leading blade member or slat **16**. Where blade structure **15** is a single flexible element, of which portions extend on both sides of arm **13**, similar to the illustrated separate members **16** and **18**, the forward member being shorter and hence relatively less flexible than the trailing member, the underlying surface of arm **13** is preferably prepainted.

Other embodiments will occur to those skilled in the art from the foregoing nonlimiting description of a preferred embodiment thereof.

What is claimed is:

1. In a fan having a hub, a plurality of arms projecting radially outwardly of said hub, and blade structures secured to said arms, said blade structures each comprising a flexible, resilient trailing portion, defining an airfoil surface terminating in the trailing edge of said blade structure, which decambers as rotational speed increases, the plane of each said arm being disposed at an acute angle to the rotational plane of said fan,

the improvement wherein each said blade structure also comprises a leading portion, less flexible than said trailing portion, extending forward of the arm to which it is secured and effectively disposed at an angle to the plane thereof lying within said acute angle, said leading portion comprising a slat defining an extended airfoil surface terminating in the leading edge of said blade structure, said trailing portion comprising the major portion of said blade structure and said leading edge and said trailing edge defining therebetween a chord disposed at a predetermined chord angle to the rotational plane of said fan.

2. The fan of claim **1** wherein said predetermined chord angle is between about 25° and about 35° when said blade structure is in an unbiased position.

3. The fan of claim **2** wherein said chord angle is about 32°.

4. The fan of claim **2** wherein said leading edge and said trailing edge are substantially parallel to one another to define therebetween a plane disposed at said chord angle to the rotational plane of said fan.

5. The fan of claim **1** wherein said leading portion is composed of a more rigid material than said trailing portion.

6. The fan of claim **1** wherein said leading edge and said trailing edge are located, respectively, on opposite sides of the rotational plane of the hub of said fan.

7. The fan of claim **1** wherein said angle between said leading portion and the plane of said arm is less than about 20°.

8. The fan of claim **7** wherein said angle between said leading portion and the plane of said arm is about 15°.

9. The fan of claim **1** wherein each said blade structure comprises a flexible, resilient trailing member including said trailing portion and a separate leading member including said leading portion, and said members are arranged to overlap one another where secured to said arm.

10. The fan of claim **9** including a separate reinforcing cap overlaying the convex side of each said blade structure, and wherein said members overlap between said reinforcing cap and said arm, and are secured therebetween with said trailing member sandwiched between said reinforcing cap and the overlapping portion of said leading member.

11. The fan of claim **10** wherein said members extend radially beyond said arm and said reinforcing can extends radially coextensively with the one of said members sandwiched against said arm and is secured to said blade structure at a point radially outwardly of said arm adjacent the end of said one of said members.

12. The fan of claim **9** wherein said trailing member extends forward of said arm and is disposed adjacent said leading member, and said leading member extends forward of said trailing member.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,639,078 Dated February 1, 1972

Inventor(s) Shrinivas V. Pratinidhi

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 29, change "The" to --the--;

Col. 2, line 50, change "200°" to --20°--;

Col. 2, line 50, delete "a separate,".

Signed and sealed this 13th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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