United States Patent

Strick

[15] **3,679,321**

[45] **July 25, 1972**

[54] PRESTRESSED FLEXIBLE BLADED FAN

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[22] Filed: **April 26, 1971**

[21] Appl. No.: **137,123**

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

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

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

[56] **References Cited**

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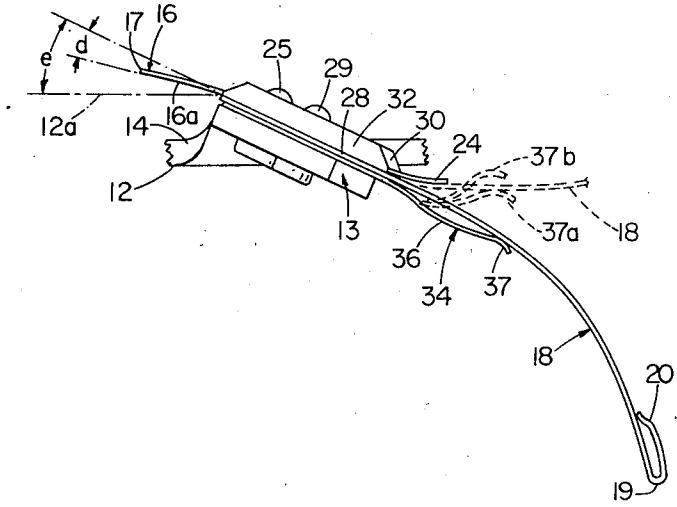
[57] **ABSTRACT**

A fan having a hub, a plurality of arms extending radially outwardly of the hub, blades, one secured to each arm, which decamber as rotational speed increases, and biasing members, one connected to each arm contacting the associated blade and urging such blade member toward its decambered position and thereby prestressing said blade member.

8 Claims, 4 Drawing Figures



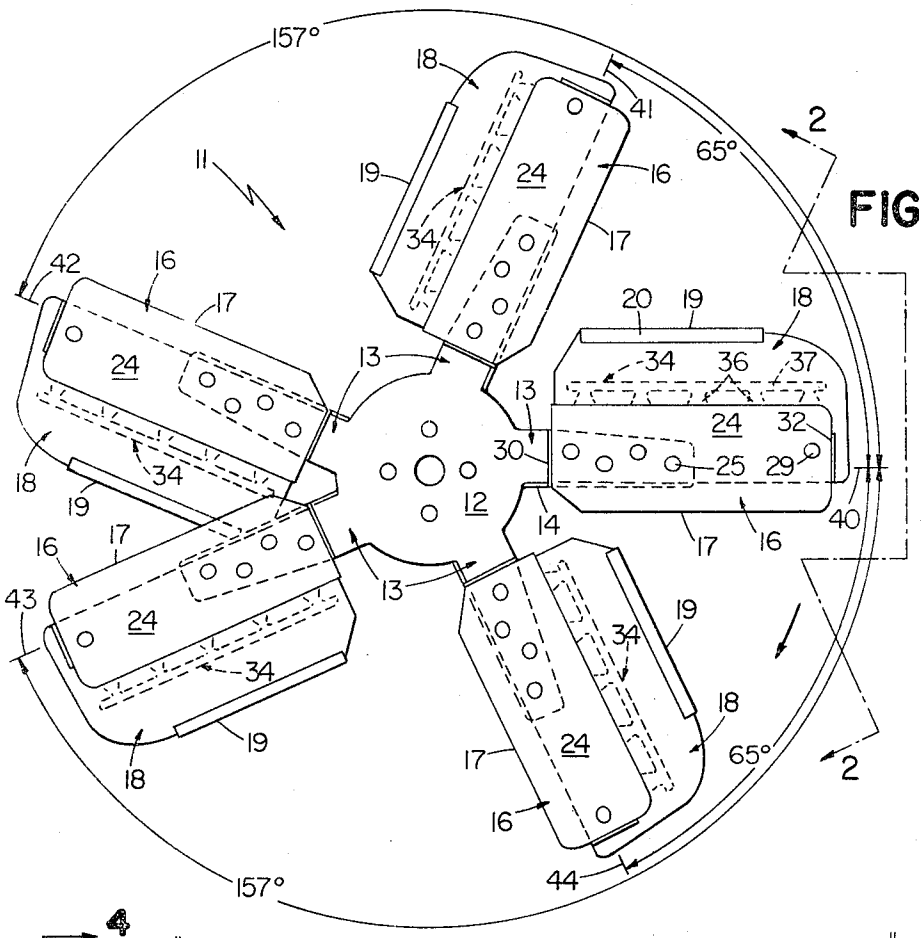


FIG 1

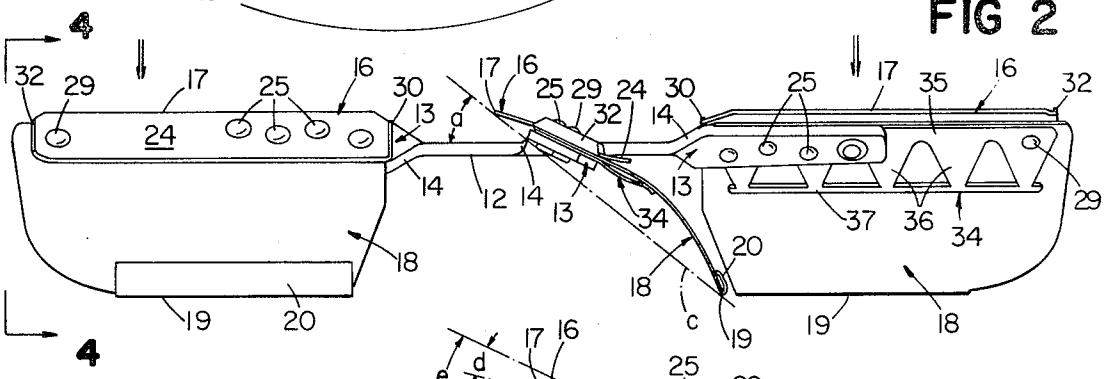


FIG 2

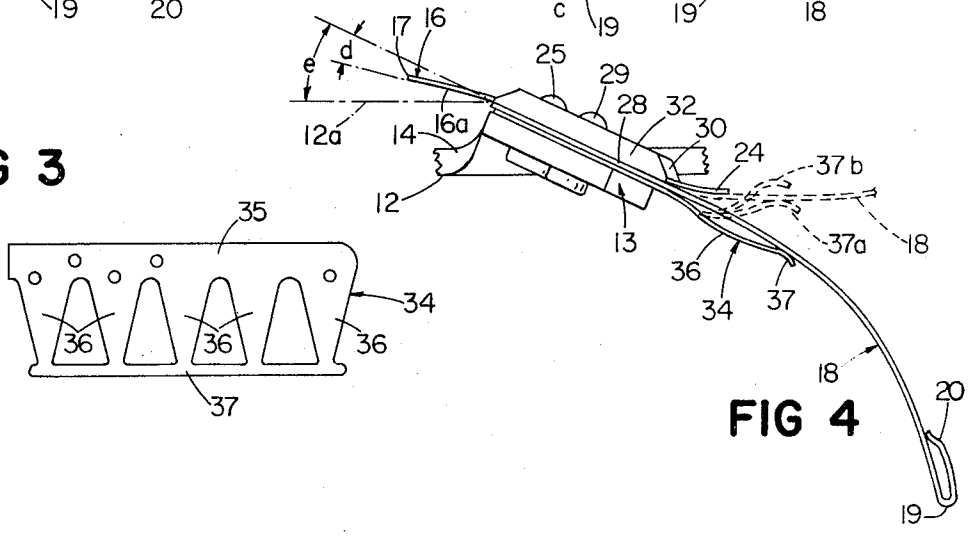


FIG 3

FIG 4

PRESTRESSED FLEXIBLE BLADED FAN

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

A principal object of this invention is to increase the pumping, and hence the cooling capacities of flexible bladed fans without increasing the projected width of the fans and without increasing the number of blades thereof, or alternatively to reduce the projected width of flexible bladed fans while maintaining cooling capacity at a predetermined level without increasing the number of fan blades. Another principal object is to substantially reduce fan vibration an concomitant dynamic stresses.

The invention features in a fan having a hub and plurality of fan blade assemblies comprising arms extending radially outwardly of the hub, and blade members secured to the arms, which decamber as rotational speed increases, the improvement wherein biasing members are also connected to the arms and contact the blade members urging them toward their decambered positions. In a preferred embodiment, the biasing members are mounted on the downstream sides of the blades and have a continuous base portion extending radially along the arm and the blade, and a continuous blade contacting outer web portion extending radially along the blade at a position spaced from said arm behind the trailing edge thereof and behind the trailing edge of a reinforcement member positioned on the upstream side of the blade. The base and outer web portions are connected by integral triangular shaped fingers having their apices connected to the blade contacting web portions and their bases connected to the other web portions. The biasing member has a configuration which permits it to contact the blade throughout its full decambering range.

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 accompanying 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 an enlarged elevation viewed along the line 2—2 of FIG. 1;

FIG. 3 is a plan view of the stamping from which the biasing member is formed; and

FIG. 4 is an enlarged end view of an arm and blade assembly taken along the line 4—4 of FIG. 2.

There is shown in FIG. 1, generally at 11, an engine cooling fan adapted for use in a motor vehicle. The fan has a central planar hub 12, with asymmetrically disposed arms 13 extending radially 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* of 25° to the plane 12*a* of the hub 12.

A blade structure is secured to the upstream side of each arm 13, and comprises air-moving or airfoil surfaces formed, as illustrated, on two separate portions, a leading member 16 and a trailing blade member 18, respectively designated with reference to the direction of fan rotation shown by the arrow in FIG. 1. The leading member 16 is here constructed as an integral portion of a reinforcement member or cap 24 formed of a relatively rigid steel (SAE 950A, 0.048 inch thick), and defines an extended airmoving or airfoil portion surface, terminating in the leading blade edge 17, the purpose and function of which is more fully described in copending United States patent application Ser. No. 86,750, filed Nov. 4, 1970, entitled Flexible Bladed Fan With Extended Blade Structure. The curved trailing blade member 18 is formed of a resilient, more flexible steel (AISI 301 stainless steel, 0.015 inch thick), and defines an air-moving or airfoil portion surface, terminating in the trailing blade edge 19, which is substantially parallel to leading edge 17. The trailing blade 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.

A biasing member 34 of resilient, flexible steel (AISI 301 stainless steel, 0.015 inch thick) is secured to each arm 13, at the relatively rigid leading portion of the blade structure between the arm and the associated blade member 18 on the downstream side of the blade member. As best shown in FIGS. 2 and 4, the biasing member extends from the arm 13 to contact the blade member 18 toward the flexible trailing edge 19 behind the trailing edge of the arm 13 to which blade member 18 is connected.

As most clearly illustrated in FIGS. 2 and 4, biasing member 34 extends radially along the length of blade member 18 contacting the blade member adjacent the ends defined by the radial extent thereof and intermediate said ends behind the trailing edges of arm 13 and reinforcement cap 24. In the preferred embodiment, as shown in FIG. 3, the biasing member 34 if formed from a blank having a base web 35 continuously extending along the length thereof. The base web 35 is suitably pierced to receive rivets 25, 29 for assembly on an arm 13. The blank is also die cut to provide a plurality of triangular shaped fingers 36 having their bases integrally connected with base web 35. The fingers 36 are in the shape of isoceles triangles and have a base to altitude ratio of about 1:1.5 to approach the characteristic in use of a spring constant which is essentially flat. A blade contacting outer web 37 is integrally connected by the apices of fingers 36 parallel to base web 35.

The blank is preformed, after cutting, to a shape approximately as illustrated in broken lines in FIG. 4 in which a flat is provided at base web 35 and the base of fingers 36. The outer portion of the fingers 36 is bent about a shorter radius than that of blade member 18 when it is fully decambered, and the outer web 37 at the apices of fingers 36 is reversely bent about a short radius to provide a height from the flat base web 35 to the outer web 37 which in an unbiased condition of member 34, extends beyond the fully decambered position of blade member 18, as shown in broken lines at 37*b* in FIG. 4. The curvature of fingers 36 and the reverse curvature of outer web 37, after assembly, provide a tangential contact with the blade member 18 by outer web 37 continuously between the radially defined ends of blade member 18 and a gap from the trailing edge of arm 13 to the point of contact at outer web 37 between the blade member 18 and biasing member 34.

As shown in FIG. 4, each blade member 18 is sandwiched between a reinforcement cap 24 and the arm 13 to which it is mounted on the upstream side of the arm, and is secured to the arm together with the reinforcement cap 24 by rivets 25. Flat 35 of biasing member 34 is sandwiched between a corresponding flat portion 28 of blade member 18 and arm 13 and is likewise secured to the arm 13 by the rivets 25 which extend therethrough. The reinforcement cap 24, with integral leading member 16, and biasing member 34 are substantially radially coextensive with the blade member 18, extending radially beyond the end of arm 13, and are secured to the blade member 18, adjacent the outer end thereof by rivet 29 to prevent any tip flutter. The curvature of the fingers 36 permits biasing member 34 to extend toward the upstream side of said fan to contact and prestress blade member 18 behind arm 13 at its predetermined most decambered position at maximum fan rotational velocity, as illustrated at 37*a* in broken lines in FIG. 4, an throughout the full range of motion of blade member 18.

The blade member 18 is curved about a radius 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 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 38° in a preferred embodiment when, as in the illustrated embodiment, the fan is idle. 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. 4) of hub 12. As illustrated, the angle *d* is about 10°.

Reinforcement cap 24 is bent about a radius away from the plane of arm 13 at its trailing edge (FIG. 4) and has reinforc-

ing 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 reinforcement cap both strong and light weight. As shown in FIGS. **2** and **4**, reinforcement cap **24** extends a limited distance toward the trailing edge **19** of blade member **18**, in spaced relationship thereto due to the oppositely directed curvatures thereof. Preferably, the the biasing member **34** contacts blade member **18** behind the trailing edge of reinforcement cap **24**.

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 :	65°
40 – 42 :	157°
40 – 44 :	65°
40 – 43 :	157°

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 remainder of the blade member **18**. Such weights are fully described in copending United States patent application Ser. No. 857,849, filed Sept. 15, 1969, now U.S. Pat. No. 3,594,098, entitled Fan With Weighted Flexible Blades.

In assembly, the blade member **18**, reinforcement cap **24**, and biasing member **34** are first secured together at the outer end by rivet **29** and then to arm **13** by rivets **25**.

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 of members **16** and **18**. As fan speed increases, air pressure and centrifugal force causes only the trailing blade members **18** to decamber—in general, to move toward the plane of hub **12**.

Biasing member **34**, contacting blade member **18** at outer web **37**, follows the blade member as it decambers. Because the blade member **18** is prestressed by the biasing member **34**, the blade member does not deflect as rapidly as an unstressed blade in a comparable fan and the fan according to the invention has a greater pumping capacity for a given projected width than a fan which does not employ the biasing member. In addition, the biasing member dampens vibration virtually eliminating torsional vibration modes and severely limiting other modes with a concomitant reduction of dynamic stress levels.

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

What is claimed is:

1. In a fan having a hub and a plurality of fan blade assemblies each comprising an arm extending radially outwardly from said hub and a flexible, resilient blade connected to said arm which blade decambers from a downstream position, relative to the direction of airflow, to a relatively more upstream position as rotational speed increases, that improvement comprising:

a resilient biasing member provided in each of said fan blade assemblies connected thereto and contacting said blade thereof urging said blade toward its decambered upstream position and thereby prestressing said blade.

2. The fan claimed in claim **1** in which said biasing member has a curved configuration with the portion of said biasing member contacting said blade extending toward the upstream side of said fan, contacting and prestressing said blade at the most decambered position thereof during rotation of said fan at a predetermined maximum speed, whereby said biasing member contacts and prestresses said blade throughout its range of motion.

3. The fan claimed in claim **1** in which said blade defines, in the direction of fan rotation, a generally radially extending leading portion which is relatively rigid and a trailing portion which is flexible, said biasing member being connected to said assembly adjacent said leading portion and contacting said blade on the downstream side thereof at said trailing portion.

4. The fan claimed in claim **3** in which said biasing member contacts said blade at said trailing portion continuously throughout the radial extent thereof along a line generally parallel to a generally radially extending leading edge defined by said leading portion.

5. The fan claimed in claim **3** in which said fan blade assembly includes a reinforcement member adjacent said leading portion on the upstream side of said blade, said reinforcement member extending and terminating toward said trailing portion in spaced relationship thereto, and said biasing member contacting said blade between a trailing edge of said blade defined by said trailing portion and the point at which said reinforcement member terminates.

6. The fan claimed in claim **3** in which said biasing member comprises a base portion extending radially continuously along said leading portion and a plurality of integral triangular biasing fingers extending therefrom toward their apices at said trailing portion said biasing member bearing upon said trailing portion adjacent said apices along a line generally parallel to a generally radially extending leading edge defined by said leading portion.

7. The fan claimed in claim **6** in which said apices are interconnected by a continuous integral outer web of said biasing member said outer web contacting said trailing portion continuously along said line.

8. The fan claimed in claim **7** in which said biasing member has a curved configuration with said outer web extending toward the upstream side of said fan, contacting and prestressing said blade at the most decambered position thereof during rotation of said fan at a predetermined maximum speed, whereby said biasing member contacts and prestresses said blade throughout its range of motion.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,679,321 Dated July 25, 1972

Inventor(s) Karl H. Strick

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

Change the Assignee from "Fran Corporation" to --Fram Corporation--;

Col. 1, line 11, change "an" to --and--;

Col. 2, line 58, change "an" to --and--.

Signed and sealed this 2nd day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334