United States Patent [19]

Woollenweber, Jr.

[11] **3,891,349**

[45]***June 24, 1975**

[54] **COOLING FAN CONSTRUCTION AND METHOD OF MAKING SAME**

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[*] Notice: The portion of the term of this patent subsequent to June 24, 1991, has been disclaimed.

[22] Filed: **Feb. 22, 1972**

[21] Appl. No.: **227,922**

[52] **U.S. Cl.** **416/132;** 416/210; 416/240

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

[58] **Field of Search** 416/132, 240, 210, 214

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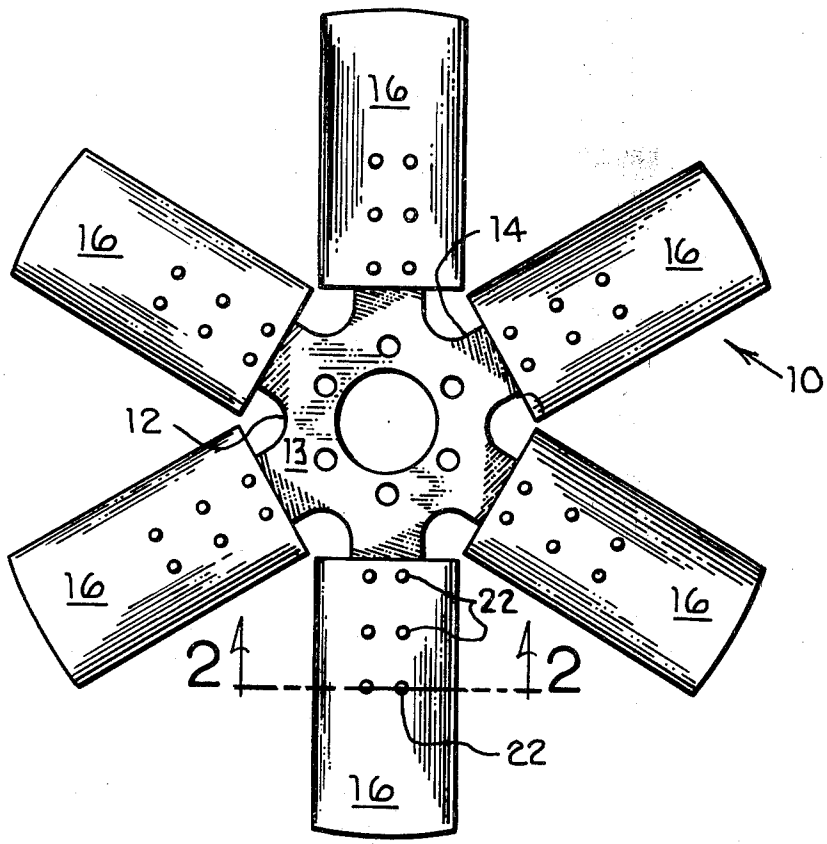
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Attorney, Agent, or Firm—Thomas J. Greer, Jr.

[57] **ABSTRACT**

A cooling fan formed of two sheet metal layers joined to a centrally contained spider arm. The configuration of the resulting blade is streamlined or an airfoil in cross section. In constructing the fan the surface pieces are normally spaced from the central support arm and during assembly are forced together and joined to the arm. The resulting stress imposed on the leading and trailing edges of the surface sheets reduces vibratory stresses in the blade. In one embodiment the trailing edge of one of the sheets is permitted to slide along the surface of the other sheet when the other sheet is decambering due to centrifugal and aerodynamic forces generated by rotation of the fan. The result is to vary the moment arm of the restraining forces imposed on the decambering trailing portion of the flexing sheet, thus giving better control of the decambering rate of that sheet.

8 Claims, 9 Drawing Figures



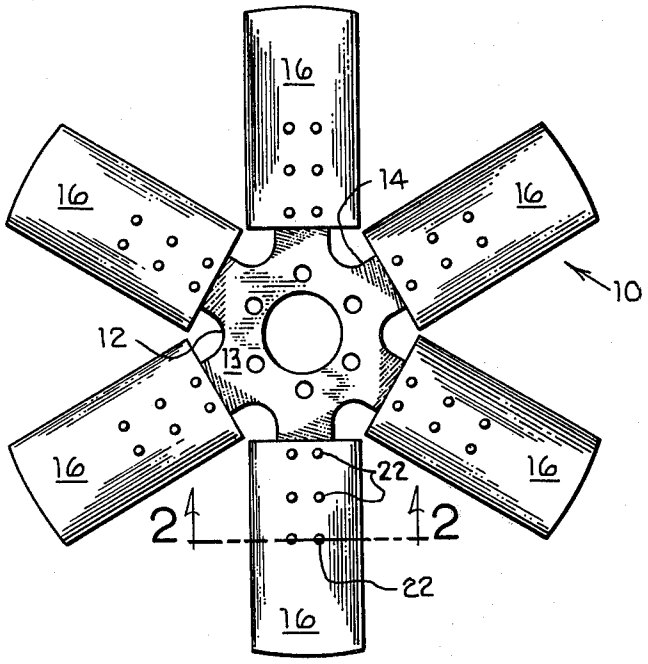


Fig. 1

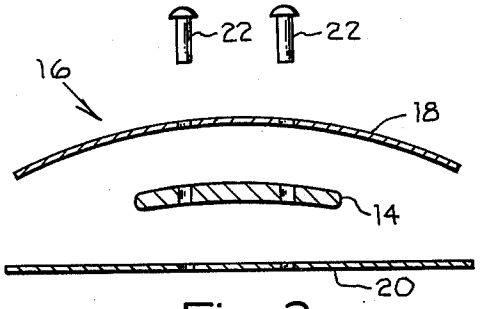


Fig. 3

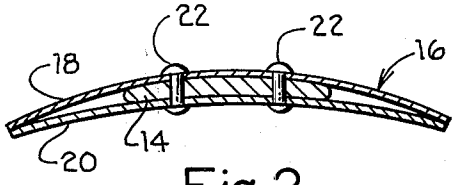


Fig. 2

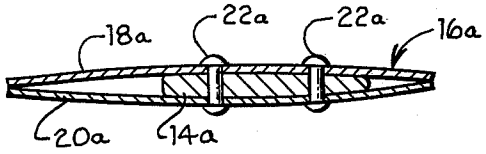


Fig. 4

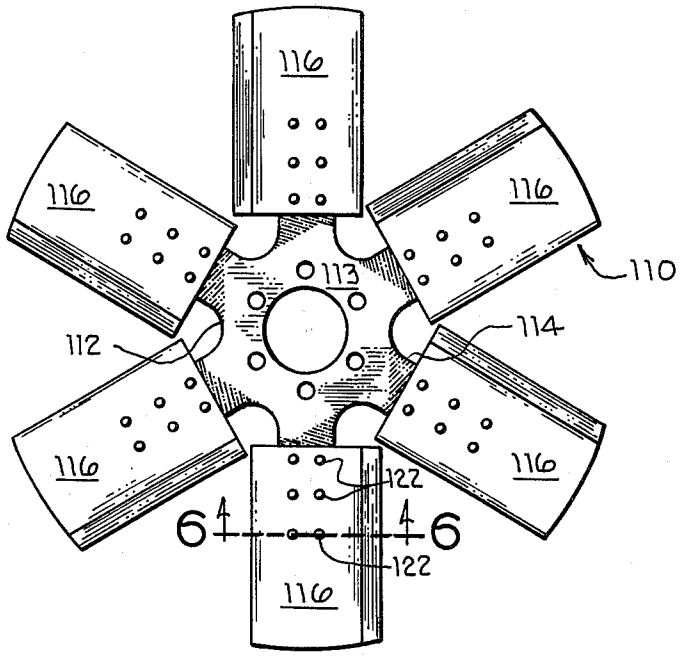


Fig. 5

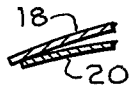


Fig. 8

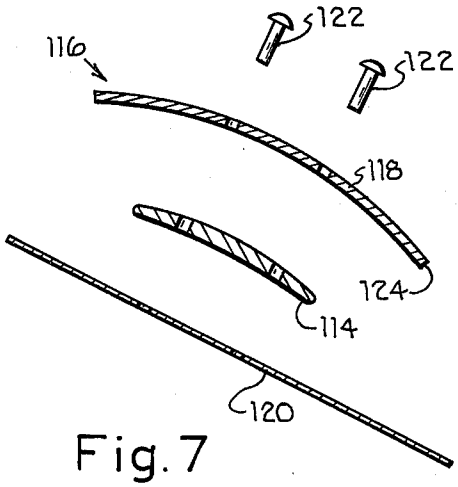


Fig. 7

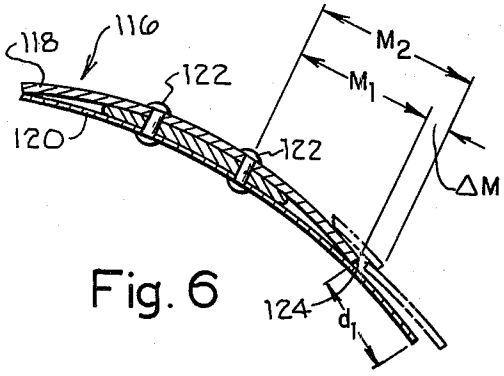


Fig. 6

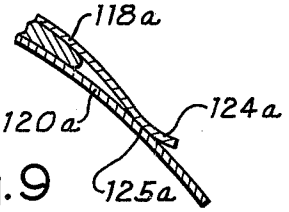


Fig. 9

COOLING FAN CONSTRUCTION AND METHOD OF MAKING SAME

BACKGROUND OF THE INVENTION

This invention relates to cooling fans for use primarily in automotive and truck applications, more specifically to an improved hollow fan construction having an airfoil or streamlined cross-sectioned configuration, and the method of making the same.

In the automotive and truck industry the goal sought for cooling fans has been that of achieving a highly efficient fan blade capable of moving large quantities of air in accordance with engine cooling requirements without generating excessive noise; capable of being produced in an economical manner, and capable of having a long service life.

In the past it has been recognized that an airfoil or streamlined cross-sectional configuration for a fan would give a greater efficiency at low speeds and less noise at higher speeds than the commonly used fan construction of the present day, which is a curved plate fastened to a single or double spider arm. The reason for the extensive use of the latter constructions is the relative economy inherent in the single blade construction versus the airfoil or streamlined construction. Therefore, the industry has chosen to live with excessive noise and less cooling efficiency until now, probably due to the prior practice of making an airfoil or streamlined construction either by casting such a blade or bonding sheets together in the desired shape, as by brazing or welding, such practices being relatively expensive.

A concept of the present invention is to take two sheets of metal, with at least one of the sheets having a curved cross-sectional configuration, and place these sheets on either side of a spider arm. The two sheets are drawn together and fastened to the supporting spider arm by appropriate means such as rivets so that the edge portions of both sheets remain discrete but are placed in a continuous compressive stress similar to the edge portions of a Belleville spring when it is compressed. One resulting benefit due to the support given by one sheet to the other along the edge portions is the prevention of flutter or high frequency vibratory stresses which may be set up in the blade along the edge portions. Where a streamlined cross-sectional configuration is desired, both sheets may be curved somewhat in excess of their desired final shape. The assembly process will provide some straightening and the edge stress.

In another embodiment the lower or pressure side sheet is extended beyond the rear edge of the upper sheet and is of sufficiently thin cross-sectional area so as to be permitted to decamber as a result of centrifugal and aerodynamic forces generated by the rotation of the blade. When this happens the top sheet rear edge will slide relative to the lower sheet as the lower sheet flexes into a decambered position. This will change the moment arm of the restricting forces imposed by the top sheet rear edge on the lower sheet, thus making it possible to better control the decambering flexing rate of the lower sheet.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is an enlarged sectional view of an arm and blade of the fan taken along line 2—2 of FIG. 1.

FIG. 3 is an exploded sectional view of the components of FIG. 2 prior to assembly.

FIG. 4 is a sectional view similar to that of FIG. 2 but of a modified form of fan blade.

FIG. 5 is a plan view of the upstream side of a different embodiment of the present invention.

FIG. 6 is an enlarged sectional view of an arm and blade of the fan of FIG. 5 taken along line 6—6.

FIG. 7 is a sectional exploded view of the construction illustrated in FIG. 6 prior to assembly.

FIG. 8 is a sectional partial view of a modification of the leading edge relationship of the present invention.

FIG. 9 is a sectional partial view of a slight modification of the trailing edge configuration of the construction of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring initially to FIG. 1 there is illustrated a cooling fan generally referred to by the numeral 10 composed of a spider 12 having a hub portion 13 and a plurality of spider arms 14. These arms are oriented perpendicularly to the axis of rotation of the fan. Joined to the spider arms are a plurality of fan blade constructions generally designated as 16.

As seen in FIGS. 2 and 3 each blade 16 is constructed of a front sheet 18 and a rear sheet 20 joined by rivets 22 to the spider arm 14. It will be noted from the illustration of FIG. 3 that the front sheet 18 is curved to the desired final shape whereas the rear sheet 20, which may be of thinner stock, is straight prior to assembly. In some instances rear sheet 20 could be pre-curved to a lesser degree than front sheet 18 and still accomplish the objectives of this invention or, if sheets 18 and 20 were of the same thickness, sheet 18 could be curved to a greater degree than the desired final configuration and would then be straightened somewhat during assembly with sheet 20.

To assemble the fan blades the front sheet 18 and rear sheet 20 are located in a spaced sandwich relationship to the spider arm 14 and then forced into continguity with the spider arm 14 while the rivets 22 are inserted and are formed into place. As can be noted from the illustrated spider arm cross section 14 the front and rear surfaces of the spider arm may be shaped to conform to the desired curvature of the final product. The curvature desired in FIG. 2 is that of an airfoil configuration in which the outer surface of the back sheet is concave in its configuration and the outer surface of the back sheet is concave in its configuration as viewed in cross section.

FIG. 4 illustrates a different configuration that can be obtained. In this illustration components corresponding to those in FIGS. 2 and 3 are given the same numeral with a subscript *a*. In this case the cross-sectional configuration is streamlined in that the outer surfaces of the front and rear sheets are both convex as viewed in cross section. The configuration of FIG. 4 may be assembled in the same manner as that of FIG. 2.

FIGS. 5 through 7 illustrate the application of the present invention to a flexible bladed fan which results in greater strength and a more desirable flexing action of the blades. The fan is geneally designated as 110 and is composed of a spider 112 which is itself made up of a hub portion 113 and a plurality of spider arms 114.

Fastened to the spider arms are blade constructions **116.**

Looking to the cross-sectional FIGS. **6** and **7** it is seen that each blade **116** of the fan consists of a semi-rigid resilient front sheet **118** and a flexibly resilient rear sheet **120** joined to the spider arm **114** by means of a plurality of rivets **122.** As will be seen in these FIGURES the rear sheet **120** is preferably of a thinner cross section than the front sheet **118** and extends to its trailing edge of a distance d_1 beyond the trailing edge **124** of front sheet **118.** The trailing edge of front sheet **118** is spaced a distance m_1 from the rearmost line of rivets **122** and constitutes the pivot edge about which the portion d_1 will rotate during flexure. Therefore the distance m_1 would also constitute the moment arm of the resisting force imposed by the trailing edge of the front sheet **118** against such flexure.

Because it has become recognized as desirable in the fan art that the greatest rate of decambering flexing should occur initially during the rotative cycle of the fan (e.g., during the transition of the vehicle from idle to beginning speed) and then diminish so that no flexing into opposite camber will occur. It is desirable to proportion sheets **118** and **120** such that some flexing does occur in the rearward portion of **118** near its trailing edge **124** but not as much as occurs in sheet **120.** The result of this relationship is that as the extending portion d_1 of sheet **120** flexes forwardly it will urge the trailing edge of **124** of front sheet **118** forwardly also, which will cause this trailing edge to slide along the extending portion d_1 by a distance shown as Δm, this will increase the moment arm of the trailing edge **124** to a new value shown as m_2 which in effect will increase the resistance to flexure against the portion d_1 as the fan increases its speed. Thus, with this type of construction all of the benefits of an airfoil shape will be derived plus the additional benefit of a variable flexing rate which can be controlled and tailored to fit the requirements of a particular cooling problem.

Under some conditions, such as a desire for a finer leading edge, or the desire to protect the thinner rear sheet **20** from damage to its leading edge it may be advantageous to carry the leading edge of the front sheet **20** over that of the rear sheet as shown in FIG. **8.**

In some applications of the FIG. **6** construction it may be found that unwanted and unduly high stress concentrations may occur at the line engagement of trailing edge **124** on sheet **120.** Under such conditions it may be desirable to curl the trailing edge somewhat as shown in FIG. **9.** By having front sheet **118***a* engage rear sheet **120***a* at the curved trailing edge **124***a* a rolling as well as sliding line of contact will occur in the vicinity of **125***a* when the sheet **120***a* flexes. This will help to prevent the build-up of high stress concentrations.

The terms "front" and "rear," and "upper" and "lower" as used in the specification and claims are for the purposes of relating various components to each other and are not intended to fix the construction of the invention in a particular spatial relationship.

I claim:

1. A fan blade construction adapted for use in cooling systems for automotive and truck applications, said construction including,

a. an elongated spider arm,

b. a pair of sheet metal, elongated sheets of generally rectangular configuration, each sheet having a leading lengthwise edge and a trailing lengthwise edge,

c. said sheets being of a width greater than the width of said spider arm,

d. said sheets each being secured to said spider arm, to sandwich the spider arm, the longitudinal axis of the arm and the said sheets being substantially parallel,

e. at least one of said sheets being convex with respect to said spider arm,

f. at least one of said leading lengthwise edges of said pair of sheets resiliently abuting the other sheet of said pair of sheets,

g. whereby force would have to be exerted to displace the resiliently abutting leading lengthwise edge from the sheet against which it bears.

2. The fan blade construction of claim **1** wherein said leading lengthwise edges abut each other.

3. The fan blade construction of claim **1** wherein at least one of said trailing lengthwise edges of said pair of sheets resiliently abuts the other sheet of said pair of sheets, whereby force would have to be exerted to displace the resiliency abutting trailing lengthwise edge from the sheet against which it abuts.

4. The fan blade construction of claim **3** wherein said trailing lengthwise edges abut each other.

5. The fan blade construction of claim **2** wherein at least one of said trailing lengthwise edges of said pair of sheets resiliently abuts the other sheet of said pair of sheets, whereby force would have to be exerted to displace the resiliently abutting trailing lengthwise edge from the sheet against which it abuts.

6. The fan blade construction of claim **3** wherein one of said trailing lengthwise edges has a curled portion, curving away from the sheet which it abuts, to thereby reduce stress concentrations.

7. The fan blade construction of claim **1** wherein said sheets are of different degrees of resiliency.

8. The fan blade construction of claim **5** wherein said sheets are of different degrees of resiliency.

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