

[54] **REVERSIBLE FAN ASSEMBLIES AND INTEGRAL BLADE AND TRUNNION UNITS**

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Related U.S. Application Data

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[52] U.S. Cl. **416/206, 416/223**

[51] Int. Cl. **F04d 29/36**

[58] Field of Search 416/206, 205, 204, 223

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Primary Examiner—Everette A. Powell, Jr.

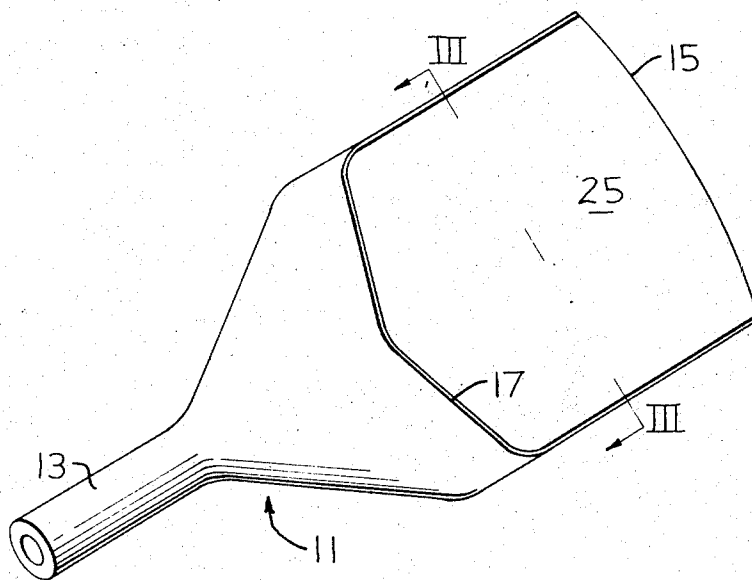
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[57]

ABSTRACT

For a reversible fan, a blade is manufactured from a tubular member of a proper gage and diameter by spreading or flattening one end into a blade shape and swaging the other end of the tubular member to a reduced diameter to form an integral trunnion. The tubular member may be first slotted to aid in spreading the blade portion into the proper blade configuration. At the distal end of the trunnion of the integral blade and trunnion unit, a portion of the trunnion can be upset to provide a shoulder for retaining and positioning the integral blade and trunnion in a fan hub in one of two positions for reversing air flow. Springs can be employed to bias each integral blade and trunnion radially outwardly so that the position of these units will be maintained by engagement with complementary indexing structure in the associated hub. As an alternative to upsetting the end of the trunnion, a washer member may be secured on its distal end and a blade indexing mechanism provided by the washer member and cooperating hub assembly.

12 Claims, 17 Drawing Figures



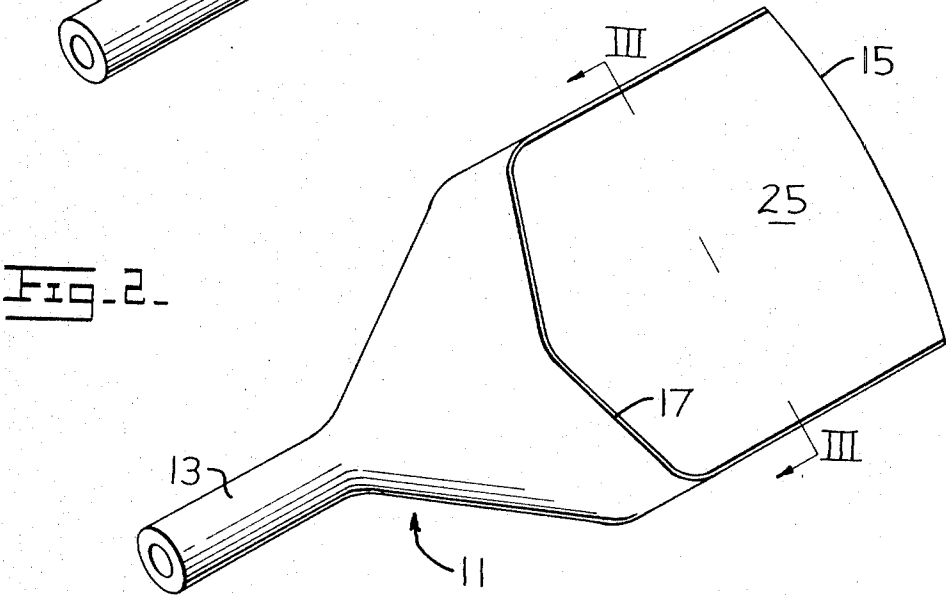
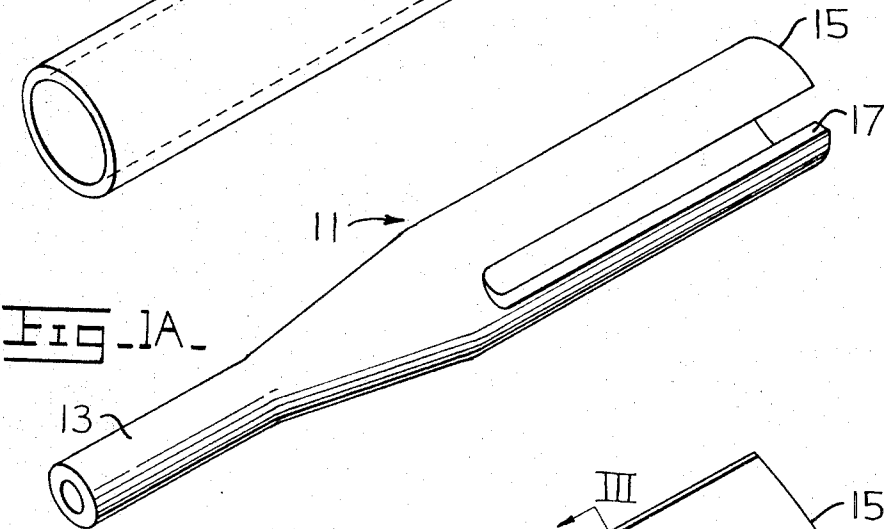
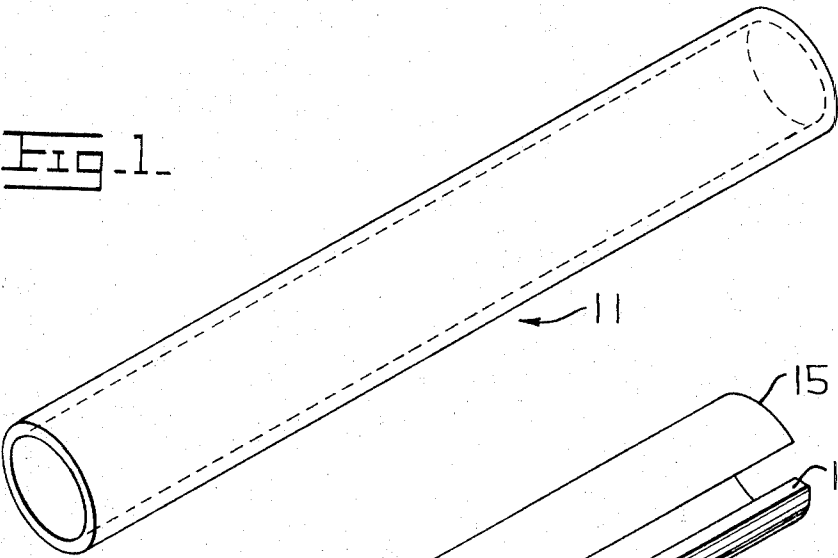


Fig. 3.

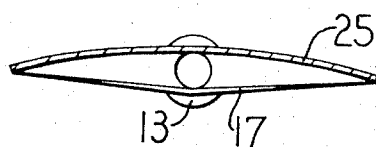


Fig. 4.

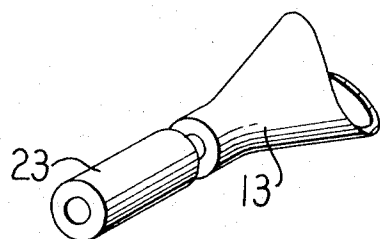
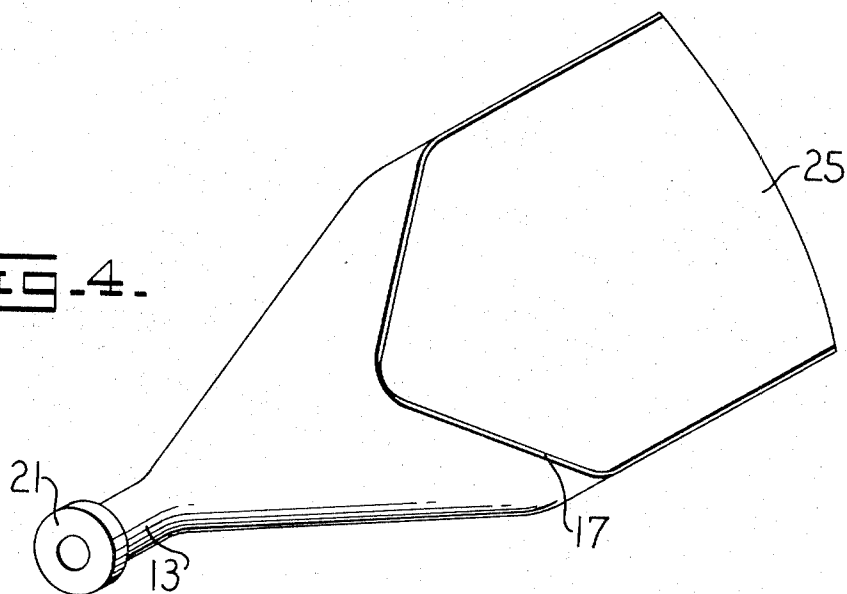
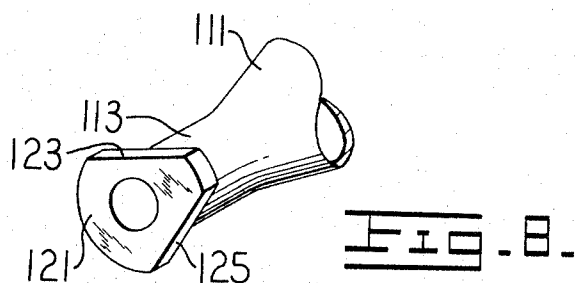
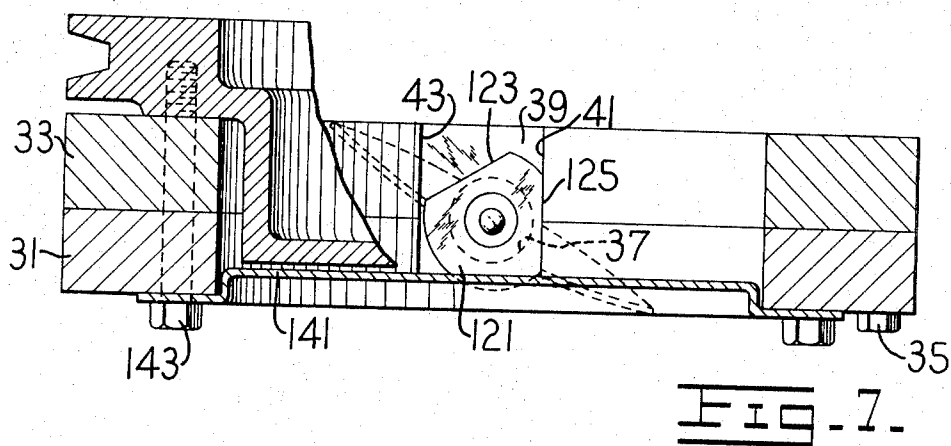
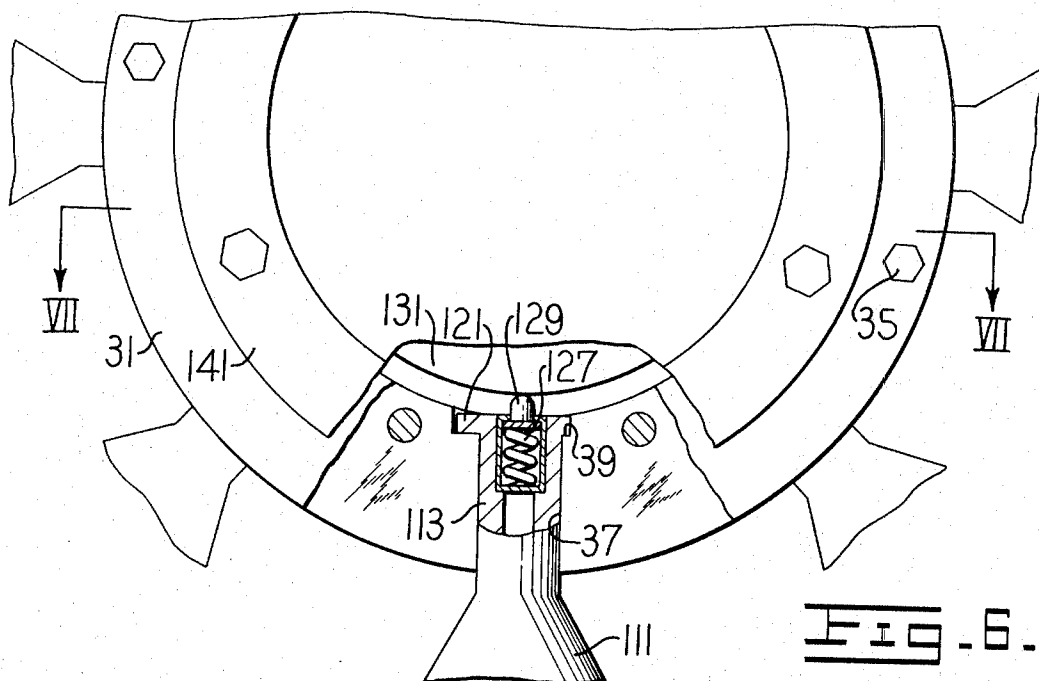


Fig. 5.



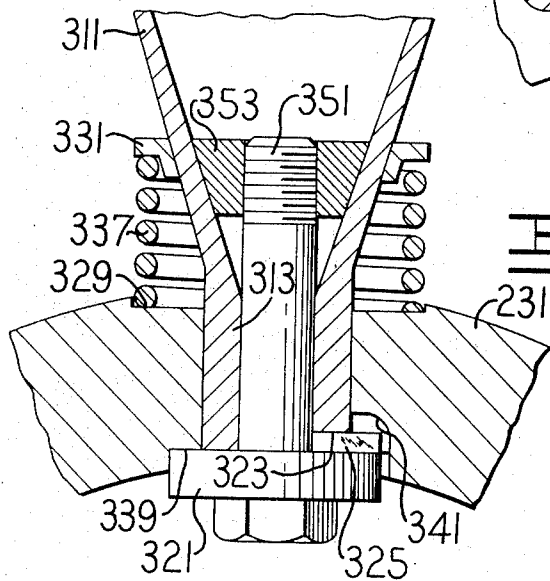
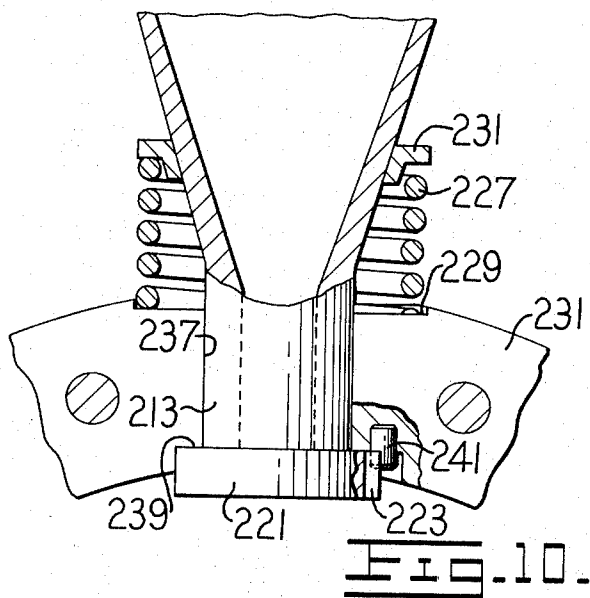
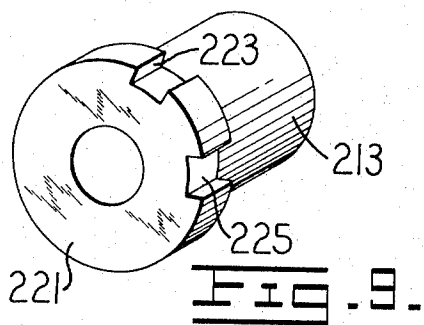
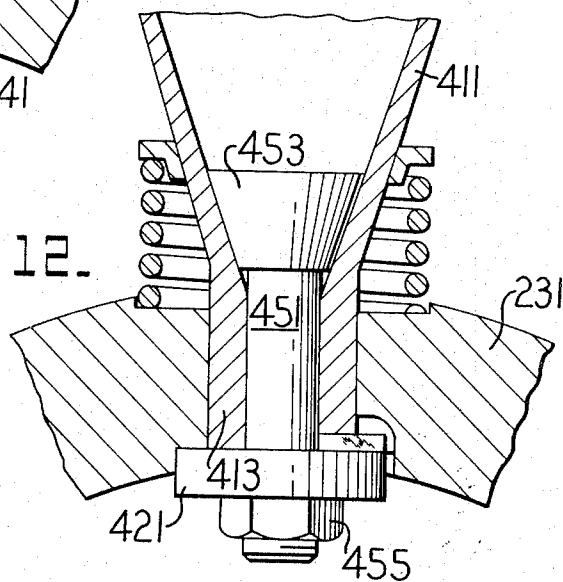


Fig. 12.



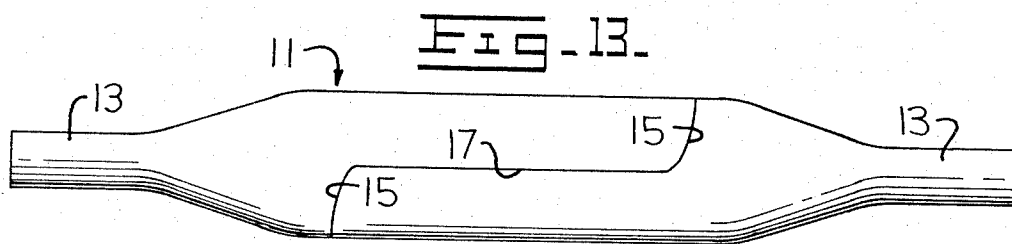


Fig. 14.

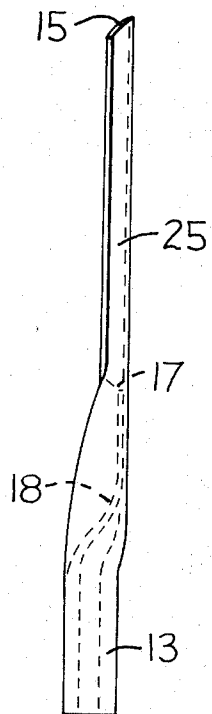


Fig. 15.

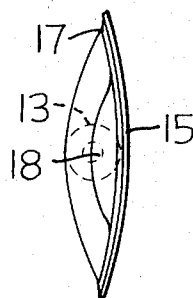
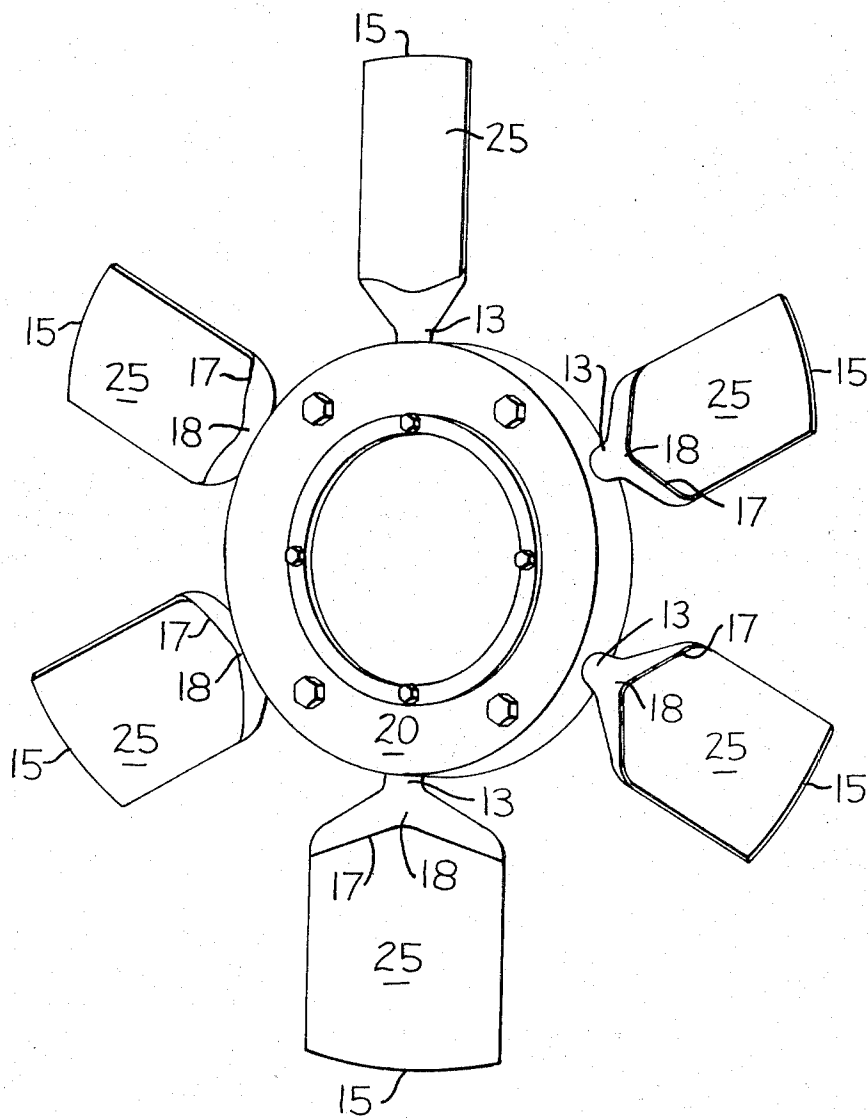


Fig. 16.



REVERSIBLE FAN ASSEMBLIES AND INTEGRAL BLADE AND TRUNNION UNITS

This application is a continuation-in-part of applicant's prior copending application, Ser. No. 813,081, filed Apr. 3, 1969, and entitled "Reversible Fan Assembly," now abandoned.

This is a division of Ser. No. 70,328, filed Sept. 8, 1970.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a fan in which the individual blades are reversed or repositioned to change the direction of air flow through the fan assembly. More particularly, the invention relates to the fabrication of the individual blades which produces increased flexibility in mounting, simplified manufacturing and reduced balancing requirements along with a reduction in total costs.

The invention described herein relates to reversible fans such as disclosed in assignee's copending U. S. application entitled "Reversible Cooling Fan," Ser. No. 733,133, filed May 29, 1968, now U. S. Pat. No. 3,452,820.

Reversible fans may be used to select several directions of air circulation through a radiator of a vehicle engine. Such reversible fans usually include mechanism for independently rotating each of the blades about its longitudinal axis to one of two positions so the direction of air circulation can be conveniently changed.

Thus, the individual blade assemblies in a reversible fan may rotate between two indexed positions in the fan hub and are retained in either position by pins or grooves for the selected angular position to obtain the desired direction of air flow through the fan. Such pins are generally located in a transverse passage in the blade supporting member (trunnion) which is normally a casting to which the blade is fixedly secured. These trunnion assemblies usually include some means to keep the individual blades from rotating a full 360° about their respective longitudinal axis. Such pin restrained blades place large shear stress concentration on blade-pin connection and on the pin. The pin diameter can be enlarged in cross-section to prevent it from shearing due to the high shear forces, but this reduces the cross-section of the pin supporting trunnion structure which often leads to fracture of this structure under high centrifugal loadings. To avoid this problem, the trunnion support structure is often increased in size, which in turn increases the shear loading on the pin due to added weight. Sometimes a shoulder is employed on the inner end of the trunnion which is disposed in a counterbore of the hub member to alleviate some of the above pin shear problems. However, such shoulder configurations also add weight. Balancing problems are further complicated due to the fact that the trunnion support member with the shoulder is usually made from a relatively heavy forging on which the thin blade is fixedly secured. Thus, prior art configurations utilizing shoulders often resulted in heavy blade and trunnion assemblies to provide the necessary mechanical strength for retaining and indexing the conventional blade and trunnion structures in the fan hub assembly.

By contrast, this invention provides a strong, lightweight blade having an integral trunnion for use in reversible fan applications. The blade is formed by swag-

ing one end of the tube of the proper gage and diameter to produce an increase in wall thickness for an integral trunnion where the maximum strength is needed, and shaping its other end into a blade. The decrease in weight in such integral or unitary blade and trunnion units results in a reduction in centrifugal forces acting upon these units during normal operation leading to a lighter, lower-cost, reversible fan assembly. Due to the lightweight blade units, this invention also offers versatility in mounting such units in a fan hub which can be a single piece hub or a split hub.

It is therefore an object of this invention to provide a lightweight integral blade and trunnion unit for reversible fan assemblies which obviates many of the above described problems of the heavier prior art reversible fan assemblies.

It is also an object hereof to provide a method of manufacturing a new lightweight integral blade and trunnion unit for reversible fan assemblies having a light strength-to-weight ratio.

It is a further object of this invention to provide a cooperating indexing means for the integral blade and trunnion units for positioning them in either of two positions when mounted in a fan hub.

Other objects and advantages of the present invention will become apparent from the following description in conjunction with embodiments illustrated in the accompanying drawings which show one embodiment of the present invention and its principles. It is recognized that other embodiments of the invention utilizing the same or equivalent principles may be used, and structural changes may be made as desired by those skilled in the art, without departing from the present invention and purview of the appended claims.

SUMMARY OF INVENTION

An integral blade and trunnion unit for reversible fan assemblies can be formed from metallic tubular member by swaging one end of the member and flattening the other end into a blade shape. By slotting the tubular member from one end to its central portion prior to flattening this end into a blade shape, it can be simultaneously spread as it is flattened to increase the blade area-to-weight ratio as the individual blade units are formed. Also, the distal end of the trunnion portion can be upset to provide a means for indexing and retaining these units in a fan assembly.

A reversible fan assembly can be formed by incorporating a plurality of the above-described blade units into a hub assembly having a plurality of inwardly directed radial holes since the transition area between the resulting blade and trunnion portions provides sufficient strength for these mounting arrangements. A depression formed in this transition area may be employed to increase its strength and decrease noise of the units in a fan assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective of a tubular metal member of a suitable gage and diameter from which the integral blade and trunnion units can be fabricated;

FIG. 1A is an isometric of the tubular member which has been swaged on one end and slotted at the other prior to shaping the integral blade portion on the resulting trunnion unit;

FIG. 2 is an isometric of the tubular member shown in FIG. 1A after the slotted end has been shaped into an integral blade configuration;

FIG. 3, is a section of a blade taken along a line III—III of FIG. 2;

FIG. 4 is an isometric of the blade shown in FIG. 2 with the distal end of the swaged end upset to form a shoulder for use in restraining and indexing the unit in a hub assembly;

FIG. 5 illustrates a partial isometric view of the blade showing an alternate embodiment wherein a trunnion extension member friction welded to the swaged end of the unit;

FIG. 6 illustrates an elevation with parts broken away of a fan blade assembly having indexing mechanisms cooperating with surfaces on the upset end of the new integral blade and trunnion units;

FIG. 7 is a section of the indexing mechanisms of the fan blade assembly shown in FIG. 6, taken along a line VII—VII thereof;

FIG. 8 is an isometric of the indexing surfaces on the units utilized with the fan assemblies shown in FIGS. 6 and 7;

FIG. 9 shows an isometric of an upset end portion of an integral blade and trunnion unit employing notches to form indexing surfaces;

FIG. 10 illustrates how springs may be utilized to maintain the indexed position in a fan hub assembly of the upset shoulder illustrated in the embodiment of FIG. 9;

FIGS. 11 and 12 illustrate cross-sectional views of alternative embodiments of the integral blade and trunnion unit wherein a washer member is secured to the distal end of the trunnion and employed to hold the blade in its indexed position in a hub structure;

FIG. 13 is an elevation of a tubular member with opposite ends swaged and sectioned to form two of the novel units thereby saving material;

FIGS. 14 and 15 are an edge elevation and end view of an integral blade and trunnion unit formed from the tubular member shown in FIG. 13; and

FIG. 16 is a perspective of fan assembly employing the integral blade and trunnion units in a hub.

DETAILED DESCRIPTION

Referring now to the drawings in greater detail, FIG. 1 shows a metal tubular member 11 from which an integral blade and trunnion unit is fabricated. In FIG. 1A, the tubular member 11 is illustrated with its end 13 swaged to a smaller diameter increasing wall thickness to form a trunnion and with its other end 15 having machined therein a blind longitudinal slot 17 for a predetermined distance toward the swaged end of the tubular member.

End 15 of the tubular member is spread in the area of the slot 17 and is then shaped to the blade contour generally indicated at 25 in FIGS. 2 and 3. As the shaping is accomplished, the transition area between the blade and the swaged portion 13 (that forms the integral trunnion) is shaped into a transition connecting portion between the blade and trunnion thereby eliminating conventional riveting of the blade portion to the trunnion portion.

The dimensions of the blade may dictate that a slot be employed so that the tubular member can be opened during blade fabrication which will reduce the weight of the blade portion eliminating a double wall thickness

in the blade. Alternatively, the tubular member could be flattened to form the blade portion. However, the slotting technique represents the most preferred technique since it forms the best compromise between a compatible swaging operation to form the trunnion and fabricated blade area by opening the tubular member to form the blade portion. Slotting also provides a single wall thickness at the distal end of the blade which is less than the thickness of the trunnion portion wall as well as a double wall thickness at the proximal end of the blade which is in the transition area.

FIG. 13 illustrates how two integral blade and trunnion units are formed from a single tubular member without wasting material.

As shown in FIG. 4, the swaged end 13 of the blade structure may also be upset so as to form an integral shoulder or collar 21 which may be utilized both to index the blade and hold it in the hub.

In the alternate embodiment shown in FIG. 5, an extension trunnion member 23 may be attached to the swaged end 13, such as by inertia welding, to increase its length since the wall thickness has been increased by swaging sufficiently to accomplish such a weld. Of course, the extension member may be either solid or hollow, as desired.

With reference to FIGS. 6 and 7, a fan hub has been illustrated having two cooperating split hub sections 31 and 33 which are joined with bolts 35. These split halves or sections are manufactured to be complementary, and when joined, form radial bores 37 extending through the hub and terminating in an internal recess 39 having faces 41 and 43. An integral blade and trunnion unit with a blade 111 and trunnion 113 is secured in each bore 37 and the upset shoulder 121 of each seats in the recess preventing outward radial movement.

The shoulder 121 can be formed by upsetting the swaged end of the blade after which it is machined to fashion two chords to form faces 123 and 125. As shown in FIG. 7, face 125 cooperates with the face 41 of the recess and face 124 operates similarly with face 41. A spring 127 acting against a pin 129 which abuts an inner hub member 131 urges each blade radially outwardly as shown in FIG. 6 to maintain the indexing when the fan is not rotating.

When reversing the blade, it is pushed radially inward, toward the hub member 131 until shoulder 121 clears slot 39. Then the blade may be rotated about its longitudinal axis so face 123 abuts on face 41 or face 125 abuts the face 41 of the slot. Since face 43 is further away from the axis of the bore, the larger, curved end of the shoulder 121 will clear the face 43 when the blade is properly positioned, but will not clear the edge of the slot at face 41 when improperly positioned. Proper positioning can occur only when face 123 or face 125 abuts on face 41.

A cover 141 may be secured over the face of the hub by bolts 143 to keep dirt or foreign matter out of the blade reversing mechanisms.

Referring now to the embodiment shown in FIG. 9, it can be seen that a swaged end 213 of a blade has been upset to form a shoulder 221 having notches 223 and 225 therein which can be used for indexing in place of the machined surfaces previously discussed. When the trunnion section 213 is situated within a bore 237 between two hub sections, one of which is illustrated as 231, shoulder 221 formed thereon will be seated within

a counterbore 239. An indexing structure, such as a pin 241 may be employed adjacent the periphery of the counterbore 239 so as to cooperate with alternately notch 223 or 225 to index the integral blade and trunnion units.

Shoulder 221 is urged against its seat within counterbore 239 by an external spring 227 acting between a hub at 229 and a collar 231 which abuts against the transition portion of the blade and trunnion unit.

Reversal of the blade from one position to another may be accomplished by manually depressing the blade until shoulder 221 completely clears the counterbore, and rotating the blade until the other notch is positioned to receive pin 241 when the blade is released and moved radially outwardly by the spring 227.

Referring now to the embodiment of FIG. 11, a fan blade 311 has been illustrated as situated within a unitary hub structure 231. An external spring 337 acting between a collar 331 on the blade and a counterbore 329 in the hub serves to bias the blade radially outwardly. The trunnion section 313 of the blade is secured to a washer member 321 which is received within a counterbore 339 in the hub. A slot 323 is machined a small distance into the end of trunnion 313 to admit a raised key 325 which projects from the washer member 321. The key member 325 also cooperates with a groove or notch 341 in the hub for indexing the integral blade and trunnion unit in its forward or reverse positions.

A bolt 351 extends through the washer member 321 and axially into the trunnion 313 so that its threaded end screws into a nut 353 that is fitted within the flattened section of the blade assembly to hold the washer member on the trunnion.

When it is desired to reverse the blade, it is manually depressed into the hub so that the key 325 clears the bottom of the counterbore 339. The blade is then rotated until the key mates with another groove (not shown) similar to notch 341.

In the embodiment of FIG. 12, a blade 411 has been illustrated which is similar in all respects to the blade 311 illustrated in FIG. 11. However, in fastening a washer member 421 on the trunnion member 413, a bolt 451 having a formed head 453 is passed into the flattened section from the blade side so it extends axially through the trunnion section 413 and washer 421. A nut 455 is employed on the threaded end of the bolt to secure the washer member. The blade of this embodiment may be reversed in a manner similar to those previously described.

FIGS. 13, 14, 15 and 16 illustrate one of the preferred embodiments of the novel blade construction since its fabrication minimizes waste in the tubular starting material. Also, as can be seen in FIGS. 14, 15, and 16, the integral blade and trunnion can be modified by forming a depression or dimple 18 in the transition zone between these structures. By closing the opening through the trunnion by flattening the opposite wall against the blade portion to be in contacting relation at its root or base as shown, the noise (whistle) in the resulting fan assembly is appreciably reduced. In addition, the resulting ridges formed in the transition area between the trunnion portion and the blade portion strengthen this area against bending on opposite sides of the depression 18.

In FIG. 16 a plurality of the integral blade and trunnion units are shown assembled on a hub 20 to form a

reversible fan assembly. The individual trunnion 13 can be adjustably secured in the hub in any of the manners previously described.

In the claims:

1. A fan blade unit for use in reversible fan blade assemblies comprising a swaged trunnion portion, said swaged trunnion portion being of generally cylindrical configuration having an opening in the distal end thereof so as to define thickened sidewalls, said trunnion portion being formed by swaging one end of a metallic tubular member to increase its wall thickness, said swaged trunnion portion also having a shoulder on the distal end thereof, and a blade portion which forms at least a part of the fan blade formed by flattening its opposite end into a blade shape so that the trunnion portion and the blade portion are of integral, one-piece construction, said blade portion defining a single wall thickness at its distal end and a double wall thickness as its proximal end which is twice the wall thickness of said single wall thickness, said thickened sidewalls of said trunnion portion being of greater thickness than said single wall thickness whereby adequate strength is obtained in the resulting transition area between said trunnion and blade portions.
2. The fan blade unit as defined in claim 1 wherein the shoulder is of integral, one-piece construction with the trunnion portion and is formed on the distal end of the trunnion portion by upsetting said distal end.
3. The fan blade unit as defined in claim 1 wherein the shoulder is a separate member, and further including attaching bolt means passing through the opening in said trunnion portion, attaching said shoulder to said trunnion portion.
4. The fan blade unit as defined in claim 1 wherein the shoulder includes indexing means formed therewith to maintain the blade unit in selected positions when cooperating with structures in a hub assembly.
5. The fan blade unit as defined in claim 1 wherein the opening extends through the trunnion portion, and further including a formed depression in the double wall thickness transition area between the trunnion portion and the blade portion opposite the base of said blade portion so that the wall portions in the transition area are in contact thereby closing off the opening through said trunnion portion and strengthen the transition area and reduce noise resulting when the unit is revolved in a hub.
6. A reversible fan assembly comprising a disc-like hub assembly attachable to a rotating shaft having a plurality of equally spaced inwardly directed radial bores in its periphery; a plurality of blade units mounted in said radial bores, each blade unit having an integral blade portion that forms at least a part of the fan blade and a swaged trunnion portion, said swaged trunnion portion being of generally cylindrical configuration having an opening in the distal end thereof so as to define thickened sidewalls, said trunnion portion being formed from a tubular member by swaging one end to form said trunnion portion and flattening the other end to a blade shape to form said blade portion so that the trunnion portion and the blade portion are of integral, one-piece construction; said trunnion portion also having a shoulder on the distal end thereof for securing said distal end within its associated radial bore in said hub assembly in one of several selected positions and against outward radial movement, said blade portion defining a single wall thickness at its distal end and

a double wall thickness at its proximal end which is twice the thickness of said single wall thickness, said thickened sidewalls of said trunnion portion being of greater thickness than said single wall thickness whereby adequate strength is obtained in the resulting transition area between said trunnion and blade portions.

7. The reversible fan assembly as defined in claim 6 wherein the shoulder is of integral, one-piece construction with the trunnion portion and is formed on the distal end thereof by upsetting said distal end.

8. The reversible fan assembly as defined in claim 6 wherein the shoulder is attached to the distal end of the trunnion portion with attaching bolt means passing through the opening in said trunnion portion.

9. The fan blade unit of claim 1 wherein said blade

portion is of generally arcuate configuration.

10. The reversible fan assembly as defined in claim 6 further including counterbores associated with each bore and spring means biasing each of said plurality of blade units whereby each shoulder is seated within a respective counterbore.

11. The invention of claim 10 wherein said spring means comprises a spring within the opening in the trunnion end portion and a pin biased by said spring into abutment with said hub assembly thereby urging each of said blades radially outwardly.

12. The invention of claim 10 wherein said spring means comprises a spring on each blade unit intermediate said hub assembly and a respective blade portion.

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