Dec. 29, 1959 S. H. FEDAN ET AL 2,918,977

BLADE ASSEMBLY

Filed June 25, 1956 4 Sheets-Sheet 1

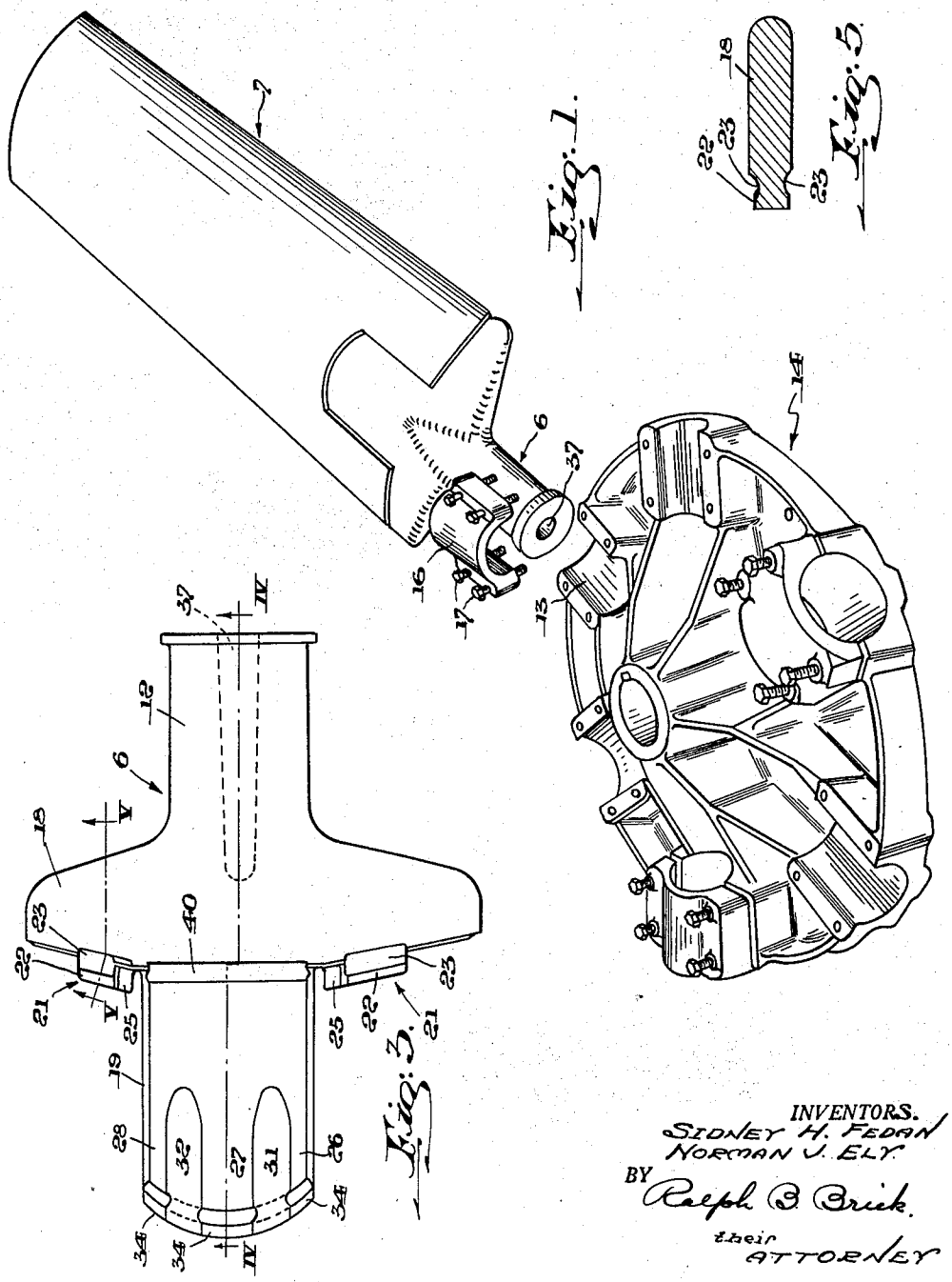

Fig. 1.

Fig. 5.

Fig. 3.

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BLADE ASSEMBLY

Filed June 25, 1956 4 Sheets-Sheet 2

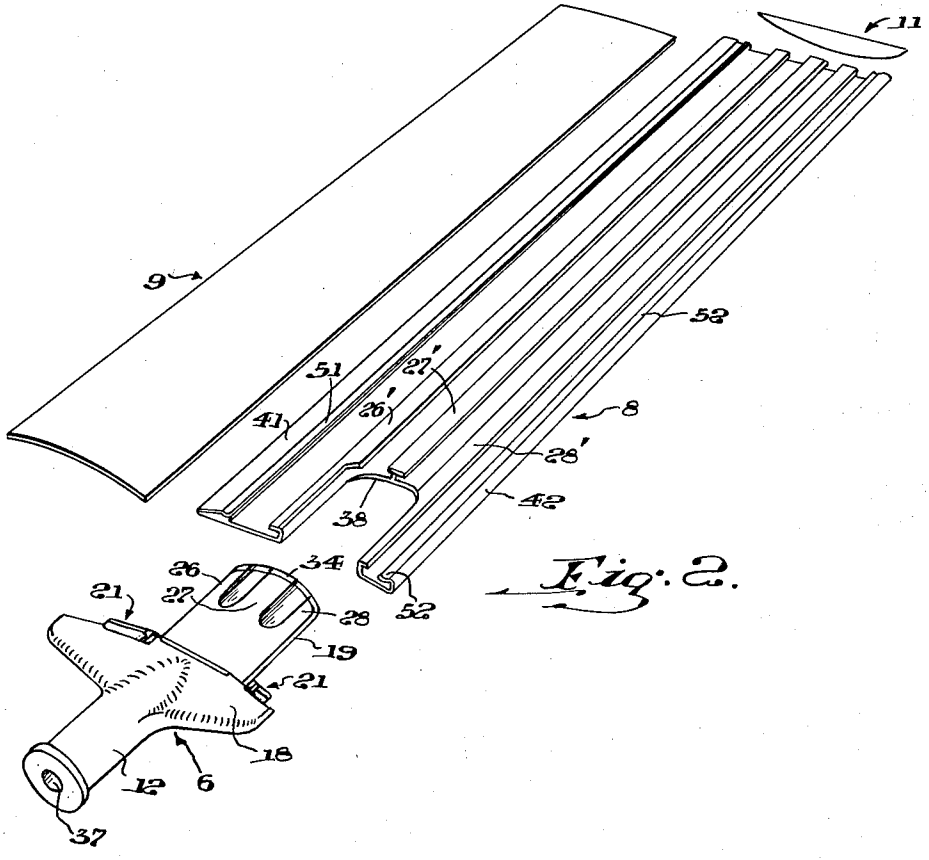

Fig. 2.

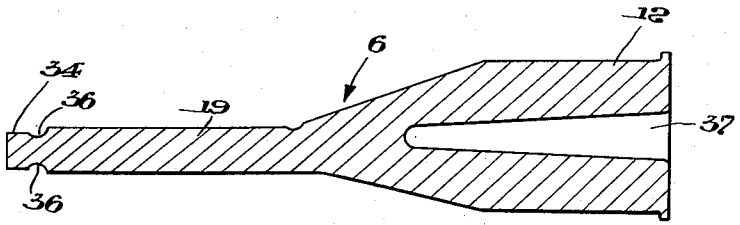

Fig. 4.

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BLADE ASSEMBLY

Filed June 25, 1956 4 Sheets-Sheet 3

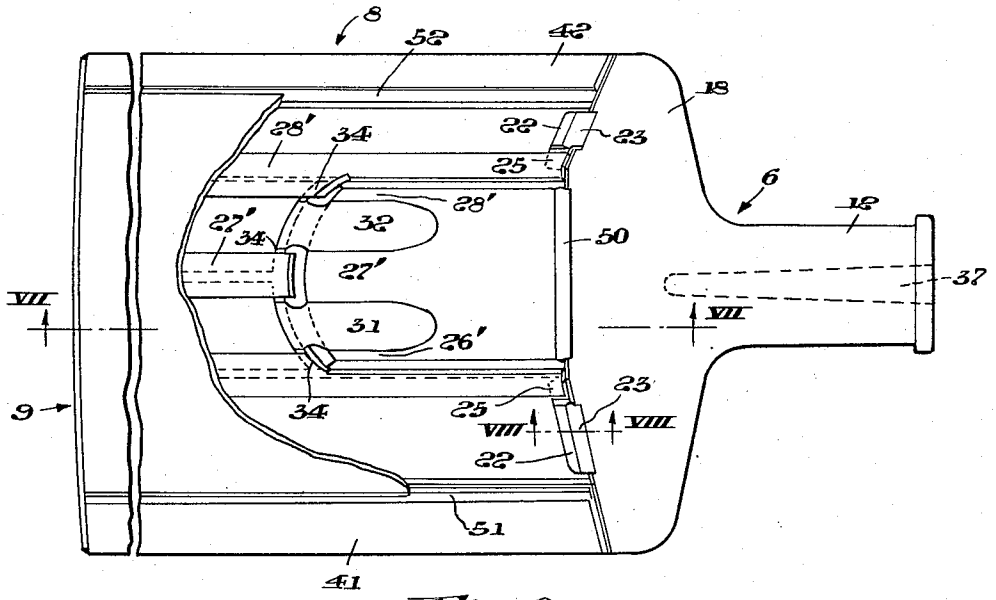

Fig. 6.

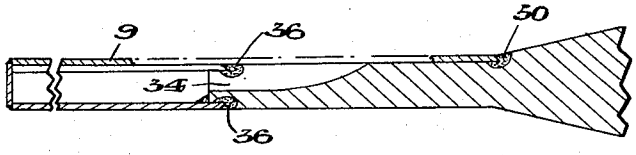

Fig. 7.

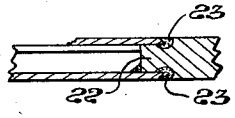

Fig. 8.

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BLADE ASSEMBLY

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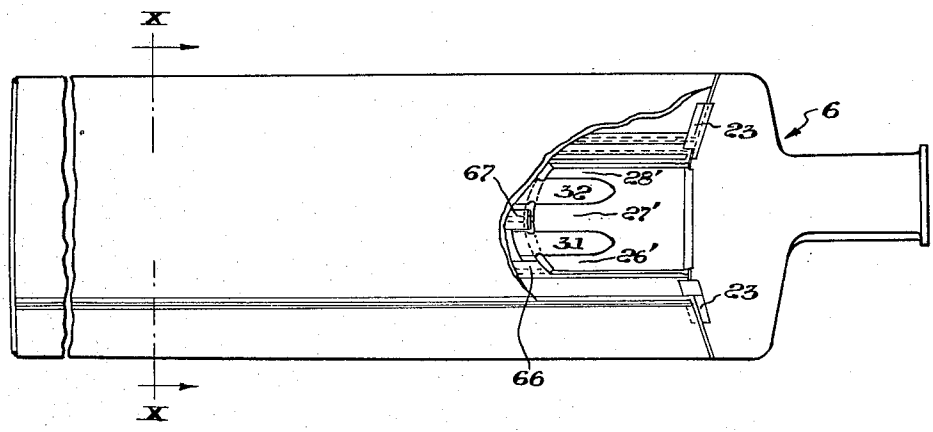

Fig. 9.

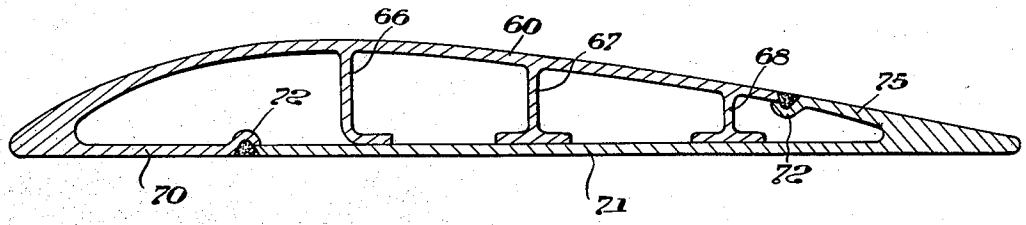

Fig. 10.

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BLADE ASSEMBLY

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Application June 25, 1956, Serial No. 593,474

6 Claims. (Cl. 170—159)

This invention relates to blade assemblies and more particularly to blade assemblies for industrial fans and to a method of making such assemblies.

With the rapid industrial expansion of today, there has been an ever increasing demand for efficient and adequate heat exchange equipment to accommodate the waste heat inherent to such expansion. To meet this demand, industry has turned to such heat exchange means as the cooling tower and the radiator-type cooler, both of which means are dependent upon the industrial cooling fan. These industrial fans have had to be more than just a paddle wheel in order to move air in an efficient manner without excessive speeds of rotation and, in the past, some of the earlier models of industrial cooling fans have been similar to the common desk fan or airplane-type propeller. Today, there are many types of fan blade assemblies as well as several well known methods of constructing such fan blade assemblies, including methods wherein laminated wood is carved and covered by plastic to form the industrial fan blade, wherein the industrial fan blade is formed from plastic material itself, and wherein the industrial fan blade is formed from cast metal. Although these various assemblies and the various methods of manufacturing them have met some of the fan blade problems of corrosion, strength, fatigue, efficiency, sound level, and balance, none has been able to meet with all of these above-mentioned problems as efficiently as has the present invention.

The present invention provides a fan blade that is lightweight, resistant to fatigue and corrosion, aerodynamically efficient, and of high strength. In addition, the present invention provides an economical and efficient method of manufacturing such a blade in a straightforward and uncomplicated manner.

Various other features of the present invention will become obvious with a reading of the disclosure set forth hereinafter.

More particularly, the present invention provides a method of making a blade assembly comprising the steps of casting a quantity of selected quality lightweight metal in a mold to form a metallic shank member, extruding a further quantity of selected quality lightweight metal to form a ribbed camber member and a thrust member of a blade section, stamping a selected quality lightweight metal plate to form a tip member of such blade section, and welding the cast shank member, the extruded camber member, the extruded thrust member, and the stamped member together to form a metallic blade assembly. The present invention also provides a blade assembly which includes a retention shank member having integral therewith a transverse flange and an anchor extending from the flange, and a blade section fixed to the shank member, the blade section including a camber member having a ribbed face, a thrust member including a face portion fixed to the camber member in facing relation with the ribbed face thereof, and a tip member closing the open end of the joined camber and thrust members, the camber member having at its root end a socket of configuration

identical to the anchor of the shank member to receive the anchor so that the sides of the anchor abut against the sides of the socket and the root end side of the camber member abuts against the side of the transverse flange of the shank member. Further, the present invention provides interlocking means along the abutting sides to interlock the blade section to the shank member.

It is to be understood that various changes can be made by one skilled in the art in the several steps of the method disclosed herein and in the several parts of the blade assembly also disclosed herein without departing from the scope or spirit of this present invention.

Referring to the drawings:

Figure 1 is a perspective view of an advantageous embodiment of the present invention, disclosing one face of an assembled blade section prior to its assembly with a hub member;

Figure 2 is an exploded perspective view of the various members which are joined together to form the blade assembly of Figure 1, this view showing the other face of the blade;

Figure 3 is an enlarged top plan view of the shank member disclosed in Figures 1 and 2;

Figure 4 is a cross-sectional side view of the shank member of Figure 3 taken in a plane passing through line IV—IV of Figure 3;

Figure 5 is an enlarged cross-sectional side view of a portion of the tranverse flange of the shank member of Figure 3 taken in a plane passing through line V—V of Figure 3;

Figure 6 is an enlarged broken plan view of a portion of the assembled blade section and retention shank member;

Figure 7 is a cross-sectional view taken in a plane passing through line VII—VII of Figure 6, showing details of a portion of the interlock between the assembled camber member of the blade section and the retention shank member;

Figure 8 is a cross-sectional view taken in a plane passing through line VIII—VIII of Figure 7, showing further details of the interlock between the assembled camber and retention shank members;

Figure 9 is an enlarged broken plan view of a modified, assembled blade section and retention shank member, disclosing a further advantageous embodiment of the present invention:

Figure 10 is a cross-sectional view of the modified assembled blade section and retention shank member of Figure 9, taken in a plane passing through line X—X of Figure 9.

As can be seen in Figure 1 of the drawings, the blade assembly of the present invention broadly comprises a retention shank member **6** and blade section **7**. Referring to Figure 2, blade section **7** includes camber member **8**, thrust member **9** and tip member **11**. When the blade is properly assembly together, as will be described hereinafter, spindle **12** of the shank member is nested in the hub socket **13** of hub **14** and held in place by clamping bracket **16** fastened to hub **14** by means of tap bolts **17** (Figure 1).

In an advantageous embodiment of the invention described hereinafter, the blade sizes can range for fans from approximately 9 feet to approximately 22 feet in diameter. For blades used in fan models 9 feet through 10 feet in diameter, the chord width of the blade can be 10 inches. For blades use in fan models 11 feet through 14 feet in diameter, the chord width can be 12 inches and for blades used in fan models 16 feet through 22 feet in diameter, the chord width can be 16 inches. In this connection, it is to be noted that when the chord width is 16 inches, a modified construction of the blade section can be provided in order to effect an economy in

extrusion, this modified construction being disclosed in Figures 9 and 10 of the drawings and described hereinafter.

Referring to Figures 2–5 of the drawings, it can be seen that shank member **6** includes the aforementioned spindle **12**, transverse flange portion **18** integral with this spindle, and anchor portion **19** integral with and extending from this transverse flange portion. Provided along the sides of the transverse flange portion **18** on either side of the extending anchor **19** are interlock projections **21**, these interlock projections serving to interlock the blade section to the shank member as will be described hereinafter.

Referring particularly to Figure 5 of the drawings, it can be seen that the interlock projections **21** each have a reduced head portion **22**. This head portion, in turn, is stepped down or reduced at one side **25** (Figure 3) so that the head portion is adapted to engage properly with channeled ribs in the camber member of the blade section when the sides of the anchor of the shank member are positioned to abut against the sides of the socket of the camber member. It also can be seen that each interlock projection **21** is provided with wells **23**. The wells **23** are adjacent the reduced head portion **22** and on opposite sides thereof, these wells serving to receive welding material used to fix the camber member to the shank member.

In addition to the aforementioned interlock projections **21**, further interlock means of similar construction are provided at the extremity of the anchor **19** of the shank member. Referring particularly to Figure 3 of the drawings, it can be seen that the extremity of the anchor member is provided with spaced ribs **26**, **27**, and **28** with a groove **31** interposed between the ribs **26** and **27**, and a groove **32** interposed between the ribs **27** and **28**. These ribs and grooves on the anchor portion are adapted to align with the hereinafter described ribs and grooves of the camber member of the blade section. As can clearly be seen in Figures 3 and 4, at the extremities of each of the rib members **26**, **27**, and **28**, there is provided a reduced head portion **34**, this head portion having adjacent thereto and on opposite sides thereof, wells **36** which are also adapted to receive welding material for fixing the camber member to the shank member. It is to be noted further that the spindle portion of the shank member **6** can be provided, as is known in the art, with a recess **37** in order to provide for proper balance of the blade assembly.

Shank member **6**, in an advantageous embodiment of the present invention, can be a permanent mold casting of aluminum alloy such as that commercially designated A356–T71. The alloy A356–T71 has a chemical composition of 7.0% silicon and 0.3% magnesium with the balance aluminum and it is a member of the silicon-magnesium family of alloys. By using such an alloy, it is possible to obtain excellent casting features in carrying out the process of casting the shank member in a permanent mold and it is further possible to obtain a shank member of high strength and good resistance to corrosion. In this connection, it is to be noted that this alloy has been found to have a tensile strength of 32,000 p.s.i., a yield strength of 24,000 p.s.i., an elongation of 10%, and an endurance limit of 11,000 p.s.i. Furthermore, the resulting permanent-mold cast shank member has proven to have higher mechanical properties due to its better metallurgical structure than a sand-cast shank member and has proven to have a superior surface finish, a fine grain size and improved soundness.

Referring to Figures 1 and 2 of the drawings wherein blade section **7** of the blade assembly is disclosed, it can be seen that the camber member **8** of this blade section is provided with inner spaced, channeled ribs **26'**, **27'**, and **28'**, each of which is substantially of T shaped cross-section, outer ribs **41**, **42**, and a socket **38**. The ribs serve to add to the desired structural rigidity of the camber member, ribs **26'**, **27'**, and **28'** being arranged to align with ribs **26**, **27**, and **28** respectively of anchor **19** when the blade is assembled.

The socket **38** (Figure 2) of the camber member is of a configuration identical to the anchor **19** of the shank member and serves to receive the anchor when the blade is assembled so that the sides of the anchor abut against the sides of the socket and the root-end sides of the camber member abut against the sides of the transverse flange portion **18** of the shank member. When this occurs, the stepped down portions **25** of the reduced head portions **22** of each of projections **21** interlock into the recesses formed at the root ends of channeled ribs **26'** and **28'**. At the same time, the reduced head portions **34** provided on each of the ribs **26**, **27**, and **28** of the anchor interlock into the recesses formed by channeled ribs **26'**, **27'**, and **28'** along the bottom side of the socket **38** in the camber member. Thus, an interlocking arrangement is effected between the camber member and the shank member. With such an arrangement, a ready positioning and alignment means is provided for assembling the two members together and blade bending moment is resisted firmly between the shank member and the camber member after such assembly.

In an advantageous embodiment of the present invention, it is to be understood that the camber member can be made from an aluminum alloy by means of any one of a number of well known extrusion processes. By extruding the camber member, the metal of the member is disposed more efficiently with relation to the stresses which it must withstand than possibly could be obtained in well known previous methods of manufacturing fan blades, i.e. standard rolling and forging processes. Furthermore, the ribs **26'**, **27'**, **28'**, **41**, and **42**, which serve to provide structural stiffness and interlock as aforedescribed, and which also serve to support the face portion of the thrust member **9** when it is assembled with the camber member, are more readily and efficiently formed by such extrusions.

In an advantageous embodiment of the invention, the aluminum alloy used to form a camber member can be one which is known commercially as 6063–T6. The physical properties of 6063–T6 have been found to include a tensile strength of 35,000 p.s.i., a yield strength of 31,000 p.s.i., an elongation of 12%, and an endurance limit of 9,500 p.s.i. The chemical composition of this alloy is 0.4% silicon, 0.7% magnesium and the balance aluminum, this alloy also being a member of the silicon-magnesium family of alloys. With the use of such an alloy for the camber member, the camber has a pleasing surface finish, adequate strength for diverse structural applications, and a good resistance to corrosion.

It is to be understood that the thrust member **9** (Figures 1 and 2) can also be of aluminum extrusion alloy 6063–T6, to thus have the same physical properties and metallurgical characteristics as described above for the camber section. In an advantageous embodiment of the invention, the minimum thickness of the camber section extrusion can be approximately 3/16 of an inch with solid sections at the leading and trailing edges of 1¼ inches and 1⅞ inches, respectively. As for the thrust member, for blades having chord widths from 10 inches through 12 inches, the thrust member can be substantially all face portion of ⅛ inch thickness and can be of substantially the same size and configuration as the camber member, as shown in the embodiment disclosed in Figure 2 of the drawings. However, in instances where blades having chord widths of 16 inches are desired, it is then advantageous that the face portion of the thrust member be increased in thickness to 3/16 of an inch and that the thrust member be extruded to include, not just the face portion, but a portion of the camber member as well, and that the camber member be extruded to include a portion of the

thrust member. With such an arrangement, it is then possible to extrude both a narrower camber member and a narrower thrust member, thus obtaining those economies commensurate with extrusion practices for narrow members and, at the same time, obtaining the wider 16 inch chord width through an interlocking of the two members. Referring to Figures 9 and 10, specific details of such an interlocked camber and thrust member arrangement are disclosed. As can be seen in Figure 10, camber member **60** of this advantageous embodiment of the invention, which for the most part is like camber member **8** of Figure 2, is provided with ribs **66**, **67**, and **68**, the ribs **67** and **68** being of T-shape cross section substantially like the ribs **27'** and **28'** of the camber member **8**. However, it will be noted that the rib **66** is of an L-shape cross section rather than a T-shape cross section. This arrangement facilitates efficient interlock of the camber and thrust members as will be described hereinafter. It also will be noted that a portion of the camber member **60** adjacent the rib **68** is omitted, and it will be further noted that a portion of the camber member adjacent the rib **66** has integral therewith a flat overlap portion **70** which cooperates with the face portion of thrust member **71**, the thrust member **71** including, in turn, an overlap portion **75** which cooperates with the camber member adjacent rib **68**. Both the overlap portions **70** and **75** are provided at their extremities with a hook-like construction **72**, this hook-like construction serving to provide effective interlocking and welding of the camber and thrust members. From the disclosure in Figures 9 and 10, it can be seen that both the camber member **60** and the thrust member **71** have a shorter overall width as a result of the interlocking arrangement, and thus economies of extrusion through shorter widths can be obtained.

The tip member in an advantageous embodiment of the invention can be stamped from a ⅛ inch thick aluminum alloy plate which can be of an alloy designated commercially as 6061–T6.

In assemblying the several above-described parts of the blade assembly as disclosed in Figures 1–8, the camber member **8** and the shank member **6** are brought together with the anchor **19** of the shank member engaging in the socket **38** of the camber member and the interlocking means on the shank member, namely reduced portions **25** and **34**, properly nesting in the recesses provided by the channeled ribs **26'**, **27'**, and **28'** of the camber member. The two members are then welded together by continuous welds of special alloy wire, which can be an alloy commercially designated 5154. A welding process known as the Consumable Electrode Process of welding has been found desirable for welding the two members together, this process utilizing an argon inert gas envelope to prevent oxidation. Such a process serves further to eliminate corrosion from flux entrapment, and its rapid application reduces the heat effect on adjacent metal.

Once the camber member and shank member are welded together, the thrust member **9** is fastened to the ribbed face of the camber member and is welded by a process like that above-described to the camber member along the sides of the outer ribs **41** and **42**. In this connection, it is to be noted that the thrust member and the camber member are not joined together along the internal ribs **26'**, **27'**, and **28'**. This serves to prevent any internal stressing at such areas. It also is to be noted that a well **50** is provided at the base of anchor **19** and that wells **51** and **52** are provided along ribs **41** and **42** respectively, these wells serving to receive welding material used to fix the thrust member to the assembled camber and shank members.

It is to be understood that the camber member **60** of Figures 9 and 10, is substantially like the camber member **8** at its root section and is assembled to a shank member **6** in substantially the same manner. In this connection, it will be obvious from the above description that the thrust member **71** is interlocked with camber member **60** and welded along the hook-like extremities **72**, the hook-like arrangement serving to receive the welding material used to fix the members together.

With the three parts of the assembly welded together, the tip plate is then welded advantageously by the continuous weld process at the extremity of the joined camber and thrust members opposite the shank member in order to close the open end formed by the camber and thrust members. It is to be noted that vent holes are not required in the assembly described since the continuous weld process allows no entrance of moisture.

As a further step in preventing corrosion which so frequently arises in the corrosive atmosphere of industrial plants, the blade assemblies described above can be provided with a special surface preparation treatment and then covered with at least one coat of corrosion resistant paint. Such a surface preparation treatment can include dipping at least the blade section of the assembly in a multi-stage acid-etch bath to form a protective surface on the aluminum and to provide an improved surface for adhesion of corrosion resistant paint coating. It is to be noted that the aforementioned multi-stage acid-etch dip bath can be of the commercially known Alodine 100, which is a protective coating for aluminum developed by the American Chemical Paint Company of Ambler, Pennsylvania. This bath serves to form a thin, tough, durable, non-metallic amorphous phosphate surface on aluminum. The coating of corrosion resistant paint can then be put on over the top of the aluminum, advantageously in two coats. The paint can be of the catalyzed epoxy type which has great resistivity to corrosive mediums and also excellent adhesive properties. In this connection, it is to be understood that other similar type bath solutions and paint coatings can also be used to prevent corrosion.

In order to prevent galvanic attack when a blade assembly of aluminum and a hub of the dissimilar metal, iron, are united in wet or moist atmospheres, it has been found desirable to insulate these two dissimilar materials from one another. To accomplish this, the aluminum retention shank member **6** can also be treated with an Alodine surface and a two coat corrosion resistive paint, and the area of the hub where contact is made can be treated with a rust inhibitive coating such as Parko Lubrite over which a coat of aluminum metal paint can be applied. In this connection, it is to be understood that other similar type solutions and paint coatings can also be used to prevent galvanic attack.

By carrying out the process above-described and by forming a blade assembly in a manner as also described above, it is possible to provide an industrial fan blade assembly that is lightweight, that is easily formed, that is resistant to fatigue and corrosion, and that is economically fabricated and assembled, thus providing an excellent answer to the ever increasing problems of waste heat in our expanding industrial economy.

The invention claimed is:

1. A blade assembly comprising a unitary retention shank member, said shank member being formed with a transverse flange and an anchor projecting from said flange intermediate the ends thereof, a blade section fixed to said flange member, said blade section including a unitary camber member having transversely spaced longitudinally extending edges terminating at their root ends at the ends of said flange, a socket formed in said camber member intermediate said edges, said socket being shaped complementary to said anchor to receive in abutting relation said anchor so that the root end side of said camber member abuts against the side of said transverse flange, and means along said abutting sides to interlock said blade section to said shank member.

2. A blade assembly comprising a unitary retention shank member, said shank member being formed with a

transverse flange and an anchor projecting from said flange intermediate the ends thereof, a blade section fixed to said flange member, said blade section including a unitary camber member having transversely spaced longitudinally extending edges terminating at the ends of said flange, a socket formed in said camber member intermediate said edges, said socket being shaped complementary to said anchor to receive in abutting relation said anchor so that the root end side of said camber member abuts against the side of said transverse flange, and complementary means formed along said abutting sides of said flange and said shank to interlock said blade section to said shank member.

3. A blade assembly comprising a unitary retention shank member, said shank member being formed with a transverse flange and an anchor projecting from said flange intermediate the ends thereof, a blade section fixed to said flange member, said blade section including a unitary camber member having transversely spaced longitudinally extending edges terminating at one end and having at least a portion of one face thereof formed with a plurality of spaced ribs at the ends of said flange, a socket formed in said camber member intermediate said edges, said socket being shaped complementary to said anchor to receive in abutting relation said anchor so that the root end side of said camber member abuts against the side of said transverse flange, and means

provided along said abutting sides of said flange and said shank coacting with said ribs to interlock said blade section to said shank member.

4. The invention as defined in claim 3 in which said blade assembly includes a thrust member fixed to said one camber face and overlies said ribbed portion.

5. The invention as defined in claim 3 in which said ribs extend coextensively with said camber member edges.

6. The invention as defined in claim 5 in which said blade assembly includes a thrust member fixed to said one camber face and overlies said ribbed portion and in which a member is fixed to the tip end of the blade to said thrust member and said camber member.

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