Sept. 23, 1958 H. J. FINDLEY 2,853,271

BLADE STRUCTURE

Filed June 28, 1951 4 Sheets-Sheet 1

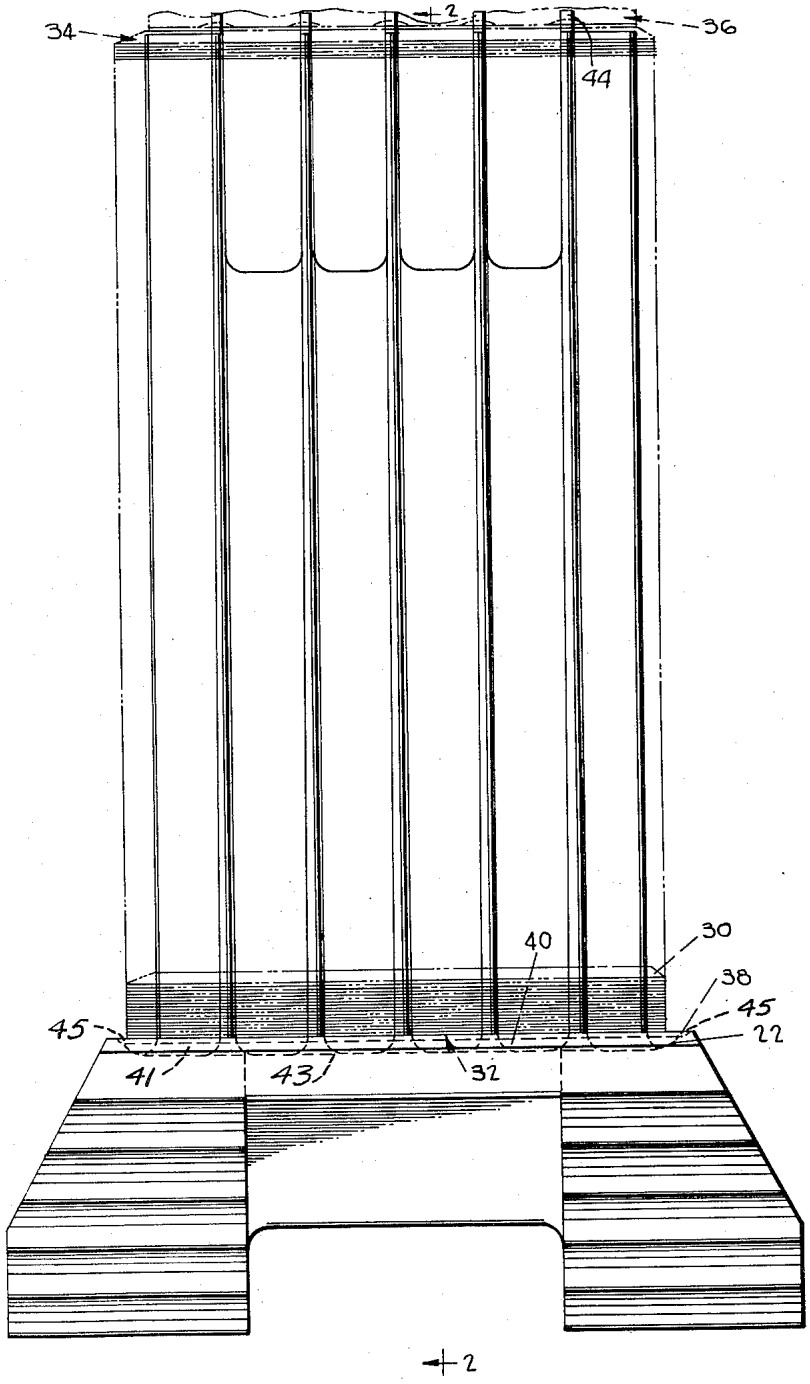

FIG. 1

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BLADE STRUCTURE

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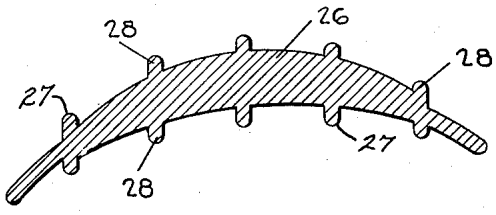

FIG_3

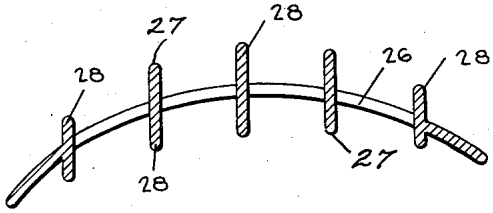

FIG_4

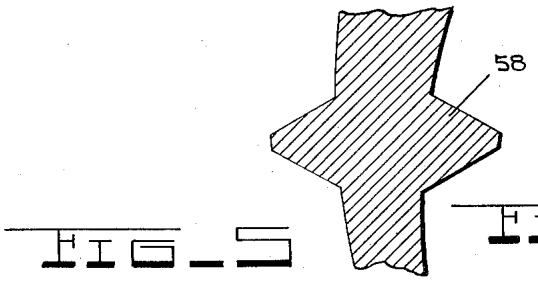

FIG_5

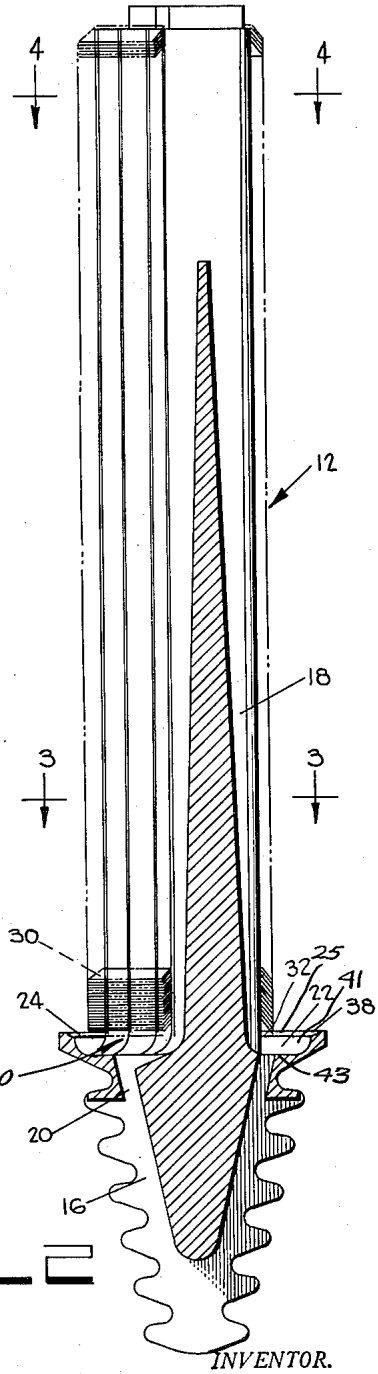

FIG_2

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BLADE STRUCTURE

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FIG_11

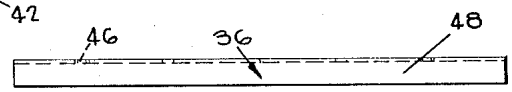

FIG_13

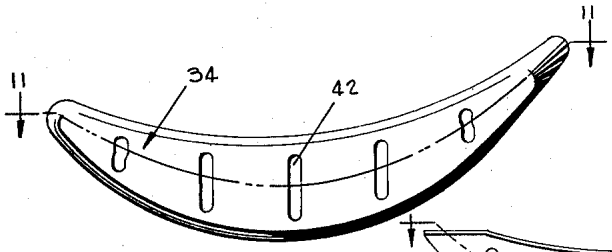

FIG_10

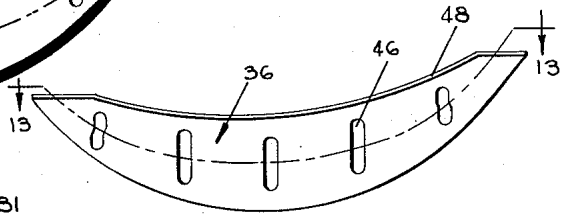

FIG_12

FIG_9

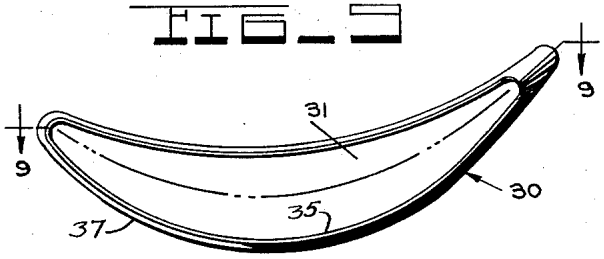

FIG_8

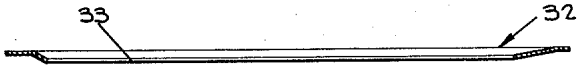

FIG_7

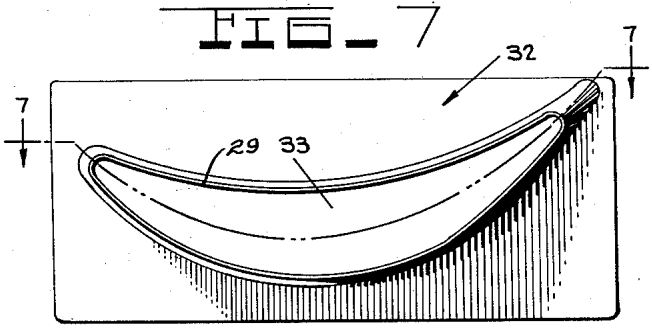

FIG_6

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Sept. 23, 1958 H. J. FINDLEY 2,853,271

BLADE STRUCTURE

Filed June 28, 1951 4 Sheets-Sheet 4

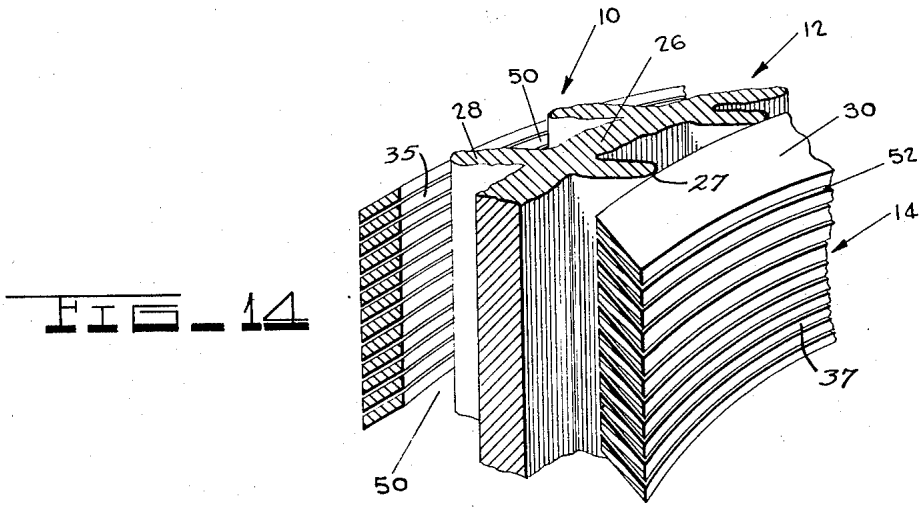

FIG. 14

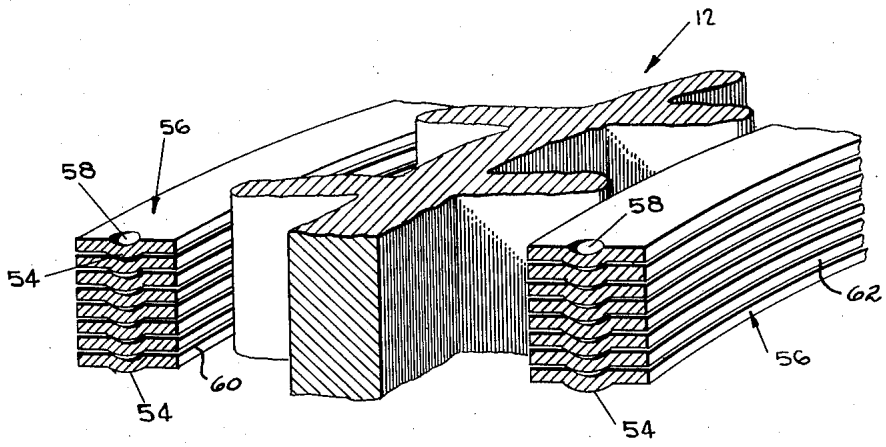

FIG. 15

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United States Patent Office 2,853,271 Patented Sept. 23, 1958

2,853,271

BLADE STRUCTURE

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Application June 28, 1951, Serial No. 233,972

9 Claims. (Cl. 253—39.15)

Among the principal objects of the invention are the provision of lamination constructed hollow blades for turbines and the like:

(1) That are simple and economical of construction;

(2) That do not require the use of strategic materials in the fabrication thereof;

(3) That improve the performance of turbines in which they are utilized;

(4) That are vibrationally dampened;

(5) That can be effectively cooled through the supplying of air or other suitable fluid to the hollow therein for passage through openings in the surface of the blade communicating with the hollow;

(6) That can further increase the output of a given turbine when limited amounts of strategic material are used; and

(7) That provides for air or other fluid flow control through the surface thereof for the delivery of air or other fluid in desired amounts to various portions thereof.

Other objects and advantages of the invention will appear from the following description taken in connection with the drawings forming a part of the specification, and in which:

Fig. 1 is a front elevation partly sectionalized view of a hollow laminated blade structure;

Fig. 2 is a cross-sectional view taken substantially along lines 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view taken substantially along lines 3—3 of Fig. 2;

Fig. 4 is a cross-sectional view taken substantially along lines 4—4 of Fig. 2;

Fig. 5 is an enlarged fragmentary view of a modified spike structure;

Fig. 6 is a top elevation view of a blade segment constituting the base member or channel coverplate of the stacked stamped laminations of Fig. 1 adapted to be fitted into assembly on the hub of the spike;

Fig. 7 is a cross-sectional view taken substantially along lines 7—7 of Fig. 6;

Fig. 8 is a top elevation view of one of several air foil shaped stamped blade segments of Fig. 1 adapted to be stacked upon the base member of Figs. 6 and 7;

Fig. 9 is a cross-sectional view taken substantially along lines 9—9 of Fig. 8;

Fig. 10 is a top elevation view of an air foil shaped stamped blade segment constituting the top member adapted to be arranged upon the members of Figs. 8 and 9 in the assembly of Fig. 1;

Fig. 11 is a cross-sectional view taken substantially along lines 11—11 of Fig. 10;

Fig. 12 is a top plan view of a stamped member constituting a screamer or end air guide plate adapted to be mounted upon the member of Fig. 10 in the assembly of Fig. 1;

Fig. 13 is a cross-sectional view taken substantially along lines 13—13 of Fig. 12;

Fig. 14 is an enlarged, fragmentary perspective view of the blade structure of Fig. 1;

Fig. 15 is an enlarged, fragmentary perspective view of a modified form of lamination structure from that shown by Fig. 14.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

The present blade was devised for the purpose of providing a blade for turbines and the like of simple and economical construction which is effective in operation such that with the use of non-strategic materials in the fabrication thereof the performance of a given turbine can be improved. Further with the use of limited amounts of strategic material higher temperature operation of the like given turbine is possible thereby providing for still better performance thereof. Through the innovation of a laminated structure, that is, the provision of a plurality of stamped or otherwise suitably manufactured external air foil shaped blade segments arranged in a laminated pile and fixedly secured to a spike or supporting member wherein a hollow section is provided internally of the air foil shaped segments in association with the spike having communication by way of the spike with an air supply for delivery thereto and with air passages provided intermediate the adjacently arranged air foil shaped segments, a blade structure is provided such that an effective film cooling of the external surfaces of the blade is accomplished. By so effectively providing for the cooling of the blade surfaces it is possible to properly utilize non-strategic metals in the manufacture thereof just so long as the external surfaces thereof are maintained at an operating temperature below the safe working temperature of the metal used. The several air foil shaped segments adapted to be made into a laminated pile are brazed, welded or otherwise suitably fixedly secured to the spike or supporting member along spaced points on their inner surface with predetermined and desired spacings between one another. This spacing can be controlled by any of several different methods depending on where and in what quantities along the blade surface more or less cooling is desired.

These segments going to make up the lamination portion of the blade are preferably stamped with a prescribed angular cross-section so that the members can be easily nested one inside the other and form together with the spike a rigid structure. In addition to the angular cross-section, the air foil shaped segments can be so formed that in the arranging of one segment on the other greater space for air flow is provided at the portions of the blade wherein in the operational use thereof they are subject to become the hottest. The spacing between the segments can be provided also by either coating one surface of each segment upon which the next is to bear or by interposing layers of paper or the like between each segment, said coating or paper to be burned out after the segments are securely bonded by brazing or welding to the spike or supporting member therefor.

The spike utilized in supporting the laminated arrangement of blade segments therein need for most purposes only be of such shape as to properly support the blade segments as a rigid stack and permit the passage of a sufficient quantity of air therebetween so that the laminated structure is effectively cooled. In cases where the blade is to be rotary rather than stationary and wherein centrifugal forces and the like are to be taken into consideration the spike can be designed accordingly but under all conditions will serve a like condition of supporting the segments as a rigid and effectively cooled assembly.

Referring to the drawings for more specific details of the invention 10 represents generally a blade structure comprising basically a spike or supporting member 12 and a laminated assembly 14 arranged on the spike.

The spike 12, which can be formed of a casting or the like, includes a base 16 and a longitudinally extended

portion or core **18** made integral with the base. The base **16** is appropriately machined so as to provide means by which the spike can be supported rigidly in a suitable ring, housing or the like with which the blade is to be associated and has passages **20** extending spanwise therethrough communicating with a channel **22** formed in the upper face **24** of the base adjoining the root **25** of core **18** of the spike, the purpose of which will hereinafter appear.

The core **18** in addition to embodying an air foil cross-sectional shaped main central body **26** includes a plurality of fins or ribs **28** integral with the body and extending therefrom predetermined distances so as to define in conjunction with the body **26** a suitable shape at their extremities upon which the inner surface of the laminated assembly is to have contacting relation.

The main body **26** of the core although shown as tapering from its base to its tip need only be made so in instances where the blade structure, to which the spike is applied, is to be rotated. The taper as employed is mass reducing in purpose so as to reduce the developed stresses in the metal of which the spike is formed in order to stay below the elastic limit thereof in temperature ranges to be encountered in operation. Under conditions where the blade structures are to be used as stationary members the body **26** of the core can be made uniform in cross-section from the root to the tip thereof, if so desired.

The laminated assembly **14** in its relation to the spike **12** comprises a plurality of reasonably thin sheet stock stamped blade segment **30**, a stamped channel cover plate **32**, a blade tip cover stamped segment **34** and a stamped screamer plate or end air guide **36**.

Each and everyone of the segments **30** is formed of external air foil shape and is provided with an opening **31** which receives the spike therein with surface interference contacting relation between the outer tangent surfaces **27** of the ribs or fins **28** at spaced points on the inner annular edge **35** of the segments **30**. Said segments as an assembly provide a hollow centrally thereof.

The segments **30** are preferably provided with an angular rectangular cross-section as shown by Fig. 9 as relates to a plane of either edge of the segments or to a horizontal plane through the spike permitting of the nesting thereof of one within the other in their general assembly upon the spike thus facilitating the manufacture thereof as well as providing a rigid structure. Furthermore, in view of the angularity of the segments; that is, the inner edge **35** of the segment being disposed in a plane parallel and spaced from the outer annular edge **37** of segment **30**, they can be readily assembled upon the body **26** of the core **18** whereby the engagement of the annular edge **35** operates as a one-way locking device resisting removal or rejection from the body **26** in the reverse direction to which they were placed thereon.

It is to be noted that whereas the inner peripheral edge **35** of each segment with outer tangent surfaces **27** of the ribs of each segment are arranged perpendicular to the top and bottom surfaces thereof; the outer annular surfaces **37** thereof can be machined if necessity requires, by grinding or other suitable means, to fall in alignment with one another and thus present a smooth continuous surface across the full peripheral area of the blade, that is, surfaces which are parallel to the longitudinal axis of the spike and segment assembly.

The channel cover plate **32** is provided with an opening **33** centrally thereof conforming to the internal shape of the segments **30** and has its surface **29** adjoining said opening set at an angle corresponding to the angular cross-section of the segments **30** such that in slipping of said plate over the core **18** and the arrangement thereof into a pocket **38** in the base of spike **12** it encloses the channel **22** to thus form a plenum chamber **40**, the purpose of which will hereinafter appear. Aside from providing the upper portion of chamber **40**, which chamber is defined by surfaces **41**, **43** and arcuate end surfaces **45**, the plate **32** affords a base member upon which the segments **30** are stacked one upon the other in parallel array extending from the root of the core **18** to a point near the tip thereof.

The blade tip cover segment **34** has an external air foil shape and is formed angular along the edge thereof for nesting relation upon the top of the stack of segments **30** and is provided with a plurality of apertures **42** for receipt therein of a like plurality of rivet ends **44** formed at the tip extremity of the core constituting portions of the ribs or fins **28**.

The screamer plate or end air guide **36** is also air foil shaped and has a plurality of apertures **46** of like size and purpose to apertures **42** of cover **34** and includes as a part thereof a right angular extended portion or flange **48**. The plate is adapted to be mounted upon cover **34** with the rivet ends **44** received in the apertures therein such that the ends of the rivets can be peened over upon the upper surface of said screamer for effectively holding the laminated assembly in locked relation upon the spike **12**.

With the laminated assembly **14** mounted upon the spike a plurality of parallel channel passages **50** are provided between the inner surface **35** of the lamination assembly, the outer surface of the body **26** and the outer surfaces of the ribs or fins **28**, communicating, by way of the plenum chamber **40**, with the passages **20** formed in the base of the spike.

The enlarged view of assembly as shown by Fig. 14 wherein parallel openings or passage means **52** are provided between the adjacent segments **30** of the laminated assembly **14** can be obtained in the process of manufacture thereof through the operational steps of first coating the tangent portions **27** of the ribs **28** with a suitable brazing material, secondly mounting the laminated assembly on the spike, said segments either having a thin sheet of paper, varnish coating or the like of a thickness corresponding to the desired spacing to be provided between the segments, applied between the segments, next peening the rivets over upon the end air guide plate to secure the assembly to the spike, then heating the spike and laminated assembly sufficiently to bond the laminated assembly to the spike and finally burning out the paper, varnish or the like from between the adjacent segments so as to afford openings **52** providing communication between the channel passages **50** and the external surface of the blade per se. The ribs **28** in being brazed to each and every one of the segments, affords a rigid structure capable of withstanding high pressures without concern for distortion of the blade from its predetermined established shape.

Spot welding of the laminations to the supporting spike can also be effectively utilized as a means of securely affixing the laminations to the spike to provide a rigid structure. Additionally, because of the structural make-up of the blade wherein the segments hug the body of the core normally resisting rejection from the body, a safety factor is provided should there be a poor or missed braze or weld at any or several points of engagement between the segments and body.

Fig. 15 illustrates a modified form of lamination structure with specific regards to means for providing openings between the segments of the blade assembly wherein raised portions or projections **54** are provided on the one surface of each lamination segment **56** adapted to nest in the depression **58** on the juxtaposed segment opposite the projection. In so nesting the projections within the depressions of the next adjacent segment a close controlled spacing of the segments relative to one another is possible while affording a strong and rigid laminated structure. Such controlled spacing is accomplished because with the formation of the depression **58** on one side of each blade segment, the opposite side of each segment has a radius of curvature greater than the depres-

sion side, such that in placing the segments upon one another, the larger radius surface will not be received fully within the depression, thus providing a definite space between the segments, aside from the point of engagement between the depression and the convex surface opposite the depression. Furthermore as will be noted that the inner edge surface **60** and the outer annular or peripheral edge surface **62** of segment **56** each lie in the same plane as compared to segments **30**.

Fig. 5 illustrates a modified rib form **58** for the spike permitting of the concentration of heat at the tips thereof in a brazing or welding operation for the effective securing of the segments to the spike.

While this invention has been described in connection with certain specific embodiments, the principle involved is susceptible of numerous other applications that will readily occur to persons skilled in the art. The invention, therefore, is limited only as indicated by the scope of the appended claims.

What I claim is:

1. A blade comprising a supporting member; having a spanwise extending portion and an air foil surface shaped assembly, fixedly secured to the supporting member having a hollow centrally thereof and passage means interconnecting the hollow and air foil surface thereof, said assembly including a plurality of like, relatively thin, air foil shaped segments stacked one upon the other in encircling arrangement to said spanwise extending portion of said supporting member, said segments having central openings therein defining an inner edge surface on each of said segments in alignment with one another to define the hollow centrally of the assembly, each of said segments being uniformly spaced apart from each other along the spanwise axis of said supporting member to define said passage means and fixedly attached to said spanwise extending portion of said supporting member.

2. A blade according to claim 1, wherein the supporting member includes a base integral with the spanwise extending portion of the supporting member, wherein the spanwise extending portion of the supporting member is a ribbed core and wherein the portions of the segments adjacent their openings are fixedly secured upon the ends of the ribs of the ribbed core.

3. A blade according to claim 2, wherein the base of the supporting member has passages therein communicating with the hollow of the assembly between the ribbed core and the inner edge surfaces of the segments adjacent the openings thereof.

4. A blade according to claim 1, wherein the supporting member includes a base integral with the spanwise extending portion thereof and wherein the spanwise extending portion of the supporting member constitutes a

core, said base and core having a channel at the junction thereof, said base having passages therein interconnected with the channel and wherein the assembly comprises a cover plate having a central opening therethrough and a relatively thin air foil shaped cover segment, said cover plate and segments being stacked upon one another with the cover plate mounted over the channel at the junction of the base and core and with the core extending through the central opening of the cover plate and openings of the segments and said cover segment being secured upon the core adjacent the top one of the stacked segments furthest disposed from the base of the supporting member.

5. A blade according to claim 4, wherein the core is ribbed and wherein the cover plate and segments are fixedly secured to the ends of the ribs of the ribbed core and wherein the core provides, in conjunction with the segments, hollow passageways having communication with the channel and with said passage means between the segments.

6. A blade according to claim 4, wherein the segments are each provided with a depression and a projection on the opposite radial surfaces thereof respectively, said projections and depressions being in spanwise alignment with the radius of curvature of said projections being greater than the radius of curvature of said depressions, thereby providing bearing relation upon one another over certain portions and spacing other portions of said segments to define said passage means.

7. A blade according to claim 1, wherein each of the segments is of substantially uniform thickness.

8. A blade according to claim 1 wherein each of said inner edge surfaces is provided with a radial outer peripheral edge portion lying in a plane parallel to and axially spaced from the radial inner peripheral edge portion of said inner edge surface with said radial inner peripheral edge portion engaging said supporting member with one-way locking interference.

9. A blade according to claim 8 wherein the outer peripheral edge surfaces of all the segments lie in alignment with one another parallel to the spanwise axis of the supporting member.

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