

Aug. 27, 1968

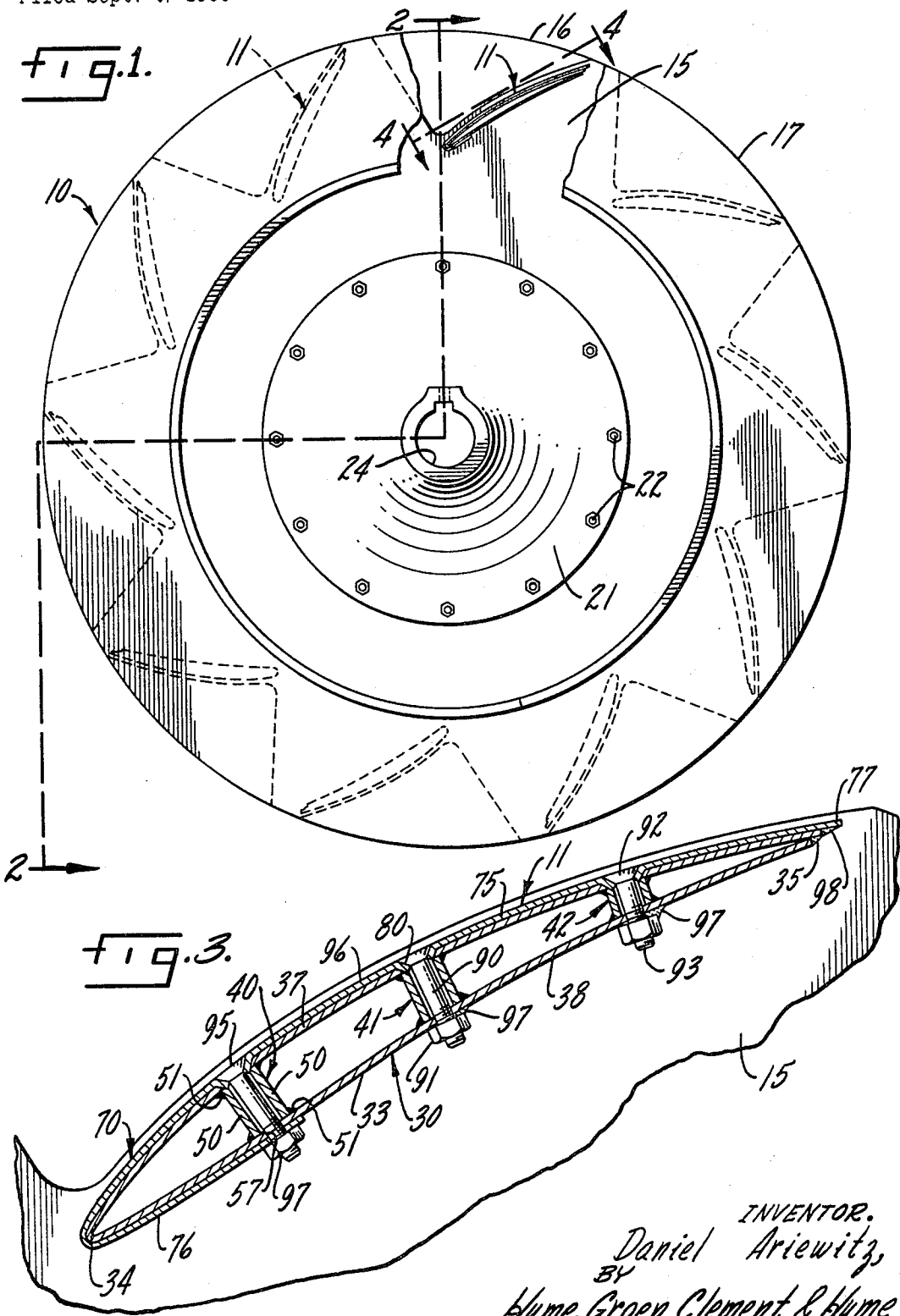
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3,398,883

FAN

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2 Sheets-Sheet 1



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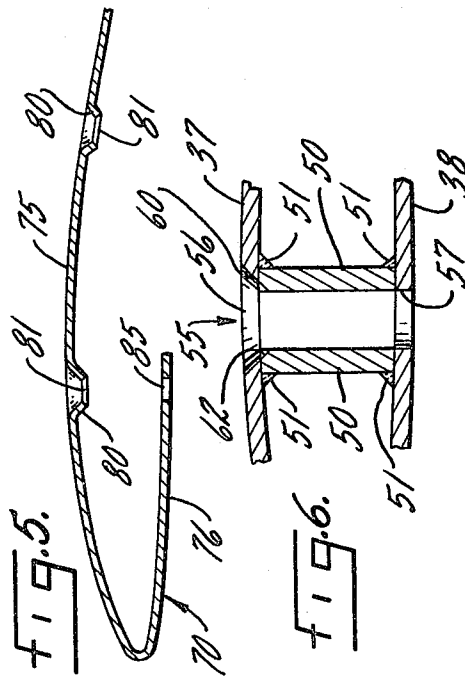
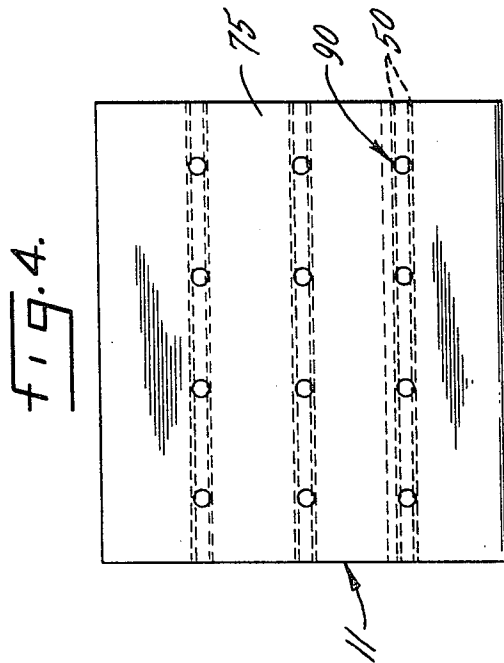
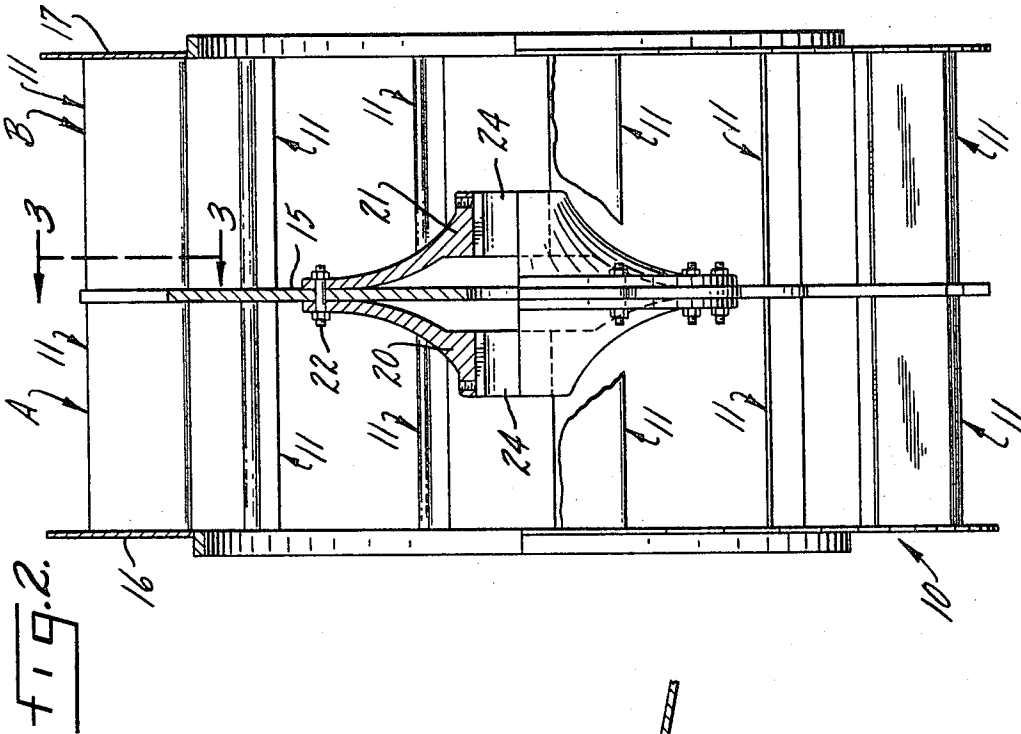
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ABSTRACT OF THE DISCLOSURE

An improved blade liner is provided for an airfoil type fan. The fan blades each utilize a hollow airfoil construction, having a skin of sheet material. In the preferred construction, the upper and lower skin segments are supported by at least one pair of spaced ribs between them and running parallel to the leading edge. The blade liner overlies at least a portion of the upper skin segment, and preferably the entire upper skin segment along with the leading portion of the lower skin segment. Aligned apertures are formed in the upper and lower skin segments penetrating between a pair of ribs. The area surrounding these apertures is most preferably counter-sunk, providing a frusto-conical section in the skin. The counter-sink also extends into the ribs, forming segmental frusto-conical indentations so that the counter-sink extends continuously into and between spaced ribs. To take advantage of this counter-sink construction, the blade liner has dimples with apertures in the center, the dimples and apertures being sized to fit into the counter-sinks in the skin. A bolt having a frusto-conical head is then employed to secure the liner to the blade.

This invention relates in general to fans and blowers and, more particularly, to blade type fans and blowers commonly employed to effect induced draft, gas recirculation and other applications.

Blade type fans or blowers are broadly conventional. A blower of this type is illustrated in U.S. Patent No. 1,983,201. It is further well known to employ replaceable blade "liners" on the blades so that the blades themselves are not subjected to wear when they are employed with corrosive or erosive gas streams. Such replaceable liners, as illustrated in U.S. Patent No. 1,985,705 are themselves subjected to the wear effected by entrained particles and can be removed and replaced without removing and replacing the entire blade.

It is an object of the present invention to provide a new and improved blade liner arrangement for a fan or blower or the like.

It is another object to provide a new and improved blade liner arrangement for air foil type blades.

It is still another object to provide a blade liner arrangement which facilitates removal, easy mounting, and replacement of the liner without removing the blade or dismantling the fan or blower.

It is yet another object to provide a blade liner arrangement which assures that the liner is snugly seated and secured on the airfoil blade.

The foregoing and other objects are realized in accord with the present invention by providing a blade liner which seats snugly on the skin of an airfoil type blade and is solidly secured to both the skin and internal structure of the blade. The blade has an airfoil configuration and comprises a sheet metal skin having an internal structure of spaced pairs of ribs. Bolt receiving apertures are formed in the upper and lower skin segments of the blade between each pair of ribs. The apertures in the upper skin segment are counter-sunk to provide frusto-conical depressions on the skin. The counter-sinking is extended into the upper edges of each pair of ribs.

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The blade liner itself has apertures formed in it corresponding to the apertures through the blade and anchoring bolts are passed through the blade liner and the blade to retain the liner on the blade. The apertures in the blade liner section extending over the upper skin segment of the air foil blade are formed inwardly to conform to the counter-sunk depressions in the upper skin segment. These inwardly formed portions of the liner are seated flush against both the counter-sunk depressions of the upper skin segment and the respective ribs.

Bolts or rivets or the like having frusto-conical heads and flat ends are inserted in the apertures through the blade liner and the blade with the liner in place. The heads seat snugly in the inwardly formed portions of the blade liner with their flat ends flush with the outer surface of the liner. The bolts or the like extend completely through the liner and the blade to a point below the lower surface of the blade where they are, in the case of bolts, the recipients of nuts which hold the bolts and, accordingly, the blade liner tightly in place on the blade.

The blade liner is quickly removable and replaceable. It is, nevertheless, solidly seated on the hollow airfoil type blade. The internal ribs of the blade are advantageously employed to secure the liner solidly without deforming the blade in any way. The smooth upper surface of the airfoil is uninterrupted because of the flush relationship of the anchoring bolt ends and the surface of the liner on the blade.

The invention, both as to its organization and method of operation, taken with further objects and advantages thereof, will best be understood by reference to the accompanying drawings, in which:

FIGURE 1 is a side elevational view of an induced draft fan having blades mounting liner assemblies according to the present invention, with parts removed;

FIGURE 2 is a view taken along line 2-2 of FIGURE 1, with parts removed;

FIGURE 3 is a view taken along line 3-3 of FIGURE 2;

FIGURE 4 is a view taken along line 4-4 of FIGURE 1;

FIGURE 5 is a side elevational view of the liner alone, with parts removed; and

FIGURE 6 is an enlarged sectional view of a blade mounting aperture.

Referring now to the drawings, and particularly to FIGURE 1, a blade wheel for a broadly conventional induced draft fan is illustrated generally at 10. The fan might be of the type conventionally utilized in evacuating erosive industrial gas. Such is the case in the present illustration where the blade wheel 10 is relatively large, being sixty-nine inches in diameter and mounting twenty airfoil type blades 11.

The blade wheel 10 comprises a central disc 15 bracketed by side plates 16 and 17. The central disc 15, which is fabricated of three-quarter inch steel plate, and the side plates 16 and 17, which are fabricated of three-eighths inch steel plate, mount the twenty blades 11 between them in two sets of ten, A and B, as illustrated in FIGURE 2. The blades 11 are secured to the disc 15 and plates 16 and 17 by welding. A pair of identical cast fittings 20 and 21 are mounted on opposite sides of the central disc 15. The fittings 20 and 21 are bolted to the disc 15 by conventional machine bolt assemblies 22 so that their centrally disposed bores 24 are axially aligned. The bores 24 receive the driveshaft of a conventional electric motor (not shown) which turns the blade wheel 10.

Each blade 11 is identical in construction and comprises a hollow airfoil 30. Referring to FIGURES 3-6, each airfoil 30 comprises a skin 33 fabricated of a single piece of sheet steel. The piece of sheet metal is formed into an airfoil shape having a leading edge 34. The free

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trailing edges of the piece of sheet metal are brought together and welded at 35 to form the trailing edge of the airfoil 30. The skin 33 thus includes an upper skin segment 37 and a lower skin segment 38.

The upper and lower skin segments 37 and 38 are structurally supported and spaced by three pairs of ribs 40, 41, and 42 extending across the width of the blade in parallel relationship with its leading and trailing edges 34 and 35. The ribs act as stiffening elements and maintain the airfoil shape of the blades 11. Each pair 40, 41 and 42 of ribs is identical in construction and arrangement, with the exception of height. Accordingly, only the pair 40 is described in detail, and corresponding reference numerals are applied to corresponding components of the rib pairs 41 and 42.

The rib pair 40 comprises two ribs 50 extending parallel to each other across the width of the blade between the upper skin segment 37 and lower skin segment 38. Each rib 50 is fabricated of sheet steel and is welded to the inner surface of the upper and lower skin segments 37 and 38 by fillet welds 51, also extending across the width of the blade. The ribs are consistently spaced at a distance of $1\frac{3}{32}$ inch along their width specifically to permit the passage of $\frac{3}{8}$ inch bolts between them, as will hereinafter be discussed in detail.

After a blade 11 has been fabricated in the foregoing manner, a series of holes 55 are drilled through the skin 33 in spaced relationship between the ribs 50 in each pair 40-42 of ribs. Each hole 55 actually comprises an upper hole 56 drilled through the upper skin segment 37 and a corresponding lower hole 57 drilled through the lower skin segment 38. As seen in FIGURE 4, four of these sets of holes 56 and 57 are drilled through the skin 33 between each pair 40-42 of ribs 50.

Each of the upper holes 56 is then counter-sunk so that it has a frusto-conical side 60 opening onto the outer surface of the skin segment 37. The counter-sinking is extended into the ribs 50 also, and forms in them opposed segmental frusto-conical sides 62 co-extensive with the frusto-conical sides 60 in the upper holes.

The blade 11 constructed in the foregoing manner is adapted to seat the blade liner 70, mounted according to the present invention. The blade liner 70 is fabricated of sheet steel similar to the material of the skin 33 and also has an airfoil configuration. The configuration of the liner 70 is adapted to conform to the configuration of the airfoil 30, of course.

The liner 70 includes an upper section 75 and a lower section 76. The upper section 75 is designed to extend over the entire upper skin segment 37 of the airfoil 30, to the extent of extending slightly past its trailing edge 35, as illustrated at 77. The lower section 76, on the other hand, is sufficiently long only to extend slightly past the first pair 40 of ribs 50 on the lower skin segment 38.

The upper liner section 75 has a plurality of frusto-conical dimples 80 formed in it, each dimple being positioned for nesting in one of the counter-sunk airfoil skin holes 56. Each dimple 80 is, in turn, apertured at its center 81. The periphery of the dimple aperture 81 extends into the counter-sunk upper skin hole 56 to the extent that the dimple rests snugly against both the frusto-conical side 60 of the hole 56 and the segmental frusto-conical sides 62 formed in the ribs 50. By employing this "dimpled" construction, rather than just counter-sinking apertures in the liner section 75, shear loading on retaining bolts or rivets or the like is relieved and liner retention improved.

The lower liner section 76 has a plurality of apertures 85 formed in it corresponding to the lower airfoil skin apertures 57 between the ribs 50 of the first pair 40 of the ribs. The holes 57 in the lower airfoil skin segment 38 are not counter-sunk and, correspondingly, the holes 85 through the lower liner section 76 are not counter-sunk.

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To seat the liner 70 solidly on the airfoil 30, a plurality of machine bolts 90 and nuts 91 are employed in this illustration, although it has been pointed out that other similar fastening means including rivets might be employed. The bolts 90 have frusto-conical heads 92 correspondingly precisely in configuration to the frusto-conical dimples 80 in the upper liner section 75. The bolts 90 associated with each series of holes 55 through the blade are just long enough to extend through the lower skin segment 38 (and the lower liner section 76 in the case of the pair of ribs 40) and receive the nuts 91 on their threaded ends 93. The bolts 90 associated with the pair 40 of ribs 55 are, of course, considerably longer than the bolts 90 associated with the pair 42 of ribs 50.

With the liner 70 seated on the airfoil 30 as illustrated in FIGURE 3, the bolts 90 are drawn tight by turning the nuts 91 in a well known manner. With the bolts 90 drawn tight the upper flattened end 95 of each bolt head 92 is flush with the outer surface 96 of the blade liner 70. The smooth upper airfoil surface 96 of the blade liner is thus uninterrupted by protruding bolt heads. The liner 70 is snugly fit up over the entire airfoil 30, obviating crevices or pockets which might gather foreign material and effect the balance of the blade 11.

After the nuts 91 have been torqued up on the bolts 90, the open sides of the nuts associated with the pairs 41 and 42 of the ribs 50 are tack-welded, as illustrated at 97. An open side remains after the nuts 91 are torqued up because the bolts 90 associated with the pairs 41 and 42 of rib 50 are canted slightly relative to the lower skin segment 38 due to the airfoil configuration of the blade 11.

The liner 70 securely seated on the blade in the afore-described manner is physically supported by both the skin 33 of the airfoil 30 and also directly by the ribs 50. As will be seen, the dimples 80 are actually in direct contact with and supported by the ribs 50 at their segmental frusto-conical sides 62. The liner 70 is thus, according to the present invention, actually supported through the internal rib structure of the airfoil blade 11. In addition, to tightly secure the trailing edge 77 of the liner 70 to the blade, a tack-weld 98 is run along the liner co-extensive with the tack-weld at the trailing edge 35 of the airfoil 30.

It will now be seen that a blade liner 70 has been described which can be quickly mounted, removed, and replaced without removing a blade or dismantling the blower. Even though the liner 70 is so readily removable and replaceable, however, it is securely and solidly seated on the blade when mounted according to the present invention.

Although the liner 70 has been described as having a full upper section 75 and a shortened lower section 76, these relative dimensions might vary with requirements. In addition, the trailing edge 77 of the liner section 75 might be bolted or the like to the airfoil 30 rather than welded, as illustrated. This is of particular importance where the liner 70 and airfoil 30 are fabricated of different materials, as they might be.

The airfoil 30 has further been described as having its rib pairs 40, 41 and 42 running across its width. It is conceivable that these rib pairs might span the airfoil from leading to trailing edge also. Furthermore, the liner 70 might be formed with lips along its side edges for nesting with the side and center plates 16 and 15 to provide the fan 10 additional protection in these areas. These side edges of the liner 70 might also be welded to the plates 16 and 15.

While the embodiment described herein is at present considered to be preferred, it is understood that various modifications and improvements may be made therein, and it is intended to cover in the appended claims all such modifications and improvements as fall within the true spirit and scope of the invention.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. In combination with an airfoil-type blade for a fan or blower or the like, said blade comprising a hollow airfoil having a skin fabricated of a unitary sheet of material, and having leading and trailing airfoil edges, said skin including an upper skin segment and a lower skin segment, said segments on opposite sides of said airfoil and joined at said leading and trailing edges, the improvement in blade liner arrangement comprising: at least one pair of spaced ribs in said blade disposed between said upper and lower skin segments in support thereof and extending parallel to each other and to said leading edge, said upper and lower skin segments having aligned apertures, said apertures substantially aligned to penetrate between the ribs of each rib pair; a blade liner overlying at least a portion of the outer surface of said upper skin segment, said liner having an aperture formed in alignment with said blade apertures; and anchor means extending through said apertures and anchoring said liner to said skin and said spaced ribs.

2. The improvement in blade liner arrangement of claim 1, further characterized in that said blade includes a plurality of said pairs of spaced ribs, said apertures being suitably formed in said skin segments and liner to facilitate passage of a plurality of anchor means between the ribs of each rib pair.

3. In combination with an airfoil-type blade for a fan or blower or the like, said blade comprising a hollow airfoil having a skin fabricated of a unitary piece of sheet material, and having leading and trailing airfoil edges, said skin including an upper skin segment and a lower skin segment, said segments on opposite sides of said airfoil and joined at said leading and trailing edges, the improvement in blade liner arrangement comprising: at least one pair of spaced ribs in said blade disposed between said upper and lower skin segments in support thereof and extending parallel to each other and to said leading edge, said upper and lower skin segments having aligned apertures, said apertures substantially aligned to penetrate between the ribs of each rib pair, and the area surrounding said apertures in said upper skin segment being counter-sunk from the outer surface of said upper skin segment inwardly to form a frusto-conical indentation, and said spaced ribs including opposed, segmental frusto-conical indentations aligned with said aperture to

provide a continuous counter-sink extending into and between said spaced ribs; a blade liner overlying at least a portion of said upper skin segment, said blade liner having an aperture formed in alignment with said blade apertures, the area surrounding said aperture in said liner being indented to form a dimple conforming in configuration to said frusto-conical indentation in said upper skin segment and said segmental frusto-conical indentations in said ribs; and anchor means extending through said apertures and anchoring said liner to said skin and said spaced ribs.

4. The improvement in blade liner arrangement of claim 3 further characterized in that each of said anchor means comprises a bolt extending through corresponding apertures, said bolt having a frusto-conical head formed on one end and being threaded at its opposite end, and a nut on said threaded end drawing said frusto-conical head into said blade liner dimple, whereby said dimple is drawn tightly against said frusto-conical indentation in said upper skin segment and said segmental frusto-conical indentations in said ribs.

5. The improvement in said blade liner arrangement of claim 4 further characterized in that said blade liner comprises an upper liner section overlying substantially the entire upper skin segment and a lower liner section underlying only a portion of said lower skin segment adjacent said leading edge.

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