Dec. 12, 1961 E. B. G. SCHNELL 3,012,709

BLADE FOR AXIAL COMPRESSORS

Filed May 14, 1956

Fig. 1.

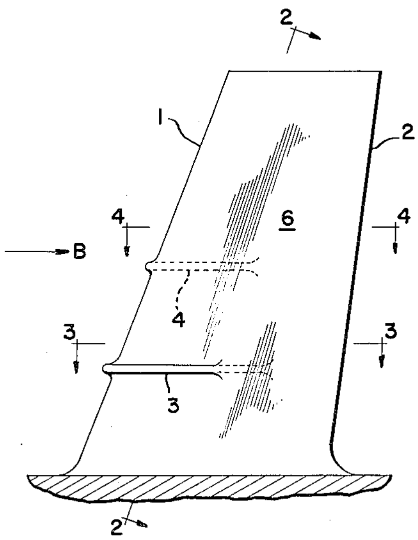


Fig. 2.

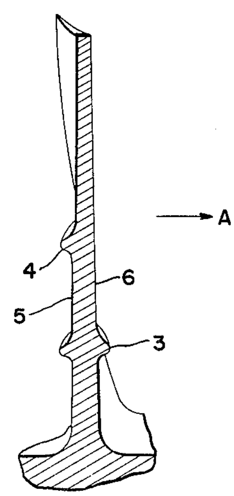


Fig. 3.

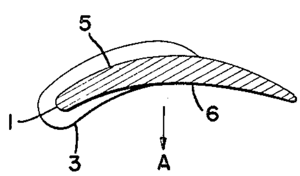


Fig. 5.

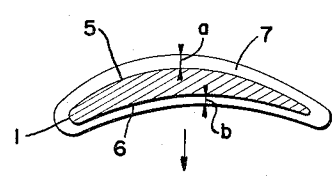
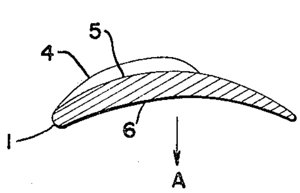


Fig. 4.



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BLADE FOR AXIAL COMPRESSORS

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The present invention relates to blades for use in axial compressors and more particularly to such blades for use in axial compressors which enable the operation thereof at relatively high speed.

Accordingly, it is an object of the present invention to provide a blade construction for axial compressors which is particularly effective at high speeds.

Still another object of the present invention is to provide a swept-back type blade for axial compressors provided with collars or shrouds to reduce the "pumping" which may result from boundary layer conditions at high speeds.

Still another object of the present invention is to provide a sturdy blade for axial type compressors which have the aforementioned advantageous operating characteristics and which are relatively simple in structure, i.e., which combine these advantageous operating characteristics with relatively light weight and good rigidity.

In the attempt to render axial compressors suitable for very high flow velocities or rotational speeds the present invention provides a swept-back blade construction, i.e., a blade construction in which the leading or entering edge of the blade is not perpendicular or nearly perpendicular to the longitudinal axis of the device but is inclined rearwardly in the direction of flow. Such blades exhibit still a high degree of efficiency even with large axial flow velocities which approach the speed of sound and consequently ordinarily would result in poor efficiency. This is due to the fact that only the components of flow which are perpendicular to the leading or entering edge of the blade are of significance in that case and the same are considerably smaller with a swept-back blade form than is the amount of the axial flow.

Blades are known in the prior art in which the leading or entering edges thereof deviate by a slight angular amount from the perpendicular to the longitudinal axis of the device or machines. However, this angular amount is so small that it does not possess any significant influence on the reduction of the components of flow which are perpendicular to the leading or entering edge of the blade. Accordingly, the angular deviation of the prior art devices or machines has no functional reason as regards flow conditions but rest solely on the fact that the blades are made somewhat smaller at the outer ends or tips than at the foot or root thereof only for reasons of rigidity.

Boundary layer regions are produced around the blade as a result of the viscosity of the flow medium during the flow through an axial blade wheel in which the flow velocities decrease from the value of free or unobstructed flow to zero along the blade surface. The particles contained in these boundary layers are, therefore, subjected to a centrifugal acceleration as a result of the rotation of the blade wheel which produces a secondary flow effect along the blade surface which is directed outwardly. This phenomena is known as "boundary layer centrifuging effect" and brings about a removal or withdrawal of the boundary layer material or mass in a manner similar or analogous to the boundary layer suction from the parts of the blades near the hub thereof and an accumulation or build-up of boundary layer material or mass near the outer rims or tips of the blades. The permissive load on the blades is the greater the thinner the boundary layer is,

expressed by the maximum lift coefficient $c_{a\ max}$, or by the permissive deceleration of the flow velocity in a cascade or row of blades, which if exceeded would result in break or collapse of the flow and produce pumping which would take place. As a result of the boundary layer centrifuging effect the permissive deceleration is larger in the blade sections nearer the hub than in the outer sections thereof. It follows therefrom that the breaking or collapse or flow or resulting "pumping" of an axial compressor, or possibly also of an axial turbine, is influenced by the boundary layer movement or transport as a result of secondary flows whereby the thickness of the boundary layer in the outer blade section is decisive. The pumping limit or boundary may therefore be pushed out or be extended considerably if the boundary layer centrifuging effect is interrupted as is possible, in principle, by the provision of a collar arranged at a constant distance from the main axis of the device or machine which is effective as a boundary layer "fence."

In swept-back type blades according to the present invention the provision of such boundary layer fences are of particular significance because with such types of blades a boundary layer flow toward the outside which is required aerodynamically and which is caused by the swept-back shape superimposes itself on the boundary layer centrifuging effect brought about by the rotation of the blades. The result is an extraordinary large increase of the boundary layer in the outer regions of the blades and therewith an increased danger of breaking or collapse of the flow or of pumping respectively.

The present invention is predicated on the discovery that it has proven itself advantageous to provide a collar having a height of approximately one-half the thickness of the blade profile or cross section. Relatively small collar heights result from such a construction which permit the use of the boundary layer fences also with relatively large rotational speeds of the runner wheel, the more so, as the boundary layer fence by reason of its arrangement itself rotates only with moderate speeds. As the flow breaks or collapses primarily along the suction side or upper side of the blade it is important to impede the boundary layer centrifuging effect thereat in an especially effective manner. It may, therefore, be advantageous if the collar height is larger on the blade suction side than on the blade pressure side, or in the alternative if the collar is provided only along the blade suction side. In that manner a sufficient effectiveness is combined with a relatively light weight construction. If considerations of weight-saving, on the one hand, and effectiveness on the other are of great importance, the present invention provides an embodiment in which the collar extends only along a part of the periphery of the blade profile or cross section, especially along one-half to two-thirds of the profile length with reference to the leading or entering edge of the blade.

Further objects, features and advantages of the present invention will become obvious from the description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein:

FIGURE 1 is a side view of a blade in accordance with the present invention.

FIGURE 2 is a cross sectional view of this blade taken along line II—II of FIGURE 1.

FIGURE 3 is a cross sectional view through the blade of FIGURE 1 taken along line III—III thereof and showing only collar portions on each side of the blade.

FIGURE 4 is a cross sectional view taken along line IV—IV of FIGURE 1 showing a collar portion only along the upper or suction side of the blade, and

FIGURE 5 is a cross sectional view similar to FIGURE

3 of a modified embodiment in which the collar extends around the entire blade profile.

In all the figures the rotary movement in the circumferential direction is indicated by arrow A, whereas the arrows B indicate the direction of flow.

Referring now more particularly to the drawing wherein like reference numerals are used throughout the various views to designate like parts, FIGURES 1 and 2 show a swept-back blade, the leading or entering edge **1** and also the trailing edge **2** of which are inclined rearwardly in the direction of flow B. Two boundary layer fences or collars **3** and **4** are arranged on the blade one behind the other in the radial direction thereof of which the inner one, designated by reference numeral **3** may be constructed as shown in FIGURE 3 which extends along the blade suction side **5** over about two-thirds of the blade width whereas on the blade pressure side **6** the collar extends over about one-half of the blade width taking the leading edge **1** as point of reference. The second fence or collar **4** may be constructed as shown in FIGURE 4 and extends only along the blade suction side **5**.

In the embodiment according to FIGURE 3 in the interest of reduction of weight the boundary layer fence or collar is concentrated only in those portions of the blade which are particularly sensitive with respect to the boundary layer displacement.

FIGURE 4 shows an embodiment of a boundary layer fence or collar in which particular importance is attributed to the small weight thereof and which in consideration of the centrifugal forces is, therefore, very advantageous as regards rigidity. Moreover, this embodiment essentially also does not require any more space in the longitudinal direction than a blade without a boundary layer fence or collar. The collar is thereby limited only to the area of larger suction, i.e., to the first half of the upper side **5** of the blade.

In the embodiment according to FIGURE 5 the collar **7** which may be substituted for the collar **3** of FIGURES 1 and 2, which is provided on the blade suction side **5** which serves as boundary layer fence has a larger height *a* than on the lower side **6** where the height is designated by reference character *b*. The boundary layer fence thereby extends along the entire blade profile or cross section.

While I have shown in FIGURES 1 and 2 a specific embodiment of a swept-back blade with two collars **3** and **4** it is understood that the number thereof as well as the particular construction may be varied within the scope of the present invention and in accordance with my disclosure in FIGURES 3 to 5, depending in each case on the particular requirements of the blade. Moreover the heights of the collars in FIGURE 3 may be dimensioned differently on the suction and pressure side thereof, in a manner similar to the different heights *a* and *b* in FIGURE 5.

While I have shown several preferred embodiments in accordance with the present invention, it is understood that my invention is susceptible of many modifications and changes and I intend to cover all such modifications and changes except as limited by the appended claims.

I claim:

1. In an axial compressor for compressing a fluid medium passing therethrough and having an axis of rotation, a blade extending essentially in a radial direction and including a leading edge and a trailing edge, said leading edge being inclined at a constant angle of inclination in the direction of flow of said fluid medium as it approaches the leading edge of said blade, said blade further including a collar extending essentially perpendicular to said radial direction so as to be effective as a boundary layer fence, said collar being disposed between the radially outermost tip and the root of said blade and extending essentially at a constant distance from said axis of rotation in the direction of said flow, the flow of fluid medium passing through said compressor producing a low pressure area on one side of the blade and a high pressure area on the other, the trailing edge of said blade being inclined rearwardly at a constant angle relative to the direction of flow of said fluid medium passing through said compressor, said collar comprising a portion disposed on said one side of said blade and a further portion on said other side of said blade, each of said portions being spaced from said trailing edge.

2. In an axial compressor, the combination according to claim 1 wherein said portion disposed on said one side of said blade is spaced a smaller distance from said trailing edge than said portion on said other side.

3. In an axial compressor, the combination according to claim 1, wherein said collar includes a further portion projecting upstream and around said leading edge.

4. In an axial compressor, the combination according to claim 1, wherein said portion disposed on said one side of said blade extends a greater amount than said portion on said other side.

5. An axial compressor for compressing a fluid medium passing therethrough and having an axis of rotation, comprising at least one blade of swept-back construction extending essentially in a radial direction with the leading edge thereof inclined at a constant angle of inclination in the direction of flow of said fluid medium as it approaches said leading edge, at least one collar extending from said blade essentially perpendicular to said radial direction and disposed between the radially outermost tip of said blade and the root thereof so as to be effective as a boundary layer fence, said collar further extending essentially in an axial direction at an essentially constant distance from said axis of rotation and over at least a portion of the axial width of said blade, the flow of fluid medium passing through said compressor producing a low pressure area on one side of the blade and a high pressure area on the other, said blade being provided with another collar disposed radially outwardly with respect to said first-mentioned collar and extending at least over a portion of the axial width of said blade with reference to said leading edge, both of said collars extending only over a portion of said axial width of said blade, and wherein said first-mentioned collar is provided on both the low pressure and high pressure side of said blade while said second-mentioned collar is provided only along the low pressure side thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

170,937	Cook et al.	Dec. 14, 1875
914,857	Miller	Mar. 9, 1909
978,677	Taylor	Dec. 13, 1910
1,022,203	Nettle	Apr. 2, 1912
1,080,964	Gays	Dec. 9, 1913
1,129,934	Wiedling	Mar. 2, 1915
1,446,011	Jackson	Feb. 20, 1923
1,793,339	Sherer	Feb. 17, 1931
1,862,827	Parsons et al.	June 14, 1932
2,027,050	Leinweber	Jan. 7, 1936
2,099,229	Possenheim	Nov. 16, 1937
2,110,621	Cohen	Mar. 8, 1938
2,150,299	Telfer	Mar. 14, 1939
2,359,466	Currie	Oct. 3, 1944
2,390,879	Hagen	Dec. 11, 1945
2,426,742	Pawlowski	Sept. 2, 1947
2,498,170	Meier	Feb. 21, 1950
2,524,870	Adamtchik	Oct. 10, 1950
2,540,968	Thomas	Feb. 6, 1951
2,839,239	Stalker	June 17, 1958

FOREIGN PATENTS

11,785	Great Britain	of 1911
19,441	Australia	Dec. 31, 1934
27,409	Great Britain	of 1906
258,376	Italy	Apr. 20, 1928
631,231	Great Britain	Oct. 29, 1949
693,727	Great Britain	July 8, 1953
719,236	Great Britain	Dec. 1, 1954
830,627	Germany	Feb. 7, 1952