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TURBOFAN BLADINGS

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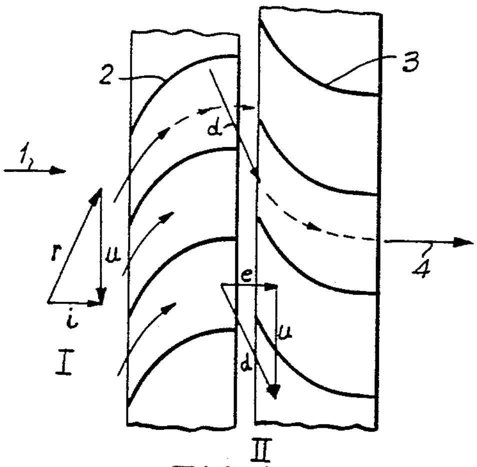

FIG. 1

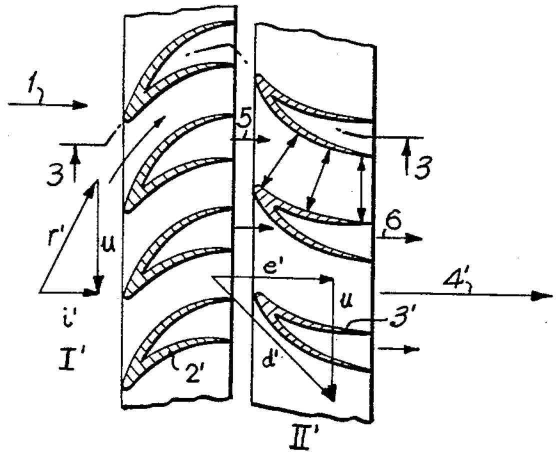

FIG. 2

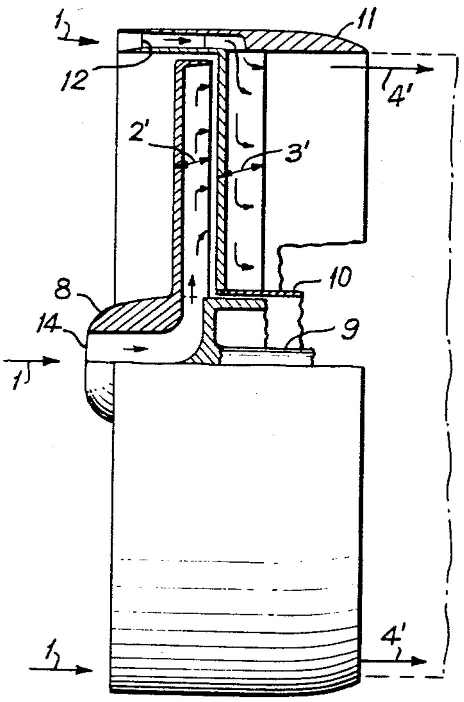

FIG. 3

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TURBOFAN BLADINGS

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ABSTRACT OF THE DISCLOSURE

The blading efficiency of an axial-flow fan or compressor is improved by configuration of the blades constant flow area of the passages across the blading and filling the dead space in the rear of the consequently widened blades by an auxiliary flow of fluid. This concept could be applied also for centrifugal type fans and compressors.

This invention features devices for improving the efficiency particularly of the single-stage fan of the turbofan engine system of Patent No. 2,603,946 (Re. 23,639), although the concerned technique could to advantage be applied to multi-stage fans and to blowers in general.

The task of the fan unit featured in the above cited patent is the effectuation of an axial acceleration of the propulsive airflow across the fan disc (the result of which is the thrust produced). While the attending intermediate pressure and velocity displacements taking place within the two bladings of the fan are undesirable secondary effects, that is, in causing flow energy losses, principally turbulence, are detrimental to efficiency of action; their elimination, respectively drastic reduction, is the objective of this invention.

FIGURE 1 shows a section through an axial-flow fan blading idealized; FIGURE 2 shows a section through the blading with the blades developed in accordance with the present invention; FIGURE 3 illustrates an application of such a blading for a turbofan engine by means of a longitudinal (partial) section through the fan unit of the engine.

The basic mode of action of the bladings of the single-stage fan under consideration is illustrated by FIGURE 1: the incoming airflow 1 enters the fan motor blading 2 axially in principle, vector *e* of the velocity triangle I, its velocity relative to the rotor blading being represented by vector *r*, and is discharged from the rotor with the absolute velocity vector *d* of the respective velocity triangle II, while *u* stands for the rotor rotational velocity. Evidently, in both, rotor and stator blading a deceleration of the air and consequent pressure rise above the ambient atmospheric air takes place within the flow passages due to the divergence of the passage flow area; the energy investment involved in this pressure differential in fact constitutes a total loss, as no benefit is gained from the irreversible re-expansion to the atmospheric pressure. Furthermore, the combination of the divergence and curvature of the blades tends to induce strong turbulence, another conspicuous source of energy loss.

The indicated advertities can be satisfactorily overcome by making the flow area of the blade passages constant, as shown by FIGURE 2, the numeral markings of which correspond to FIGURE 1. However, in order to provide coherent flow conditions throughout, an auxiliary airflow is provided to fill the otherwise stagnant spaces in the rear of the blades modified as shown; the auxiliary

airflow issuing from the rotor blades 2′ is marked 5, that of the stator blades 3′ is marked 6. Obviously, the optimum flow conditions obtain when the auxiliary air jetting velocity is of the order of that of the principal airflow as discharging from the respective blading passages. In the case of the rotor blading, the therefor requisite velocity potential is provided by ram effect due to the flight speed, secondly by centrifugal action within the blades and finally, by the ejector action induces by the principal airflow at the blade trailing edges. In the case of the stator blading, the centrifugal potential is missing: the possibility presents itself to make up for that defect by tapping air from the engine compressor at a suitable pressure stage. A third alternative consists in applying the concerned blade modification only to the rotor while substantially reducing the detriment of blade passage divergence by resort to unconventionally close spacing of the stator blades (it should be noted that at infinitely close blade spacing both divergence and turbulence induction effects vanish).

One aspect of the effectiveness of the concerned technique is directly visualized by comparing the magnitude of the fan discharge velocity 4 of FIGURE 1 with the respective velocity 4′ of FIGURE 2, both of which are resulting from the same intake velocity 1 and the same circumferential velocity *u*.

It should be noted that although power is required for the acceleration of the auxiliary airflow, it also provides the contribution of a substantial complement to the engine thrust production at comparable efficiency.

FIGURE 3 shows the fan unit in semi-section 33, as marked in FIGURE 2: The auxiliary airflow for the rotor blading is taken in at inlet 14 of hub 8 of the rotor and ram-compressed virtue of appropriate figuration of the admission nozzle, thence flowing into the rearward open rotor blade 2′, shown in cross-section by FIGURES 2 and 4: the auxiliary air for the stator blades 3′ is taken in at the front edge of rim member 11, ram-compressed by appropriate intake passage configuration and flowing into the rearward open stator blades 3′, shown in cross-section by FIGURE 2. Longitudinal plates 12 between the part 11 and its inner ring portion 12 serve for rim structure stiffening. Centrally, the stator blades connect to cylindrical member 10, which is part of the engine/compressor unit; the bearing is interposed between member 10 and rotor drive shaft 9.

Velocity vector triangle I, respectively I′, represents the relations of flow entrance into the rotor blading, the triangle II, respectively II′, those of flow exit from the rotor blading.

This description of the invention and pertinent figures and claims set forth its basic concepts, and as admitting certain variations of structure, should not limit its scope.

I claim:

1. An axial-flow fan having a rotor impeller and a stator with stator blading opposed to the blading of said impeller and spaced axially downstream therefrom, said impeller blading and stator blading being curved and of increasing variable thickness in a downstream direction, the low pressure and high pressure surface of each blade terminating in a pair of circumferentially spaced trailing edges, adjacent blades forming flow passages of constant cross-sectional area throughout the blade width when measured normally to the curved surface of one blade to the surface of the adjacent blade.

2. A fan according to claim 1 including means providing an auxiliary flow to fill the space between each pair of circumferentially spaced edges and the intermediate space downstream thereof, thereby providing an orderly streamline flow throughout.

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