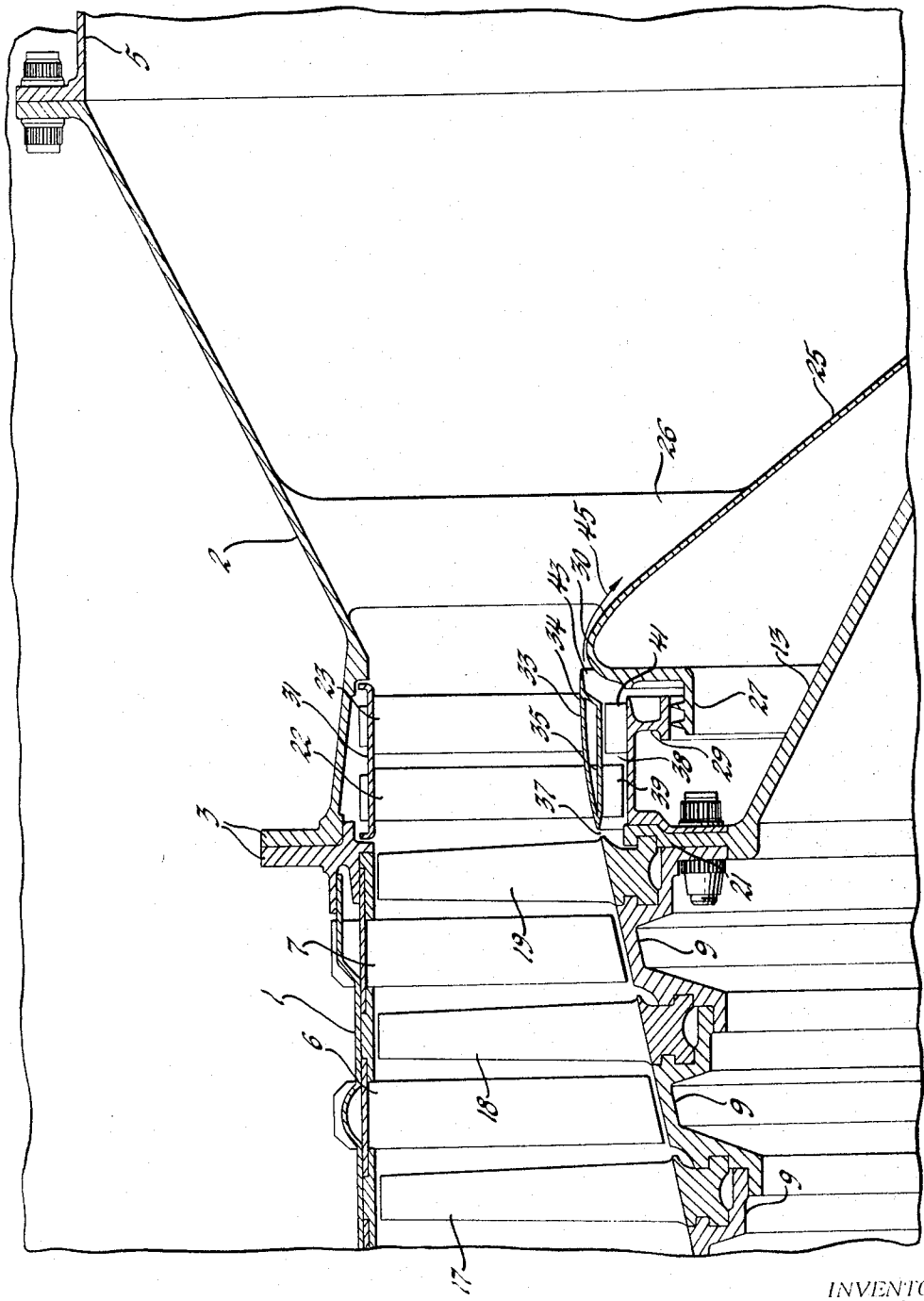
Jan. 24, 1967 D. JOHNSON 3,300,121

AXIAL-FLOW COMPRESSOR

Filed Feb. 24, 1965



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3,300,121

Patented Jan. 24, 1967

3,300,121

AXIAL-FLOW COMPRESSOR

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Filed Feb. 24, 1965, Ser. No. 434,835
4 Claims. (Cl. 230—122)

My invention relates to axial-flow compressors and particularly to a structure incorporating a diffusing outlet passage from the compressor which diverges at a sharp angle. A compressor according to the invention includes an auxiliary axial compressor stage effective to discharge a layer of high-velocity air adjacent the wall of the diffuser. The added flow of air energizes the boundary layer along the wall and thus prevents flow separation and insures efficient non-turbulent diffusion of the compressor discharge.

By way of background, it is generally understood that axial-flow compressors of the usual types employed in jet engines discharge the air at relatively high velocity. A divering diffusing passage is provided between the compressor and the combustion apparatus downstream of it. This may structurally be the initial part of the combustion apparatus housing, but aerodynamically may be considered to be the terminal portion of the compressor. In this diffuser the air flow is decelerated and the velocity head of the air is converted with a reasonable degree of efficiency into static head. The air thereupon flows through the combustion apparatus where it is heated and is thereafter expanded and accelerated through the nozzle of the turbine which drives the compressor.

It is generally realized that efficient recovery of the velocity head of the air requires a rather small angle of divergence of the diffuser, of the order of 10°, unless some special means for preventing flow separation and turbulence which greatly reduce the efficiency of the diffusion process are provided. Such a small angle of divergence requires a relatively long diffuser, which is quite acceptable in many cases. Particularly, however, in the case of a direct lift gas turbine engine mounted with its axis vertical, it is important that the overall length of the engine be relatively small so that it can be installed in a wing or in a shallow nacelle to minimize drag in normal flight of the vehicle. Also, a more compact engine is lighter in weight.

My invention makes it possible to greatly shorten the diffuser of a compressor and therefore the overall gas turbine engine in which it is incorporated. This is effected with a relatively simple and inexpensive modification of the compressor to energize boundary layer air in the diffuser and cause efficient diffusion with a large angle of divergence.

As illustrated in its preferred embodiment in the drawing, the invention involves the addition to an axial-flow compressor, which may be otherwise of conventional structure, of a small auxiliary compressor or fan stage at the outlet of the compressor which blows a sheet of air over the transition into the sharply divergent diffusing wall. As illustrated, the auxiliary compressor or fan stage is at the inner diameter of the compressor discharge, but such a fan stage could be incorporated alternatively or additionally at the outer diameter.

The nature of the invention and the advantages thereof will be clear to those skilled in the art from the accompanying drawing of the preferred embodiment of the invention and the succeeding detailed description thereof. The drawing is a partial view of the terminal stages and diffuser of an axial-flow compressor for a gas turbine engine, the drawing being a sectional view taken on a plane containing the axis of the compressor. The compressor includes a main cylindrical case 1 and a diverging outlet

section or outer diffuser wall 2, these being bolted together at the flanges 3. The downstream end of the wall 2 is bolted to the outer combustion chamber case 5, only the forward end of which is illustrated. Such a compressor ordinarily includes from eight to twelve compressor stages, only the final stages being illustrated. The last two compressor stages include stator vanes 6 and 7, respectively, fixed in the wall 1 and extending radially inwardly. The compressor also includes a rotor made up of a number of rings 9, the final ring 9 being bolted to a conical shaft 13 by which it is coupled to the turbine (not shown). The rings 9 may be held together by a tie bolt (not shown) extending from the turbine to the first stage of the compressor. The final three stages of compressor rotor blading are defined by blade rows 17, 18 and 19. In the structure illustrated, the blades include roots which are fixed in circumferential undercut grooves defined between the adjacent rings 9 and between the final ring and a flange 21 on the forward end of shaft 13.

Two rows 22 and 23 of fixed outlet guide vanes are mounted immediately downstream of the final rotor stage 19. These blades serve to remove the tangential component of velocity from the air discharge from the rotor and direct it axially into the compressor outlet. The compressor outlet passage or diffuser is an annular space defined by the outer wall 2 and by an inner wall 25, which inner wall diverges at a considerable angle, approximately 45° from the axial direction. Walls 2 and 25 may be connected by radial struts 26 which constitute a part of the engine structure. The forward end of wall 25 terminates in the inner member 27 of a labyrinth seal at the compressor outlet, the rotating member of which is a ring 29 bolted to the flange 21 of shaft 13. Except for the strongly divergent angle of wall 25, the structure so far described may be regarded as conventional so far as this invention is concerned, and the details of the structure are immaterial to the present invention.

The present invention lies in the auxiliary compressor or fan which is provided to blow air over the curved transition 30 at the entrance to the inner wall 25. The outlet guide vanes 22 and 23 are fixed in an outer shroud ring 31 mounted between the sections 1 and 2 of the outer wall within the section 2 and are also fixed to an inner shroud 33. The inner shroud is hollow, having an outer wall 34 defining the normal flow path through the outlet guide vanes and an inner wall 35. The shroud 33 is downstream of the blade row 19 so as to define an air entrance 37 to a passage 38 between the shroud wall 35 and the ring 29. Stator blades 39 of very short span are fixed to the forward portion of shroud 35 and a ring of air propelling rotor blades 41 are mounted on the exterior of ring 29 downstream of blades 39 in the passage 38. These stator and rotor blades constitute a fan or compressor stage in the stator 38 which discharges a layer of air through the annular opening 43 between the rear edge of shroud 33 and the wall transition portion 30. This air, which is flowing at higher velocity than the main compressor discharge, tends to follow the surface of the wall 30 and 25, as indicated by the arrow 45, energizing the boundary layer and inducing flow to follow the sharply diverging wall 25. By the provision of this simple auxiliary stage, which requires very little space and has substantially no weight, the diffusing space of the compressor can be greatly shortened and thus the overall length and weight of the engine can be substantially reduced. With respect to the weight, it will be readily understood that shortening of the diffuser and combustion chamber inner and outer walls and of the engine main shaft will effect substantial weight savings.

Suitable combustion and fuel injection apparatus (not illustrated) are mounted within the space defined by walls

2, 5 and 25. Since the structure and disposition of the combustion liners and fuel nozzles is immaterial to the invention, it is not illustrated. The principles of the invention may, of course, be advantageously applied to compressors for other applications than gas turbines.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, as many modifications may be made by the exercise of skill in the art.

I claim:

1. In combination, an axial-flow compressor having an outlet and a diffusing passage extending downstream from the outlet defined by outer and inner annular walls, one of said walls diverging sharply from the axial direction adjacent the outlet; the compressor including outlet guide vanes having an annular shroud adjacent said one wall separating an annular auxiliary air passage from the compressor outlet, the upstream end of the auxiliary air passage having an inlet connecting with and supplied from the compressor adjacent the outlet of the compressor; and an additional compressor stage, including a rotating blade stage, disposed in said auxiliary air passage; the auxiliary air passage terminating in an annular discharge passage disposed to blow a sheet of air energized by said rotating blade stage over said one wall to energize the boundary layer thereon.

2. In combination, an axial-flow compressor having an outlet and a diffusing passage extending downstream from the outlet defined by outer and inner annular walls, one of said walls diverging sharply from the axial direction adjacent the outlet; the compressor including outlet guide vanes having an annular shroud adjacent said one wall separating an annular auxiliary air passge from the compressor outlet, the upstream end of the auxiliary air passage having an inlet connecting with and supplied from the compressor adjacent the outlet of the compressor; and an additional compressor stage, having rotating blades of very short span, disposed in said auxiliary air passage; the auxiliary air passage terminating in an annular discharge passage disposed to blow a sheet of air energized by said additional compressor stage over said one wall to energize the boundary layer thereon.

3. In combination, an axial-flow compressor having an outlet and a diffusing passage extending downstream from the outlet defined by outer and inner annular walls, one of said walls diverging sharply from the axial direction adjacent the outlet; the compressor including two rows of outlet guide vanes having an annular shroud adjacent said one wall separating an annular auxiliary air passage from the compressor outlet, the upstream end of the auxiliary air passage having an inlet connecting with and supplied from the compressor adjacent the outlet of the compressor; and an additional compressor stage, including a stator blade row aligned with the first row of outlet guide vanes and a rotating blade row aligned with the second row of outlet guide vanes, disposed in said auxiliary air passage; the auxiliary air passage terminating in an annular discharge passage disposed to blow a sheet of air energized by said additional compressor stage over said one wall to energize the boundary layer thereon.

4. In combination, an axial-flow compressor having a stator, a rotor, an outlet, and a diffusing passage extending downstream from the outlet defined by outer and inner annular walls, the inner wall diverging sharply from the axial direction adjacent the outlet; the compressor including two rows of outlet guide vanes having an annular shroud adjacent said inner wall separating an annular auxiliary air passage from the compressor outlet, the upstream end of the auxiliary air passage having an inlet connecting with and supplied from the compressor adjacent the outlet of the compressor; and an additional compressor stage, including a stator blade row extending from said shroud aligned with the first row of outlet guide vanes and a rotating blade row mounted on said rotor aligned with the second row of outlet guide vanes, disposed in said auxiliary air passage; the auxiliary air passage terminating in an annular discharge passage disposed to blow a sheet of air energized by said additional compressor stage over said inner wall to energize the boundary layer thereon.

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