

[54] APPARATUS FOR ADJUSTING FAN BLADES IN A TURBOJET ENGINE

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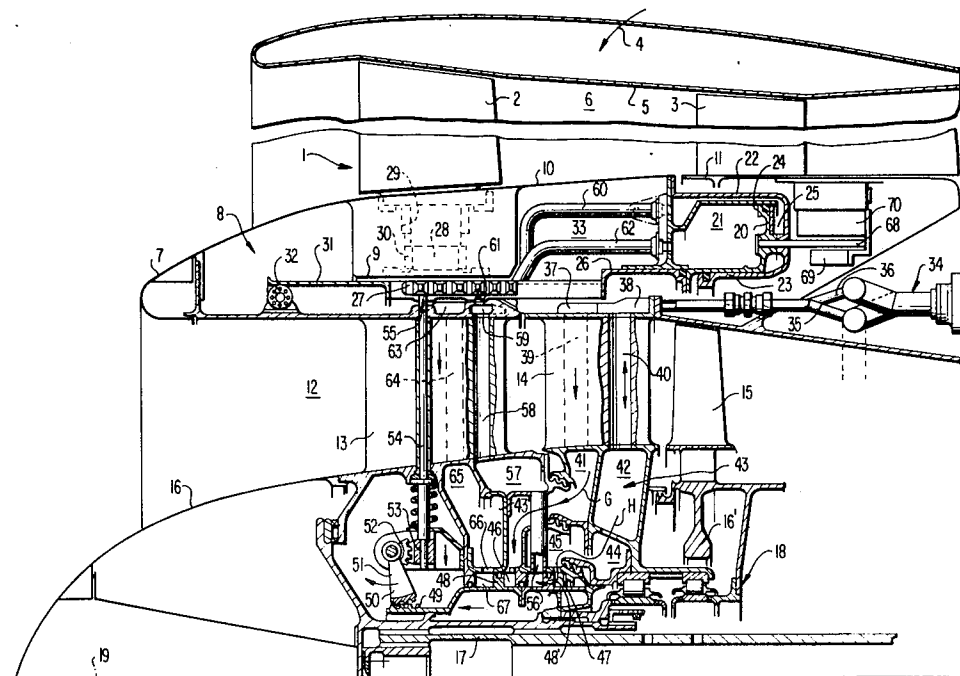
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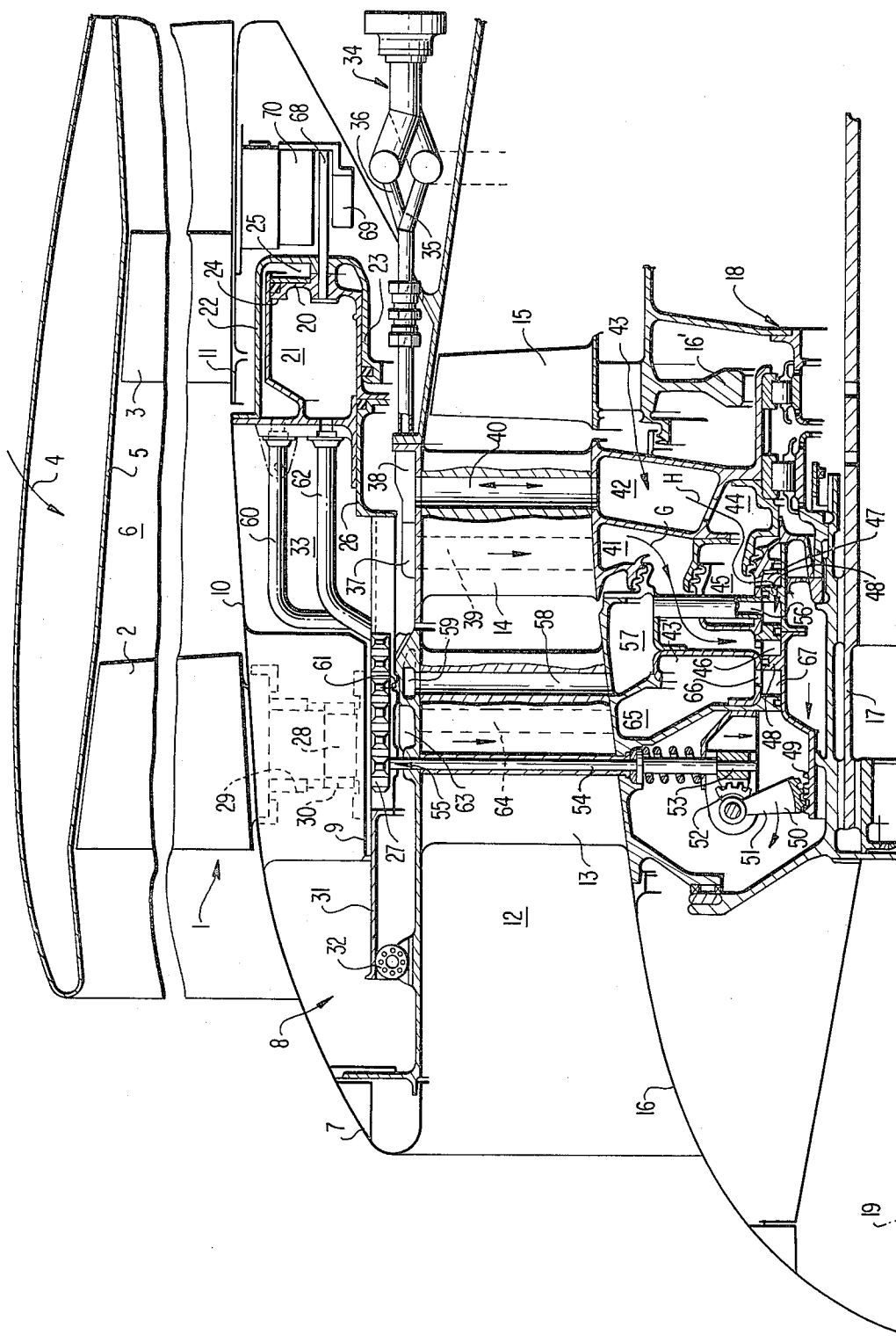
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ABSTRACT

Apparatus for adjusting fan blades in a turbojet engine of the type which has a primary duct for conducting air to an engine compressor rotor and a secondary bypass duct with the fan blades extending there-across to form part of an axial flow fan of the engine. The adjusting apparatus is positioned substantially within an annulus arranged between the primary and secondary ducts. The adjusting apparatus includes an annular piston attached to toothed adjusting racks which engage teeth on said fan blades to adjust the fan blade angle of attack upon movement of the annular piston. An arresting or locking mechanism actuatable by an auxiliary piston serves to lock the adjusting racks in position. Compressed air supply from the engine to the annular and auxiliary pistons is controlled to prevent actuation of the annular piston while the adjusting racks are locked by the locking mechanism.

16 Claims, 1 Drawing Figure





APPARATUS FOR ADJUSTING FAN BLADES IN A TURBOJET ENGINE

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to apparatus for changing the blade angle of fan blades in a turbojet engine of ducted-fan construction.

In modern turbojet engines of the above-mentioned generic category, the greater portion of the available engine thrust is normally provided by relatively large-diameter axial-flow fans. The use of these axial-flow fans makes it possible to achieve bypass ratios, relative to the core engine unit of the respective jet engine, of the order of 10:1 and over.

One particularly helpful tool in the promotion of engine efficiency has been to adapt the fan to the changed conditions at cruise flight with the aid of variable-pitch fan blades. It has also been contemplated to generate reverse thrust by employing negative airfoil angles.

The implementation of such proposed means for varying the pitch of fan rotor blades nevertheless gives considerable trouble from the design point of view because the outer row of rotor blades, the angle of which outer row of blades is intended to vary in an axial-flow fan, is normally an integral part of the basic engine unit, especially where in such an arrangement the variable-pitch outer fan blades form a jointly rotating unit with an inner row of rotor blades of a compressor in the basic engine.

French Pat. No. 2,046,297 proposes to vary the angle of the fan blades in a turbojet engine of the above-discussed type by means of a complex planetary gear arranged within a centrally disposed member downstream of the hub of the compressor of the basic engine. At least one power shaft extends from said planetary gear and through the primary flow duct of this compressor to transfer the actuating movements from the gear to the fan blades via further geared arrangements in the space between the primary duct and the secondary duct. Apart from the complexity of the particular arrangement of the actuating gear and the large number of connecting drives between adjacent variable fan blades, a further disadvantage of said apparatus is that it will scarcely ensure uniformity and directness of transfer of the torque needed to operate the fan blades.

The present invention contemplates providing improved apparatus for operably changing the angle of the fan rotor blades of a turbojet engine of the ducted-fan construction such that direct transfer of the actuating movement from the drive system to the fan blades is ensured at relatively little complexity, that uniform transfer of the actuating moment and proper locking of the fan blades in all selected end positions is possible and that the drive system, as well as the actuating mechanism, will economize space.

It is particularly contemplated by this invention to provide an arrangement where the drive system and the actuating mechanism for adjusting the fan blades are arranged essentially within an annulus intervening between the primary duct and the secondary duct of the jet engine.

The present invention also contemplates a novel arrangement of compressed air controlled actuating piston means for adjusting the fan blade angle and compressed air auxiliary piston means for controlling arresting plunger means to lock the fan blades in respec-

tive adjusting positions. The present invention also contemplates a valving and conduit system for selectively supplying compressed air from a compressor rotor of the engine to actuate the actuating and auxiliary piston means. The present invention also contemplates an electrical switching means for controlling a three-way valve of the valving and conduit system in response to the position of the actuating piston means. The compressed air supplying system optimally connects the fixed and rotatable parts of the engine so as to minimize space and constructional expenditures while assuring a reliable control of the respective arresting plunger means and blade angle adjusting rack means.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawings which show, for purposes of illustration only, a single embodiment in accordance with the present invention.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing is a sectional view taken at the longitudinal centerline of a turbojet engine constructed in accordance with the present invention and illustrates the upper half of the forward portion of the engine.

DETAILED DESCRIPTION OF THE DRAWING

With reference to the drawing, an axial fan 1 essentially consists of variable-pitch rotor blades 2 and downstream of them, fixedly connected guide vanes 3. An outer bypass casing 4 externally confines secondary or bypass duct 6 by its inner wall 5.

The unitary rotating portion of the axial fan 1 further comprises, read from left to right, a central member 8 having a flow-promoting leading edge contour 7, and a supporting means 9 to carry the variable-pitch fan rotor blades 2 which extends to form an inner wall section 10 of the secondary duct 6 between the fan rotor blades 2 and the bottom platforms 11 of the guide vanes 3. Fixedly connected to the rotating portion of the axial fan 1 are further supporting blades 13 which extend through the primary duct 12 to form a unitary arrangement, through a centrally disposed engine hub 16, with an inner shaft 17 of the turbine engine. Arranged in and extending through the primary duct 12 are stay vanes 14 downstream of supporting blades 13. Hub 16 rotates along with shaft 17, blades 13, central member 8, blades 2, and below described piston housing 22 and piston 20.

The stay vanes 14 are followed by further compressor rotor blades 15 which connect, through a rotor disk 16', to a further shafting 18 which envelops the inner shaft 17.

The rotating unitary portion of the axial fan 1 further comprises and communicates with an annular piston 20 which extends coaxially to the longitudinal centerline 19 of the engine, said piston being arranged for axially directed sliding motion within a correspondingly arranged, equally cylindrical piston chamber 21. The annular piston 20 is further surrounded by a shroud 22 which extends coaxially to the longitudinal centerline 19 of the engine and the lower wall 23 of which serves to guide the annular piston 20.

The shroud 22 further confines a separately sealed cylinder chamber 25 formed between it and an upper guide wall 24 for the annular piston 20 and that side of the annular piston 20 which opposes the cylinder

chamber 21.

The annular piston 20 is connected, through an annular support 26, to toothed racks 27 the teeth of which cooperate with the mating teeth on the necks 28 of the variable-pitch fan rotor blades 2 which are supported in needle bearings 29, 30. During the actuating movement of the fan rotor blades 2, extensions 31 of the racks 27 are carried over rollers 32 which are supported in ball bearings.

As it will become apparent from the drawing all essential elements of the actuating system of the fan rotor blades are arranged within the annulus 33 confined by the primary duct 12 on the one hand and the secondary duct 6 on the other.

Arranged further within this annulus 33, downstream of rotating central part 8, is a stationary three-way control valve 34 energized with air from the engine compressor in a manner which is not detailed on the drawing. Inlet lines 35, 36 which extend and are energized commonly or independently with compressor air from the three-way control valve 34, lead respectively to chambers 37, 38 which in turn communicate, via ducts 39, 40 through the stationary vanes 14, with chambers 41, 42 which are arranged separately from one another within an air manifolding system 43. From the chambers 41, 42 the compressor air is directed along the direction depicted by arrowheads G, H and into annular chambers 46, 47 of an auxiliary piston 48 which is arranged adjacent to the shafting 17 and extends coaxially to the longitudinal centerline 19 of the engine.

The auxiliary piston 48 is movable towards the lefthand side in response to a pressure build up in the annular chamber 47. A toothed rack 49 of this auxiliary piston 48 cooperates with mating teeth 50 on a bellcrank 51. Engagement of a further toothed portion 52 of this bellcrank 51 with a sleeve 53 causes a spring-loaded plunger 54 to move downward and clear a slot 55 in the toothed rack 27 so that the fan blade 2 is free to move under the action of the annular piston 20.

A plurality of such disengageable arresting devices may be provided to suit any number of supporting blades 13.

It is only when the auxiliary piston 48 has reached the extreme of its lefthand travel and when the respective arresting means of the fan blades 2 have been released that the edge 48' of the piston allows passage of the compressor air from the annular chamber 47 to a pipe line 56. Through this line 56 the compressor air reaches a further annular chamber 57, continues through a hole or cavity 58 incorporated in the supporting blade 13 and arrives in a chamber 59 which communicates with an air supply line 60. The cylinder chamber 25 is then energized with air from the compressor and the annular piston 20 is moved to its lefthand side to position the fan blade 2.

When the actuating movement of the fan blades 2 is completed, the control pressure from the three-way control valve 34 on the auxiliary piston 48 is relieved and the auxiliary piston 48 moves to the righthand side (under the force of the spring and the centrifugal force of the plungers) to engage the plungers 54 in further slots 61 in the toothed racks 27 and so arrest the fan blades 2 in their new position.

The air displaced from the cylinder chamber 21 by the annular piston 20 during the said movement of the fan blades 2 is allowed to flow, through a line 62, annular chamber 63 and a further hole 64 extending through the supporting blade 13, into a chamber 65 of the air

manifolding system 43', continue through holes 66 to the chamber 46 of the auxiliary piston 48 and leave the air manifolding system 43 through the hole or cavity 39 in the guide vane 14 in a direction opposite to that indicated by the arrowhead G.

Owing to the described operation and arrangement, the annular piston 20 cannot be pressurized with air from the compressor so long as the fan blades 2 are arrested in one or the other end position, e.g., decelerating or cruise position, by means of the arresting plungers 54.

A further useful aspect of the present invention involves functionally interrelating the control of the annular piston 20 with the actuation of the three-way control valve 34 so that the auxiliary piston 48 is automatically restored to secure the fan blades 2 again in position or for other purposes when a predetermined axial displacement of the annular piston 20 and proportionally therewith a certain stagger angle of the fan blades 2 are reached. For this purpose, iron cores 68 which project from the shroud 22, connect to the annular piston 20 and corotate with the axial-flow fan or engine in operation, are slideably arranged between oppositely connected secondary windings 69, 70 of a differential transformer and induce voltages between the secondary windings that tend to cancel each other out to a degree dependent on the position of the iron cores 68. Then when the annular piston 20 has reached a certain end or other position to serve a new stagger angle of the fan blades 2, a so-produced voltage drop initiates an electrical signal causing the three-way control valve 34, through a restoring member, e.g. to relieve the air pressure on the auxiliary piston 48.

While I have shown and described only a single embodiment in accordance with the present invention, it is understood that the same is not limited thereto but also contemplates numerous changes and modifications as would be known to those skilled in the art given the present disclosure of the invention, and I therefore do not wish to be limited to the details shown and described herein only schematically but intend to cover all such changes and modifications.

I claim:

1. Apparatus for adjusting fan blades in a turbojet engine of ducted-fan construction of the type which has primary and secondary ducts; said apparatus comprising:

drive system and actuating mechanism means positioned substantially inside of an annulus arranged between said primary and secondary ducts and including a piston connected to toothed rack means mounted for movement within said annulus, said fan blades including blade teeth which matingly engage corresponding rack teeth of said toothed rack means,

selectively engageable arresting means engageable with said toothed rack means to prevent movement of said toothed rack means,

and supporting blade means extending across said primary duct for supporting said annulus, wherein said arresting means includes resiliently biased plunger means extending through cavity means in said supporting blade means, said plunger means being engageable with respective spaced slots in said toothed rack means for arresting said toothed rack means in positions corresponding to predetermined adjusted positions of said fan blades.

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2. Apparatus according to claim 1, wherein said primary duct is a duct for supplying air to a compressor rotor of said engine, and wherein said secondary duct is a bypass duct with said fan blades forming part of an axial flow fan of said engine.

3. Apparatus according to claim 2, wherein said engine has a longitudinal engine centerline extending in the direction of air flow through said engine, and wherein said secondary duct is arranged radially outwardly of said primary duct with respect to said engine centerline.

4. Apparatus according to claim 3, wherein said piston is an annular piston which is movable coaxially with respect to said engine centerline in response to pressurized air supplied thereto.

5. Apparatus according to claim 4, wherein said annular piston is mounted within said annulus for movement parallel to said engine centerline.

6. Apparatus according to claim 5, wherein means are provided for directing compressed air from a compressor rotor of said engine as said pressurized air to move said annular piston.

7. Apparatus according to claim 5, wherein said toothed rack means are connected to the annular piston through a ring-shaped rack carrier which extends coaxially to the engine centerline.

8. Apparatus according to claim 7, wherein control means are provided for controlling the supply of compressed air to said annular piston such that supply of compressed air to said annular piston is prevented until an auxiliary piston disposed adjacent central shafting of said engine has first released said arresting means.

9. Apparatus according to claim 8, wherein said auxiliary piston is operated by compressed air and is movable in a direction parallel to said engine centerline.

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10. Apparatus according to claim 2, wherein said piston is an annular piston which is supplied with said compressed air by way of an air manifold system adjacent to central shafting means of the engine, through ducts in supporting blades extending across said primary duct, and through line means within said annulus to said annular piston.

11. Apparatus according to claim 9, wherein said annular piston is supplied with said compressed air by way of an air manifold system adjacent to said central shafting means, through ducts in said supporting blade means, and through line means within said annulus to said annular piston.

12. Apparatus according to claim 11, further comprising valve means interposed downstream of a compressor rotor of said engine for selectively controlling the supply of compressed air from said compressor rotor to actuate said annular and auxiliary pistons.

13. Apparatus according to claim 9, further comprising valve means interposed downstream of a compressor rotor of said engine for selectively controlling the supply of compressed air from said compressor rotor to actuate said annular and auxiliary pistons.

14. Apparatus according to claim 12, further comprising valve control means responsive to the position of said annular piston for controlling said valve means.

15. Apparatus according to claim 14, wherein said valve control means includes iron core means connected to said annular piston and electrical coil means adjacent said iron core means, said iron core means and coil means being operatively arranged to generate electrical signals for controlling the valve means as a result of inductive voltage changes upon changes in position of said annular piston.

16. Apparatus according to claim 15, wherein said valve means is a three-way valve.

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