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Wildner

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[54] **ROTOR WHEEL FAN BLADE ADJUSTING APPARATUS FOR TURBOJET ENGINES AND THE LIKE**

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[52] **U.S. Cl.** ..... **415/130,** 416/157, 60/226 R

[51] **Int. Cl.** **F01d 7/00**

[58] **Field of Search** ..... 415/129, 130, 141, 140; 416/157, 156, 162, 166; 60/226 R

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Primary Examiner—Henry F. Raduazo
Attorney, Agent, or Firm—Craig & Antonelli

[57] **ABSTRACT**

A fan blade adjusting apparatus for adjusting fan blades on a rotor wheel of a turbojet engine of the type having compressor blades and fan blades arranged radially spaced from one another on a common rotatable rotor wheel with the compressor blades supplying air to a primary flow duct of the engine and with the fan blades supplying air to a secondary flow duct of the engine. Piston-cylinder arrangements are arranged in the annular space between the primary and secondary flow ducts for imparting axial movement to an annular member attached by way of pivotal arms to the fan blades such that axial movement of the annular member effects pivotal adjustment of the fan blades. The annular member is attached to and rotatable with the rotor wheel and the forces are transferred from the piston-cylinder arrangement by way of an antifriction bearing having the outer race rotatably fixed but axially movable by way of the piston-cylinder arrangement and an inner race which moves rotatably and axially with the annular member. The fixed casing of the engine in the annular space includes guide elements and open spaces for permitting axial movement of the bearing and associated structure while radially supporting same.

17 Claims, 3 Drawing Figures

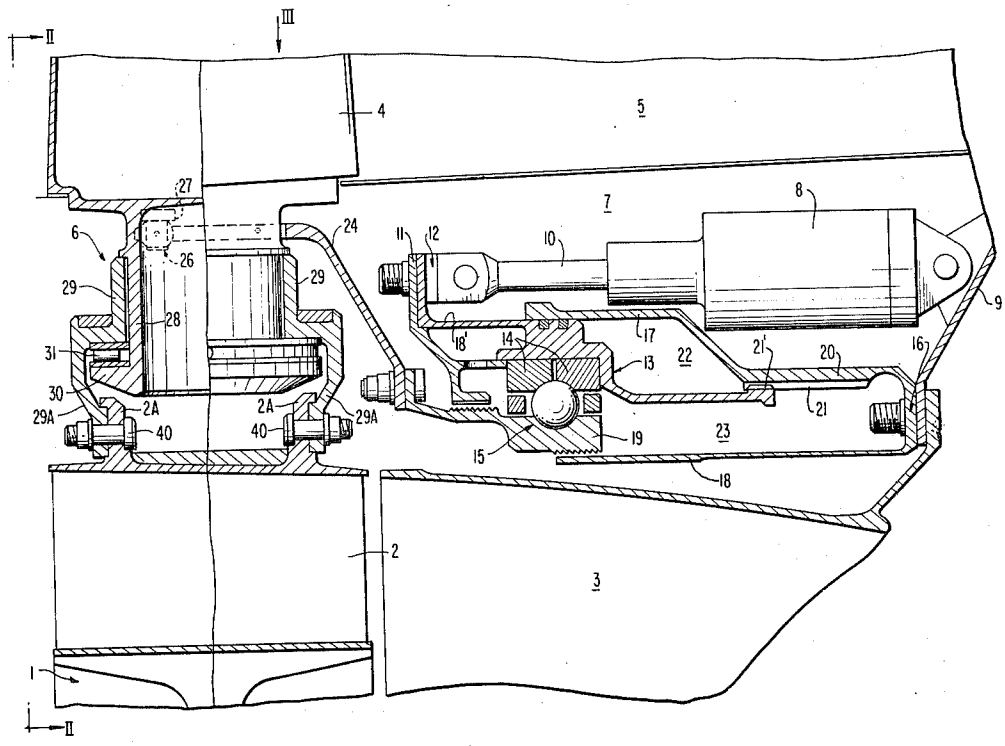

FIG.1

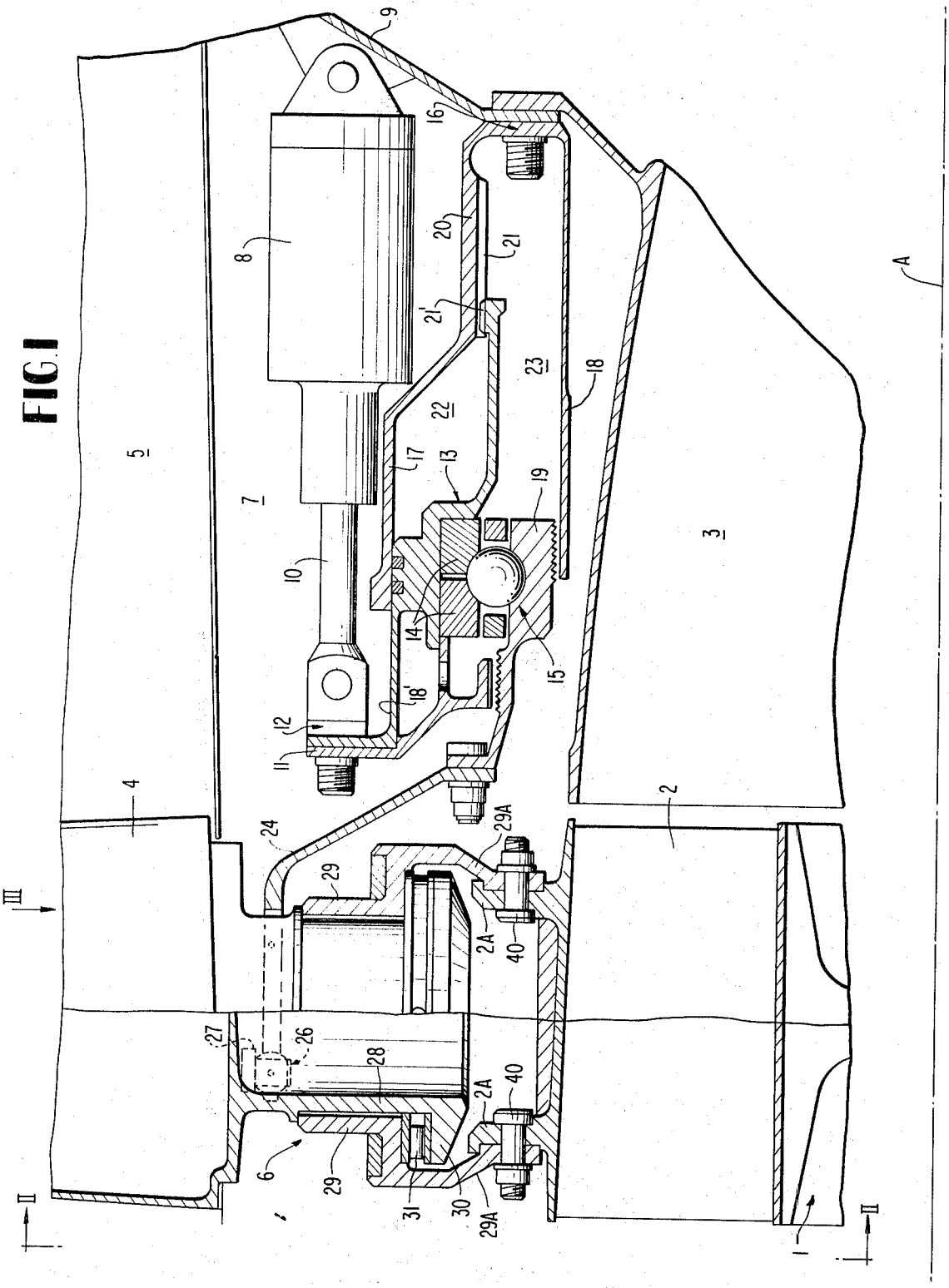
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FIG. 2

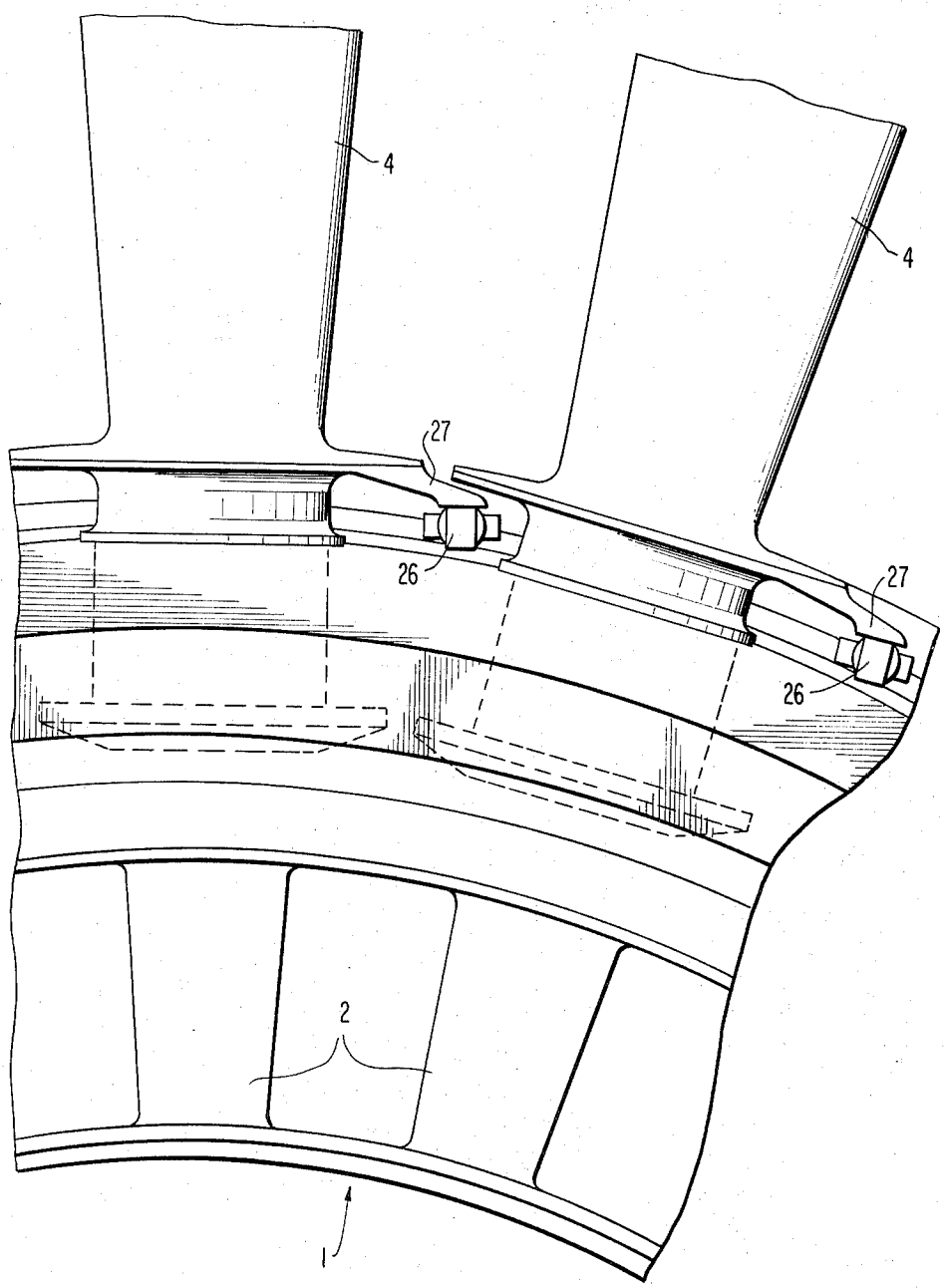
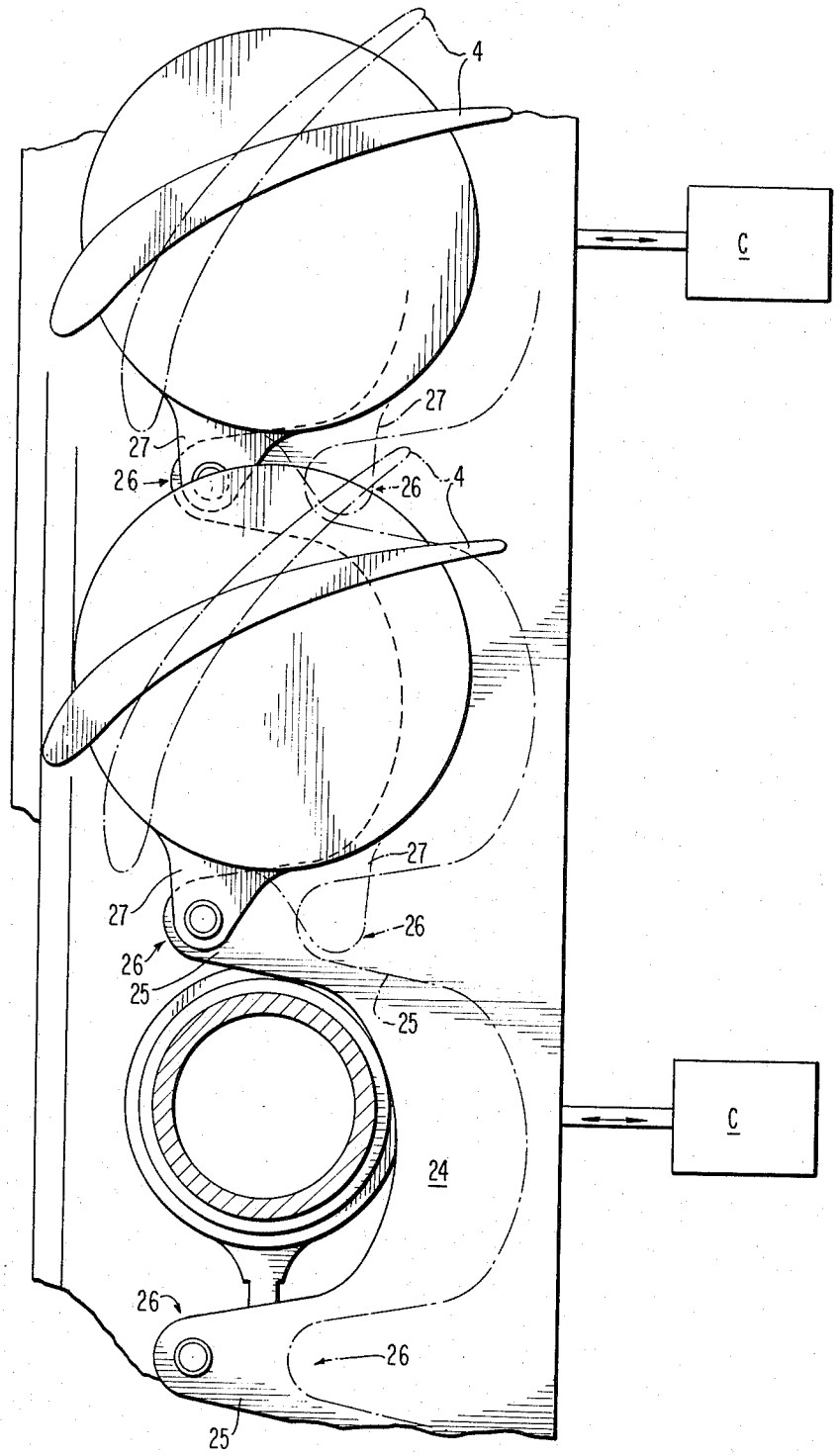


FIG. 3



ROTOR WHEEL FAN BLADE ADJUSTING APPARATUS FOR TURBOJET ENGINES AND THE LIKE

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to apparatus for varying or adjusting the inclination of fan blades on a turbojet engine rotor wheel of the type designed to pass different concentric mass flows.

In modern turbojet engines a greater portion of the available engine thrust is frequently provided by axial-flow fans of relatively large diameter.

The use of these axial-flow fans permits bypass ratios — relative to the core engine unit of the respective jet engine — to be achieved as high as 10:1 or over.

With such bypass ratios a particularly useful practice has been to adapt the fan to the changed conditions at cruise flight by making the inclination of the fan blades variable and thus optimize efficiency without adversely affecting the operating characteristics of the core engine unit. A further objective of the variable fan blades has been to achieve reverse thrust by giving the fan blade contours a negative pitch.

The construction of apparatus for varying the fan blades has nevertheless given considerable trouble from the design aspect in that the variable outer row of rotor blades of an axial-flow fan normally forms an integral part of the basic engine unit, particularly so in constructions where the variable outer fan blades and an inner row of rotor blades of a compressor of the basic engine are mounted on a single rotor wheel.

According to the teaching of a French Pat. No. 2,046,297, the fan rotor blades of a turbojet engine are made variable by means of a complex planetary gearset within a central body arranged immediately aft of the hub of the compressor of the basic engine unit, where at least one tower shaft extends from the planetary gearset and through the primary flow duct of said compressor to transmit the actuating movement of the gearset to the fan blades via further gearsets disposed in the space intervening between the primary duct and the secondary duct. Apart from the complexity of construction as a result of the particular arrangement of the actuating gear and of the plurality of intermediate drives between the variable fan rotor blades this arrangement exhibits a further disadvantage in that uniform and direct transmission of the necessary actuating moment to the fan blades is not adequately ensured.

The present invention contemplates providing improved apparatus for adjusting the fan rotor blades of a rotor wheel of the type having different rows of blades along a radial stacking line, especially for use with turbojet engines of multiflow construction, such that direct transfer of the actuating force from the drive system to the fan blades is ensured in a relatively uncomplicated fashion. Additionally, the apparatus enables uniform transfer of the actuating moment to be achieved in all selectable positions of the fan blades. The drive system and the actuating system of said apparatus furthermore economize space both by construction and arrangement.

The present invention more particularly contemplates arranging the apparatus for adjusting the fan blades between a primary flow duct extending coaxially to the rotor wheel axis and a secondary flow duct, and

to provide said apparatus with a bearing arranged coaxially to the rotor wheel axis for axial sliding movement within fixed recesses in a fixed engine casing, where the blade actuating force is transmitted to the outer bearing race of said bearing while the inner race of said bearing is connected with an annular member which is arranged coaxially to the rotor wheel axis and is coupled with blade stems of pivotally mounted fan rotor blades via actuating levers.

The present invention provides an advantage over previously disclosed solutions in that it permits the necessary blade actuating force to be transmitted directly and in a surprisingly simple fashion from a fixedly mounted actuating means (hydraulically or pneumatically operated actuating cylinders) to the fan blades through the operably rotating rotor wheel.

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 DRAWINGS

FIG. 1 is a partial longitudinal sectional view which substantially illustrates a preferred embodiment of the present invention;

FIG. 2 is a partial front view taken along line II—II of FIG. 1 which illustrates details of a pair of variable fan blades arranged on a rotor wheel in accordance with FIG. 1, with parts broken away for clarity; and

FIG. 3 is a partial top schematic view (horizontal development of a view taken in direction of arrow III of FIG. 1) which illustrates details of the apparatus of this invention on a portion of a rotor wheel.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a portion of a rotor wheel 1 for use in a turbojet engine of multiflow construction. The rotor wheel 1 exhibits an inner row of compressor rotor blades 2 which are arranged coaxially to the longitudinal axis A of the rotor wheel and which discharge compressed air into a primary flow duct 3 of the core engine unit. The rotor wheel 1 is externally provided with a plurality of circumferentially equally spaced variable fan blades 4 which discharge compressed air into a secondary flow duct 5 which extends coaxially to the produced axis of the rotor wheel or longitudinal centerline of the engine. Since details of the remainder of a turbojet engine with which the present disclosure is associated will be readily understood by one skilled in the art, given the present invention, such details have not been included herein in order not to obscure the invention. In this connection, the air passing through flow duct 3 will serve as combustion air for a combustion chamber arranged downstream thereof, and jet exhaust nozzle means and/or propellor rotor means as well as turbine means to drive the rotor wheel will be powered by exhaust gases from the combustion chamber.

Reference numeral 6 generally indicates the bearing and retaining provisions for the fan blades 4.

The apparatus for varying the fan blades 4 is arranged within an annulus 7 formed between the primary flow duct 3 and the secondary flow duct 5.

The apparatus includes a plurality of equally circumferentially spaced actuating cylinders 8 which are arranged concentrically to axis A within the annulus 7

and which contain hydraulically or pneumatically operated actuating pistons for sliding movement relative to the cylinders **8.**

The actuating cylinders **8** are attached to a fixed portion **9** of the engine casing.

It is also contemplated by the present invention to utilize electromagnetically operable means (e.g. solenoids) of conventional design in place of the actuating cylinders and pistons.

Connected to the actuating pistons and extending from the actuating cylinders **8** are piston rods **10** which connect, through ring elements **11, 12** and **13,** to outer race **14** of a bearing **15** (antifriction bearing) which extends coaxially to the production of the rotor wheel axis or longitudinal centerline A of the engine.

A further ring element, **16,** is fixedly connected with portion **9** of the casing and envelopes with its axially directed portions **17, 18** a portion **18'** of ring **12** on the one side and inner race **19** of the bearing **15** on the other. A portion **20** of the ring element **16** further provides axially directed ways or guide slots **21** for engagement with teeth **21'** on the ring element **13** which is connected with the outer race **14** of the bearing **15.**

With this arrangement, the bearing **15** is flexibly radially supported and recesses **22, 23** are formed in the casing to permit the bearing **15** to slide axially.

For transmission of the force needed for varying the fan blades **4** from the bearing **15** via the rotor wheel **1** which rotates when the jet engine is in operation, the inner bearing race **19** which invariably rotates together with the rotor wheel is connected with an annular member **24** which extends coaxially to the axis A of the rotor wheel. Blade adjusting forces are transmitted from rod **10** to inner race **19** by way of member **13** axially moving outer race **14** with consequent axial movement of inner race **19.**

With reference now to FIG. **3** which illustrates the apparatus of the present invention in horizontal development, the annular member **24** exhibits equally spaced protuberances **25** which connect to actuating levers **27** (FIG. **2**) of the fan blades **4** via articulated bearings **26.**

Using contours drawn in solid and dash-dotted line, FIG. **3** further illustrates two different positions of the fan blades **4** as a result of an actuating movement of the annular member **24** from left to right accompanied by an analogous change in the position of the protuberances **25.** (Right most position of member **24,** and corresponding position of blades **4,** depicted in dash-dotted lines and left most position depicted in solid lines.) In FIG. **3,** each of the sets of piston-cylinder arrangements and associated linking structure to annular member **24** are shown in schematic form as control apparatus C, with two such control apparatus C being depicted to indicate a plurality of same equally circumferentially spaced about axis A.

As best illustrated in FIG. **1,** the fan blades **4** are each radially supported by their stem **28** within an annular bearing support **29.** For axial support and absorption of the centrifugal forces acting on the blades during rotation of the rotor wheel **1,** use is made of a needle bearing **31** arranged between a rotationally symmetrical step **30** on the respective blade stem **28** and the bearing support **29.** Radially inward extensions **29A** of support **29** are connected to extensions **2A** of compressor rotor blades **2** by pins **40.**

The above-described apparatus of the present invention is also contemplated for use with jet engine configurations where the respective longitudinal centerline of a fan rotor wheel does not coincide with the longitudinal centerline of the core engine unit.

The apparatus of the present invention may also be used in conjunction with a rotor wheel which serves the function of an aft fan of a jet engine, said rotor wheel conceivably being provided with an inner row of turbine rotor blades arranged concentrically to the axis of the rotor wheel and being driven by the gas flow from the core engine unit.

It is furthermore contemplated by this invention that the apparatus of this invention be used for axial-flow fan rotors of lift engines in pancake construction.

Although the most preferred embodiments relate to turbojet engines, the present invention also contemplates utilization of the apparatus for adjusting fan blades in other fluid flow machines having a single rotor wheel with two sets of blades supplying two separate ducts and with at least one set of the blades being adjustable.

While I have shown and described several embodiments in accordance with the present invention, it is understood that the same is susceptible of numerous changes and modifications as known to those skilled in the art and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. Fan blade adjusting apparatus for adjusting fan blades on a rotor wheel of a fluid flow machine of the type having compressor blades and fan blades circumferentially around said compressor blades on a common rotatable rotor wheel with the compressor blades supplying fluid to a primary flow duct of the flow machine and with the fan blades supplying fluid to a secondary flow duct of said flow machine; said apparatus comprising:

bearing means including an inner bearing race, an outer bearing race, and antifriction means interposed between said inner and outer races for permitting relative rotation of said races with respect to one another about the axis of rotation of the rotor wheel,

actuating force applying means engageable with one of said inner and outer races for axially moving said bearing means,

actuating force transmitting means connected to and movable with the other of said inner and outer races,

and coupling means for coupling said transmitting means to said fan blades such that axial movement of said transmitting means effects pivotal adjustment of said fan blades about fan blade pivot axes extending transverse to said axis of rotation of the rotor wheel.

2. Apparatus according to claim **1,** wherein said primary and secondary flow ducts extend coaxially to said axis of rotation of the rotor wheel, and wherein said bearing means, actuating force applying means, and actuating force transmitting means are disposed in an annular space between said primary and secondary flow ducts.

3. Apparatus according to claim **1,** wherein said flow machine includes a fixed casing, wherein said force ap-

plying means includes a first portion fixed to said casing and a second portion which is connected to said one of said inner and outer races and is axially movable with respect to said fixed portion.

4. Apparatus according to claim **3,** wherein relatively fixed axially extending guide means are connected to said fixed casing for slidably guiding axial movement of said bearing means while also radially flexibly supporting said bearing means.

5. Apparatus according to claim **4,** wherein said second portion includes ring elements which engage axially facing shoulders of said one of said inner and outer races, and wherein an extension of one of said ring elements includes way means which are axially slidably guided in teeth means of said fixed guide means.

6. Apparatus according to claim **5,** wherein said fixed guide means includes guide extensions positioned radially inwardly and outwardly of the respective inner and outer races for radially guiding said bearing means and for forming recess means accommodating axial movement of said bearing means.

7. Apparatus according to claim **1,** wherein said actuating force applying means is engageable with said outer race and said transmitting means is connected to and movable with said inner race.

8. Apparatus according to claim **7,** wherein said actuating force applying means includes a piston and cylinder movable with respect to one another, with one of said piston and cylinder being attached to a fixed casing of the flow machine and the other of said piston and cylinder being connected to said outer race for movement therewith.

9. Apparatus according to claim **1,** wherein said flow machine is a turbojet engine, said primary flow duct leading to combustion chamber means of said engine and said secondary flow duct being arranged in bypassing relationship to said primary flow duct for applying thrust forces to said engine.

10. Apparatus according to claim **9,** wherein said fan blades are arranged radially outwardly of said compressor blades and are pivotal about said pivot axes independently of the compressor blades.

11. Apparatus according to claim **6,** wherein said flow machine is a turbojet engine, said primary flow duct leading to combustion chamber means of said engine and said secondary flow duct being arranged in bypassing relationship to said primary flow duct for applying thrust forces to said engine.

12. Apparatus according to claim **9,** wherein said actuating force applying means includes a piston and cylinder movable with respect to one another, with one of said piston and cylinder being attached to a fixed casing of the flow machine and the other of said piston and cylinder being connected to said outer race for movement therewith.

13. Apparatus according to claim **1,** wherein said transmitting means includes an annular member, wherein said fan blades include actuating levers extending radially with respect to their respective blade pivot axes, and wherein said actuating levers are connected to said annular member by way of articulated bearings such that axial movement of said annular member results in pivotal movement of said actuating levers.

14. Apparatus according to claim **1,** wherein said actuating force applying means includes one of hydraulic operated means, pneumatically operated means and electromagnetic operated means.

15. Apparatus according to claim **1,** wherein said actuating force applying means includes a plurality of fluid operated piston-cylinder systems which extend parallel to said axis of rotation of the rotor wheel and which are spaced circumferentially equally from one another about said axis.

16. Apparatus according to claim **10,** wherein said transmitting means includes an annular member, wherein said fan blades include actuating levers extending radially with respect to their respective blade pivot axes, and wherein said actuating levers are connected to said annular member by way of articulated bearings such that axial movement of said annular member results in pivotal movement of said actuating levers.

17. Apparatus according to claim **16,** wherein said actuating force applying means includes a plurality of fluid operated piston-cylinder systems which extend parallel to said axis of rotation of the rotor wheel and which are spaced circumferentially equally from one another about said axis.

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