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GB 1301615
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(54) **Actuation system for use on a gas turbine engine**

(57) Yoke 60 interconnect crankshanks 40 for conjoint rotation by actuator 50 via crank 56, the yoke moving circumferentially of the gas turbine. Crankshafts 40 may operate an annular slide valve 20 between inner and outer bypass ducts 18, 24 of a variable cycle gas turbine engine or rear variable area bypass injector chutes.

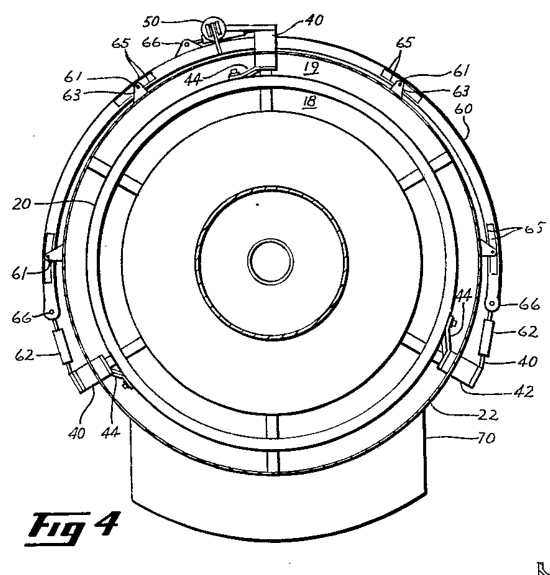


Fig 4

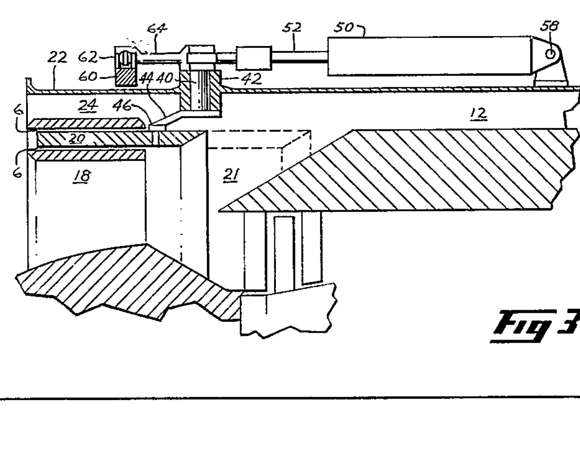
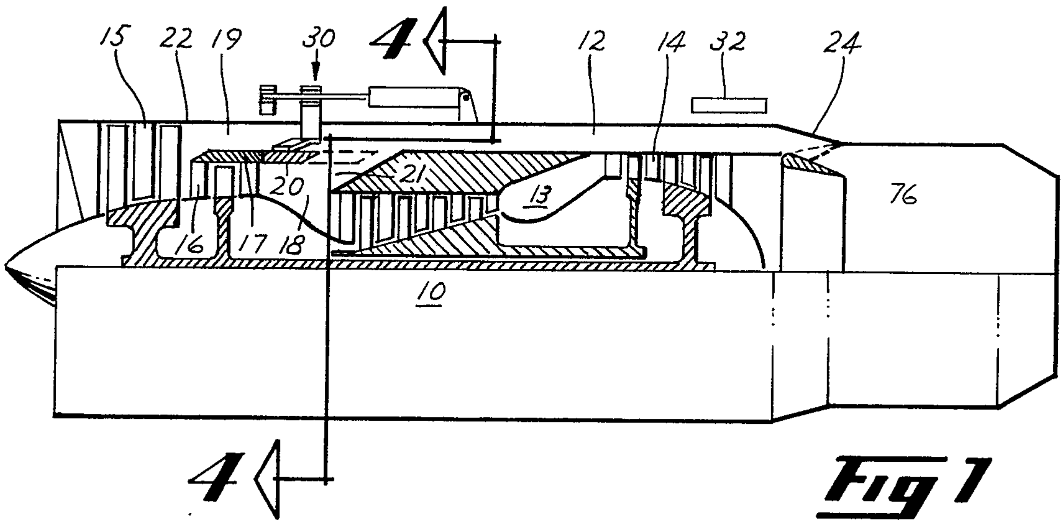


Fig 3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4

Fig 1

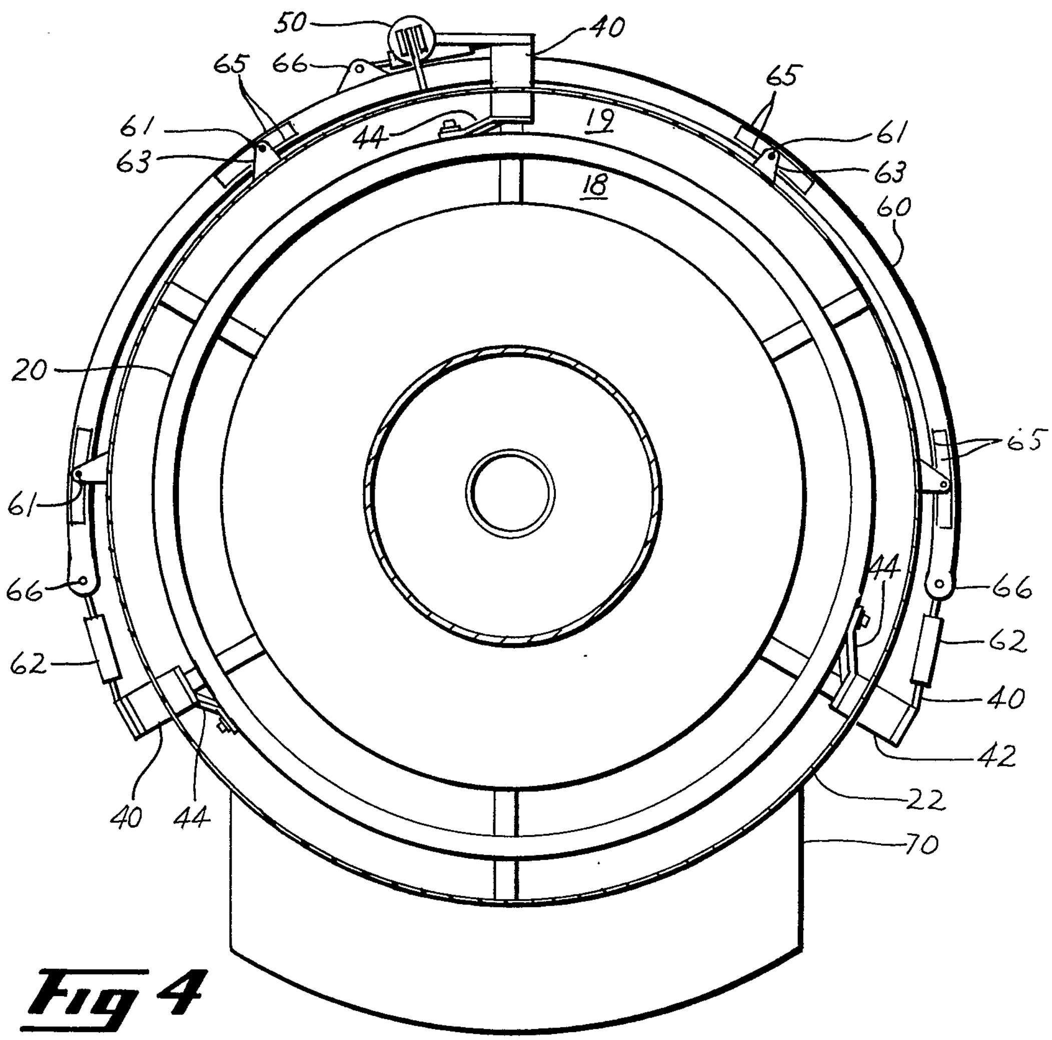
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Fig 4

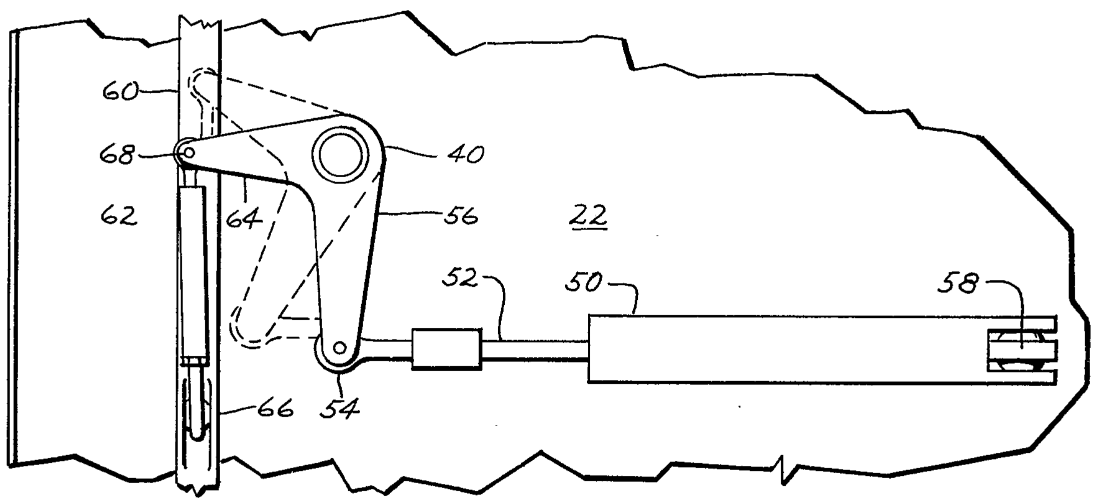
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Fig 2

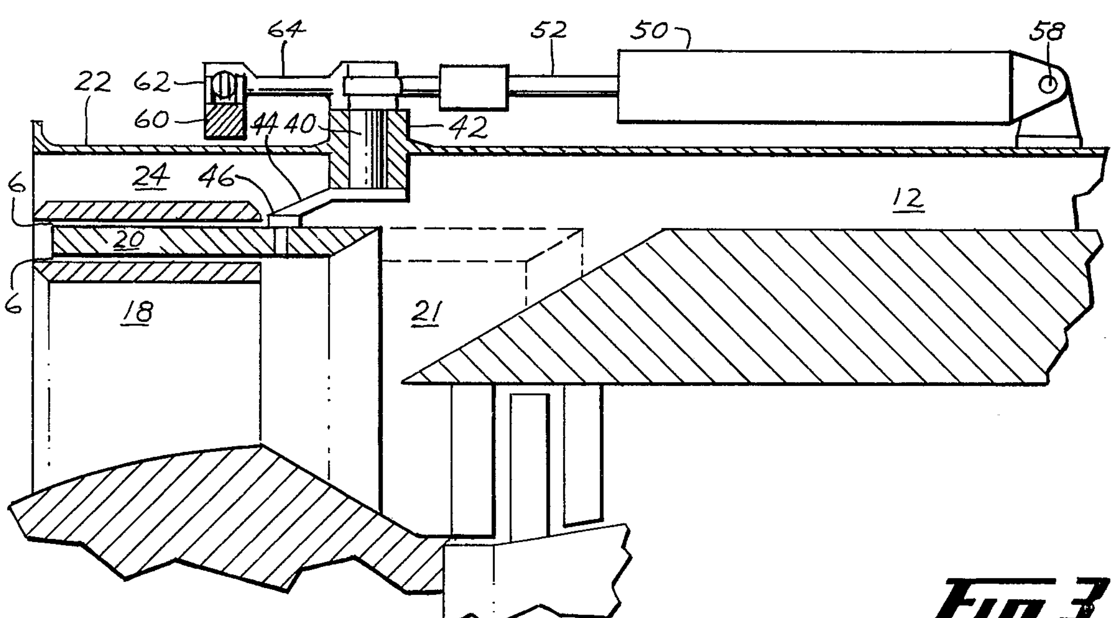
64
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Fig 3

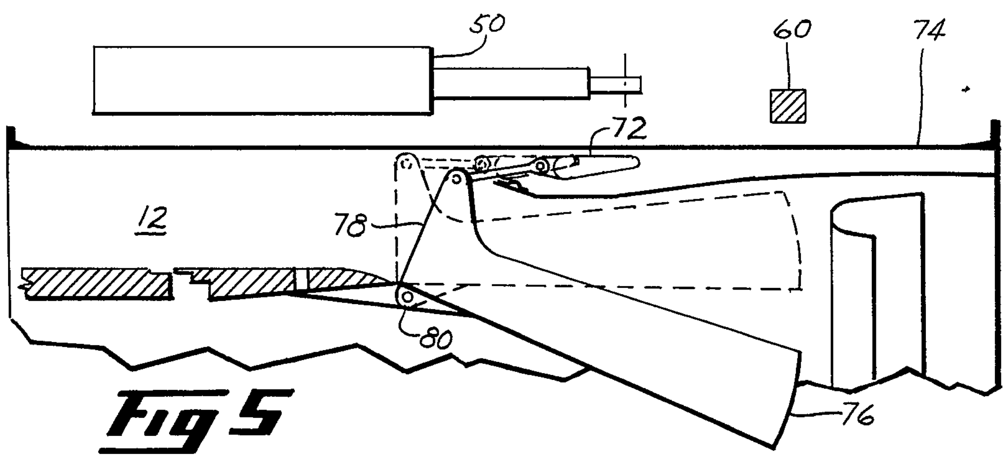

Fig 5

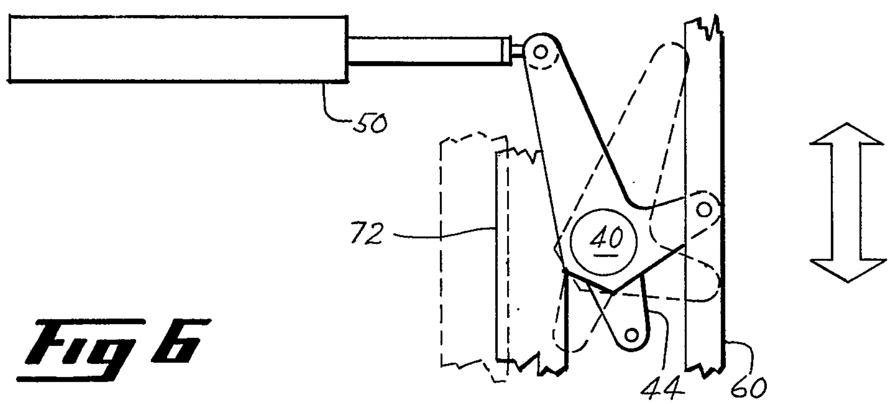

Fig 6

SPECIFICATION

Actuation system for use on a gas turbine engine

This invention relates to actuation systems for use in gas turbine engines and, more particularly, actuation systems for transferring movement of an external actuator into an interior of a gas turbine engine to actuate an internal sliding member or valve.

The development of this invention was precipitated by advanced versions of variable cycle gas turbine engines. Since the 1950's, there has been ongoing development of this type of engine for use in jet aircraft. In the variable cycle engine, relative amounts of air directed through a fan bypass cycle, as opposed to a combustion cycle, are varied under different operating conditions to improve engine performance. In one embodiment of this engine, airflow is controlled by a forward sliding valve system, called a variable area bypass injector (forward VABI), that is located in a passage between an inner and outer bypass duct, and is opened and closed to vary the amount of fan air flowing into the outer bypass duct and, therefore, bypassing the combustion cycle. An additional valve-like mechanism, called a rear variable area bypass injector (rear VABI), is provided at the end of the bypass duct for injecting bypass airflow back into the core engine flow. For a detailed description of this type of variable cycle engine, the reader is referred to U.S. Patent No. 4,068,471, issued January 17, 1978, assigned to the same assignee as the present invention, and the disclosed material of which is incorporated herein by reference.

The forward and rear bypass valves are designed to be operated by an actuating mechanism that is capable of transferring axial motion from external actuators through an outer casing of the engine to the internally mounted valve. In prior art mechanisms, this type of transfer of motion is often accomplished by multiple radial shafts extending through the engine casing. Mechanisms capable of driving a multiple radial shaft arrangement by means of two or more actuators have been developed. Well known examples that have been used on turbojet engines for many years are the systems used to actuate variable angle compressor stator vanes. Variable angle compressor stator vanes are rotated as engine speed is varied to accommodate the varying rotor discharge vector angles. These vanes are simultaneously actuated by rotating unison rings which interconnect all the vanes by means of cranks attached to the vane shanks. The vane shanks project radially through the aircraft engine casing wall so that rotating the vane shanks causes all of the vanes inside the engine to rotate through an identical angle. Motion is initiated by two symmetrically arranged actuators that rotate the unison rings.

While this type of system is ideal for rotating multiple engine stator vanes with multiple radial shafts, it has limitations where relatively few radial shafts are to be rotated in unison, as in the case of the forward and rear VABI's on the variable cycle engine. In the variable cycle engine, it is desirable to use as few as three radial shafts to actuate the valve in order to eliminate weight and complexity. When fewer radial shafts are employed, the shafts are more widely separated physically, and it is more difficult to mechanically synchronize the rotation of the shafts.

An additional problem occurs on the forward sliding valve, because it is located in the forward portion of the aircraft engine where controls and accessories necessarily occupy a considerable portion of the underside of the engine casing. The unison ring employed in previous mechanisms circumferentially surrounds the entire engine casing and therefore would occupy part of the same space. Physical interference of the ring with the controls package would result in both increased size of a surrounding envelope and in maintenance problems due to difficulty involved in assembly or removal of an actuation ring inside the controls package.

Finally, it is desirable to employ an actuation system using only one actuator to save weight and reduce complexity.

The present invention is a unique actuation system that is capable of transferring a linear notion of a single or a plurality of actuators located outside an aircraft engine casing, into an engine interior, to advance and retract a sliding member. In one embodiment of this present invention, a single actuator activates the system by rotating a single crankshaft. That crankshaft is mechanically linked to a plurality of crankshafts to rotate simultaneously. The crankshafts extend through the outer casing of the engine interior. Inside the engine, the motion is communicated from the crankshafts to an annular sliding member or valve, causing the sliding member to advance and retract axially. In one embodiment of this invention, the actuation system is used to open and close a sliding valve between inner and outer bypass ducts on a variable cycle engine.

FIGURE 1 depicts a cross-sectional view of a gas turbine aircraft engine employing the present invention;

FIGURE 2 depicts a fragmentary elevation view of the subject invention;

FIGURE 3 depicts a plan view, partly in section and partly broken away, of the subject invention in conjuction with a slide valve;

FIGURE 4 depicts a plan view of the subject invention as seen along line 4-4 from Figure 1;

FIGURE 5 depicts a plan view, partly in section and partly broken away, of one embodiment of the subject invention in conjunction with a rear variable area bypass injector; and

FIGURE 6 depicts an elevation view of the embodiment of the subject invention shown in Figure 5.

Referring now to Figure 1, a variable cycle gas turbine aircraft engine 10 is shown of the type that precipitated the development of the subject invention. This engine 10 employs multiple ducts to vary the relative amount of air directed through a bypass duct 12, rather than through combustor 13 and turbine 14, under different operating conditions to improve engine performance. The engine's capability to vary this airflow permits the engine 10 to operate in a high bypass cycle at subsonic speeds and, conversely, operate in a low bypass cycle at supersonic speeds. Variataion of the engine operating cycle in this manner greatly improves the overall operating efficiency of the engine. For a detailed description of this type of variable cycle engine, refer to the previously referenced U.S. Patent No. 4,068,471.

In engine 10, incoming air is initially accelerated by a first fan 15. An annular divider 17 splits this airflow and directs a portion of the flow through an inner bypass duct 18 and the remaining portion through an outer bypass duct 19. Air flowing through the inner duct 18 is further accelerated by a second fan 16. Because of changes in operating conditions, it is desirable to direct varying amounts of airflow from the inner duct 18, through passage 21, to the bypass duct 12. To control the amount of air flowing from the inner duct 18 into the bypass duct 12, a translating member or annular sliding valve 20, known as a forward variable area bypass injector (forward VABI) is provided in passage 21. This sliding valve 20 is retained in a forward position, as shown by solid lines in Figure 1, to permit maximum airflow to enter the bypass duct 12 under subsonic aircraft cruise conditions. As the aircraft enters supersonic operation, the valve 20 is translated to an aft position, as shown by the dotted outline in Figure 1. In the aft position, the valve 20 restricts the amount of flow entering the bypass duct 12, thereby forcing a larger volume of second fan air to enter the combustor 14 and add to the combustive flow of thrust-producing gases.

To operate valve 20, the present invention provides a simple, effective, and lightweight actuation system 30. The bulk of this actuation system 30 is located outside an outer casing 22 surrounding the outer duct 19 and the bypass duct 12. Thus, the actuation system 30 does not significantly interfere with the passage of air through the outer duct 19. Additionally, the actuation system 30 is constructed to eliminate leakage causing holes in the outer casing 22, thereby preventing any major loss of air from outer duct 24.

Referring now to Figure 2, this elevation view of the actuation system 30 shows one embodiment of the system mounted on the outer casing 22 of the aircraft engine. Only the external components of the actuation system 30 are shown, and the sliding valve 20 is hidden from view by the outer surface of the casing 22.

A plurality of rotating crankshafts 40, one of which is shown in Figures 2 and 3, are provided to transfer an actuating force or rotational movement through the outer casing 22 into the outer duct 24. A rotating crankshaft is ideal for this function because it is easily enveloped by a bushing 42 that prevents leakage airflow from escaping the outer duct 24 around the sides of the crankshaft 40.

The crankshaft shown in Figures 2 and 3 is described first because it forms the focal point of the actuation system components. The basic mechanical theory of this system 30 is to transform a linear motion outside the casing 22 into a partial rotation of each of the plurality of crankshafts 40; then inside the outer casing to transform the partial rotation of the crankshafts back into a linear, axial movement of a sliding member. In the embodiment shown in Figures 2, 3, and 4, the sliding member is a slide valve 20. The transfer of mechanical action through the outer casing 22 is particularly easy to see in Figures 3 and 4. A detailed explanation follows of the components employed to effect this transfer and of the advantages of these components.

Referring again to Figure 2, a hydraulic actuator 50, employing hydraulic pressure as an actuating force, is provided for initiating the linear motion in the actuation system 30. The actuator 50 is controlled by a separate control system, not shown, which does not form a part of the subject invention. At appropriate stages in aircraft operation, the control system causes the actuator to extend or retract an actuator rod 52. The actuator rod 52 is connected with a pin attachment 54 to an actuating crank arm 56, later referred to herein as a third crank arm. The crank arm 56 is, in turn, directly attached to one of a plurality of crankshafts 40 thereby causing partial rotation of that crankshaft upon extension of the actuator rod 52. The dashed line drawing in Figure 2 of the actuator rod 52 and crank arm 56 shows the extended position of the crank arm and the corresponding partial rotation of the crankshaft. The actuator 50 is mounted, such as with a ball and socket mount 58, to allow the actuator to pivot through a slight angle during extension or retraction of the actuator rod 52. When the actuator and actuator rod 52 are in an extended mode, the sliding member valve 20 is an "open" position, shown with solid lines in Figure 3; and, conversely, when the actuator is in a retracted mode, the valve 20 is in a "partially closed" position, shown in dashed lines in Figure 3. The manner in which this is accomplished will become apparent from the remainder of this description.

As stated earlier, in the currently described embodiment of this invention, a single actuator 50 is directly linked to a single crankshaft. Apparatus is provided for the purpose of simultaneously causing partial rotation of the remainder of the plurality of crankshafts 40 upon rotation of the single crankshaft by the actuator 50. Referring now to Figure 4, there are shown three crankshafts 40 and a single actuator 50. The primary component of the apparatus provided for synchronously actuating all of the crankshafts is an annular actuating member of yoke 60 circumferentially mounted for rotation about a portion of the outer casing 22. The yoke 60 is carried by a plurality of rollers 61 that engage concentric tracks 65 mounted on the yoke 60. The rollers are held in place with brackets 63 that are fixed to the outer casing 22. The sides of the brackets 63 interface with the track on yoke 60, and employ a friction-reducing material to allow the yoke 60 to rotate freely on the roller 61.

The yoke extends around approximately two-thirds of the casing 22, thereby leaving a lower region free of any external actuating system apparatus. Most aircraft engines occupy this space with what is commonly referred to as a controls and accessories envelope 70.

Referring now to Figures 2 and 4, the yoke 60 is linked to each of the crankshafts with individual link arms 62. The link arms are attached at their opposite ends to individual crank arms 64 extending from the crankshafts. This linkage of the yoke to the crankshafts 40 causes each of the crankshafts to rotate an equivalent amount when the yoke 60 is partially rotated around the casing 22. Thus, when the single actuator 50 directly rotates one crankshaft, the remainder of the plurality of crankshafts 40 are caused to simultaneously rotate an equivalent amount.

The link arms 62 must be attached in a manner that accommodates nonlinear movement of the link arms during partial rotation of the crankshafts 40. Therefore, in the embodiment shown, the link arms 62 are connected with a ball and socket 66 to the yoke 60 and with a ball and socket 68 to the crank arms 64.

It can now be appreciated that extension of the actuator rod 52 will cause all of the crankshafts 40 to rotate an equivalent amount. Referring now to Figures 3 and 4, a mechanism is shown for transforming this common rotational movement to a linear, axial movement of a sliding member of valve 20 within the outer casing 22. As stated earlier, the crankshafts 40 extend through the outer casing 22 into the outer duct 19. Inside this outer duct 19 an internal crank arm 44 (later referred to as a second crank arm) and attached to the crankshaft for rotation therewith, extends axially and radially inward to the valve 20. This crank arm 44 is connected to the valve with a ball and socket 46; and the crank arm 44 is elastically deflected radially to accommodate a slight change in radial position of the end of crank arm 44 relative to the engine axis as the crank arm rotates to move the valve 20 axially.

The valve 20 is sandwiched between inner and outer guides 26 for aerodynamic continuity of the flowpath. When the actuator 50 is in the extended mode, the valve 20 is in the "open" position, shown by the solid outline in Figure 3, and when the actuator 50 is in the retracted position, the valve is in the "partially closed" position, shown by the dashed lines in Figure 3.

As is readily appreciated from the foregoing description, the actuation system of the subject invention is a unique, simple, and lightweight apparatus. The advantages of this invention are useful in other applications on an aircraft engine, particularly in conjunction with a rear variable area bypass injector 24 (rear VABI) on the variable cycle engine 10 in Figure 1.

The general location of the actuation system 32 for the rear VABI is shown in Figure 1 and the components of this embodiment of the actuation system are shown in Figures 5 and 6. This includes the hydraulic actuator 50, a crankshaft 40, an outer synchronizing ring or yoke 60 and an actuation ring 72, the motion of which generally corresponds to that of the sliding valve in the forward VABI discussed earlier. In the embodiment of the actuation system 32 for the rear VABI, the actuation ring 72 is translated forward and aft by a pivoting of arms 44, shown in Figure 6, one each extending from each of three partially rotating crankshafts 40. The crankshafts 40 are mounted on an augmentor casing 74 and transmit an actuating force of the actuators 50 through the casing wall to the actuation ring 72. The initial actuating force is accomplished by three or more actuators 50 and the motion of these actuators is synchronized by means of a circumferentially moving synchronizing ring or yoke 60 that interconnects all the crankshafts 40, as shown.

Connecting elements of the actuation system 32 to a plurality of pivoting chutes 76 are shown in Figure 5. Inside the augmentor casing 74, the actuation ring 72 is linked to an upper extension 78 of each of approximately twenty chutes 76 that are symmetrically distributed around the aft end of the bypass duct 12. The chutes 76 are pivotally mounted about pivots 80 so that translation of the actuation ring 72 along with the upper extension 78 causes the chutes 76 to pivot radially in and out of the core engine flowpath. The location of the chutes 76 and the effect of their movement inside the engine can be seen in Figure 1. During engine operation, the action of the rear VABI is coordinated with the action of the forward VABI to properly direct bypass flow of fan air through the bypass duct and reintroduce the bypass flow to core engine flow prior to exhaust through the engine nozzle.

CLAIMS

1. An actuation system for translating a member internally mounted within a cylindrical outer casing of a gas turbine engine, wherein said actuation system comprises:

a plurality of crankshafts extending through said casing for transmitting rotational movement;

actuating means for rotating one or more of said crankshafts;

means for inducing synchronous partial rotation of the plurality of crankshafts upon partial rotation of one of said crankshafts, said means comprising:

(a) a crank arm extending from each of said crankshafts and rotating therewith;

(b) an annular actuating member circumferentially mounted for partial rotation around at least a portion of said casing; and

(c) a link arm corresponding to each of said crank arms, said link arms having one end pivotally attached to a crank arm and another end pivotally attached to said annular actuating member; and

means connecting each of said crankshafts to said translating member for causing translation of said member upon rotation of said crankshafts.

2. The actuation system recited in claim 1 wherein said means connecting each of said crankshafts to said translating member comprises a second crank arm extending within said casing from each of said crankshafts and pivotally connected to said sliding member to induce axial movement of said member upon rotation of said crankshaft.

3. The actuation system recited in claim 1 wherein said annular actuating member is a yoke that extends around only a portion of an outer circumference of said casing.

4. The actuation system recited in claim 3 wherein said yoke comprises dual, concentric annular bands, carried by roller cams positioned between said bands, and wherein said cams are positioned by brackets with rub pads that prevent axial movement

of said bands.

5. The actuation system recited in claim 1 wherein said outer casing circumferentially surrounds a bypass duct of a turbofan engine, and wherein said translating member is an annular sliding valve for regulating airflow through a passage from a fan section of said engine to said bypass duct.

6. The actuation system recited in claim 1 wherein said actuating means comprises a linear actuator pivotally connected to a third crank arm extending from said crankshaft.

7. An actuation system for controlling an annular sliding valve, wherein said valve regulates airflow through an annular passage connecting a fan section of a gas turbofan engine to a bypass duct and wherein said actuation system comprises:

a plurality of crankshafts for transmitting rotational motion and extending through an outer cylindrical casing surrounding said bypass duct;

an actuating means for partially rotating one of said crankshafts, comprising a linear actuator pivotally connected to an actuating crank arm extending from one of said crankshafts;

a yoke circumferentially mounted for partial rotation around a portion of said casing, wherein said yoke comprises dual concentric annular bands carried radially by roller cams positioned between said bands, and wherein said cams are positioned by brackets with rub pads that prevent axial movement of said bands;

means connecting said yoke to each of said crankshafts comprising a first crank arm extending from said crankshaft and rotating therewith, and a link arm having one end pivotally attached to said first crank arm and another end pivotally attached to said yoke wherein partial rotation of one crankshaft will induce said yoke and connecting means to synchronously rotate all remaining crankshafts an equivalent amount; and

valve connecting means comprising a second crank arm extending within said casing from each of said crankshafts and pivotally connected to said sliding valve to induce axial movement of said valve upon partial rotation of said crankshafts.

8. An actuataion system for pivoting chutes of a rear variable area bypass injector internally mounted within a cylindrical outer casing of a gas turbine engine at a downstream end of a bypass duct, wherein said actuation system comprises:

a plurality of crankshafts extending through said casing for transmitting rotational movement;

actuating means for rotating one or more of said crankshafts;

means for inducing synchronous partial rotation of the plurality of crankshafts upon partial rotation of one of said crankshafts, said means comprising an annular synchronizing ring or yoke circumferentially mounted for partial rotation around at least a portion of said casing, and means corresponding to each of said crankshafts for connecting said crankshafts to said ring wherein partial rotation of said ring will induce synchronous partial rotation of said crankshafts;

means connecting each of said crankshafts to a translating member within said outer casing for causing translation of said member upon rotation of said crankshafts;

means connecting said translating member to an upper extension of each of said chutes for translation thereof; and

a pivot upon which each of said chutes is mounted whereby translation of said upper extension causes pivoting of each of said chutes.

New claims or amendments to claims filed on 14 April 1980

New or amended claims:—

9. An actuation system substantially as hereinbefore described with reference to and as illustrated in Figs. 1 to 4 or Figs. 5 and 6 of the drawings.

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