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STATOR ADJUSTING MEANS FOR AXIAL FLOW COMPRESSORS OR THE LIKE

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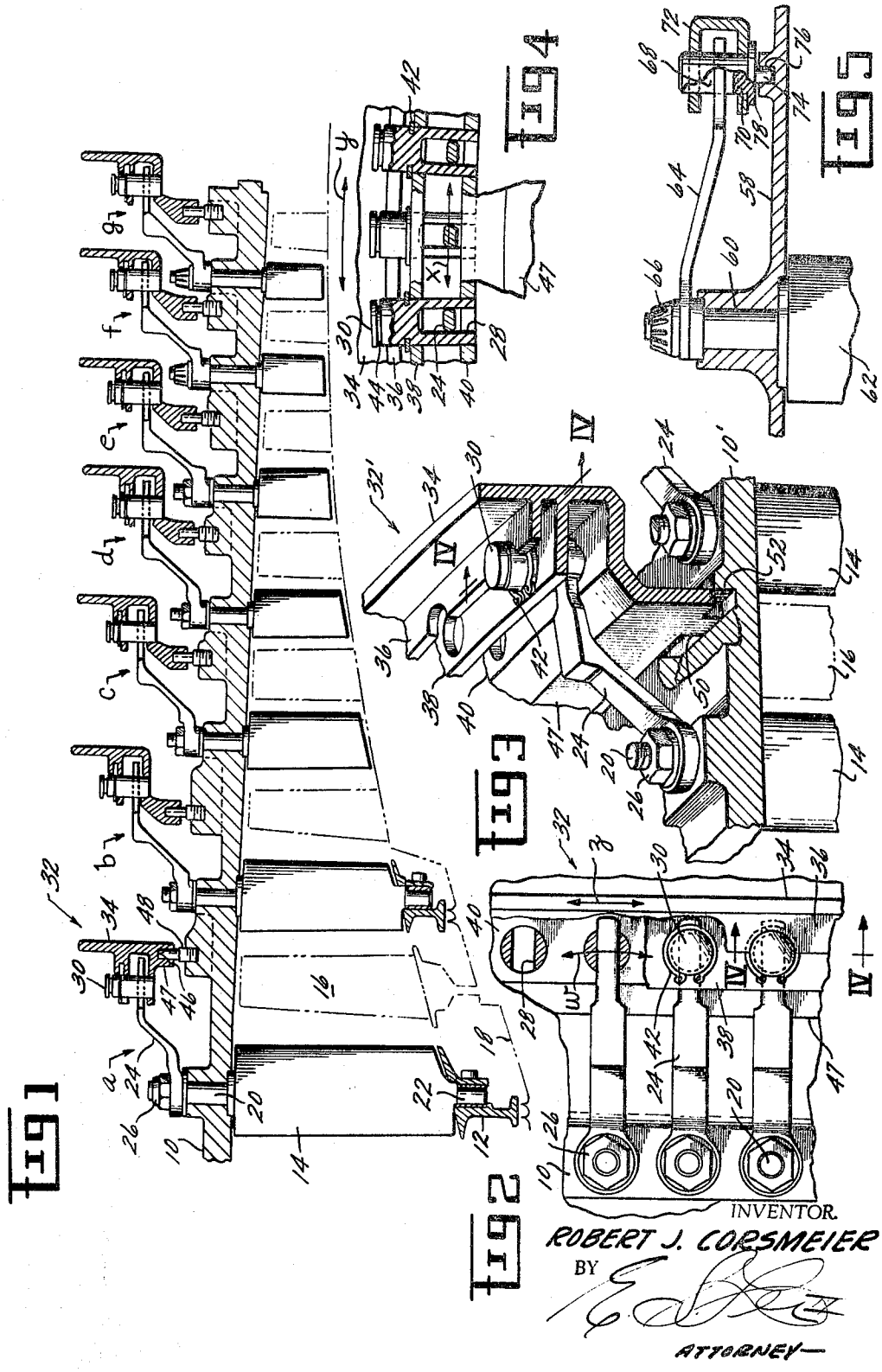


Fig 1

Fig 2

Fig 3

Fig 4

Fig 5

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STATOR ADJUSTING MEANS FOR AXIAL FLOW COMPRESSORS OR THE LIKE

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ABSTRACT OF THE DISCLOSURE

An axial flow compressor or the like includes axially spaced-apart rows of stator vanes, each vane being disposed radially and being mounted for rotation about its radial axis. Simple and economic means are provided for accurately and simultaneously adjusting the angular positions of the stator vanes.

The present invention relates to improvements in axial flow compressors and more particularly to improved means for adjusting the relative angular disposition of stator vanes employed in such compressors or the like.

Axial flow compressors, as used in gas turbine engines, generally incorporate a plurality of stages, each comprising a fixed row of radially disposed, angularly spaced stators and a row of rotating radially disposed and angularly spaced turbine blades. In order that maximum operating efficiency be obtained from the compressor, it is desirable that the stators be pivotally adjustable about a radial axis of the compressor in order that the angle of attack of the air or other gas may be properly maintained for maximum efficiency at various rates of gas flow and velocity.

Recent developments in compressor design have resulted in the successive stages of the compressor being very closely spaced in an axial sense. This has presented a serious problem in being able to obtain the necessary or desired pivotal adjustment of the individual stator blades of each stage. It has been an accepted practice to attach a lever to each stator on the exterior of the compressor housing. An actuator ring for each stage will swing these levers the necessary distance to impart the pivotal adjustment required for each of the stators in a given stage. The close axial spacing above referred to makes it difficult, if not impractical, to obtain sufficient accuracy in the pivotal adjustment of the stators for maximum efficiency and reliable operation.

Accordingly, it is an object of the present invention to provide simple and economical means for accurately and simultaneously adjusting the relative angular position of the stator vanes of a given stage in an axial flow compressor or the like, and particularly to provide such improved means which give a high degree of accuracy where the stages of the compressor are closely spaced in an axial direction.

In obtaining the broader aspects of the above ends, lever arms, disposed exteriorly of the compressor housing, are provided on each of the stators. Each of the lever arms is received by a clevis pin which is pivotally mounted in an actuator ring. Each actuator ring is guided for oscillating movement in a fixed plane disposed normal to the axis of the compressor casing. This arrangement enables a high degree of accuracy in obtaining a desired angular position of each of the stators relative to its radial axis.

This structural arrangement further enables the use of levers of a maximum length which overlies the structure of an adjacent stage of stators so as to provide the desired accuracy of adjustment where the stator stages are closely spaced in an axial sense.

The above and other related objects and features of

the invention will be apparent from a reading of the following description of the disclosure found in the accompanying drawing, and the novelty thereof pointed out in the appended claims.

In the drawing:

FIG. 1 is a fragmentary longitudinal section of an axial flow compressor embodying the present invention:

FIG. 2 is a plan view of a portion of the compressor seen in FIG. 1:

FIG. 3 is a perspective view illustrating a modified embodiment of the invention:

FIG. 4 is a section taken on line IV—IV in either of FIGS. 2 or 3: and

FIG. 5 is a longitudinal section of an axial flow compressor illustrating a modified embodiment of the invention.

FIG. 1 fragmentarily illustrates an axial flow compressor comprising an outer casing **10** and inner frame members **12**. Seven adjustable compressor stages *a*, *b*, *c*, *d*, *e*, *f*, and *g* are shown, though more or less might be used. Each stage comprises a row of stator blades **14** and a row of rotating compressor blades **16**. The compressor blades **16** are mounted on a rotor **18** and function in conventional fashion insofar as the present invention is concerned. In the following description, the structure of the various compressor stages is identified by like reference charatcers for ease of understanding and the differences in structure between stages is pointed out where appropriate.

The stators **14** are each mounted by stud shafts **20**, **22** journaled in the casing **10** and frame **12** respectively for pivotal movement about an axis extending radially from the center of rotation of the rotor **18**, i.e., the axis of the compressor which in turn is the axis of the casing **10**. The stators **14** of each stage are preferably equi-angularly spaced from each other in a plane which is generally normal to the casing axis.

A lever arm **24** is secured to the outer end of each stud **20** by a nut **26** and accurately positioned in predetermined relation relative to the contour of the stator **14** to which it is connected. The free end of each lever **24** extends into a slot **28** (FIGS. 2 and 4) formed in a clevis pin **30** associated therewith. An actuator ring **32** pivotally receives all of the clevis pins **30** for a given stage of the compressor.

The actuator ring **32** comprises an annular ring **34** disposed in a radial plane and has three concentric, spaced circular flanges projecting therefrom which are respectively identified by reference characters **36**, **38**, and **40**. The flanges **38** and **40** have holes formed therein which pivotally journal the pins **30**. The flange **36** is shorter than the flange **38** and has semicircular openings therein providing access to the holes in the flanges **38**, **40**. The pins **30** are each slotted to receive snap rings **42** employed in retaining the pins on the actuator ring **32**. A second groove indicated at **44** is formed in each of the pins **30** to facilitate its removal. Thus the snap ring **42** may be spread by the use of appropriate pliers and a screw driver or a person's fingernail may be employed to withdraw the pin **30** from the actuating ring.

Each of the actuator rings **32** is mounted for pivotal movement in a plane normal to the axis of the compressor. The means for so mounting the actuator rings may take different forms but advantageously each of the actuator rings is provided with a circumferential slot **46**, formed in an inwardly projecting flange **47**, which guidingly receives a series of angularly spaced studs **48** threaded into the casing **10**. It will, of course, be appreciated that the rings **34** may be formed of two halves and joined together to facilitate assembly.

One of the advantages of the present stator adjusting means is that the structure for adjusting one stage may

overlie the structure of an adjacent stage and thus provide the levers **24** with a sufficient length for obtaining a high degree of accuracy in the angular positioning of all the stators. The spacing between compressor stages *a* and *b* is such that the flange **47** of the actuator ring **32** is most conveniently an extension of the annular ring **34**. However, the axial spacing between the remaining stages, as for example between *e* and *f*, is such that the actuator ring **32** and the free end of the levers **24** overlie the structure of the adjacent stage in order to provide the desired lever length. This overlapping is readily accommodated by simply offsetting the flange **47** (as is the case for the rings **32** of compressor stages *b–g*) which forms a part of the cooperating groove and tongue means employed in mounting each ring **32** for oscillatory movement.

FIG. 3 illustrates an alternate form of cooperating tongue and groove means for mounting actuator rings for oscillatory movement. Thus the ring **32'** has an inwardly projecting flange **47'** on which are formed projections or feet **50** that are received or journaled in a circumferential groove **52** formed in the compressor casing **10'**. FIG. 3 illustrates that with this form of tongue and groove means the flange **47'** may also be offset so that the actuating ring **32'** overlies the structure employed for angularly adjusting the stators of the next adjacent stage.

In usual practice the stators of the several stages of an axial flow compressor are simultaneously adjusted through the use of a common lever arm or like system. Such means in the present instance may be connected to the several actuator rings **32** or the rings **32** may be individually adjusted as desired with all the attended advantages of the present invention.

In either of the embodiments of FIG. 2 or 3 there is compound movement between the levers **24** and the actuator rings **32**. This will best be understood from FIGS. 2 and 4 wherein it will be noted that the levers **24** swing arcuately along path *w* through plane *x*, while the actuator ring **32** and clevis pins **30** move through arcuate path *y* in plane *z*. The arcuate path *w* is accommodated as the clevis pins **30** oscillate in the journals on the ring **32** and project to a greater or lesser extent through the slots **28**. The depth of the slots **28** is such that there can be relative movement between the levers **24** and the clevis pins **30** in an axial sense relative to the latter to accommodate the arcuate path *y*.

It will also be noted that the free ends of the levers **24** are rounded on a diameter equal to the distance between the opposed walls of the slots **28**, so as to accommodate the relative rotational movement between the levers and the clevis pins without binding and yet maintaining a close control of the relative movement of the levers **24**.

These latter advantages are also found in the modified embodiment of the invention illustrated in FIG. 5 wherein the casing **58** pivotally receives a stud shaft **60** projecting from a stator **62**. A lever **64** is secured to the stud shaft **60** by a nut **66**. The stator **62** is illustrative of the several stators employed in a compressor stage in the same fashion as described in the previous embodiment. Each of the levers **64** of such a stage is received in a slot **68** disposed centrally and axially of a clevis pin **70** in the same fashion that levers **24** are received by clevis pins **30** in the previous embodiments.

The clevis pins **70** are pivotally mounted in an actuator ring **72** having a C-shaped cross section, the open end of which faces the adjacent stators so that the lever arms **64** may project therein. Again it is contemplated that the actuator ring may be compositely formed for convenience of assembly.

The clevis pins **70** are disposed radially of the casing **58** and are journaled in holes formed in the opposed arms of the ring **72**. Integral concentric studs **74** project respectively from the inner ends of the pins **70** and are received by a groove **76** formed circumferentially of the casing **58**. The actuator ring **72** is thus mounted for oscillatory movement in a plane generally normal to the axis

of the casing **58**. The clevis pins **70** are formed with a flange **73** which is captured between the actuator ring **72** and the portion of the housing **58** defining the groove **76** to maintain the clevis pins **70** in assembled relation on the actuator ring **72**.

It will be apparent that the levers **64** follow the same arcuate paths of movement in fixed planes as the levers **24** and that likewise the ring **72** follows an arcuate path in fixed plane, as did the ring **32**. The action of the clevis pins **70** is therefore the same in accommodating the compound movements of these members to accurately impart a desired movement to the stators **62** upon oscillation of the ring **72**. In this connection it will also be apparent that the free ends of the levers **64** are rounded in the same fashion as the free ends of the levers **24** so that there can be relative rotation between the pins **70** and levers **64** as previously described.

While the present invention has been described as it would be employed in an axial flow compressor, it will be apparent to those skilled in the art that the same concepts could also be used in adjusting the angular position of nozzle stators employed in turbines as well. This and other modifications of the invention will come within the scope of the invention which is to be derived from the appended claims.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. In an axial flow compressor or the like,
a generally cylindrical casing,
a plurality of stators disposed within said casing, each stator being pivotal about an axis radial of said casing,
said stators being arranged in a stage disposed generally in a plane normal to the axis of the casing,
each stator having a lever secured thereto, disposed exteriorly of said casing, and extending laterally from its pivotal axis,
an actuator ring mounted adjacent said stage of stators for oscillatory movement in a plane generally normal to the axis of the casing,
said actuator ring having a plurality of clevis pins mounted therein and pivotal about angularly spaced axes radial of the casing,
each of the clevis pins having a radially disposed elongated slot therein,
the levers of the stators being received in the slots of respective ones of the clevis pins such that compound relative movement can occur therebetween in the axial sense with respect to both the levers and the respective clevis pin,
whereby movement of the actuator ring will impart simultaneous pivotal movement to the stators.

2. In an axial flow compressor or the like,
a generally cylindrical casing,
a plurality of stators disposed within said casing, each stator being pivotal about an axis radial of said casing,
said stators being arranged in a stage disposed generally in a plane normal to the axis of the casing,
each stator having a lever secured thereto, disposed exteriorly of said casing, and extending laterally from its pivotal axis,
an actuator ring mounted adjacent each stage of stators, said actuator ring having a C-shaped cross section facing towards said stators with the free ends of said levers received therein,
said actuator ring having a plurality of holes disposed radially of said casing and extending through the opposed portions of its C-shaped cross section,
a plurality of clevis pins journaled at their opposite ends in the holes through the opposed portions of the actuator ring, each clevis pin embracing respectively one of said levers,

said casing having a circumferential groove underlying said actuator ring and said clevis pins having axial projections extending into said groove to provide for oscillatory movement of the actuator ring and resultant simultaneous movement of the stators.

3. In an axial flow compressor or the like,
a generally cylindrical casing,
a plurality of stators disposed within said casing, each stator being pivotal about an axis radial of said casing,
said stators being arranged in stages spaced along the length of the casing with the stators of each stage being disposed generally in a plane normal to the axis of the casing,
each stator having a generally flat lever secured thereto disposed exteriorly of said casing and extending laterally of its pivot axis,
an actuator ring mounted adjacent each stage of stators for oscillatory movement in a plane generally normal to the axis of the casing,
each actuator ring having a plurality of clevis pins mounted therein and pivotal about angularly spaced axes radial of the casing,
the free ends of the levers of the stators of each stage being embraced respectively by the clevis pins of the associated actuator ring,
said clevis pins having open ended slots with opposed parallel walls,
the side edges of said levers engaging the slot walls being rounded on a diameter equal to the spacing between said walls,
the actuator ring of at least one stage overlying the structure of an adjacent stator stage,
whereby movement of a given actuator ring will impart simultaneous pivotal movement to the stators of that stage.

4. In an axial flow compressor or the like,
a generally cylindrical casing,
a plurality of stators disposed within said casing, each stator being pivotal about an axis radial of said casing,
said stators being arranged in stages spaced along the length of the casing with the stators of each stage being disposed generally in a plane normal to the axis of the casing,
each stator having a stud shaft journaled in said casing and extending therethrough to provide for its pivotal movement,
a generally flat lever secured to the outer end of each stud shaft, and extending laterally of the pivot axis,
an actuator ring adjacent each stage of stators,

cooperating groove and tongue means on the compressor and actuator rings providing for oscillatory movement of the actuator rings in a plane generally normal to the axis of the casing,
each actuator ring having a plurality of clevis pins mounted therein and pivotal about angularly spaced axes radial of the casing,
the free ends of the levers of the stators of each stage being embraced respectively by the clevis pins of the associated actuator ring,
said clevis pins having open ended slots with opposed parallel walls,
the side edges of said levers engaging the slot walls being rounded on a diameter equal to the spacing between said walls,
the actuator of at least one stage overlying the stud shafts of an adjacent stator stage, said actuator ring being in spaced concentric relation with said adjacent stud shafts,
said one actuator ring having an inwardly projecting flange axially offset towards said one stage and forming a part of said cooperating groove and tongue means,
whereby movement of a given actuator ring will impart simultaneous movement to the stators of a given stage.

5. A combination as in claim 4 wherein
the actuator ring comprises three spaced, concentric circumferential flanges,
the inner two flanges having bores therein providing journals for mounting the clevis pins,
said levers projecting between said inner flanges and into the slots of said clevis pins,
said outer flange being relieved to permit insertion of said clevis pins into said journals,
said clevis pins each being grooved, and
snap rings received by said grooves and captured between said outer and middle flange to releasably secure the clevis pins on the actuator ring.

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