

June 11, 1957

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2,795,393

ROTORS OF MULTI-STAGE AXIAL FLOW COMPRESSORS OR TURBINES

Filed Dec. 11, 1953

2 Sheets-Sheet 1

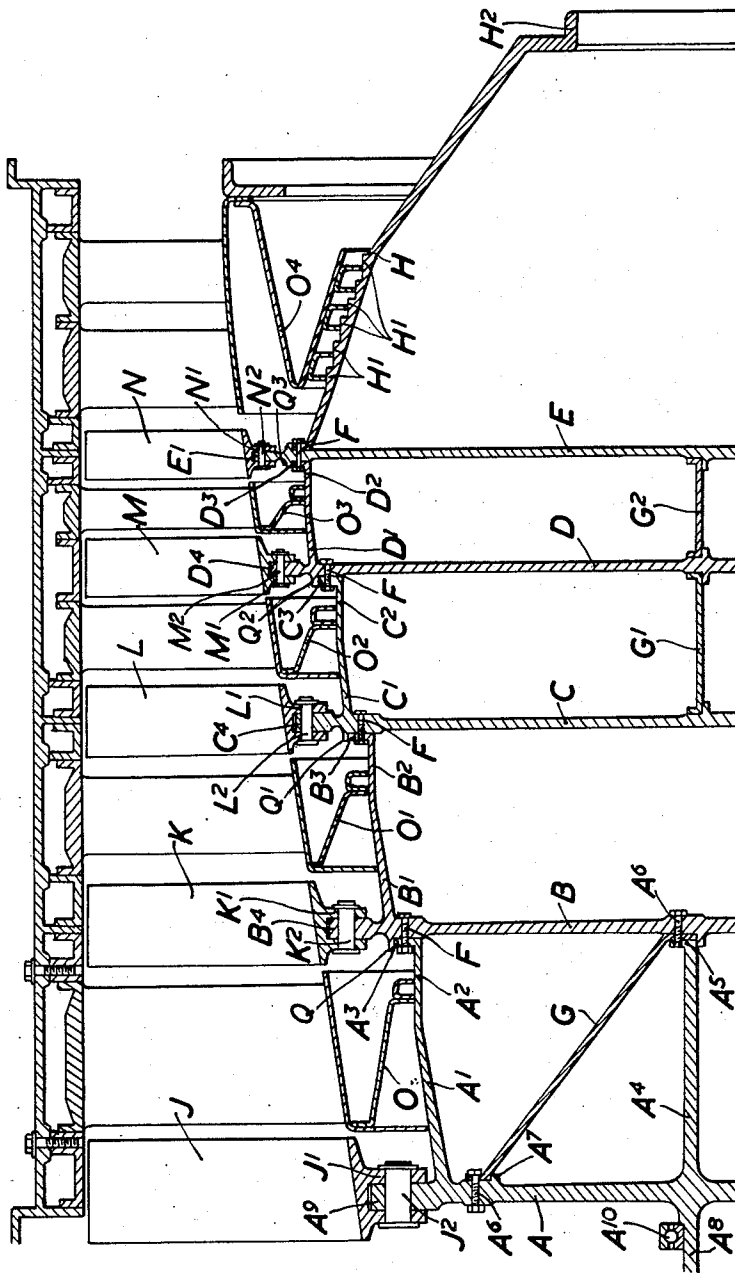


FIG. 1.

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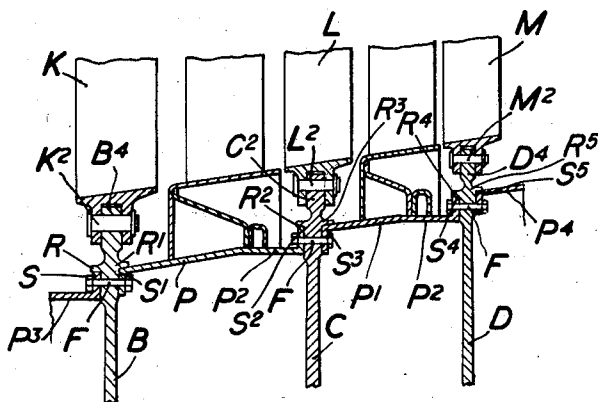


FIG. 2.

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ROTORS OF MULTI-STAGE AXIAL FLOW
COMPRESSORS OR TURBINES

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Application December 11, 1953, Serial No. 397,742

1. Claim. (Cl. 253—39)

This invention relates to rotors for multi-stage axial flow compressors or turbines, and has for its object to provide a light and yet rigid rotor construction.

A rotor construction for a multi-stage axial flow compressor or turbine according to the present invention comprises two or more axially displaced discs lying in planes normal to the axis of rotation of the rotor, tubular connecting pieces extending between each adjacent pair of discs and rigidly connected thereto, each tubular connecting piece being concentric with the axis of rotation of the rotor and having such dimensions relatively to the diameters of the discs between which it extends that the edge portion of each of such discs extends radially outwards beyond the adjacent end of the tubular connecting piece, and blades constituting a ring of blades connected to the outer edge portion of each disc, as for example by having the root portion thereof connected by one or more pins to such edge portion.

Conveniently the root of each blade is forked to receive the edge portion of the appropriate disc and is connected to such edge portion by one or more pins or the equivalent passing through the edge portion of the disc and the parts of the forked blade root lying respectively on the two sides of such edge portion.

Moreover it will generally be preferred to connect each blade root to the edge portion of its disc by a single pin about which the blade is free to swing to a limited extent under the combined influence of centrifugal force and gas reaction thereon. With such an arrangement by suitable positioning of the blade root section and tilting of the longitudinal axis of the blade relatively to the pin axis, the bending stresses due to centrifugal force and gas reaction on the blade can be largely minimised for most conditions of operation, the ideal to be aimed at being to provide for zero bending stresses at all sections of the blade.

The tubular connecting pieces extending between each adjacent pair of discs may be formed integral with one of such discs and be spigoted and bolted or riveted to the other disc, or may be formed separately from both discs and spigoted and bolted or riveted to the two discs.

In any case the male and female parts of each spigot joint will be arranged so that the fit of the parts tends to be tightened during operation by centrifugal loading, that is to say the male part is formed on the member which tends during operation to expand circumferentially relatively to the member carrying the female part.

Moreover each of the tubular connecting pieces preferably includes a cylindrical portion which can constitute a surface with which sealing means on the stator can cooperate to prevent unwanted fluid leakage between the stages of the compressor or turbine. Since in many cases the diameter of the discs will increase progressively from the low pressure stage end of the rotor to the high pressure stage end thereof, it will usually be desirable for each tubular connecting piece to have a smaller diameter at one end than at the other. Thus each tubular connecting

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piece may comprise a frusto-conical portion and an externally cylindrical portion, the frusto-conical portion providing for the desired increase in diameter while the cylindrical portion provides the desired cylindrical surface to cooperate with the sealing means referred to.

Moreover in any case in addition to the tubular connecting pieces extending between the pairs of adjacent discs, one or more tubular or other strut members and/or spacers may extend between the discs constituting one or more of the pairs at a point within the tubular connecting piece for the purpose of assisting in preventing distortion and/or vibration of the discs.

It will be realised that in rotor constructions according to the invention the need for a normal central rotor shaft is obviated.

The details of construction may vary considerably according to the requirements of each individual case but one construction according to the invention as applied to a five-stage compressor is shown by way of example together with a modification thereof, in the accompanying drawings, in which—

Figure 1 is a sectional side elevation in a plane containing the axis of the rotor, the arrangement being shown in half section for convenience of illustration on an adequate scale, and

Figure 2 is a scrap sectional view showing a modification of the construction shown in Figure 1.

In the construction shown in Figure 1 the rotor comprises five spaced parallel discs A, B, C, D and E, the discs A, B, C and D each having formed integral with it a tubular connecting piece A¹, B¹, C¹, D¹. The discs lie in planes normal to the axis of rotation of the rotor while the tubular connecting pieces are concentric with respect to such axis. Each of the tubular connecting pieces A¹, B¹, C¹ and D¹ has a frusto-conical part at the end adjacent to the disc with which it is formed integral, and a cylindrical section, A², B², C², D², adjacent to its other end, terminating in a flange A³, B³, C³, D³.

Each of the discs B, C, D and E is provided on its appropriate face with an annular rib Q, Q¹, Q², Q³, forming with the adjacent flange A³, B³, C³ or D³ a spigot joint of which said flanges constitute the male parts, by which spigot joints, therefore, the discs A, B, C and D and the tubular distance pieces A¹, B¹, C¹ and D¹ are maintained concentric and coaxial with one another, the flanges being rigidly secured to the discs which they engage by means of rings of axial bolts F.

Formed integral with the disc A is also a tubular strut part or spacer A⁴ extending between the discs A and B and connected to the disc B by a spigot joint and bolts as indicated at A⁵, A⁶. In addition a frusto-conical strut member or spacer G extends, as shows, between the discs A and B to assist in preventing distortion and/or vibration of the discs, and is connected at one end by the spigot joint A⁵ and the bolts A⁶ to the disc B and at its other end by a spigot joint A⁷ and bolts A⁸ to the disc A.

In addition tubular strut members or spacers G¹, G² extend respectively between the discs C and D to assist in preventing distortion and/or vibration of the discs, and the discs D and E and are located on the discs between which they extend by spigot joints as shown.

Rigidly connected to the face of the disc E remote from the disc D by a spigot joint and the bolts F associated with the spigot joint D² is a connecting piece H of generally frusto-conical form having a series of step-like cylindrical surfaces H¹ formed thereon and provided at its smaller end with a tubular flange H² by which it can be connected to one end of a turbine shaft or the equivalent.

The disc A is also provided with a tubular extension A⁸ by which it can be supported in a suitable bearing as indicated at A¹⁰. Each of the discs A, B, C, D and E has a rim portion, A⁹, B⁴, C⁴, D⁴, E¹, which extends radially

outwards beyond the adjacent tubular connecting piece or pieces A¹, B¹, C¹, D¹, and a ring of rotor blades J, K, L, M, N, is connected to each of these rim portions as shown each blade having a forked root J¹, K¹, L¹, M¹, N¹, the sides of which lie on opposite sides of the rim portion of the disc and are connected to it by a single pin J², K², L², M², N² passing through bores respectively in the disc and the root portion and on which the blade is free to rock to a limited extent. The disposition of each pin J², K², L², M², N² in relation to the longitudinal axis of its blade and the blade root section is such that bending stresses on the blade due to centrifugal force and gas reaction are largely eliminated.

The various spigot joints between the parts A¹, B, B¹, C, C¹, D, D¹, E, H, G, G¹ and G² are so arranged, as regard the parts on which the male and female parts of each spigot joint are respectively formed, that in operation the loads imposed on the parts by centrifugal force will tend to cause greater expansion of the male part on each spigot joint than of the female part. Thus, for example it will be seen that in the spigot joint between the parts A and G the male part is on the disc A which, being relatively heavily loaded centrifugally during operation, will tend to expand more than the adjacent end of the conical strut member G. Thus centrifugal force tends to tighten the spigot joints during operation.

Small bleed holes (not shown) will preferably be provided between the spaces between the discs A, B, C, D and E to prevent the risk of pressure build-up in these spaces, as for example when rapid changes in altitude or operating conditions occur.

In the construction shown the stator assembly, within which the rotor assembly is mounted, is constructed in accordance with the invention forming the subject of co-pending British patent application No. 17,413 of 1952 with the various blade rings of the stator carrying annular sealing members O, O¹, O², O³ and O⁴ provided with sealing parts cooperating, as shown, with the parts A², B², C², D² and H¹ of the rotor to limit unwanted flow of working fluid between the stator blade rings and the rotor.

It is to be understood, however, that the form of stator assembly shown is shown by way of example only and that rotor assemblies according to the present invention may be employed with other forms of stator assembly.

It will, moreover, be readily understood that in constructions according to the invention any one or more of the tubular connecting pieces extending between the discs may either be formed integral with one of the two discs between which it extends or may be formed separately from each of these discs and connected to each of the two discs by a spigot or like joint and bolts, rivets or the like, while the tubular strut members, when provided, may either be connected at one or both of their ends to the discs between which they extend or may merely make a close fit with appropriate locating surfaces on these discs so as to be held in position without being positively connected to the discs.

Thus, in the modification shown in Figure 2 of the accompanying drawings, which is to be regarded as applied to a structure of rotor otherwise similar to that shown in Figure 1, the discs constituting each of the pairs B, C and C, D are connected to one another by a tubular connecting piece P or P¹ the ends of which are connected to the appropriate discs by means of spigot joints, and bolts F. The spigot joints comprise respectively female parts R, R¹, R², R³, R⁴, R⁵ on the discs and male parts S, S¹, S², S³, S⁴, S⁵ constituted by flanges on the ends of the tubular connecting pieces. The connecting pieces P and P¹ moreover includes cylindrical parts P² similar to the parts B² and C² of the connecting pieces B¹ and C¹ in Figure 1 and cooperating with the sealing members C¹, C². In Figure 2 it is also assumed that the connecting pieces A¹ and D¹ of Figure 1 have been replaced by connecting pieces P³ and P⁴ formed separate respectively from the discs A and B and from the discs D and E and connected by spigot joints and bolts to the discs between which they extend.

What we claim as our invention and desire to secure by Letters Patent is:

A rotor construction for a multi-stage axial flow compressor or turbine comprising at least two axially displaced discs lying in planes approximately normal to the axis of rotation of the rotor, tubular connecting pieces extending between each adjacent pair of discs and rigidly connected thereto, each tubular connecting piece being concentric with the axis of rotation of the rotor and having such dimensions relatively to the diameters of the discs between which it extends that the edge portion of each of such discs extends radially outwards beyond the adjacent end of the tubular connecting piece, each tubular connecting piece being separate from at least one of the discs between which it extends, being located concentrically with respect to that disc by a spigot joint and connected to the discs at a radial diameter greater than the diameter of the said tubular connecting pieces by a series of axially extending bolts the heads of such bolts being accessible from outside the rotor and the outer edge portion of each disc being separately formed to independently support the root portions of a ring of rotor blades, and including at least one unstressed tubular strut member extending between at least one adjacent set of discs at a point within the tubular connecting pieces.

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