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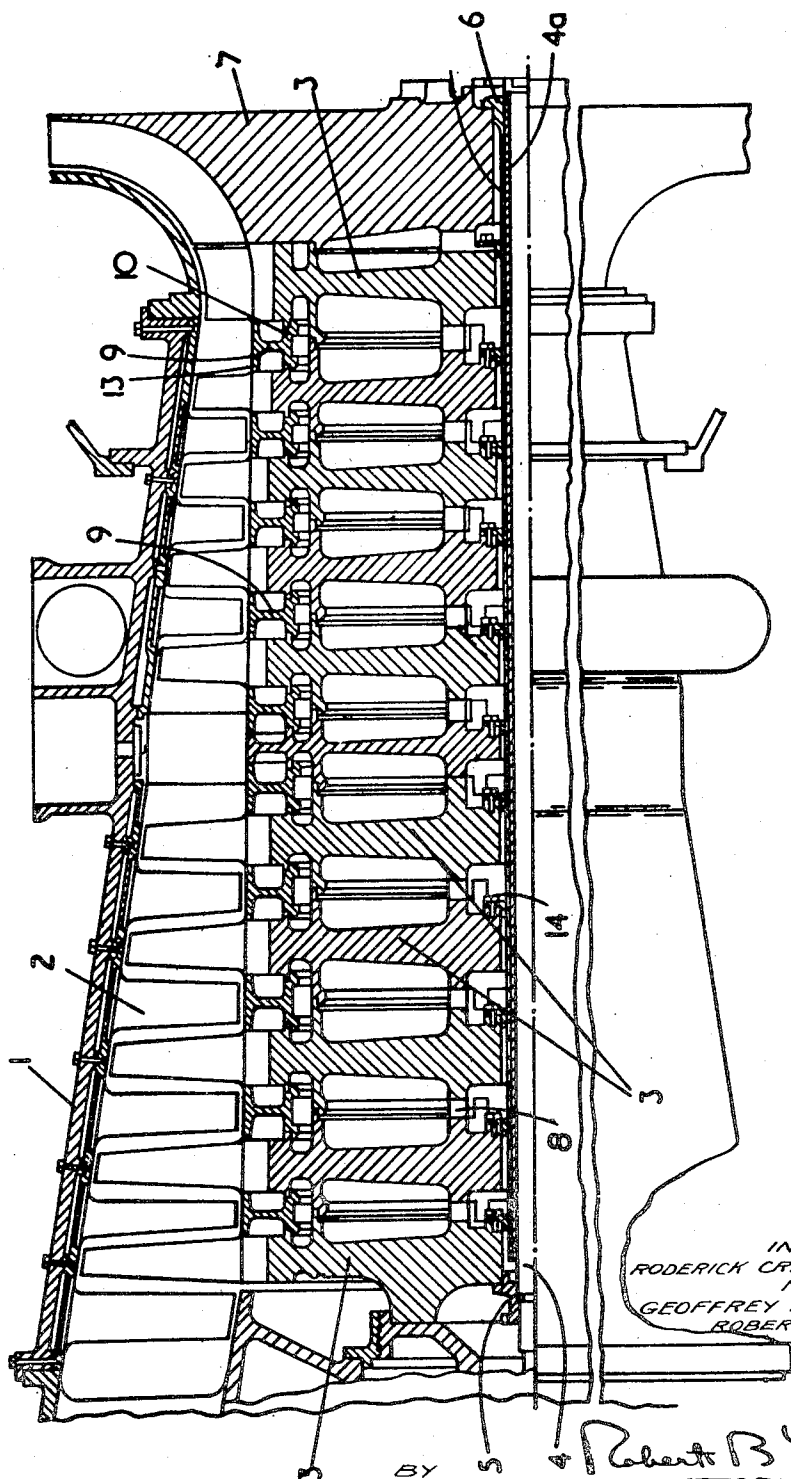
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CONSTRUCTION OF ROTORS FOR COMPRESSORS
AND LIKE MACHINES

2,452,782

Filed Jan. 15, 1946

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FIG. 1



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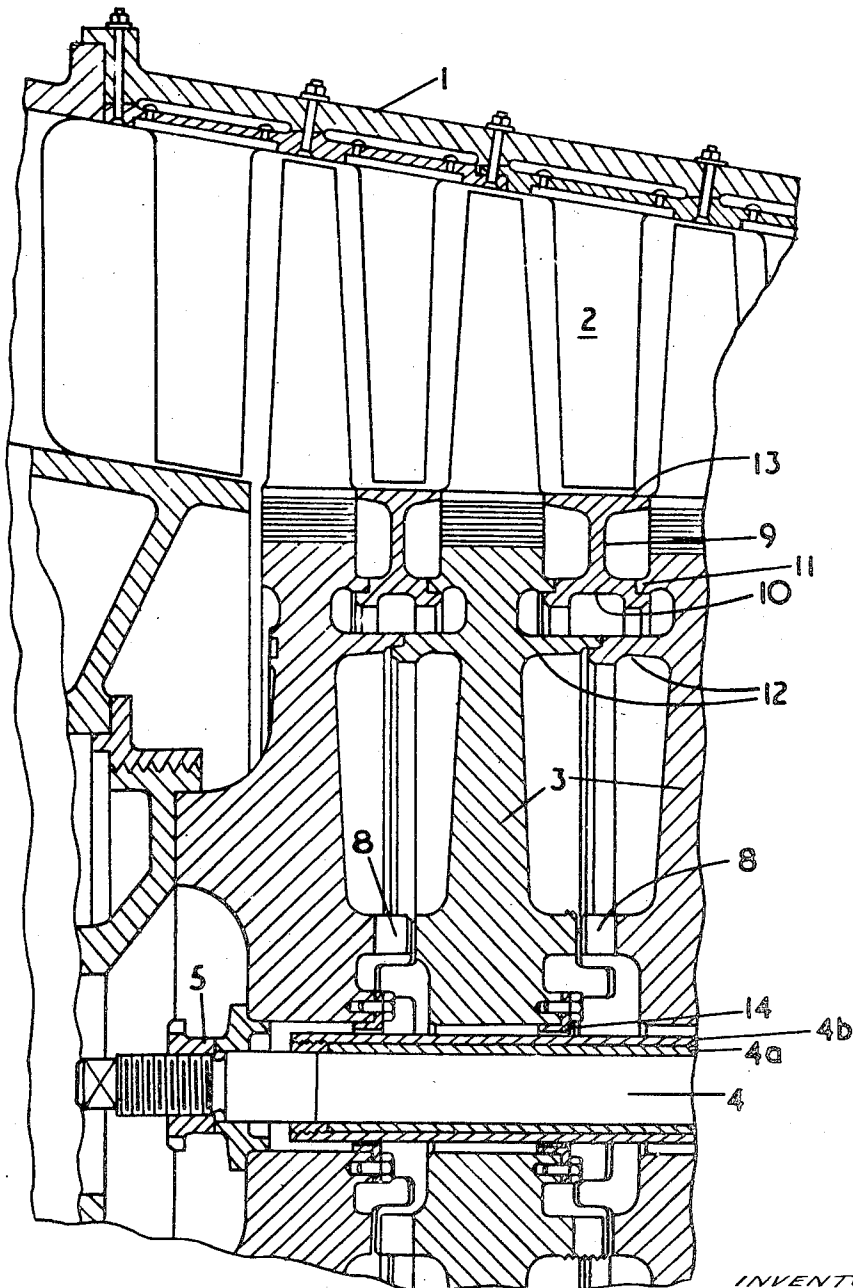
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FIG.2



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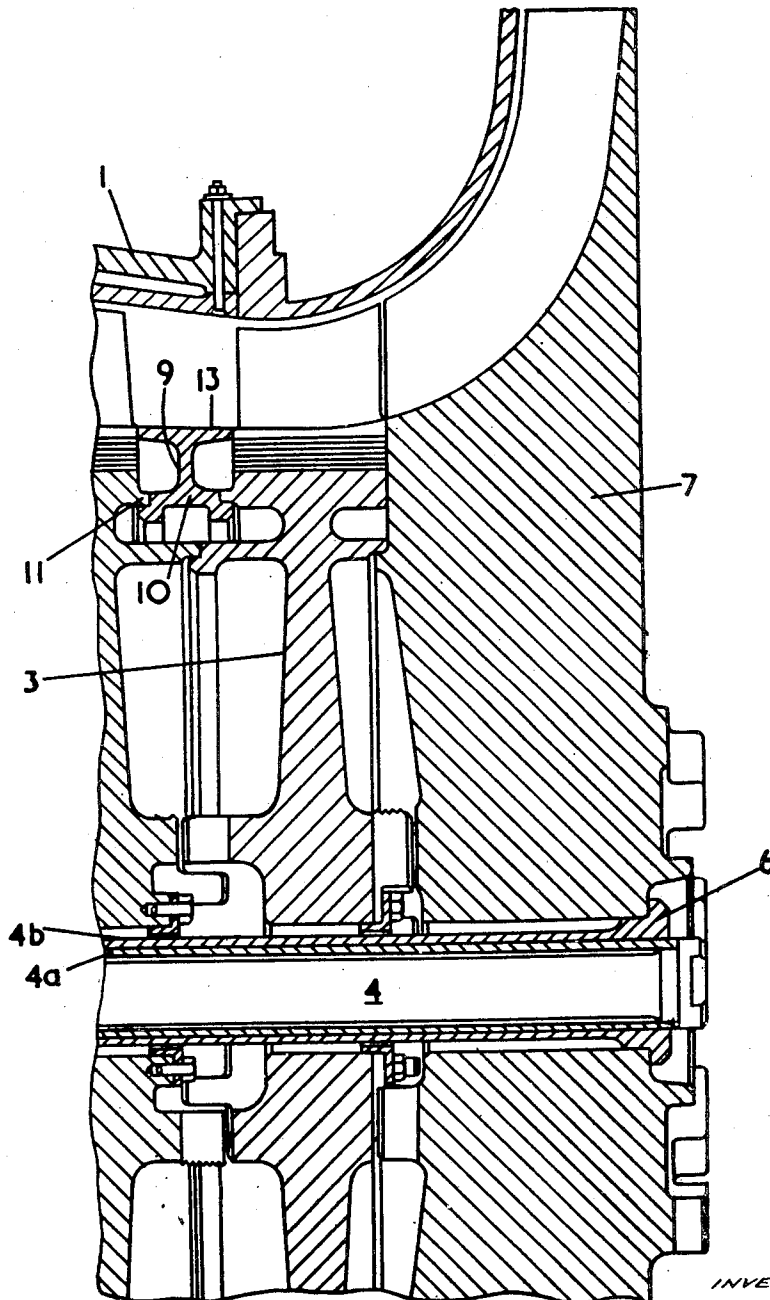
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Filed Jan. 15, 1946

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FIG. 3



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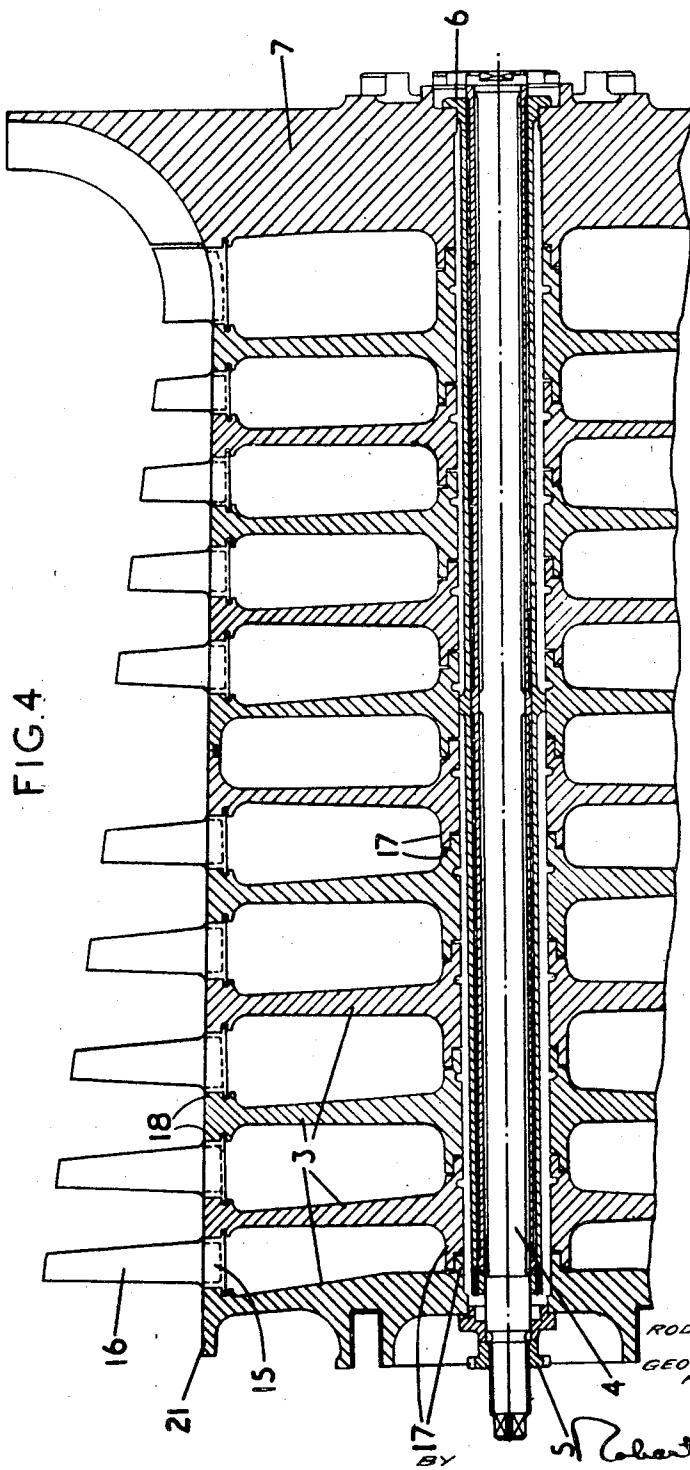
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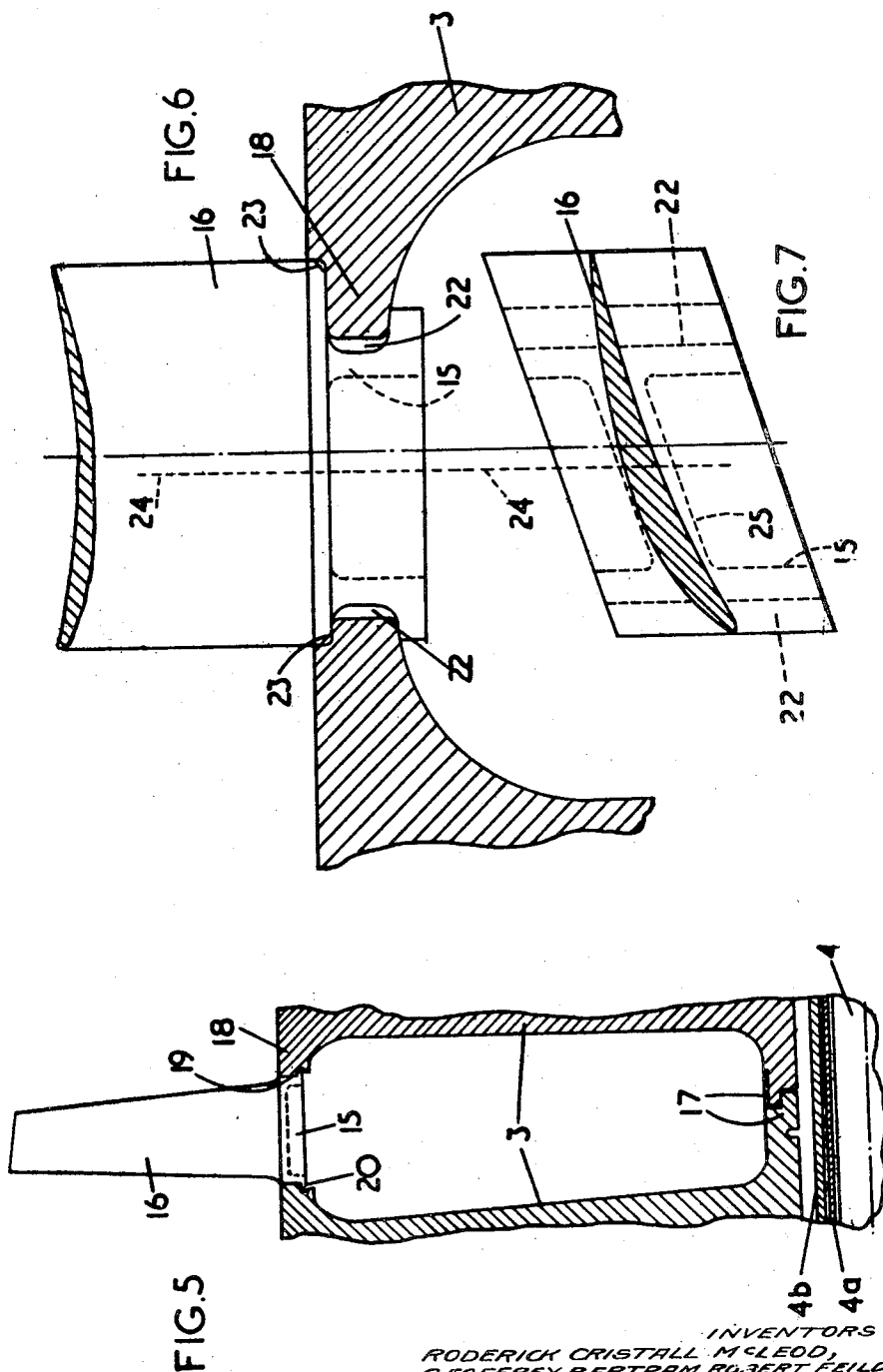
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2,452,782

CONSTRUCTION OF ROTORS FOR COMPRESSORS AND LIKE MACHINES

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Application January 15, 1946, Serial No. 641,305
In Great Britain January 16, 1945

3 Claims. (Cl. 230—134)

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This invention relates to the construction of rotors for multistage axial flow compressors, turbines and like machines. It has special, though not exclusive, application in the construction of a rotor for a compressor or turbine which is to form an element in a gas turbine engine suitable for aircraft propulsion, in which the requirements of robust construction allied to light weight are of importance. The invention lends itself to accuracy of manufacture, freedom from distortion, facility in the attachment of blading and assembly or removal of individual parts, which being broken down into comparatively small units are capable of close inspection. The construction also lends itself to the uniform distribution of temperature by virtue of the provision of favourable internal cavities in which air may be circulated or set in relative motion to act as a convective or cooling agent.

According to the invention a rotor comprises a plurality of axially spaced substantially disc-type wheels each carrying peripherally in axially extending root anchorages at least one row of blades fabricated separately from the wheel, which takes the whole centrifugal load of such blading, the wheels surrounding a tensioning element lying on the axis of rotation and being separably held together by compressive stress applied by said element, abutment means located radially inwardly of the blade roots but towards the wheel peripheries and transmitting the whole of such compressive stress, and shroud rings between the peripheries of adjacent wheels to fill the spaces between adjacent blade rows and to locate the latter axially.

According to a further feature of the invention the shroud rings have radially outer and inner concentric axially extending flanges of which the outer forms the shroud and the inner has with the adjacent wheels complementary interengagement providing for its location and abutment in the radial sense and for the transmission of centrifugal stress thereon to said wheels.

The discs or wheels may have at or towards their hub portions complementary radially locating or/and torque-transmitting formations which, however, are arranged to have an axial clearance to ensure that they do not take part in the transmission of the compressive stress applied by the tension element.

Other and more detailed features of the invention will appear from the following description with reference to the accompanying drawings, which illustrate by way of example one construc-

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tional embodiment of the invention, and in which

Fig. 1 is a part longitudinal section of an axial flow compressor having a rotor constructed in accordance with one form of the invention;

Figs. 2 and 3 are enlarged details of parts of Fig. 1;

Fig. 4 is a part longitudinal section of a rotor of an axial-centrifugal compressor constructed in accordance with another form of the invention;

Fig. 5 is an enlarged detail of part of Fig. 4;

Figs. 6 and 7 are detail views illustrating a modified form of blade root and mounting suitable for the construction of Figs. 4 and 5.

Referring to Figs. 1 to 3, it will be seen that the compressor comprises a casing 1 mounting stator blading 2 (which forms no part of the present invention), and a rotor comprising a plurality of substantially disc-type wheels 3 each carrying peripherally in axially extending root anchorages a row of separately fabricated blades and mounted in the form of a pack which is held together by the compressive stress applied by a tension element 4 passing through the hollow centres of the discs and having a tensioning nut 5 bearing on the last disc at one end and a head 6 bearing on the other end of the rotor, which in this case is formed by an additional disc 7 providing a centrifugal impeller stage of the compressor. The discs 3 have near their hubs complementary interengaging dogs 8 to ensure adequate torque-transmitting coupling between the discs, but these dogs have a clearance in the axial direction so that they do not transmit any of the compressive stress applied by the tension element. That stress is transmitted entirely near but not at the periphery of the discs by abutment means located radially inwardly of the blade roots, for example by the axially abutting engagement of the radially inner flanges 10 to skeleton I-section rings 9 with peripheral shoulders 11 on the discs 3. These flanges 10 and shoulders 11 also have a formation such that the rotors and rings are located and abut in the radial direction. By this means there is a distribution of the stress due to centrifugal force such that the rings are in part reinforced by the discs, a feature which may be of considerable importance when operating at high speeds, particularly with a rotor of light alloy construction. The radial location may be supplemented by complementary formations on annular ribs 12 on the discs. These ribs may also be used instead of the ring flanges 10 to take the axial compressive stress, the rings 9 then acting merely as shrouds between blade stages. If, as described, the ring flanges 10 take the com-

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pressive stress, the formations of the ribs 12 will have an axial clearance so as not to take part in the transmission of the compressive stress applied by the tension element. On the other hand, axial clearance may be provided between ribs 11 and the inner flanges 10 of the rings 9 so that all of the compressive stress is transmitted through annular ribs 12.

The radially outer flange 13 of each ring 9 is made of the same peripheral diameter as the adjacent discs so as to form a shroud in axial register therewith at its edges, so providing that the general profile of the fluid passages through the blades has a smooth continuous contour. Again, although the outer flanges 13 are not used for transmission of the compressive stress, they are close enough to the discs 3 to ensure axial location of the blade roots therein, particularly after the parts have expanded due to heating in use.

The central bores of the discs 3 through which the tension element 4 extends, are provided with rings 14, which may be split for ready insertion, which come into use for purposes of extraction during dismantling, these rings offering a step or surface in the axial direction and being intended to be engaged by a tool forming part of an extractor, the other part of which engages a threaded member mounted for the purpose on the hub portion of the end discs.

In the form of the invention illustrated in Figs. 4 and 5 which show a multi-stage axial compressor followed by a centrifugal impeller the construction has been considerably simplified and lightened as compared with the previous arrangement, the fundamental difference being that in the present case the function previously performed by the spacing rings 9 is fulfilled by the roots 15 of the blades 16. Thus, the discs 3, which are held together as a pack as before by a tension element 4, have at their hubs complementary spigot and socket formations 17 to locate the parts radially and transmit centrifugal stress, but which, however, have an axial clearance so as not to transmit any compressive stress. The hubs also have internal grooves to co-operate with a disc or wheel extracting tool. At their peripheries the discs 3 have flanges 18 which are spaced axially by the blade roots 15, the latter and the discs abutting at 19 for the transmission of the compressive stress, and the roots having also shoulders 20 engaging with an axial clearance in corresponding recesses of the discs 3 to offer radial location to take centrifugal stress.

The discs 3 forming the left hand end of the rotor as viewed in the drawing is dished so that under the influence of centrifugal force when running it will tend to straighten and thus supplement the compressive stress transmitted axially of the rotor by the discs and blade roots. It also has an axially extending flange 21 the dimensions of which are adjusted so as to produce under the influence of centrifugal force a bending moment at the rim of the disc opposing and compensating for the bending load due to the first row of blading at the same point.

The construction illustrated in Fig. 4 is of course applicable also to a purely axial compressor in which case the end disc at both ends of the rotor will be provided with an axially extending flange.

As can be seen, the blade roots are of hollow formation, thus enhancing the lightness of the structure.

In the modified blade root and mounting illustrated in Figs. 6 and 7 (which in fact is the pre-

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ferred form) the axially outermost points at which the root walls 15 meet the blade proper, and through which the centrifugal stress is transmitted from the blade 16, are axially inset from the axially outermost points of the line of junction between the blade and root, with the object of obtaining a wider distribution of the stress path between blade and root. The centrifugal stress due to the blade is taken by the discs 3 through the entry of their flanges 18 with axial clearance into a groove formation at 22 in the sides of the roots, and the compressive stress due to the tensioning element 4 by the abutment of the upper part of the root without axial clearance at 23 with rebated portions of the flanges 18. The blade and root are also so arranged that the line of action 24—24 of the centre of gravity of the blade lies in the median plane of the gap between adjacent discs 3, and a stiffening rib 25 is provided in the hollow root to minimise outward bowing of the blade platform due to centrifugal force during running.

It will be noted that ample internal cavities are afforded which may be used either for the forced or natural circulation of cooling air, or for the bleeding of air under pressure from any stage of the compressor, for example through the passage formed within the disc hubs.

It should be observed that the tension element 4 must have appreciable elasticity and to achieve this without the use of springs the tension element is made up of a central member 4, upon which the tensioning nut 5 is threaded, attached at its other end to an intermediate compression sleeve 4a which extends back along the member 4 almost to the nut 5 and is there attached to an outer tension sleeve 4b which extends away from the nut 5 again and carries the head 6 by which the tensioning element is anchored. By means of this arrangement, the inner and outer members 4, 4b, are placed in tension and the intermediate sleeve 4a in compression, and the effective length of the element as a whole, and thus its effective elastic movement, are substantially trebled.

As a further modification, the blades may be secured or formed together in groups of two or more by suitable connecting means or members, or all the blades may be so secured or formed together.

We claim:

1. A rotor for a multistage axial flow compressor, turbine, or like machine, comprising a plurality of axially spaced substantially disc-type wheels each having peripheral blade root anchorages formed by seating recesses extending axially from side to side thereof, at least one row of blades fabricated separately from the wheel and having roots engaged in said recessed anchorages with said wheels taking the whole centrifugal load of such blading, said blade roots and seatings having complementary axially extending blade retaining formations permitting axial entry and removal of the blades to and from said seatings, a tensioning element lying on the axis of rotation surrounded by said wheels and separably holding said wheels together by compressive stress, abutment means located radially inwardly of the blade roots but near the wheel peripheries and transmitting the whole of such compressive stress, and shroud rings between the peripheries of adjacent wheels to fill the spaces between adjacent blade rows and to locate said blades axially.

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2. A rotor as claimed in claim 1, wherein each shroud ring has radially outer and inner axially extending concentric flanges of which the outer forms the shroud and the inner is in axial abutment with the adjacent wheels to constitute said abutment means transmitting said compressive stress, said wheels being dimensioned to provide axial clearance with respect to adjacent wheels at all times.

3. A rotor as claimed in claim 1, wherein each shroud ring has radially outer and inner concentric axially extending flanges of which the outer forms the shroud, and complementary interengaging structure formed on said inner flange and the adjacent wheels providing location and abutment of the ring in the radial sense and for the transmission of centrifugal stress thereon to said wheels.

4. A rotor as claimed in claim 1, wherein each shroud ring has radially outer and inner axially extending concentric flanges of which the outer flange forms the shroud, and complementary interengaging structure formed on said inner flange and the adjacent wheels providing location and abutment of the ring in the radial sense and for the transmission of centrifugal stress thereon to said wheels, and means forming part of the interengaging structure formed on said inner flange and the wheels constituting said abutment means for transmitting said compressive stress, said wheels being dimensioned to provide axial clearance with respect to adjacent wheels at all times.

5. A rotor as claimed in claim 1, said abutment means comprising axially abutting parts carried by the wheels radially inwardly of the shroud rings to transmit said compressive stress, said shroud rings being dimensioned to provide at all

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times axial clearance between themselves and the wheels.

6. A rotor as claimed in claim 1, said abutment means comprising axially abutting parts carried by the wheels radially inwardly of the shroud rings to transmit said compressive stress, said shroud rings being dimensioned to provide at all times axial clearance between themselves and the wheels, and complementarily engaging structure in the radial sense on said axially abutting parts for relative radial location of the wheels.

7. A rotor as claimed in claim 1, wherein the shroud rings are of skeleton construction forming air chambers between themselves and the peripheral parts of the wheels.

8. A rotor as claimed in claim 1, wherein the discs or wheels have in the vicinity of their hub portions complementary formations having at least one of the two functions of radial location and torque transmission, and which have an axial clearance to ensure that they do not take part in the transmission of the compressive stress applied by said tension element.

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