

[54] **AXIAL POSITIONER AND SEAL FOR COOLED ROTOR BLADE**
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[22] Filed: **Aug. 27, 1971**
[21] Appl. No.: **175,590**
[52] U.S. Cl. **416/95**
[51] Int. Cl. **F02d 5/08**
[58] Field of Search. 416/92, 95, 96, 97, 416/220, 221

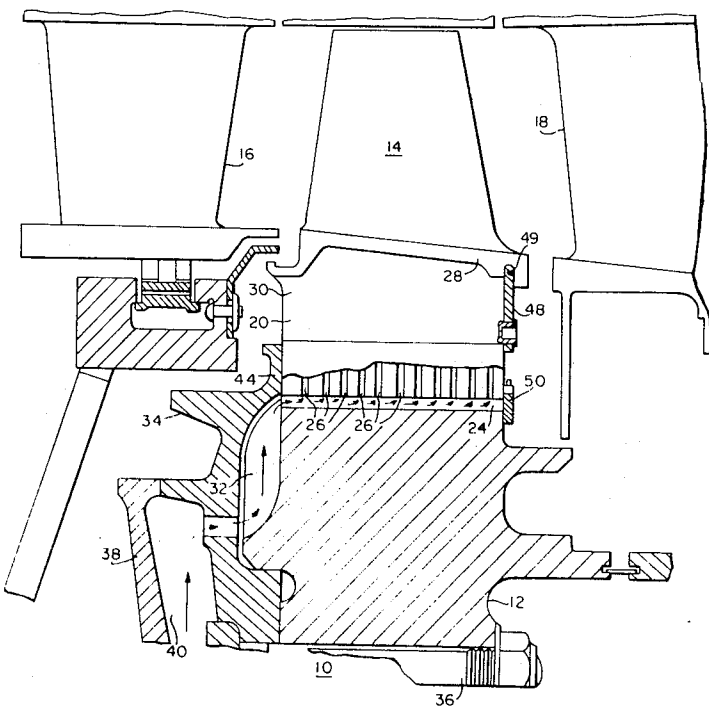
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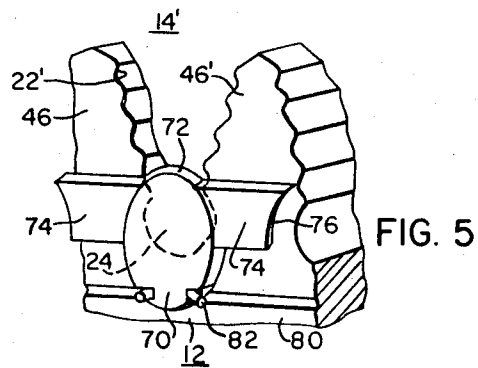
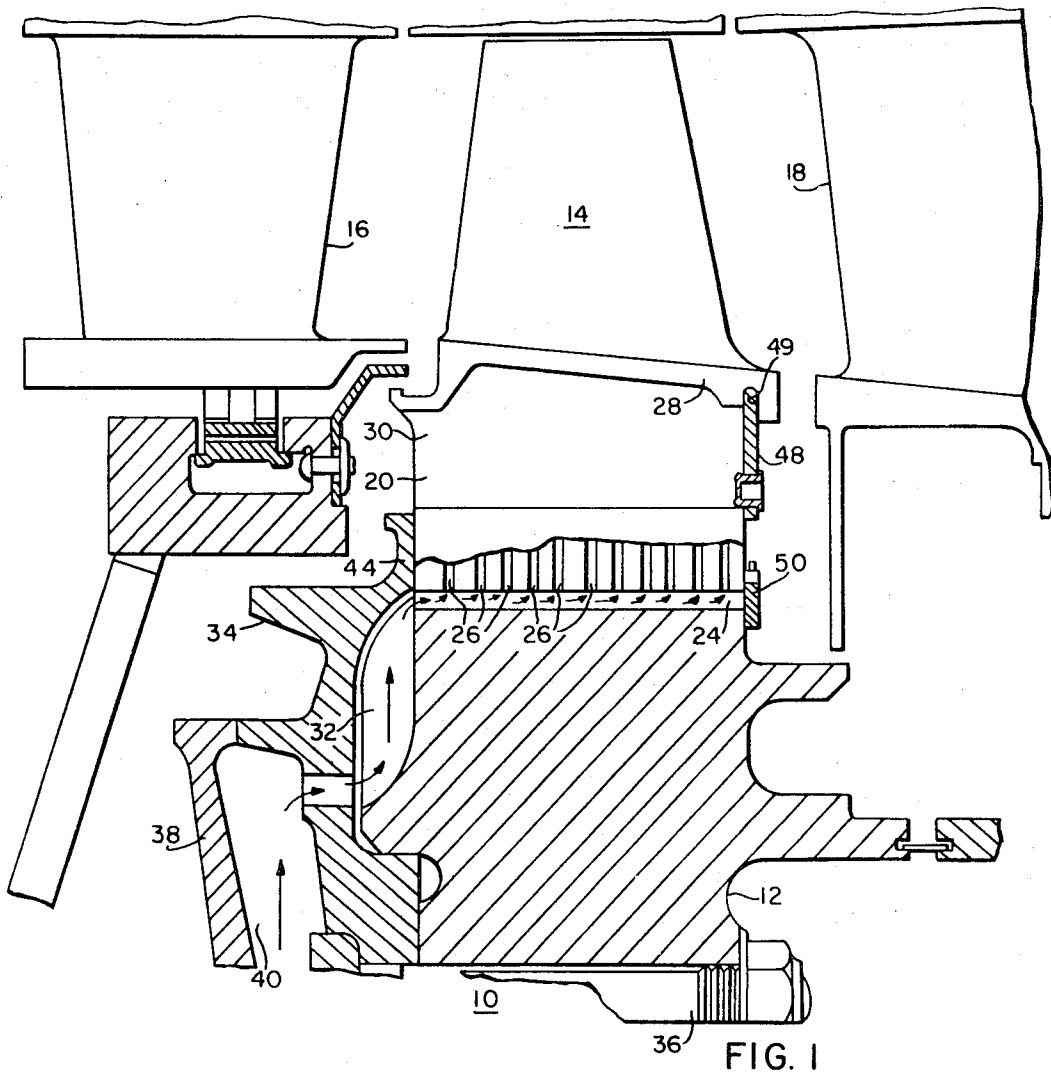
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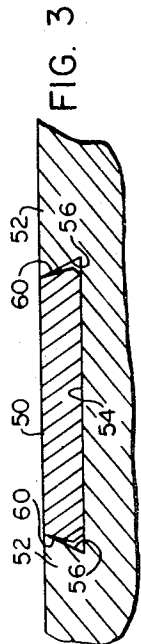
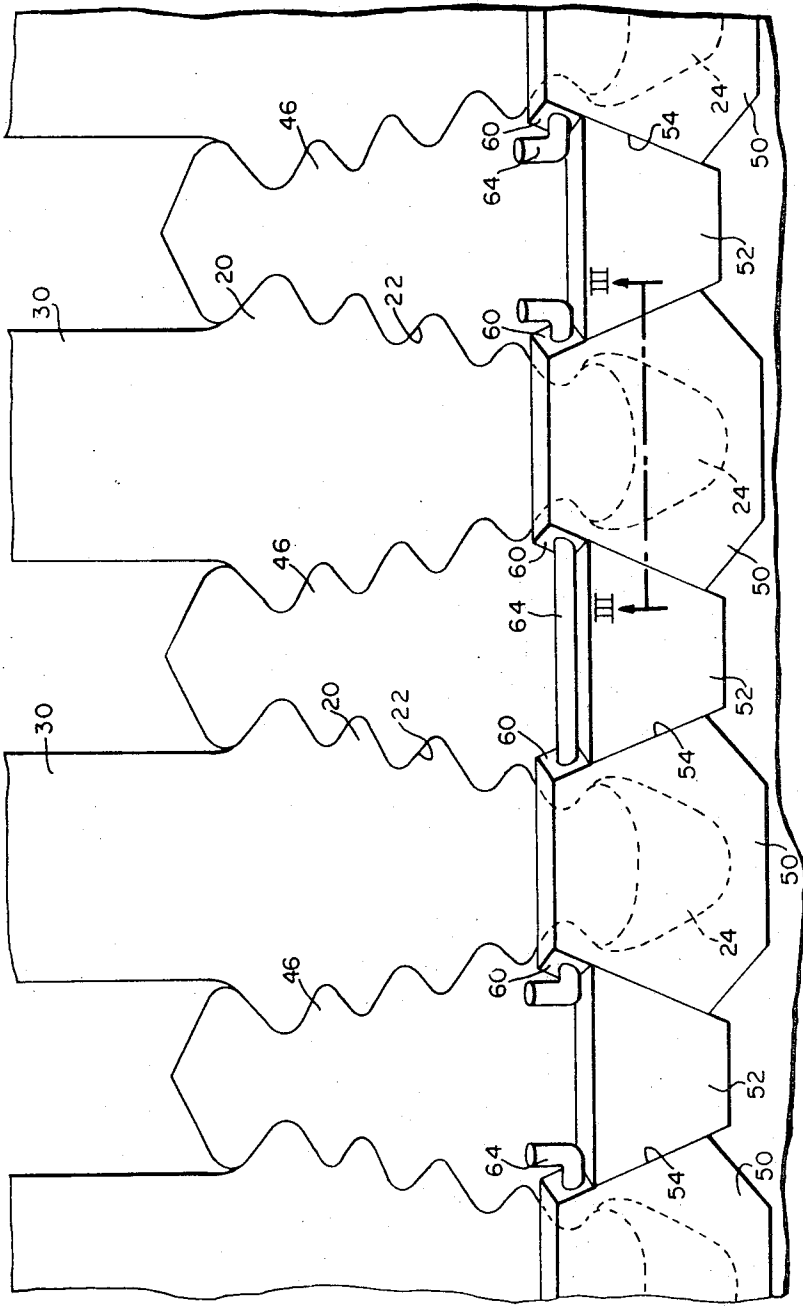
[57] **ABSTRACT**
An axial positioning and sealing means for axially positioning turbine blades with respect to a rotor disc and for sealing the downstream side of cooling fluid flow passageways below the root portions of the blades is disclosed. The periphery of the rotor disc is provided with axial channels for receiving the root portions of turbine blades having radial cooling bores extending from the root portions through the tips of the blades. The channels are formed to provide an axially extending passageway communicating with the cooling bores whereby a cooling fluid flows through the passageway and into the bores to cool the plates. Sideplates means are provided for retaining the blades to the rotor disc.
Pads or protrusions are provided on each steeply of the rotor disc, with the pads being positioned and shaped such that the side faces of two adjacent pads define a radially extending, radially outwardly tapering channel over each of the passageways. Each positioning and sealing plate has tapered sides complementary in shape to the tapered channel whereby when said rotor disc is rotated at high speeds, the centrifugal force acting on said plate will urge the plate radially outwardly of the rotor disc to thereby wedge the plate against the pad and the root portion of the turbine blades. Locking means are provided for securing each plate against unlimited radial inward movement with respect to the rotor disc.

7 Claims, 5 Drawing Figures



SHEET 1 OF 3





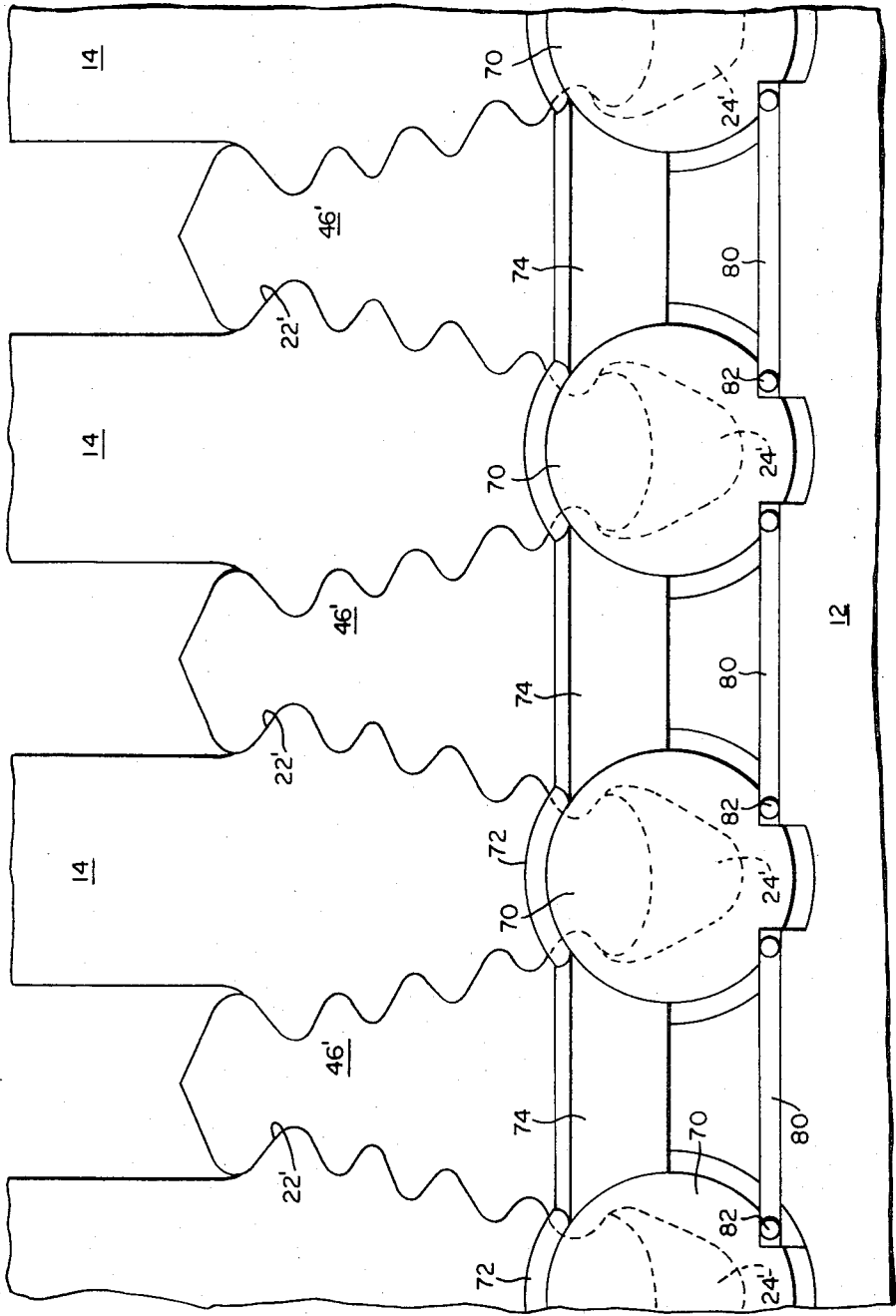


FIG. 4

AXIAL POSITIONER AND SEAL FOR COOLED ROTOR BLADE

BACKGROUND OF THE INVENTION

The present invention relates generally to turbine rotors and particularly to a structure for axially positioning and sealing fluid cooled turbine blades within the periphery of a blade supporting disc.

It is a well-known practice to use sideplates to secure turbine rotor blades of the side entry type in a rotor disc of a turbine. In one turbine blade and rotor disc arrangement where the blades are cooled by cooling fluid flowing through radial bores in the blades, the blades are abutted against a ledge of an upstream sideplate mounted on the rotor disc and individual sideplates are disposed in grooves formed on the downstream side of the blades for securing the blades to the rotor disc. The sideplates are usually positioned at the radially outer region of the root portions of the turbine blades. An axial positioning and sealing plate is disposed at the radial inner region of the root portions of each blade for axially positioning the blade with respect to the rotor disc and for sealing an axial passageway radially inwardly of the bottom of the root portion. The axial passageway communicates with the radial bores through the turbine blades whereby a cooling fluid flows through the passageway and into the bores to cool the blades.

One type of axial positioning and sealing plate structure includes a sealing plate fitted into grooves formed at the radial inner region of the blade root portion and an opposing rotor disc section. A locking plate fits on the downstream side of the sealing plate, with both the plates being secured in place by a lock bolt extending through the rotor disc and the locking plate. The bolts are locking in place by use of lockwashers or lockwires. Although the double plate type of structure provided adequate axial positioning of the blades as well as sealing for the cooling fluid passageway, the structure is somewhat complex since it requires four parts as well as the machining of circumferential grooves on both the blade root portions and rotor disc. In addition, the double plate structure is undesirable in that it is not capable of simple assembly and disassembly between the turbine blades and the rotor discs. The double plate structure requires sequential installation within the grooves, and when one blade needs to be removed from the rotor disc all of the plates to one side of that blade must be removed first. This requires a time consuming and expensive procedure.

The known axial positioning and sealing plate structures are also subject to buckling due to the stress they are placed under as a result of the tangential forces on the plates during rotation of the rotor disc. In order to avoid such buckling the plates are thick and strong enough to resist the buckling stresses. By so designing the plates the weight and costs of the sideplates increase.

BRIEF SUMMARY

The present invention overcomes the undesirable features noted above with respect to the known axial positioning and sealing plate structures. Thus, the present invention provides a simple plate structure which is easy to assemble and disassemble and may be removed and replaced without moving adjoining plates,

is shaped to provide effective axial positioning and sealing of the turbine blades with respect to the rotor disc, and is shaped and arranged for diminishing the tendency to buckle, thereby permitting a thinner plate construction. The noted advantages result from a structure which includes pad or protrusion means on the downstream surface of each steeple of a rotor disc having channels provided in the periphery thereof for receiving the root portions of turbine blades, which pad means is positioned and shaped such that the side faces of two adjacent pad means define a radially extending radially outwardly tapering channel. Each of the axial channels in the rotor disc are provided with axial passageways for conducting a flow of cooling fluid. The passageways communicate with radially extending cooling bores in the turbine blades so that cooling fluid will flow from the passageways through the cooling bores to thereby cool the turbine blades. The radial channels defined by the pad means are arranged over each of the axial passageways. Axial positioning and sealing plates are provided with each plate being received in one of the radial channels and having tapering sides complementary in shape to the tapering sides of the radial channel, whereby when the rotor disc is rotated at high speeds the centrifugal force acting on the plate will urge the plate radially outwardly to thereby wedge the plate against the pad means and the root portions of the turbine blades. Locking means, such as lock wires through the radially outer portions of the blades, are provided for securing the plates against unlimited radial inward movement with respect to the rotor disc. In the preferred form, the radial channel and plate are provided with complementary bevelling on the sides thereof to enhance the wedging effect due to the radially outward movement of the plates during high speed rotation of the rotor disc. Also, in the preferred form the bevelling of the radial channel and plate are shaped so that the tangential stress on the plates are borne by the axial downstream portion of the sides of the plates thereby reducing the tendency of the plates to buckle.

THE DRAWINGS

The present invention, along with its details and advantages, will be better understood from the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a longitudinal section of a radial portion of an axial flow turbine showing a rotor disc and axial positioning and seal plate structure constructed in accordance with the principles of the present invention;

FIG. 2 is a perspective view of the root and blade extension portion of turbine blades and portion of a rotor disc showing the axial positioning and seal plate structure of the present invention arranged to seal the cooling fluid passageway below the blade root portions;

FIG. 3 is a sectional view looking along the line III-III of FIG. 2 showing the angular relationship between the side faces of the axial positioning and seal plate and the pads on the steeples of the rotor disc;

FIG. 4 is a perspective view similar to that of FIG. 2 showing another configuration of axial positioning and seal plates, and pads of the present invention, and

FIG. 5 is a perspective view of an axial positioning and seal plate as shown in FIG. 4 showing more clearly the spherical contour of the side edges thereof.

PREFERRED EMBODIMENTS

Referring now to the drawings, FIG. 1 shows a portion of a rotor 10 of an axial flow turbine in longitudinal section. The rotor 10 may comprise an aggregate of rotor discs, only one of which 12 is shown, secured together by circumferentially disposed tie or stay bolts extending through the discs.

The rotor disc 12 is a first stage disc and supports turbine blades 14 extending radially outwardly therefrom, the blades being disposed between axially spaced inwardly extending fixed stator or nozzle blades 16 and 18. The turbine blades 14 are provided with root portions 20 of the side entry type which may be of the serrated or "fir tree" type for disposition in axially extending serrated slots 22 formed in the outer periphery of rotor disc 12, as shown in FIG. 2. The lower or radial inward section of the slots 22 are formed and sized to provide a clearance with the lower end of root portion 20, which clearance serves as a passageway 24 for directing cooling fluid to the root portion and the rotor disc as shown. The passageway 24 communicates with radial cooling holes or bores 26 extending from the bottom of the root portion 20 of the blades 14 through the tips of the airfoil portion thereof. The turbine blades 14 are further provided with the usual platform and a blade extension 30 between the platform and the root portion 20.

The rotor disc 12 is also provided with a passageway 32 at the upstream side thereof, and formed by an upstream sideplate 34 secured to the upstream face of the main body portion of the rotor disc by circumferentially disposed tie bolts 36 extending through the upstream sideplate and rotor disc, only one tie bolt being shown in FIG. 1. Passageway 32 is arranged to communicate with passageway 24 in the manner shown. An air separator plate 38 is secured to upstream sideplate 34 in any well-known manner, with the separator plate and upstream sideplate shaped to define a passageway 40 communicating with passageway 32. Passageway 40 is connected with a source of cooling fluid, not shown, whereby the cooling fluid will flow through the intercommunicating passageways 40, 32, and 24 and through the cooling bores 26 for cooling the turbine blades 14.

The upstream sideplate 34 is formed with a radial outer, annular ledge 44 arranged to extend from the top of passageway 24 to slightly above the top of the steeple 46 of the rotor disc 12. The ledge 44 serves as the upstream stop for the turbine blades 14 when they are positioned in the slots 22 of the rotor disc 12. The ledge 44 is also designed to provide close abutting contact with the steeples 46 and root portions 20 of the turbine blades 14 to thereby seal the root portions from the hot motive fluid at the upstream side of the turbine blades. The turbine blades 14 are secured to rotor disc 12 by means of sideplates 48 fitted into grooves 49 provided in the downstream end of the platforms 28 of turbine blades and arranged to snugly abut blade extensions 30 of the turbine blades and the adjacent steeples 46 of the rotor disc 12.

The downstream end of passageway 24 is sealed by axial positioning and sealing plates 50 which also serve to axially position the turbine blades 14 within slots 22 of rotor disc 12. Each plate 50 is sized and shaped to fit snugly between two adjacent steeples 46 to overlap the downstream end of passageway 24. As shown in FIG. 2,

a protrusion or pad 52 having a radially inwardly tapering frustopyramidal shape, is provided on the lower section of each steeple 46 adjacent the passageways 24. A pair of adjacent pads 52, thus, define a radially outwardly tapering channel 54 which extends over each passageway 24. The side edges 56 of the pads 52 are provided with a bevelling which tapers outwardly as viewed in FIG. 2 or, stated differently, taper in an axially convergent direction relative to the direction of motive fluid flow. Thus, looking downstream of rotor disc 12, the side edges 56 of a pair of adjacent pads 52 taper or converge towards a line parallel to the axis of rotor disc 12 and passing midway between the channel 54 defined between the pads.

Each axial positioning and sealing plate 50 has a generally frusto-pyramidal shape and is provided with side edges 60 having bevelling complementary in pitch to that of the side edges 56 of pads 52. The taper of each plate 50 complements that of a channel 54 defined between a pair of adjacent pads 52. Thus, when a plate 50 is fitted in a channel 54 and urged in a radially outward direction the upstream face of the plate will cover the downstream end of passageway 24 and will snugly engage the adjoining surface portions of the root portion 20, rotor disc 12 body, and steeples 46 to thereby seal the downstream end of passageway 24.

When the rotor disc 12 is rotated at high speeds the centrifugal force acting on the axial positioning and sealing plates 50 will cause the plates to move radially outwardly in channels 54. The bevelling between the engaging side edges 56 and 60 of the pads 52 and plates 50, respectively, will result in the plates wedging between the pads in a manner to urge the turbine blades 14 into axial position in the slots 22 of rotor disc 12, and also to tightly abut the surfaces around the downstream ends of the passageways 24 to provide effective seals for the passageways 24.

Locking means are provided for securing the plates 50 within the channels 54 against radial inward movement when the rotor disc 12 is at rest or rotating at low speeds. A retaining wire 64 is fitted in circumferentially extending openings in the radial outward portion of the plates 50. The wire 64 may extend between two or more sequentially spaced plates 50 and the free ends turned radially outwardly in the manner shown in FIG. 2. The retaining wires 64 are located such that they will engage the upper or radially outward surfaces of the pads 52 and thereby prevent unlimited radial inward movement of the plates 50.

The taper angle of the channel 54 and the plates 50, should be selected to as to avoid excessive tangential forces acting on the plates 50 while at the same time the tapers should be such as to provide a good wedging action between the plates 50 and pads 52 to thereby give good axial positioning for the turbine blades 14 and effective sealing of the downstream end of the passageways 24. Tangential forces acting on the plates 50 tend to buckle the plates and therefore such forces should be minimized. The maximum tangential force will occur where there would be no taper in a channel 54. Making the taper angle of a channel 54 too large would diminish the wedging effect between the plates 50 and the pads 52. Thus, a suitable taper angle of the channels 54 and plates 50 should be selected to achieve the desired minimization of tangential forces acting on

the plates 50 while providing the desired wedging effect between the plates 50 and pads 52. Those skilled in the art would readily recognize how to calculate the desired taper angle of the channels 54 and plates 50. The tangential forces, which depend on speed and radius of rotor disc 12, would be one factor which would determine the taper angle.

As shown in FIG. 3, the bevel angle of the side edges 60 of plates 50 is less than that of the side edges 56 of pads 52 whereby when the plates 50 are positioned between the pads 52, the downstream section of the side edges 60 of plates 50 will engage the downstream section of the side edges 56 of pads in the manner shown in FIG. 3. This arrangement of the respective side edges 56 and 60 will reduce the effect of tangential forces acting on the plates 50 since the stress on the plates 50 will be borne by the downstream section of the side edges of the plates. With the side edges of the plates 50 and pads 52 being flush with each other, the stress on the plates 50 due to the tangential forces would more than likely be borne by the upstream section of the side edges 60 of the plates 50 with the tendency of the plates 50 to buckle being greater than when the stresses are borne at the upstream section of the side edges. Thus, the relationship between the side edges of the plates 50 and pads 52 just described and shown in FIG. 3, reduce the tendency of the plates 50 to buckle.

FIGS. 4 and 5 show another embodiment of the present invention. The axial positioning and retaining plate 70 shown is generally circular or disc shaped and has a spherically shaped edge 72. Pads 74 are provided on the steeples 46' of the rotor disc 12 with the pads 74 having a generally frusto-pyramidal shape tapering radially inwardly whereby a radially outwardly tapering channel is defined between each pair of adjacent pads. The side edges 76 of the pads 74 are generally spherically shaped complementary to the shape of the edge of plates 70. The configuration of the plates 70 and pads 74 will result in a wedging of the plates with respect to the pads with the consequent positive effect on the axial positioning of the turbine blades 14' within 22' of rotor disc 12' and the sealing of the downstream end of the passageways 24'. The same considerations with regard to the taper of the channels between the pads 74 and the shape of the plates 70 for purposes of minimizing tangential forces and maintaining effecting wedging, would be made in this embodiment as would be made with the earlier described embodiment.

Locking means are provided for securing the plates 70 against unlimited radial inward movement with respect to the rotor disc 12'. A circumferential groove 80 is provided on the downstream face of the rotor disc 12' and is sized and located to receive the free ends of a retaining wire 82 fitted through a circumferentially extending opening provided through the radially inward or bottom section of plate 70. Thus, when rotor disc 12' is at a standstill or rotating at low speeds, the retaining wires 82 cooperating with groove 80 will secure the plates 70 between the pads 72.

Since the axial positioning and sealing plates 50 and 70 are not readily susceptible to buckling, thinner material may be used as compared with the plate structures used heretofore, with attendant savings in weight and cost. Also, the plates 50 and 70 may be assembled

and disassembled individually without moving adjacent plates. These, and other positive results are realized, by this invention while the invention at the same time provides effective axial positioning of the turbine blades in the rotor disc and effective sealing of the downstream end of the blade cooling fluid axial flow passageway in the rotor disc.

Though the invention has been shown and described in preferred forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of changes without departing from the spirit and scope thereof. For example, the locking means for securing the axial positioning and sealing plates, rather than being retaining wires, could be lock bolts extending through the plates partially into the axial passageway below the root portion of the turbine blades.

We claim:

1. In a rotor for an axial flow fluid machine, the rotor comprising at least one rotor disc with slots provided in the periphery thereof for receiving the root portions of rotor blades said slots defining steeples therebetween, said rotor blades having radial cooling bores extending from the root portions through the tips of the blades, passageways extending axially of the root portions, said passageways communicating with the cooling bores and being capable of conducting a flow of cooling fluid therethrough, and sideplate means associated with said blades for securing said blades to said rotor disc, the improvement comprising:

an axial positioning and sealing plate associated with each blade for positioning the blades axially with respect to said rotor disc and for sealing the downstream side of each of said passageways;

pad means on each steeple of said rotor disc positioned and shaped such that the side faces of two adjacent pad means define a radially outwardly extending, radially outwardly converging tapering channel over each of said passageways;

said plate being received in said channel and having tapering sides complementary in shape to said tapering channel whereby when said rotor disc is rotated at high speeds the centrifugal force acting on said plate will urge said plate radially outwardly of said rotor disc to thereby wedge said plate against said pad means and the root portions of the turbine blades; and

locking means for securing said plate against unlimited radial inward movement with respect to said rotor disc.

2. The structure recited in claim 1 in which the side faces of said pad means are bevelled in an axially convergent direction relative to the direction of fluid flow, and said plates are provided with bevelled side surfaces complementary in shape to the bevelling of said side faces of said pad means.

3. The structure as recited in claim 1 in which the side faces of said pad means and the sides of said plates are generally flat planar surfaces.

4. The structure as recited in claim 1 in which said plates are generally circular in shape with the sides thereof being generally spherically shaped, and the side faces of said pad means are generally spherically shaped complementary to the shape of said sides of said plates.

5. The structure as recited in claim 1 in which said locking means is an elongated retaining member extending through a portion of each of said plates disposed radially outwardly relative to said pad means and arranged to engage said pad means to secure said plates.

6. The structure as recited in claim 1 in which said locking means includes a circumferential groove provided in said rotor disc radially inwardly of said pad means, and an elongated retaining member extending through a portion of each of said plates disposed radially inwardly relative to said pad means and arranged to fit within said circumferential groove to secure said

plates.

7. The structure as set forth in claim 2 in which the side faces of said pad means and the sides of said plates are generally flat planar surfaces, and the angle of the bevelling of said side faces of said pad means is greater relative to the axis of said rotor disc than the angle of the bevelling of the side surfaces of said plates, the difference of the angles being such that the downstream portions of the respective side surfaces of said plates and pad means engage each other while a clearance exists between the upstream of the respective side surfaces.

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