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MULTI-STAGE TURBINE ROTOR

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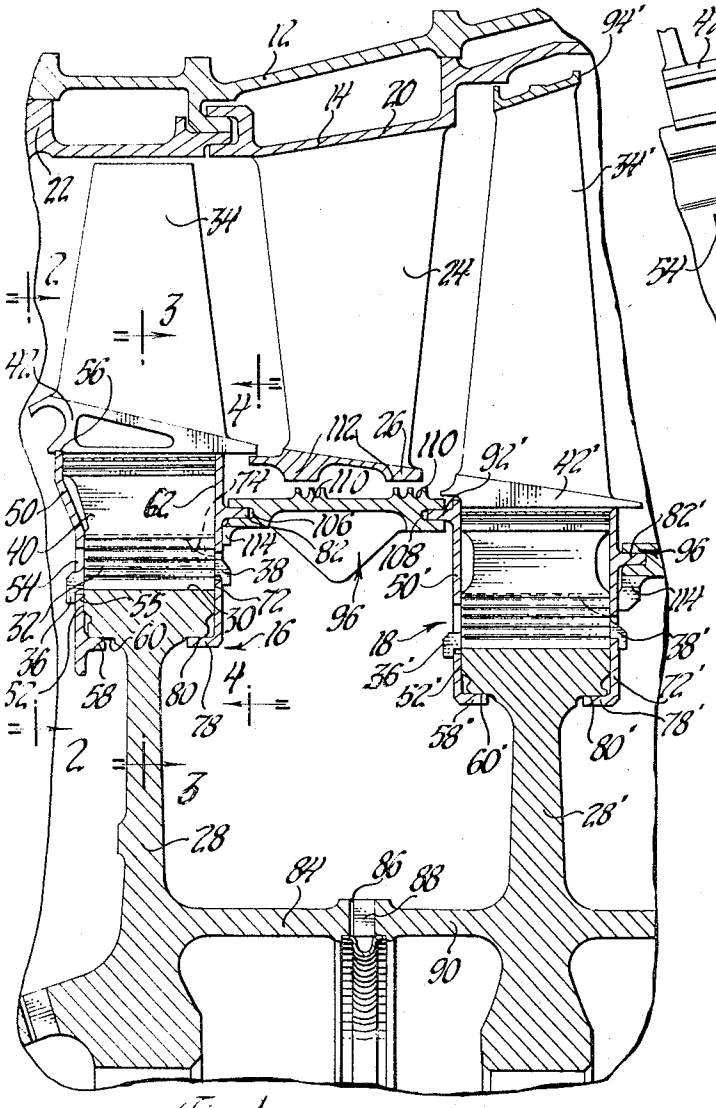


Fig. 1

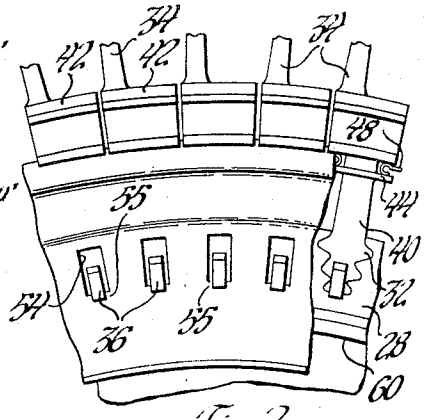


Fig. 2

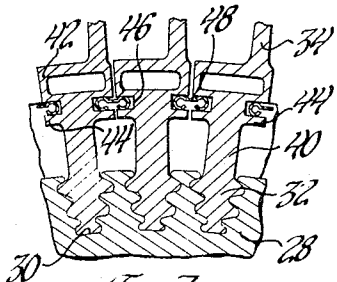


Fig. 3

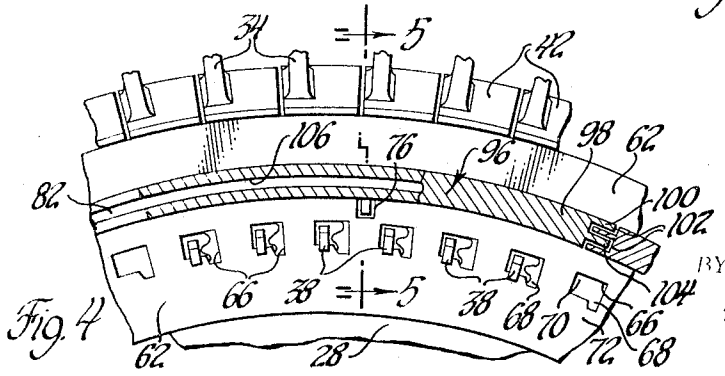


Fig. 4

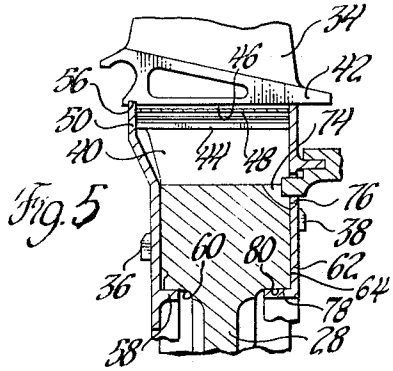


Fig. 5

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MULTI-STAGE TURBINE ROTOR

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This invention relates generally to a multi-stage turbine rotor and more specifically to a multi-stage turbine rotor having an annular spacer disposed between successive stages thereof.

It is common practice to utilize turbine rotors comprising a rotor wheel having axial circumferentially spaced slots in which are mounted the roots of a plurality of radially extending turbine blades. Obviously, in this type of construction some means must be provided for preventing the blade roots from sliding out of the slots. It is also common to provide an annular spacer between successive stages in a multi-stage turbine rotor.

The turbine section of a gas turbine engine is subjected to thermal transients in its normal operation. These terminal transients induce thermal stresses in the parts located therein. Any rotating annular part in the turbine section, such as a spacer, is also subjected to centrifugal forces which produce free ring hoop stresses in the part. The stress resulting from these two sources is of a transient nature varying in magnitude and sense, i.e., compressive to tensile to compressive, etc. This transient type of stress fatigues the part, causing premature failure. Segmenting the spacer overcomes the stress fatigue problem since it no longer carries hoop stress and the thermally induced circumferential expansion stresses. However, in order to provide for sufficient circumferential growth, other problems may arise such as providing radial flow paths through the spacer or providing a rotating body having shiftable weights which may become unbalanced and produce undesirable vibrations.

It is, therefore, an object of this invention to provide a multistage turbine rotor having an annular spacer disposed between successive stages which will not prematurely fatigue.

Another object is to provide a multi-stage turbine rotor having an annular spacer disposed between successive stages which is segmented to eliminate the stresses therein to provide a longer life.

Another object is to provide a multi-stage turbine rotor having an annular segmented spacer which remains balanced at all times and under all conditions.

Another object is to provide a multi-stage turbine rotor having a segmented annular spacer which will not produce undesirable vibrations.

Another object is to provide a multi-stage turbine rotor having a segmented annular spacer which minimizes radial flow therethrough.

Another object is to provide a multi-stage turbine rotor having stages comprising separable blades retained in mounting slots in a rotor with a segmented spacer between successive stages.

Another object is to provide a multi-stage turbine rotor having a segmented spacer disposed between successive stages and means to positively locate segments and retain the separable blades in the rotor mounting slots to eliminate parts and provide a relatively simple device.

The exact nature of this invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the annexed drawings in which:

FIGURE 1 is a transverse section of a gas turbine engine showing two stages of a multi-stage turbine rotor in accordance with the present invention.

FIGURE 2 is a section taken along the line 2—2 of FIGURE 1 and looking in the direction of the arrows.

FIGURE 3 is a section taken along the line 3—3 of FIGURE 1 and looking in the direction of the arrows.

FIGURE 4 is a section taken along the line 4—4 of FIGURE 1 and looking in the direction of the arrows.

FIGURE 5 is a section taken along the line 5—5 of FIGURE 4 and looking in the direction of the arrows.

FIGURE 1 shows two stages of a multi-stage turbine rotor for a gas turbine engine. The turbine rotor is rotatably mounted in a casing **12** with a guide vane ring **14** mounted between the axially spaced stages **16** and **18**. The guide vane ring **14** comprises an outer shroud **20** which clamps a liner **22** within the forward portion of the casing **12**, a plurality of radially inwardly extending guide vanes **24** and an inner shroud band **26** which connects the inner ends of the vanes **24**. The front stage **16** comprises a rotor wheel **28** having a plurality of axial slots **30** spaced about its rim as can best be seen in FIGURE 3. The slots are of conventional fir tree cross-section and receive the fir tree roots **32** of a plurality of blades **34**. Spaced radially outwardly from the root **32** by stalk **40** is a hollow platform **42**. The stalks **40** are provided with circumferentially extending ears **44** which, together with the platforms **42**, form chambers **46** which house vibration dampers **48**.

Returning to FIGURE 1, it can be seen that the roots **32** have L-shaped forward and rearward tangs **36** and **38**, respectively, extending axially therefrom. An annular front side plate **50** abuts the leading edge wall **52** of the front rotor wheel **28** with the forward tangs **36** extending through slots **54** therein. The outer edge of plate **50** rests in a groove **56** in the underside of platform **42** and an annular flange **58** adjacent the inner edge abuts shoulder **60** on the wheel **28** positioning the plate **50** on wheel **60**. The portions **55** of the side plate **50** lying just inwardly of the slots **4** are disposed between the axial legs on the forward tangs **36** and the leading edge wall **52** and thus prevent the roots **32** from being withdrawn axially rearwardly from the slots **30**. A frontal view of the plate **50** is shown in FIGURE 2.

A rear side plate **62** abuts the trailing edge wall **64** of front rotor wheel **28** with the rear tangs **36** extending through bayonet slots **66** therein. An annular flange **78** is provided on the inner circumferential edge of the back side plate **72** to engage the shoulder **80** on the front rotor wheel **28** to mount the plate **72** thereon. A second flange **82** is located radially outwardly from the flange **78**. The bayonet slots **66** which can best be seen in FIGURE 4 have right-hand portions **68** substantially radially coextensive with the rear tangs **36** and left-hand portions **70** which are somewhat smaller. After the rear side plate **62** has been threaded onto the rear tangs into abutment with the wheel **28**, it is rotatably indexed slightly clockwise. Retaining edges **72** on the rear plate **62** now occupy the spaces between the axial legs of the L-shaped tangs **36** and rotor wheel **28** to prevent the roots **32** from being withdrawn axially forwardly from slots **54**. The rear side plate **62** has a plurality of pilot apertures **76** which will align with a corresponding number of pilot cavities **74** in rotor wheel **28** when the rear side plate **62** is in its interlocking position. Flange **82**, pilot cavities **74** and apertures **76** have a function to be described later.

The rotor wheel **28** has a cylindrical extension **84** provided with face splines **86** which mesh with splines **88** on a cylindrical extension **90** on the rear turbine stage **18**. The parts of the rear stage **18** are substantially identical to those of the front stage and carry primed identifying numerals which are the same as the unprimed numerals used in the first stage. However, the following modifications are present: the front side plate **50'** has an annular flange **92'** adjacent its outer circumferential edge, the

platform 42' is not hollow, and the tips of the blades 34' are connected by a shroud ring 94'.

An annular spacer generally indicated at 96 is provided between the front stage 16 and the rear stage 18. This annular spacer 96 comprises a plurality of arcuate spacer segments 98, as can best be seen in FIGURE 4. The circumferential edge walls 100 are grooved at 102 forming spaced tongues 104. The tongues on the right-hand walls are displaced from those on the left-hand walls so that adjacent segments 98 will interfit the tongues on one segment being received in the grooves on the adjacent segment and vice-versa. This interfit allows for sufficient radial growth without providing a path for radial flow through the shroud. The leading and trailing edge walls of the spacer segments 98 have arcuate mounting grooves 106 and 108 respectively. The grooves 106 and 108 respectively receive the annular flange 82 on the front stage and annular flange 92' on the rear stage 18 to support each segment 98 as a simple beam. The outer surface of the spacers 96 have spaced fluted portions 110 which cooperate with spaced annular lands 112 on the inner shroud band 26 to form a labyrinth seal. Each spacer segment is also provided with a depending pilot lug 114 which extends centrally from its leading edge. The pilot lug 114 extends through the aperture 76 in the rear side plate 72 and into pilot cavity 74 in the rotor wheel 28. Thus the lug serves to locate the individual segment 96 as well as restrains the rear side plate 62 from rotatable movement and retains it in its interlocking position where edge 72 interferes with the axial legs on the rear tangs 38. When all of the segments 98 are mounted on the flanges 82 and 92', they will form an annular spacer 96. The spacer 96 will be segmented with the ends of the segments 98 abutting to permit radial and circumferential thermal growth without stress transfer and overlapping to reduce radial flow therethrough. Each individual spacer segment will be positively located to prevent shifting and unbalance and vibration. The segments cooperate with the wheel 28 to retain the rear side plate 62 indexed at its interlocked position wherein the blades 34 are locked to the rotor wheel 28 to form the front stage 16.

Thus it can be seen that I have provided a multi-stage turbine rotor having a segmented annular spacer between successive stages wherein each of the segments of the annular spacer is positively located so as to retain the radially extending blades mounted to the rotor to eliminate parts and provide a simple device while attaining all of the above-mentioned objects.

It should be understood, of course, that the foregoing disclosure relates only to a preferred embodiment of the invention and that modifications or alterations may be made therein without departing from the spirit and scope of the invention set forth in the appended claims.

I claim:

1. In a multi-stage bladed rotor, the combination comprising:
- a first rotor wheel having a plurality of circumferentially spaced axial slots,
- a plurality of radially extending blades having roots mounted in said slots,
- first and second tangs on said roots,
- means engaging said first tangs to prevent said blades from being withdrawn axially in one direction from said first wheel,
- an annular side plate having a plurality of bayonet slots abutting the edge wall of said first wheel and said roots with said second tangs extending through said slots, said side plate being indexable to an interlocking poistion to engage said second tangs and prevent said blades from being withdrawn axially in the opposite direction from said first wheel,
- a plurality of spacer segments mounted at one end to said side wall, said segments abutting adjacent segments to form an annular spacer,

- pilot means on said segments engaging said side plate and said first wheel to locate said segments and to retain said side plate in said interlocking position, and
- a second bladed rotor wheel spaced axially from and connected to said first wheel, said second wheel including means to mount the opposite end of said spacer segments thereon.

2. In a multi-staged bladed rotor, the combination comprising:
- a first rotor wheel having a plurality of circumferentially spaced axial slots,
- a plurality of radially extending blades having roots mounted in said slots,
- means to prevent said blades from being withdrawn axially from said first wheel in a first direction,
- tangs extending from the end wall of said roots, in said first direction,
- an annular side plate having a plurality of bayonet slots abutting the end wall of said first wheel and said roots with said tangs extending through said slots, said side plate being rotatable to an interlocking position to engage said tangs and prevent said blades from being withdrawn axially in an opposite direction from said first wheel,
- a plurality of spacer segments mounted at one end to said side wall, said segments abutting adjacent segments to form an annular spacer,
- pilot means on said segments engaging said side plate and said first wheel to locate said segments and to retain said side plate in said interlocking position, and
- a second bladed rotor wheel spaced axially from and connected to said first wheel, said second wheel including means to mount the opposite end of said spacer segments thereon.

3. In a multi-stage bladed rotor, the combination comprising:
- a first rotor wheel having a plurality of axial slots spaced about its circumference and a plurality of pilot cavities in its end wall,
- a plurality of radially extending blades having roots mounted in said slots,
- means to prevent said blades from being withdrawn axially in one direction from said first wheel,
- tangs extending axially from said roots in said one direction,
- an annular side plate having a plurality of bayonet slots and a plurality of pilot apertures, said plate abutting the end wall of said first wheel and said roots with said tangs extending through said slots, said side plate also being indexable to an interlocking position wherein said tangs are engaged to prevent said blades from being withdrawn axially from said first wheel in an opposite direction and wherein said pilot apertures are aligned with said pilot cavities,
- a plurality of spacer segments mounted at one end to said side wall, said segments abutting adjacent segments to form an annular spacer,
- pilot means on said segments extending into said aligned pilot apertures and cavities to locate said segments and to retain said side plate in said interlocking position, and
- a second bladed rotor wheel spaced axially from and connected to said first wheel, said second wheel including means to mount the opposite end of said spacer segments thereon.

4. In a multi-stage bladed rotor, the combination comprising:
- a first rotor wheel having a plurality of axial slots spaced about its circumference and a plurality of pilot cavities in its end wall,
- a plurality of radially extending blades having roots mounted in said slots,

means to prevent said blades from being withdrawn axially in one direction from said first wheel,

tangs extending axially from said roots in said one direction,

an annular side plate having a plurality of bayonet slots and a plurality of pilot apertures abutting the end wall of said first wheel with said tangs extending through said slots, said side plate being indexable to an interlocking position wherein said tangs are engaged to prevent said blades from being withdrawn axially in an opposite direction from said first wheel and wherein said pilot apertures are aligned with said pilot cavities,

an annular flange extending axially from said side plate in said one direction,

a plurality of arcuate spacer segments having arcuate grooves in their end wall, said segments abutting adjacent segments to form an annular spacer with an annular groove which receives said flange to support said spacer on said side wall,

a depending pilot lug on each segment extending into said aligned pilot apertures and cavities to locate said segment and to retain said side plate in said interlocking position, and

a second bladed rotor wheel spaced axially from and connected to said first wheel, said second wheel including means to mount the opposite end of said spacer segments thereon.

5. In a multi-stage bladed rotor, the combination comprising:

a first rotor wheel having a plurality of axial slots spaced about its circumference and a plurality of pilot cavities in its trailing edge wall,

a plurality of radially extending blades having roots mounted in said slots,

front and rear tangs on said roots,

means engaging said front tangs to prevent said blades from being withdrawn axially rearwardly from said first wheel,

an annular side plate having a plurality of bayonet slots and a plurality of pilot apertures abutting the trailing edge wall of said first wheel with said rear tangs extending through said slots, said side plate being indexable to an interlocking position wherein said rear tangs are engaged to prevent said plates from being withdrawn axially forwardly from said first wheel and wherein said pilot apertures are aligned with said pilot cavities,

an annular flange extending radially from said side plate,

a plurality of arcuate spacer segments having arcuate grooves in their leading and trailing edge walls,

grooves in their one side wall and tongues on their opposite side wall, said segments abutting adjacent segments with said grooves receiving said tongues whereby an annular spacer is formed, said annular spacer having an annular groove in its leading edge wall which receives said flange to support said spacer on said side wall,

a depending pilot lug on each segment extending into said aligned pilot apertures and cavities to locate said segment and to retain said side plate in said interlocking position,

a second bladed rotor wheel spaced axially from and connected to said first wheel,

an annular flange extending forwardly from said second wheel, and

an annular groove in the trailing edge wall of said spacer, said annular groove receiving said annular flange to support the opposite end of said spacer.

6. In a multi-stage bladed rotor, the combination comprising:

a first rotor wheel having radially extending blades with roots mounted in circumferentially spaced axial slots,

means to prevent said blades from being withdrawn axially from said first wheel in a first direction,

further means mounted on said rotor so as to be circumferentially indexable between a first and second position, said further means permitting axial withdrawal of said blades in an opposite direction when said further means is in said first position and preventing axial withdrawal of said blades in said opposite direction when said further means is in said second position,

a plurality of spacer segments mounted at one end to said first wheel, said segments abutting adjacent segments to form an annular spacer,

pilot means on said segments to locate said segments with respect to said first wheel and to retain said further means in said second position, and

a second bladed rotor wheel spaced axially from and connected to said first wheel, said spacer segments mounted at their opposite end to said second wheel.

7. In a multi-stage bladed rotor, the combination comprising:

a first rotor wheel having a plurality of circumferentially axial slots,

a plurality of radially extending blades having roots mounted in said slots,

means to prevent said blades from being withdrawn axially from said first wheel in a first direction,

tangs extending from the end wall of said roots in said first direction,

an annular side plate having a plurality of bayonet slots abutting the end wall of said first wheel and said roots with said tangs extending through said slots, said side plate being rotatable to an interlocking position to engage said tangs and prevent said blades from being withdrawn axially in an opposite direction from said first wheel,

an annular spacer mounted at one end to said side wall,

pilot means on said spacer engaging said side plate and said first wheel to retain said side plate in said interlocking position, and

a second bladed rotor wheel spaced axially from and connected to said first wheel, said second wheel including means to mount the opposite end of said spacer thereon.

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