April 2, 1963 A. RUBIO ETAL 3,084,343

COMPENSATING DEVICE FOR TURBOMACHINE BUCKET WHEEL

Filed Nov. 15, 1961

FIG.1

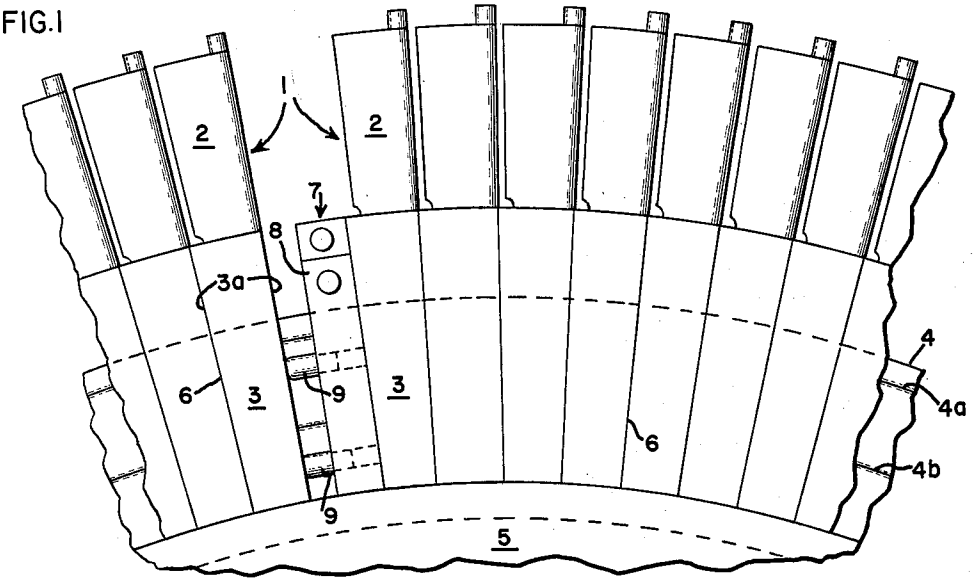


FIG.2

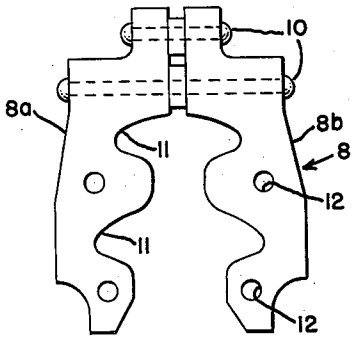


FIG.3

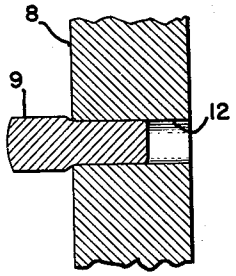


FIG.4

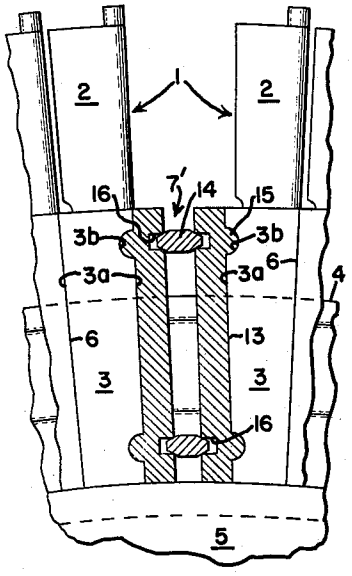


FIG.5

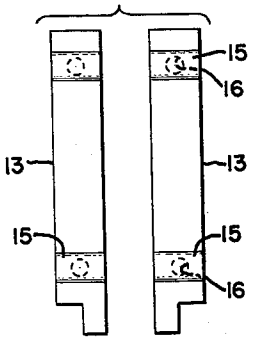
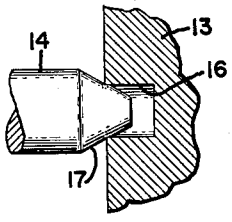


FIG.6



INVENTORS:
ABDON RUBIO,
CHARLES R. ERNEST JR.,
BY W. C. Crutcher
THEIR ATTORNEY.

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COMPENSATING DEVICE FOR TURBOMACHINE BUCKET WHEEL

Abdon Rubio, Schenectady, and Charles R. Ernest, Jr., Esperance, N.Y., assignors to General Electric Company, a corporation of New York

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This invention relates to a compensating device for turbine wheels carrying a number of blades thereon subject to scale formation or oxidation between blade bases, and more particularly to a device for compensating for a phenomenon in turbines known as "arch binding."

In a steam turbine, the bladed elements or "buckets" are often mounted on the rim of a turbine wheel in a fashion such that the buckets are radially inserted one at a time at a specified location on the rim, and then are slid circumferentially in dovetail mounting grooves in the rim until there is a full circumferential row of buckets on the rim. With such a construction, the dovetailed base portions of the buckets often have planar faces lying in a radial plane which abut similar faces of adjacent buckets, so that each bucket is held circumferentially in place by buckets pressing against it on either side thereof. With this construction, it is desirable to have a tight structure in order to assure the correctness of the assembly, to determine the natural vibration frequencies, and to prevent any looseness which may lead to unbalance. The aforedescribed type of turbine wheel construction is, however, subject to a phenomenon known as "arch binding" which causes a gradual increase in the diameter of the wheel to which the buckets are attached.

While we do not wish to be limited to any theory, it is suggested that arch binding takes place in the following manner. Since the rates of thermal expansion of the buckets and the turbine wheel are different, due to their being made of different materials, and since the wheel and buckets are exposed to radial thermal gradients, a change in temperature can cause spaces to open up between adjacent faces of the bucket bases. Such an opening is also caused by the centrifugal stresses. Steam is throttled through the spaces which can cause oxidation or leave a deposition of scale, resulting in a minute incremental increase in the circumferential dimension of the bucket base. This increase, when multiplied by the number of buckets in a row, causes an "effective" circumference for the ring of buckets, which is greater than that of the circumference of the mounting grooves available on the turbine wheel. The buckets obtain the required circumference by stretching the turbine wheel radially as temperatures are equalized. During increasing temperature, where the wheel is colder than the buckets, the arch binding condition is magnified and the rim of the wheel may be further stretched radially.

This condition is cumulative and the same process occurs over again, with each new cycle causing further radial stretching of the wheel. The stresses caused by the arch binding phenomenon can be of a magnitude great enough to exceed the yield and rupture strength of the wheel, thereby causing failure.

Accordingly, one object of the present invention is to provide a device compensating for cumulative circumferential growth of the buckets on a turbine wheel.

Another object of the invention is to provide a device for preventing radial stretching of the turbine wheel due to "arch binding" of the turbine buckets.

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawing in which:

FIG. 1 is a view, looking in the axial direction, of a portion of a turbine wheel with attached buckets;

FIG. 2 is a view looking in a circumferential direction of a portion of the arch binding compensating device;

FIG. 3 is an enlarged view, in section, illustrating the operation of the device; and

FIGS. 4–6 are views corresponding to FIGS. 1–3 respectively and illustrating a modification of the invention.

Briefly stated, the invention is practiced by providing a non-resilient separator arranged to yield at a predetermined compressive circumferential force exerted thereon so as to compensate for scale accumulation or oxidation between bucket base interfaces so as to reduce the effect of arch binding.

Referring now to FIG. 1 of the drawing, a plurality of turbine buckets 1 have bladed portions 2 and dovetail base portions 3. The buckets 1 are disposed on the rim 4 of a turbine wheel, a portion of which is indicated at 5. The rim 4 includes circumferential radially-spaced ribs 4*a*, 4*b* forming arcuate dovetail retaining means for the bucket bases 3. Each of the bucket bases 3 has opposite planar faces 3*a*, which abut one another along a radial interface indicated at 6. When the buckets 1 are properly assembled on the turbine wheel 5, there is no clearance at the interfaces 6. It will be apparent that, under thermal transients, the different rates of expansion and contraction between the buckets 1 and the wheel 5 can cause gaps to open at the interfaces 6. Steam can flow into these spaces and leave deposits or cause oxidation.

According to the invention, a special non-resilient compensating device 7 is employed which comprises a retaining block 8 holding a plurality of pins 9.

The construction of the retaining block 8 can be seen by reference to FIG. 2. The block 8 comprises mating halves 8*a*, 8*b* held in place on rim 4 by suitable means such as rivets 10. The retaining block 8 includes dovetail grooves 11 which mate with arcuate ribs 4*a*, 4*b* on the rim 4 of the turbine wheel. Circumferentially directed holes 12 form seats for pins 9.

Reference to FIG. 3 of the drawing illustrates that the diameter of each of the pins 9 is slightly greater than the diameter of the hole 12 so that pin 9 fits with a negative clearance, as illustrated by the exaggerated sectional drawing. A considerable force is required to push pin 9 deeper into hole 12 and, in so doing, it will be apparent that pin 9 is actually crushed or extruded into hole 12. The materials and clearances selected will, of course, vary with the application, but to illustrate the order of magnitude, a force on the order of 1 ton may be required to extrude pin 9 deeper into hole 12.

It will be apparent that when the compressive force on the end of pin 9 is such that the yield point of the material of pin 9 is no longer exceeded, pin 9 will simply remain

where it is. Therefore, cyclical re-application of a predetermined compressive force on pin **9** will continue to shorten the circumferential dimension of the compensating device **7** in incremental steps, rather than continue to build up a greater and greater reactive force as would be the case with a resilient member.

The operation of the emobdiment disclosed in FIGS. 1–3 is as follows. When the interfaces **6** between bucket bases **3** open up to allow oxidation deposition of steam scale during thermal transients, the circumferential dimension of each bucket will increase slightly. Although each bucket may become enlarged over a period of time by only a few thousandths of an inch, the net growth of 60 to 90 buckets will constitute a considerable circumferential growth. As the temperature is equalized and the gaps between bucket bases close, a compressive circumferential force between buckets will provide a radial component due to the taper on the bases which, without the invention, could stretch the wheel radially. However, by employing the compensating device **7**, this compressive force acts on the pins **9** to cause them to extrude deeper into holes **12** in the retaining block **8**. Since the condition is cumulative and occurs cyclically, it is not desired that the compressive force become continually greater as the buckets grow circumferentially, as would be the case with a resilient spacer. This would merely aggravate the condition and would cause a gradual increase in compressive stress. Since compensating device **7** exactly compensates each time for the circumferential growth, the average tightness between bucket bases **3** is maintained at a substantially constant level.

FIGS. 4–6 illustrate a second modification of the invention. There, the compensating device **7'** is made up of four retaining blocks **13** with crushable pins **14** separating a pair of blocks **13** on each side of the rim **4**. Each of the retaining blocks **13** has projections **15** fitting in special grooves **3***b* in faces **3***a* on the separated bucket bases. Each retaining block **13** also has holes **16** extending partially therethrough which perform the function of holes **12** in FIG. 3.

FIG. 5 is a circumferential view showing the pair of retaining block members **13** on either side of the turbine wheel. FIG. 6 illustrates that each pin **14** terminates in a frusto-conical tip **17** which fits into hole **16** in block **13**. The operation of the modification of FIGS. 4–6 is similar to that of FIGS. 1–3, in that the conical tip **17** of pin **14** extrudes into hole **16** when the compressive force on pin **14** becomes such that the local yield point of the pin is exceeded. Therefore, the modified compensating device **7'** becomes shorter in its circumferential dimension an incremental amount as the compressive force due to deposition or oxidation between bucket base interfaces **6** is cyclically repeated.

It will be apparent that in some cases, the retaining blocks **7**, **13** of the two modifications shown might be omitted and the adjacent bucket bases used to perform this function. That is, holes **12**, **16** would merely be formed in two separated bucket bases with the pins extending therebetween.

While the invention has been described with particular reference to a turbine wheel, it will be apparent that the invention is also applicable to any member having a number of segments disposed thereon with planar faces tightly abutting one another where the faces are prone to separate during some conditions of operation to allow deposition or oxidation therebetween. However, it will be apparent that the arrangement is primarily useful in a wheel where the planar faces are radial, whereby an increased compressive stress between the segments can become relieved by yielding in a direction normal to the compressive stress, i.e., radially. By designing the pins properly, so that the predetermined compressive stress at which they yield is always less than that at which the wheel would yield radially to relieve this compressive stress, the problems heretofore caused by arch binding are significantly reduced.

While there has been described herein what is at present considered to be a preferred embodiment of the invention, and one modification thereof, it may be understood that various other modifications may be made, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a turbine rotor, the combination of a rotor wheel having a rim defining circumferentially extending dovetail ribs, a plurality of turbine buckets disposed on said rim each including base portions defining dovetail grooves mating with said dovetail ribs, said base portions defining radial faces on opposite circumferential sides thereof which abut those of adjacent base portions and which are subject to oxidation and scale accumulation when cyclically exposed to a motive fluid, and means separating the bases of two spaced adjacent buckets, said separating means comprising a first member defining a recess and a second member disposed in the end of said recess, said first and second members being disposed between said spaced buckets so that a circumferential closing movement thereof will extrude the second member into said recess and permanently shorten the circumferential dimention of said separating means under a predetermined circumferential compressive force.

2. In a turbine rotor, the combination of a rotor wheel having an outer rim, a plurality of turbine buckets held on said rim, each bucket including a dovetail base portion defining opposite radial faces tightly abutting adjacent bucket base faces, said faces being subject to incremental cumulative growth due to oxidizing or scaling properties of a motive fluid upon temperature changes thereof, and means separating the bases of two spaced adjacent buckets, said separating means comprising at least one member defining a recess, and circumferentially directed pin means having portions slightly larger than said recess and constructed so as to extrude into the recess under a predetermined circumferential compressive force between bucket bases, whereby the separating means will shorten permanently in a circumferential direction to compensate for the circumferential growth of the bucket bases.

3. In a turbine rotor the combination of a rotor wheel having an outer rim, a plurality of turbine buckets held on said rim, each bucket including a dovetail base portion defining opposite radial faces tightly abutting adjacent bucket base faces, said faces being subject to incremental cumulative growth due to oxidizing or scaling properties of a motive fluid upon temperature changes thereof, and means separating the bases of two spaced adjacent buckets, said separating means comprising retaining block means engaging one bucket base, said retaining block means defining circumferentially directed holes, and a plurality of pins having ends engaging the other bucket base and having their other ends disposed in the retaining block holes, said pins having portions slightly larger than said holes so as to extrude into said holes under a predetermined circumferential compressive force between bucket bases, whereby the separating means will shorten permanently in a circumferential direction to compensate for incremental circumferential growth of the bucket bases.

4. In a turbine rotor, the combination of a rotor wheel having an outer rim, a plurality of turbine buckets held on said rim, each bucket including a dovetail base portion defining opposite radial faces tightly abutting adjacent bucket base faces, said faces being subject to incremental cumulative growth due to oxidizing or scaling properties of a motive fluid upon temperature changes thereof, and means separating the bases of two spaced adjacent buckets, said separating means comprising first and second spaced retaining block means each engaging

the base of one of said spaced buckets, said first and second retaining block means each defining circumferentially extending holes in line with one another, and a plurality of pins having tapered portions on opposite ends and extending between said first and second retaining block means and disposed in said holes at either end thereof, said tapered portions extending only partially into said holes so that they will be extruded deeper into said holes under a predetermined circumferential compressive force between bucket bases, whereby the separating means will shorten permanently in a circumferential direction to compensate for the circumferential growth of the bucket bases.

References Cited in the file of this patent

UNITED STATES PATENTS

894,659 Kallberg ---------- July 28, 1908