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3,137,478

COVER PLATE ASSEMBLY FOR SEALING SPACES BETWEEN TURBINE BUCKETS

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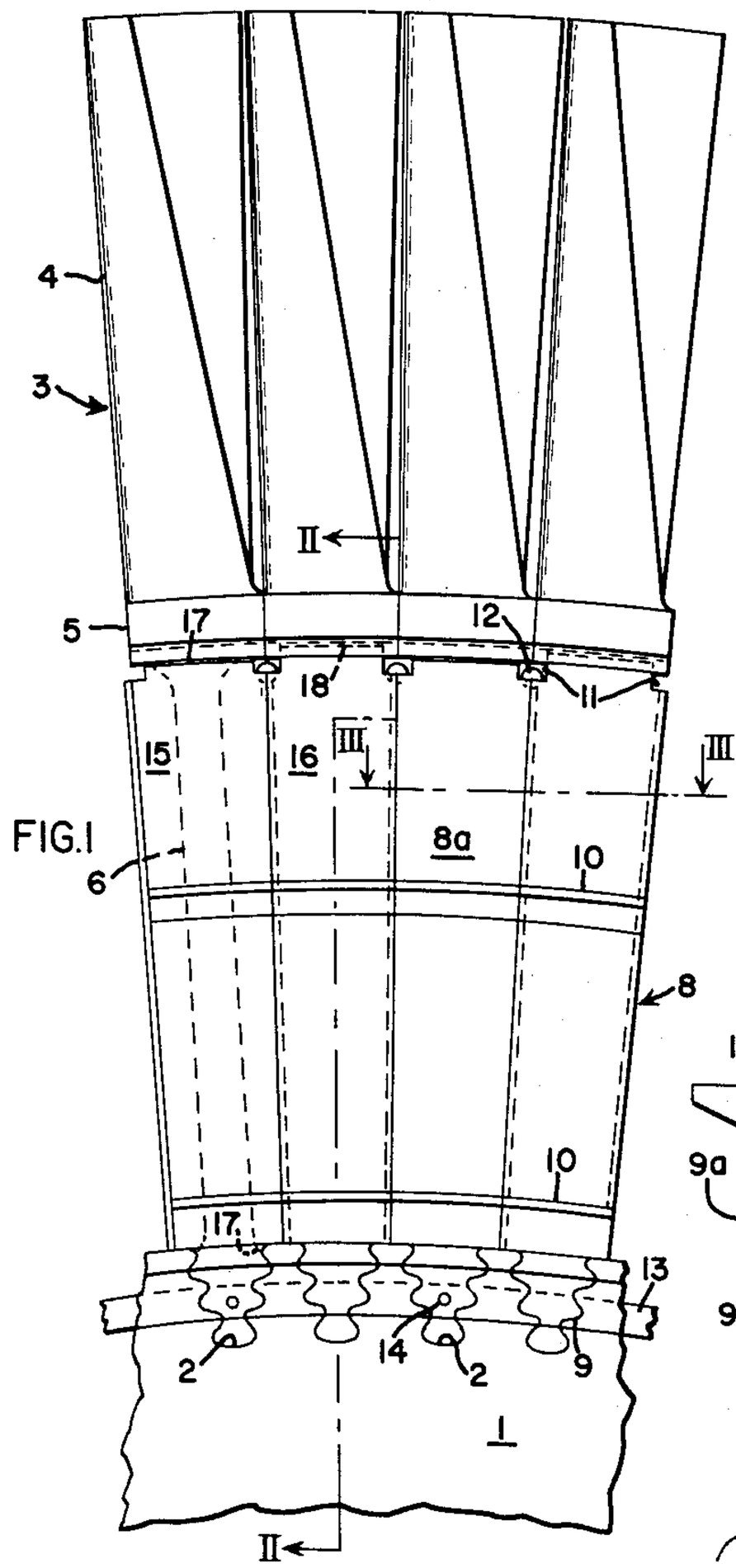

FIG.1

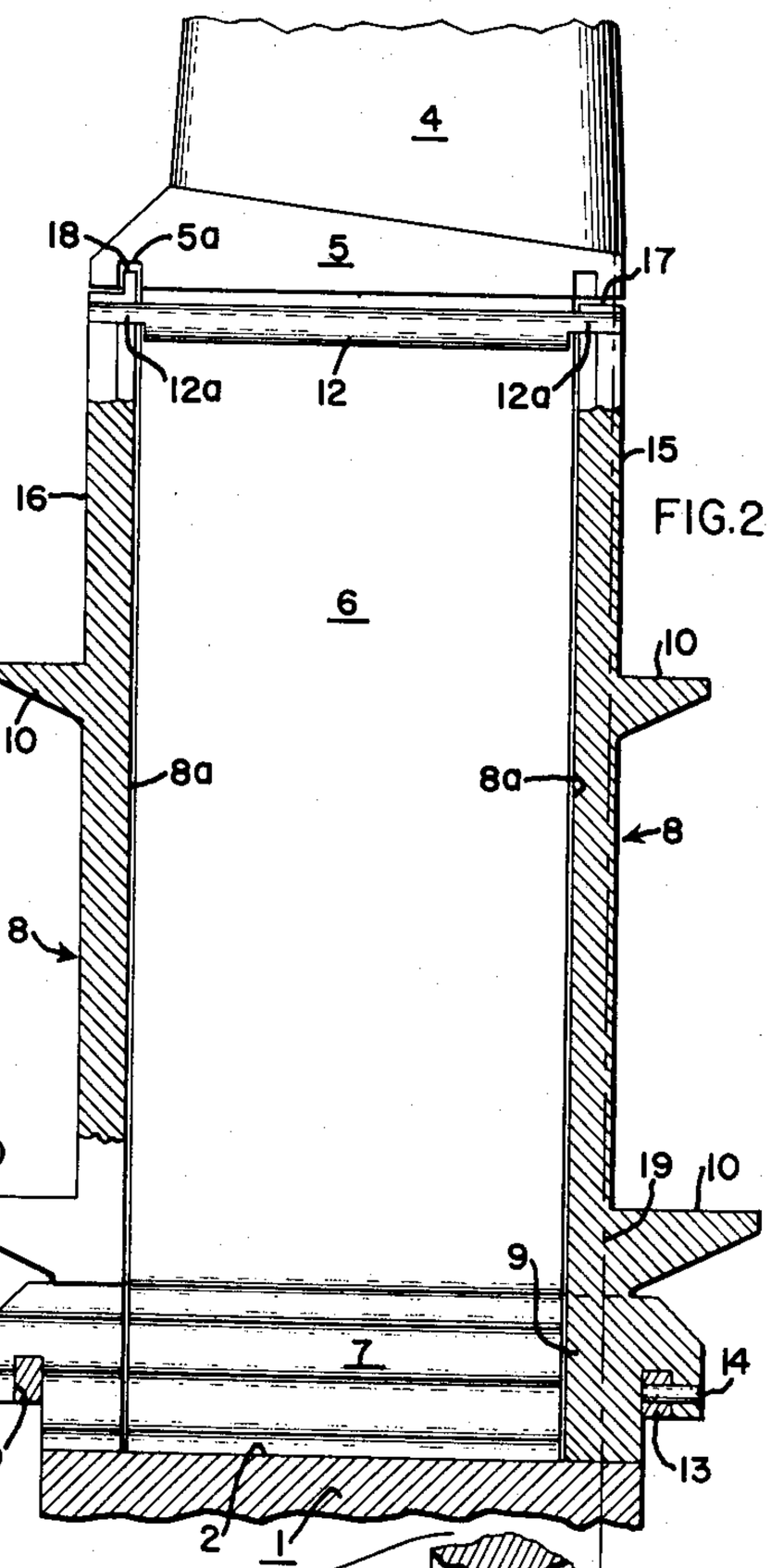

FIG.2

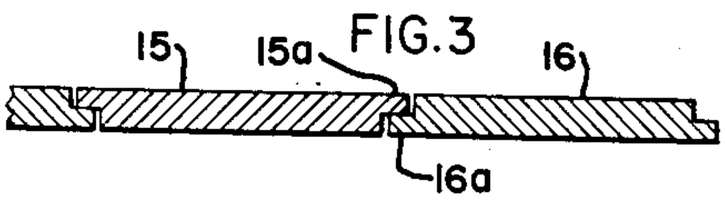

FIG.3

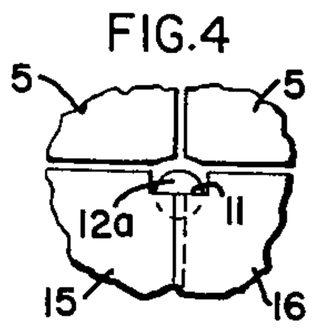

FIG.4

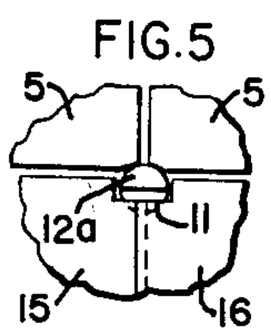

FIG.5

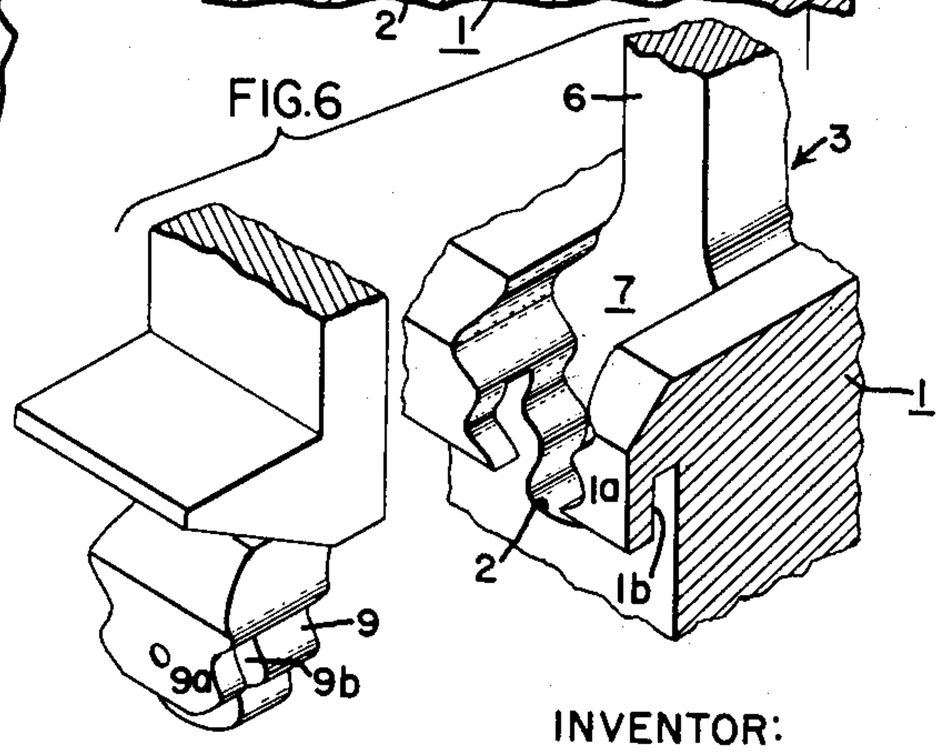

FIG.6

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COVER PLATE ASSEMBLY FOR SEALING SPACES BETWEEN TURBINE BUCKETS

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7 Claims. (Cl. 253—77)

This invention relates to an improved cover plate for sealing off fluid leakage between certain portions of turbine buckets, and more particularly to an improved means of attachment therefor.

In some types of turbines operating with very high temperature motive fluid, such as gas turbines, the blades are often attached to the turbine wheel by means of long, relatively thin "shanks," which connect the vane of the bucket with the dovetail base portion. These shanks make it possible to attach the bucket to the turbine wheel at a location of lower temperature. With such constructions, segmented cover plates have generally been employed to block off the gas flow between the narrow bucket shanks and also, in some cases, to provide other functions such as holding the buckets in place and serving as gas seals with adjacent stationary members of the turbine. These cover plates may be held in place at their radially outermost parts, and thereby loaded in compression when the wheel rotates, as disclosed in U.S. Patent 3,043,562 issued in the names of F. H. Van Nest and G. R. Fusner on July 10, 1962, and assigned to the assignee of the present application. Alternately, the cover plates may be held at their radially innermost ends and thereby loaded in tension, as disclosed for example in U.S. Patent 2,998,959 issued to L. Hayworth et al. on September 5, 1961.

In many cases, the local loading stress on the turbine wheel caused by the cover plate is greater than that caused by the turbine bucket itself. This is because the bucket shank and bucket vane are of relatively thin cross-section and a plane taken radially through the shank and bucket normal to the turbine axis reveals a relatively small amount of metal acting upon the dovetail base in that plane. On the other hand, a radial plane taken through the cover plate normal to the turbine axis often reveals the local loading to be quite high in that plane.

Whether the cover plate is held on the turbine rim by means of hooks or lugs holding the cover plate at its innermost end, or whether the cover plate loads the underside of the bucket platform, the load is ultimately transferred to the rim of the turbine wheel. The increased local loading on the rim is more than often accompanied by bending moments, due to the fact that the cover plate is not radially in line with the point where it ultimately loads the turbine wheel rim. These bending moments serve to increase the local stress, and make the means of attachment of the cover plates a critical matter.

Accordingly, one object of the present invention is to provide improved cover plate structure and means of attachment therefor.

Still another object of the invention is to provide a cover plate which loads the rim of the turbine wheel without imposing additional bending moments thereon.

Still another object of the invention is to provide an improved cover plate which, in addition to sealing off flow between buckets, provides the additional functions of holding the turbine buckets against axial dislodgement from the wheel and serves as a mounting for flanges which form a circumferential sealing ring.

Yet another object of the invention is an improved means of locking turbine buckets together at the platforms when the wheel is rotating.

A more specific object of the invention is an improved cover plate, which is attached in a very efficient manner to permit a low weight part, and which loads the turbine wheel rim in a uniform manner free from bending moments.

Briefly stated, the invention is practiced by providing a segmented cover plate, each segment having a dovetail base which fits in an axially lengthened dovetail slot in the rotor rim together with the dovetail base of the long shank turbine bucket.

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 drawings in which:

FIG. 1 is a portion of a turbine wheel, looking in an axial direction, showing several long shank turbine buckets, with cover plates, mounted on a turbine wheel rim;

FIG. 2 is a cross-section, looking in a circumferential direction along lines II—II of FIG. 1, showing the cover plate and means of attachment to the rim;

FIG. 3 is a plan view in cross-section, taken along lines III—III of FIG. 1, through the cover plates only.

FIGS. 4 and 5 are enlarged schematic views, looking in an axial direction, of the means for locking turbine bucket platforms together, shown when the turbine wheel is at rest and when it is turning, respectively; and,

FIG. 6 is an exploded perspective view showing the dovetail attachment for the improved cover plate.

Referring now to FIG. 1 of the drawing, a portion of a turbine rim **1** is shown which is furnished with a group of circumferentially-spaced axially extending dovetail slots **2** extending around its periphery. Diposed in each of the slots **2** is a long-shank turbine bucket, shown generally as **3**, which includes a vane portion **4**, an arcuate bucket platform **5**, which forms a portion of the inner boundary wall for the motive fluid flowing through the turbine, and a radially extending bucket shank **6**. Shank **6** serves to connect platform **5** to a dovetail base portion **7** which fits in slot **2**. Throughout this specification and in the claims, it will be understood that the term "dovetail" refers to the multiple dovetail or "fir tree" type of attachent, as the term is generally understood in the turbine art.

Extending radially between rim **1** and bucket platforms **5** are a number of improved cover plates, shown generally as **8**, which likewise have dovetail base portions **9** fitting in dovetail slots **2**, together with the base portion **7** of the buckets. The cover plates have relatively thin flat plate portions **8***a*, which serve to block gas flow between shanks **6** and which are tapered toward their radially innermost ends where they are attached to base portions **9**. Plate portions **8***a* are preferably thinner toward their outermost edges. The tapered plate portions **8***a* may be provided with arcuate axially-extending flanges **10**, which cooperate to form two circumferential, axially extending sealing rings. These rings form close clearances with a stationary diaphragm (not shown) to prevent the flow of gas radially between the rotor and the diaphragm. Cover plates **8** also define notches **11** at their radially outermost edges which support the opposite ends of locking pins **12**.

Referring to FIG. 2 of the drawing, it will be observed that the axial length of the dovetail slot **2** in the rotor rim is substantially greater than the axial length of the bucket dovetail base portion **7**. The dovetail bases **9** of the cover plates **8** thus fit in the remaining length of the slot **2** on either side of the bucket bases **7**.

Dovetail bases 9 of the cover plates have axial extensions 9*a* thereon, into which are cut inwardly-facing, radial grooves 9*b*. An arcuate retaining strip 13 fits into grooves 9*b* and is held in place by pins 14 passing through aligned holes in the strip and in base extensions 9*a*. (See also FIG. 1.) Retaining strips 13 may be of any convenient length and pins 14 may be upset in place or "staked" to prevent dislodgment. It is to be particularly noted that there are no radial hooks or lugs with this means of attachment to increase "windage losses" for the rotor.

Referring to FIG. 3 of the drawing, the manner of sealing against gas leakage between cover plates 8 will be apparent. The cover plates are divided into two types: inner cover plates 15 and outer cover plates 16, having half-thickness overlapping edges 15*a* and 16*a* respectively. Although there will be no tendency for the outer tips of the cover plates to move away from the buckets, they are nevertheless arranged to prevent this possibility. Inner cover plates 15 are not allowed to move axially away from the buckets because of the overlapping edges 16*a* of the outer cover plates. Hence, the radially outer tips of cover plates 15, indicated as 17 in FIGS. 1 and 2, terminate just short of the bucket platforms 5, for ease of insertion. The outer cover plates 16, however, have extending lips seen at 18 in FIGS. 1 and 2, which extend into grooves 5*a* in the bucket platforms so as to prevent lips 18 from moving outward. Grooves 5*a* are formed of ample size to allow ease of insertion of the outer cover plates 16, and clearances provided so that the outer cover plates 16 do not actually touch or load the bucket platform 5.

Reference to FIGS. 2, 4 and 5 together will indicate the manner of operation of locking pin 12. The pin is cylindrical and is notched at its ends to provide semi-circular extensions 12*a* which fit in notches 11 in the inner and outer bucket cover plates. When the wheel is stationary, as in FIG. 4, the pins merely rest in grooves 11, but when the wheel is rotating, the pins assume the position shown in FIG. 5. The force exerted by centrifugal action is very great and serves to center the pin between adjacent bucket platforms 5 and effectively lock them together so there is no relative movement between buckets. This is not a damping device, but actually serves to clamp the bucket platforms firmly together.

The exploded view of FIG. 6 shows the method of assembly of the cover plate into the slot 2. It will be observed that the rim 1 of the turbine wheel is provided with an axial projection 1*a* and an undercut groove 1*b*, which correspond to axial projection 9*a* and undercut groove 9*b* on the cover plate base 9.

To assemble the cover plate to the turbine wheel, first, the base portion 7 of the turbine bucket 3 is centered in slot 2 and then the base portions 9 of the cover plates are inserted from either side of the wheel. Grooves 1*b* and 9*b* on the wheel and cover plate respectively are aligned and the retaining strip 13 (see FIGS. 1 and 2) is then inserted radially outward to fit in the aligned grooves, at the same time aligning its holes with those in the cover plate base. Then pins 14 are inserted and secured in place. It will be apparent that strip 13 then prevents relative axial movement between rim extensions 1*a* and cover plate base extensions 9*a*. Therefore, both buckets and cover plates are locked to the rim 1 and can move neither radially nor axially.

The arrangement and construction of the cover plate 8 is such that it presents a moment-free loading on its dovetail base portion 9. Reference to FIG. 2 of the drawing will show that a radial plane 19 passing through the axial center of the dovetail base portion 9 represents a line along which the base 9 will be loaded in tension with no bending moments. In other words, if the moments of the cross-sectional area taken from line 19 have a sum of zero, then there will be no bending moments imposed on dovetail base 9 to add to its tensile loading.

The metal in the cover plate proper is so distributed and arranged on either side of line 19 that the bending moments in opposite axial directions are balanced. Here the bulk of the tapered plate portion 8*a* is balanced by the extending sealing flanges 10, which have a much greater effect in bending than the plate portion 8*a*, since they extend farther in an axial direction. The axial extension 9*a* of the base portion 9 has a negligible effect, since it carries only its own weight.

The operation and advantages of the improved cover plate will be apparent from the following description. A dovetail arrangement is one of the most efficient turbine bucket attachments known, for such a part which has to be removable. The theories and design of the contours of the dovetail slot and mating dovetail portion to fit in that slot have reached a high degree of perfection. Hence it is that the improved cover plate, by virtue of being retained in place on the rim by a dovetail base, permits an extremely light-weight cover plate. The cover plate imposes its own uniform tensile force on the rotor rim without imposing any bending moments thereon. The cover plate shown, by virtue of distributing the metal about the center of the dovetail base portions 9, exerts a pure radial force on the rim and has no tendency to bend inward or outward under the action of centrifugal force. The cover plate shown neither loads the turbine bucket (which, in turn, would increase the local loading on a portion of the bucket base portion), nor does it attach to the bucket or turbine rim by means of lugs or hooks (which create undesirable bending moments and/or local increased stresses).

Locking of bucket platforms 5 together is accomplished uniformly across the axial surface of the platform by means of the pins 12, which are conveniently held in place by notches in the cover plates when the wheel is at rest. Since the cover plates are made in segments, i.e., one for each turbine bucket, they are easily replaced in the event that rubbing of the seals provided by flanges 10 takes place. The overlapping feature of the cover plates shown in FIG. 3 prevents the leakage of gas between plates. Although the preferred embodiment is with inner and outer cover plates, they can also be manufactured identical in form so that they overlap consecutively in "shiplap" style. The means of attachment of the cover plates to the rim with retaining strip 13 and pins 14 reduces windage losses, and also prevents the axial movement of the buckets in the slots 2.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications will occure to those skilled in the art, 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 I claim as new and desire to secure by Letters Patent of the United States is:

1. A cover plate for a long shank turbine bucket comprising:

a flat plate portion tapering in front elevation and having a dovetail base attached to the smaller radially inner end thereof defining dovetail grooves extending in the direction of the plate thickness, said plate being arranged with respect to a plane passing through the center of the base portion transverse to said grooves so that bending moments caused by centrifugal forces when the plate is attached to extend radially outward from a turbine rotor rim by said dovetail base portion will cancel.

2. A cover plate for a long shank turbine bucket comprising:

a flat plate portion tapering in front elevation and including at least one arcuate flange extending normal to the plate across its width, and a dovetail base attached to the smaller radially inner end of said plate defining dovetail grooves extending in the direction of the plate thickness, said plate portion

and flange being disposed with respect to a plane passing through the center of the base portion transverse to said grooves so that bending moments caused by centrifugal forces when the plate is attached to extend radially outward from a turbine rotor rim by said dovetail base portion will cancel, whereby the flat plate portion is substantially balanced by the flange.

3. In a turbine, the combination of a turbine wheel having a rim defining circumferentially spaced, axially extending dovetail slots, a plurality of long shank turbine buckets having dovetail base portions disposed in said slots, said bucket base portions having axial lengths less than those of said dovetail slots, a plurality of cover plates disposed at opposite sides of the bucket shanks, each plate having radially extending flat plate portions tapering in front elevation and disposed adjacent one another so as to block the spaces between bucket shanks, each plate portion having a dovetail base portion disposed in a dovetail slot adjacent a bucket base portion, and means preventing relative axial movement between the cover plate base portions and the turbine wheel rim, whereby the cover plates and turbine buckets are individually supported by their respective dovetail base portions.

4. In a turbine, the combination of a turbine wheel having a rim defining circumferentially spaced, axially extending dovetail slots, a plurality of turbine buckets having dovetail base portions disposed in said slots, the buckets also having arcuate platform portions radially spaced from said dovetail base portions and connected thereto by relatively slender shanks, a plurality of cover plates disposed at opposite sides of the bucket shanks, each plate having a radially extending flat plate portion tapering in front elevation and having opposite radial edges defining flanges overlapping portions of similar adjacent cover plates, each of said cover plates also having attached to the smaller radially inner end thereof a dovetail base portion disposed in a dovetail slot adjacent a bucket base portion, the flat plate portions of said cover plates being so disposed with respect to the cover plate base that bending moments on the cover plates caused by centrifugal forces are substantially balanced when the turbine wheel rotates.

5. In a turbine, the combination of a turbine wheel having a rim defining circumferentially spaced, axially extending dovetail slots, a plurality of turbine buckets having dovetail base portions of a lesser axial length than that of said dovetail slots, said turbine buckets also having arcuate platforms radially spaced from said base

portions and connected thereto by relatively slender shanks, a plurality of cover plates disposed at opposite sides of the bucket shanks, each plate including a dovetail base portion disposed in one of said dovetail slots, there being a cover plate dovetail portion at either side of each bucket base portion and having attached thereto a flat plate portion tapering in front elevation and extending radially between said rim and said bucket platforms, said plate portions also including at least one axially extending arcuate flange thereon, the flat plate portions and flange being so disposed with respect to the cover plate base portion so as to balance bending moments about the base portion caused by centrifugal forces when the wheel rotates to provide moment-free loading of the cover plates on the rim.

6. The combination, according to claim 5, including a plurality of cylindrical locking pins extending over the axial length of the bucket platforms and loosely supported in notches defined at the radially outer portions of axially opposite cover plates, said notches being disposed radially inward from the bucket platforms where they are adjacent one another, so that said pins will move outward under the action of centrifugal force to lock the bucket platforms together.

7. The combination, according to claim 5, wherein said cover plate base portions and said rim include axially extending projections defining aligned radially undercut grooves, arcuate retaining strips disposed in said grooves to prevent relative axial movement between cover plates and turbine rim, and means fastening said retaining strips in said grooves, whereby both cover plates and turbine buckets are held in said dovetail slots against radial and axial disengagement.

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