Inventor:
John H. Doran

by Harry E. Snelley
His Attorney.
This invention relates to elastic fluid turbine bucket wheels and more particularly to arrangements for fastening the buckets to the rim of the disk.

Buckets of axial flow turbines are normally subject to two major forces in the operation of a machine. The greater of these, the centrifugal force due to the rotational velocity of the wheel, acts radially or along the longitudinal axis of the buckets. The lesser force, due to the operating fluid impinging upon the bucket surfaces, acts tangentially of the wheel and against the buckets substantially at right angles with respect to the centrifugal force. Due to the fact that a certain amount of play usually exists in the fastening means, the buckets are rocked relatively to the rim in the plane of the wheel when passing through the jets of operating fluid. With the usual bucket mounting arrangements, this rocking of the buckets takes places more or less independently of the centrifugal force. The repeated rocking of the buckets is accompanied by a corresponding distortion of the cover band which ultimately becomes fatigued and fails.

It is an object of this invention to provide a new and improved arrangement for fastening turbine buckets to the rim of the disk so as substantially to preclude rocking movements of the buckets with respect to the rim during the operation thereof.

It is a further object of this invention to provide a new and improved fastening arrangement for turbine buckets so that the buckets will be held substantially rigidly in position by the centrifugal force acting thereon to preclude rocking movements of the buckets on the rim of the disk due to the force of the operating fluid acting thereagainst tangentially of the wheel.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto taken in connection with the accompanying drawing.

In the drawing, Fig. 1 is a perspective view of a section of a turbine bucket wheel illustrating one modification of my invention, Fig. 2 is an enlarged diagrammatic sketch illustrating certain principles of the bucket fastening arrangement, while Figs. 3 and 4 illustrate further modifications of the invention.

Referring to Fig. 1, 10 is the web of the rotor disk and 11 the rim thereof on which is mounted a plurality of buckets 12. For securing the buckets thereto, the rim is provided with a plurality of axially extending V-shaped notches 13, one side wall 14 of each has a substantially smooth plane surface while the other side wall 15 is provided with a plurality of axially extending serrations 16. The turbine buckets 12 are provided with base portions or depending roots 17 of such configuration as to conform with the shape of the slots 13, one face 18 thereof being smooth and plane so as to cooperatively engage with the side wall 14 while the opposite face of the roots is provided with a plurality of axially extending serrations 19 to cooperatively intermesh with the serrations 16 provided on the corresponding side wall of the rotor rim slot. The turbine buckets may be assembled upon the rim by sliding the roots into the slots axially with respect to the wheel with the two serrated faces intermeshing with each other. The buckets may be suitably secured in position against lateral movement after assembly as by peening over the slightly extending edges 20 of the rim slots.

The lower portion of each bucket base or root, as pointed out above, is essentially V-shaped in cross-section and has one side plane or smooth and the other side serrated in axial direction. The upper portion of each bucket base or root forms a projection 21 extending in tangential or circumferential direction of the bucket wheel disk and broadly constituting an overhanging portion with regard to the V-shaped lower base portion. In a preferred embodiment, as shown in the drawing, the projection 21 engages the base of an adjacent bucket. Thus the bases of the buckets engage the V-shaped slots of the disk and also have portions engaging and mutually supporting each other. The projections 21 not only form a means for rigidly supporting the buckets on the disk but they also constitute a means for firmly supporting the thin inlet and outlet edge portions of the corresponding bucket blades, thereby reducing vibrations of the thin bucket blade portions.

The relationship of the intermeshing serrations with respect to the opposite flat surfaces is such that the buckets under the influence of the centrifugal force will be shifted outwardly and in such a manner that the flat face 18 of the bucket root will be held rigidly and in square engagement against the flat slot side wall or face 14. Referring to the enlarged detail view, Fig. 2, it will be noted that the serrations are of substantially uniform pitch and depth and also that the face angle A of the serrations is somewhat greater than the angle B of the opposite engaging flat faces relative to the radii of the disk. By this arrangement, the centrifugal force repre-
sented by the vector $R$ acting upon the buckets radially outwardly will tend to move the buckets in the slot in the direction of the parallel planes of the loaded serration faces indicated by the arrow $C$. Movement in this direction, depending upon the amount of play between the root and slot, however, will be arrested with the face $18$ of the bucket root being forced into square engagement with the slot face $14$. The greater the centrifugal force acting upon the buckets, the more rapidly these flat faces are held together. The force of the elastic fluid represented by the vector $S$ acting against the buckets tangentially of the wheel will be substantially ineffective in causing a separation of the engaging root and slot faces, $18$ and $14$, respectively. Since the load of the centrifugal force is carried only by the intermeshing serrations, the force of operating fluid cannot shift the loading to other circumferentially displaced points so as to cause the disengagement of the flat faces $14$ and $18$ to permit rocking movements of the buckets.

It will be noted that the angle $A$ of the serrations may be varied within certain limitations. If the angle $A$ is very large, of the order of 90 degrees or more, the centrifugal force acting outwardly upon the buckets will have little or no effect in moving the buckets to the left to bring the faces $14$ and $18$ solidly together. Furthermore, if the angle $A$ is equal to or less than the angle $B$, it is obvious that the root will not be locked in place but may be moved outwardly parallel with the slot side wall $14$ without restriction. Thus, in order to secure the desired result, it is necessary that the angle $A$ be somewhat less than 90 degrees and greater than the angle $B$, the slope of the slot side wall $14$.

For greater ease and accuracy in the manufacture of the disk rim slots, it is preferred to machine one face, for example, in an axial plane of the disk and taper the other face $14$ outwardly with respect to the first. In the manufacture of the bucket roots, one face may be machined parallel with the longitudinal axis of the blade, while the other face may be machined at the desired angle with respect to the first. The serrations may be provided in either pair of cooperating faces, as desired, with substantially similar results. As indicated in Fig. 3, the serrations are provided in the tapered faces $14$ and $18$, while in Fig. 4, the arrangement of the slots and bucket roots is reversed as compared with the modification shown in Fig. 3.

While in the drawing cooperating serrations are shown on both the bucket root and the slot side wall, these being of substantially uniform pitch and depth, it is obvious that in lieu thereof of intermeshing portions of any other suitable configuration may be embodied. Such intermeshing portions must have engaging surfaces whereby the buckets are acted upon by the centrifugal force, will allow the bucket roots to shift in accordance with the amount of play between the roots and the slot so as to cause the square and solid engagement of the opposite cooperating faces.

By the V-shaped arrangement of slots and bucket roots, maximum strength of the cooperating parts is obtained. The bucket roots are relatively narrow at the extremity where the load stress carried thereby is a minimum while toward the upper end where the total load carried by the root is maximum, the cross-section thereof is proportionately greater. The same is true of the disk rim. The outer ends of the rim section between adjacent slots are narrow while toward the bottom where the total load stresses are maximum, they are relatively wider.

Thus, with my invention, I have accomplished an improved bucket wheel construction. Broadly, such construction comprises a central or disk element forming a plurality of axial slots V-shaped in cross-section, one side of each slot having a smooth surface while the other side of each slot has an axially serrated or grooved surface. A plurality of members extending radially from the rim are securely held in the slots. Each of these members has a root or base with an inner portion directly engaging both walls of a slot and an outer base portion projecting circumferentially and engaging the outer base portion of an adjacent member.

Having described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

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

1. The improved bucket wheel construction comprising a disk having a plurality of axially extending and substantially V-shaped slots, one side wall of each of said slots lying in a substantially axial plane, the other side wall of each of said slots lying in a plane inclined with respect to the first mentioned wall, a plurality of buckets mounted on said rotor, each of said buckets having a base portion shaped to cooperatively fit in one of said slots, means for securing said base portions in said slots comprising substantially axially extending and cooperating serrations provided in one of said slot side walls and in the adjacent face of the base portion, the base angle of said serrations being greater than the angle of inclination of said opposite side wall with respect to the radius of said rotor and less than 90 degrees.

2. The combination of a turbine rotor having axially extending and substantially V-shaped slots in the periphery thereof, buckets having substantially V-shaped base portions for cooperatively fitting in said slots, substantially axially extending intermeshing serrations provided in the second pair of cooperating faces of said slots and said bases, the angular relationship of the engaging faces of said serrations being such with respect to the opposite first pair of cooperating faces as to cause said buckets under the influence of centrifugal force to tend to move toward said opposite first pair of cooperating faces.

3. The combination of a turbine rotor having axially extending V-shaped slots in the periphery thereof, buckets having V-shaped bases for cooperatively fitting in said slots, a first pair of cooperating faces of said slots being plane, axially extending intermeshing serrations provided in the second pair of cooperating faces of said slots and self bases, the angular relationship of the engaging faces of said serrations being such with respect to the opposite first pair of cooperating faces as to cause said buckets under the influence of centrifugal force to tend to move toward said opposite first pair of cooperating faces.

4. In an elastic fluid turbine, a bucket wheel having a rim provided with axially extending and substantially V-shaped slots, one face of each of said slots lying in an axial plane, buckets having bases with a portion shaped to conform with
said V-shaped slots, means for securing said bucket base portions in said slots comprising substantially axially extending intermeshing serrations in only one face of said base portions and in the corresponding face of said slots.

5. The combination of a turbine rotor, the periphery of said rotor being provided with axially extending and substantially V-shaped slots, buckets having base portions shaped to conform with said slots, means for securing said base portions in said slots comprising substantially axially extending and intermeshing integral portions provided in one of said slot faces and in the adjacent face of said base portions, the relationship of said intermeshing portions being such that the bucket under the action of centrifugal force will be forced toward the opposite engaging faces of said slots and said base portions said opposite engaging faces being plane.

6. The combination of a turbine rotor, the rim having an axially extending and substantially V-shaped slot, one side wall of said slot lying in a substantially axial plane, a bucket having a base with a portion shaped to conform with said slot, means for securing said base portion in said slot comprising substantially axially extending cooperating projections and grooves provided in one pair of adjacent faces of said base portion and said slot, the relationship of the engaging portions of said projections and grooves being such that the bucket under the action of centrifugal force will tend to be moved toward the opposite cooperating faces said opposite cooperating faces being plane.

7. An article of manufacture comprising an element having an outer annular rim forming a plurality of axial slots substantially V-shaped in cross-section, one side of each slot forming a smooth surface and the other side of each slot forming an axially serrated surface, and a plurality of members extending radially from the rim, each member having a base with an inner portion filling a slot and an outer portion with a circumferentially extending projection for engaging the outer base portion of an adjacent member, one side of each base having serrations intermeshing with the serrated surface of a slot.

JOHN H. DORAN.