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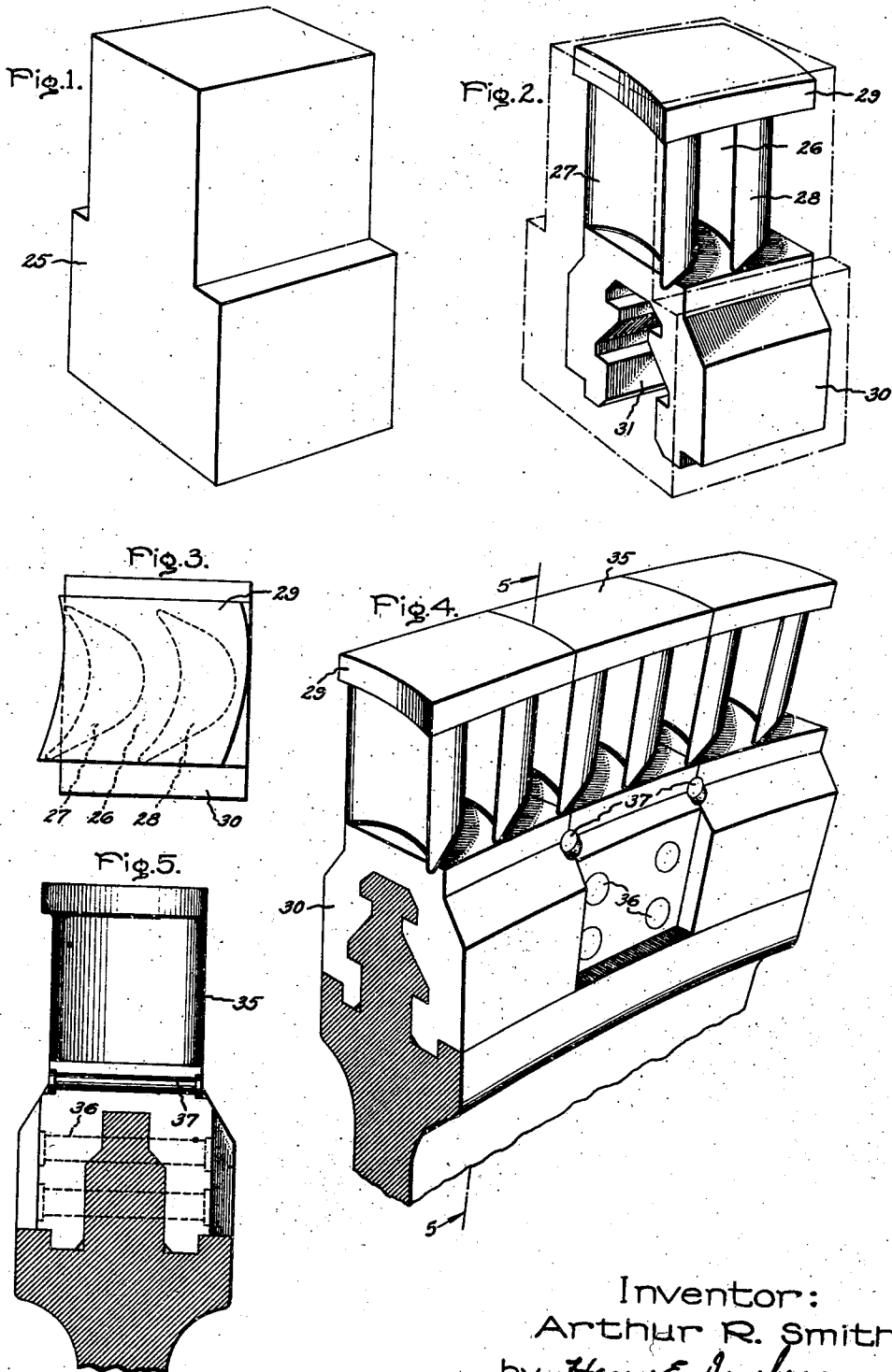
A. R. SMITH

2,221,685

ELASTIC FLUID TURBINE BUCKET UNIT

Filed Jan. 18, 1939

2 Sheets-Sheet 1



Inventor:
Arthur R. Smith,
by *Harry E. Dunham*
His Attorney.

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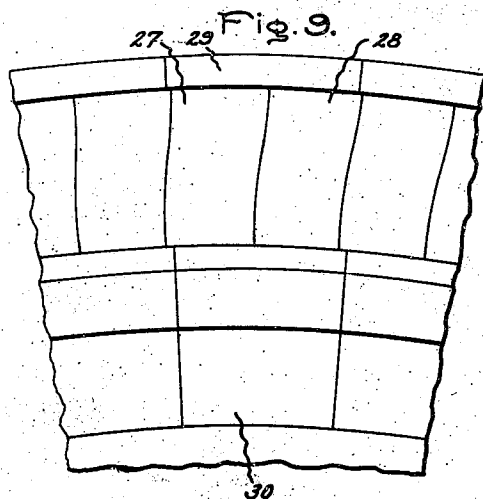
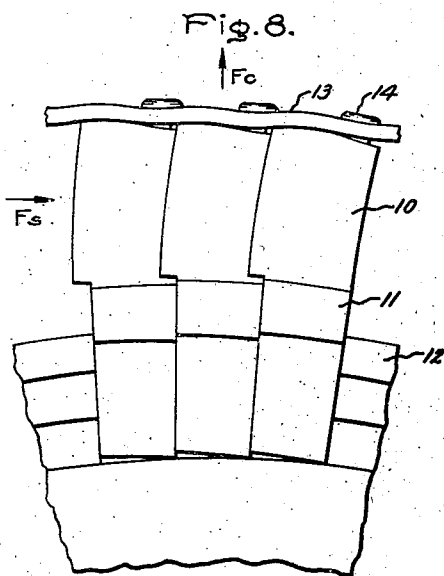
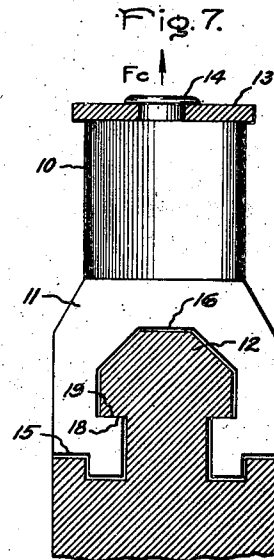
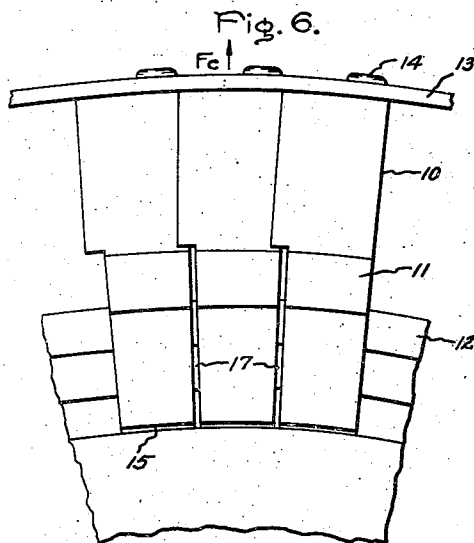
A. R. SMITH

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ELASTIC FLUID TURBINE BUCKET UNIT

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2 Sheets-Sheet 2



Inventor:
Arthur R. Smith,
by *Harry C. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

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ELASTIC FLUID TURBINE BUCKET UNIT

Arthur R. Smith, Schenectady, N. Y., assignor to
General Electric Company, a corporation of
New York

Application January 18, 1939, Serial No. 251,574

2 Claims. (Cl. 253-77)

This invention relates to elastic fluid turbine buckets and more particularly to removable buckets for turbines of the axial flow type.

It is desirable that buckets of axial flow elastic fluid turbines be removably attached to the rotor in order that they may be readily replaced if necessary. Such buckets usually consist of a blade portion and an integral base portion which is fastened onto the rim of the rotor by a dovetail connection. Such a fastening arrangement is preferred because of its relatively greater strength and its comparative ease of manufacture. Groups of buckets are usually tied together by a cover secured onto the ends of a number of adjacent blades, which cover adds to the rigidity of the blades and prevents the escape of operating fluid from the working passage. Such buckets, however, are not suitable for use in high pressure stages of turbines designed for high admission pressures of operating fluid, such as, for example, of the order of 1200 pounds per square inch and higher. In such turbines, the buckets in the high pressure stages tend to be displaced in the peripheral direction, from the normal radial position, due to the force of the operating fluid jet acting tangentially of the rotor. The buckets passing from one jet to the next are alternately loaded and unloaded, and the repetition of the deflection of the blade ends and the accompanying distortion of the cover ultimately causes the fatigue of the latter and its resultant failure.

It is an object of this invention to provide a new and improved elastic fluid turbine bucket unit which is adapted to be removably fastened to the rotor rim and which possesses a maximum of strength and rigidity.

It is a further object of this invention to provide a new and improved high pressure turbine bucket unit particularly adaptable for use in the high pressure stages of the turbine and which will not be appreciably distorted when subjected to the jets of operating fluid therein.

In the illustrated embodiment, a turbine bucket unit is disclosed comprising a cover portion, a plurality of blades and a base portion formed from a solid piece of forged steel, the unit being adapted to be removably attached to the rotor rim.

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 drawings.

In the drawings, Figs. 1, 2 and 3 are detail

views illustrating steps in the manufacture of bucket units according to the invention; Fig. 4 is a perspective view of a portion of a bucket wheel provided with bucket units according to the invention; Fig. 5 is a cross sectional view taken along the line 5-5 of Fig. 4; Figs. 6, 7 and 8 are enlarged diagrammatic sketches illustrating certain operational characteristics of typical turbine bucket arrangements; and Fig. 9 is a diagrammatic sketch illustrating certain operational characteristics of bucket units according to the invention.

For a better understanding of the invention, the attention is first directed to Figs. 6, 7 and 8, which illustrate a typical turbine bucket arrangement in which the blades 10 are shown having individual bases 11 dovetailed onto the rotor rim 12. The cover band 13 is riveted onto the upper ends of the blades by means of the tenons 14 which project through suitable apertures provided in the cover. In order that the buckets may be slid around the periphery of the wheel into position, after the bases are inserted into the rim slots, it is necessary that a certain clearance be allowed between the co-operating dovetails of the rotor rim and the bucket bases. Such clearance, which usually varies at different parts of the dovetail between two and fifteen thousandths of an inch, is illustrated in an exaggerated manner in Figs. 6 and 7 at 15 and 16 between the bucket base and the adjacent portions of the rotor rim. Because of minor inaccuracies of manufacture of the co-operating dovetail parts, also because of improper positioning of the buckets so that the abutting faces are not forced into solid engagement with each other, and due to the falling of particles of foreign matter between the abutting faces during the wheel assembly, and other similar reasons, slight spaces are also likely to exist between the abutting bucket base faces. While the average spacing between each pair of adjacent buckets may only be of the order of one ten thousandth of an inch, it is understood that this is cumulative around the periphery of the wheel until at some particular point a spacing of several thousandths of an inch may occur. Such a bucket spacing condition is shown in an exaggerated manner in Fig. 6, at 17. In Figs. 6 and 7, the turbine rotor is assumed to be rotating at normal speed at which time the centrifugal force, represented by the vector F_c , maintains the buckets in the outermost position with the shoulder 18 of the bucket bases seating firmly against the co-operating shoulder 19 of the rotor rim dove-

tail. When the buckets are moved outwardly under the centrifugal force, the spaces 17 are further widened, due to the withdrawal of the wedge shaped bucket bases.

Thus it is evident that while it is intended that the buckets be substantially rigidly mounted on the wheel rim, in actual practice many of the buckets are relatively loose on the rim, contacting therewith only at the points of load transmission. A predetermined variation of the tangential bucket loading, indicated by the vector F_t in Fig. 8, therefore, will cause a shifting of the centrifugal load distribution and physical rocking of such buckets relative to the rim. When the blades are subjected to the impact of the jets of operating fluid, particularly during light load conditions of the turbine, when the load carried by the high pressure stage buckets is greatest, the buckets may be rocked on the rim to some such position as indicated in Fig. 8. The total deflection of the blade ends is due to the cumulative effect of the deformation of the blade portions because of their relative resiliency, and the rocking movement above described. The deflection of the blade ends is accompanied by the distortion of the cover band as indicated in Fig. 8. It must be remembered that the cover band and its fastening must also withstand the centrifugal force and the expansive force of the operating fluid, both acting outwardly thereon. Primarily because of the continuous alternating bending stresses, the cover band ultimately becomes fatigued and fails.

In accordance with my invention, the turbine rotor is provided with bucket units formed from a single, solid piece of suitable forged steel each unit comprising a cover portion, a plurality of blades, and a base portion. As indicated in Figs. 1, 2 and 3, a single block of metal 25, selected for the desired characteristics as to strength, is first squared to the approximate outer dimensions of the bucket unit. It is then transversely slotted in any suitable manner, as at 26, to provide an elastic fluid passageway therethrough of a shape corresponding to the channel normally provided between adjacent turbine blades for the most efficient functioning thereof. The blades 27 and 28 may then be completed by machining the opposite sides of the block leaving the cover portion 29 and the base block 30 integrally bridging the ends of the blades. The base block 30 may then be machined out in a well-known manner to form the dovetail fastening slot 31 and suitably tapered for assembly onto the rotor rim as indicated in Fig. 4. Such finishing operations as the turning down of the outer surface of the cover portions may be done with the bucket units assembled on the rotor.

Although a greater number of blades may be formed in each bucket unit, I prefer to provide only two blades per unit for the reason that the rigidity of the bucket assembly is thereby sufficiently increased for successful operation under the most extreme conditions of present day turbine design. By the arrangement shown, with a common base block for each pair of blades, relative sliding or tilting between the base portions of each individual blade is positively precluded. Further, since the centrifugal force acting outwardly on each blade is transmitted to the rotor rim over a base width twice as great as in the case of individual bases, the resistance to the rocking moment of the operating fluid jet is doubled. The most extreme condition of bucket loading, according to present practice, will be

ineffective to rock the bucket units relative to the rim against the opposing moment due to the centrifugal force. Assuming, however, that due to unforeseen conditions the bucket units may be so loaded as to cause the rocking thereof within the limits of the spacings between adjacent bucket units, corresponding to inherent spacings indicated at 15, 16 and 17 in Figs. 6 and 7, it will be obvious that the maximum possible angle of deflection of the upper end of each bucket unit will be but one-half as much as in the case of the individual base buckets. Even such rocking of the bucket units will not cause a distortion of the cover portions because the blades, being integrally united at opposite ends, must move as a unit carrying the cover portion parallel with the base block.

The cover portion will be stressed somewhat due to the force acting against blade portions under load. For withstanding this stress the cover portion is made relatively heavy, for example of the order of one-half inch for a blade length of two inches, so that the stress will be distributed substantially equally between the base block and the cover portion necessitating the compound bending of the blades, if at all, as indicated in the diagrammatic sketch, Fig. 9. At least twice the force will be required to distort the blades in this manner than will be required if the ends were free or merely loosely connected.

As shown in Figs. 4 and 5, the notch closing bucket unit 35 may be riveted onto the periphery of the rim by means of the pins 36 extending therethrough. The bucket unit is further secured to the ends of the adjacent bucket units by means of the keys 37 extending transversely therebetween which assist in precluding relative movement between the notch closing bucket unit and the adjacent units.

Thus, with my invention I have accomplished an improved construction of bucket units for high pressure elastic fluid turbine wheels. Briefly, such bucket units are made from a single piece of forged steel and each unit has a base forming a dovetail for connection to a circumferentially extending dovetail formed by the rim of a bucket wheel. Each unit includes at least two bucket blades having ends integral with the base and other ends integral with an outer cover. The cover is relatively inflexible, that is, of a thickness of the order of 25% of the blade length with regard to blades of about 2 inch length. The units are machined in any suitable manner from a solid block of material, for example, in the manner set forth in the copending application of A. M. Reynolds, Serial No. 251,573, filed on January 18, 1939 and assigned to the same assignee as the present application.

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. A bucket unit for high pressure elastic fluid turbine wheels comprising a base forming a dovetail for connection with the dovetailed rim of a bucket wheel disk, two spaced bucket blades each having an end integrally formed with the base, and a cover integrally formed with the other ends of the blades, the entire bucket unit being machined from a single piece of forged steel.

2. A high pressure elastic fluid turbine wheel

5 comprising a disk having a rim with circumferentially extending grooves forming a dovetail, and a plurality of bucket units forming a row of bucket blades secured to the disk, each unit being machined from a single piece of forged steel and having a base forming a dovetail con-

nected to the dovetail of the rim, two spaced blades each having an end integral with the base and a cover integral with the other ends of the blades, the covers of adjacent units abutting each other.

ARTHUR R. SMITH.