No. 735,107. PATENTED AUG. 4, 1903.

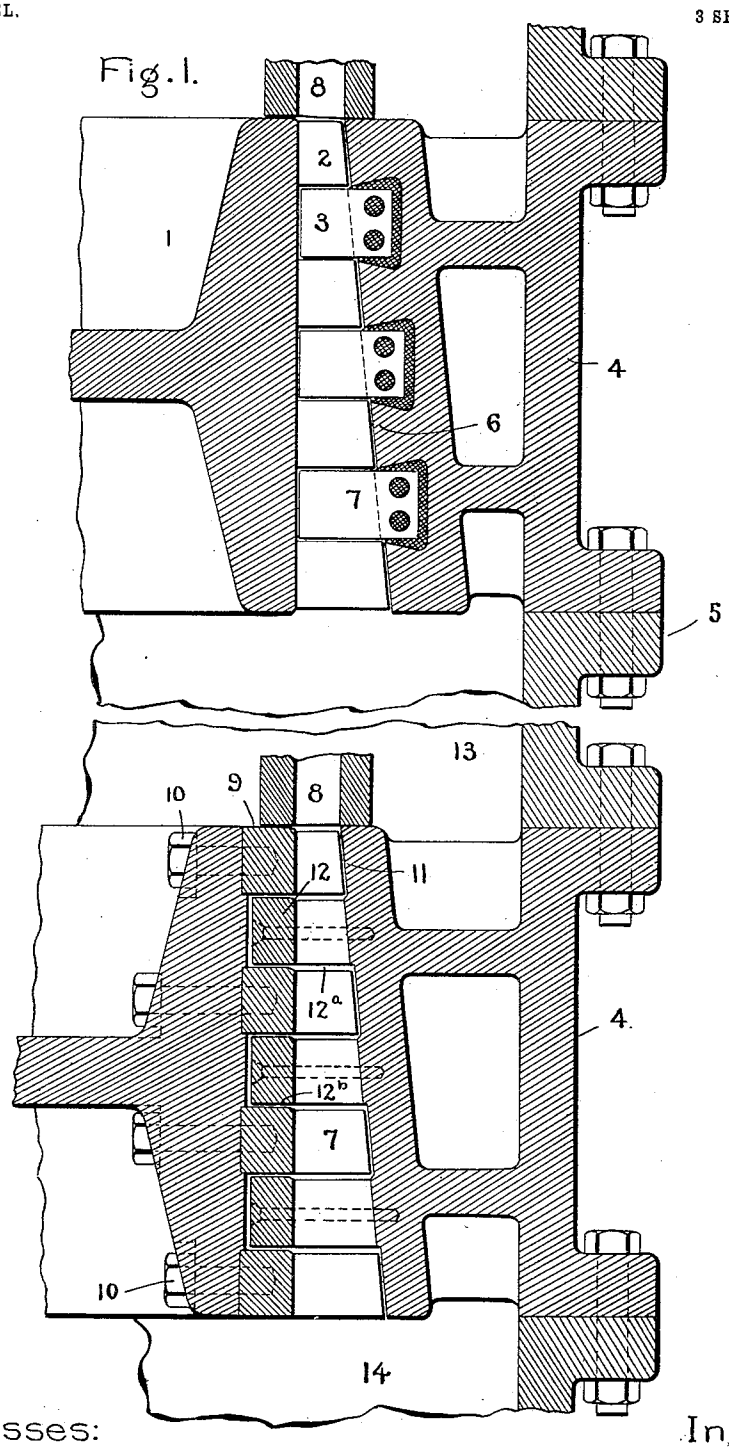
O. JUNGGREN.

TURBINE.

APPLICATION FILED OCT. 20, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1.



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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 2

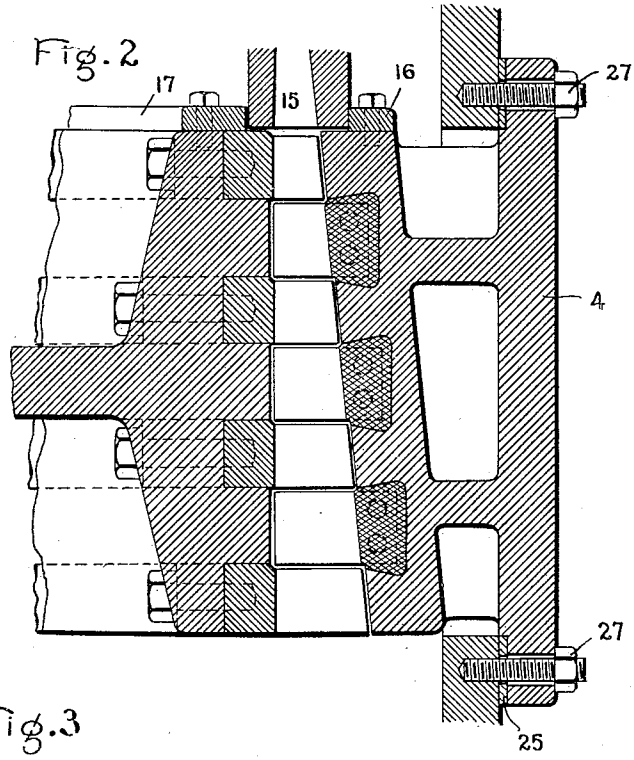


Fig. 3

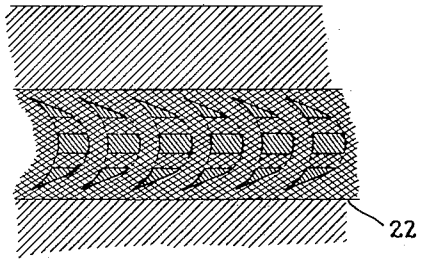


Fig. 4

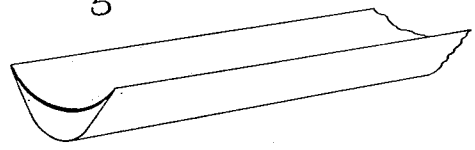
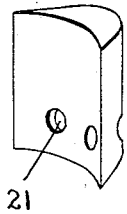


Fig. 5



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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 6

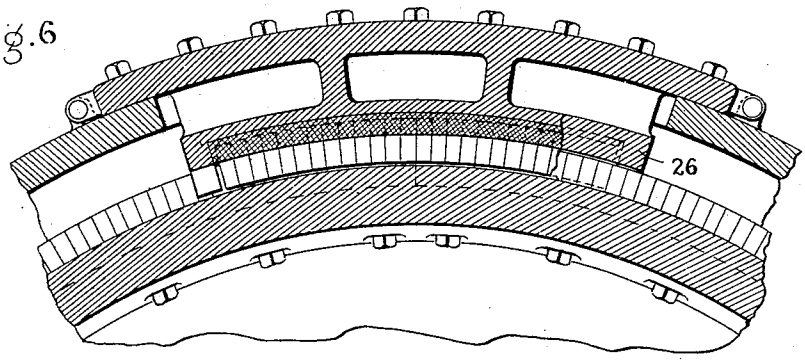


Fig. 7

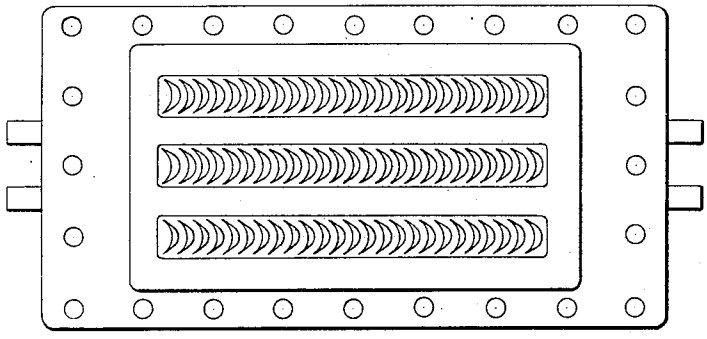
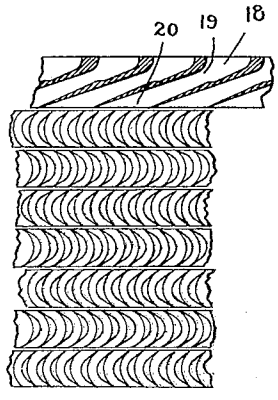


Fig. 8



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No. 735,107. Patented August 4, 1903.

UNITED STATES PATENT OFFICE.

OSCAR JUNGGREN, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

TURBINE.

SPECIFICATION forming part of Letters Patent No. 735,107, dated August 4, 1903.

Application filed October 20, 1902. Serial No. 127,924. (No model.)

To all whom it may concern:

Be it known that I, OSCAR JUNGGREN, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Turbines, of which the following is a specification.

In elastic-fluid turbines comprising rows of moving and stationary buckets it is necessary to provide a clearance between the end of the nozzle, when a nozzle is used, and the first row of buckets to prevent them from rubbing on each other. It is also necessary to provide a clearance between the adjacent rows of buckets. The clearance between the moving and stationary parts is very slight, being as low as six one-hundredths of an inch in some cases; but even this small space permits a large amount of motive fluid to leak into the wheel casing without performing useful work. Where the leak is between the nozzle and the adjacent row of buckets, the escaping fluid, which does no work whatsoever, may be collected and used with the remainder of the fluid in a second stage when the turbine is staged. The amount of this leakage is governed principally by the pressure at the delivery end of the nozzle. As the pressure at the delivery end of the nozzle is increased or decreased the leakage will be correspondingly increased or decreased.

Where the pressure of the fluid passing through the nozzle in a jet is converted to a greater or less degree into *vis viva* or velocity, the leakage is less than where the fluid is delivered in a jet to the first row of buckets under the maximum for a given boiler-pressure, because the terminal pressure is less. The present invention relates more particularly to the former of the two types of turbines above mentioned, although it is also applicable to the second type. The amount of leakage between the moving and stationary elements of an expanding-nozzle type of turbine is variously estimated by different engineers, due to the difficulty of making accurate tests, and while they do not agree as to the amount they do agree that it materially reduces the efficiency of the machine.

It has heretofore been considered necessary to provide the moving and intermediate rows of buckets in a jet-turbine with covers, which covers are costly and are somewhat difficult to manufacture. In order to prevent the water due to condensation from collecting between the outer surface of the covers of the moving buckets and the support for the stationary intermediates and acting as a water-brake, it has been customary to separate the parts by such a distance that the water cannot collect. It has also been customary to provide a certain clearance between the covers of the intermediates and the support for the moving buckets for the same reason. I have discovered that by properly constructing and arranging the supports for the movable and intermediate buckets the covers for both sets of buckets can be dispensed with and that at the same time the leakage can be greatly reduced. By the same arrangement the losses in efficiency due to the water of condensation collecting between the moving and stationary parts can be reduced to a minimum.

In the annexed description and claims appended thereto is set forth with particularity what I consider to be novel and of my invention.

In the drawings, which show one embodiment of my invention, Figure 1 represents a partial vertical section of a jet-turbine. Fig. 2 is also a partial vertical section of a jet-turbine, showing a slightly-different construction for the moving buckets with rings for decreasing the leakage around the nozzle. Fig. 3 is a partial longitudinal section of an intermediate and its support developed in the plane of the paper. Fig. 4 is a perspective view of a piece of stock used in forming the buckets. Fig. 5 is a perspective view of a bucket. Fig. 6 is a partial transverse section of a turbine, showing the stationary or intermediate buckets. Fig. 7 is a bottom plan view of a modified form of an intermediate support with its sets of buckets developed in the plane of the paper, and Fig. 8 is a detail view showing a sectionalized expanding-nozzle arranged to deliver motive fluid to the buckets.

1 represents a wheel having a number of rows of curved buckets 2 of any desired shape

and depth. The buckets gradually increase in depth from the receiving toward the discharge end, so that the working passages may enlarge in the proper ratio. The periphery of the wheel is shown as being cylindrical; but it can be made in the form of a frustum of a cone, if desired, in which case the support for the intermediates may be parallel therewith or otherwise. The buckets may be made detachable from the wheel or integral therewith, depending upon the wheel structure. They extend radially, or substantially so, after the manner of the spokes in a wheel, and are uncovered at their outer ends. Situated between adjacent rows of moving buckets are rows of stationary or intermediate buckets 3 of any desired shape. Viewed from their ends they may with advantage have the curvature shown in Fig. 8. These buckets extend toward a common center and are also uncovered. Between adjacent rows of buckets is a small clearance, so that they will not rub while in operation. This clearance can with advantage be from two to six hundredths of an inch; but it is not necessarily limited thereto. The intermediates are sectionalized—that is to say, each comprises a number of passages extending therethrough between the buckets.

The intermediates do not extend entirely around the wheel, but are arranged in the form of segments and are arranged at one or more places in operative relation to the wheel-buckets. The arc of the segments varies, of course, for different turbines, and the segments on the stages after the first will naturally cover more buckets in order to handle the increased volume of fluid due to the decrease in pressure. In Fig. 1 the intermediates are detachably secured to a support 4, and the latter is bolted to the wheel-casing 5. The support 4 in the present instance in addition to carrying the intermediate buckets forms a part of the wheel-casing; but the invention is not limited thereto, since a separate cover may be employed. It will be observed that the support is flanged on the outer end, which flange conforms to the configuration of the casing and is bolted thereto. The retaining-bolts are located on the outside, where they are readily accessible. By reason of this construction the portions of the intermediate support which are directly opposite the ends of the rotary buckets and in close proximity thereto act as stationary covers for the rotary buckets. To put the matter in a different way, the portions 6 of the support of the intermediate buckets are situated so close to the ends of the revolving buckets that all tendency of the steam or other motive fluid to escape radially is prevented and the fluid is in part confined thereby to the working passages 7.

The ends of the intermediate buckets are so close to the revolving wheel that the latter acts as a movable cover therefor and assists to confine the motive fluid to the working passages. There being no covers secured to the ends of the buckets, the water due to condensation does not have an opportunity to collect between them and the stationary parts and act as a brake. The water that is formed is swept through the working passages with the motive fluid.

Situated in the proper position to deliver fluid to the buckets is a nozzle 8, which is so designed that it imparts velocity to the motive fluid before delivering it to the buckets. The velocity imparted to the motive fluid can be changed by changing the relation of the walls of the nozzle with respect to each other. I do not wish to be understood as limiting myself to a nozzle of the precise character shown, for in certain of its aspects the invention is not limited thereto. The nozzle is clamped against the support for the intermediates, so as to prevent leakage at that point, and the clearance between the delivery end of the nozzle and the moving wheel is made as small as possible. It is customary to have a slight clearance between the nozzle and the intermediate-bucket support, which results in considerable leakage of the motive fluid; but by placing the two in contact, as shown, the leakage at this point is entirely eliminated.

In the lower part of Fig. 1 is represented the second stage of the turbine, and the construction of the buckets and the support for the intermediates have been slightly modified. The rotating buckets are formed on rings 9, and these are securred to the wheel-support by bolts 10. The rings are let into grooves formed in the wheel-rim to prevent longitudinal movement. The ends of the rotating buckets are uncovered, as before, and are situated in close proximity to the support 4 of the intermediates. The support is cut away slightly at 11, and into this cut-away portion the ends of the buckets project. The object in this is to decrease the leakage for a given clearance. The motive fluid traveling at a high rate of speed will naturally tend to take the path or paths of least resistance, which will be the working passage or passages 7, and not pass through space situated out of the direct line, and consequently of greater resistance. The ends of the intermediates have a covering 12, which is secured by screws or bolts that pass through the buckets into the support, as is illustrated in dotted lines. The covering is relatively thick and projects between the rings 9 on the wheel, and the clearance between them is as small as possible. Between the rows of buckets, as at 12^a, the clearance can be somewhat greater. This clearance has been exaggerated in the drawings in order to bring it out more clearly. The clearance at 12^b being more restricted, the motive fluid will flow through the working passages 7. In other words, the clearance-space 12^b offers such a high resistance to the passage of the motive fluid that the latter flows through the more open or work-

ing passage. By this arrangement the covers for the rotary buckets are dispensed with and a working passage is provided that gradually opens or increases in cross-sectional area from the nozzle 8 to the exhaust. In designing the machine care must be exercised to provide for the increased volume of fluid due to its decreased pressure as it passes from the inlet to the exhaust.

Situated between the stages is a chamber 13, that collects all of the motive fluid that is discharged from the working passages and all of that due to leakage. The fluid thus collected is delivered to the nozzles 8 of the second or lower stage. Situated below the wheel is an exhaust-chamber 14, that may be connected to a condenser in the ordinary manner.

In Fig. 2 is shown a means for preventing leakage between the expanding-nozzle 15 and the support for the intermediates. The support 4 of the intermediates is adjustable in a plane parallel with the turbine-shaft and is retained in place by bolts 27. The adjustment required between the intermediates and the rotary buckets is very small, and the bolt-receiving slots are large enough to take care of it. In order to adjust the support toward or away from the wheel, a shim or packing 25 can be placed between it and the wheel-casing. By means of the slots the support as a whole can be adjusted angularly to compensate for inaccuracies. In other words, the support is capable of a universal although limited adjustment.

Bolted to the intermediate and arranged to closely engage the nozzle is a ring 16, which is thick enough to engage the nozzle in any position that the support 4 is capable of assuming. This prevents any radial leakage at this point. It is important to provide this ring, for the leakage or spill varies directly as the pressure at the discharge end of the nozzle. The ring 16 can be considered as a part of the intermediate support. Bolted to the wheel and separated from the nozzle by a small clearance is a second ring 17, which serves the same purpose. The rings are concentric with each other and the main shaft and perform the same function for each nozzle or group of nozzles. In the case of the ring 16 it may be made in segments and a segment bolted to each support for the intermediate buckets. The ring 17 must be complete, because it is on the rotary member. It can of course be made in segments and the ends of the several segments arranged to make butt-joints.

In Fig. 6 the relation of the parts when considered on a horizontal plane is shown. The intermediate buckets and their support cover a certain number of moving buckets. This number varies with the character of the machine, and the arc covered thereby is greater in the second stage than in the first.

It is to be noted that the extreme ends 26 of the support are not provided with buckets and that they extend beyond the intermediates and also between certain of the wheel-buckets. This further tends to decrease the leakage, and, moreover, the exposed portion at this point or end is small as compared to the total area of the wheel that is covered by the intermediates. While I have shown the projections 26 and prefer to use them, it is within the scope of my invention in certain aspects to omit them and to depend upon the structures previously described to reduce leakage. What little fluid does pass beyond the intermediate buckets is caught between the rotary buckets and is to a certain degree made use of, although the passage is not full enough to work at full efficiency. It is obvious that with a solid wall between intermediates, such as is presented by the portion 6, Fig. 1, and the projecting ends 26, the only chance for the fluid to escape is at the ends of the support, where there is only a very small area presented. By making a tight joint between the nozzle and the intermediate support the leakage at that point is halved. There is a small leak around the ring 17; but by making the clearance small and the opposing surfaces of some considerable extent the leakage is reduced to a minimum.

Fig. 7 shows the relation that one row of intermediates bears to another. In the present form that my invention takes three rows of curved buckets are shown, each of which is mounted in a socket formed in the support, as will appear hereinafter. The support is rigidly secured to the wheel-casing by a number of bolts that are distributed around the edge.

Fig. 8 shows the relation between a sectionalized nozzle and the buckets. In the present embodiment the nozzle is of the expanding type. 18 represents the bowl of each nozzle-section, 19 the throat, and 20 the discharge end. The motive fluid in passing from the throat to the end has its pressure largely converted into *vis viva*, so that it travels at a high rate of speed at this point. The nozzle discharges the fluid against a row of moving buckets, which in turn discharge it to a set of stationary buckets, and so on, every alternate row being movable.

The nozzle of Fig. 8 is divided into sections because it is somewhat simpler to govern a turbine when so constructed, since by cutting out one nozzle-section the volume of the motive fluid can be reduced without altering its velocity. A further advantage resides in the fact that to cut out one nozzle-section cuts out of service or renders inoperative the buckets directly in front of it. My invention can, however, be used with other types of nozzles.

Referring to Fig. 4, I have shown a piece of stock having the peculiar configuration that is desirable for making buckets. It can be rolled or drawn or otherwise manufactured. The buckets are sawed from the strips and either before or afterward provided with holes

21 or equivalent retaining devices. In the support 4 is provided a socket 22, having inclined side walls, as shown in Fig. 2. The next step is to place the ends of the buckets in the socket and hold them by a proper gage or gig, after which Babbitt or a similar metal is poured into the socket and fills all of the holes 21 or surrounds the other retaining devices. Before the babbitt is poured means should be provided, of course, to prevent it from running across the face of the support. When the metal hardens, the gage and other accessories can be removed, and the buckets will be retained in their proper places. Buckets when constructed in accordance with this plan are simple in construction and very cheap, since no expensive machinery is required in cutting and the work can be done by relatively unskilled labor. By heating the whole or a portion of the support all or a part of the buckets can be removed.

In accordance with the provisions of the patent statutes I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

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

1. In a turbine, the combination of a casing, a nozzle for delivering motive fluid to the buckets at a predetermined velocity, a wheel mounted in the casing having buckets which are uncovered at their outer ends, and a cover for the buckets which is detachably secured to and forms a part of the casing.

2. In a turbine, the combination of a casing, a nozzle for delivering motive fluid to the buckets, a wheel having buckets which are uncovered at their outer ends, intermediate buckets arranged to extend partially around the circumference of the wheel, and a detachable support for the intermediates which also forms a cover for the wheel-buckets.

3. In an axial-flow turbine, the combination of a casing, a wheel having radial buckets which are uncovered at their outer ends, a nozzle for delivering motive fluid under a predetermined velocity to one side of a portion of the wheel-buckets, a cover which is detachably secured to the outside of the casing and forms a cover for the revolving buckets, and intermediate stationary buckets which are carried by the cover and present their ends to the wheel in such manner that the latter forms a cover therefor.

4. In a turbine, the combination of a wheel-casing, a nozzle for delivering fluid to the buckets under relatively high velocity, a wheel mounted in the casing having radially-extending buckets which are uncovered at their outer ends, a stationary cover for the buckets, and means for detachably securing the cover to the wheel-casing, the means being located external to said casing.

5. In a turbine, the combination of a wheel-casing, a wheel having a plurality of radially-extending buckets mounted thereon which are open or uncovered at their outer ends, a stationary support which forms a cover for the buckets, and means whereby the support can be adjusted.

6. In a turbine, the combination of a wheel-casing, a wheel having a plurality of buckets mounted thereon which are uncovered at their outer ends with finished surfaces between the buckets, a stationary support which forms a cover for the buckets, intermediate buckets which are secured to the support at one end and are unconnected at their opposite ends, the said surfaces on the wheel acting as a cover for the intermediate buckets, and means external to the wheel-casing for adjusting the support.

7. In a turbine, the combination of a bucket-wheel having working passages in its periphery that are uncovered at the sides and on one end, intermediates, and a segmental support for the intermediates which also acts as a cover or closure for the ends of the moving buckets.

8. In a turbine, the combination of a wheel having buckets that are unconnected at their outer ends, adjustable intermediate buckets, an adjustable support for the intermediate buckets which forms a cover for the revolving buckets, and a wheel-casing.

9. In a turbine, the combination of a wheel having uncovered buckets, a wheel-casing, and an adjustable support carried by the casing which acts as a cover for the buckets.

10. In a turbine, the combination of a wheel having uncovered buckets, a wheel-casing, an adjustable support carried by the casing which acts as a cover for the buckets, and a nozzle that delivers motive fluid to the side of the bucket-wheel.

11. In a turbine, the combination of a wheel having a plurality of buckets that are open at the outer end, a wheel-casing, a stationary support for the intermediate buckets that also forms a cover for the wheel-buckets, and means whereby the support can be adjusted with respect to the wheel-casing.

12. In a turbine, the combination of a bucket-wheel, a wheel-casing, intermediate buckets that extend between the buckets on the wheel, a support to which the intermediate buckets are rigidly attached, the said support also forming a cover for the wheel-buckets, and means whereby the support can be adjusted so as to move the intermediate buckets toward or away from a row of buckets on the wheel.

13. In a turbine, the combination of a wheel-casing, a bucket-wheel mounted therein and having the buckets thereon arranged in rows, rows of intermediate buckets which extend

between the rows of moving buckets, the wheel acting as a cover for the intermediate buckets and the support as a cover for the moving buckets, a support for the rows of intermediate buckets, and means whereby the support can be adjusted longitudinally with respect to the wheel.

14. In a turbine, the combination of a wheel-casing, a nozzle, a support for the intermediate buckets, means for adjusting the support, and a means movable with respect to the nozzle for preventing leakage.

15. In a turbine, the combination of a wheel-casing, a nozzle, a support for the intermediate buckets, means for adjusting the support toward or away from the nozzle, and a means carried by the support and arranged to engage the nozzle for preventing leakage.

16. In a turbine, the combination of a wheel-casing, a nozzle, a support for the intermediate buckets, a ring-segment mounted on the intermediate and arranged to engage the nozzle, and a ring which is mounted on the wheel and in close proximity to the nozzle for decreasing the leakage at that point.

17. In a turbine, the combination of a wheel-casing, a bucket-wheel, intermediate buckets, and a support therefor which is provided with overhanging ends or extensions that cover the buckets adjacent thereto and decrease leakage.

18. In a turbine, the combination of a wheel-casing, a wheel having buckets that are unconnected at their outer ends, intermediate buckets which extend between the wheel-buckets, a support for the intermediate buckets which also acts as a cover for the moving buckets, and projections or extensions at the ends of the support for decreasing the leakage.

19. In a turbine, the combination of a socket having retaining-walls, individual buckets which are mounted therein and spaced a suitable distance apart, and a soft-metal filler for retaining the buckets in the socket and holding them at the proper distance apart.

20. In a turbine, the combination of a wheel, a casing, a nozzle, intermediate buckets, and a support for the buckets which engages with the nozzle to prevent leakage.

In witness whereof I have hereunto set my hand this 17th day of October, 1902.

OSCAR JUNGGREN.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.