No. 850,501. PATENTED APR. 16, 1907.

F. T. SNYDER.

TURBINE.

APPLICATION FILED APR. 20, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

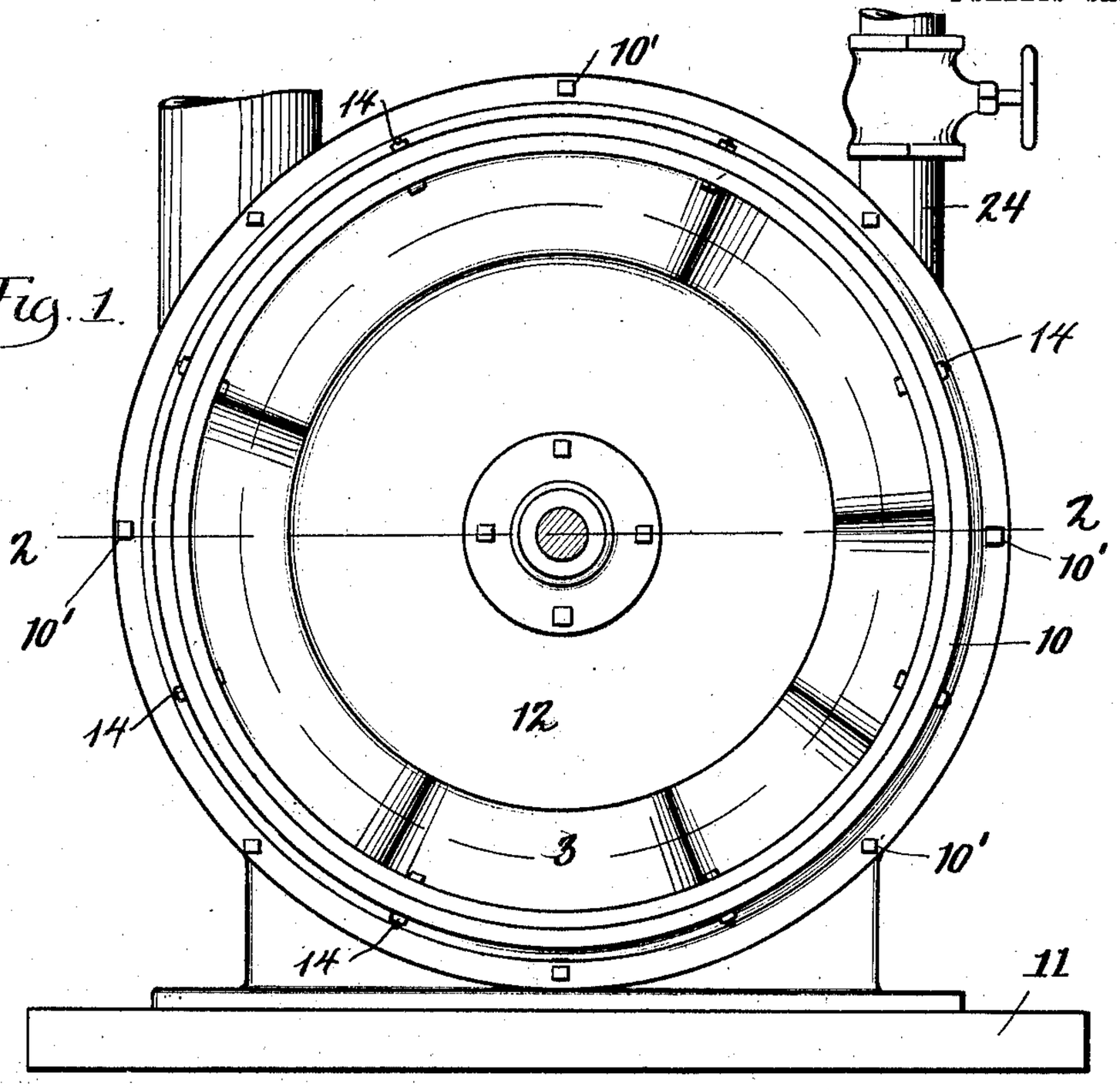
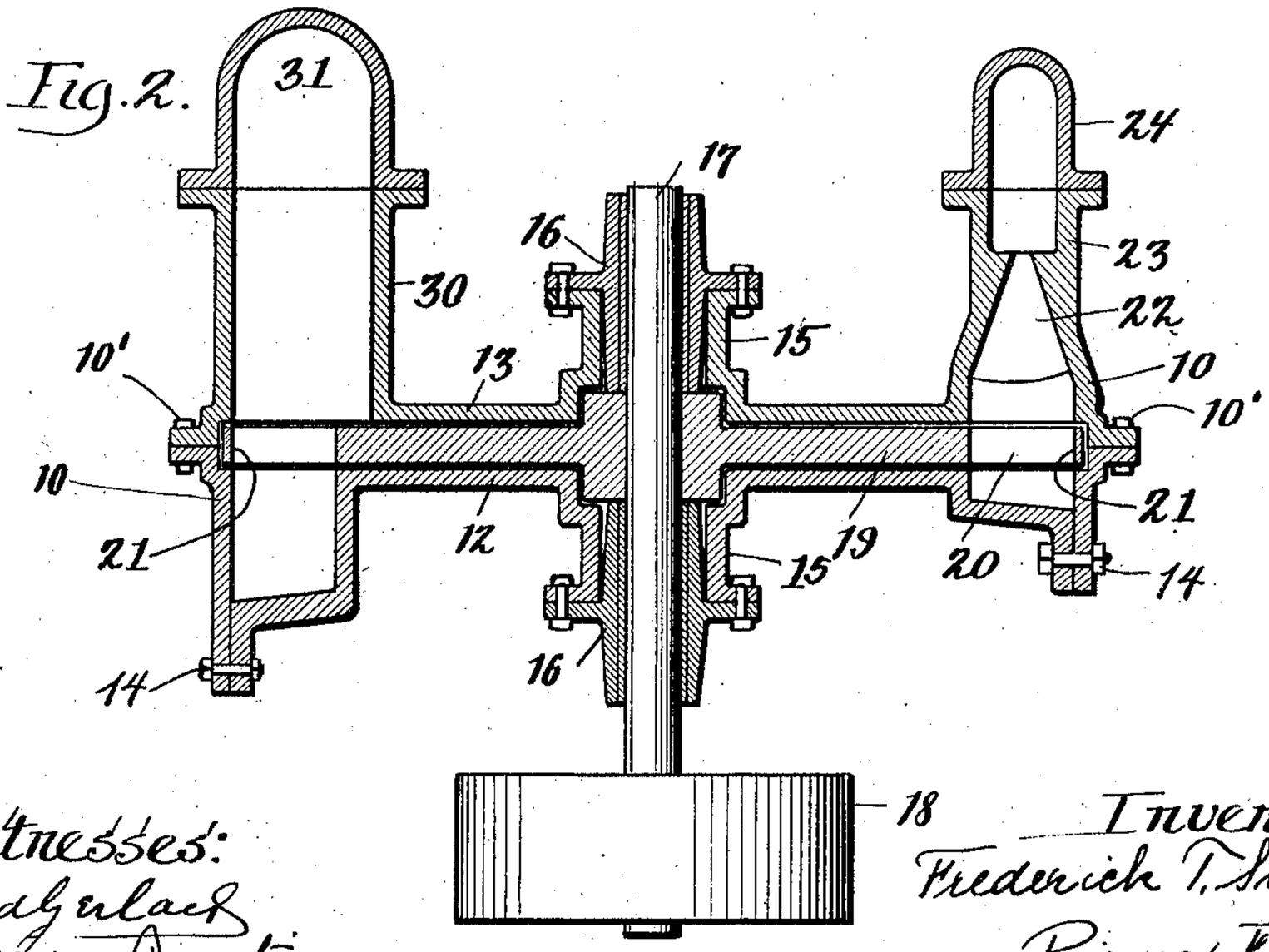


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 3.

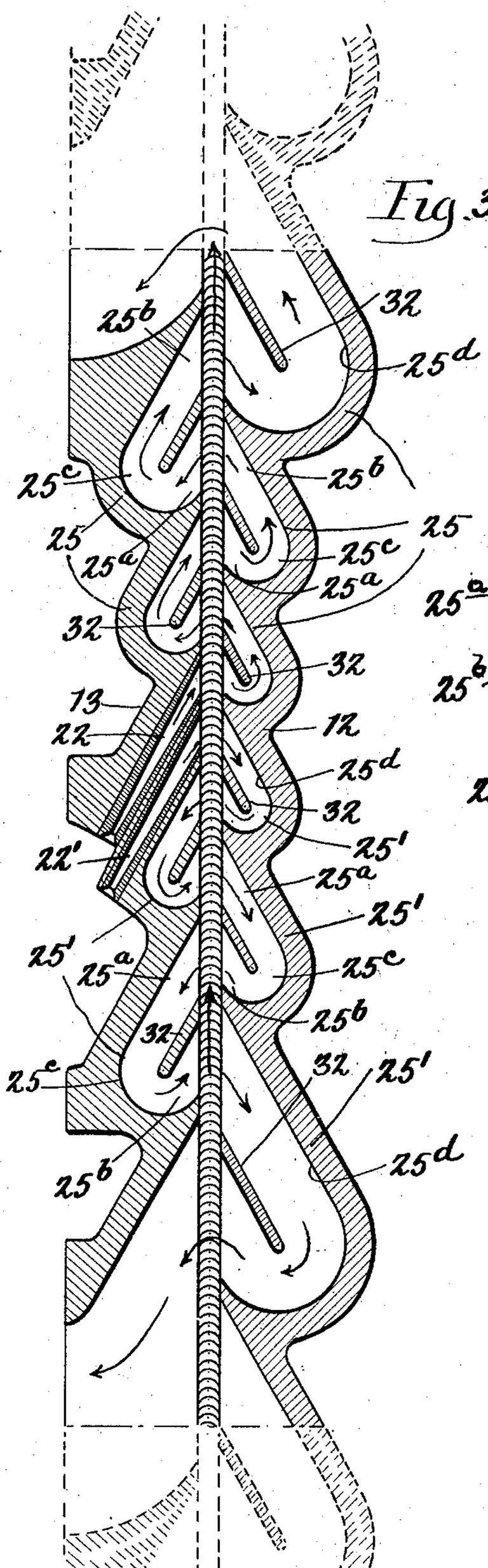
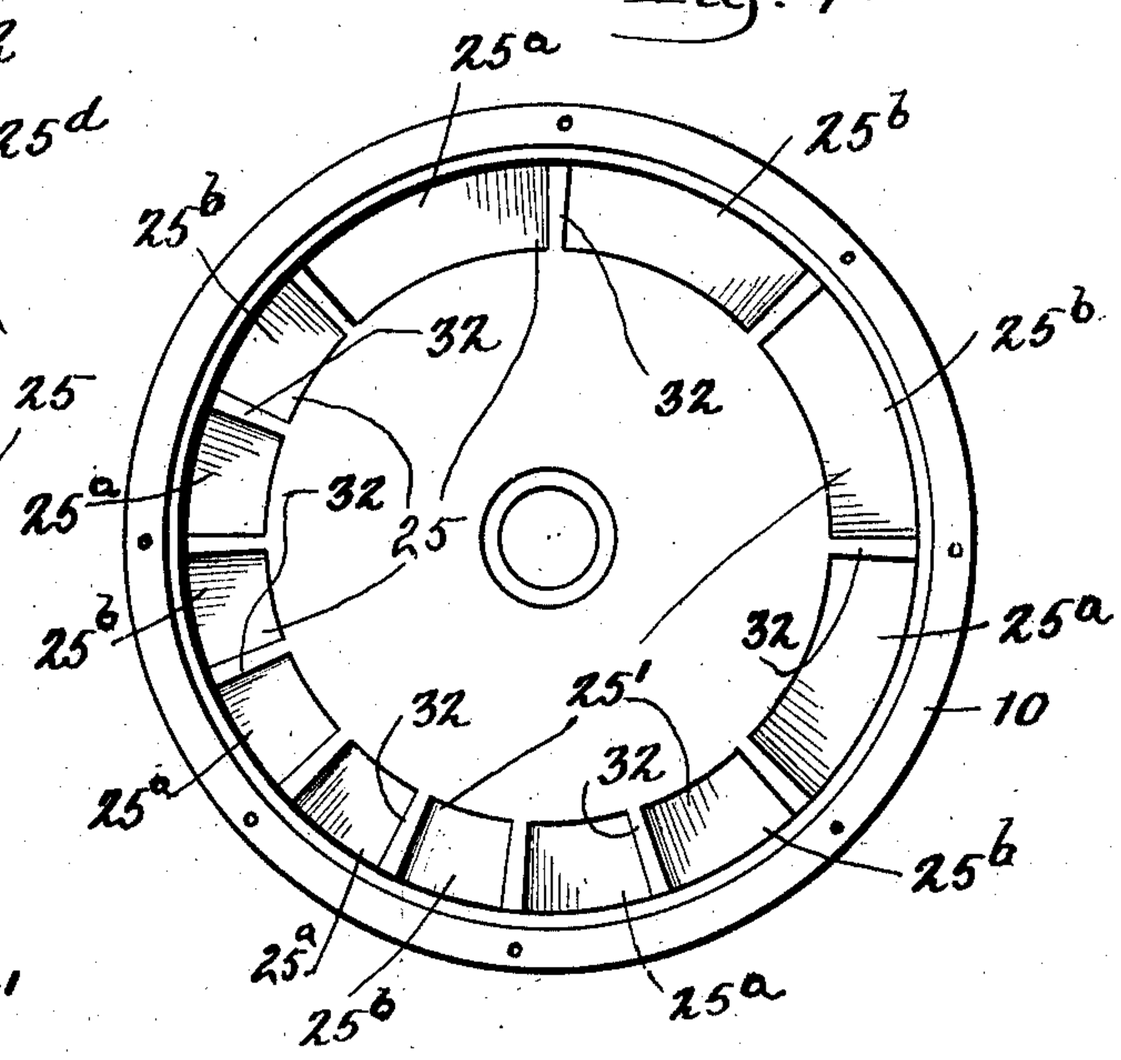


Fig. 4.



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UNITED STATES PATENT OFFICE.

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TURBINE.

No. 850,501. Specification of Letters Patent. Patented April 16, 1907.

Application filed April 20, 1904. Serial No. 203,982.

To all whom it may concern:

Be it known that I, FREDERICK T. SNYDER, a citizen of the United States, and a resident of Oak Park, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Turbines, of which the following is declared to be a full, clear, and exact description.

The improvement relates to impact-turbines in which the steam or other motive fluid is expanded in the admission-nozzle to the exhaust-pressure.

The invention seeks to provide simple and efficient means for causing the successive or multiple impact of the expanded steam against the turbine-wheel and thereby obtain good economy with a comparatively low wheel velocity.

The invention consists in the features of construction, arrangements, and combinations of parts hereinafter set forth, illustrated in the accompanying drawings, and more particularly pointed out in the appended claims.

In the drawings, Figure 1 is a side elevation of the improved turbine. Fig. 2 is a longitudinal section on line 2 2 of Fig. 1. Fig. 3 is a development of the turbine-wheel and guide-buckets on the line 3 of Fig. 1, and Fig. 4 is a view of the inner face of one of the plates wherein the guide-buckets are formed.

Expansive-fluid impact-turbines in which the steam or other motive fluid is passed once only through the buckets of the turbine-wheel necessitate a high wheel velocity for good economy. Indeed, for maximum efficiency with a turbine of the De Laval type, for example, the velocity of the wheel-buckets must be about one-half that of the velocity of the steam-current from the expansion-nozzle, and the latter is as high as from three thousand to five thousand feet per second when the steam is expanded from high pressures. Single-impact turbines are therefore designed to rotate at very high speeds, the wheel must be constructed with great care and hung on flexible shafting, the factor of safety is small, and even at the best they cannot be driven at sufficient speed to attain maximum economy. Moreover, expensive step-down gearing must be employed with such motors to utilize the power. To avoid such dangerously-high speeds and the step-down gearing and to obtain better economy, turbines have been designed in which the steam is successively passed through a series of wheels; but here the cost of construction and the complication of parts are large. It has also been proposed to utilize the current of expanded steam in the same wheel by providing guide buckets or channels in the casing about the wheel through which the steam proceeds and is successively passed through the wheel-buckets. Under ideal conditions such a multiple-impact turbine may attain maximum economy with a comparatively low wheel velocity; but in a turbine which utilizes the energy of the expanded steam due to its high velocity the steam-current must be guided and its direction of motion changed without shock—*i. e.*, there should be no sharp angles in the steam-path formed by the wheel-buckets and guides or the steam particles will be ineffectually dispersed or diverted from their proper course. So, also, the guide-buckets should be such that they can be readily constructed and provided with a smooth-finished surface by the use of ordinary tools.

In some prior constructions helical guide-channels have been proposed, but are quite impracticable, since they can only be constructed with great difficulty and expense. In others the guide buckets and channels are not so shaped as to fully utilize the energy of the steam-current or the path formed for the same is not devoid of sharp angles.

The present improved turbine avoids the objections noted and provides an arrangement of wheel and guide buckets which may be easily constructed and by which the current of steam from the expansion-nozzle is guided without shock and successively projected through the wheel to fully utilize its energy. In the preferred form of the invention the wheel is of the well-known De Laval type, having a series of radially-disposed buckets opening on opposite sides of the wheel, and radially-disposed reversing-guides on opposite sides of the wheel are arranged to pass the current of steam through the buckets alternately from side to side in the zigzag path.

A ring-like or annular casing 10, formed of separate sections connected by bolts 10′, is mounted upon a suitable base-plate 11. Within opposite sides of the casing are snugly fitted the circular heads or plates 12 and 13, which are held in position by bolts 14. Central projecting cored bosses 15 on the heads 12 and 13 support suitable bearings 16, within which the turbine-shaft 17 is jour-

naled. The projecting end of shaft 17 carries a pulley 18 or other drive-gear from which the power may be taken. If desired, the armature of an electric dynamo, the fan of a centrifugal blower or pump, or other rotary element to be driven may be mounted directly on the shaft, since the speed of the turbine is not excessive. The turbine-wheel 19 on shaft 17 is preferably of the well-known De Laval type, having a series of curved buckets 20 radially disposed upon its periphery and opening on opposite sides of the wheel.

The casing 10 and heads 12 and 13 may be of cast metal machined to proper form. The wheel 19 may be of cast or wrought metal. The buckets 20 are preferably formed of separate pieces of forged steel secured to the main body of the wheel in any suitable manner, and preferably the buckets are provided at their end with laterally-projecting offsets 21, which bridge the intermediate spaces and prevent any dispersion of the steam by centrifugal action.

The circular heads or plates 13 and 14 are provided with enlarged peripheral portions in which the reversing guide-buckets are formed. The nozzles and steam inlet and exhaust chamber are also formed in or carried by the enlarged peripheral portion of the head 13. The development of these heads, Fig. 3, must clearly illustrate the arrangement of the nozzles, wheel-buckets, and guides.

The nozzles 22 and 22′ are of suitable conformation to totally expand the steam down to the pressure of the exhaust and are arranged at the side of the wheel and at an acute angle to the plane of rotation. One or more nozzles may be employed, two being shown in the illustrated form of the invention. The nozzles are preferably formed separate from the body of the head 13 and are inserted in suitable openings therein, as indicated in Fig. 3. A projecting cored boss 23 upon the plate 13 forms a steam-chamber about the outer ends of the nozzles which is in communication with the steam-pipe 24, as shown. Stop-valves may be provided, if desired, at the outer ends of the nozzles and the steam-pipe may have a controlling throttle or governor valve.

The wheel-buckets 20 are concave in circumferential direction, and the edge or inlet and outlet portions of the bucket are inclined rearwardly (*i. e.*, in a reverse direction to that in which the buckets move) and extend at an angle to the plane of rotation. The forwardly-inclined nozzles deliver the current of expanded steam into the open sides of the buckets and in line with the inclined edge portions thereof. The steam passes through the buckets, its direction of motion is changed by the concave working faces of the buckets, and it is projected rearwardly from their inclined edge portions of the buckets on the opposite side of the wheel. The turbine is thus of the combined impact and reaction type. The steam enters and leaves the buckets of the wheel at oppositely-disposed or divergent angles to the plane of rotation, the direction of movement of the steam-current being changed without shock or dispersion of its particles by the curved faces of the buckets. The reversing guide-buckets are arranged to properly receive the current of steam from the wheel-buckets, reverse its direction, and redirect it at a proper angle through the wheel.

One or more guide buckets or channels may be employed in accordance with the number of times the steam is to be passed through the wheel; but preferably several of such guides coöperate with each nozzle, since the speed of the wheel may be thereby correspondingly decreased.

The series of guide-buckets 25 coöperate with the nozzle 22, and are preferably formed, as shown, in the enlarged peripheral portions of the heads 12 and 13 adjacent the path of movement of the buckets 20. The inlet and outlet portions of each guide-bucket are arranged at proper angle to receive the steam-current from the wheel-buckets and redirect it thereto. The series of guide-buckets are staggered or alternately arranged on opposite sides of the wheel, the inlet of the first of the series being opposite the outlet of the nozzle 22 and the inlets of each of the others being opposite the outlet of the preceding guide-bucket. The steam thus passes from the outlet of each guide through the wheel and into the inlet portion of the succeeding guide bucket, is projected through the wheel alternately from side to side thereof, and proceeds from the nozzle through the wheel and guide buckets in a zigzag path, as indicated in Fig. 3. With the number of guides shown the steam is passed six times through the wheel-buckets and then to the exhaust.

Any suitable number of nozzles and sets of reversing guide-buckets may be arranged about the periphery of the wheel in accordance with its power and size. In the arrangement shown two nozzles 22 and 22′ are employed, and the steam proceeds from each through the corresponding sets of guide-buckets in opposite directions to a common exhaust-chamber formed in a projecting boss 30 and communicating with the exhaust-pipe 31. By this arrangement the general direction of the steam-current from nozzle 22′ through the set of guide-buckets 25′ is the reverse of that of the wheel-buckets.

The guide-buckets 25 and 25′ are radially disposed to correspond with the radially-arranged wheel-buckets. The guide-buckets are of similar form and are of general wedge shape in section divergently inclined on opposite sides of the wheel. The inlet portion

25[a] of each of the buckets leads rearwardly or away from the direction of movement of the wheel-buckets and at angle thereto, so that the steam-current projected rearwardly from the curved wheel-buckets will be properly received. The outlet portion 25[b] of each bucket leads forwardly at a proper angle to project the steam in line with the rearwardly-inclined edges of the wheel-buckets, and the inlet and outlet portions are connected by a curved portion 25[c], in which the steam-current is reversed without shock as it passes through the guide-bucket.

The inlet and outlet portions 25[a] and 25[b] of each guide-bucket are thus inclined in the same general direction at an angle to the plane of rotation and substantially in line with the rearwardly-inclined edge portions of the guide-buckets. With wheel and guide buckets of the form described there are no sharp angles in the path formed for the steam-current, either in the buckets themselves or between the moving wheel-buckets and stationary guide-buckets.

The working face 25[d] of the buckets is of course of similar outline—that is, the end portions at the inlet and outlet of the buckets are inclined in the same direction at an angle to the path of movement of the buckets and the central mid-portion is concave in circumferential direction and merges without forming abrupt angles into the inclined end portions.

By reason of the inclined arrangement of the guide-buckets the outlet portion 25[b] of the series 25 are longer than the inlet portions 25[a]. The guide-buckets 25′, which cooperate with the nozzle 22′, are similar in form to guide-buckets 25; but as the steam-current proceeds through the former series in the opposite direction the inlet portion 25[a] are longer than the outlet portions 25[d], as clearly indicated in Fig. 3.

The several guide-buckets may be entirely open from end to end; but preferably partitions 32 divide the inlet and outlet portions, so that the guides are in the form of channels or passages, with inlet and outlet legs or ports of different length.

While the inlet and outlet legs or ports of the guide buckets or channels and the admission-nozzles are inclined to the plane of rotation, the edges of the buckets and nozzles are parallel to such plane and arranged closely adjacent to the open sides of the wheel-buckets, so that the steam may not overflow in its passage between the stationary and revolving parts.

Ample provision is made for the increase in cross-section of the steam-current due to its decrease in velocity by increasing the cross-sectional area of the succeeding guide buckets or channels of each set. If desired, the angle of inclination of the succeeding guide-buckets in each set may be decreased in accordance with the diminishing velocity of the steam-current.

The increase in the cross-sectional area of the succeeding guide-buckets of the set is preferably effected by increasing their width in circumferential direction, as shown in Fig. 3. In radial direction the working faces of the guide-buckets are preferably straight and of a width equal to the length of the wheel-buckets.

The side walls of the guide buckets or channels preferably extend in radial direction to the outer peripheral surface of the circular heads or plates 12 and 13, so that the channels may be readily cast in the plates or formed therein by suitable tools. The channels of this simple form may be easily and cheaply machined and provided with smooth-finished surface by employing a milling-tool in the form of a frustum of a cone. The outer peripheral sides of the guide buckets or channels are closed (see Figs. 2 and 4) by the ring-casing 10.

The improved construction thus provides for the successive passage of the steam through the wheel-buckets in such a manner as to fully utilize the *vis viva* of the current of expanded steam, and the speed of the wheel may be comparatively low and yet operate with efficiency. Moreover, the simple form of guide-buckets employed may be easily constructed.

It is obvious that the details of construction may be varied without departure from the essentials of the invention.

By the term "forwardly leading or inclined" as used in the following claims is meant leading or inclined in the same general direction as that in which the wheel-buckets move, and by the term "rearwardly leading or inclined" is meant leading or inclined in a general direction the reverse of the direction of movement of the wheel-buckets.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In multiple-impact turbines, the combination of a turbine-wheel, provided with a series of radial buckets having working faces concave in circumferential direction and rearwardly-inclined edge portions, a forwardly-inclined nozzle on one side of the wheel delivering into said buckets and a reversing guide-bucket on the other side of said wheel opposite said nozzle, said guide-bucket being wider at its outer end than at its inner end and having an inclined working face with a rearwardly-leading inlet portion and a forwardly-leading outlet portion, both inlet and outlet portions being inclined in the same direction and at an angle to the plane of rotation of said wheel.

2. In multiple-impact turbines the combination of a turbine-wheel, a series of radial buckets thereon opening on opposite sides of

the wheel and having working faces concave in circumferential direction, a forwardly-inclined nozzle on one side of the wheel delivering into said buckets and a set of reversing guide buckets or channels alternately arranged on opposite sides of the said wheel-buckets, said guide-channels being wider at their outer ends than at their inner ends and having inclined working faces, each provided with a rearwardly-inclined inlet and a forwardly-inclined outlet portion connected by a concave portion.

3. In multiple-impact turbines, the combination with a ring-like or annular casing, oppositely-arranged circular heads fitted within said casing, a shaft journaled in said heads, a turbine-wheel on said shaft having a series of radially-disposed buckets, and a series of guide-buckets formed in said heads, and extending radially to the peripheral surface thereof, the outer ends of said guide-buckets being closed by said annular casing.

4. In a multiple-impact turbine, the combination of a turbine-wheel, a series of radial buckets thereon, ring-disks arranged on opposite sides of the wheel and provided with radially-disposed guide-buckets and a ring-frame about said disks closing the outer ends of said buckets, substantially as set forth.

5. In multiple-impact turbines, the combination with a turbine-wheel having radially-disposed buckets and opening on opposite sides of the wheel, circular heads having enlarged peripheral flanges arranged on opposite sides of the wheel, radially-disposed guide-buckets formed in said heads and extending radially to the peripheral surface thereof, and an inclosing covering ring or frame encircling said heads and closing the outer ends of said guide-buckets, substantially as set forth.

6. In multiple-impact turbines, the combination of a turbine-wheel having radial buckets opening on opposite sides of the wheel, a nozzle delivering into said buckets and two sets of reversing guide-buckets arranged on opposite sides of the wheel and leading in opposite directions from said nozzle about the wheel.

7. In multiple-impact turbines, the combination with the turbine-wheel and the inlet-nozzle, of the two sets of reversing guide-buckets extending in opposite directions from the nozzle about the wheel, said guide-buckets arranged to direct the current of fluid alternately in opposite directions through the wheel-buckets.

8. In multiple-impact turbines, the combination with the turbine-wheel having radial buckets opening on opposite sides of the wheel, of an inlet-nozzle and two sets of reversing guide-buckets leading therefrom in opposite directions about the wheel to a common exhaust, said guide-buckets arranged to pass the motor fluid alternately in opposite directions through the wheel-buckets.

9. In multiple-impact turbines, the combination with the turbine-wheel having radial buckets opening on opposite sides of the wheel, of two expansion inlet-nozzles therefor and two sets of reversing guide-buckets leading from said nozzles respectively in opposite directions about the wheel, said guide-buckets being arranged on opposite sides of the wheel to pass the current of motor fluid alternately through the wheel-buckets in opposite directions.

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