

G. B. COLLIER.
TURBINE.

APPLICATION FILED MAR. 20, 1912.

Patented Jan. 21, 1913.

4 SHEETS—SHEET 1.

1,050,918.

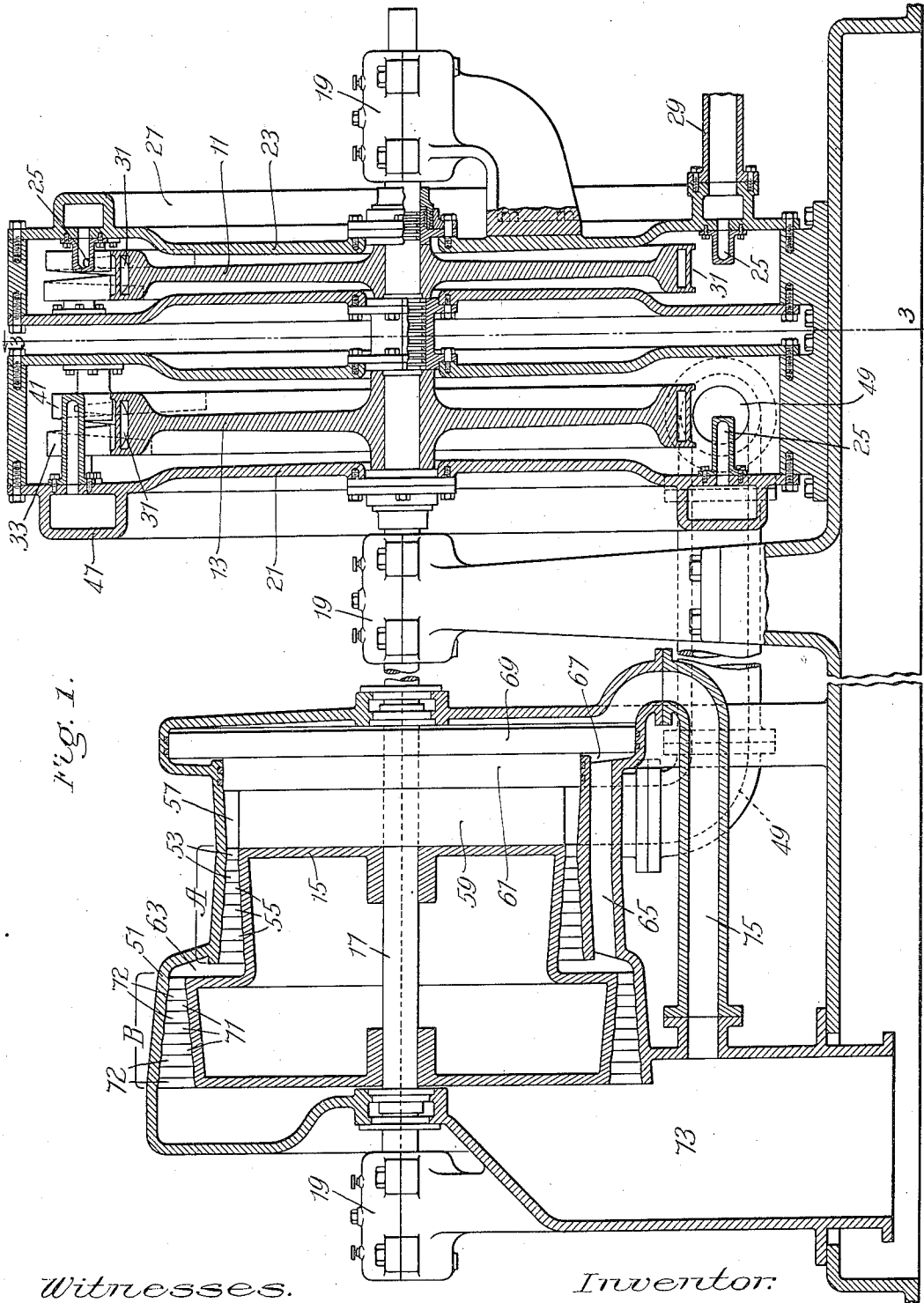


Fig. 1.

Witnesses.
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Inventor:
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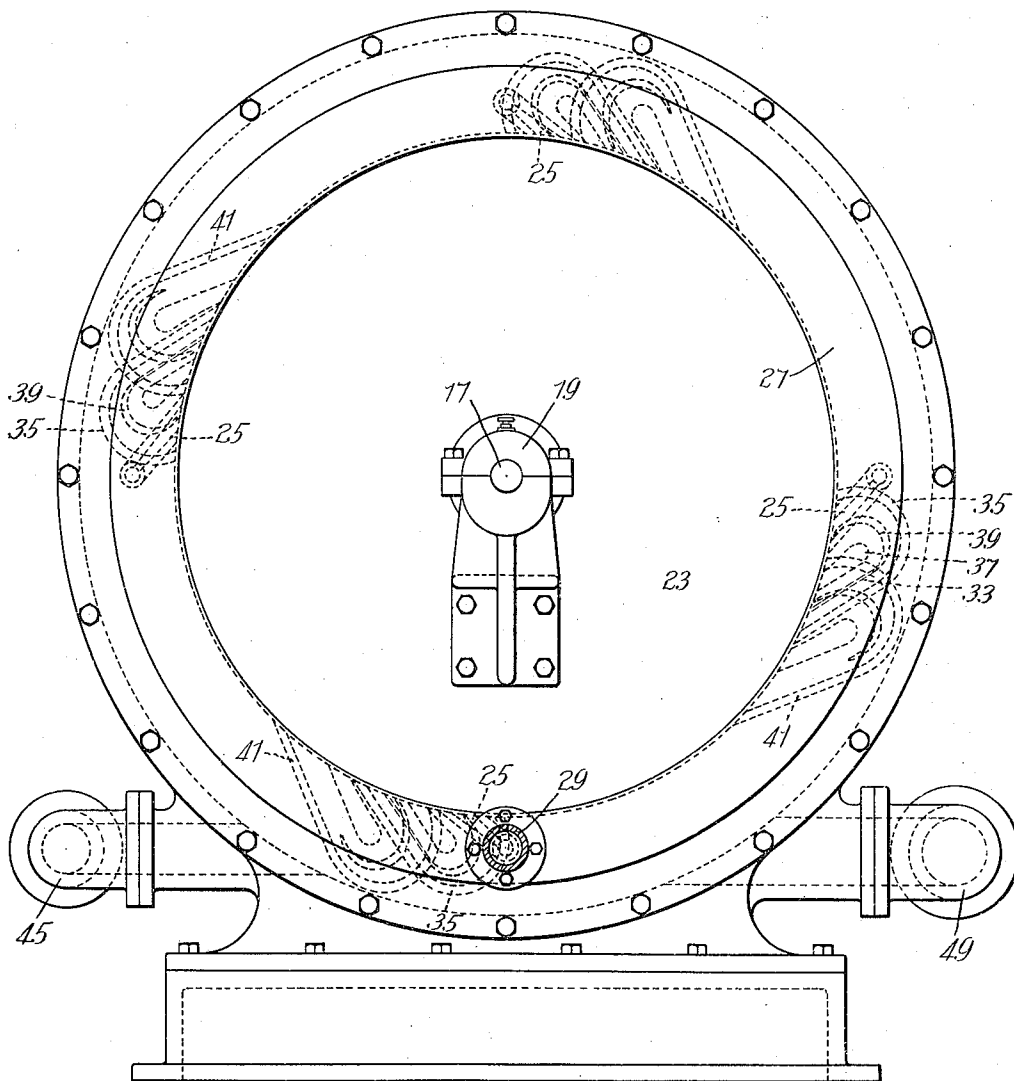
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Fig. 2.



Witnesses.
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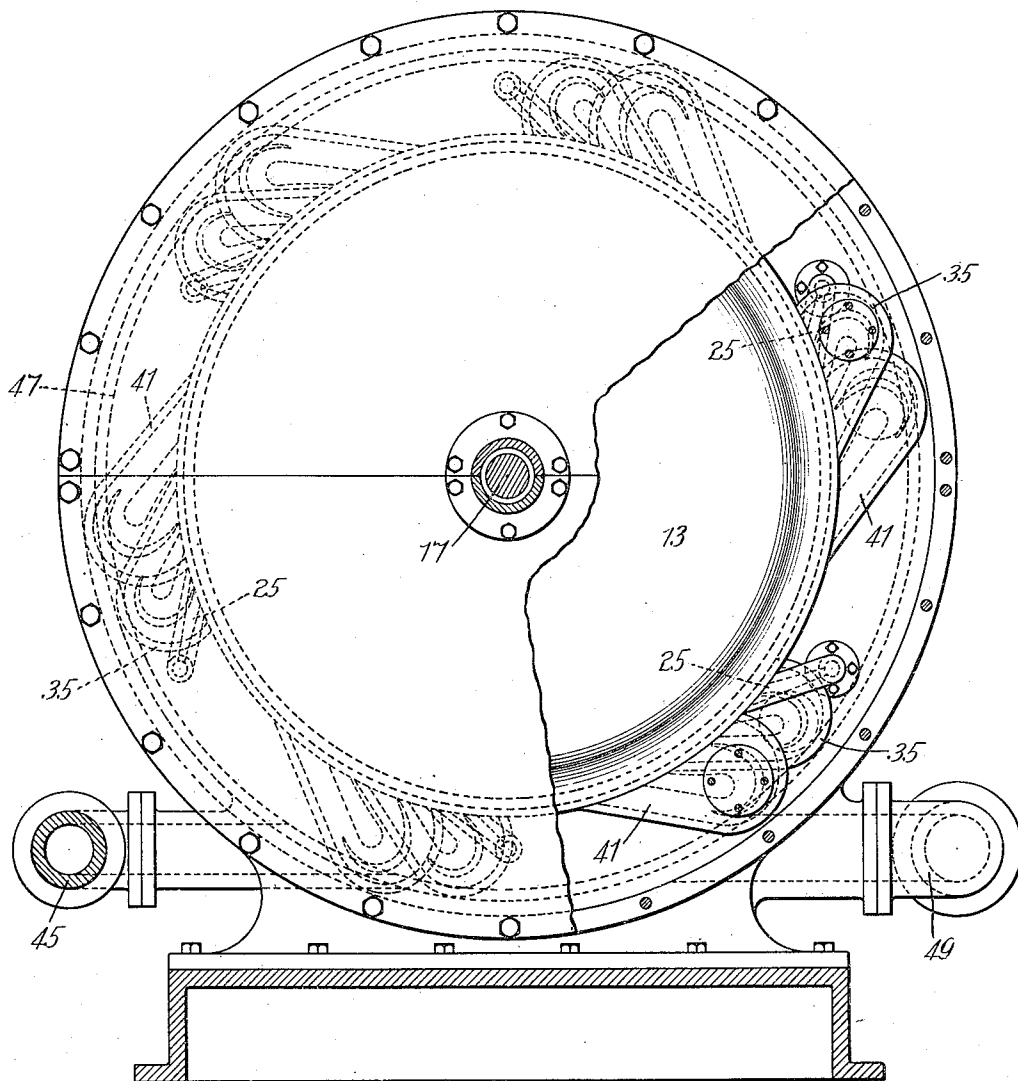
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Fig. 3.



Witnesses.
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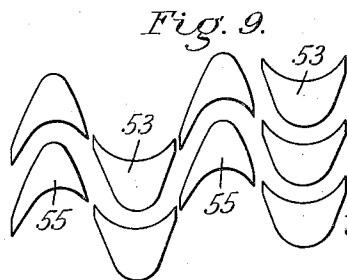
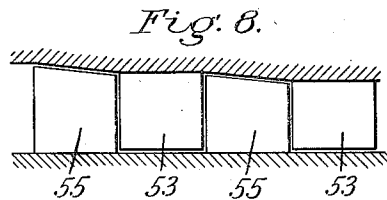
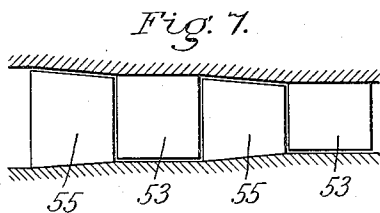
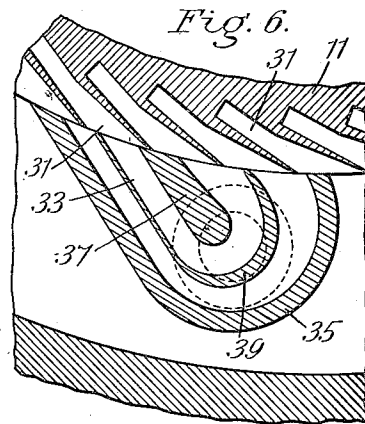
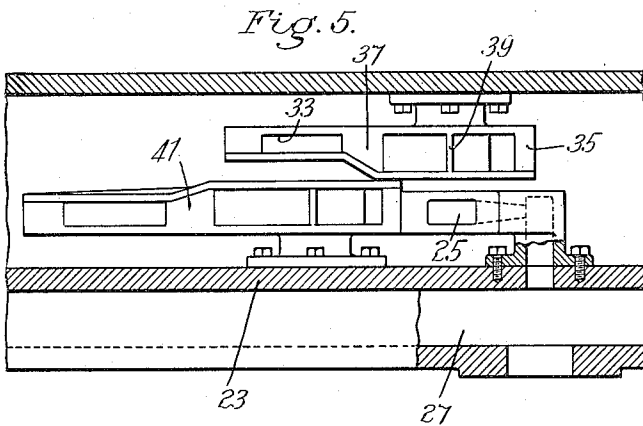
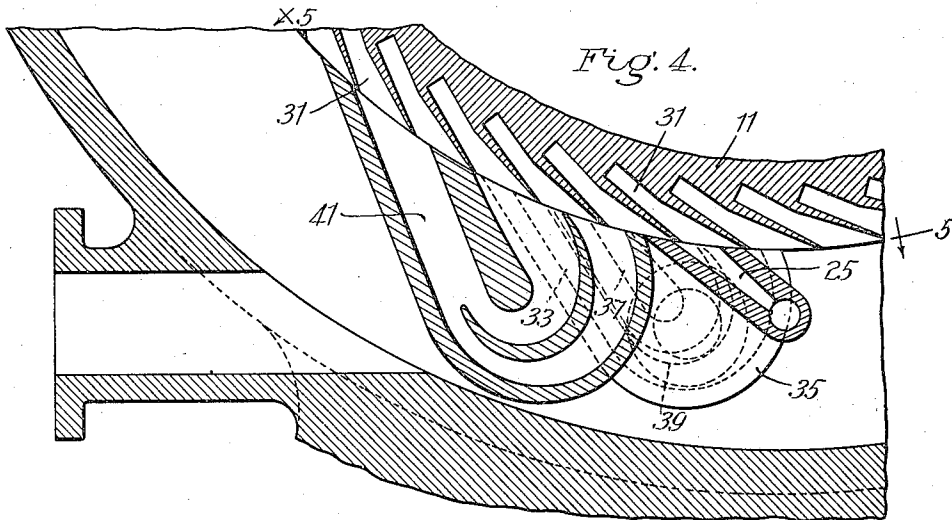
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4 SHEETS—SHEET 4.

1,050,918.



Witnesses.
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UNITED STATES PATENT OFFICE.

GUY B. COLLIER, OF KINDERHOOK, NEW YORK.

TURBINE.

1,050,918.

Specification of Letters Patent.

Patented Jan. 21, 1913.

Application filed March 20, 1912. Serial No. 684,929.

To all whom it may concern:

Be it known that I, GUY B. COLLIER, a citizen of the United States, and a resident of Kinderhook, in the county of Columbia and State of New York, (whose post-office address is 9 Burton Halls, 10 Dana street, Cambridge, Massachusetts,) have invented an Improvement in Turbines, of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

This invention relates to elastic fluid turbines, and more particularly to the construction and organization of a succession of parts to distribute the elastic fluid to a rotor or a succession of rotors.

Among other objects, the invention is designed to utilize the elastic fluid with the highest efficiency and minimum loss by features simple in construction and of durable material.

The character of the invention may be best understood by reference to the following description of an illustrative embodiment thereof shown in the accompanying drawings, wherein:

Figure 1 is a vertical axial section of an illustrative steam turbine embodying the invention comprising a succession of pure-impulse stages and pure-reaction stages; Fig. 2 is an end elevation of Fig. 1; Fig. 3 is a vertical section taken on line 3—3 of Fig. 1, parts being broken away to disclose an arrangement of buckets and guides; Fig. 4 on an enlarged scale is a sectional detail of rotor buckets and guides shown in Fig. 2; Fig. 5 is a section taken on the curved line 5—5 of Fig. 4; Fig. 6 is a sectional detail of rotor buckets and a primary guide shown in Fig. 4; and Figs. 7, 8 and 9 are enlarged details of blades and guides employed in the illustrative reaction stages shown in Fig. 1.

Referring now to Fig. 1, the illustrative construction there shown comprises primary impulse stages having a rotor 11, secondary impulse stages having a rotor 13, and a succession of reaction stages having a rotor drum 15. The rotors 11, 13 and 15 are fast on a rotor shaft 17 supported in journals 19. The two rotors 11 and 13 of the impulse stages are inclosed preferably in separate casings, as for instance casings 21 and 23.

For convenience, the construction of the

impulse stages will be first described and then the reaction stages will be described and explained in their coöperative relation to the impulse stages.

The initial distribution of steam to the rotor 11 preferably takes place at a plurality of points simultaneously, as for example, through nozzles 25 (Figs. 2 and 4) secured to the interior of the casing 23 and receiving steam from an annular steam chest 27 (Fig. 1), the latter in turn receiving its supply from an inlet 29. Any suitably proportioned nozzles may be used and their proper inclination relative to the buckets may be readily predetermined by one skilled in the art, in accordance with the general requirements which the turbine is designed to fulfil.

The rotor 11 is provided with buckets 31 formed in the periphery of the rotor and having rounded bottoms, and the fluid stream is directed toward the portions or walls of the buckets at one side of the rotor and whirled transversely across the rotor and out at the opposite side of said rotor.

To recover the steam initially applied to the rotor by the nozzles, stator guides such for example as 33 (Figs. 2, 4, 5 and 6) are provided, each comprising a wall 35, a partition 37 and a curved partition 39. The latter in some instances may extend throughout the passage formed between the wall 35 and the partition 37.

The guide 33 while disposed peripherally beyond the rotor and in the same plane with the rotor, is offset from the nozzle 25 adjacent thereto and is preferably located so that the end of the curved partition 39 nearest the rotor is on a line about in the middle of the nozzle delivery mouth. Therefore, the steam delivered from the nozzle to a bucket at one side thereof will whirl around and be delivered from the opposite side of the bucket into the guide passage between partitions 37 and 39. This passage will receive the portion of the steam stream leaving the bucket with greatest force, while the passage between the wall 33 and partition 39 will receive the portion of the steam stream of less force. The provision of the curved partition 39 prevents the steam streams of different character from crossing or interfering with one another in a manner such as would tend to retard or detract from the efficiency thereof.

It has been attempted heretofore to prac-

tise the general idea of recovering the steam initially applied to the rotor and thereafter reapplying it, but the manner in which this has been essayed prior to this invention has given rise to serious loss in efficiency and difficulty of construction which is substantially obviated in a construction embodying this invention.

The steam stream on leaving a bucket spreads more or less in a form simulating that of a brush with flaring bristles. This spreading of the stream will extend not only peripherally of the rotor but also transversely thereof. In order that this flaring steam stream may be caught and utilized, it is desirable that the guide have a wide mouth of suitable cross section and form to receive substantially the entire steam issuing from the buckets. To this end the illustrative guide shown herein has a total inlet opening of suitable cross section and form sufficient to receive the steam brush referred to.

It is not only desirable that the steam issuing from the buckets be thus received, but also that the steam be delivered back to the rotor in a suitable form and cross section to pass to the buckets in substantially the same manner as exists with the steam delivered from the nozzle. To this end the total guide passage is not of the same width or cross section at its introduction end as at its receiving end, but on the contrary is made sufficiently less to cause the steam to enter the buckets in a most efficient manner. As a result, the steam introduced by the guide into the buckets has its stream lines substantially parallel to the entrance walls of the buckets, and the steam whirls around the bottoms of the buckets and across the same to the opposite sides thereof without objectionable crossing or mutual obstruction of stream lines. The steam thus recovered and applied to the rotor buckets may be again recovered and reapplied to the rotor as many times as practicable. Herein, a second guide 41 (Figs. 2 and 4) is provided which may be similar in construction and operation to the guide 33 described but with this difference—that the passages of the guide 41 are larger to provide for the lower velocity of steam therein. As shown herein, the curved partition which divides the guides into two steam receiving passages is not extended to the end of the outlet of the guide, but terminates some distance therefrom, although in some instances such partition may be extended to the end of said outlet substantially in the manner shown with respect to the primary guide shown in Fig. 6.

The steam delivered from the outlet of the secondary guide 41 is peripherally presented in a narrowed stream to one side of the rotor, sweeps or whirls transversely

across the rounded bottoms of the buckets to the opposite side of the rotor and is discharged into the space within the casing 23 and thence conducted by a pipe 45 to an annular steam chest 47 (Fig. 1) which supplies steam to nozzles for the rotor 13 of the secondary stages.

The construction and arrangement of the rotor, nozzles, and guides in the stator of the secondary impulse stages may be similar to that already described in connection with the initial stage. The number of nozzles or guides, or both, may be varied within practicable limits as desired. The nozzles and guides of the secondary stages are preferably of greater dimensions than those of the first stages, as will be understood by those skilled in the art, to accommodate the larger volume of the steam.

The steam may be finally taken from the buckets of the secondary impulse stages through a pipe 49 which leads to the reaction stages to be described.

When the steam has once been introduced to the buckets by the initial nozzle 25 it suffers a loss in relative velocity while passing through the buckets so that the absolute velocity when the stream is taken off the buckets and enters the guide 33 is less than the initial absolute velocity. Consequently, the stream when reapplied to the buckets by said guide has less absolute velocity than it had at the nozzle. Therefore, the preferred embodiment of the invention has a steam guide 33 arranged to deliver a steam stream to the buckets at a less introduction angle than that of the steam stream entering the buckets from the nozzle. In like manner, the successively acting guide 41 is arranged to introduce a steam stream at a still less introduction angle corresponding to a further loss of velocity of the steam in passing from the guide 33 through the buckets to the guide 41. As stated, there may be as many guides as practicable acting successively to take the steam off of one side of the rotor and reapply it in narrowed stream at the same side of the rotor.

In taking the steam from the buckets the reception angle is greater for a relatively low absolute velocity just as the steam enters the guide than for a higher velocity. Accordingly, the preferred embodiment of this invention has the inlet end of the guide 33 arranged to take the steam stream from the buckets at a reception angle appropriate to the prevailing absolute steam velocity which is less than the initial velocity at the introduction of the stream to the buckets by the nozzle.

The inlet end of the secondary guide 41 is arranged to take the steam from the buckets at a greater reception angle than that of the guide 33 appropriate to the fall in absolute velocity since the last preceding in-

roduction of the stream from the buckets to the guide 33. Similar successive increases in the described reception angles of successive guides are preferably provided for if more than the specifically described guides are employed.

To recapitulate, the specific impulse stages shown in the drawings are constructed and arranged to apply and reapply the elastic fluid in narrowed streams to the buckets at progressively decreasing angles; and to take off steam from the buckets at progressively increasing angles. Such an arrangement contributes to reduce losses from shock and eddies and from other causes, and also provides for applying the steam in effective streams to the buckets at increasingly effective angles as the absolute velocity of the steam decreases; hence contributing much to the improvement in action and reduction of steam consumption.

Referring now to the reaction aspect of the invention, the specific embodiment shown in the drawings comprises reaction stages, utilizing the rotor drum 15, referred to fast on the same shaft 17 which carries the impulse rotors 11 and 13. The stator of the reaction stages comprises a casing 51 supporting guides 53 which are arranged alternately with blades 55 of the rotors 15. Communicating with the pipe 49 which leads from the second impulse stage is an annular chamber 57 which opens in the direction of the axis of the shaft 17 toward the entrance guides 53 of the first reaction stage. The chamber 57 is formed between a portion of the casing 51 and a piston 59 fast upon the shaft 17 adjacent one end of the rotor drum 15. A wall of the chamber 57 is formed by a piston adjacent the piston 59 and also fast on the shaft 17. With this arrangement the steam admitted to the chamber 57 exerts substantially balancing opposite axial thrusts upon the blades 55 and the piston 61, thereby more or less completely eliminating end thrusts. From the first group of reaction stages, which may be designated by A, the steam enters an annular chamber 63 formed between a portion of the casing 51 and an enlargement of the drum 15, from which the steam enters the second group of reaction stages, which may be designated as B. The chamber 63 communicates by a passage 65 with another annular chamber 67 formed between a portion of the casing 51 and a third piston 69 larger than the preceding pistons, adjacent the piston 61 and also fast upon the shaft 17. Steam in the chamber 63, passage 65 and chamber 67 exerts substantially balancing opposite axial thrusts upon the piston 69 and the blades 72 of the second group of reaction stages. From the second reaction group B the steam passes into a chamber 73 having an exit to the condenser. To conduct away such leak-

age as may occur around the pistons there is provided a pipe 75 which leads to the chamber 73.

Desirable constructions of guides and blades for the reaction stages are shown in Figs. 7, 8 and 9. The mean radii of the blades are substantially uniform throughout each reaction group, but it will be noted that the radial dimensions of the rotor blades increase from the entrance end toward the exit end. For instance, as shown in Fig. 7, the blade 55 may have its radial dimension increased from entrance to exit symmetrically with respect to the general direction of movement of the steam, or as shown in Fig. 8, the dimension may be increased radially outward only.

By the arrangement described, the transverse dimensions between adjacent blades may remain substantially uniform if desired from entrance to exit while at the same time permitting the axial clear cross-sectional area (that is, the area in a plane perpendicular to the axis) of the rotor blade passages to increase from inlet to exit by reason of the increase in the radial dimension.

It is preferred that the guide passages between adjacent guide blades be substantially uniform from entrance to exit in cross sectional area perpendicular to the direction of flow through said passages as indicated in Fig. 9, whereby to all intents and purposes velocity and pressure changes are confined to the rotor blades to the exclusion of the guides so that the groups A and B operate by pure reaction. Throughout each group A and B the successive blade passages preferably increase in cross sectional area to accommodate the increasing volume of steam stream passing therethrough.

While as shown herein, the high and low pressure impulse stages are connected in series with the reaction stages it will be understood that the impulse stages might in parallel be connected with the reaction stages.

The combination of impulse stages with reaction stages as described constitutes a highly desirable construction since the energy of the steam is utilized to a very advantageous degree.

The high pressure steam may be best distributed, utilized and controlled for varying conditions in impulse stages where it can be directed to the rotor at as many different points as desired which may be remote from the axis of the rotor. Owing to the mechanical advantage and torque thus obtained, high efficiency results. The low pressure steam, on the other hand, may be best distributed to the reaction stages located on a drum of large radius and with full peripheral admission since the steam has expanded to a large volume, and obviously greater power may be obtained from a large volume of steam at low pressure

applied in this manner. In other words, the combination of the impulse and reaction stages enables the most efficient utilization of steam under a high pressure and then the most efficient utilization thereof under a low pressure.

It will be understood that it is not indispensable that all of the features of the invention be used conjointly since some of them may be used separately to advantage.

Having described one embodiment of the invention without limiting the same thereto, what I claim as new and desire to secure by Letters Patent is:

1. In an elastic fluid turbine, the combination of impulse stages comprising a rotor, means to introduce the elastic fluid initially to the rotor, and a guide to recover the fluid initially so introduced and to reintroduce it to the rotor in a direction more nearly perpendicular to a radius of the rotor at the point of introduction than the direction of initial introduction of the fluid; subsequently acting reaction stages; and means to receive elastic fluid from the initial impulse stages and introduce it to said reaction stages, the latter having provision whereby substantially all pressure changes occur within the moving blade passages.

2. In an elastic fluid turbine, the combination of impulse stages comprising a rotor; means to introduce the elastic fluid initially to the rotor; a plurality of successively-acting means to recover the fluid initially so introduced at progressively-increasing reception angles; pure reaction stages having provision whereby substantially all pressure changes occur within the moving blade passages; and means to conduct the fluid from said impulse stages to said reaction stages.

3. In an elastic fluid turbine, the combination of a rotor; means to introduce the elastic fluid initially to the rotor; and a plurality of successively-acting means parallel to the plane of the rotor to recover the fluid

initially so introduced and to reapply it in narrowed streams at progressively-decreasing introduction angles.

4. In an elastic fluid turbine, the combination of a rotor; means to introduce the elastic fluid initially to the rotor; and a plurality of successively-acting means parallel to the plane of the rotor to recover the fluid initially so introduced at progressively-increasing angles and to reapply it in narrowed streams at progressively-decreasing introduction angles.

5. In an elastic fluid turbine, the combination of a rotor; means to introduce the elastic fluid initially to the rotor; a plurality of successively-acting means in planes parallel to the plane of the rotor to recover the fluid initially so introduced at progressively-increasing angles and reapply it to said rotor; and subsequently-acting reaction stages having provision whereby substantially all pressure changes occur within the moving blade passages.

6. In an elastic fluid turbine, the combination of a rotor having peripheral buckets opening tangentially and formed with rounded bottoms; means initially to introduce and direct elastic fluid into said buckets on one side thereof whereby the fluid is whirled within the buckets and discharged backwardly from the opposite side thereof; and guide means for recovering the fluid initially so introduced and reapplying it in narrowed streams at progressively decreasing introduction angles, said guide means having plural passages for separating steam streams of different velocities.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

GUY B. COLLIER.

Witnesses:

HARRY T. WILLIAMS,
EVERETT S. EMERY.