No. 791,415. PATENTED MAY 30, 1905.

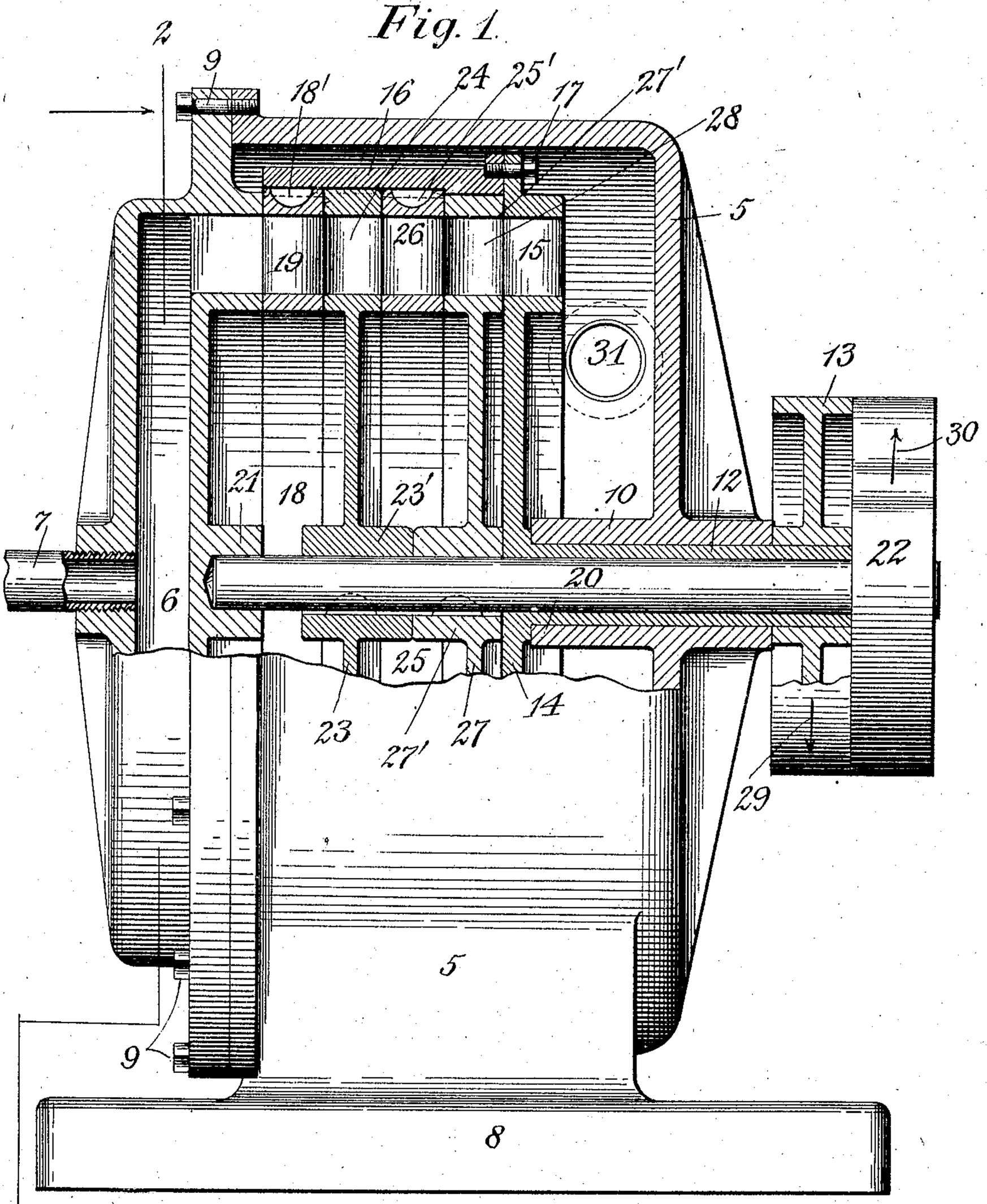
F. W. GORDON.

FLUID ACTUATED TURBINE.

APPLICATION FILED JULY 15, 1903.

3 SHEETS—SHEET 1.

*Fig. 1.*




Witnesses:
Chas. F. Schwelz
Frances E. Blodgett.

Inventor:
Frederick W. Gordon,
By his Attorney
Wm. H. Blodgett

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3 SHEETS—SHEET 2.

*Fig. 2.*




*Witnesses:*
Chas. P. Schmelz

Frances E. Blodgett.

*Inventor:*
Frederick W. Gordon,
By his Attorney
Wm. H. Blodgett

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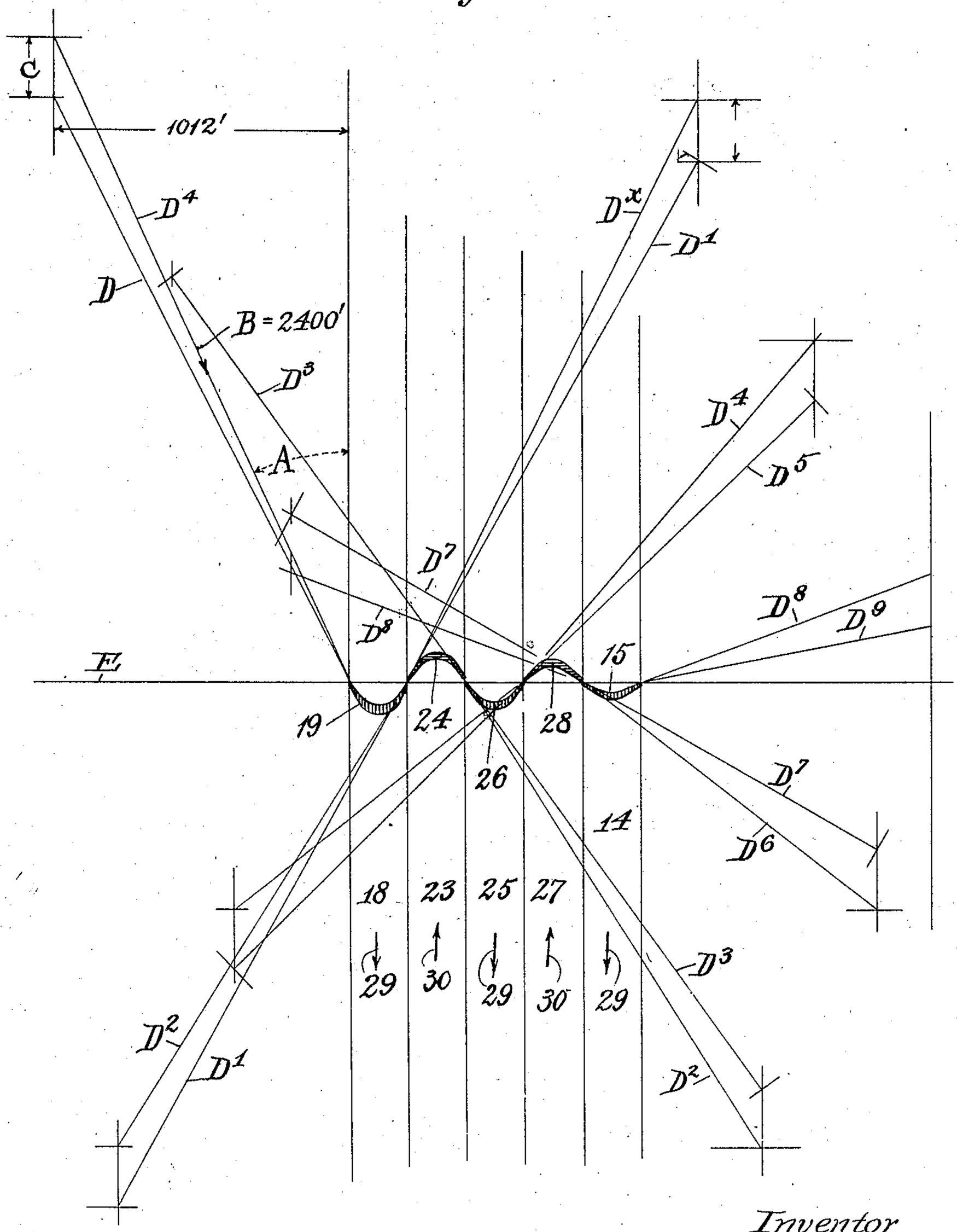
3 SHEETS—SHEET 3.

*Fig. 3.*




Witnesses:
Chas. F. Schneck
Frances E. Blodgett.

Inventor
Frederick W. Gordon,
By his Attorney
Wm. H. Blodgett

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# UNITED STATES PATENT OFFICE.

FREDERICK W. GORDON, OF HARTFORD, CONNECTICUT, ASSIGNOR OF ONE-HALF TO ALEXANDER GORDON, OF ASBURY PARK, NEW JERSEY.

## FLUID-ACTUATED TURBINE.

SPECIFICATION forming part of Letters Patent No. 791,415, dated May 30, 1905.

Application filed July 15, 1903. Serial No. 165,552.

*To all whom it may concern:*

Be it known that I, FREDERICK W. GORDON, a citizen of the United States of America, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Fluid-Actuated Turbines, of which the following is a specification.

My invention relates to fluid-actuated turbines, and has for its object the provision of an improved machine of the kind mentioned.

A further object of the invention is the provision in a fluid-actuated turbine of a series of connected sets of carriers having peculiarly-formed blades against which the force of the motive fluid is exerted, one set of carriers rotating in one direction and another set in an opposite direction.

A further object of the invention is the provision of a casing having a steam-chest, shafts mounted within said casing, a set of blade-carriers controlling one shaft, and a set of oppositely-rotating blade-carriers controlling the other shaft.

Further objects of the invention will be hereinafter stated.

In the accompanying drawings, Figure 1 is a longitudinal vertical section of my improved turbine with parts in elevation. Fig. 2 is a transverse section on line 2 2 of Fig. 1 looking in the direction of the arrow, and Fig. 3 is a diagram illustrating the mode of operation of the invention.

Like characters designate similar parts throughout the several views.

Referring to the drawings, the numeral 5 designates a casing; 6, a steam-chest; 7, an inlet-pipe leading to said steam-chest, and 8 a base from which the casing rises. Designated by 9 are bolts for securing the steam-chest to the casing, although other devices for accomplishing this result may be employed, if desired.

Journaled in a bearing 10 of the casing is a tubular shaft 12, which carries a pulley or other power-transmitting instrumentality 13, and rigid with this shaft is a carrier 14, having a series of semicircular blades 15. Projecting from the carrier 14 is a drum 16, which may be secured to a flange of said carrier by bolts 17 or otherwise. Keyed or otherwise secured to the drum at 18′ is a carrier 18, having a chamber adjacent to its periphery, in which are transverse blades 19, spaced regularly from each other and of the form or approximately the form illustrated in the diagram Fig. 3. Designated by 20 is a shaft which passes through the tubular shaft 12 and is stepped at one end in a bearing 21 of the steam-chest and carries at its opposite extremity a pulley 22 or other device by which power may be transmitted. Keyed to this shaft is a carrier 23, located adjacent to the carrier 18 and having a chamber in which semicircular blades 24, formed on a shorter arc than that of blades 19, are transversely disposed, as illustrated in Figs. 1 and 3. Keyed to drum 16 at 25′ is a carrier 25, also having a chamber adjacent to its periphery in which transverse semicircular blades 26 are mounted, the arc on which said blades are formed being shorter than the arc of blades 24. Secured to shaft 20, between the carriers 14 and 25, is a carrier 27, having a chamber 27′ adjacent to its periphery in which semicircular blades 28 are mounted, the arc of said blades being shorter than that on which blades 26 are formed, as shown in Figs. 1 and 3.

From what has been stated it will be seen that the connected carriers 18, 25, and 14 and drums 16 rotate together and impart movement to the tubular shaft 12 and pulley 13 in the direction of the arrow 29, Fig. 3, while the carriers 23 and 27 impart their movement to the shaft 20 and pulley 22 in the opposite direction, or that of the arrow 30. It will also be seen that the peripheries of the carriers 23 and 27 run in as close contact with the inner surface of the drum 16 as is possible, sufficient clearance being of course permitted.

In the casing 5 is a port 31 for the escape of the exhaust, which may be conveyed to any desired point.

Referring to the diagram Fig. 3, the invention operates as follows: A is a line representing the angle at which the motive fluid supplied through inlet 7 to steam-chest 6 strikes the semicircular blades 19 of the car-

rier 18, and this angle is about twenty degrees. B is a line representing the direction and velocity of the steam or other motive fluid, and this velocity may be taken at two thousand four hundred feet per second, and the speed of each carrier or section of the turbine may be taken at two hundred feet per second. C on the diagram by its direction and length represents the speed of the blade or bucket of the carrier, and as the length of line B is nine inches and the length of C is three-quarters of an inch the proportion will be that of twelve to one, the same ratio as the speed of the steam and the speed of said blade or bucket. The receiving edge of the first blade or bucket 19 coincides with the line D, and the steam will issue from this bucket at the same speed at which it enters; but in the direction in which the bucket is running it will have lost twice the speed the bucket has traveled during its passage along the surface of the bucket. As the steam acts against the the bucket on the line D it would, were the bucket stationary, be deflected on the line $D^{\times}$, the angle of which is equal to the angle made by line D with the center line E; but it loses the distance C, representing the speed of the bucket, and it will act upon the buckets 24 of carrier 23 on the line D′, said line indicating the angle of the receiving edge of each bucket 24. Line D denotes the direction and velocity of the steam when it reaches the buckets 19 of carrier 18, and after acting on said buckets it reacts at the same angle and with the same velocity and loses by the velocity of the bucket to line D′, in which direction and velocity it would act upon the second bucket 24 were it not for the fact that the carrier 23 of said second bucket is moving at its effective velocity, the result being that the steam will reach said second bucket 24 of carrier 23 on the line designated by $D^2$ in the diagram. Steam issues from said second bucket at the same velocity and angle as designated by the second line $D^2$, but, due to the speed of the carrier of said second bucket, is thrown therefrom on the line $D^3$ and were it not that the carrier 25 of the third series of buckets 26 is in motion would act upon the third bucket in the direction of said line $D^3$; but as said carrier 25 is also in movement in a direction opposite to carrier 23 the effective speed and velocity with which the steam will act upon the third bucket will be approximately on the line designated by $D^4$ on the diagram. By reason of the speed of the carrier 25 steam will issue from each of the third series of blades or buckets 26 about on the line designated by $D^5$ and would act upon the fourth blade or bucket 28 of carrier 27 on said line $D^5$ were it not that said fourth bucket is moving in the opposite direction, and the effective velocity of the steam will, due to this fact, be exerted against said fourth bucket about on the line $D^6$. Steam would issue from said fourth bucket on the line $D^6$ were it not that said bucket is moving in a contrary direction to that of the third bucket 26, and due to this fact the steam leaves the fourth bucket about on the line $D^7$, and it would act upon the fifth bucket 15 of carrier 14 on said line $D^7$ were it not that said carrier is rotating in a direction opposite to that of carrier 27 and will therefore cause the steam to escape on about the line $D^8$, on which line the exhaust would escape if carrier 14 were stationary; but as said carrier is in motion in a direction opposite to carrier 27 the exhaust from said fifth bucket will be about on line $D^9$.

From the diagram it will be seen that with steam delivered at a velocity of two thousand four hundred feet per second and with the carriage rotating at a velocity of two hundred feet per second four hundred feet will be absorbed by the buckets 19 of the first carrier 18, four hundred feet by the buckets 24 of the second carrier 23, four hundred feet by the buckets 26 of the third carrier 25, four hundred feet by the buckets 28 of the fourth carrier 27, and four hundred feet by the buckets 15 of the fifth carrier 14, or, in all, two thousand feet, the sole waste being a velocity of four hundred feet, part of which will be taken up by the parts through which the steam is applied and through which it exhausts and another part in the skin or surface resistance of the buckets. Furthermore, as the angle of discharge from each bucket is substantially the same as the angle at which the steam acts upon it and as the speed of the steam is constant the parts will be so balanced that the carriers will have substantially no tendency to move longitudinally of their shafts. It will be observed from said diagram that the blades or buckets of the carriers are formed on progressively-varying arcs, thereby providing for the full action of the steam on the blades of the respective carriers at continually-changing angles, so that the flow of steam is gradually converted into an axial line. This first set of buckets 19, against which the steam acts, is as near a semicircle as the permissible direction of the steam will admit, and if the jet of steam is thrown against said buckets at an angle of substantially twenty degrees then if the buckets 19 were stationary the entrance edge of each bucket would have an angle of exactly twenty degrees with the plane of the carrier 18; but as the carrier 18 is in motion in the same direction as the steam the velocity of the steam in relation to the buckets is the difference of the velocities of the steam and carrier, and this is the velocity of the steam on each bucket. So, too, the velocity of the ejection of steam from a bucket would be the initial velocity of the steam (less friction) if the bucket were stationary; but the carrier being in rotation the bucket is leaving the steam behind, and hence the velocity of the moving steam and the bucket is the initial

velocity of the steam less twice the velocity of the bucket, and the resultant direction of the steam would be determined by a line representing the initial direction of the steam and a line representing twice the velocity of the bucket in the direction the bucket is moving, and the third line completing the triangle would be the resultant of the other two, giving the direction and the velocity. To further absorb the force of the steam, the carrier 23, having the buckets 24, is arranged in close proximity to the carrier 18, and the working surfaces of the blades or buckets of said carrier 23 are each formed on an arc shorter than the arc of each bucket of the first set. The arc of each bucket 26 of the third carrier is shorter than that of buckets 24 of the second carrier, and so on, the bucket 28 of the fourth carrier 27 and buckets 15 of the fifth carrier 14 being on progressively shorter arcs, as shown by the diagram. Preferably the arcs of all the sets of buckets from the first to the last are arcs of a circle of the same diameter to facilitate their manufacture and limit the number of tools necessary for milling the bucket-surface; but the form of the buckets may be varied in other ways to accomplish the desired result without departure from the invention. By judicious plotting the entrace-angles of each set of buckets are determined, so that the steam will not strike the bucket at its entrance-angle, but slides over it. As the steam leaves one carrier it acts without a blow upon the buckets of the next carrier and is reversed in its direction to the extent of the contained angle formed by tangents to the entrance-angle and the delivery-angle of each bucket less the change due to double the velocity of each bucket, and so on, until it leaves the last set of buckets. In this manner the work done by the steam is multiplied in a practical way, the high peripheral velocities of other constructions are avoided, and a better absorption of the power of the steam is obtained.

I am well aware that in prior constructions reversely-rotating wheels or carriers having curved blades have been employed; but in no instance of which I am aware have said blades been provided with working surfaces on gradually shorter or shallower arcs for the purpose herein described.

While the sides of the carriers are shown in close relation to each other, yet they may, if desired, be spaced a slight distance apart, for with the velocity at which the steam travels it could leap a considerable distance without appreciable loss.

By inclosing the carriers within the drum 16 a compact and strong engine is provided, and leakage or "spill" of the steam from the respective carriers to the interior of the casing is avoided.

It will be observed that the carriers 18 and 25 are in the form of rings or wheels having no hubs, whereas the oppositely-rotating set of carriers 23 and 27 are spaced the desired distance apart on the shaft 20 by their hubs 23' 27'.

The shafts and carriers may be readily assembled and placed in position through the open side of the casing, after which the steam-chest 6 and pulley 13 and 22 may be secured in place.

While semicircular blades or buckets are deemed preferable, other forms may be substituted therefor without departure from the invention. Furthermore, the invention is not limited to any particular number of sets of oppositely-rotating carriers, nor to any particular number of carriers to the set, for these may be varied within wide limits. So, too, the invention is not restricted to pulleys for transmitting power from the oppositely-rotating shafts, for any suitable devices may be employed for this purpose without departure therefrom. The blade-carriers may also be of different form from that shown without departure from the invention.

Having thus described my invention, what I claim is—

1. The combination, with a rotatable carrier having a series of curved blades, of a second rotatable carrier having a series of curved blades formed on an arc shorter than that on which the blades of the first carrier are formed, one of said carriers being rotatable in a direction opposite to that of the other; and a casing having supply and exhaust ports.

2. The combination, with a casing having supply and exhaust ports, of a shaft journaled in said casing; carriers secured to said shaft, and each having a series of curved blades, the arc on which one series of blades is formed being shorter than that of the other series; a second shaft surrounding the first-named shaft, and also journaled in the casing; a series of carriers secured to said second shaft, a series of curved blades on each carrier of the second shaft, each series of blades being formed on an arc shorter than the arc on which the preceding blades are formed; and means for transmitting power from the shafts.

3. The combination, with a casing having supply and exhaust ports, of a pair of shafts, one mounted within the other; a series of carriers, each having a chamber adjacent to its periphery, secured to the inner shaft; curved blades in each of said chambers; a carrier secured to the outer shaft, and having a chamber adjacent to its periphery, and curved blades in said chamber; a drum projecting from said carrier; carriers, each having a chamber adjacent to its periphery and curved blades in said chamber, secured to the drum, the blades of all the carriers being progressively shallower; and power-transmitting elements carried by the shafts.

4. In a fluid-actuated turbine, the combina-

tion, with a carrier having curved blades, of a second reversely-operable carrier also having curved blades drawn on an arc shorter than the arc of the blades of the first carrier; and means for transmitting power from said carriers.

5. The combination, with a series of connected carriers operable in one direction and having progressively-varying curved blades, of a second series of reversely-operable carriers also having progressively-varying blades; and means for transmitting power from said carriers.

6. The combination, with a casing having supply and exhaust ports, of a tubular shaft journaled in the casing; a carrier rigid with said tubular shaft, and having blades; a drum projecting from the carrier; annular carriers keyed to the drum, and each having blades; a shaft within the tubular shaft; a carrier having blades, the hub of said carrier being keyed to the shaft within said tubular shaft; another carrier having blades, and the hub of which is keyed to the shaft within the tubular shaft; and means for transmitting power from said shafts.

7. The combination, with a carrier having curved blades, and operable in one direction, of a second carrier having blades varying in curvature from the blades of the other carrier, and operable in an opposite direction, whereby the motive fluid will be received by one set of blades at an angle varying from that at which it is received by the other set of blades.

8. The combination, with a casing having supply and exhaust ports, of reversely-operable sets of carriers, and blades or buckets of progressively-varying curvature carried by said carriers.

9. The combination, with a casing having supply and exhaust ports, of reversely-operable carriers, each carrier having curved blades, and the curve of one set of blades varying in depth from that of the other set of blades.

10. The combination, with a casing having supply and exhaust ports, of a primary carrier having curved blades to receive the motive fluid; a reversely-operable carrier having curved blades of less depth than the blades of the primary carrier; a carrier operable in the same direction as the primary carrier, and having curved blades less in depth than the interposed, reversely-operable carrier; a second reversely-operable carrier having curved blades of less depth than the preceding carrier; a third carrier operable in the same direction as the primary carrier, and having curved blades of less depth than the preceding reversely-operable carrier; a shaft to which one set of carriers is secured; a tubular shaft surrounding the other shaft; and a drum projecting from said tubular shaft, and to which the other set of carriers is secured.

In testimony whereof I affix my signature in presence of two witnesses.

FREDERICK W. GORDON.

Witnesses:

FRANCES E. BLODGETT,

CHAS. F. SCHMETZ.