No. 677,082. Patented June 25, 1901.

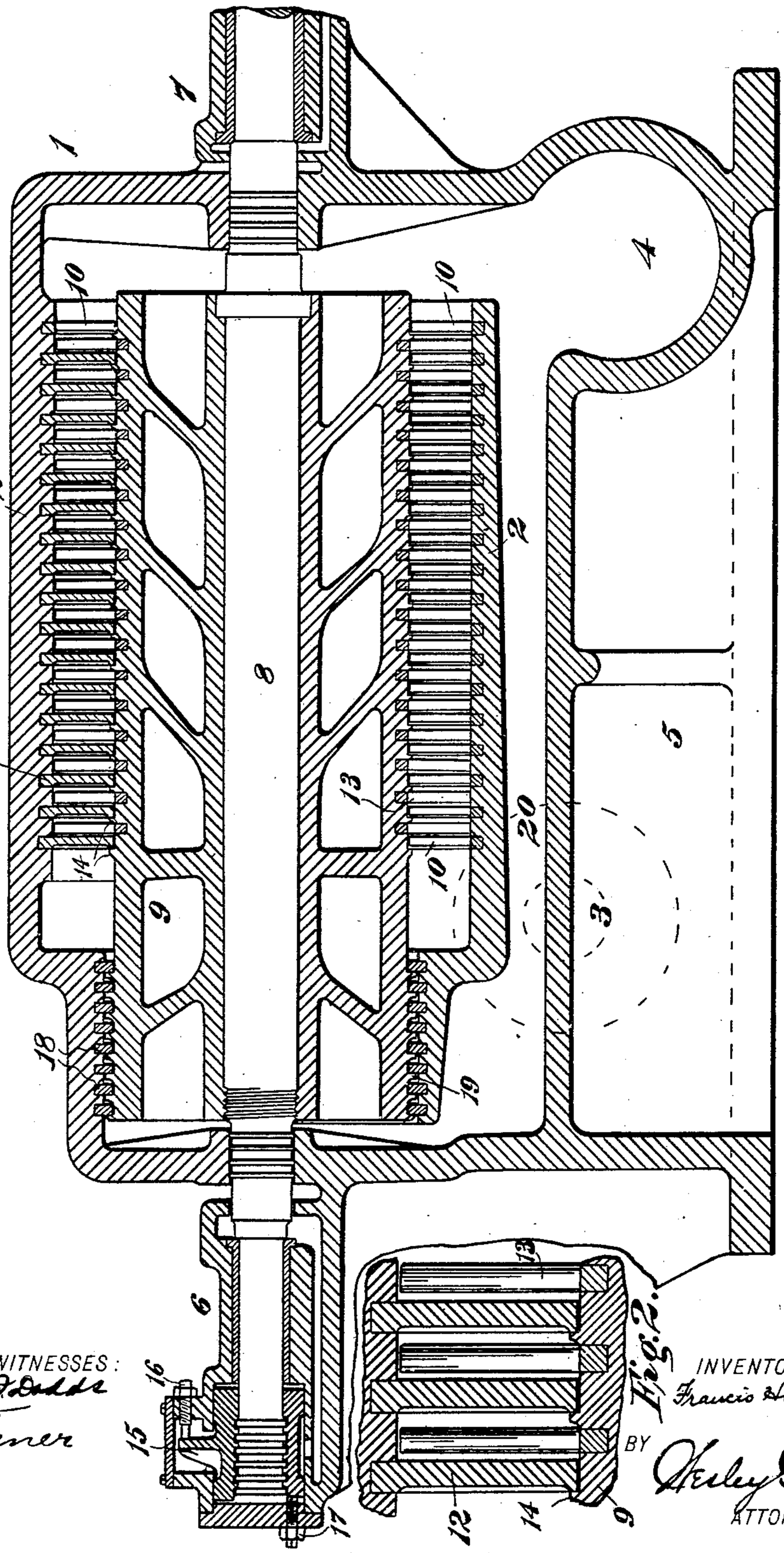
F. HODGKINSON.

FLUID PRESSURE TURBINE.

(Application filed Apr. 3, 1899. Renewed May 31, 1901.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.



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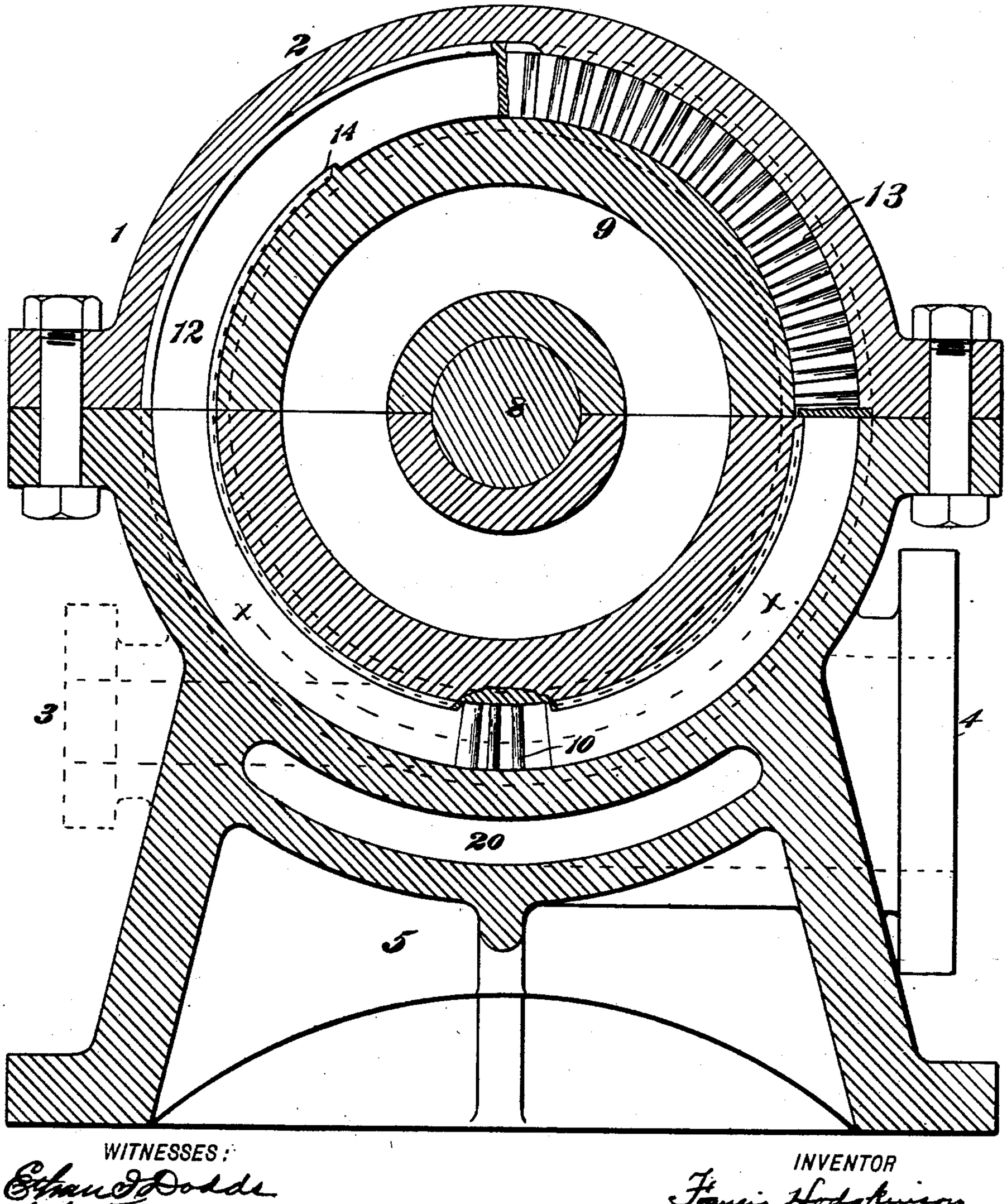
(No Model.) 4 Sheets—Sheet 2.

Fig. 3.



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(No Model.) 4 Sheets—Sheet 3.

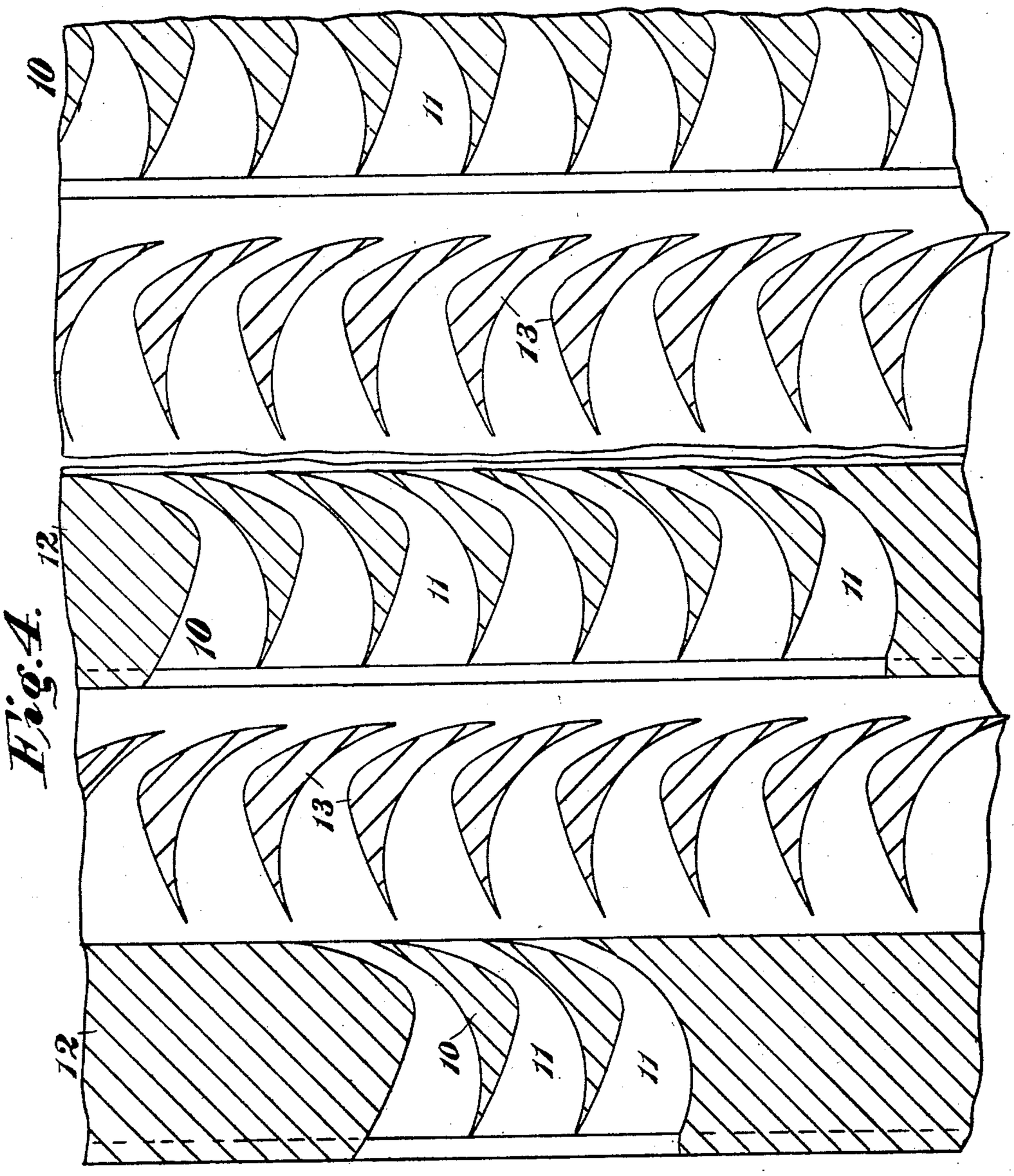

Fig. 4.

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(No Model.) 4 Sheets—Sheet 4.

Fig. 5.

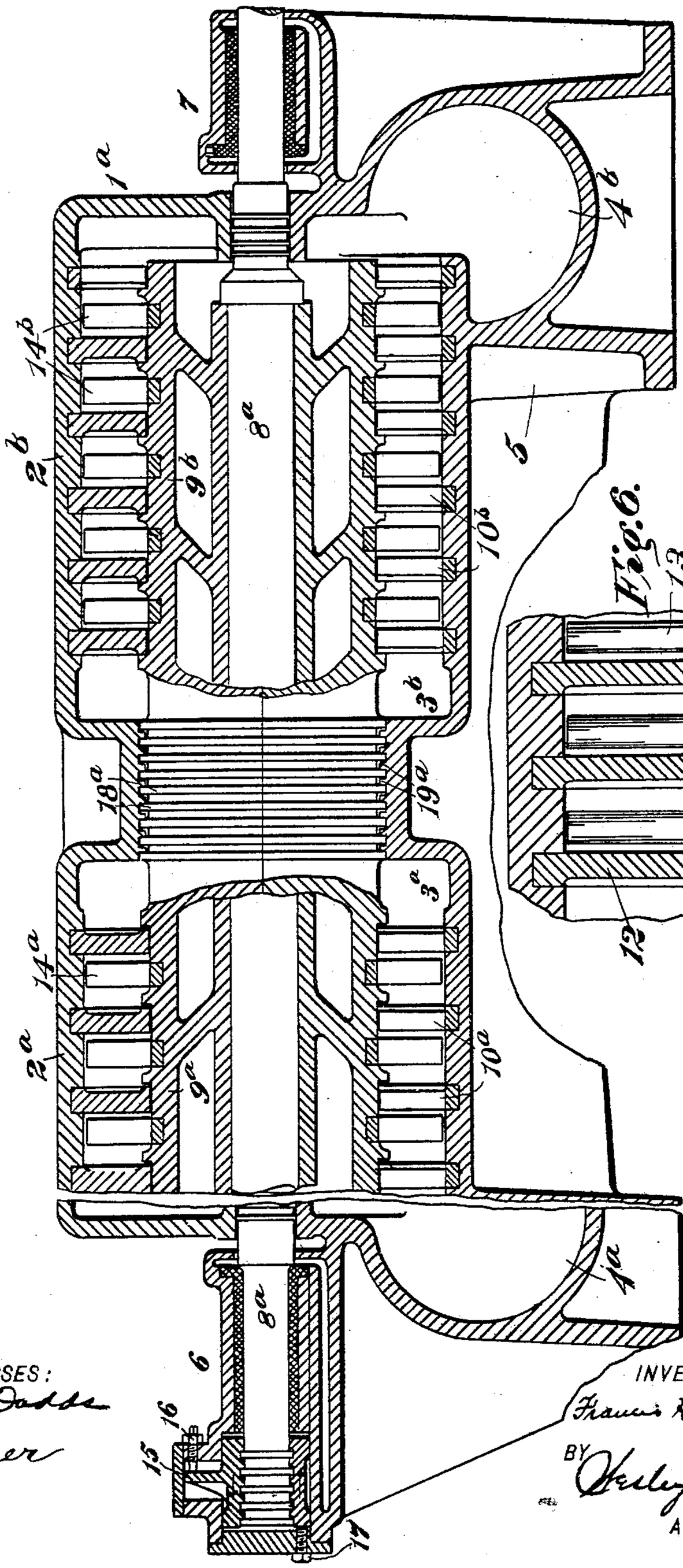

Fig. 6.

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UNITED STATES PATENT OFFICE.

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FLUID-PRESSURE TURBINE.

SPECIFICATION forming part of Letters Patent No. 677,082, dated June 25, 1901.

Application filed April 3, 1899. Renewed May 31, 1901. Serial No. 62,626. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS HODGKINSON, a subject of the Queen of Great Britain and Ireland, residing at Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Fluid-Pressure Turbines, of which the following is a specification.

My invention relates to fluid-pressure turbines; and it has for its object to provide an engine of this type which shall be compact and comparatively inexpensive in construction and which shall be economical in its consumption of motive fluid and have a maximum output of mechanical energy.

In the accompanying drawings, Figure 1 is a longitudinal section through a turbine embodying my invention, a portion of the frame and of one of the shaft-bearings being broken away. Fig. 2 is a detail sectional view of a portion of the engine shown in Fig. 1. Fig. 3 is a transverse sectional view of the engine, a portion of one of the ring-segments being broken away. Fig. 4 is a detail sectional development, on an enlarged scale, of a portion of the mechanism, the section being taken on line $x\,x$ of Fig. 3. Fig. 5 is a longitudinal sectional view of a double reversible engine, parts being broken away. Fig. 6 is a detail sectional view corresponding to Fig. 2, but showing a modified construction.

Referring particularly to Figs. 1, 2, 3, and 4 of the drawings, the frame 1 of the engine comprises a cylinder 2, an inlet-port 3 at one end and an exhaust-port 4 at the other end of said cylinder, a suitable base structure 5, and shaft-bearings 6 and 7. A shaft 8 is journaled in the bearings 6 and 7 and is provided with a drum 9, the diameter of which is materially less than that of the internal bore of cylinder 2. It will be understood that instead of making the parts 8 and 9 separately and fastening them together, as shown, they might be formed as a single integral structure of either solid or hollow formation and of any desired length and diameter.

The interior of the cylinder 2 is provided with a series of sets of circumferentially-arranged guide-vanes 10. The individual guide-vanes are so constructed and arranged as to provide passages 11 of desirable form and location to properly direct the motive fluid against the movable members, to be hereinafter described. The form and arrangement shown in the drawings I have found to be well adapted for successful operation; but my invention is not limited in this regard.

The drum 9 is provided with a plurality of sets of blades or buckets 13, which may have approximately the same form and dimensions as the guide-vanes 10. These blades or buckets are circumferentially arranged on the periphery of the drum, and the several sets alternate with the sets of guide-vanes 10. Each set of blades or buckets occupies the entire circumference, and in order to utilize the motive fluid most advantageously the blades are reversed and reversely inclined with reference to the guide-vanes.

In an engine having its cylinder and its drum each of uniform diameter from end to end the number of guide-vanes 10 will be a minimum in the set adjacent to the inlet-port and a maximum in the set adjacent to the exhaust-port, the numbers in the intervening sets being properly graduated to provide progressively-increasing passage-space corresponding to the rate and degree of expansion of the motive fluid. The circumferential space between the terminal guide-vanes of each set is occupied by a ring-segment 12, which may be either solid or hollow, it being understood that passages 11 of suitable shape and dimensions are provided between the terminal guide-vanes and the adjacent ends of the ring-segments. In engines having two or more diameters of cylinder or drum, or both, a progressively-increasing passage-space will be provided between the inlet-port and the exhaust-port; but the desired initial passage-space for any diameter other than that at the inlet end may be secured in whole or in part by a variation in the length of the guide-vanes instead of by an increase in number with reference to the number in the last set corresponding to the preceding diameter. In general it may be stated, therefore, that for any given diameter of cylinder and drum the number of guide-vanes per set will vary progressively from end to end. The set adjacent to the exhaust-port may occupy the

entire circumference or only a portion of the circumference, as may be found desirable.

In case it should be found expedient and desirable to make the cylinder and drum of the engine of conical form—*i. e.*, of gradually-increasing diameter from end to end—the variation in the number of guide-vanes per set would also preferably be approximately uniform between the inlet and exhaust ports.

It will be seen that the ends of the guide-vanes 10 and the inner peripheries of the ring-segments 12 are in close proximity to the surface of the drum 9 and that the ends of the blades or buckets 13 are in close proximity to the inner surface of the cylinder 2. There will be a considerable leakage of motive fluid, however, unless auxiliary packing devices are used.

In order to minimize the leakage, I provide the drum 9 with a series of annular shoulders 14, these shoulders being located adjacent to the ends of the several sets of guide-vanes and in close proximity to the edges of the corresponding ring-segments on the inlet-port side.

In order to insure a proper working relation between the ring-segments 12 and the shoulders 14, I provide the bearing 6 with means for effecting a limited longitudinal adjustment of the shaft 8 and for preventing longitudinal reciprocation of the same when in operation. This means comprises a longitudinally-adjustable head 15, having a series of annular internal grooves, in which are located corresponding rings, formed on the shaft 8, and adjusting-screws 16 and 17. Suitable packing-rings or stuffing-boxes surround the shaft at the ends of the frame or casing 1, as is usual in such relations.

Both the drum 9 and the casing 1 are extended beyond the inlet-port toward the bearing 6, and suitable packing-rings 18 are located between these parts. (See Fig. 1.) I have shown the drum as provided with annular shoulders 19, similar to shoulders 14, for cöoperation with the rings 18; but other forms of packing devices may be employed, if desired. The casing or frame 1 is also provided with a passage 20, leading from the space at the end of drum 9 to the exhaust-port 4 for the egress of any motive fluid that may leak through or around the packing devices 18 and 19.

It will be understood from the foregoing description that when the steam or other motive fluid is admitted through the inlet-port it will pass through the passages 11 between the guide-vanes 10 of the first set, by which it will be directed against the adjacent blades 14 of the first set and by its impact and expansive force will set the drum in motion. As the drum rotates the steam will expand and be directed by the next set of passages 11 against the adjacent blades of the next set, and so on, until the exhaust-port is reached. The successive increase in the number of passages 11 per set enables the expanded steam to act against a progressively-increasing number of blades 14.

I desire it to be understood that any desired number of passages 11 may be provided in the first and last sets and also in the intervening sets, the ratio of increase in number from set to set depending upon the conditions of fluid-pressure and speed under which the turbine is to operate.

In Fig. 5 I have shown a reversible engine suitable for use in any relation where it is desired to drive the engine-shaft in either direction at the will of the engineer. This engine comprises a frame or casing 1^a, having two cylinders 2^a and 2^b, provided, respectively, with sets of guide-vanes 10^a and 10^b, like those shown in Figs. 1 to 4. The motive fluid is supplied to the respective cylinders through inlet-ports 3^a and 3^b and exhausts through ports 4^a and 4^b. The shaft 8^a is provided with two drums 9^a and 9^b or a single drum extending through the two cylinders, as may be desired. The drum or drum portions, as the case may be, are respectively provided with sets of blades or buckets 14^a and 14^b, and suitable packing devices 18^a and 19^a are provided intermediate the two cylinders. It will be readily seen that if the guide-vanes and blades are properly constructed and arranged the shaft 8^a may be rotated in either direction at will by admitting motive fluid into the one or the other of the inlet-ports.

In Fig. 6 I have shown a means of modified construction for preventing the passage of fluid through the engine without doing work. This means consists of spring-rings 21, set into annular recesses of like cross-section in the drum 9^c, so as to make working contact with the ends of the guide-vanes and with the inner peripheries of the corresponding ring-segments.

It will be understood that any suitable kind of motive fluid may be utilized, though steam will generally be found most readily available. It will also be understood that any suitable kind of governor may be employed and that the details of construction may be varied from what is shown and described without departing from the spirit and scope of the invention.

I claim as my invention—

1. In a steam-turbine, the combination with a rotatable drum having a series of annular groups of blades or buckets, of a stationary member having a cylinder for said drum, an inlet-port adapted to supply steam at boiler-pressure, an exhaust-port and a series of groups of guide-vanes alternating with said rotatable groups of blades or buckets, the number of vanes in the successive groups increasing from one end to the other of a given diameter of engine cylinder and drum, whereby the expansion of the steam is advantageously utilized.

2. In a steam-turbine, the combination with a rotatable member provided with a series of annular groups of blades or buckets, of a sta-

tionary member provided with an inlet-port adapted to supply steam at boiler-pressure, an exhaust-port and a series of groups of guide-vanes alternating with said rotatable groups of blades or buckets, the number of vanes per group increasing progressively from a minimum at the inlet end to a maximum at the exhaust end of the turbine, whereby the expansion of the steam is advantageously utilized.

3. In a fluid-pressure turbine, the combination with a rotatable drum provided with a series of annular groups of blades or buckets, of a casing having inlet and exhaust ports, and a plurality of groups of guide-vanes alternating with said rotatable groups of blades or buckets, the number of vanes per group increasing progressively from one end to the other of a given diameter of engine cylinder and drum, and a series of ring-segments occupying the spaces between the terminal vanes of the several groups.

4. In a fluid-pressure turbine, the combination with a shaft or drum provided with a series of annular groups of blades or buckets, of a casing provided with inlet and exhaust ports and with a series of groups of guide-vanes alternating with said groups of blades or buckets, the number of vanes per group increasing progressively from the inlet to the exhaust end, and a series of ring-segments occupying the spaces between the terminal vanes of the several groups.

5. In a fluid-pressure turbine, the combination with a casing having a plurality of groups of annularly-arranged guide-vanes and ring-segments, of a shaft or drum provided with a plurality of groups of blades or buckets alternating with the groups of guide-vanes and ring-segments and with a plurality of annular shoulders which are respectively in close lateral proximity to the edges of the ring-segments of the several groups.

6. In a fluid-pressure turbine, the combination with a casing having inlet and exhaust ports and a series of annularly-arranged groups of guide-vanes and ring-segments, of a rotatable shaft or drum provided with a series of annular groups of blades or buckets alternating with the groups of guide-vanes and ring-segments and with a series of annular shoulders in close lateral proximity to the edges of the respective ring-segments, and a thrust bearing for said shaft or drum to maintain a proper working relation between said shoulders and said ring-segments.

7. In a fluid-pressure turbine, the combination with a casing having inlet and exhaust ports and a series of annularly-arranged groups of guide-vanes and ring-segments constructed and arranged to provide a progressively-increasing passage-space from the inlet to the exhaust end, of a shaft or drum provided with a series of annular groups of blades or buckets alternating with said groups of guide-vanes and ring-segments and with a series of annular shoulders respectively in close lateral proximity to the edges of the ring-segments of the several groups, and means for maintaining a proper working relation between said shoulders and said ring-segments.

8. In a fluid-pressure turbine, the combination with a casing having inlet and exhaust ports, a series of annularly-arranged groups of guide-vanes increasing in number per group from the inlet to the exhaust end and ring-segments occupying the spaces between the terminal vanes of the several groups, of a shaft or drum having a series of annular groups of blades or buckets alternating with the groups of guide-vanes and a series of annular shoulders in close proximity to the edges of the ring-segments of the several groups and means for maintaining a proper working relation between said shoulders and said ring-segments.

9. In a fluid-pressure turbine, the combination with a casing having inlet and exhaust ports and a series of annularly-arranged groups of guide-vanes and ring-segments constructed and arranged to provide a progressively-increasing passage-space from the inlet to the exhaust end, of a shaft or drum provided with a series of annular groups of blades or buckets alternating with said groups of guide-vanes and ring-segments and with means for preventing or reducing the leakage of motive fluid between the ring-segments and the shaft or drum.

In testimony whereof I have hereunto subscribed my name this 28th day of March, 1899.

FRANCIS HODGKINSON.

Witnesses:
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WESLEY G. CARR.