No. 749,196. PATENTED JAN. 12, 1904.

P. F. HOLMGREN.

TURBINE ENGINE.

APPLICATION FILED FEB. 9, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

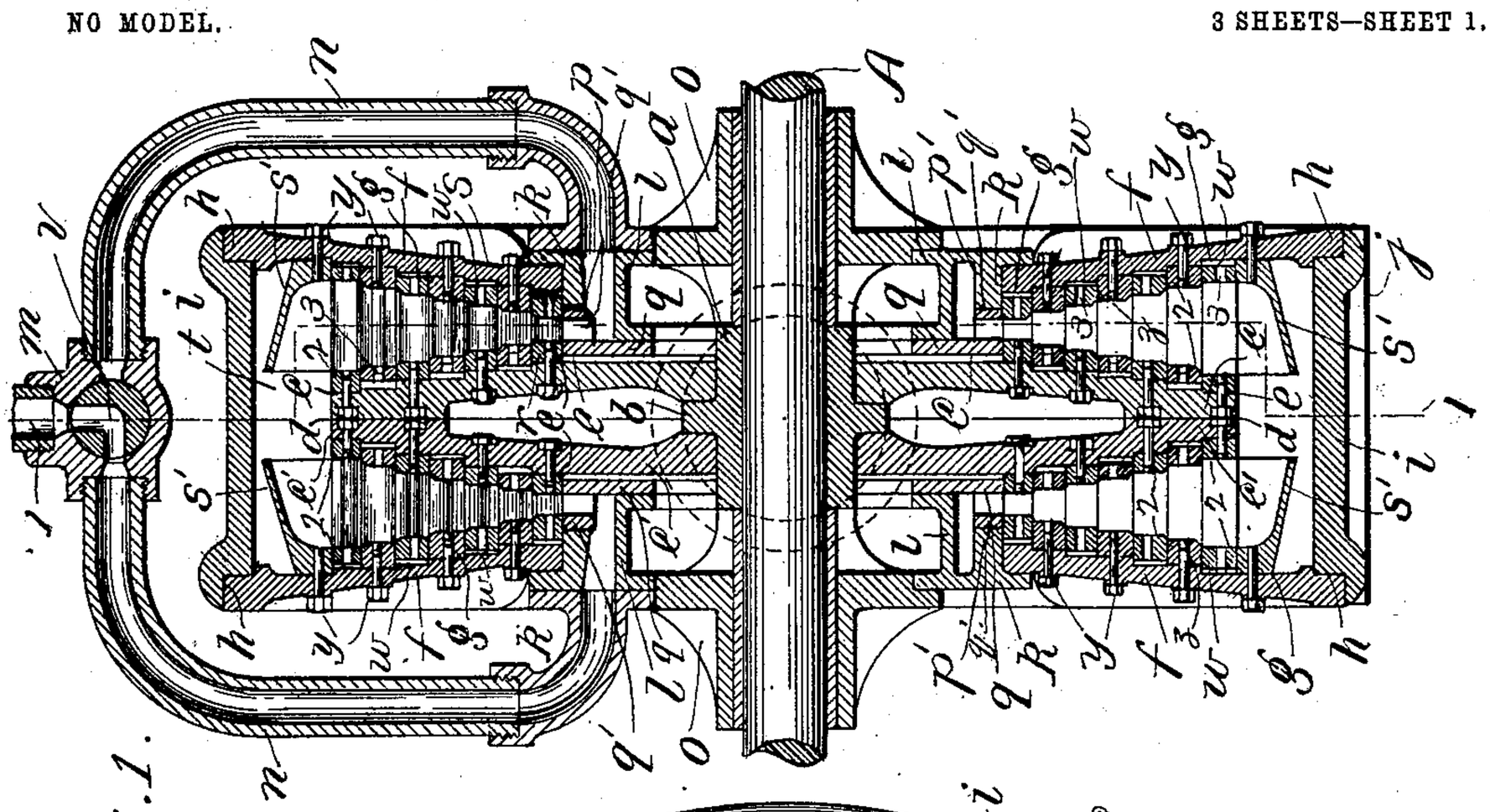

Fig. 1.

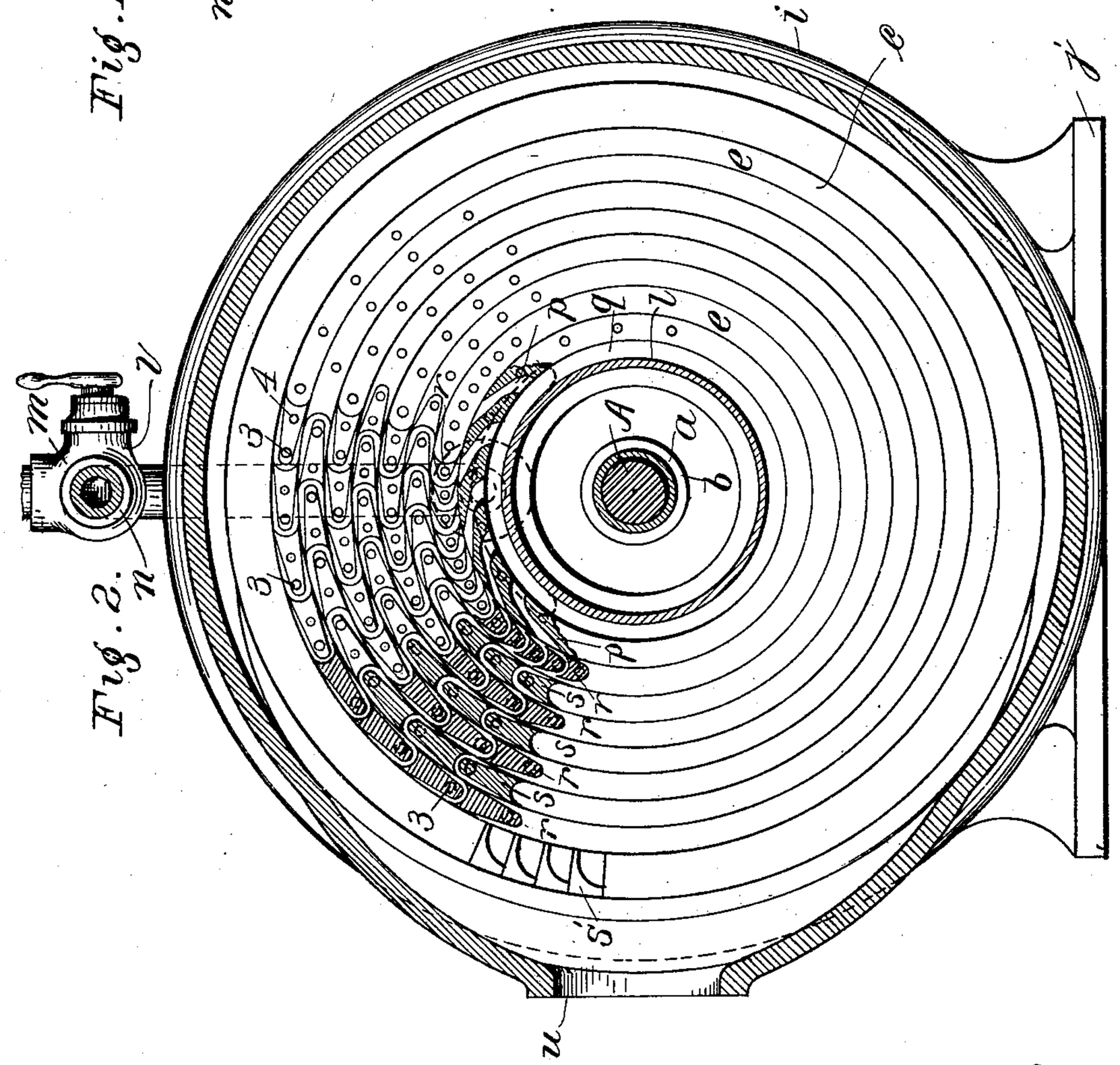

Fig. 2.

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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 3.

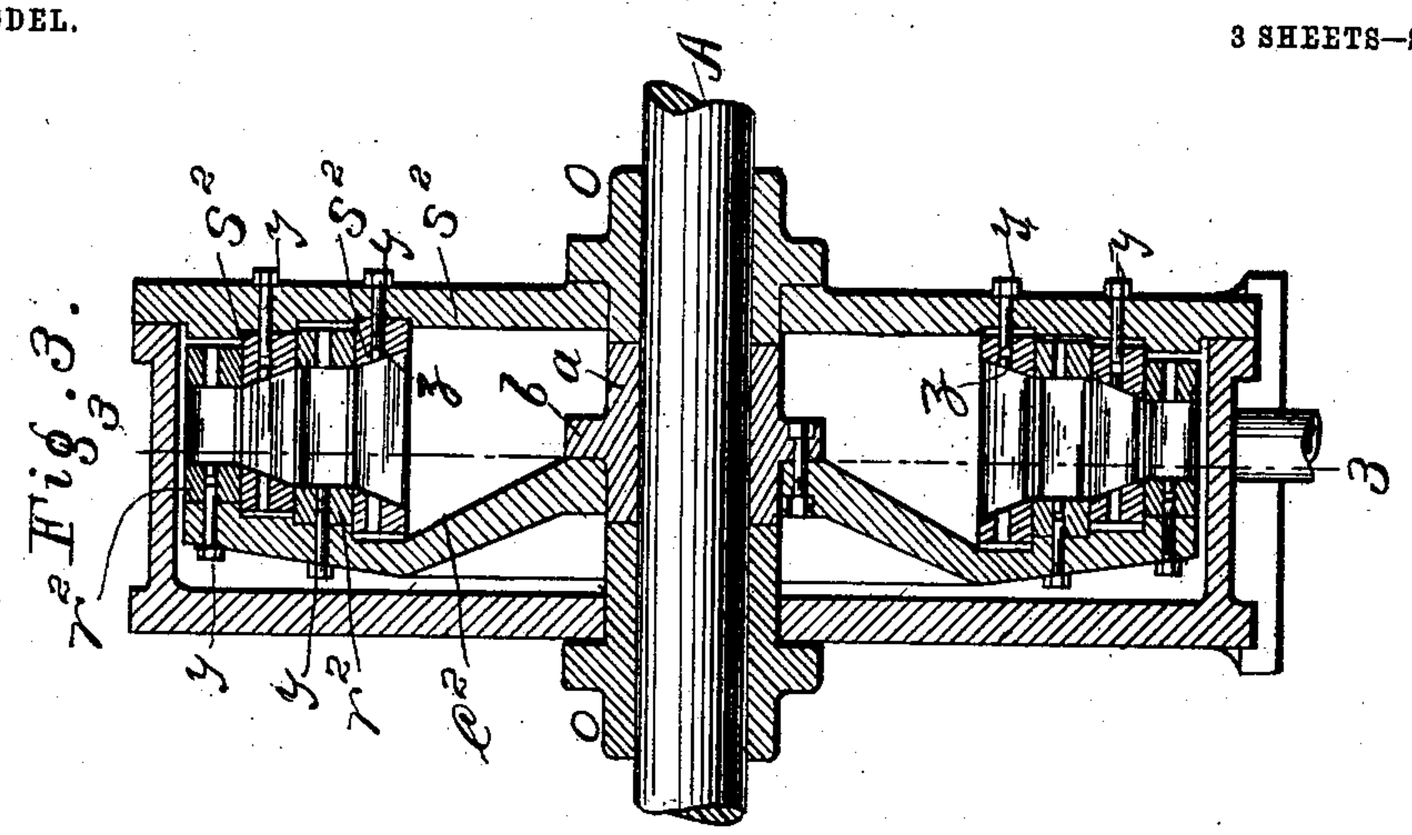
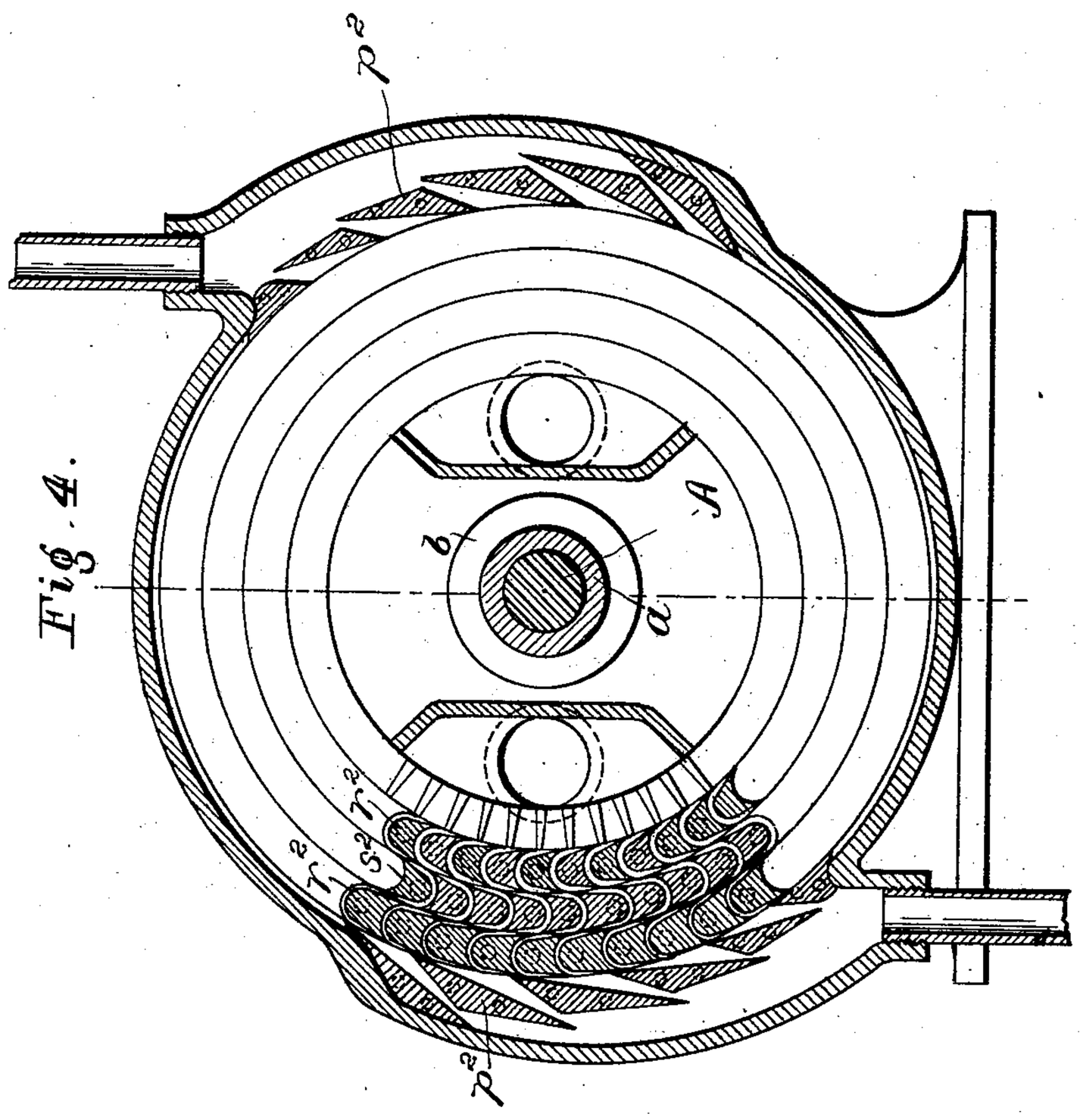


Fig. 4.



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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 5.

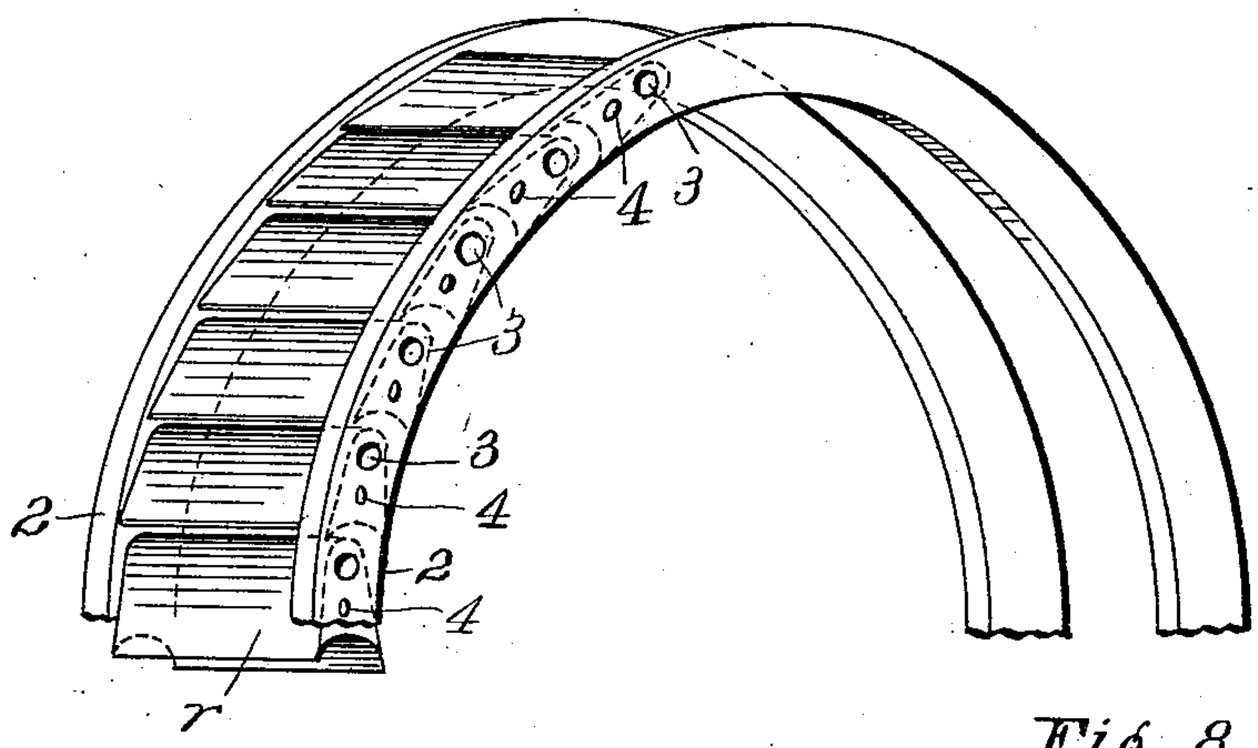
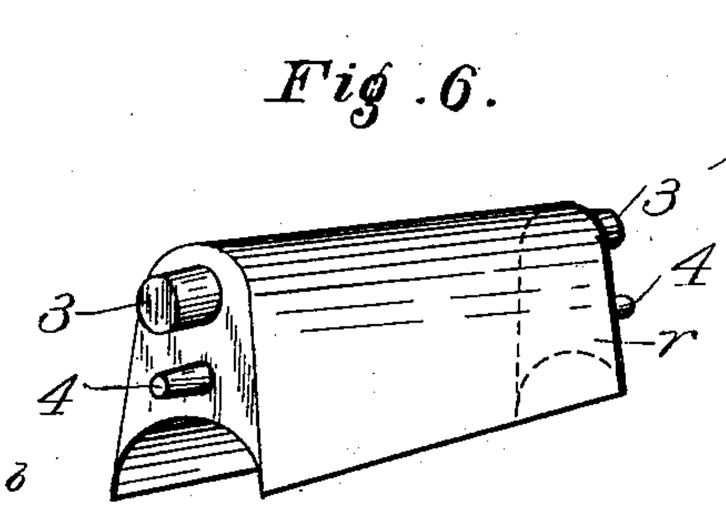


Fig. 8.

Fig. 6.



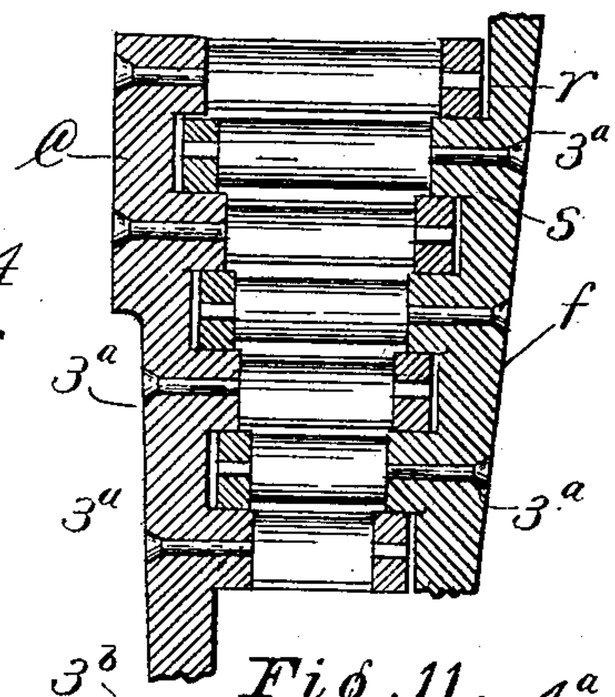


Fig. 9.

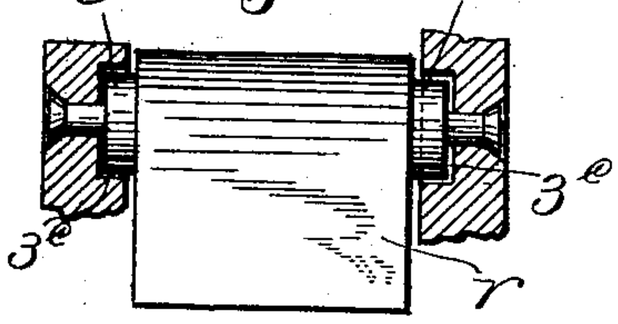


Fig. 7.

Fig. 11.

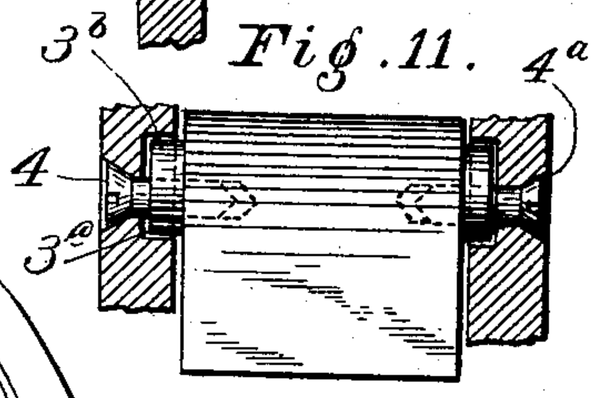
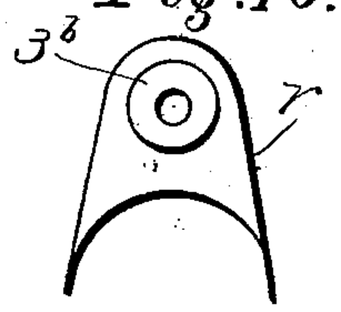


Fig. 10.



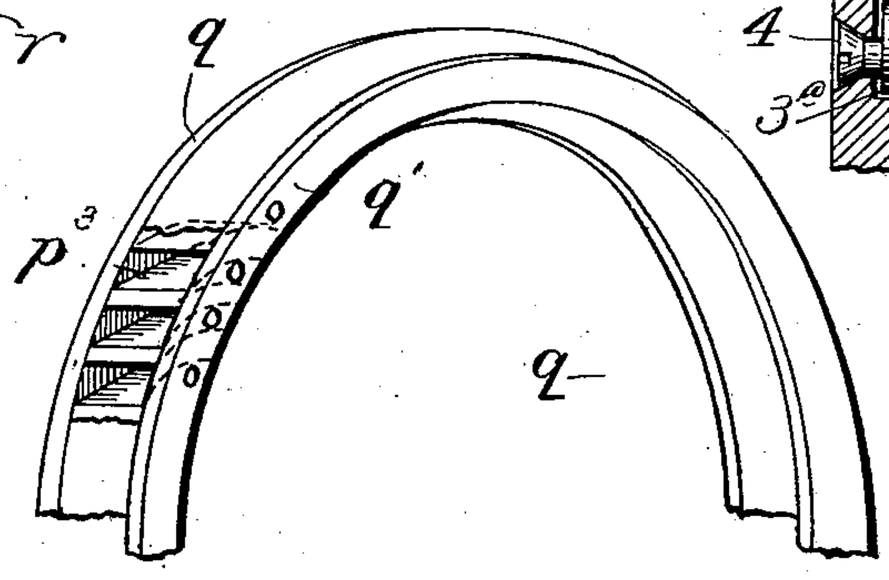
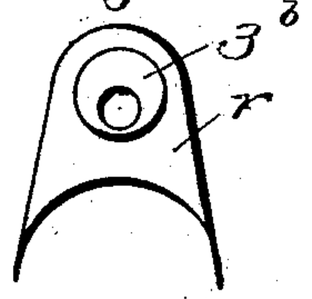


Fig. 12.



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No. 749,196. Patented January 12, 1904.

UNITED STATES PATENT OFFICE.

PER F. HOLMGREN, OF NEW YORK, N. Y.

TURBINE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 749,196, dated January 12, 1904.

Application filed February 9, 1903. Serial No. 142,617. (No model.)

To all whom it may concern:

Be it known that I, PER F. HOLMGREN, a citizen of the United States of America, and a resident of the borough of Brooklyn, New York city, and State of New York, have invented certain new and useful Improvements in Turbine-Engines, of which the following is a specification.

My invention relates to multiple-expansion turbine-engines and comprises various details of improvements in the construction of closely-fitting concentric bucket-carrying and chute-holding rings one within the other, alternately reversing the direction of the impelling fluid and also expanding the same in its onward course, including simple and efficient means of reversing the direction of motion of the shaft, as hereinafter described, reference being made to the accompanying drawings, in which—

Figure 1 is a vertical central section of my improved engine in duplex form, the section being taken in the longitudinal direction of the shaft. Fig. 2 is a vertical transverse section on the line 1 1 of Fig. 1, with parts omitted to avoid unnecessary repetition. Fig. 3 is a vertical section in the plane of the shaft, showing modification. Fig. 4 is a vertical section on the line 3 3 of Fig. 3. Fig. 5 is a perspective view of parts of a bucket-ring. Fig. 6 is a perspective view of a bucket detached from the ring members. Fig. 7 is a perspective view of parts of a chute-ring. Fig. 8 is a detail showing a modification in which the buckets are riveted directly to the cover and disk without the ring elements. Fig. 9 is a detail showing the buckets having enlargements of the connecting-studs countersunk in the ring elements. Fig. 10 is an end view of the bucket of Fig. 9. Fig. 11 shows the buckets with enlarged countersunk studs secured by screws inserted through the ring elements eccentrically to the studs in lieu of the dowel-pins for preventing the shifting of the buckets by centrifugal force. Fig. 12 is an end view of the bucket of Fig. 11.

A represents the shaft.

a represents a hub keyed or otherwise made fast to the shaft for rotating with it, said hub having a central radial flange *b*.

c represents a disk bolted to one side of flange *b*, and *c'* a like disk similarly bolted to the other side of disk *b*, so that they may be separated from each other to facilitate bolting on the bucket-carrying rings, as will appear farther on, said disks having marginal back faces in bearing contact with each other, as shown at *d*, and on the other sides they have a wide marginal zone divided into a series of concentric faces *e*, whereof each successive face from the inner one outward is offset relatively to the preceding face toward the opposite side of the disk, the number of these faces being seven in Fig. 1, but more or less may be employed, according to the number of expansions desired. The sides *f* of the case confronting these offset zones of the disks are formed with corresponding offset faces *g*, the outermost face of each side being preferably wider radially than the rest, or they may be formed in two faces alike offset, as the others if preferred. The sides *f* are bolted at *h* to the peripheral member *i* of the case which is carried on the base-support *j*, and they are bored axially at *k* and have each an annular steam-chest *l* fitted thereon, which are respectively connected with the steam-pipe *m* by the branches *n*.

Shaft-bearings *o* are fitted centrally within the steam-chests and, together with the steam-chests, are properly secured to the sides *f* of the case.

The steam-chests each communicate with a concentric series of centrifugal chutes *p*, carried on a ring *q*, attached to and forming the inner part of the shell of the steam-chest for distributing the steam and giving direction to it in taking effect on the buckets. A ring *q'* covers the other sides of the chutes. Surrounding these chutes and fitted closely thereto is a series of buckets *r*, formed in a ring and bolted to the inner face of disk *c*, and around these buckets is another ring of buckets *s*, which are bolted to the appropriate offset face *g* of the side *f* of the case, these buckets being directed reversely to the direction of the buckets *r* for causing reactionary effect of the steam on them and for directing it into another ring of buckets *r*, similarly bolted to the appropriate face *e* of the disk *c*, when it

may be desired to utilize the expansive force of the steam through several sets of reversely-operating buckets, as usual in this kind of engine. In this example I have represented in Figs. 1 and 2 four sets each of the respective buckets.

It is to be noted that besides the expansion radially through the increased number of buckets and chutes afforded by the progressive increase in length of the circumferential lines there is also progressive increase laterally, which is accomplished by the before-described offset arrangement of the bucket-holding faces of the disk *c* and the cover *f*, and the corresponding widening of the buckets thereby afforded.

I provide for reaction of the steam escaping from the last series of buckets against said buckets by a series of laterally-discharging chutes *s'*, located in the annular exhaust-steam space *t*, to which the exhaust-pipe connects at *u*, affording some advantage as against discharging directly into said space, as usual. These chutes are bolted to covers *f*, same as the others.

In Figs. 1 and 2 I represent a three-way cock *v* intermediate of the steam-pipe *m* and the branches *n* to indicate the arrangement when, for providing a reversing-engine, the units of the duplex engine may have their respective chutes and buckets disposed for running in opposite directions; but when the units are to operate in unison for rotation one way only as the components of a single unit the said cock will be omitted and both branches *n* will connect directly with the steam-pipe *m*.

It will be seen that the bucket-carrying rings can be very accurately fitted within each other and be very cheaply constructed by lathework with practically no clearance between them, as being accurately turned they will run true radially, whereby the loss of steam by leakage in the joints will be slight; but as it is more difficult to guard against lateral vibrations I provide slight clearances at *w* between the sides of the rings and the opposing parts working free of each other. There is, however, no outlet for escape through these clearances, and leakage through them is consequently very slight.

An essential feature of my invention consists of the construction of the buckets and their carrying-rings of the particular form herein employed in separate pieces and then connected as against the common way of producing the rings and the buckets of each set in integral construction, whereby the expensive process of shaping the buckets by cutting away from a single ring the material not required is avoided and the interior surfaces of the buckets may be made smoother. To this end I provide what I have before mentioned as rings in two separate plain ring elements 2 and make the buckets separately, with a stud 3 on each side, and connect the buckets and ring elements by inserting the bucket-studs in holes in the ring elements and riveting the ends of the studs, as shown in Fig. 5, with dowel-pins 4 to guard against displacement of buckets by turning on the connecting-studs through the effect of centrifugal force, the buckets being unbalanced on said studs. Where the ring elements are bolted to the disk or cover-faces, which is only at intervals of several buckets, the bucket-studs will be cut short of the full thickness of the ring elements, as shown at *z*, to afford entry of the fastening-bolts *y* for proper holding, and of course one bucket-stud cannot in these instances be riveted, but as both studs of all the buckets intermediate of the fastening-bolts will be riveted ample fastening of the buckets and ring elements will be secured. The chutes *p* are also constructed in two ring elements with separate chute-pieces p^3, formed with studs and riveted in the ring elements in the same way. (See Fig. 7.) The attaching-ring *q*, by which the chutes are secured in place, also constitutes one of the ring elements of the chutes. The other is designated by reference character *q'*.

It is to be noted that the buckets have concave faces on which the steam takes effect adapted to give direct reverse action of the steam escaping and taking effect on the successive buckets, and that the faces have the same radial width as the radial width of the bucket-rings, and the backs have reverse forms, dimensions, and relative positions respecting the succeeding buckets, providing uniform passages through the bucket-rings, which maintain uniform flow with the least resistance, while there is open passage from the buckets of one ring into the buckets of the next ring, and when the edges of the buckets of the respective rings pass each other they cut off closely by reason of their full width on the face, and thus effectually prevent waste of steam by blowing through at the moment of not taking steam effectually on the face.

In Figs. 3 and 4 a single unit engine for running one way only and arranged to take the steam from the outer circumference and discharge it centrally is represented. A single bucket-carrying disk c^2 is used with external chutes p^2, preferably in two opposite series, only partly surrounding the bucket-rings, said disk being similarly mounted on a shaft A by means of a flanged hub *a b*, said shaft being mounted in similar hubs *o*, centrally fitted in the disks *f'* and f^2 of the case. Like rings of buckets r^2 and s^2 are attached to the disk c^2 and the case-cover f^2, respectively, with the buckets widened inward instead of outward for lateral expansion of steam, and an interior series of laterally-deflecting chutes s^3 receive the escaping steam, so as to have

reactionary effect to some extent on the last series of buckets. r^2 and direct it to the exhaust. The rotating bucket-rings being thus carried by a disk that is independent of the case-disks and inclosed by the case avoids a working joint between the stationary and rotating sides of the case, as where the rotating disks are carried by a rotating cover-disk of the case, thus avoiding a large measure of friction.

Owing to the increasing lateral breadth of the buckets in direction of the escaping steam lateral leakage of steam between the rings is less than without such increase, because the outward flow passes said joints with less lateral pressure.

Instead of using the ring elements in the application of the buckets they may be applied directly between the disk *c* and cover-disk *f* by inserting their studs 3^a in holes of the disk and cover and riveting them therein, as shown in Fig. 8.

The bucket-studs may be reinforced with enlarged shoulders, as 3^b, Fig. 9, to engage corresponding sockets 3^c of the ring elements 2 for greater support against the lateral stresses due to the action of the steam and centrifugal force with the rest of the smaller size adapted for inserting and riveting in the holes of the ring elements, as shown in Fig. 2, or these smaller parts of the studs may be omitted and countersunk screws, as 4^a, may be substituted for securing the buckets and rings, and these screws may be inserted eccentrically to the studs for protection against shifting of the buckets by centrifugal action.

What I claim as my invention is—

1. In a duplex steam-turbine, the combination of a rotatory shaft, a hub thereon carrying two rotatory disks side by side, a plurality of bucket-carrying rings connected to each disk in concentric series, a stationary disk having coacting and reversely-operating bucket-rings to each rotating disk, said stationary disks forming sides of the inclosing case respectively, a central annular chute-ring delivering the steam outwardly to each of the bucket systems, and means for directing the steam through either system at will.

2. In a duplex steam-turbine, the combination of a rotatory shaft, a hub thereon carrying two rotating disks side by side, a plurality of bucket-carrying rings connected to each disk in concentric series, a stationary disk having coacting reversely-operating bucket-rings to each rotating disk, said rotatory and stationary disks diverging from each other outwardly, and the bucket-rings correspondingly divergent, and said stationary disks forming sides of the case respectively, a central annular chute-ring delivering the steam outwardly to each of the bucket systems, and means for directing the steam through either system at will.

3. In a steam-turbine, the combination of a steam-distributing chute-ring, a plurality of concentric impelling bucket-rings arranged in series and successively taking steam reversely, carrying-disks for said bucket-rings, a rotatory shaft carrying one of said disks, and a series of concentric laterally-directing chutes for the steam escaping from the terminal series of bucket-rings.

4. In a steam-turbine, the combination of concentric bucket-rings, a rotatory shaft, means for application of the steam to the buckets, for applying rotatory motion to said shaft, said bucket-rings comprising two ring members of equal diameter and separately-constructed buckets secured to said ring members intermediately and connecting them in parallel relation to each other, said connections consisting of studs of the buckets secured in perforations of the ring members, and means to prevent displacement of the buckets by centrifugal action, consisting of the bucket studs and sockets of the ring members and the eccentrically-fitted tap-screws.

Signed at New York this 20th day of January, 1903.

PER F. HOLMGREN.

Witnesses:
C. SEDGWICK,
A. P. THAYER.