No. 733,119. PATENTED JULY 7, 1903.

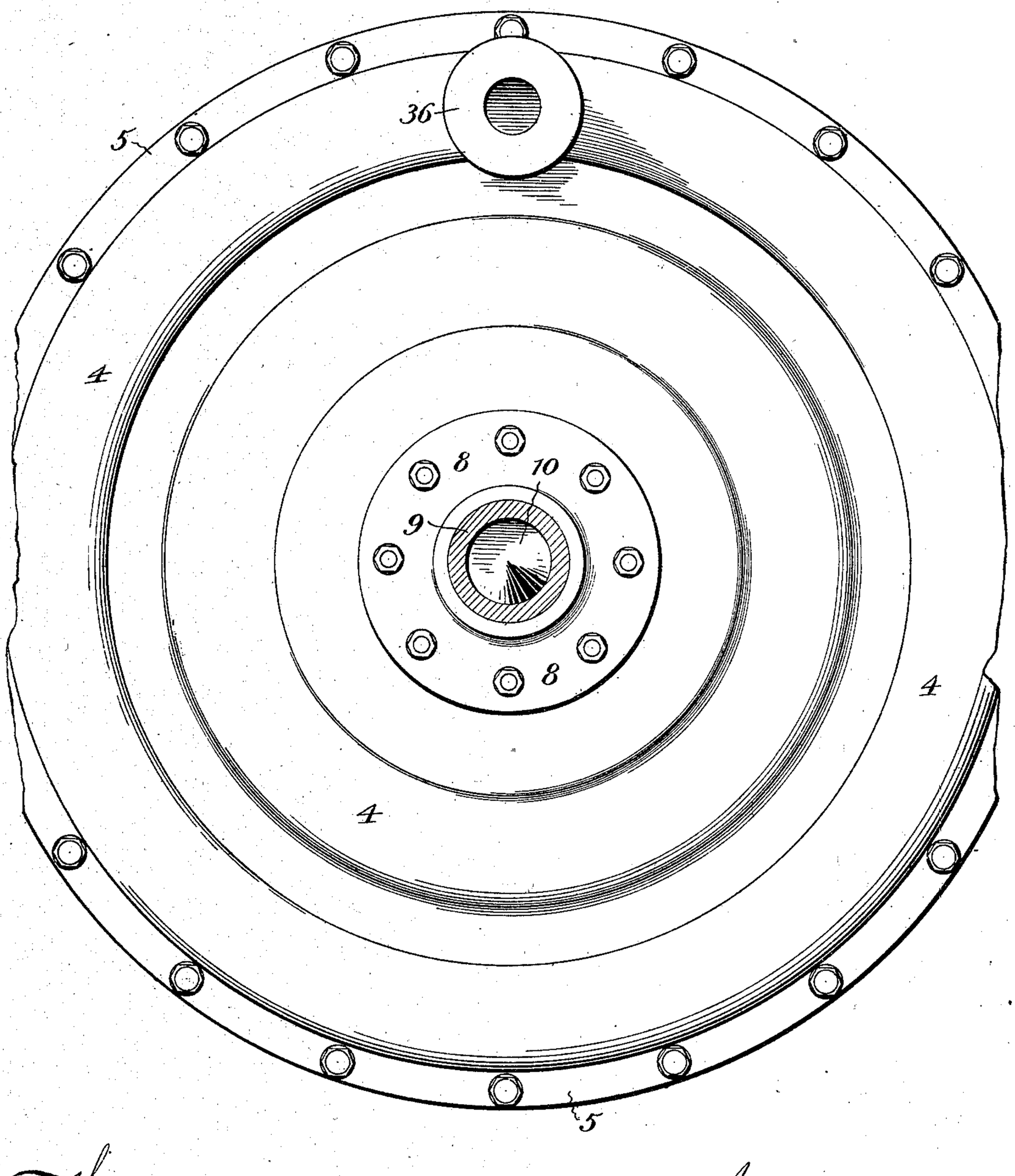
D. F. ASBURY.

STEAM TURBINE.

APPLICATION FILED NOV. 29, 1902.

NO MODEL. 7 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
Jas. E. Hutchinson.
J. B. Keller

Inventor.
Dorsey F. Asbury,
By James L. Norris.
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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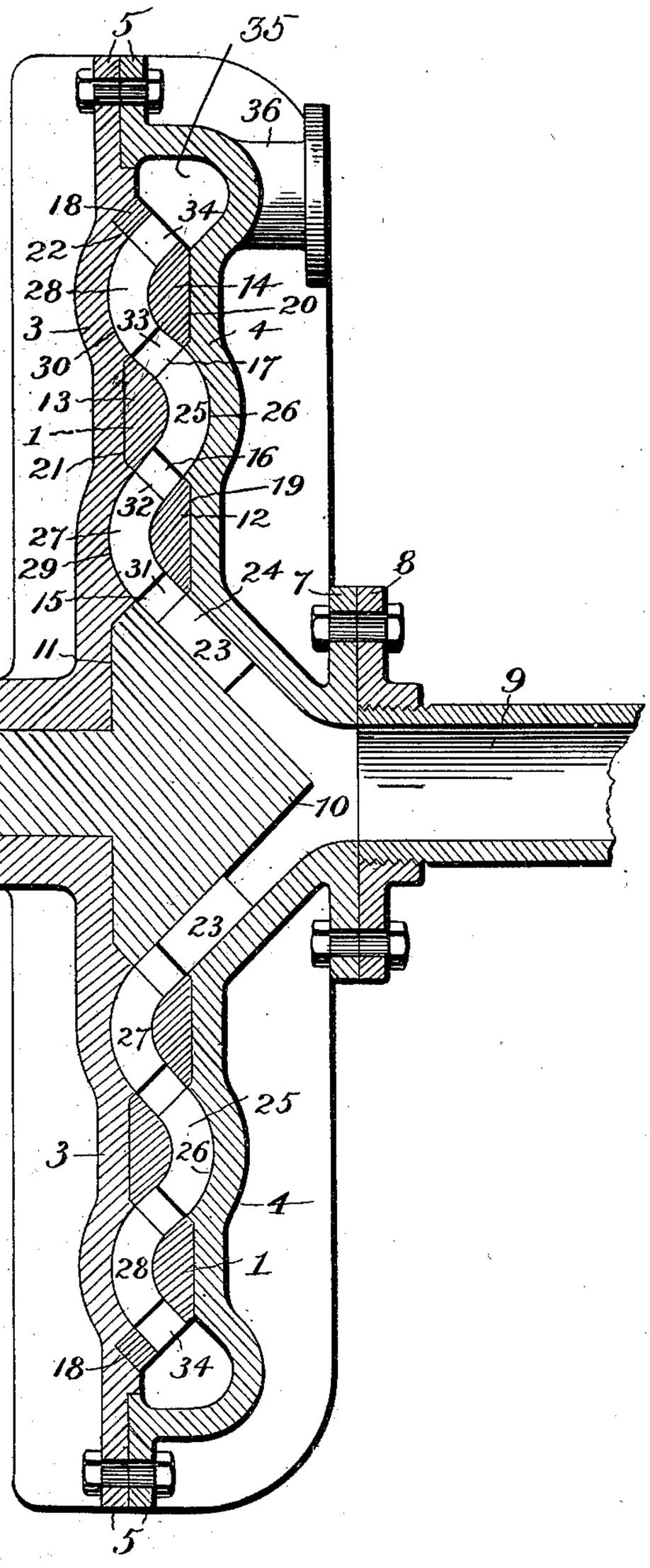
NO MODEL. 7 SHEETS—SHEET 2.

Fig. 2.



Witnesses:
Jas. E. Hutchinson
J. B. Keedy

Inventor.
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By James L. Norris.
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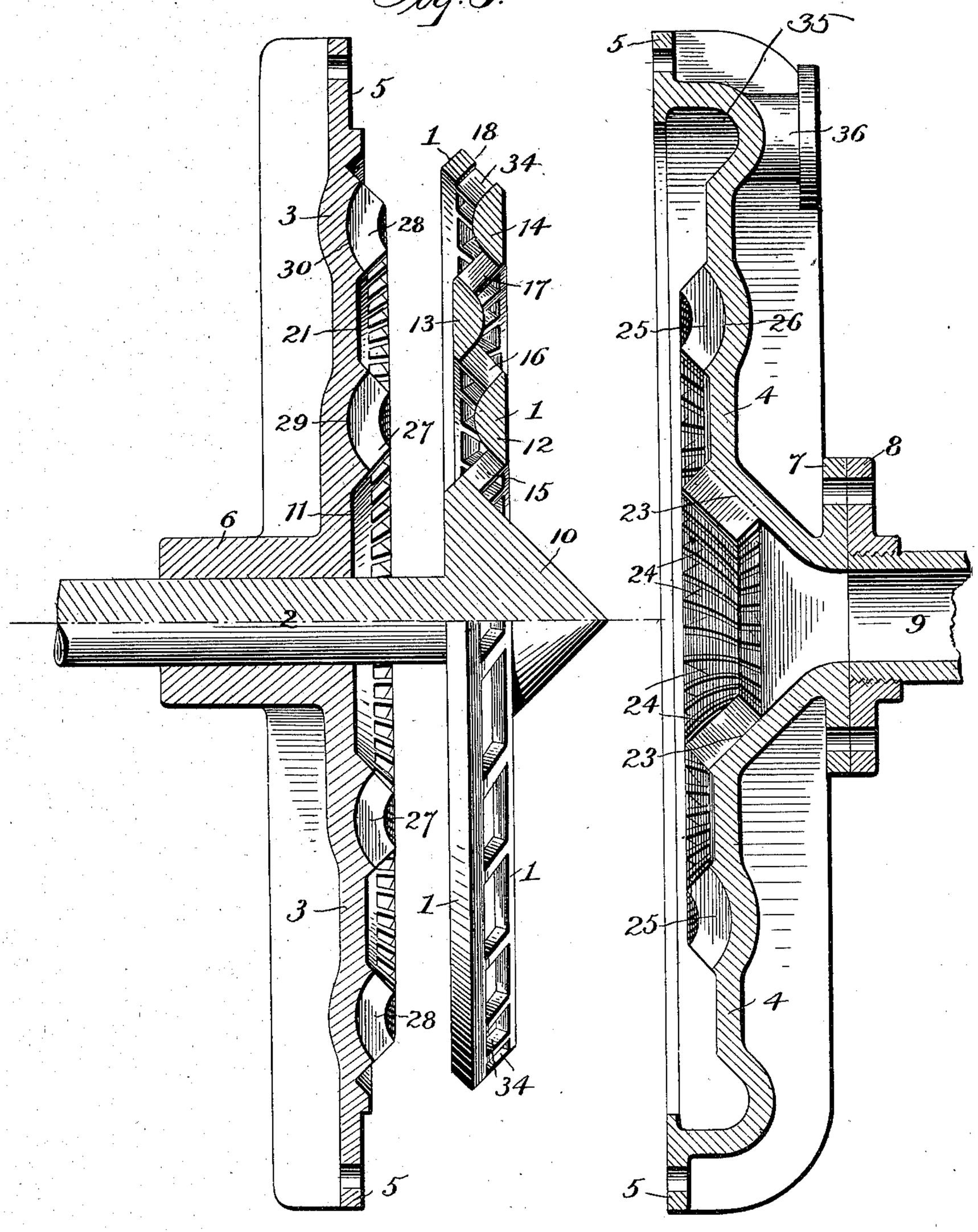
NO MODEL. 7 SHEETS—SHEET 3.

Fig. 3.



Witnesses:
Jas. E. Hutchinson
J. B. Kelly

Inventor
Dorsey F. Asbury
By James L. Norris.
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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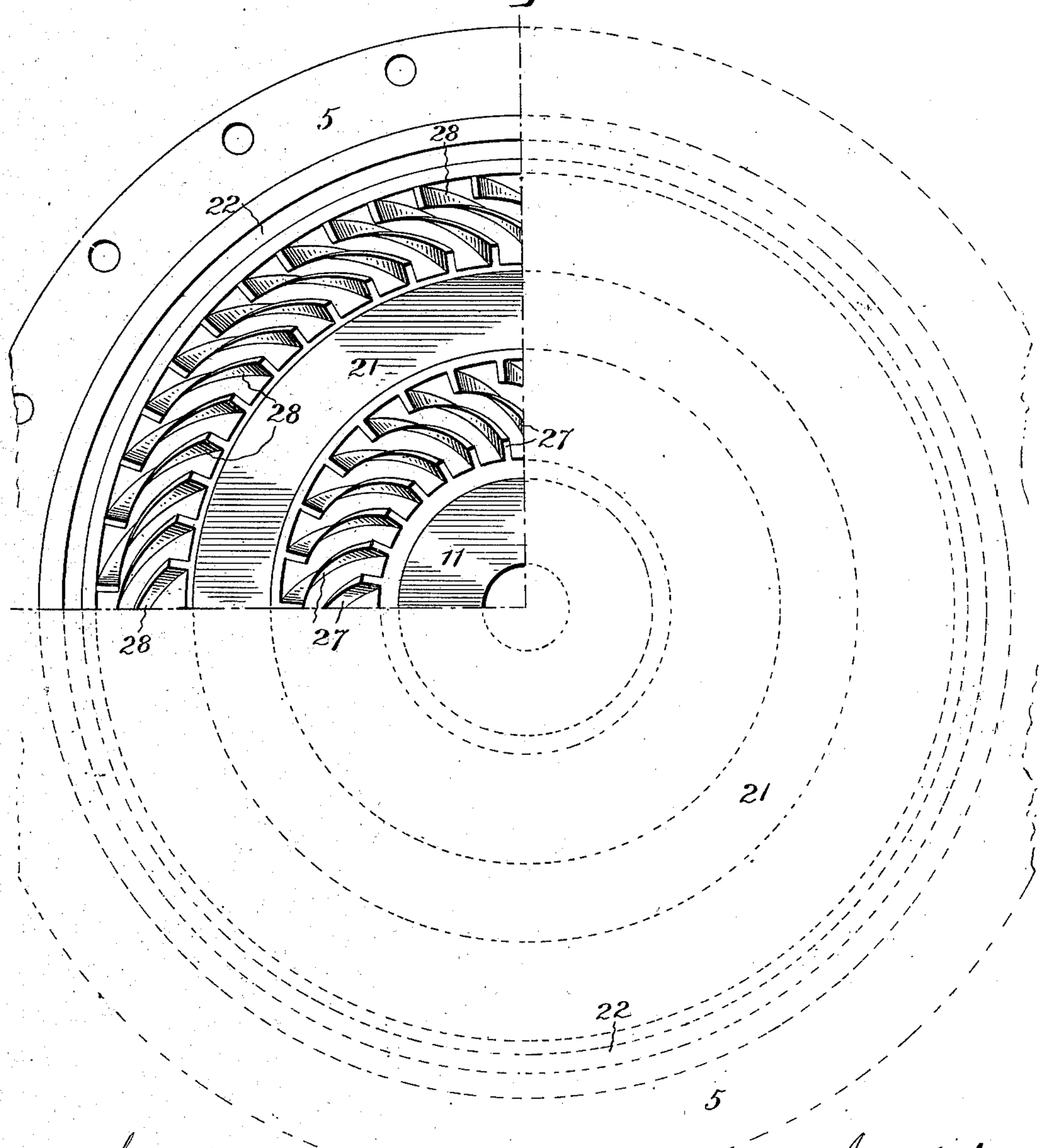
NO MODEL. 7 SHEETS—SHEET 4.

Fig. 4.



Witnesses:
Jas. E. Hutchinson.
J. B. Keeler

Inventor.
Dorsey F. Asbury.
By James L. Norris.
Atty

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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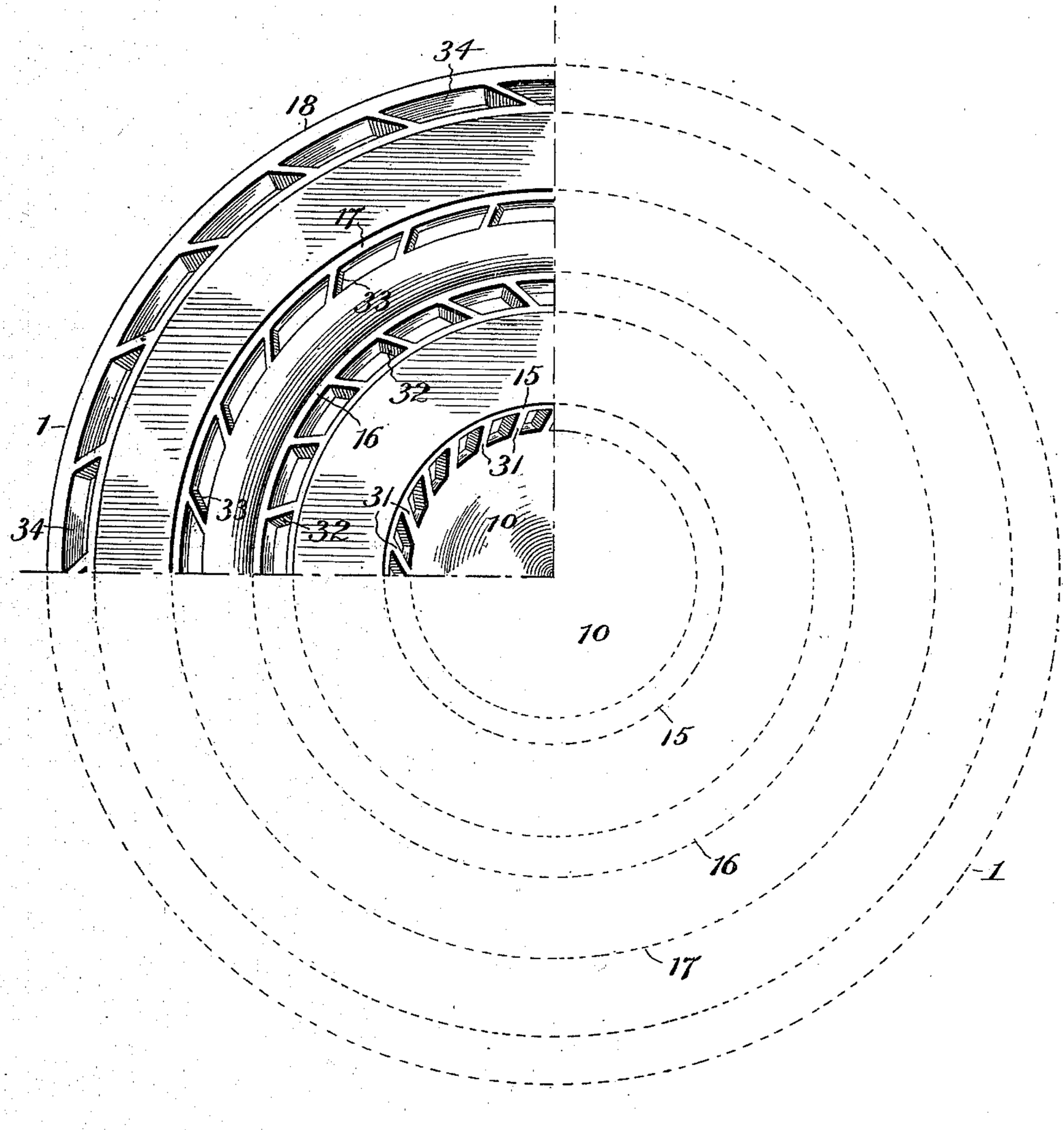
NO MODEL. 7 SHEETS—SHEET 5.

Fig. 5.



Witnesses:
Jas. E. Hutchinson.
H. B. Keelor

Inventor.
Dorsey F. Asbury
By James L. Norris.
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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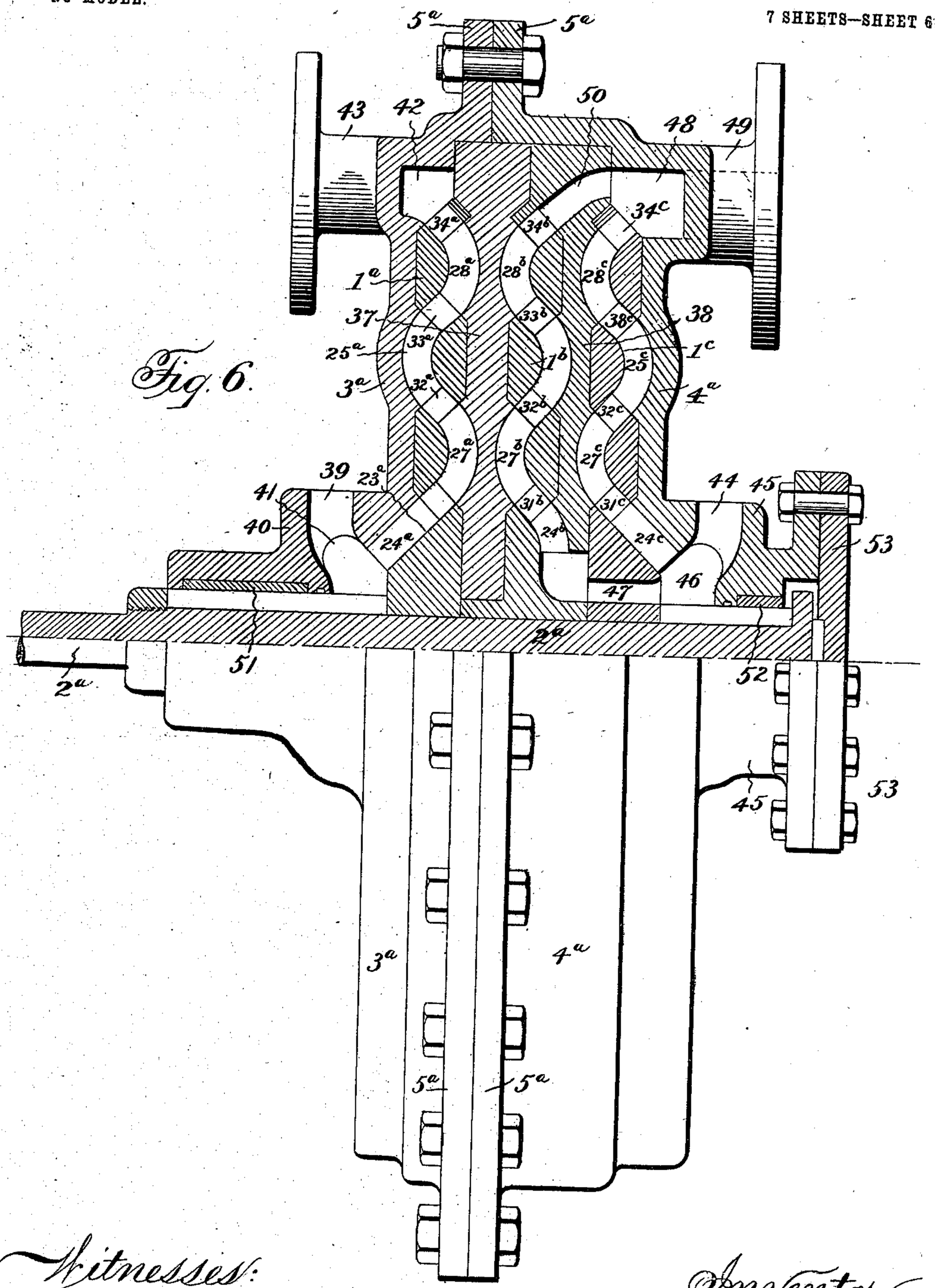
APPLICATION FILED NOV. 29, 1902.

NO MODEL. 7 SHEETS—SHEET 6.

Fig. 6.



Witnesses:
Jas. E. Hutchinson
W. B. Keeler

Inventor.
Dorsey F. Asbury
By James L. Norris.
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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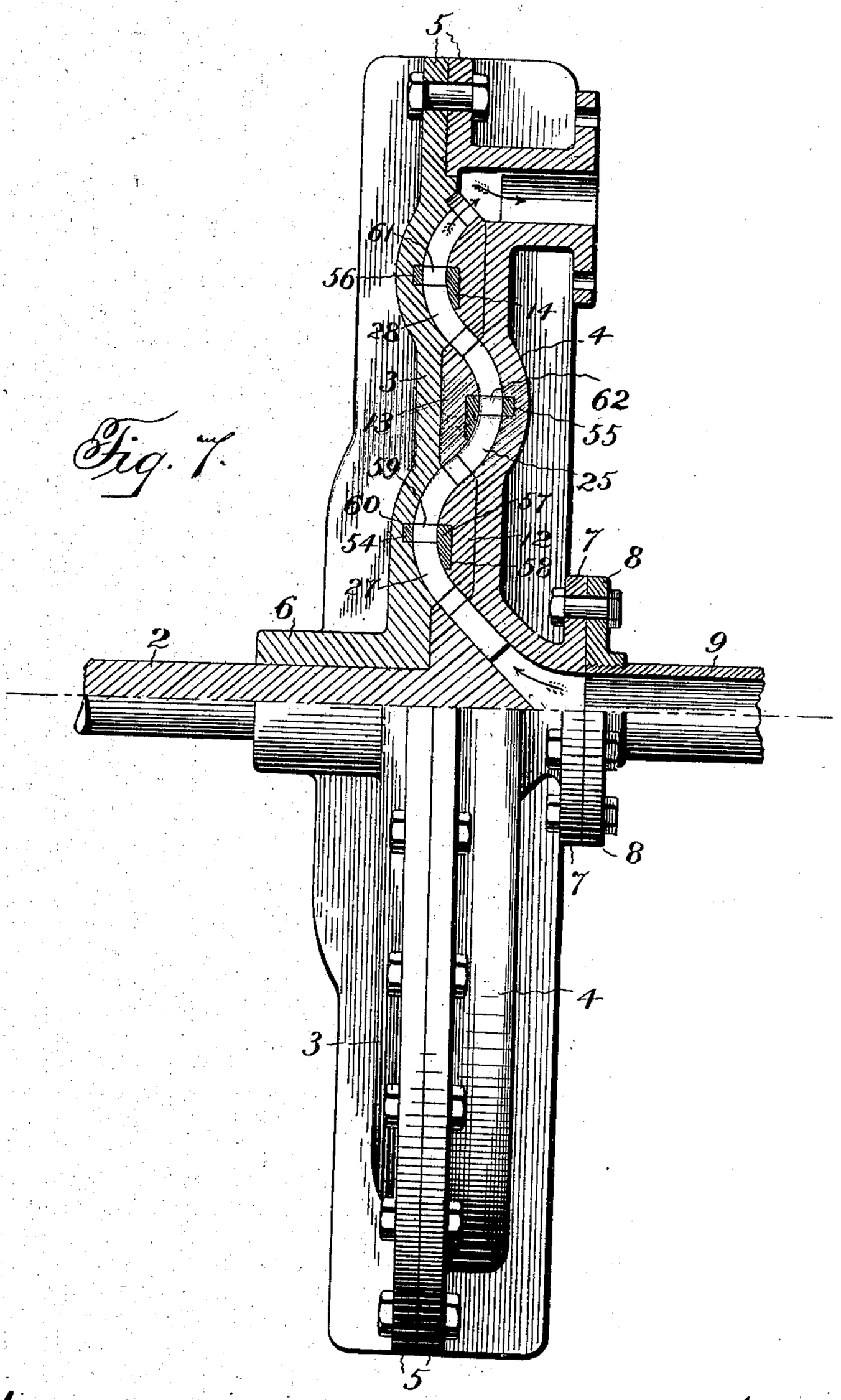
APPLICATION FILED NOV. 29, 1902.

NO MODEL. 7 SHEETS—SHEET 7.

Fig. 7.



Witnesses.
Jas. E. Hutchinson.
J. B. Keely

Inventor.
Dorsey F. Asbury.
By James L. Norris.
Atty.

THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D. C.

No. 733,119. Patented July 7, 1903.

UNITED STATES PATENT OFFICE.

DORSEY F. ASBURY, OF NEWPORT NEWS, VIRGINIA.

STEAM-TURBINE.

SPECIFICATION forming part of Letters Patent No. 733,119, dated July 7, 1903.

Application filed November 29, 1902. Serial No. 133,255. (No model.)

To all whom it may concern:

Be it known that I, DORSEY F. ASBURY, a citizen of the United States, residing at Newport News, in the county of Warwick and State of Virginia, have invented new and useful Improvements in Steam-Turbines, of which the following is a specification.

My invention relates to steam-turbines, the object of the same being to simplify and otherwise improve the construction of this class of devices whereby increased efficiency is obtained.

A further object of the invention is to provide a steam-turbine which is made of but few parts and is consequently less complicated and easier to build and operate.

A further object of the invention is to provide a turbine of such construction that each part is easily accessible and may readily have a tool or machine applied thereto for the purpose of grinding or shaping the same, whereby the cost of manufacture is greatly reduced.

Other objects and advantages of the invention will hereinafter appear and that which I regard as new will be set forth in the claims.

In the drawings forming part of this specification, Figure 1 is an elevation of a turbine constructed in accordance with my invention. Fig. 2 is a vertical central section of the same, taken longitudinally of the shaft. Fig. 3 is a similar view showing the different parts of the turbine separated from each other. Fig. 4 is an elevation showing the inner surface of one part of the casing. Fig. 5 is a side elevation of the rotary disk. Fig. 6 is a section similar to Fig. 2, showing a modified construction; and Fig. 7 is a sectional view similar to Fig. 2, showing a modified construction.

Like numerals indicate like parts in the different views.

In carrying out my invention I employ a rotary disk 1, secured to or formed integral with a shaft 2 and mounted within a casing made up of the two parts 3 and 4. The two parts of the casing are provided with the flanges 5 5, which abut against each other and provide means for securing the same together. The part 3 of the casing is also provided with a bearing sleeve or boss 6, through which the shaft 2 extends and in which said shaft is mounted to be turned. Suitable packing may be provided between the shaft 2 and the bearing-sleeve 6. The part 4 of the casing is also provided with an outwardly-extending flange 7 for connection therewith of a similarly-shaped flange 8 on the supply-pipe 9. The said supply-pipe has been shown as located in line with the shaft 2; but it is obvious that the same may be otherwise disposed, if desired, the only essential being that it shall communicate with the casing at the center thereof. The end of the shaft 2 adjacent to the point of connection of the supply-pipe 9 with the casing is formed with a cone-shaped head 10, and the disk 1, above referred to, extends outwardly from said head. The inner surface of the part 3 of the casing opposite the bearing-sleeve 6 is formed with a recess 11, in which the inner end or shouldered portion of the head 10 of the shaft 2 fits.

The disk 1 is made up of a series of annular concentric rings or imperforate portions 12, 13, and 14, which are connected to each other and to the head 10 of the shaft 2 by the angularly-arranged webs 15, 16, 17, and 18—that is to say, the ring or imperforate portion 12 is connected to the head 10 of the shaft 2 by the angularly-arranged web 15. The ring 12 is connected to the ring 13 by the angularly-arranged web 16. The ring 13 is connected to the ring 14 by the angularly-arranged web 17, and the ring 14 has leading outwardly from the periphery thereof the angularly-arranged web 18. These webs are all integral with the parts to which they are connected, and by the arrangement of the same, as described, it will be seen that the general shape of the disk 1 is zigzag in cross-section. The webs 15 and 17 are parallel to each other, and the webs 16 and 18 are parallel to each other; but the webs 15 and 17 are set at an angle to the webs 16 and 18. The outer faces of the rings or imperforate portions 12 and 14 of the disk 1 lie and move in close contact with the inner surface of the part 4 of the casing, the same fitting, respectively, in recesses 19 and 20, formed in said part 4. Similarly the outer face of the ring or imperforate portion 13 of the disk 1 and the outer end of the web 18 of the disk 1 lie and move in close contact with the inner surface of the part 3 of the casing, the same fitting, respectively, in the recesses 21 and 22, formed in said part 3. Formed in the part 4 of the casing adja-

cent to the center thereof opposite the head 10 of the shaft 2 and communicating with the supply-pipe 9 is an annular chamber 23, having a series of guide-vanes 24 therein. The said guide-vanes are curved in shape, the same extending from the inner end of the chamber 23 outwardly at an angle to the radii of the disk 1 and in the direction which it is desired the disk 1 shall be rotated. Between the recesses 19 and 20 in the part 4 of the casing the inner surface of said part is provided with a series of guide-vanes 25, the same being located opposite the ring or imperforate portion 13 of the disk 1, being curved in form and extending in substantially the same direction as the guide-vanes 24. The opposite side edges of the vanes 25 are substantially parallel to the curved inner surface of the ring or imperforate portion 13, for which purpose the inner surface of the part 4 of the casing is dished or recessed, as shown at 26. Similarly-arranged guide-vanes 27 and 28 are formed in the inner surface of the part 3 of the casing. The vanes 27 are located between the webs 15 and 16 on the disk 1, are curved in shape, and extend outwardly at an angle to the radii of the disk 1 and in substantially the same direction in which it is desired to rotate said disk. The vanes 28 are similar in shape and arrangement to the guide-vanes 27, but are located between the webs 17 and 18 on the disk 1. The guide-vanes 27 and 28 are located opposite the rings or imperforate portions 12 and 14 of the disk 1, and the side edges of the same are substantially parallel to the curved surfaces of said rings. For this purpose the part 3 of the casing is dished out or recessed, as shown at 29 and 30. It will be noted that the guide-vanes 27 and 28 are located on one side of the disk 1, whereas the guide-vanes 24 and 25 are located on the opposite side thereof. Coöperating with the guide-vanes 24, 27, 25, and 28 are the concentric series of impact-blades 31, 32, 33, and 34 on the disk 1. The blades 31 are formed in the web 15, which connects the ring or imperforate portion 12 of the disk with the head 10 of the shaft 2. The said blades are set at substantially right angles to the vanes 24 in the part 4 of the casing, so that the steam or other fluid under pressure passing between the said blades 24 may act directly upon the blades 31 for the purpose of rotating the disk 1 and the shaft 2, connected therewith. The blades 32 are formed in the web 16 of the disk 1 and are located at substantially right angles to the guide-vanes 27 in the part 3 of the casing. Said blades 32 are, however, set at an angle to the blades 31, this construction being necessary by reason of the fact that the vanes 24 and 27, through which the steam passes directly to said blades, are located on opposite sides of the disk 1. The blades 33 are formed in the web 17 of the disk 1 and are set at substantially right angles to the guide-vanes 25 in the part 4 of the casing. Said blades 33 lie at an angle to the blades 32, but are substantially parallel to the blades 31. The blades 34 are formed in the web 18 on the disk 1 and are set at substantially right angles to the guide-vanes 28 in the part 3 of the casing. Said blades 34 lie at an angle to the blades 33 and 31, but are substantially parallel to the blades 32.

Outside the annular angularly-arranged web 18 on the periphery of the disk 1 an annular recess or chamber 35 is formed within the casing in which the disk 1 is mounted. The said chamber receives the steam which is finally discharged through the blades 34 and has a suitable exhaust pipe or conduit 36 leading therefrom.

Constructed as above described the operation of my improved turbine is as follows: Steam being admitted through the supply-pipe 9 passes into the annular angularly-arranged chamber 23 at the center of the casing and by the guide-vanes 24 therein is deflected outwardly through all the passages between said vanes at an angle to the radii of the disk 1, so as to impart a circular movement thereto. On reaching the blades 31, which are set at right angles to the guide-vanes 24, the steam acts by direct impact thereon so as to cause a rotary movement to be imparted to the disk 1 in the direction of travel of the steam between the vanes 24. After acting upon the blades 31 the steam passes through the same to the opposite side of the disk 1 into the spaces between the guide-vanes 27. Here the steam expands and increases in volume and has a gyratory movement imparted to it by the vanes 27. Passing from between the vanes 27 the steam acts upon the blades 32, formed in the web 16 of the disk 1, and as said blades are set at substantially right angles to the vanes 27 the steam acts to impart a rotary movement to the disk 1 in the same direction as that imparted by the action of the steam on the blades 31. In a similar manner the steam passes through the guide-vanes 25, acting upon the blades 33, and through the guide-vanes 28, acting upon the blades 34, until it is finally discharged into the annular chamber 35, whence it is exhausted through the pipe or conduit 36. After acting upon each set of impact-blades on the disk 1 the steam is permitted to more fully expand before it acts upon the next adjacent set of blades. As a result a very high degree of efficiency is obtained, as the action of the steam upon each set of impact-blades serves to rotate the disk 1 and the shaft 2, to which the same is connected, in the same direction.

While the steam acts by impact upon the blades 31, 32, 33, and 34, a pushing effect as distinguished from a striking effect is obtained when the disk 1 is rotating at a regular speed. When the speed of rotation of the disk 1, however, falls below the velocity of the steam entering through the supply-pipe 9, a combined pushing and striking effect is obtained.

As will be observed, my improved device is constructed of the lowest possible number of parts. It is therefore much less complicated and more easy to build and operate than any of the devices of a similar nature which have preceded mine.

In manufacturing the device each part is readily accessible, and there are no portions of the apparatus to which a tool or machine may not be easily applied. The blades 31, 32, 33, and 34 may be produced by operating from either side of the disk, and the guide-vanes 24, 27, 25, and 28 may all be made with an ordinary milling-machine. The remaining portions of the turbine may all be produced by straightforward lathework and the device as a whole may be constructed at a lower cost per horse-power than any other small turbine. The steam from the inlet-pipe 9 is very directly applied to the operative parts of the device, and thereby the steam is able to acquire a great velocity before coming in contact with the blades 31. No one part of the turbine is subjected to more than one temperature, and each part of the machine is always maintained at a constant temperature and pressure. By this arrangement I avoid the great loss of power which is due to condensation when the steam is brought in contact with a mass of cold metal. An important feature of the machine is a regular expansion of the steam. As the same moves outwardly, the temperature and pressure lower, whereas the volume increases directly and steadily.

In the turbine above described I contemplate the use of but a single rotary disk 1, secured to or formed integral with the power-shaft. It is obvious, however, that two or more of such disks may be secured to the power-shaft, to which steam may be admitted either through separate conduits from the steam-generator or other source of supply, or the exhaust from one of said disks may be utilized upon the other or others, thus producing a compound turbine. I have illustrated one form of such a turbine, the same consisting of a casing made up of the parts 3^a and 4^a, suitably secured together by bolts or other fastening devices extending through the flanges 5^a, rotary disks 1^a, 1^b, and 1^c, mounted in said casing, and a shaft 2^a, to which said disks are secured. Within the casing are secured two diaphragms or partitions 37 and 38 substantially parallel to the sides of the parts 3^a and 4^a of said casing. The disk 1^a is mounted for rotation between the part 3^a of the casing and the diaphragm or partition 37 therein, the disk 1^b is mounted for rotation between the diaphragms or partitions 37 and 38, and the disk 1^c is mounted for rotation between the diaphragm or partition 38 and the part 4^a of the casing. The space between the part 3^a of the casing and the partition 37 constitutes what may be termed a "high-pressure" chamber, and the space between the partition 37 and the part 4^a of the casing constitutes what may be termed a "low-pressure" chamber. A steam-inlet port 39 leads inwardly through the neck 40 on the part 3^a of the casing to an annular chamber 41, surrounding the shaft 2^a. This chamber 41 communicates with an annular cone-shaped or angularly-arranged chamber 23^a at the inner end of the part 3^a of the casing, which chamber 23^a is similar to the chamber 23 in the form of my invention above described and is provided with vanes 24^a, similar to the vanes 24. The partition 37 is provided with the two annular series of guide-vanes 27^a and 28^a, both located on the same side of the disk 1^a, the said series of vanes being concentrically arranged and similar to the vanes 27 and 28, heretofore referred to, the only difference being that they are located on the opposite side of the disk with which they coöperate to that of the vanes 27 and 28. Likewise the part 3^a of the casing is formed with an annular series of guide-vanes 25^a, located on the opposite side of the disk 1^a to that of the vanes 27^a and 28^a, as shown. The vanes 25^a are similar in all respects to the vanes 25, heretofore referred to, except that they are located on the left side of the disk with which they coöperate instead of on the right side. The disk 1^a is provided with four concentric series of impact-blades 31^a, 32^a, 33^a, and 34^a, similar in all respects to the blades 31, 32, 33, and 34, heretofore referred to, except that they are oppositely disposed, so as to coöperate with the guide-vanes 24^a, 27^a, 25^a, and 28^a. Adjacent to the periphery of the part 3^a of the casing the same is formed with a recess 42, forming an annular chamber into which the steam discharges, the said chamber having communicating therewith a pipe 43, through which the steam may exhaust. The diaphragm or partition 38 is provided with guide-vanes 24^b and 25^b, similar in all respects to the guide-vanes 24 and 25. The diaphragm 37 is provided with guide-vanes 27^b and 28^b, similar to the guide-vanes 27 and 28, and the disk 1^b is provided with impact-blades 31^b, 32^b, 33^b, and 34^b, similar in all respects to the blades 31, 32, 33, and 34 on the disk 1. The part 4^a of the casing is provided with the guide-vanes 24^c and 25^c, similar in all respects to the guide-vanes 24 and 25. The diaphragm or partition 38 is provided with the guide-vanes 27^c and 28^c, similar in all respects to the guide-vanes 27 and 28, and the disk 1^c is provided with impact-blades 31^c, 32^c, 33^c, and 34^c, similar in all respects to the blades 31, 32, 33, and 34. The steam-inlet port 44 for the low-pressure chamber leads in through the sleeve or boss 45 on the part 4^a of the casing to an annular chamber 46, surrounding the shaft 2^a. This chamber 46 communicates directly with the spaces between the guide-vanes 24^c and communicates through the port 47 with the space between the guide-vanes 24^b. Adjacent to its periphery the part 4^a of the casing is provided with an annular recess 48, forming an annular chamber

into which the steam which has passed through the low-pressure chamber may be discharged. Leading from the annular chamber 48 is an exhaust-pipe 49. The outer edge of the diaphragm 38 is provided with the curved ports 50 for establishing communication between the spaces between blades 34^b and the annular chamber 48. The shaft 2^a is mounted in bearings in the bearing-sleeves or tubular extensions formed on the parts 3^a and 4^a, suitable packing-rings 51 and 52 being interposed between these parts. A suitable thrust-bearing is also provided between the shaft 2^a and the head or plate 53, secured to the flanged end of the part 4^a of the casing. The operation of this form of my invention is similar to that above described and requires no detailed description. It is sufficient to say that steam is admitted through the inlet-ports 39 and 44 to the operative parts of the device and is exhausted through the pipes 43 and 49, respectively. These inlet-ports 39 and 44 may be separately connected to the steam generator or boiler, or the inlet-port 44 of the low-pressure chamber may be connected with the exhaust-pipe 43 of the high-pressure chamber.

While I have described the disk 1 and the disks 1^a, 1^b, and 1^c as being mounted for rotation within a fixed casing, it is obvious that without departure from my invention the disk or disks may be stationary and the casing in which the same are mounted may be rotatable about said disk or disks. In this connection I desire to state that however carefully the disk 1 of my improved turbine may be manufactured it will be impossible on account of the unevenness of the material of which the same is made to get the center of gravity of the disk to correspond exactly with its geometrical axis of rotation; furthermore, however small the difference may be it becomes very noticeable when running at high speeds. To overcome this unevenness in the disk, I propose to remove a portion of the material on the heavy side thereof by drilling into the rings 12, 13, and 14 at the proper points.

I have described the rotary disk or disks forming part of my improved turbine as being provided with four angularly-arranged webs 15, 16, and 17, connecting the rings or imperforate portions 12, 13, and 14, the said webs being provided with impact-blades 31, 32, 33, and 34, coöperating with the guide-vanes 24, 27, 25, and 28, respectively. In addition to the webs referred to I may employ supplemental webs 54, 55, and 56, this construction being clearly illustrated in Fig. 7 of the drawings. Each of said supplemental webs is located at the crest of one of the rings 12, 13, and 14 of which the disk 1 is made up, the web 54 being secured to the ring 12, the web 55 to the ring 13, and the web 56 to the ring 14. The web 54 is provided with a base 57, which is seated in a corresponding recess 58 in the ring 12 and bolted or otherwise secured in place. Said web is also provided with an annular series of impact-blades 59, which coöperate with the guide-vanes 27 in the part 3 of the casing. Said guide-vanes 27 are necessarily cut away annularly to provide for the passage of the web 54 between them. The part 3 of the casing is also provided with an annular groove or recess 60, in which the outer or projecting edge of the web 54 fits and moves. The impact-blades 59 in the web 54 are set at an angle to the guide-vanes 27, so that the steam passing between said guide-vanes will act on said blades to rotate the disk 1 in the same direction that it is rotated by the action of the steam on the other blades thereof. The supplemental web 56 is identical in construction with the web 54 and is provided with impact-blades 61, which extend in the same direction as the impact-blades 59. The said blades 61 coöperate with the guide-vanes 28 and are disposed with relation thereto so that the action of the steam thereon will serve to rotate the disk in the same direction that it is rotated by the action of said steam on the remaining blades. The web 55 is similar in construction to the webs 54 and 56, the difference being that the parts thereof are reversed in position, the same being secured to the ring 13 and extending therefrom in the opposite direction to which the webs 54 and 56 extend from the rings 12 and 14, to which they are respectively attached. The impact-blades 62 in the supplemental web 55 coöperate with the guide-vanes 25 and are of course reversed in position to that of the blades 59 and 61. The steam passing through the guide-vanes 25 acts upon the blades 62 to rotate the disk 1 in the same direction that it is rotated by the action of the steam on the remaining blades. It is of course obvious that these supplemental webs and the blades therein may be connected with the disks 1^a, 1^b, and 1^c in the form of my invention illustrated in Fig. 6 of the drawings. The said blades are fitted and secured in place after the apparatus has been otherwise completed and are employed to impart greater efficiency to the turbine.

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

1. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of concentric series of transversely-curved guide-vanes, arranged alternately on opposite sides of said disk and extending at an angle to the radii of said disk, and the said disk having a plurality of concentric series of impact-blades, located respectively at and disposed across the ends of said vanes, as and for the purpose set forth.

2. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing hav-

ing a plurality of annular concentric series of transversely-curved guide-vanes therein, arranged alternately on opposite sides of said disk and extending from their inner ends outwardly and across the radii of said disk, and the said disk having a plurality of annular concentric series of impact-blades, located respectively at the ends of said vanes, disposed across the vanes with which they coöperate, and forming passages through said disk which connect the spaces between the adjacent series of said vanes, as and for the purpose set forth.

3. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of concentric series of guide-vanes, arranged alternately on opposite sides of said disk and extending at an angle to the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions and angularly-arranged webs connecting said rings, the said webs separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they cooperate, as and for the purpose set forth.

4. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of concentric series of guide-vanes, arranged alternately on opposite sides of said disk and extending at an angle to the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions, the alternate ones of which are disposed in different planes and bear against the opposite sides of said casing, and angularly-arranged webs connecting said rings, the said webs separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they coöperate, as and for the purpose set forth.

5. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of annular concentric series of curved guide-vanes therein, arranged alternately on opposite sides of said disk, and extending from their inner ends outwardly and across the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions and angularly-arranged webs connecting said rings, the said webs separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they coöperate and extend entirely through said webs, the spaces between said blades forming passages which connect the spaces between the adjacent series of said vanes, as and for the purpose set forth.

6. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of annular concentric series of curved guide-vanes therein, arranged alternately on opposite sides of said disk, and extending from their inner ends outwardly and across the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions, the alternate ones of which are disposed in different planes and bear against the opposite sides of said casing, and angularly-arranged webs connecting said rings, the said webs separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they coöperate and extend entirely through said webs, the spaces between said blades forming passages which connect the spaces between the adjacent series of said vanes, as and for the purpose set forth.

7. In a steam-turbine, a casing, a rotary disk mounted therein, a shaft secured to said disk, and means for admitting steam to the center of said casing, the said casing having a plurality of concentric series of transversely-curved guide-vanes arranged alternately on opposite sides of said disk, and extending at an angle to the radii of said disk, and the said disk having a plurality of annular concentric series of impact-blades, located respectively at and disposed across the ends of said vanes, as and for the purpose set forth.

8. In a steam-turbine, a casing, a rotary disk mounted therein, a shaft secured to said disk having bearings in said casing and provided with a cone-shaped head at one end, a cone-shaped chamber at the center of said casing surrounding said head, means for admitting steam to said chamber and means for exhausting steam from the periphery of said casing, the said chamber and the remaining portions of the interior of said casing being provided with a plurality of concentric series of guide-vanes, arranged alternately on opposite sides of said disk, and extending at an angle to the radii of said disk, and the said disk having a plurality of annular concentric series of impact-blades, located respectively at and disposed across the ends of said vanes, as and for the purpose set forth.

9. In a steam-turbine, a casing, a partition therein dividing the same into a plurality of chambers or compartments, a plurality of rotary disks mounted in said chambers, a shaft secured to said disks, and means for admitting steam centrally to each of said chambers, each of said chambers having a plurality of concentric series of transversely-curved guide-vanes arranged alternately on opposite sides of the disk therein, and extending at an angle to the radii of said disk, and each of said disks having a plurality of annular concentric series of impact-blades, located respectively

at and disposed across the ends of the vanes with which they coöperate, as and for the purpose set forth.

10. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of concentric series of guide-vanes arranged alternately on opposite sides of said disk and extending at an angle to the radii of said disk, and the said disk having a plurality of concentric series of impact-blades located respectively at and disposed across the ends of said vanes and also having a plurality of supplemental series of impact-blades located respectively at points between the ends of said vanes and disposed across the same.

11. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of annular concentric series of curved guide-vanes therein, arranged alternately on opposite sides of said disk and extending from their inner ends outwardly and across the radii of said disk, and the said disk having a plurality of annular concentric series of impact-blades, located respectively at the ends of said vanes, disposed across the vanes with which they coöperate, and forming passages through said disk which connect the spaces between the adjacent series of said vanes, and the said disk also having a plurality of supplemental series of impact-blades located respectively at points between the ends of said vanes and disposed across the same.

12. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of concentric series of guide-vanes, arranged alternately on opposite sides of said disk and extending at an angle to the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions and angularly-arranged webs connecting said rings, the said webs separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they cooperate, and supplemental webs secured respectively to said rings, extending through and across the adjacent guide-vanes in said casing and provided with impact-blades set at an angle to and coöperating with said guide-vanes.

13. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of concentric series of guide-vanes, arranged alternately on opposite sides of said disk and extending at an angle to the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions, the alternate ones of which are disposed in different planes and bear against the opposite sides of said casing, and angularly-arranged webs connecting said rings, the said rings separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they coöperate, and supplemental webs secured respectively to said rings, extending through and across the adjacent guide-vanes in said casing and provided with impact-blades set at an angle to and coöperating with said guide-vanes.

14. In a steam-turbine, a casing, a disk mounted therein, one of said parts being mounted for rotation, and means for admitting steam to said casing, the said casing having a plurality of annular concentric series of curved guide-vanes therein, arranged alternately on opposite sides of said disk, and extending from their inner ends outwardly and across the radii of said disk, and the said disk comprising a plurality of concentric rings or imperforate portions, and angularly-arranged webs connecting said rings, the said webs separating the adjacent series of said guide-vanes and provided with impact-blades which are disposed across the vanes with which they cooperate and extend entirely through said webs, the spaces between said blades forming passages which connect the spaces between the adjacent series of said vanes, and supplemental webs secured respectively to said rings, extending through and across the adjacent guide-vanes in said casing and provided with impact-blades set at an angle to and coöperating with said guide-vanes.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

DORSEY F. ASBURY.

Witnesses:
GEO. B. EARLY,
N. W. BRYANT.