No. 793,857. PATENTED JULY 4, 1905.

E. C. TERRY.

STEAM TURBINE.

APPLICATION FILED JUNE 25, 1904.

3 SHEETS—SHEET 1.

Fig. 1.

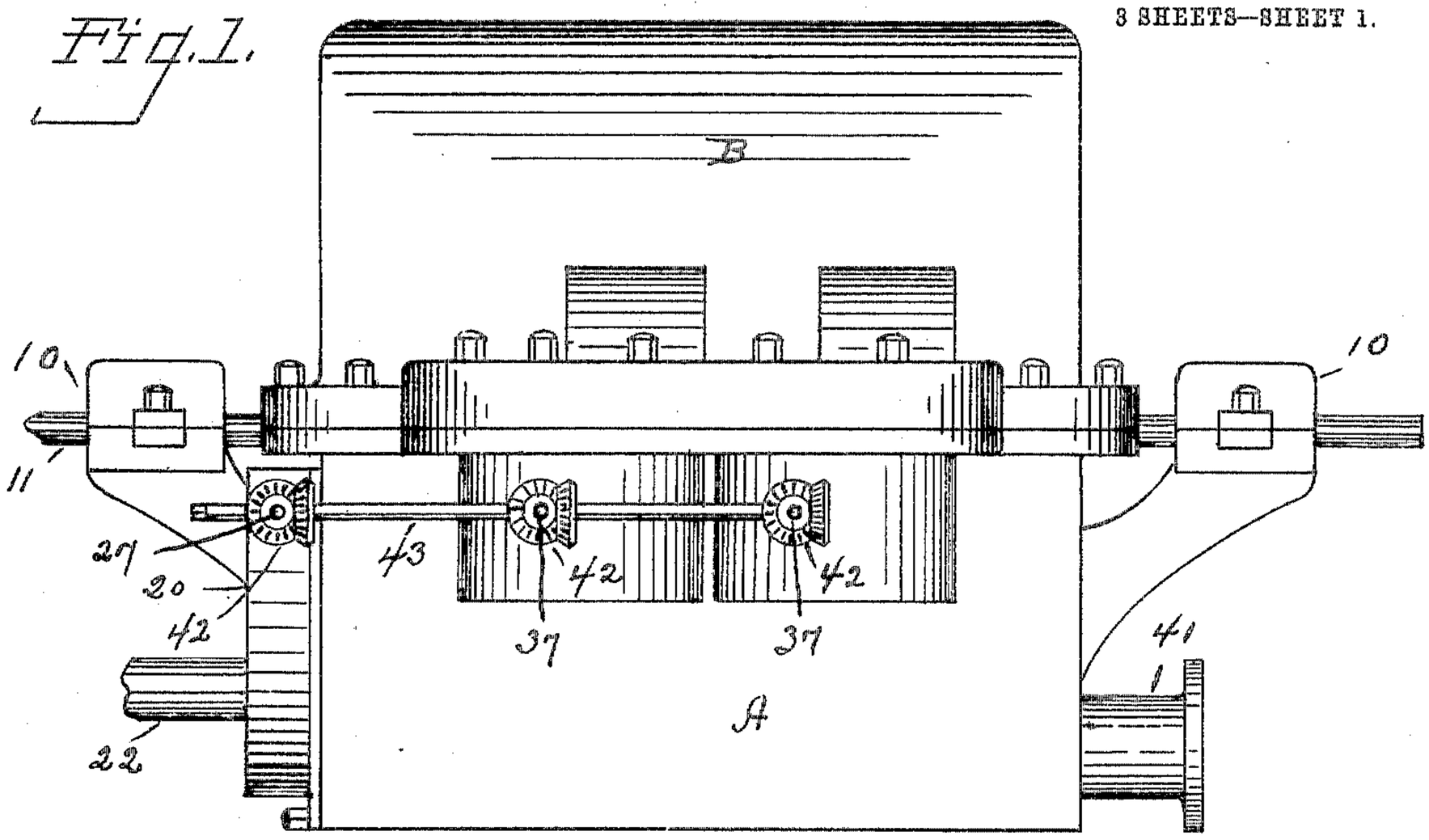
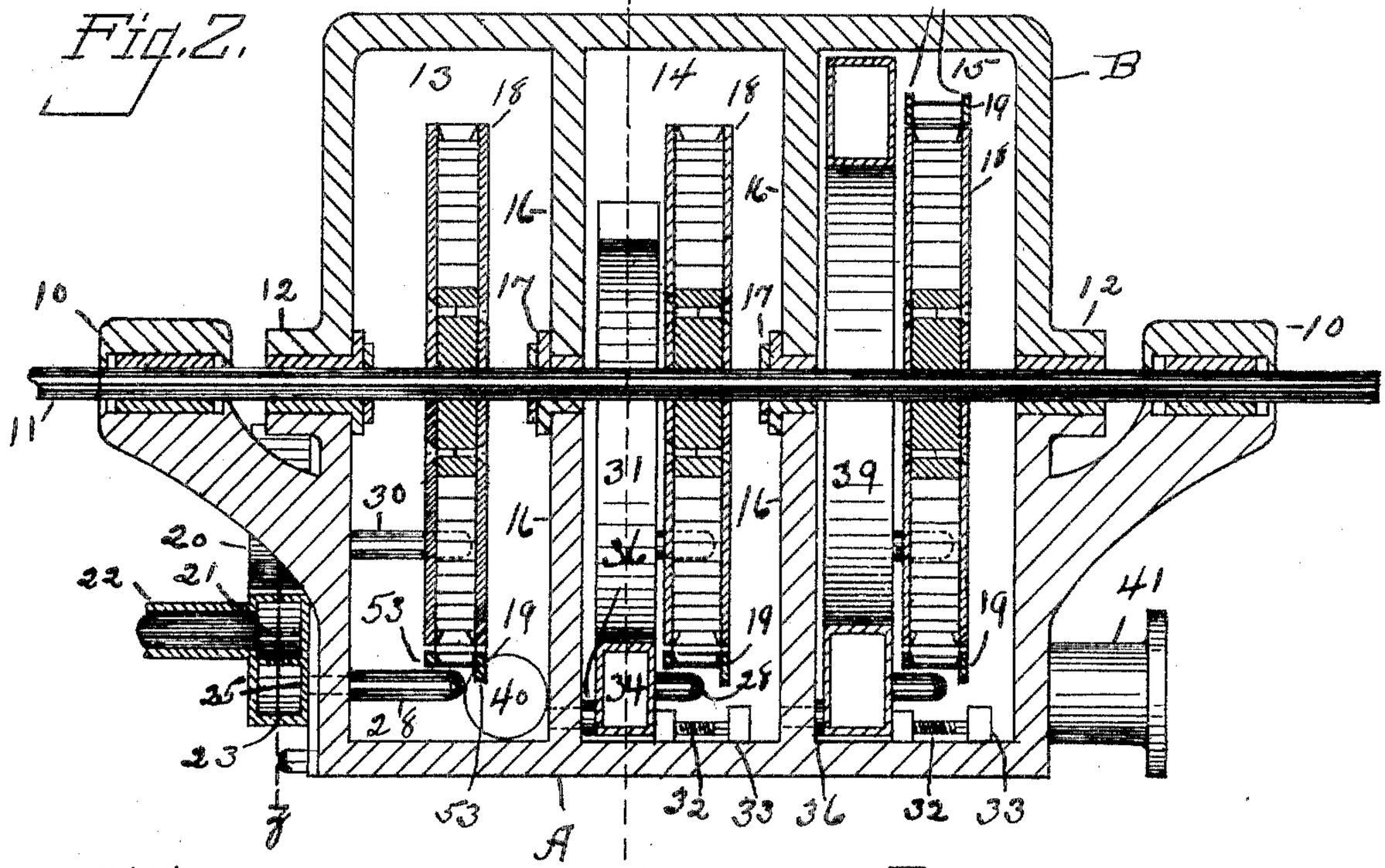


Fig. 2.



Witnesses.

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3 SHEETS—SHEET 2.

Fig. 3.

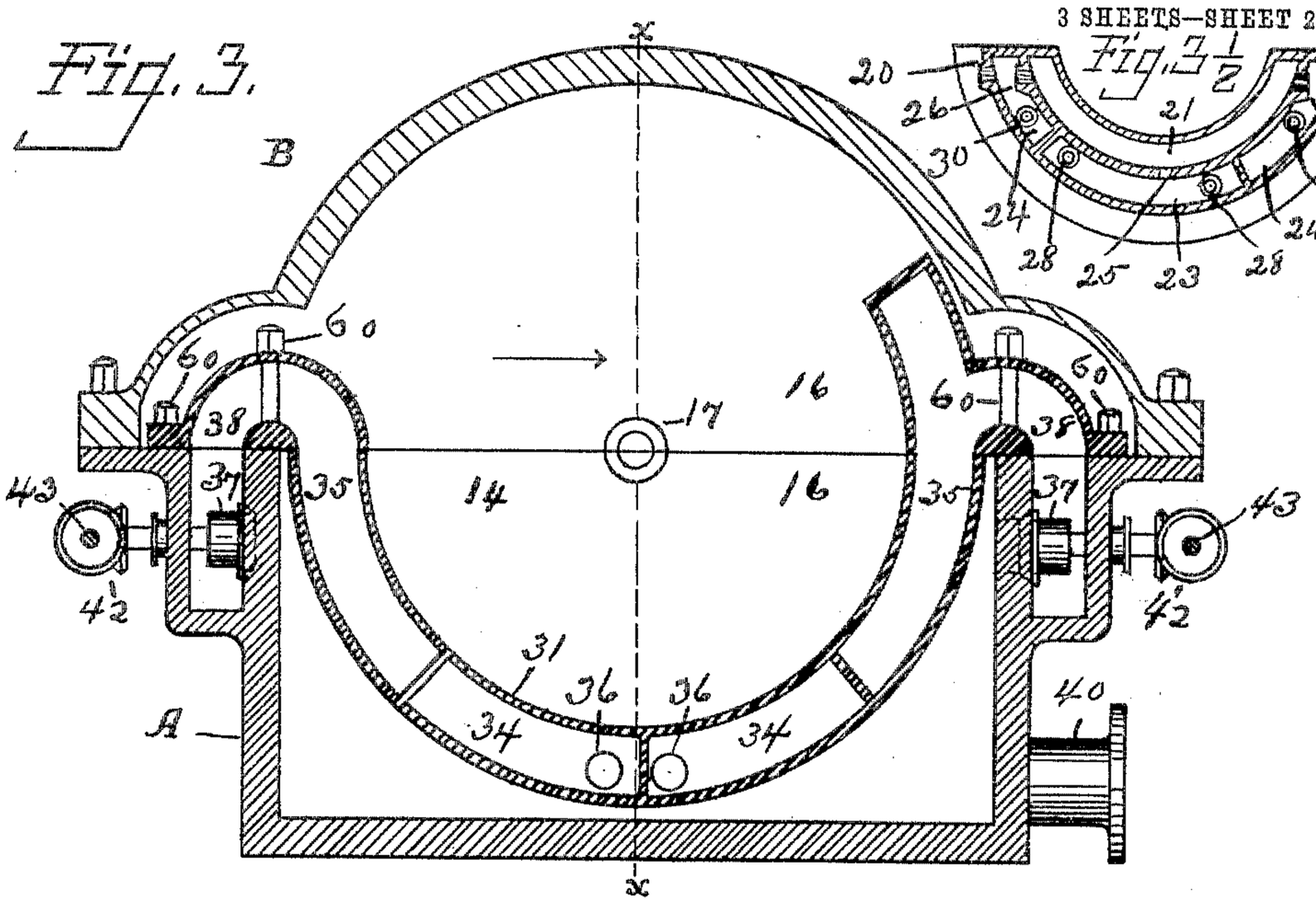
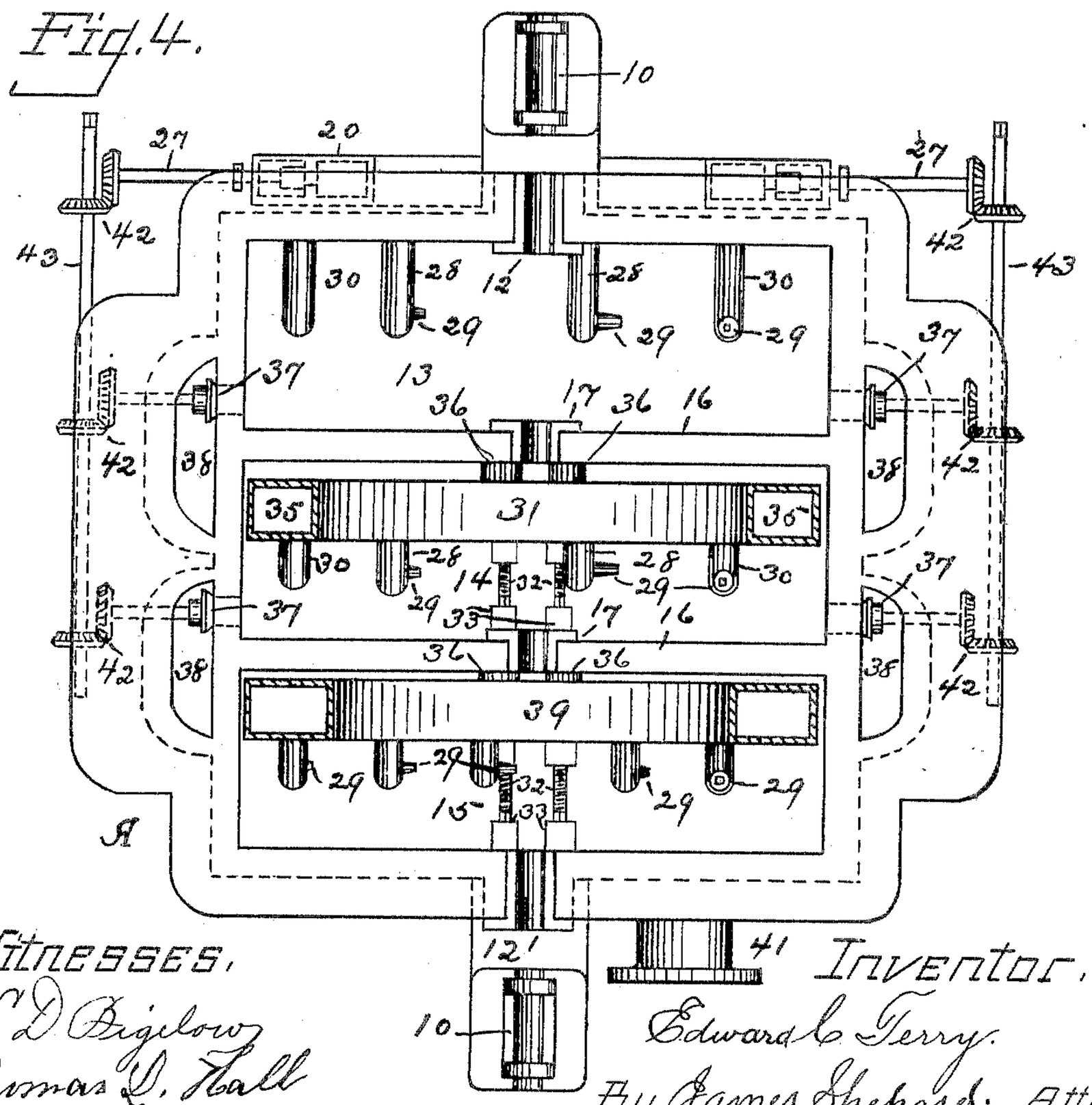


Fig. 3½.

Fig. 4.



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3 SHEETS—SHEET 3.

Fig. 5.

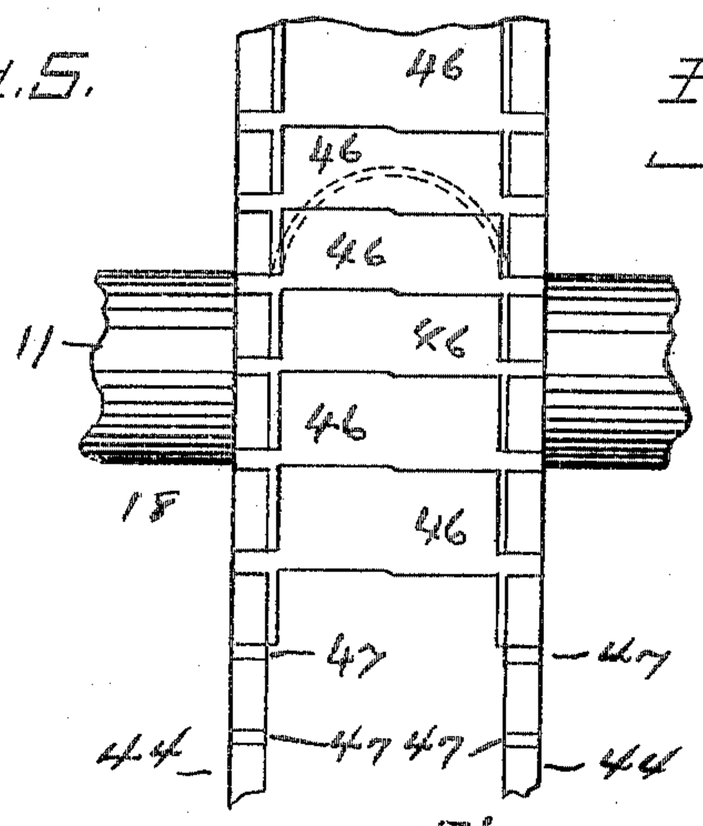


Fig. 6.

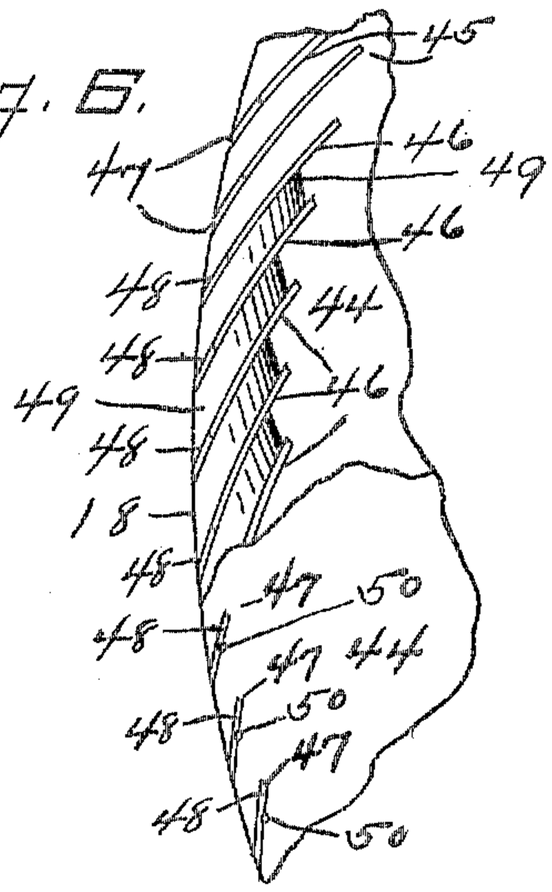


Fig. 8.

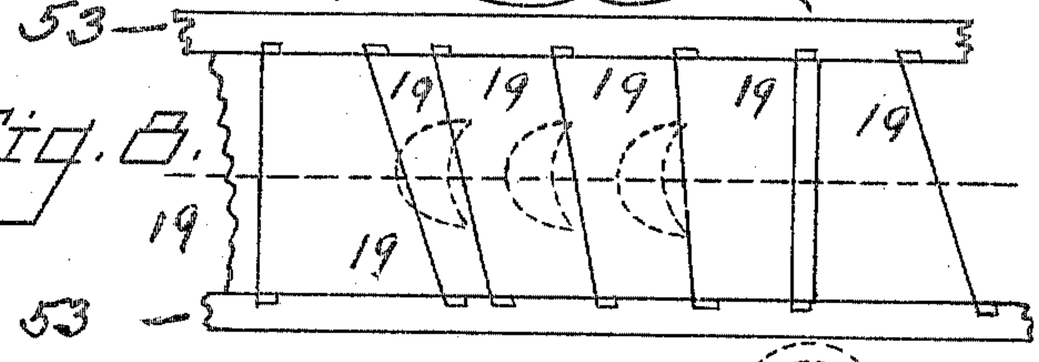


Fig. 7.

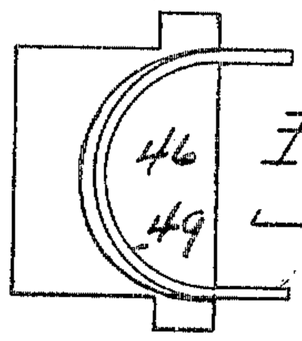
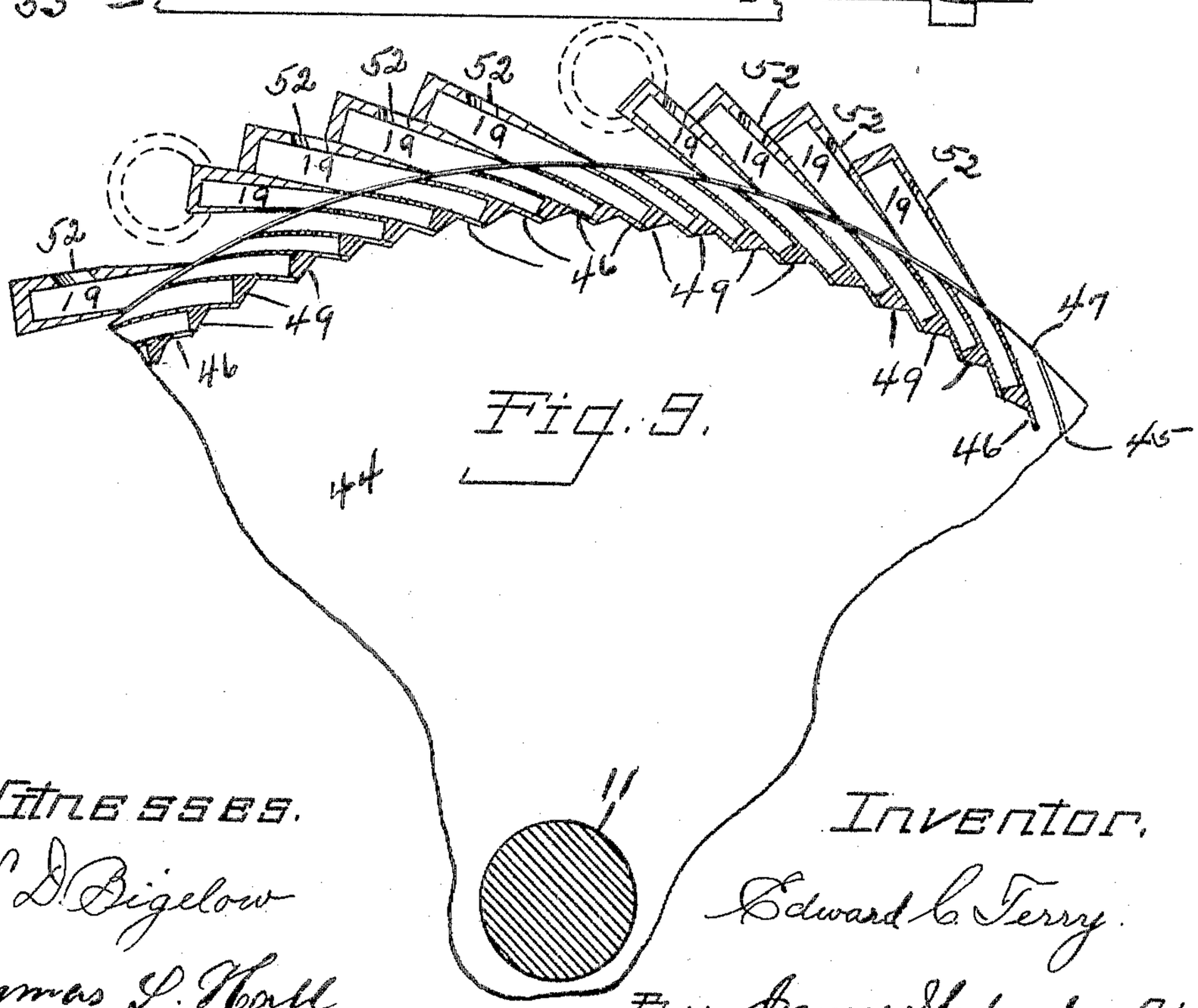


Fig. 9.



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UNITED STATES PATENT OFFICE.

EDWARD C. TERRY, OF HARTFORD, CONNECTICUT.

STEAM-TURBINE.

SPECIFICATION forming part of Letters Patent No. 793,857, dated July 4, 1905.

Application filed June 25, 1904. Serial No. 214,108.

To all whom it may concern:

Be it known that I, EDWARD C. TERRY, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Steam-Turbines, of which the following is a specification.

My invention relates to improvements in steam-turbines; and the objects of my improvement are simplicity and economy in construction and efficiency in use.

In the accompanying drawings, Figure 1 is a front elevation of my turbine. Fig. 2 is a longitudinal vertical section of the same on the line *x x* of Fig. 3. Fig. 3 is a transverse vertical section on the line *y y* of Fig. 2. Fig. 3½ is a reduced vertical section of the first induction-casing on the line *z* of Fig. 2. Fig. 4 is an enlarged sectional plan view of the lower part of the case or frame with the upper part removed. Fig. 5 is an enlarged edge view of a portion of the wheel with two of the buckets removed. Fig. 6 is a broken-out side elevation of a portion of the wheel, two buckets being left out to show the curved slots and recesses that receive the bucket-plates. Fig. 7 is a detached plan view of one of the bucket-plates and integral curved wall of the bucket, showing the inner face of the said bucket-plate. Fig. 8 is an edge view showing the inner edge of a group of reversing-chambers and the two plates to which they are attached. Fig. 9 is a central transverse section of a portion of the wheel and a few of the reversing-chambers.

My turbine is of the class in which there is a series of semicircular or U-shaped buckets and a series of semicircular or U-shaped reversing-chambers, the said buckets and chambers being arranged mouth to mouth, either at the edge or side of the wheel, all substantially as shown and described in my Patent No. 741,385, dated October 13, 1903. While following the general construction of the said patent as to the wheel and reversing-chambers, I have made some changes therein, as will be hereinafter described. I have also combined two or more wheels with two or more fluid-tight chambers with jets and means for causing the fluid passing from each jet to act more than once on the same set of buckets. In the particular example shown I employ three wheels and three fluid-tight chambers, two of the said chambers having therein an induction-casing, while the induction-casing for the other chamber is on the outside.

A designates the lower part or half of the casing or frame and B its cap or upper half. At each end of the lower part of the frame there is a suitable bracket or arm, upon which the main bearings or boxes 10 for the wheel-shaft 11 is mounted, the minor bearings or boxes 12 being formed in the outer walls of the parts A and B. The parts A and B are divided into three fluid-tight chambers 13, 14, and 15, the same being formed by the outer walls of the said parts A and B and the two diaphragms or partitions 16, partly on the lower part A and partly on the cap B, as best shown in Fig. 2. Still other shaft-boxes, packings, or closures 17 for the wheel-shaft 11 are provided at the junctions of the partitions 16 in the parts A B. Mounted on the wheel-shaft there is a wheel 18 within each of the three chambers, and outside of the said wheels, but within the said chambers, there are groups of reversing-chambers 19. Outside of the main casing or frame there is an induction casing or chamber 20; but in order to clearly distinguish from the wheel-chambers the term "casing" instead of "chamber" will be hereinafter used to designate this casing 20 and the corresponding parts that are inclosed within the wheel-chambers. This induction-casing 20 is divided into four compartments, the first compartment 21 being provided with the steam or fluid inlet pipe 22, that receives the steam for all of the wheels. This compartment is arranged concentrically with the other three compartments 23, 24, and 24 of the induction-casing 20, and it is in permanent communication through the outlet 25 with the middle one 23 of these three compartments and may be also in communication with both of the compartments 24 when desired through the openings 26, Fig. 3½, and valves 27. Two jet-pipes 28 with properly-directed jets 29 extend from the middle compartment 23 to the under side of the wheel 18 in the first chamber 13, and like pipes 30 and jets 29 extend in

like manner from the compartments 24. An induction-casing 31 is placed inside of the second chamber 14, where it is held in place by the bolts 60 and set-screws 32, the outer end of which abuts against a lug 33, so that turning the screw outwardly forces the opposite side of the casing 31 against the opposite wall of the said chamber 14 (or against suitable bosses on the said wall) and securely fastens the said induction-casing in place. The said casing 31 is divided into four compartments, the two lower and middle ones being designated 34, Fig. 3, and the other two 35, Figs. 3 and 4. As shown, these two compartments 34 are intended to be supplied with live steam when in use, and hence the partition is not essential. If, however, it should be desired to let steam pass through only one of them, then the partition between the said two compartments 34 would become useful. The compartments 34 are in permanent communication with the preceding chamber 16 through the connections 36. The other compartments 35 may be placed in communication with the preceding chamber 16 when desired by means of the valves 37. The compartments 35 are extended from their upper ends upwardly and downwardly to the side passages 38, in which the valves 37 are located, and which passages are wide enough to bring the said valves opposite the said first chamber 16, as shown in Fig. 4. This induction-casing is also provided with jet-pipes 28 and 30, having jets 29, the same as before described for the first induction-casing. The third chamber 15 has an induction-casing 39 and pipes with jets 29, as hereinbefore described, only it extends farther around in the chamber, so as to deliver to a greater portion of the periphery of the wheel or wholly around the wheel, as may be desired. It is supported in place and connected with the preceding chamber in the same manner as described for the induction-casing 31. The first chamber 13 is provided with an exhaust-outlet 40, while the third chamber 15 has an exhaust-outlet 41, either of which may be used when desired; but an illustration and description of means for closing the unused exhaust is thought to be unnecessary. The several valves 27 and 37 on each side may be all operated simultaneously by means of beveled gears 42 and operating-shafts 43.

As in my aforesaid patent, the wheel 18 comprises two disks 44 with U-shaped or semicircular buckets confined between the said two disks. In the present construction I form the said disks with curved grooves 45, extending inwardly from the circumference at an acute angle to receive the two opposite edges of the bucket-plates 46, which are formed with a curve in edge view correspondingly to the curve of the said grooves. A small portion of these grooves near the periphery is cut entirely through the disks to form the notches or recesses 47 to receive the lugs 48, that project beyond the side edges of the main portion of the bucket-plates 46. In Fig. 6 the lower part shows the outer face of one of the disks 44, while the inner face of the other disk is shown at the upper part except when it is hidden from view by the buckets. Two buckets are omitted in order to show the grooves and slots 45 and 47. In my former patent the curved edge or wall of each bucket was formed separately from the bucket-plate, but as herein shown the said walls 49 are formed integral with the plates 46, and in order to enable them to be so formed by drop-forging I have beveled the said wall on the outer side, as shown, leaving the said wall on the inner side at substantially a right angle to the surface of the bucket-plate. It will also be noticed that in the integral structure a portion of the edge wall at the mouth of the buckets extends beyond the corresponding edge of the bucket-plate on which the said wall is built, and this projecting portion is left substantially straight to fit up against the side of the disks 44, as shown in Fig. 5. These combined bucket-walls and plates are placed between the two disks 44, with the edge of the narrower portion of the plates within the curved grooves, while the wider portion has its lugs 48 within the recesses 47. When so placed, the edge of the curved wall on each bucket-plate rests against and is fitted to the broad side of the adjacent bucket-plate, thereby inclosing both broad sides of each bucket. They are secured in place by pins 50, inserted in drilled holes, so that the said pins are partly in the lugs and partly in the disks to form a lock-joint of an ordinary construction in other devices to hold the said plates against moving in an edgewise direction. After fastening the buckets in place the edge of the wheel is turned off and the buckets finished as may be desired. It is, however, preferred to bring the edge of each bucket-plate at the mouth to substantially a sharp edge and to do so by beveling the inlet half of each plate, (the right-hand side, as shown in Fig. 5, by removing the metal from the outer face and the discharge side by removing the metal from the inner face,) whereby there is a slight offset at the middle portion of the edge of each bucket-plate when seen in the edge view.

The reversing-chambers 19 are or may be constructed substantially as in my aforesaid patent and secured between two annular plates or segments of annular plates 53 by letting the edges into grooves in the said plates. As in the said patent, it is proposed to arrange the reversing-chambers in groups of four chambers for one jet; but in the construction herein shown one or more reversing-chambers are omitted between each group and the succeeding jet and group. In Fig. 9 the jet-pipe is indicated in broken circles and its jet is arranged to discharge into the following revers-

ing-chamber, as in the aforesaid patent. The first reversing-chamber in each group is made of substantially the same thickness or dimensions from plate to plate as are the buckets of the wheel at the periphery, while the other chambers are of greater dimensions from plate to plate by a distance about equal to the dimensions of one and a half buckets. It is preferred to make the terminal edge of the plate of the reversing-chambers slanting, with the exception of the last plate in each group, and to have the edge of this last plate extend squarely across, or nearly so, from side to side. Inasmuch as the first reversing-chamber in each group is not backed by another chamber, it has two plates, while all the others are formed of only one plate and the curved wall, so that there are five plates in a group of four reversing-chambers. In Fig. 8 the left-hand one of the plates (marked 19) shows the square across terminal edge of the last plate in a group of four reversing-chambers. The four slanting lines and succeeding square across line included within the bracket 51 represents the terminal edges of the five plates of the four reversing-chambers of one group, while the plate 19, with slanting edge at the right in said Fig. 8, is the first plate in the succeeding group of four reversing-chambers. Instead of making the slanting edges all on the same angle or slant the plate or plates of the first reversing-chamber has the most slant, and then the succeeding plates slant gradually less until the edge of the last plate stands square across, as before described. The last three of the reversing-chambers in each group have the central discharge-orifice 52, as in the aforesaid patent. Making the dimensions of the reversing-chambers greater than the dimensions of the bucket-spaces measured at the periphery of the wheel has somewhat the effect of making the terminal edge slant, whereby when a bucket and reversing-chamber register with each other on the side where the steam passes from the reversing-chamber to the bucket the side where the steam returns from the wheel-bucket to the reversing-chamber will not register. It is not essential in making these chambers of greater dimensions than the buckets that the terminal edge of the plates in the reversing-chambers should slant nor if slanted that the angle should gradually change.

If steam is let into the induction-casing 20 when the valves 27 and 37 are closed and the exhaust 40 also closed, it will pass through to the compartment 23, then through the pipes 28 and jets 29 to the reversing-chambers 19 and wheel 18 in the lower part of the fluid-tight chamber 13 for driving the said wheel. The motive fluid discharged from each jet passes into the buckets of the wheel and then out into a reversing-chamber, which again returns the said fluid to the wheel, whereby the fluid passing from each jet acts more than once on the same set of buckets. By "the same set of buckets" is meant one circle of buckets around the wheel, which set is always presented to the same jet and its group of reversing-chambers which cause that jet to act more than once on that same set of buckets. With a group of four reversing-chambers, as shown in Figs. 8 and 9, each jet acts four times on the set of buckets that lies opposite the said chambers. The steam discharges from the first wheel into the said first chamber 13, from whence it flows through the lower part of the said chamber into the lower compartments 34 of the second induction-casing within the second fluid-tight chamber and in like manner through the pipes 28 and jets 29 to the reversing-chambers and wheel at the lower part of this second fluid-tight chamber. In like manner it passes into and through the third wheel and chamber and out at the final exhaust 41. If the valves 27 and 37 are open, the steam passes through in the manner before described, and in addition thereto it passes from the compartment 21 through the valve-orifice 26 in the first induction-casing into the compartments 24, then through the pipes 30 to the wheel in chamber 13, then through valve 37 to the side passage 38 into the compartments 35 of the induction-casing 31 to the second wheel and chamber, then in like manner to the third wheel and chamber and out at the exhaust 41. The exhaust 40 may be located in any chamber before that containing the final exhaust 41, according to the degree of expansion which is desired to utilize. When the exhaust 40 is used, the steam does not act on the succeeding wheels.

While some portion of the detachable induction-casing projects upwardly above the dividing-seam between the parts A B, the part B may be removed without disturbing the induction-casing.

I claim as my invention—

1. The combination of two or more fluid-tight chambers with a wheel in each chamber, one or more jet-nozzles for each wheel, means for causing the fluid-jet after first leaving the wheel to return and act more than once on the same set of buckets and means for connecting each chamber with the succeeding chamber.

2. The combination of two or more fluid-tight chambers with a wheel and reversing-chambers in each of the said fluid-tight chambers, the buckets of the said wheel and the said reversing-chambers being of substantially a semicircular form, facing each other mouth to mouth and discharging one into the other and means for connecting each chamber with the succeeding chamber.

3. The combination of two or more fluid-tight wheel-chambers divided into separable upper and lower parts, and a detachable induction-casing attached to the lower part within one or more of the said chambers.

4. The combination of two or more com-

munication fluid-tight chambers with a wheel and detachable induction-casing for each of the said chambers, the said induction-casing having separate compartments, and means for opening and closing the said compartments for the passage of the fluid through a part only or all of the said compartments, as may be desired.

5. The combination of the two-part case or frame A, B, having diaphragms dividing the same into separate wheel-chambers, with an induction-casing located within part of the said chambers and secured to the lower part of the said frame, and passages leading from the preceding chamber into the said induction-casing in the succeeding chamber.

6. A wheel consisting of two disks having notches in their edges and grooves extending inwardly from the said notches on the confronting sides of the said disks, and bucket-walls and bucket-plates, the said bucket-plates having their edges received in the said notches and grooves, and the bucket-walls being between the said plates.

7. A wheel consisting of two disks having notches extending inwardly from their edges and grooves extending inwardly from the said notches, bucket-walls and bucket-plates with the edges of the said plates in the said notches and grooves, and a pin partly in the said disks and partly in the said plates for holding the said plates within the said grooves.

8. A wheel having a series of hollow buckets with open and unobstructed semicylindrical spaces within the said buckets, and confronting series of hollow reversing-chambers with open and unobstructed semicylindrical spaces therein, the spaces within the said reversing-chambers measured at the periphery of the wheel being in excess of the spaces within the buckets by a fraction of a bucket-space.

9. A wheel having a series of buckets and confronting reversing-chambers the spaces within the said reversing-chambers measured at the periphery of the wheel being in excess of the spaces within the buckets and the edge of the reversing-chambers at the discharging side being in advance of the edge at the receiving side by the fraction of a bucket-space measured at the periphery.

10. A wheel having a series of buckets and confronting series of reversing-chambers arranged in a group or groups, and a jet leading into the first reversing-chamber in each group, the said reversing-chambers consisting of curved walls and plates with the terminal edges of the successive plates arranged at different angles to the axis of the wheel.

11. A wheel consisting of two disks with buckets between, each bucket consisting of a curved wall and integral plate the said buckets being held between the said disks by means of the said plates.

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Witnesses:
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