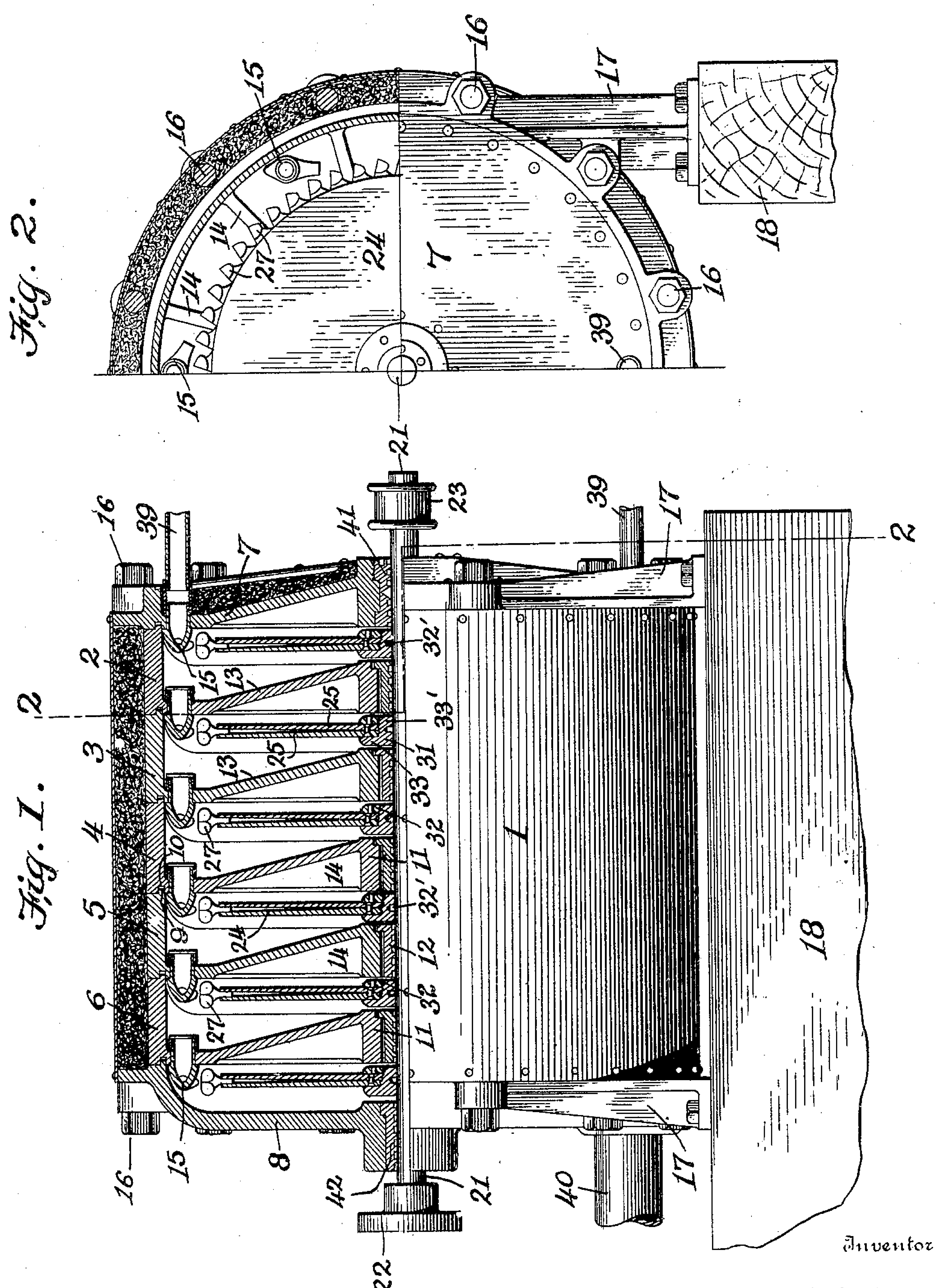
No. 798,105. PATENTED AUG. 29, 1905.

C. V. KERR.

COMPOUND STEAM TURBINE.

APPLICATION FILED OCT. 10, 1904.

3 SHEETS—SHEET 1.



Inventor

Charles V. Kerr

Witnesses

Ernest Pulsford

John H. Holt

By W. E. Schoenborn

Attorney

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3 SHEETS—SHEET 2.

Fig. 3.

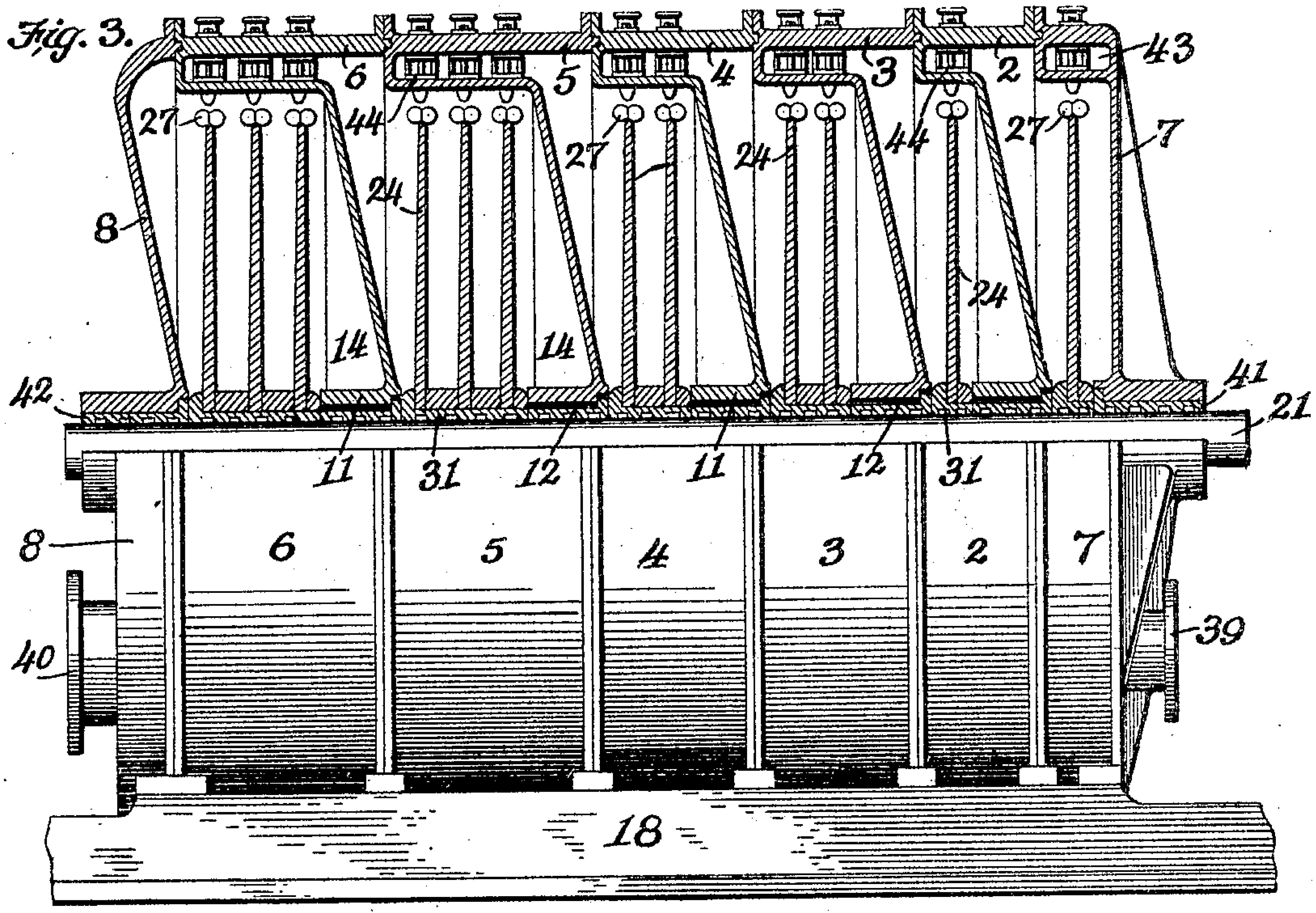
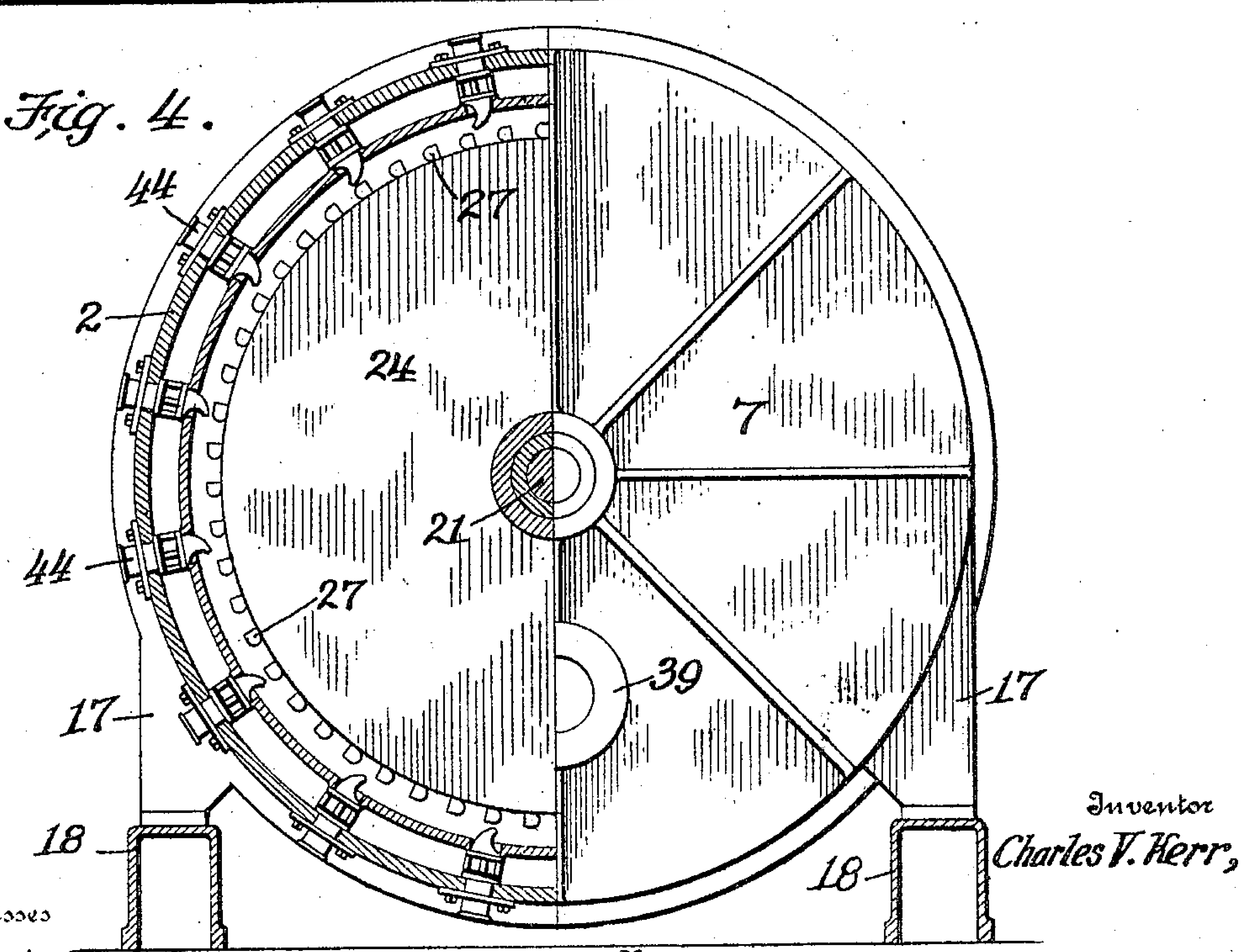


Fig. 4.



Witnesses

Ernest Pulsford

John H. Hall

Inventor

Charles V. Kerr,

By W. E. Schoenborn

Attorney

ANDREW B. GRAHAM CO., PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

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3 SHEETS—SHEET 3.

Fig. 6.

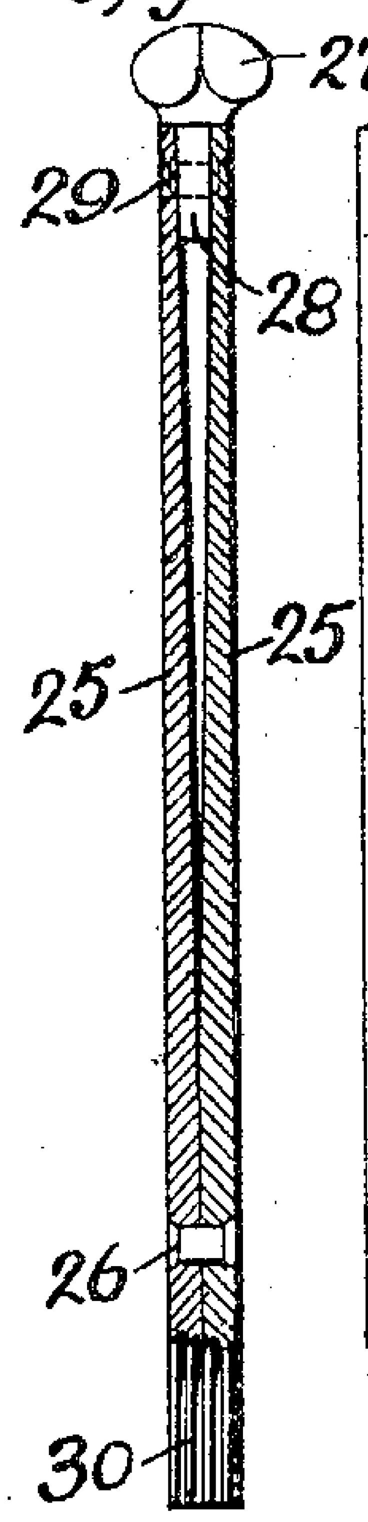


Fig. 5.

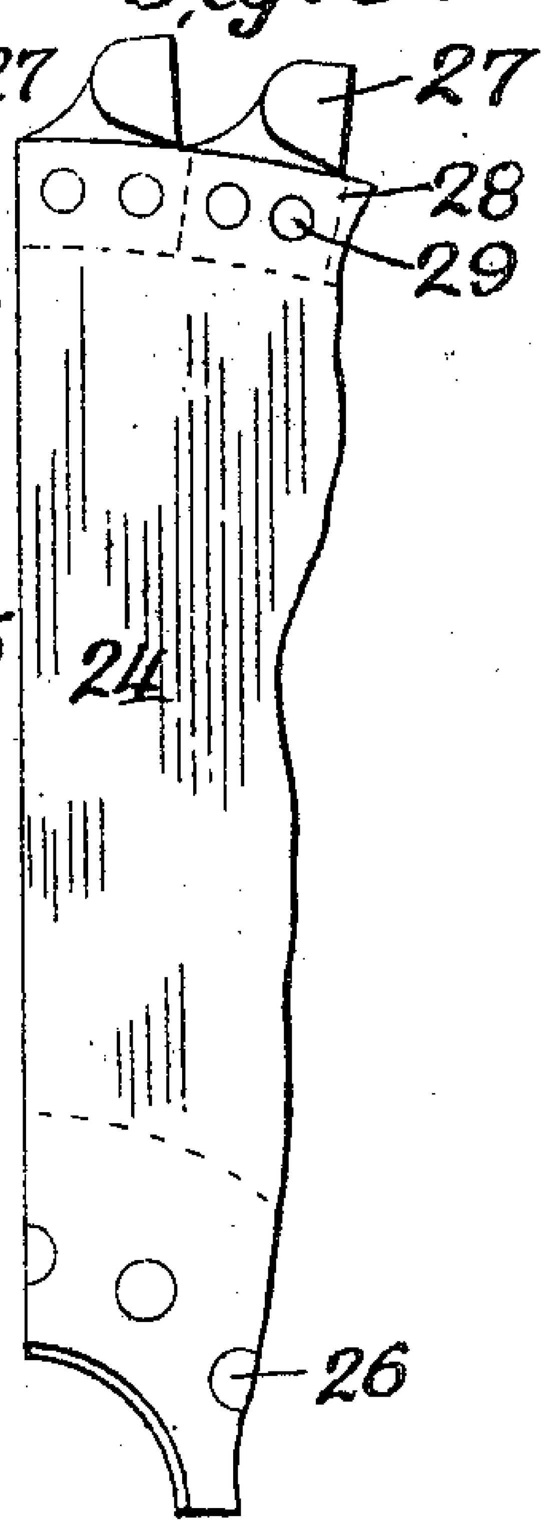


Fig. 8.

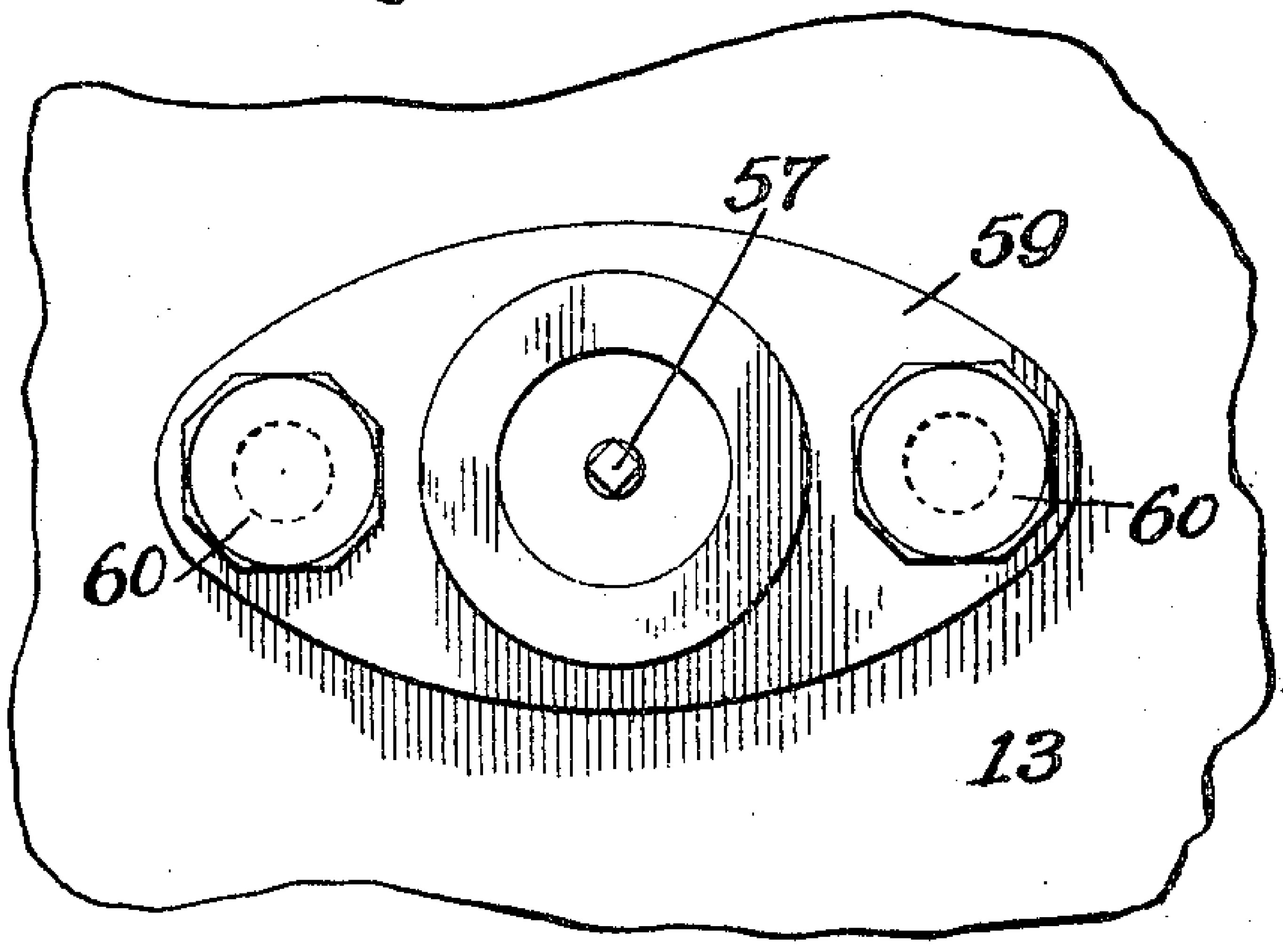


Fig. 7.

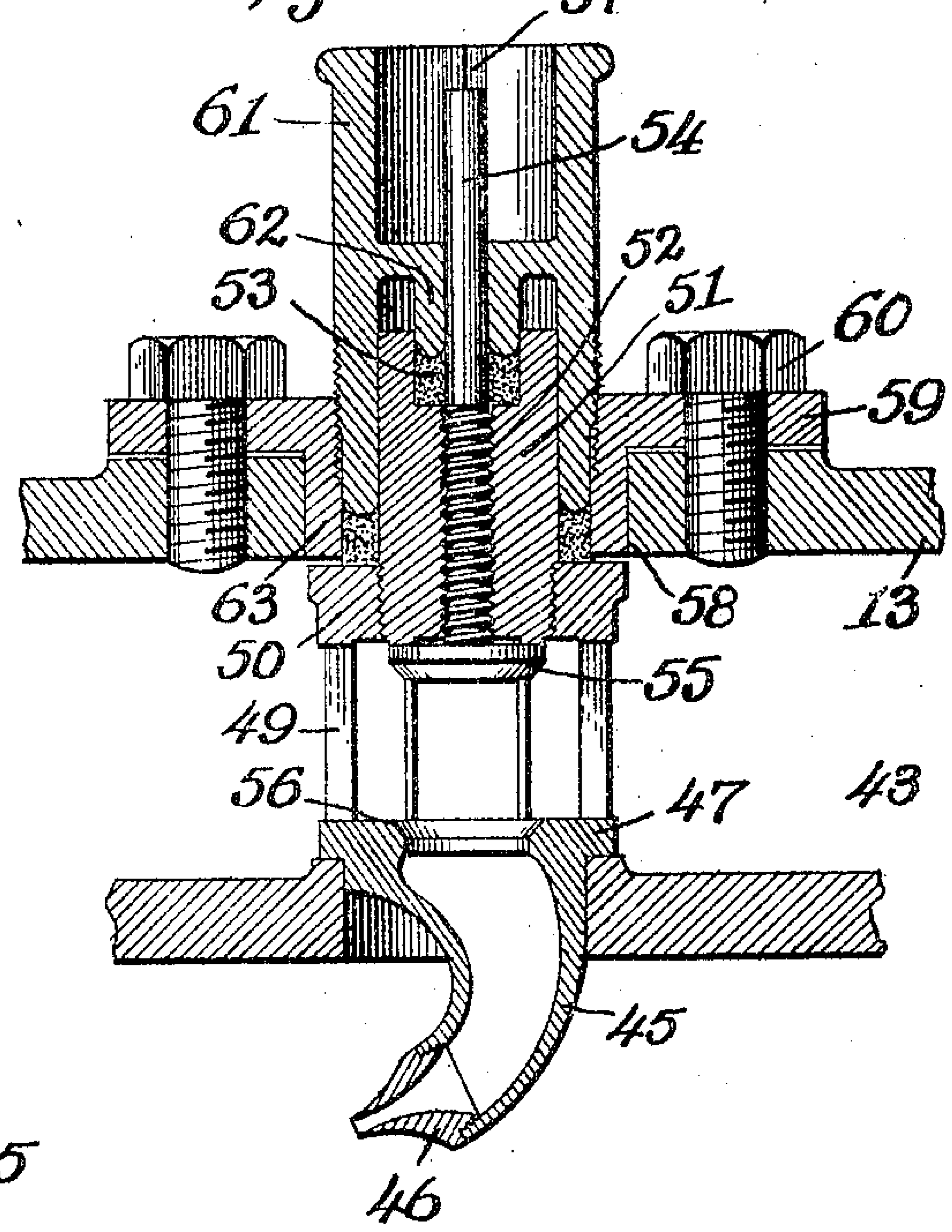


Fig. 10.

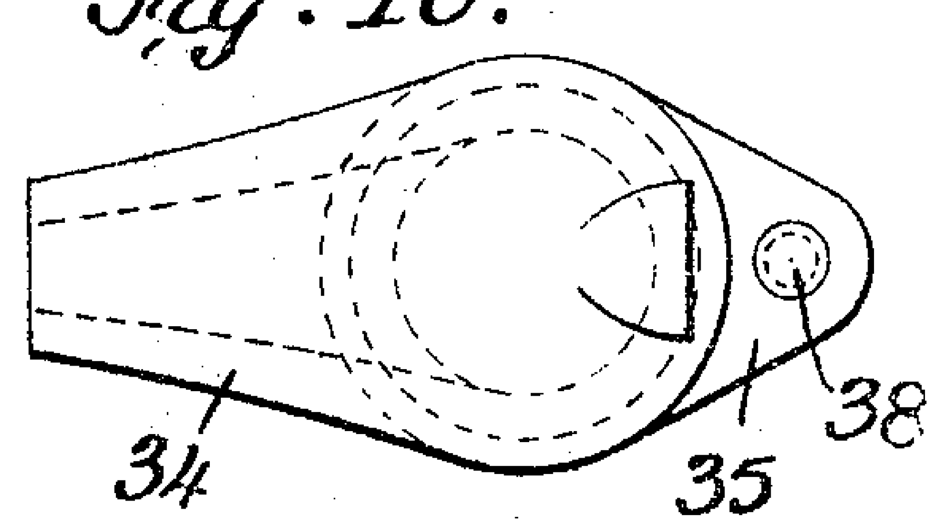
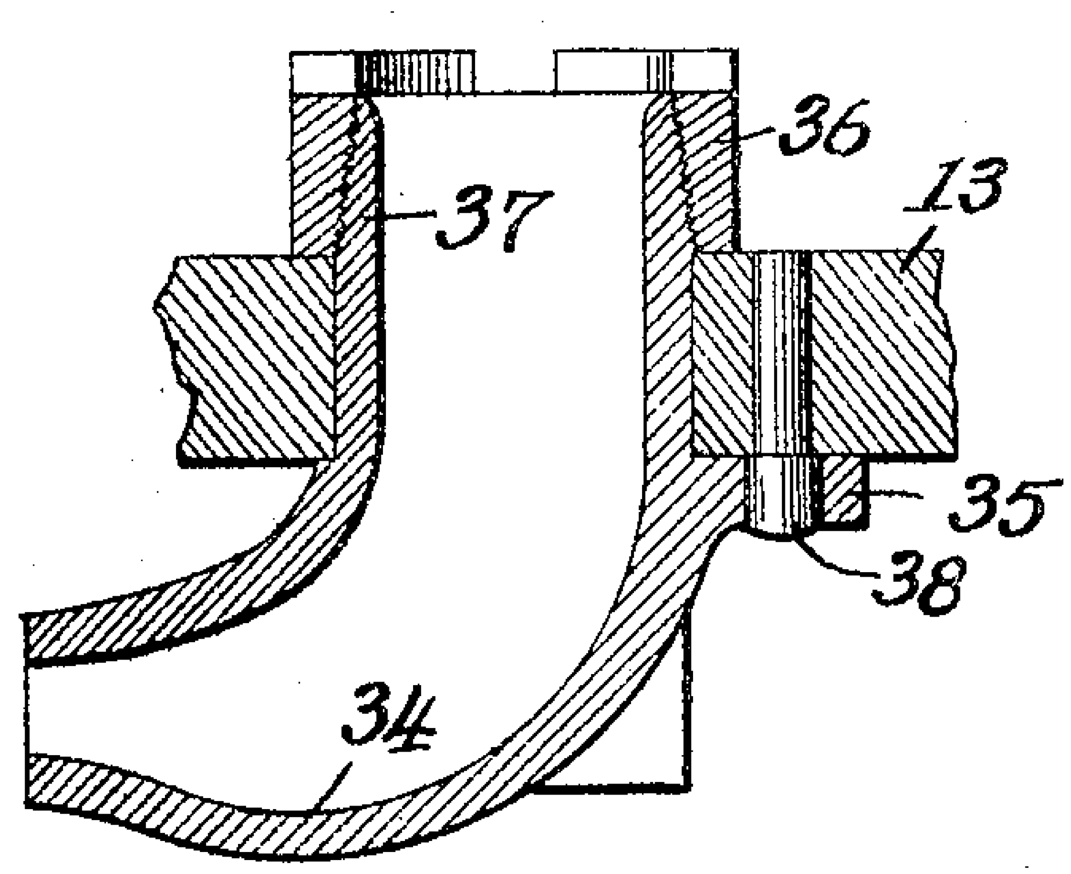


Fig. 9.



Inventor
Charles V. Kerr,

Witnesses
Ernest Pulsford
John H. Holt

By W. E. Schoenborn
Attorney

UNITED STATES PATENT OFFICE.

CHARLES V. KERR, OF WELLSVILLE, NEW YORK, ASSIGNOR TO KERR TURBINE COMPANY, OF WELLSVILLE, NEW YORK, A CORPORATION OF NEW YORK.

COMPOUND STEAM-TURBINE.

No. 798,105. Specification of Letters Patent. Patented Aug. 29, 1905.

Application filed October 10, 1904. Serial No. 227,804.

To all whom it may concern:

Be it known that I, CHARLES V. KERR, a citizen of the United States, residing at Wellsville, in the county of Allegany and State of New York, have invented certain new and useful Improvements in Compound Steam-Turbines, of which the following is a specification.

My invention relates to that class of compound steam-turbines known more especially as the "multicellular type" and shown, for example, in my former patent, No. 756,241, dated April 5, 1904, of which the present invention is an improvement.

The objects of this invention are, first, to construct a casing for the rotary members of the turbine in which the different sections or units comprising the casing may be quickly and easily assembled or separated and with a minimum of cost of manufacture; second, to construct a casing which comprises a number of sections or units of uniform diameter and of the same or variable width, so that a turbine of a higher or lower horse-power or mode of expanding the motive fluid can be quickly installed or varied without necessitating much additional cost or discarding any portion of the old turbine; third, to form and construct the disks carrying the buckets which form the rotary member of the turbine so that said disks and buckets may be quickly attached or detached from the rotary shaft or readily arranged in different relations along the axis of the same; fourth, to attach the buckets on the periphery of the disks or wheel so that they may be quickly removed or repaired and at the same time be strong, durable, and inexpensive; fifth, to construct the nozzles in relation to the casing and their seats so that they may be firmly held therein with a steam-tight joint and at the same time be quickly and readily adjusted at any angle with respect to the rotary buckets or easily removed when repairs are necessary; sixth, other evident advantages and features of the specific construction and arrangement of the parts which will hereinafter appear from the detailed description of the engine and manner of using the same.

My invention consists of structural features and relative arrangement of elements, which will be hereinafter more fully and clearly described, and pointed out in the appended claims.

Referring to the three sheets of drawings, in which similar reference characters indicate the same parts in the several figures, Figure 1 is a side view of one form of my invention with the upper half shown in longitudinal section. Fig. 2 is an end view, partly in transverse section, on line 2 2 of one-half of the form of engine shown in Fig. 1. Fig. 3 is a side and part sectional view similar to Fig. 1 of a modified form of my invention. Fig. 4 is an end view similar to Fig. 2 of the form shown in Fig. 3. Fig. 5 is a fragmentary and enlarged view of the disks forming the turbine-wheel with two buckets attached. Fig. 6 is a sectional view of one-half of the wheel, showing the manner of building up the same and fastening the buckets to the periphery. Fig. 7 is an enlarged sectional view of the casing and nozzle shown in Figs. 3 and 4. Fig. 8 is a top view of the nozzle shown in Fig. 7. Fig. 9 is an enlarged sectional view of the nozzle shown in Figs. 1 and 2. Fig. 10 is a plan view of nozzle shown in Fig. 9 looking toward the lower or outlet end.

Referring to Figs. 1 and 2, 1 represents the cylinder of the turbine, which consists, as indicated in the present showing, of five similar and separable sections 2, 3, 4, 5, and 6, an inlet or head section 7, and an exhaust end section 8. Each of the annular rims of the sections 2 to 6 has a tongue 9 on one and a corresponding groove 10 on the opposite side, whereby they may be easily fitted to each other or any number of the separable sections be added or interposed between the inlet and exhaust sections 7 and 8. The separable sections 2 to 6 are provided at their centers with hubs 11, which surround and form fluid-tight joints with circular bearing blocks or bushings 12. 13 is a thin wall or web connecting the periphery of each hub 11 of the separable sections to the other or opposite side of the annular rim, which is provided with a groove 10, thereby forming in each section a dish-shaped center which on one side slants toward the center and on the other side toward the rim. By this construction of separable sections it will be seen there is formed a series of chambers in the cylinder-casing whose separating walls or web 13 13 are inclined toward the exhaust end section 8. 14 14 are radial ribs cast integral with the wall or web 13 for the purpose of making a light as well as a strong form of construction. At regular intervals in the walls 13, adjacent to the inner and grooved sides of the sections 2 to 6, are openings which are provided with a nozzle 15, through which the motive fluid is injected against the buckets 27, to be hereinafter described. 16 16 are bolts passing through suitably-spaced lugs and openings in the inlet and exhaust end sections 7 and 8 and which when screwed up securely hold the separable sections 2 to 6 and end sections together. 17 17 are standards cast integrally or attached to the end sections 7 and 8 for the purpose of supporting and firmly securing the turbine to the usual foundation or bed 18. 19 is the ordinary lagging outside of the cylinder for the purpose of preventing radiation and which is provided with the usual sheet-metal covering 20, secured to the cylinder ends. Passing through suitable bearings in the inlet and exhaust sections 7 and 8 and through the steam-tight bearings 12 of each of the separable sections 2 to 6 is a rotary shaft 21, from which at one end power may be taken by means of a coupling 22 or other expedient. 23 at the other end of the shaft is a pulley from which a belt or other means may be connected to a governor for the purpose of regulating the motive fluid to the turbine. Secured to the shaft 21 and interposed between each of the end sections 7 8 and the separable sections 2 to 6 is a rotary wheel 24. Each of these wheels (see Figs. 5 and 6) consists of two annular disks 25 25, which are firmly held together, preferably near the center, by rivets 26 26. The outer sections of the disks are separated slightly, and shanks 28 28 on the buckets 27 27 are inserted between the separated disks and securely held therein by rivets 29 29. The said flanges of the buckets are so machined and curved to properly fit to the outer curvature of the disks and the radial edges of the adjacent buckets in order to insure an integral and finished appearance and prevent any possibility of the motive fluid passing between the disks of the wheel and injuring the same. The buckets 27 27 are of a double construction, with a division-wall or motive-fluid-stream splitter between the same, and so positioned with relation to the nozzles 15 15 that the impact is received by the buckets, and the fluid leaves the same in an efficient manner. 30 is a straight or tapered and threaded opening in the center of the bucket-wheel 24. 31 (see Fig. 1) is a split collar fixed to the rotary shaft 21, having a shoulder 33 on one end and a correspondingly straight or tapered threaded section 33′, as the opening in the wheel 24, at the other end, on which the wheel is readily passed. 32 is a circular nut having threads engaging the tapered section 33′ and securely holding the wheel 24 against rotation on the shaft 21. The nozzles 15 15 are distributed about and adjacent to the periphery of the wheels 24 and connect through suitable openings in the outer portion of the walls 13, one wheel-chamber with that of the next chamber in the series. The nozzles 15 15 (see Figs. 9 and 10) are each provided with an end or tip 34, which may be varied in length or diameter accordingly as the motive fluid is to have a low or high velocity or greater or less expansion and is held in the opening of the wall 13 by means of flange 35 and a nut 36, engaging a tapered and threaded extension 37. 38 is a dowel-pin entering an opening in the nozzle-flange and a corresponding opening in the supporting wall or web 13, the function of which is to assist in properly adjusting and preserving the correct angle of the center line of the nozzle with the circle described by the buckets, and thereby insure an efficient impact and outflow of the motive fluid from the wheel.

From the foregoing description it will be seen I have provided a construction in which the nozzles may be easily removed by unscrewing the lock-nuts 36, and the same relation and proper adjustment may be quickly arrived at when replaced by the insertion of the dowel-pin 38.

The number of nozzles 15 15 in each section or stage may be varied to suit the circumstances at which the initial pressure of the motive fluid is obtained or manner of expanding the same; but in the turbine shown I use two nozzles in the first two sections or stages 7 and 2, four in the third and fourth sections 3 and 4, and six in each of the fifth and sixth sections 5 and 6. One nozzle in each section or stage is located at the lowest point to facilitate the passage of water of condensation when starting up, and I find no drip-cocks are necessary with this arrangement.

39 39 are the pipes leading the motive fluid to the nozzles in the first section or stage, and 40 a pipe connected to the exhaust section or end for leading the exhaust to the atmosphere or a condenser.

It will be readily understood from the foregoing construction of the castings comprising the sectional cylinder that any number of sections or stages could be used or interposed between the end sections with the least amount of work and expense and the number of nozzles applied and adjusted to regulate the flow and expansion of the motive fluid to obtain the highest economy for a given initial pressure of the motive fluid and desired rotary speed of the shaft. It will also be seen that the disks for carrying the buckets are firmly secured to the rotating shaft by means of a split collar 31 and a lock-nut 32. The split collar is made of steel and in two parts, which are located by dowel-pins 32′ (see Fig. 1) or keys at proper points on the shaft. The collar being in position, the disks forming the bucket-wheel 24 are screwed in position against the shoulder 33 and is followed up by the lock-nut 32. The tapered thread used on the split collar 31 causes the disk to bind the split collar to the shaft, and the direction of rotation in turning the bucket-wheel or the threaded collar is such that the impulse of the motive-fluid jet against the buckets tends to tighten the disks on the collar and the lock-nut against the disks. Slipping on the shaft is prevented both by friction and the dowel-pin, which pin also has the function of locating the disks of the bucket-wheel properly with respect to the nozzles.

The disks are dismounted by backing off the lock-nut by the use of a spanner-wrench and unscrewing the disks by hand. The bushing 41 for supporting the shaft in the end casting 7 is preferably screwed in by a spanner-wrench, and the rotation is such as to be set up against the packing by the friction of the rotating shaft, while the bushing 42, forming the other bearing, is simply a light press fit in the exhaust end 8.

To prevent leakage of the motive fluid from one section or stage to the next and also dampen the vibration of the rotary shaft, I preferably construct the bushings 12 12 of the "free-running" type, which are inserted in the bores of the hubs 11 11. These bushings ride freely on the shaft with a slight play in the bore and the difference of pressure in the adjacent sections holds them on their seats in the hubs with sufficient friction to prevent sliding and to allow the shaft to rotate freely on its own center with a minimum friction. The bushings are made of graphite and bronze.

Referring to Figs. 3 and 4, I have shown a modification of the invention as disclosed hereinabove and illustrated in Figs. 1 and 2, with the exception that sections of variable width are provided and in several of the sections or stages are a plurality of bucket-wheels and a set of nozzles for each series of buckets on the wheels. The general construction of the cylinder casing and standards, its shaft, bearings for the shaft, bucket-wheels, bushings, collars, and means for fastening the wheels on the shaft may be the same as already described and indicated by the same reference character and will need no further detailed description. The lagging, metal covering for the cylinder, and bolts for holding the several sections of cylinder together are not shown and whose structure and relation will be clearly understood from the detailed description given in connection with Figs. 1 and 2. The differences of construction of the modification shown in Figs. 3 and 4 from what is illustrated in Figs. 1 and 2 is that the first inlet-section is provided with an annular steam-chest 43. Between the two annular walls of the inlet-section 7 and sections 2 to 6 is interposed a circular series of nozzles 44 44, which control the motive fluid from the steam-chest 43 to the first series of buckets or to the buckets in sections 2 to 6 in passing from one of the sections to the next section or stage until finally exhausted at 40 to the atmosphere or condenser. (Not shown.) The number of the several sections or stages may be varied in any manner, and if it is desired to work against a higher initial pressure another high-pressure section or stage 2 may be added or when running non-condensing and exhausting with five or ten pounds pressure for steam heating one of the low-pressure sections or stages 5 or 6 may be removed. The form of nozzle 44 to be used in connection with the buckets can be varied in many ways, but I have found an injector-nozzle, such as shown in detail in Figs. 7 and 8, well adapted for the present invention. This nozzle consists of a nozzle end 45, having a removable tip 46. The end 45 is provided with a flange 47, which engages the outer edge of an opening 48 in the steam-chest 43 or cylinder-section casting. Extending from the upper side of the flange 47, separated from each other, are lugs 49, supporting an internally-threaded annular disk 50. Engaging the internal threads of the disk 50 is a cylindrical plug 51, having a central threaded opening 52 and at its upper end an annular recess 53. Passing through and engaging the opening 52 is a threaded rod 54, provided at one end with a valve 55, which is capable of being screwed into seat 56 of the nozzle-opening by any suitable tool engaging the outer and preferably squared end 57. 58 is an opening in the outer wall of the steam-chest 43 or cylinder-section, through which the nozzle end 45 is inserted and seated by means of the flange 47 in the opening 48 in the inner wall. 59 is an annular-shaped casting secured to the outer wall of the steam-chest 43 or cylinder-section by bolts 60 and having a circular depending flange fitting into and sufficiently closing the opening 58 to prevent the withdrawal of the nozzle 45 and the integral annular disk 50. 61 is an annular plug screw-threaded at its lower end which engages corresponding threads in the inner circular wall of the casting 59 and is provided in its internal and central portion with a depending projection 62, registering with the recess 53 of the plug 51. Suitable packing material is placed between the upper side of the disk 50, the lower end of the plug 61, and the lower section of the annular flange 63 and in the recess 53, so that when the plug 61 is screwed down it will make a steam-tight joint between the interior of the steam passage-way and the outside air and at the same time provide means whereby the valve controlling the steam through the nozzle can be easily adjusted or removed from the engine-casting in case of needing repairs.

The operation of the invention is as follows: Referring to Figs. 1 and 2, the motive fluid enters, by means of pipes 39, to the nozzles of the first section or stage of the cylinder and impinges against the buckets of the first wheel and then passes in succession through the different sets of nozzles to their respective wheels and is finally exhausted by means of the pipe 40. The degree of expansion can be regulated by the number of separate sections which is interposed between the inlet and exhaust sections, and the jet velocity of the motive fluid or impact of the same on the several bucket-wheels is controlled by the number and size of nozzles which are disposed about the periphery of the wheel. In the modification shown in Figs. 3 and 4 the operation is substantially the same, except two sets of bucket-wheels and nozzles are employed in the third and fourth stages of expansion and three sets of wheels and nozzles in the fifth and sixth stages. However, it can be readily seen that this relation can be modified and the number of nozzles increased or decreased by means of opening and closing the controlling-valves of the nozzles.

From the foregoing arrangement it will be seen I have devised an engine in which in the mounting and dismounting of the parts composing the turbine they may be readily slipped over the end of the shaft, and by the adjustment of the number and size of the nozzles the same jet velocity and power is developed at each section or stage of expansion of the motive fluid.

Various changes may be made in the specific construction of the cylinder herein described in order to provide separable sections which may be easily assembled or taken apart or of the means of providing a fluid-tight joint between the several sections and the rotary shaft, and while I have shown my preferred form I do not care to limit myself to these specific arrangements, as they could be modified in many ways without departing from the spirit of my invention and accomplish the same results.

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

1. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a series of longitudinal and through bolts for holding said sections together, a shaft passing centrally through each of said sections, a loose and pressure-seated bushing around said shaft within each section, a wheel or disk within each section and fixed to the shaft, a row of buckets on the periphery of each wheel or disk and a set of stationary nozzles opposite each row of buckets and extending into said sections and forming a direct communication between any section and the next succeeding section.

2. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, each of said sections being formed with an outer flanged rim, a central hub, and a wall or web connecting the outer rim and hub, a shaft passing centrally through each of said sections and hubs, a loose and pressure-seated bushing around said shaft within each section, a rotary wheel or disk within each section and fixed to the shaft, a row of buckets on the periphery of each wheel or disk and a set of stationary nozzles piercing the walls or webs opposite each row of buckets and extending into said sections and forming a direct communication between any one section and the next succeeding one.

3. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a series of longitudinal and through bolts for holding said sections together, a shaft passing centrally through each of said sections, a rotary wheel or disk within each section and fixed to the shaft, a row of buckets in the periphery of each wheel or disk, a set of nozzles opposite each row of buckets and extending into said sections and forming a direct communication between any section and the next succeeding section, the nozzles in the successive sections progressively increasing in number from the high-pressure stage to the low-pressure stage of expansion.

4. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a shaft passing centrally through each of said sections, a rotary wheel or wheels within each section and fixed to the shaft, the number of wheels in the successive sections progressively increasing in number from the high-pressure stage to the low-pressure stage of expansion, a row of buckets on the periphery of each wheel, and a set of nozzles opposite each row of buckets and extending into said sections and forming a communication between any one section and the next succeeding section.

5. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a shaft passing centrally through each of said sections, a rotary wheel or wheels within each section and fixed to the shaft, the number of wheels in the successive sections progressively increasing in number from the high-pressure stage to the low-pressure stage of expansion, a row of buckets on the periphery of each wheel, and a set of adjustable nozzles opposite each row of buckets and extending into said sections and progressively increasing in number in each succeeding section from the high-pressure stage to the low-pressure stage of expansion.

6. A multicellular turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a rotary shaft

passing centrally through all the sections, wheels within each section mounted on said shaft, the wheels in the successive sections progressively increasing in number from the high-pressure stage to the low-pressure stage of expansion, a row of buckets on the periphery of each wheel, a set of nozzles opposite each row of buckets and extending into said sections, and valves for separately and individually controlling said nozzles.

7. A multicellular compound turbine comprising an inlet and an outlet section, a series of separable and independent sections interposed between the inlet and outlet sections, each of said separable sections being formed with an outer rim having a groove on one edge and a tongue at the other, a central hub, and a wall or web connecting the outer rim and hub, a rotary shaft passing through all the sections and central hubs, a loose and fluid-tight bushing about the shaft at each hub of the separable sections, bearings for the shaft in the inlet and outlet sections, wheels within each section and mounted on said shaft between the hubs, a row of buckets on the periphery of each wheel, a set of nozzles piercing the walls or webs opposite each row of buckets and forming a direct communication between any one section and the next succeeding one.

8. A multicellular compound turbine comprising an inlet and an outlet section, a series of separable and independent sections interposed between the inlet and outlet sections, each of said separable sections being formed with an outer rim having a groove on one edge and a tongue on the other, a central hub and a wall or web connecting the outer rim and hub, bolts for firmly holding the assembled separable sections between the inlet and outlet sections, a rotary shaft passing centrally through each of said sections, suitable fluid-tight bearings between the shaft and the hubs of the separable sections, wheels within each section and fixed to the rotary shaft between the hubs of the sections, a series of buckets on the periphery of each wheel, a set of nozzles opposite each row of buckets and forming a direct communication between any one section and the next succeeding one.

9. An impulse-wheel for turbines comprising a shaft, a series of securing means properly disposed along the shaft, split collars engaging said securing means, each of said collars being provided with a shoulder at one end and a tapered section with threads extending to the other end, bucket-wheels each having a central tapered opening with threads corresponding with those of the split collars, lock-nuts engaging the tapered sections and holding the wheels against the shoulders and assisting in securing the split collars and wheels to the shaft.

10. An impulse-wheel for turbines comprising a shaft, a series of dowel-pins properly disposed along the shaft, split collars engaging the dowel-pins, each of said collars being provided with a shoulder at one end and a tapered section with threads extending to the other end, bucket-wheels each having a central tapered opening with threads corresponding with those of the split collars, lock-nuts engaging the tapered sections and holding the wheels against the shoulder and assisting in securing the split collars and wheels to the shaft.

11. A wheel for a motive-fluid turbine comprising two circular disks riveted together near their centers and separated at their peripheries, a series of double buckets having shanks interposed between the separated peripheries of the disks, means passing through the peripheries of the disks and the shanks for securing the buckets to the wheels, and a screw-threaded and tapered circular opening in the center of the disks.

12. A nozzle for motive-fluid turbines comprising a nozzle-section, a flange on said nozzle-section having a lateral extension with a dowel-pin opening therein, a threaded section extending normally from the flange and on the other side from that of the nozzle-section, and a lock-nut engaging the end of the threaded section.

13. An impulse-wheel for turbines comprising a shaft, a series of securing means properly disposed along the shaft, split collars engaging said securing means, each of said collars being provided with a shoulder at one end and a section with threads extending to the other end, bucket-wheels each having a central opening with threads corresponding with those of the split collars, lock-nuts engaging the threaded sections and holding the wheels against the shoulders and assisting in securing the split collars and wheels to the shaft.

14. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, each of said sections being formed with an outer rim having a tongue on one side and a groove on the other, a central hub, and a wall or web connecting the outer rim and hub, a shaft passing centrally through each of said sections and hubs, a rotary wheel or disk within each section and fixed to the shaft, a row of buckets on the periphery of each wheel or disk and a set of stationary nozzles piercing the walls or webs opposite each row of buckets and extending into said sections and forming a direct communication between any one section and the next succeeding one.

15. A wheel for a motive-fluid turbine comprising a circular disk or wheel, a series of double buckets having shanks engaging the periphery of the disk or wheel, and a screw-

threaded and tapered circular opening in the center of the disk or wheel.

16. A wheel for a motive-fluid turbine comprising a circular disk or wheel, a series of double buckets having shanks engaging the periphery of the disk or wheel, and a screw-threaded circular opening in the center of the disk or wheel.

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

CHARLES V. KERR.

Witnesses:
W. H. CRANDALL,
WM. D. APPLEBEE.