No. 787,980. PATENTED APR. 25, 1905.

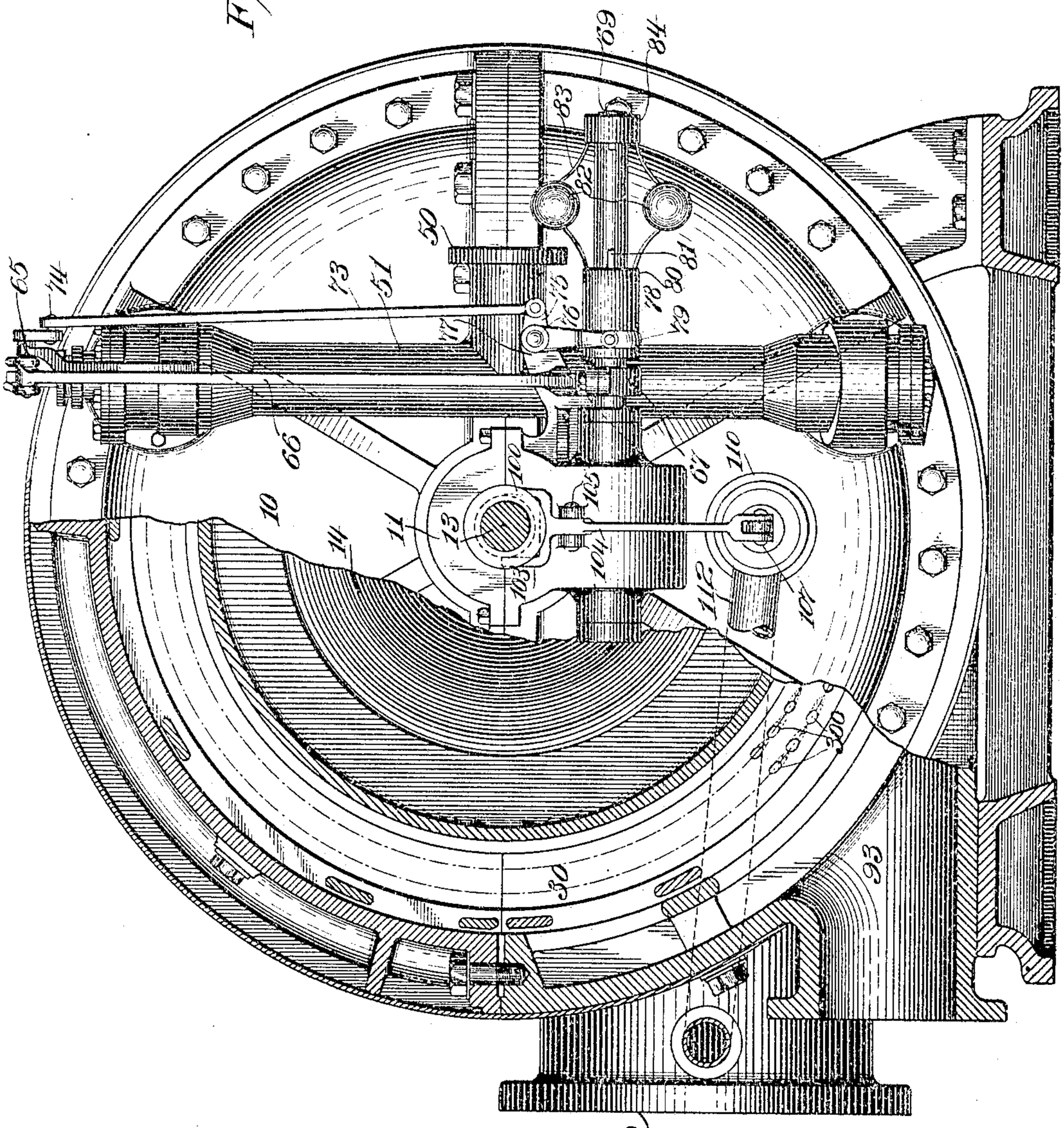
E. S. FARWELL.

TURBINE ENGINE.

APPLICATION FILED DEC. 22, 1903.

3 SHEETS—SHEET 1.

FIG. 1.



Witnesses:

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R. W. Pittman

Inventor:

Elmer S. Farwell.

By his Attorney

F. A. Richards.

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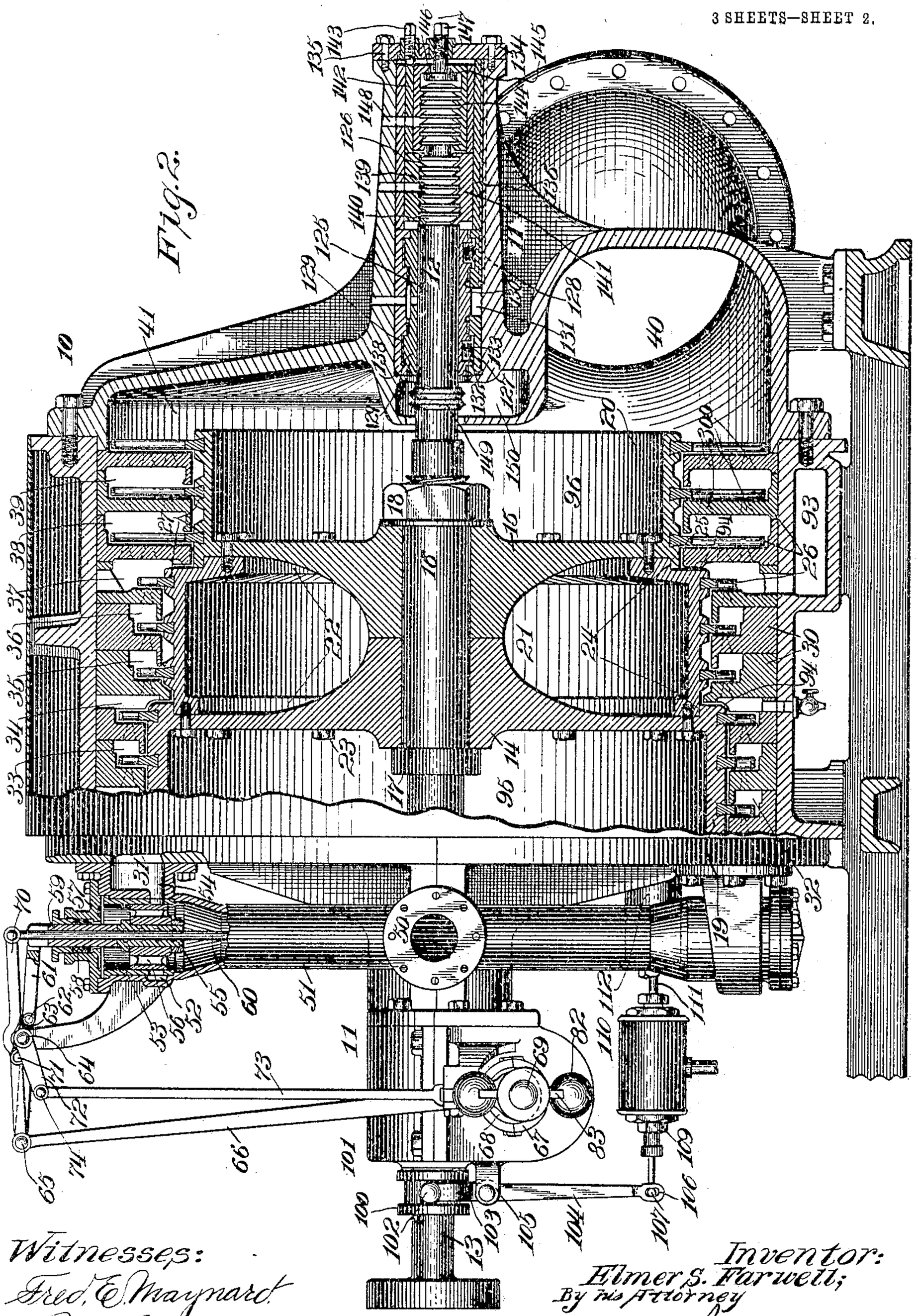
3 SHEETS—SHEET 2.

Fig. 2.



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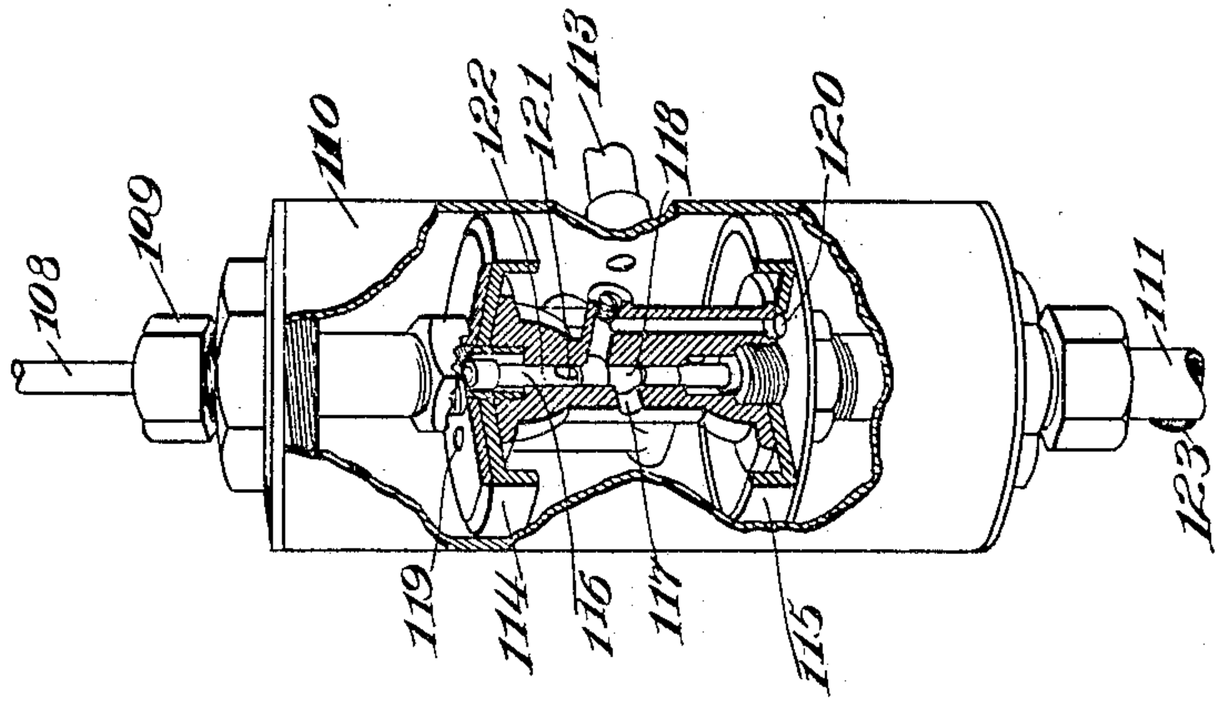

Fig. 5.

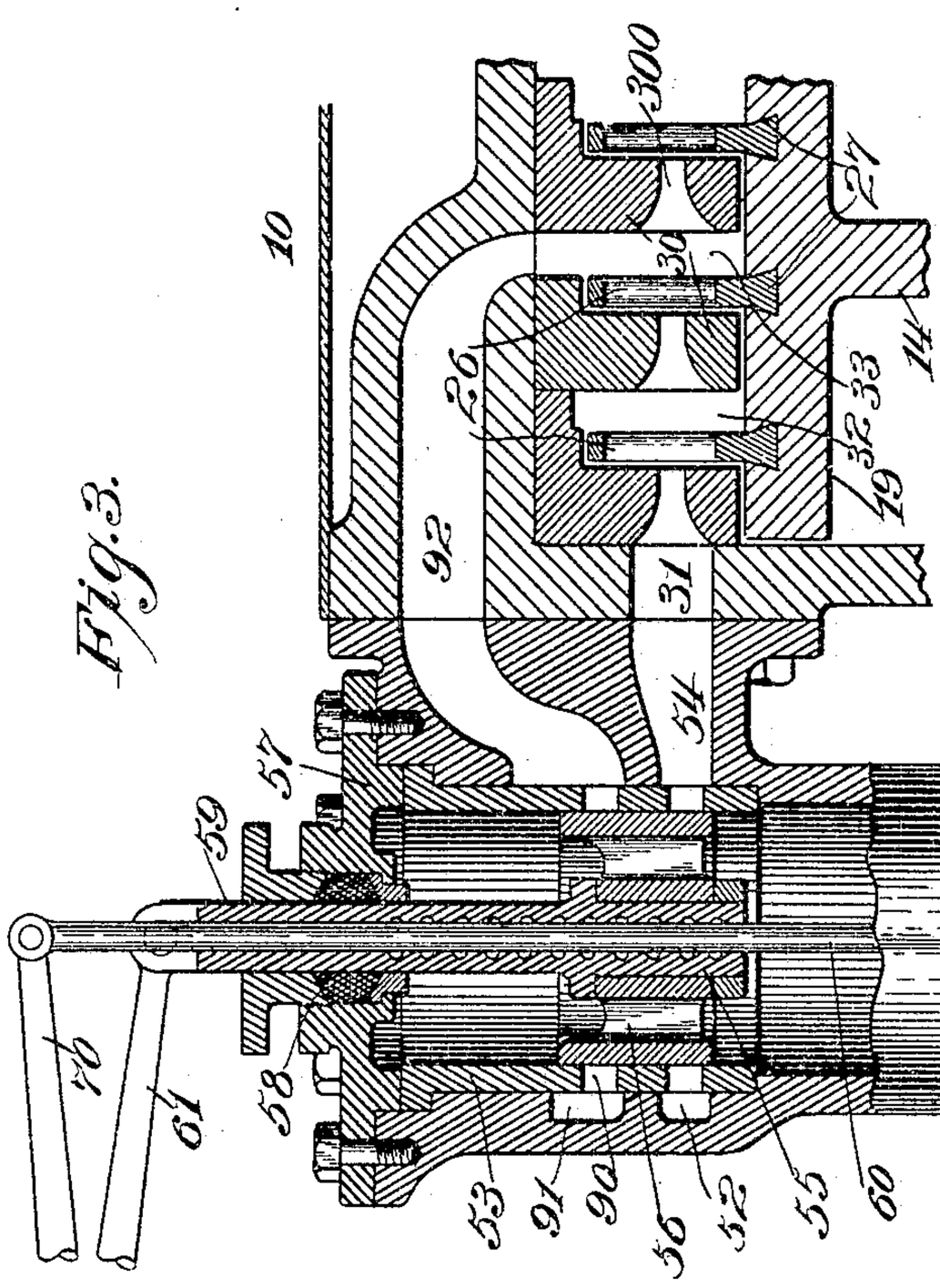

Fig. 3.

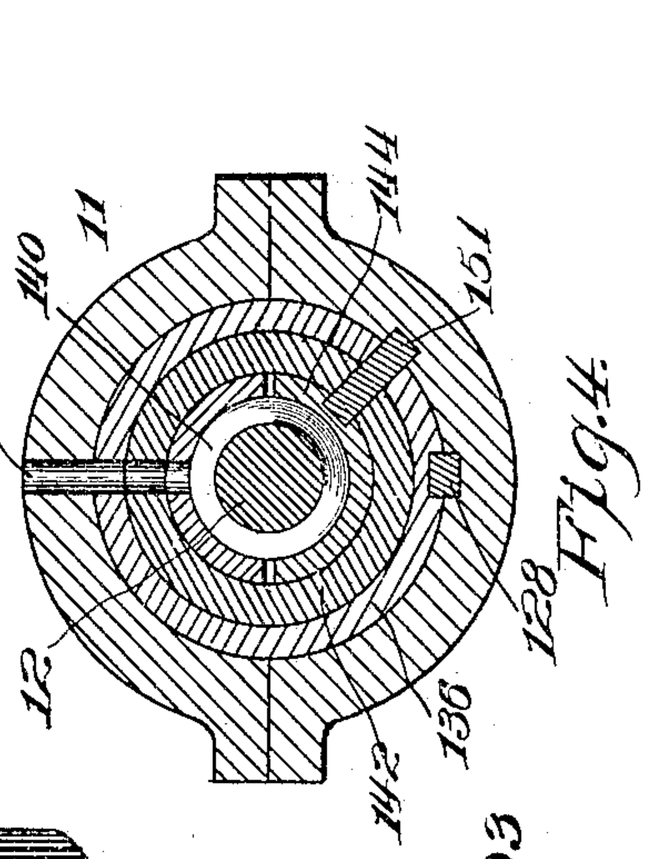

Fig. 4.

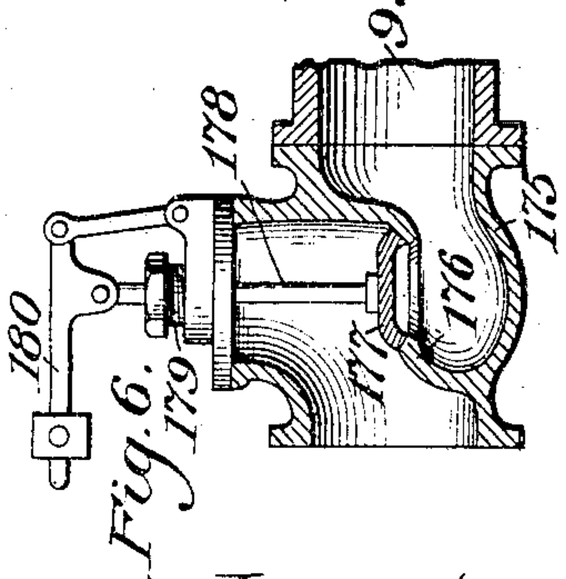

Fig. 6.

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No. 787,980. Patented April 25, 1905.

UNITED STATES PATENT OFFICE.

ELMER S. FARWELL, OF RIDGEWOOD, NEW JERSEY, ASSIGNOR TO EDWIN H. LUDEMAN, OF BROOKLYN, NEW YORK.

TURBINE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 787,980, dated April 25, 1905.

Application filed December 22, 1903. Serial No. 186,191.

To all whom it may concern:

Be it known that I, ELMER S. FARWELL, a citizen of the United States, residing in Ridgewood, in the county of Bergen and State of New Jersey, have invented certain new and useful Improvements in Turbine-Engines, of which the following is a specification.

This invention relates to and has for an object to provide an improved turbine-engine.

These present improvements have to do with a motor or engine wherein an elastic expansive fluid under pressure is utilized or forced to perform its work at a number of successive stages in its expansion, and in the embodiment of the invention illustrated herein the expansive fluid, which may be steam, is caused to pass from point to point at its successive stages and impinge upon vanes or buckets of a rotary body, thereby impelling the same forward, in the present instance at a transverse direction in angular movement to that at which the steam is admitted.

In the drawings accompanying and forming a part of this specification a form of my invention is illustrated, wherein—

Figure 1 is an end view, partly shown in central cross-section. Fig. 2 is a side view, partly shown in central longitudinal section. Fig. 3 is a detail of a device for changing the admission-point of the fluid. Fig. 4 is an enlarged cross-section of a thrust-bearing at the right-hand end of Fig. 2, taken at about the region of the outermost oil-hole. Fig. 5 is a detail of a valve which may be employed to assist certain parts of the device, and Fig. 6 is a detail of a relief-valve.

The working parts are shown within a casing designated in a general way by 10 and which has at each of its ends a bearing or bearing-casing 11, in which are a number of bushings supporting the journals 12 of a shaft 13, upon which the wheel or turbine is mounted. Such wheel or turbine in the present instance in the form illustrated herein comprises two sections 14 and 15. Each has its hub fitted upon a portion 16 of the shaft, one abutting a collar 17 and the other clamped against it and held in place by means of a nut 18.

The portion which is arbitrarily indicated by the character 14 has a flange 19 projecting outwardly or toward the adjacent bearing, the perimeter of which flange will constitute a portion of the body of the drum, the wheel in the present instance being in the form of a drum.

The portion of the wheel arbitrarily indicated by 15 has a flange 20 projecting toward its adjacent bearing and which flange will constitute another portion of the drum. In the present instance the flange 20 is shown of less diameter than the flange 19. Between the bodies 14 and 15 is fastened a ring 21, having flanges 22, secured by bolts 23 to such body portions and which flanges are formed to make shoulders 24, resting behind shoulders 25 upon the respective portions of the wheel, whereby the ring is securely held in place without respect to its bolts. Such portion of the drum is shown as of less diameter than the first portion of the drum and of a diameter intermediate the portions of the drum comprised by the flanges 19 and 20. The perimeter of the drum is shown as carrying the buckets or vanes for receiving the impact or force of the steam or other fluid in the propulsion of the turbine or wheel.

There are shown herein for the purpose of illustration nine rings of vanes 26, three carried by each of the respective portions of the drum referred to, and the last three rings are shown as having vanes considerably longer than the other vanes. The vanes are shown as having wedged or flaring edges 27 taking into corresponding chambers around the perimeter of the drum. Each ring of vanes is shown as running adjacent to a nozzle-ring, (designated in a general way by 30,) which nozzle-rings are each separate from the others and separate from the casing and may be slid into position. The steam will be received in a chamber 31 back of the first nozzle-ring and will enter the nozzles 300, passing through the same in jets. The first set of nozzles will be sufficient in area to deliver the steam at a desired velocity and during a determined interval of time. The steam will then be received into a chamber 32, where it will pass through the next nozzles, which will be of larger area,

and will impinge upon the vanes or buckets of the second ring, entering a chamber 33, from which it will pass through the third nozzle-ring into a chamber 34, and so on through the respective nozzles, rings of vanes, and chambers 35, 36, 37, 38, and 39, from which latter chamber it will pass through the last nozzle-ring and the last ring of buckets or vanes into the exhaust 40, which may be connected to a condenser, and a vacuum may be maintained in such exhaust.

Each chamber will be proportioned to receive and discharge the steam at each of the several successive stages in the same interval as the other chambers receive and deliver. In the first ring of nozzles there might be but two nozzles, in the second a larger number, all in the same line. The seventh ring might have nozzles in two rows and the ninth have the same in three, and the last ring may have nozzles around its entire area, thus discharging steam through the entire ring of vanes into a chamber 41, which is located at one end of the casing and is in communication with the exhaust and in which chamber the last ring of vanes travels.

Steam will be received from some suitable source (not shown) by a pipe connected to a coupling, (shown at 50,) which coupling is shown connected and in communication with a pipe 51 to supply steam to different points upon the circumference of the drum, at the present instance at the top and bottom. There are in the illustration passage-ways, chambers, &c., at two different points, two being employed in the present instance for the purpose of convenient illustration and shown at the top and bottom for similar reasons and to avoid needless repetition. When the position "top" or "bottom" or the expression "up" and "down" are used, I do not mean that my invention must arbitrarily work in such positions and directions, but that the drawings in their positions on the sheets so show them, and this description has followed the drawings for the sake of simplicity and ease.

The upper port and slide-valve only are shown in Fig. 2, the casing at that region being broken away. In the lower compartments the parts will be substantially the same. The pipe 51 comprises a steam-chest, in which is located a suitable slide-valve. The port by which the steam passes to the first chamber comprises an annular chamber 52, partially formed by a bushing 53, and a passage 54 in direct communication with the first chamber 31. The bushing 53 acts as a bearing for the slide-valve 55, which has ports 56 through it to admit steam to the top of the chamber or steam-chest, which is closed by a cap 57, having a gland or stuffing-box 58, through which the stem of the slide-valve passes. The stem 59 is shown as hollow and permitting the passage of the stem 60 of the lower slide-valve. The stem 59 is pivoted to a lever 61, which is pivoted at 62 to one end of an arm 63, carried upon a rock-shaft 64, and is pivoted at 65 to an eccentric-rod 66, having an eccentric-strap 67, embracing an eccentric 68 upon a shaft 69, which is geared by reducing-gear to the main shaft of the engine.

The stem 60 is connected to a lever 70, which is pivoted at 71 to the other end of the arm 63 and is pivoted at 65 to the eccentric-rod 66. The rock-shaft 64 has fast thereon an arm 72, which is pivoted to a link 73, pivoted at 74 to one end of a bell-crank lever 75, which is pivoted at 76 to a bracket 77 from the frame of the engine, the other end of which bell-crank lever has forked ends embracing pins 78 on a collar 79, running in a groove in a sleeve 80, mounted upon the shaft 69 and constrained to rotate therewith by a spline 81. Such collar is connected to a ball-governor comprising balls 82 and springs 83 and a collar 84, whereby upon the rapid rotation of the shaft and the flying apart of the balls the link 73 will be raised and the position of the fulcrum 71 and 62 will be changed. The fulcrum 62 will be lowered and the fulcrum 71 raised, thus changing the position of the path of movement of the slide-valves without changing their length of stroke, so that the amount of the uncovering of the valve from the steam-chest will be regulated, or the strokes of the slide-valve may be idle, owing to the position thereof, until the speed of the wheel has been sufficiently reduced to permit the governor-balls to assume their normal position, when the slide-valve will open and close the ports in regular order. Upon the governor-balls falling sufficiently to change the fulcrum the port may remain open continuously, there being sufficient lead respectively above and below the ports for the slide-valves to move without covering the ports at all.

In Fig. 3 a device is shown whereby the steam may upon the governor dropping below the position to keep the ports continuously open open a port 90 in the bushing 53, leading to a port 91 in the pipe 51, which port 90 leads into a passage-way 92, leading into the chamber 33, whereby the steam will pass to a point where it will be discharged in much larger jets than the jets in the first ring, permitting the steam to be used in greater volume, but also requiring, as is obvious, a larger amount of steam. This would happen when the governor-balls drop below the normal condition of low rotation—as, for instance, falling off in steam-pressure, increased load being thrown upon the engine, or loss of vacuum in the condenser. As was before pointed out or indicated, the slide-valve will be reciprocated with strokes of constant length, the governor having a tendency to shift the path in which such excursions take place or the region of their happening, accordingly as the speed may rise or fall. At certain conditions of the governor the slide-valve

will reciprocate and will maintain both the ports 52 and 90 closed. At other times it will reciprocate and regularly open and close the port 52, holding the port 90 closed, at which time the steam will act at intervals or by impulses. Still greater change in the condition of the governor will hold the port 52 continuously open and the port 90 closed, and a still further change in condition will leave the port 52 continuously open and will open and close regularly the port 90, so that the steam will work from the chamber 92 at intervals or in impulses, and in cases of abnormally excessive load according to the present organization both ports may remain continuously open. Assuming that the steam admitted into the chamber or by-pass 92 is at boiler-pressure, no steam will pass through the chamber 54, but steam at boiler-pressure will remain idly in such chamber and in the chambers 31 and 32, the steam then passing as it is permitted by the slide-valve through the by-pass 92 and through the nozzle 300 from the chamber 33. When steam is admitted by intermittent partial openings of the port 90, the steam passing through the by-pass 92 will be below boiler-pressure. Then it may be assumed that a certain amount of steam will pass through the passage 54, and when the two streams meet they will be at the same pressure. The amount of steam which will pass through the passage 54 when communication is open to the by-pass will be dependent upon the pressure in the by-pass below boiler-pressure. In such emergencies increased amount of steam is thrown into the engine, and in case of loss of vacuum it may be desirable to exhaust it at an earlier period, and a port 93 is provided for such exhaust, which will be provided with an automatic relief-valve to open and close the same, a valve for which purpose is shown in Fig. 6 and comprising a casing 175, adapted to be secured to the intermediate exhaust 93 and wherein there is a valve-seat 176 and plate 177, seating thereon. The plate is shown as carrying a stem 178, traversing a stuffing-box 179 in the cover of the casing. A weighted lever 180 may be attached to the stem for seating the valve. This device acts in the nature of a relief-valve, and upon the vacuum or the predetermined condition of pressure materially rising in the exhaust the plate will be lifted from its seat against the weight and the compartments or working faces between the intermediate exhaust and the exhaust will be cut out. If an unweighted plate or valve were placed in the intermediate exhaust, whenever the pressure in the exhaust rose to such an extent that the pressure in the chamber communicating with the intermediate exhaust rose above atmosphere then such intermediate exhaust would become active; but in the present organization it is contemplated that the pressure in the exhaust must rise more than enough to raise the pressure at the chamber communicating with the intermediate exhaust above atmosphere. Consequently a weight is provided. In other organizations of course more or less weight may be used, as occasion may demand, the valve may be unencumbered by a weight, or may in certain conditions be counterpoised.

The reductions in the diameter of the perimeter of the drum, as before referred to, will produce certain shoulders 94, having radially-projecting faces, so that steam in the chambers 34 and 37 will have a tendency to exert a pressure upon such radial faces and induce the wheel toward the left-hand end—the end from which the steam comes. Steam will escape around the left-hand end of the head or wheel, escaping from the compartment 31 into the inside of the flange 19, which may be regarded as constituting a chamber 95. This escape of steam will be gradual, of course; but nevertheless there will generally be steam in the same, and as the compartment 41, which communicates with the compartment 96 within the flange 20, is in communication with the exhaust, which will frequently be a vacuum, the pressure in the chamber 95 will in many cases overbalance the pressure against the radial shoulders as reduced by the vacuum within the chamber 96. To maintain such balance, it may be desirable to connect some device to the shaft or some part of the head, so that pressure being overbalanced the parts will immediately be regulated, the balancing of the pressure on the turbine-head, and be permitted to again float in its bearings. The shaft is shown as carrying a sleeve 100, having a channel in which is carried a collar 101, to which pins 102 are attached, they being received by the forked end 103 of a lever 104, pivoted to a bracket 105 and having at its end an elongated slot 106, receiving a pin 107 of a piston-stem 108, which enters through a suitable stuffing-box 109 a chamber 110, which controls a steam-valve having a piston 111 for regulating a valve within a conduit 112, connecting the chamber 95 with the exhaust.

Briefly, the operation of this steam-piston is as follows: Steam will be admitted at 113 to the cylinder 110. The cylinder has located within it a double-headed piston or a piston having two heads 114 and 115 and between which heads or the chamber between the same the steam or other operating fluid is admitted at the inlet 113. The principle of the device is that a slight movement of the piston-rod 108 will place the parts in position so that the steam will be ported to one end or the other of the cylinder 110 and exhausted from the other and produce a greater movement of the valve-stem 111 and in the same direction. When the valve-stem 108 is moved down, the valve 116, which it carries, will also be moved down and will open communication through the port 117 to the interior of the body of the piston, where it will pass by a channel 118 in

the piston 116 and pass through the opening 119 to the upper end of the head 114 and press such head down, which is rendered possible by the steam within the lower end of the casing being exhausted through the opening 120, the port 121, the chamber 122, and out through the hollow stem 111 to the port 123. When the piston moves in the opposite direction or upwardly, of course the upper part of the cylinder is exhausted and steam is admitted to the lower part. Thus it will be seen that when the wheel is overbalanced by the pressure within the chamber 95 exceeding the pressure upon the radial shoulders as reduced by the vacuum within the chamber 96 the shaft will move toward the right and will draw the stem 108 in the direction which would be upwardly in Fig. 5, causing the valve or piston within such cylinder to move in the same direction and open a valve between the chamber 95 and the exhaust, and immediately upon the balancing of such pressures the turbine will float back to its normal position and cause the parts to close, when the same will run evenly until the overbalancing again should take place. By this means a floating turbine is had, and in this instance it may be stated that the specific means for maintaining the balance of pressure at the respective ends of the turbine-wheel may be altered as the various occasions require, the present being shown for the purpose of illustration.

It may be found desirable in certain employments of the mechanism to provide a thrust-bearing. In Fig. 2 one of the bearing-casings 11 is shown in longitudinal section, and the shaft within such casing is shown with a plain bearing portion 125 and a portion 126 provided with rings. The plain or bearing portion may be supported by a suitable bearing member, in the present instance supported by floating bushings, and the ring portion may be incased in thrust-bushings. The bearing-casing is shown as having within it a split bushing 127, conforming to the casing and held from rotation therein by means of a spline, (shown in dotted lines by 128.) Within such bushing is a floating bushing 129, having a working fit with the shaft, but having a loose fit with the surrounding bushing, permitting an oil-cushion between them. The floating bushing in the form herein shown is provided with rings 129′ to prevent it from longitudinal movement and with a wing 130, entering a chamber or seat 131 in the bushing 127 to prevent rotation of such floating bushing. To support the dead-weight of the turbine when the engine is not running or is not running rapidly, suitable chambers 132 may be provided and supplied with elastic cushions, shown as springs 133. After the engine becomes free in its running the turbine will float in its bearings, as is well known.

The end of the bearing-casing is closed by a suitable cap 134, removably held in place by tap-bolts 135, and has within it a bushing 136, abutting at one portion the cap and resting against the split bushing 127, whereby the cap will hold the same in place. A suitable soft packing 138 may be provided at the inner end of the casing, so as to prevent air leaking into the chamber.

It will be noticed that one portion of the rings upon the shaft has radially-projecting faces 139 and faces 140 sloping toward one end and that the other portion has its radial faces projecting in the opposite direction, as are also the sloping faces, this affording bearings against thrust in different directions. One section of the thrust-bearing portion of the shaft is illustrated seated in a split bushing 141, held in place by means of a bushing 142, adjusted by a set-screw 143. The other section may be surrounded by a split bushing 144, having its end reduced to form a shoulder 145 to receive a head 146 of a set-screw 147. By means of the set-screws 143 and 147 the several bushings or sections constituting the thrust-bearing may be shifted longitudinally in the same direction or may be shifted in opposite directions, so as to adjust the position of the wheel and also to adjust its limit of movement or to prevent it having any movement in an axial direction. A number of oil-holes 148 are shown, and oil will be freely supplied to the bearing. The shaft may be surrounded with a number of oil-rings 149, running within a chamber 150, so that the centrifugal force will throw the oil into the chamber, which chamber is in communication with the chamber 40, which is connected with the exhaust, so that oil will be drawn into the bearing, the oil of course maintaining the bearings tight, so that they will not leak to disturb the vacuum; but the vacuum will have a tendency of keeping the parts well oiled by a continuous flow of oil, and the oil-rings will prevent the oil running along the shaft and getting into the parts of the device where it is not desired.

Fig. 4 is taken on about the position of the outermost oil-hole and shows the various bushings held in their place by means of a key 151. It will be noted that the key 128 not only holds the bushing 127 in place, but also the bushing 138.

It will of course be apparent that many details of construction may be made in practice without departing from the spirit of my invention, which is not limited to the precise details of the present illustration.

Having thus described my invention, I claim—

1. A turbine-engine having upon its rotary element a series of vanes; a series of ports of progressively-increasing area to admit an expansive fluid thereto and arranged at various points about the path of rotation of the said vanes; means to convey the fluid supplied to the vanes from one port to the next port in

the progression; a passage leading to the first port; a passage leading to a subsequent port in the progression; a single valve adapted to admit steam to either of said passages in impulses; and governor-controlled means to shift the range of activity of said single valve from one to the other of said passages.

2. A turbine-engine having upon its rotary element a series of working faces to receive the influence of an expansive elastic fluid; a series of ports of progressively-increasing area to admit the fluid thereto and arranged at various points about the path of rotation of the said series of faces; means to convey the fluid supplied to the working faces from one port to the next port in the progression; a chamber leading to the first port; a chamber leading to a subsequent port in the progression; a port in communication with each of said chambers; a single slide-valve for said ports; means to reciprocate the slide-valve, and means to change its region of reciprocation.

3. A turbine-engine having upon its rotary element a series of working faces to receive the influence of an expansive elastic fluid; a series of ports of progressively-increasing area to admit the fluid thereto and arranged at various points of utilization about the path of rotation of the said series of faces; means to convey the fluid supplied to the working faces from one port to the next port in the progression; means to supply the fluid to the first port; an exhaust normally connected with the last point of utilization; means controlled by the load to shift the supply to a subsequent port in the progression; and means controlled by the pressure in the exhaust to shift the connection of the exhaust to an earlier point of utilization.

4. In a turbine-engine, the combination with a series of vanes arranged at different points along the perimeter of a turbine-head, of means to supply steam to the rings at one end of the head, an exhaust at the other end of the head and means controlled by the pressure in the exhaust to exhaust the steam from a point intermediate the said supply and the said exhaust.

5. In a turbine-engine, the combination with a casing, of a rotary element supported therein; means for driving the rotary element by the action of an elastic fluid at successive expansive stages; means for producing a pressure toward the supply end of the engine; and means controlled by such rotary element for maintaining an equilibrium between said pressure, and pressures tending to move the rotary element in the opposite direction.

6. In a turbine-engine, the combination with a casing, of a rotary element supported therein, adapted to receive a pressure toward the discharge end, the diameters of successive portions of which decrease toward the discharge end receiving a pressure toward the supply end; means for driving the rotary element by the action of an elastic fluid at successive expansive stages and means for equalizing the said pressures.

7. In a turbine-engine, the combination with a casing, of a rotary element supported therein, the diameter of successive portions of which decreases toward the discharge end; a series of rings of vanes upon the perimeter thereof; means for supplying steam to said vanes, which when so supplied acts on the decreasing area of said rotary element to press the same toward the supply end of the engine; a chamber formed by the head of the rotary element and the casing at the supply end adapted to contain steam, causing a pressure toward the discharge end; and means for maintaining an equilibrium between said pressures.

8. In a turbine-engine, the combination of a casing carrying journal-bearings, of a turbine having journals supported by said bearings and embodying a drum portion, a series of rings of vanes upon the perimeter thereof to receive the reaction of steam at its successive expansive stages, the diameter of successive portions of the drum decreasing and having shoulders adjacent thereto with substantially radially extending faces directed away from the supply end of the engine; means to supply steam to the ring of vanes at the first stage; means to exhaust from the ring of vanes at the last stage; chambers formed by the drum, its respective shoulders and the casing and when containing steam tending to cause the turbine to press toward the supply end of the engine; a chamber formed by the head of the drum and the casing at the supply end; a chamber formed by the casing and the drum at the exhaust end; a conduit having a valve connecting said chambers at the respective ends of the drum; and means controlled by the turbine when the pressure upon the head of the drum at the supply end is not balanced by the pressure upon the said radial shoulders and the head of the drum at the exhaust end to actuate said valve.

9. In a turbine-engine, the combination of a casing carrying journal-bearings, of a turbine having journals supported by said bearings and embodying a hub portion, a series of rings of vanes upon the perimeter thereof to receive the reaction of steam at its successive expansive stages, the length of the vanes of the respective rings progressively increasing from stage to stage and the diameters of the portions of the hubs respectively carrying the same correspondingly decreasing and having shoulders adjacent thereto with substantially radially extending faces directed away from the supply end of the engine; means to supply steam to the ring of vanes at the first stage; means to exhaust from the ring of vanes at the last stage; chambers formed by the hub

and its respective shoulders and the casing and when containing steam tending to cause the turbine to press toward the supply end of the engine; a chamber formed by the head of the hub and the casing at the supply end; a chamber formed by the casing and the hub at the exhaust end; a conduit having a valve connecting said chambers at the respective ends of the hub; and means controlled by the turbine when the pressure upon the head of the hub at the supply end is not balanced by the pressure upon the said radial shoulders and the head of the hub at the exhaust end to actuate said valve.

10. In a turbine-engine, the combination with a casing having journal-bearings, of a turbine having journals carried by said bearings and embodying an enlarged hub, a series of rings of vanes upon the perimeter thereof to receive the reaction of steam at its successive stages, the length of the vanes increasing from the first stage to the last stage and the diameters of the portions of the hub respectively carrying the same correspondingly decreasing and having shoulders adjacent thereto with substantially radially extending faces such faces directed away from the supply end of the engine; means to supply steam to the first ring; means to exhaust from the last ring; chambers formed by the hub, its respective shoulders and the casing and when containing steam tending to cause the turbine to shift on its journals toward the supply end of the engine; a chamber formed by the head of the hub and the casing at the supply end and adapted to receive leakage steam; a chamber formed by the casing and the hub at the exhaust end and open to the exhaust; a conduit having a valve connecting said chambers at the respective ends of the hub; and means controlled by the turbine in its movement incident to the unbalancing of the pressure between such radial shoulders and the head of the hub at the exhaust end and the head of the hub at the supply end to open and close said valve and maintain the balance.

11. In a turbine-engine, the combination with a casing having journal-bearings, of a turbine having journals carried by said bearings and embodying a series of rings upon the perimeter thereof to receive the reaction of steam at its successive stages, the turbine having shoulders with substantially radially extending faces such faces directed away from the supply end of the engine; means to supply steam to the first ring; means to exhaust from the last ring, chambers formed by the turbine, its respective shoulders and the casing and when containing steam tending to cause the turbine to shift on its journals toward the supply end of the engine; a chamber formed by the head of the turbine and the casing at the supply end and adapted to contain steam; means to supply steam thereto; a chamber formed by the casing and the head of the turbine at the exhaust end and open to the exhaust; a conduit having a valve connecting said chambers at the respective ends of the turbine; and means controlled by the turbine in its movement incident to the unbalancing of the pressure between such radial shoulders and the head of the turbine at the exhaust end and the head of the turbine at the supply end to open and close said valve and maintain the balance.

12. In an engine, the combination with a casing, of a wheel rotatable therein; means for driving the wheel by the influence of steam; a shaft upon which the same is mounted; and a valve controlled by such shaft in its longitudinal movement to equalize the pressure tending to move the shaft endwise.

13. The combination with a casing, of a shaft; a steam-driven wheel mounted upon the shaft and located within the casing and making compartments at each end thereof; and means controlled by the longitudinal movement of the shaft incident to unequal pressures within such chambers at the heads of the wheel to open and close a port between such chambers.

14. In a steam-engine the combination with a casing, of a turbine journaled therein and having an amount of play longitudinally of its journals; an exhaust open to the casing at one side of the turbine, a compartment within the casing at the other side thereof, and means controlled by the longitudinal movement of the journals to balance the pressure upon the respective sides of the turbine.

Signed at Nos. 9 to 15 Murray street, New York, N. Y., this 18th day of December, 1903.

ELMER S. FARWELL.

Witnesses:

CHAS. LYON RUSSELL,

FRED. J. DOLE.