No. 822,798. PATENTED JUNE 5, 1906.

J. WILKINSON.

TURBINE AND CONTROLLER MECHANISM THEREFOR.

APPLICATION FILED SEPT. 26, 1904.

2 SHEETS—SHEET 1.

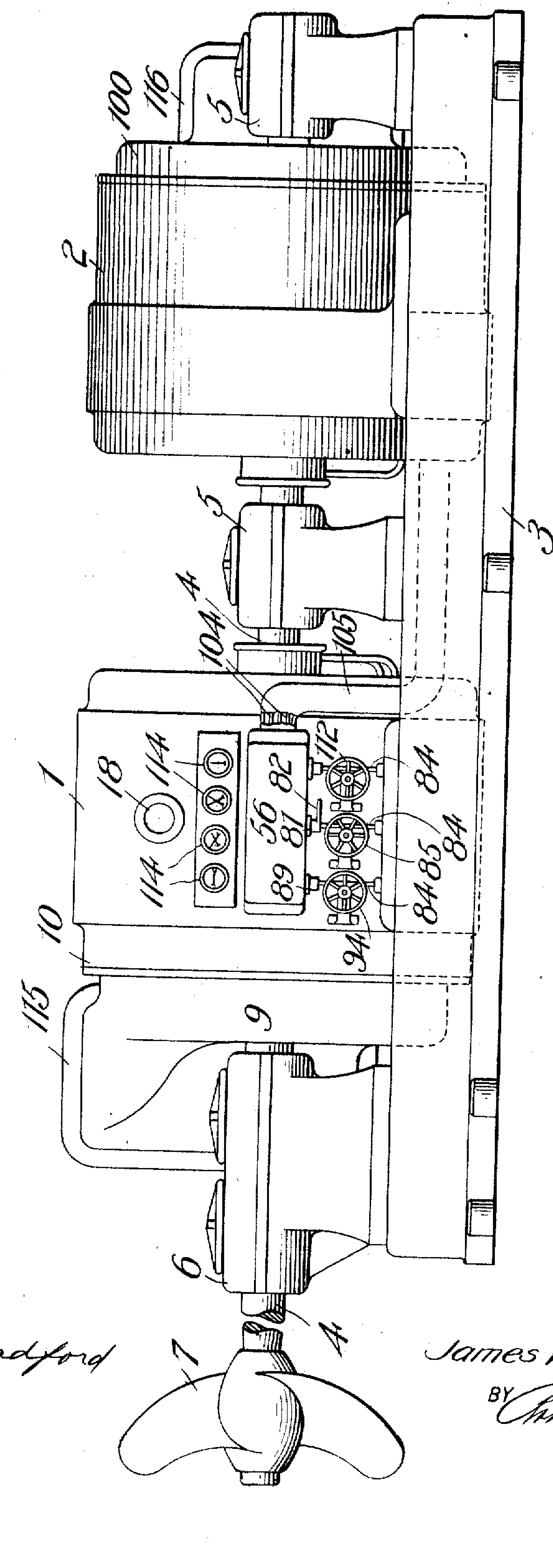

Fig. 1.

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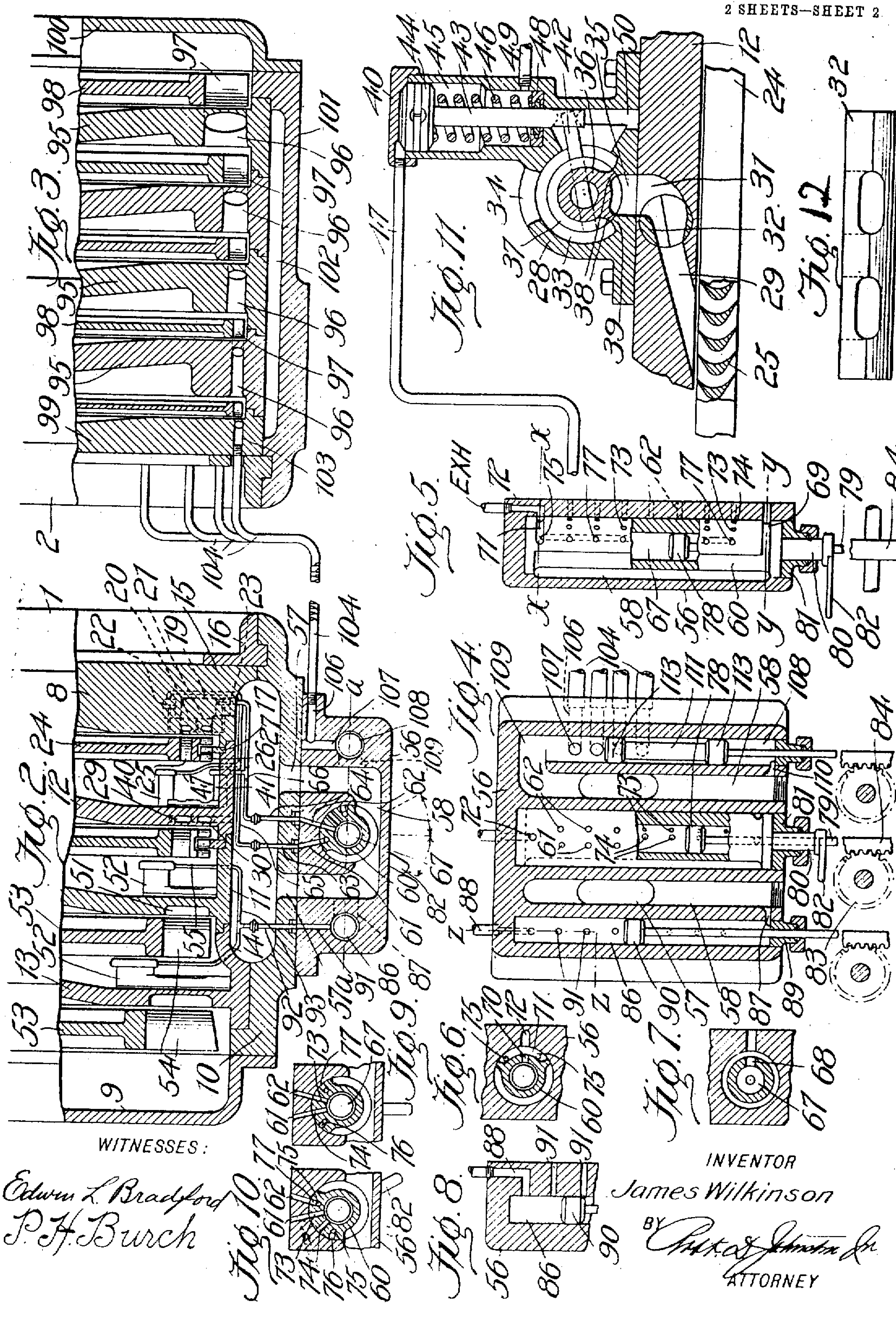

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TURBINE AND CONTROLLER MECHANISM THEREFOR.

No. 822,798. Specification of Letters Patent. Patented June 5, 1906.

Application filed September 26, 1904. Serial No. 226,017.

To all whom it may concern:

Be it known that I, James Wilkinson, a citizen of the United States, residing at Birmingham, in the county of Jefferson and State of Alabama, have invented new and useful Improvements in Turbines and Controller Mechanism Therefor, of which the following is a specification.

My invention relates to elastic-fluid turbines and controller means therefor.

In Letters Patent heretofore issued to me I have shown and described a compound turbine of the jet type operating by stage expansion and provided with two or more independent sets of working passages which act to drive the turbine in the same direction at different speeds.

It is one object of my present invention to simplify the construction and arrangement of these working passages by providing one or more of the high-pressure stages with these independent sets of working passages, while the other low-pressure stages have but one set of working passages which coöperate with either or both of the sets of high-pressure passages. Broadly considered, this feature of my invention contemplates providing a turbine of any type with a working passage which is divided at its supply end, there being different arrangements of buckets in the divided portions of the working passage. I am thus enabled to vary the number of rows of buckets against which the motor fluid acts in its passage through the turbine by passing it through one or the other of the sets of initial buckets arranged in the divided portion of the working passage. The arrangement and number of rows of buckets in the initial working passages may be varied to suit different requirements or to produce different effects as to speed or power.

To control a turbine of the character above described, it is essential that the valves controlling the single set of working passages in the low-pressure stages should be operated independently of the valves for the two sets of working passages leading through the high-pressure stage or stages. To this end I provide an improved controller mechanism, preferably utilizing fluid-pressure as a means to effect the desired control of the valves of the two sets of working passages, and an independent controller mechanism, also utilizing fluid-pressure for regulating the flow of motor fluid through the low-pressure stages.

It is a further object to improve the construction of the motors for operating the turbine-valves and also the manner of forming the nozzle-passages in the supply-heads for the several wheel-compartments.

I have shown the improvements hereinbefore described embodied in a two-speed forward-driving turbine, which is more particularly designed for marine propulsion, where it is preferably used in combination with a reversing turbine connected to its shaft.

It is a further object of my invention to supply motor fluid to this reversing turbine by conduits communicating with the supply-chamber of the forward-driving turbine and successively opened and closed by a valve preferably forming a part of the compound controller mechanism for the forward-driving turbine.

It is a further object to provide the reversing turbine with a strengthening-shell surrounding the inner casing thereof and to provide a dead-air chamber between the shell and casing to prevent the radiation of heat therefrom.

The construction and arrangement of parts hereinafter described, and illustrated in the drawings, constitute a preferable embodiment of my invention, it being understood that the details of construction may be varied and such substitution of equivalents made as is within the spirit of my invention.

According to the drawings, Figure 1 is a side elevation of a compound marine turbine comprising a two-speed forward-driving and a single-speed reversing turbine mounted upon a common shaft and provided with a common controller mechanism. Fig. 2 is an enlarged view of the two-speed turbine broken away and shown partly in section through the controller mechanism. Fig. 3 is a similar view of the reversing turbine. Fig. 4 is a section through the controller mechanism along the line *a a* of Fig. 2, showing the rotary valve-shell partly in section and broken away to indicate the arrangement of ports in its seat. Fig. 5 is a transverse vertical section through the middle controller-chamber of Fig. 4, the rotary shell appearing in side elevation partly broken away. Fig. 6 is a section through the line $x\,x$, and Fig. 7 is a section through the line $y\,y$ of Fig. 5. Fig. 8 is a section along the line $z\,z$, Fig. 4. Figs. 9 and 10 are broken-away sectional views showing the controller-valve shell in different operating positions. Fig. 11 is an enlarged detail view in section of one of any desired number of nozzle-passages with the motor-actuated valve therefor, the motor shown being one adapted for use in high or low pressure stages. Fig. 12 is a detail view of the part forming an intermediate portion of a pair of nozzles.

Similar reference-numerals refer to the same parts throughout the drawings.

The two-speed forward-driving turbine 1 and the reversing turbine 2 are mounted upon a bed-plate 3 and drive a common shaft 4, mounted in suitable bearings 5 and 6 and carrying a propeller 7.

Referring to Fig. 2, the two-speed forward-driving turbine comprises a supply-head 8 and exhaust-head 9, which latter is connected to a shell 10, which surrounds the inner casing formed by the abutting flanged peripheries 11 of the dished diaphragm-partitions 12, which divide the interior of the turbine into stages or wheel-compartments. The low-pressure diaphragm 13 projects beyond the intermediate diaphragms, its flanged periphery being seated in a cut-away portion of the shell and provided with an inwardly-disposed flange 14, which interlocks with a flange of the adjacent diaphragm. The supply-head 8 has an overhanging shoulder 15, which abuts against the shell, being held in place by a locking-ring 16, engaging a channel in the end of the shell. The inner periphery of the shell itself is cut away, so that a chamber 17 is formed between the inner casing and the shell to which motor-fluid pressure is supplied by a port 18. From the chamber 17 the motor-fluid pressure flows through a plurality of radially-disposed passages 19 (one of which is shown in dotted lines, Fig. 2) and enters a plurality of nozzle-passages disposed in two sets at different radial distances from the shaft-center. The construction and arrangement of these nozzle-passages and of the rotary fluid-actuated valves for controlling the admission of motor fluid thereto is more fully explained in my Letters Patent No. 752,496. Briefly described, the valves 20 control the inner set of supply-passages and the valves 21 the outer set, both sets of valves being disposed in the supply-head and connected to stems of pistons disposed in motors 22 and 23, respectively. The cylinders for these motors may be formed in the head or inserted therein in any desired manner. The sets of supply-nozzle passages for the first stage, which are controlled by the valves 20 and 21, discharge motor fluid against a bucket-wheel 24 in the first stage. This wheel has an inner row of buckets 25 coöperating with the inner set of supply-nozzles and a double row of buckets 26 coöperating with the outer set of supply-nozzles and having disposed between them a stationary row of intermediate buckets mounted upon a body portion 27, which is held in position between the interlocking shouldered portion of the supply-head and the peripheral flange 11 of the first diaphragm. This secures the set of intermediates firmly in place and at the same time enables them to be readily removed when the machine is taken apart. The body portion 27 is preferably in the form of a segmental ring.

Heretofore in patents issued to me I have shown the diaphragm-partitions provided with thickened peripheral shoulders which were recessed or chambered to receive the stage-valves and their actuating-motors. According to my present construction I dispense with this shoulder, leaving only the flange 11, which corresponds in height with the dip of the diaphragm, which has a pronounced dish to increase its strength. It will be noted that these flanges 11, which at their upper ends are shouldered to interlock with the preceding head-diaphragm and hold a set of intermediates in place, leave space below the bucket-wheel for the reception of a valve and motor casing 28, which is bolted or otherwise secured to the top of the diaphragm adjacent to its flange. From the first stage or wheel compartment two sets of nozzle-passages 29 and 30 lead through the first diaphragm and discharge motor fluid respectively against buckets 25 and 26 of bucket-wheel 24 in the second stage or wheel compartment. I preferably form these stage-nozzle passages as shown in Fig. 11. The bowl or admission end 31 of each nozzle is cut downwardly into the diaphragm in any desired manner and a plug 32, provided with a transverse channel, inserted radially into the diaphragm, so that the channel in the plug forms the curved intermediate portion of the nozzle-passage and the rounded entrance of the nozzle proper, as 29 or 30. The nozzles 29 and 30 when disposed in radial alinement may have their rounded entrances formed by the same plug, which will be driven radially through each pair of nozzles. This arrangement greatly simplifies the construction of curved nozzle-passages, which are desirable in my present construction.

Referring now to the valve and motor casing 28 for the first stage, this comprises two valve-chambers 33, communicating through ports 34 with the stage-compartment and through ports 35 with the bowls 31 of two nozzles 29 and 30. A rotary valve 36 is disposed within each valve-chamber, having circular end portions 37 disposed within circular seats at either end of the valve-chamber. The valve is adapted to be inserted into its chamber through one end thereof. The valves are reduced to leave two parallel lips 38, which when they are closed engage pairs of shoulders 39, disposed on each side of the ports 35. In each compound casing the valve for the nozzle 29 is operated by a motor 40 and the valve for the nozzle 30 is operated by an independent motor 41. The valves and motors are similar in construction and arrangement, and only one will therefore be described. By reference to Fig. 11 it will be seen that a valve 36 is connected by a crank 42 with the stem 43 of a piston 44, disposed in a chamber 45, which is formed in the compound casing as a preferred form. The piston-cylinder is beveled at each end and the piston itself has beveled faces, the lower end of the cylinder being of reduced diameter and provided with an opening through which the stem 43 passes. The manner in which the operation of these pistons may be controlled differs according to the pressure of the stage and other conditions. I have shown one form in Fig. 11, wherein a spring 46 engages the under face of the piston, tending to move the valve to its closed position, while a pipe 47 enters the upper end of the cylinder and, subject to a controller mechanism hereinafter described, admits a high pressure against the upper beveled face of the piston, tending to move it to a lowered position to open the valve. When the spring acts against the piston in opposition to pressure admitted by the pipe 47, it is evident that if a high stage-pressure have access to the lower side of the piston the controller-pressure will not be sufficiently in excess of the combined action of spring and stage pressure to insure a positive opening movement for the valve. It is therefore necessary to expose the piston below to a low pressure, and I accordingly use packing 48 around the stem 43 to prevent the entrance of stage-pressure to the cylinder, which has a port 49, adapted to communicate with a low or atmospheric pressure in any desired manner. It is obvious, however, that if the spring be so placed as to coöperate with the pressure admitted through pipe 47 that the cylinder could then be opened to the stage-pressure below and the packing and port 49 dispensed with. This construction may be used in all intermediate stages. When the motor is operating in a stage where the pressure is below that of the atmosphere, the port 49 may be used to admit the atmosphere to assist the spring 46 in closing the valve. The lower end of the stem 43 and the crank 42 move in a chamber 50, which leads from the valve-chamber 33.

One or more of the high-pressure stages may be provided with double sets of nozzles and compound valve and motor casings, which act to independently control the discharge of motor fluid between stage-compartments. To simplify construction, it is my purpose to control the flow of motor fluid through the remaining stages by means of single sets of nozzle-passages 51 and valves 36 therefor, mounted in single valve and motor casings 52. The bucket-wheels 53 for the low-pressure stages will therefore be provided with a single set of buckets 54, arranged at the same distance from the shaft center. As many stages as desired may be provided with these single sets of nozzle-passages, and the motors for controlling them will correspond in construction and operation with the motors already described. Controller fluid-pressure is admitted to the piston-cylinders in these latter casings through pipes 55. I have shown but one each of the inner and outer sets of working passages leading through the several stages, it being considered unnecessary to duplicate the description for the several sets of working passages with which the turbine is preferably provided. It will be noted hereinafter by reference to the controller mechanism that the turbine 1 is preferably provided with seven each of the several sets of supply and stage valves.

The controller mechanism for the turbine 2 comprises a casing 56, communicating with the fluid-pressure-supply chamber 17 through two ports 57, leading through the shell 10 and communicating with a passage 58, which leads over a central shoulder 59 in the casing, which serves as a seat for the rotary valve-shell 60. The seat in the shell is preferably formed as a semicircular groove in the shoulder 59, through which lead two rows of ports 61 and 62, which respectively communicate with pipes 63 and 64, connected by couplings with the pipes 65 and 66. The pipes 65 by suitable couplings connect with the several pipes 47, leading to the motors 40, and also with channels leading through the supply-head and entering the motor-cylinders 22. The pipes 66 by similar branch connections communicate with the motor-cylinders 41 and 23. The valve-shell 60 is provided with an inner cylindrical chamber 67, communicating at one end through a port 68, Fig. 7, with a groove 69 opening into the high-pressure chamber 58. At its other end the chamber 67 communicates by a port 70, Fig. 6, with a channel 71, which opens through a port 72 to the atmosphere or other source of low pressure. The shell 60 is reduced over its upper portion, leaving a lower segmental shouldered portion which engages the multiported seat. This shouldered portion is provided with two rows of ports 73 and 74, which lead from the chamber 67 and are adapted to register with one or the other, or both, of the rows of ports 61 and 62 in the seat 59. Two longitudinal passages 75 lead from the exhaust-channel 71 and communicate, respectively, with rows of by-passage exhaust-ports 76 and 77, disposed on each side of and equidistant from the rows of ports 73 and 74. A piston 78 moves pressure-tight within the chamber 67, having a stem 79, which passes out through a tubular spindle 80, formed integral with the valve-shell 60. This spindle projects through a removable plug 81, suitable packing means being used to prevent the escape of pressure around it from the chamber 58. A crank 82, connected to the spindle, acts to move the shell, so that, as seen in Fig. 2, its row of ports 74 register with the ports 62, while the exhaust-ports 76 communicate with the ports 61. In Fig. 9 it will be seen that the ports 73 and 74 register with the ports 61 and 62, while in Fig. 10 the exhaust-ports 77 register with ports 62, while ports 73 communicate with ports 61. It being noted that the ports 61 and 62 communicate through pipe connections with the independent sets of valve-motors for the inner and outer working passages, respectively, it will be seen that whenever either set of ports 61 or 62 are exposed to the low or exhaust pressure through the ports 76 or 77, passages 75, and exhaust-port 72 the valve-motors to which they are connected will move the valves 36 under their control by springs or stage-pressure to a closed position, as seen in Fig. 11.

By moving the crank 82 to one or the other of its three operating positions I can cut the inner or the outer set of working passages out of service or admit fluid-pressure to both of them simultaneously. To control the admission of motor fluid to the active working passages, I provide a gear-wheel 83, which meshes with the rack 84, connected to or formed integral with the stem 79 for the piston 78. A wheel 85 is used to turn the gear 83, and by shifting the piston 78 back and forth in its cylinder I admit the high or low pressure successively to the ports in the valve-shell and through the communicating passages to the valve-motors.

The controller mechanism for the low-pressure stages comprises a controller-chamber 86, preferably formed in one side of the casing 56 and communicating at one end with the pressure-chamber 58 through a port 87. At its other end the chamber is exposed to the exhaust-pressure through a passage 88, Fig. 8. A removable plug 89 closes the other end of the cylinder and serves as a packing for the stem of piston 90, which moves pressure-tight within the chamber and admits the high and low pressure to a series of ports 91, leading through the casing and communicating with the pipes 92. These pipes are suitably coupled to pipes 93, which lead through the flanges 11 and 14 of the low-pressure diaphragms and connect with the cylinders in the valve-casings 52. The operation of the valves and motors in these latter casings being identical with those described in the high-pressure stages, it follows that the admission of high or low pressure through the pipes 93 will cause the valves to open or close in accordance with the position of piston 90. This latter piston is operated by a wheel 94 through a gear and rack similar to 83 and 84. By this means I provide an independent control for the single set of working passages of the low-pressure stages by means of which I can adjust the volume of motor fluid flowing through them in accordance with the volume of motor fluid passing through the high-pressure stages. Thus when motor-fluid pressure is flowing through the full-speed working passages a greater number of low-pressure valves will be opened than when the low or cruising speed working passages are in action, and similarly a greater number of low-pressure stage-valves will be opened when both sets of high-pressure working passages are thrown open to compensate an overload condition.

I have thus described the construction and arrangement and a preferred mechanism for controlling the turbine 1, which may be used independently of other turbines or as shown in combination with the reversing turbine 2, which I shall now describe.

The turbine 2 comprises a series of shouldered diaphragms 95, through which lead nozzle-passages 96, adapted to discharge motor fluid against rows of buckets 97, carried by bucket-wheels 98, one of which is disposed within each compartment. The interlocking peripheries of the diaphragms form the inner casing of which the supply-head 99 and exhaust-head 100 are engaged and held in place by a shell 101, corresponding with shell 10. The chamber 102, formed between the shell and casing, serves as a dead-air chamber to prevent excessive radiation of heat from the turbine. Motor-fluid pressure is admitted to this turbine through four nozzle-passages 103, leading through the supply-head and communicating with pipes 104, which are disposed within the casing 105, through which they lead to a series of passages 106 in casing 56. Each of passages 106 communicates with a port 107, leading from a chamber 108 in the opposite side of the controller-casing from chamber 86. The high pressure in passage 58 enters both ends of chamber 108 through passage 109 and port 110, so that the controller-piston 111 therein is practically balanced. This piston is operated under the control of a wheel 112 in the manner described for the other pistons. The piston 111 comprises two heads 113 between which its body portion is reduced, the distance between the heads being sufficient to cut off the admission of high pressure to all of the ports 107 simultaneously or to each of them successively. In this manner the motor-fluid supply to the turbine 2 flows directly from the chamber 58 of the turbine 1 to the pipes 104 through the supply-nozzles 103, its volume being controlled by the position of the piston 111.

The principles of operation of my present invention may be carried into effect in connection with turbines employing a plurality of rows of buckets mounted equidistant from the shaft-center on the bucket-wheels of each stage, and also where the several stage-compartments are formed in separate shells or casings or even where the high-pressure stages provided with two sets of working passages are disposed in one casing, while the low-pressure stages operating in series therewith and having a single set of working passages are disposed in a separate casing. It may also be adapted for use in turbines of the reaction type or where a portion of the working passage acts with reaction effect. I provide each compartment or stage of turbine 1 with a pressure and temperature indicator 114, mounted, preferably, above the controller-casing 56 on the shell 10.

The exhaust-heads 9 and 100 of the two turbines communicate through passages 115 and 116, respectively, with the atmosphere or with a condenser, as may be desired. When driving a propeller, the bearing 6 of the turbine-shaft will be of any desired type of thrust-bearing. The port 117 (shown in Fig. 3) may be used to drain the water of condensation in chamber 58 into the chamber 17, from which it may be withdrawn by a steam-trap or in any suitable manner. The chambers 86 and 109 will be also drained by this means.

To simplify construction, the plug 32 may be split at one end and spread apart to enable the portions thereof to be machined or cut out to form the apertures.

Though I have shown the valve-casings and motor-cylinders as formed integral, it is to be understood that they may be formed separately and connected in any suitable manner, or the two may be independently connected to the diaphragms. These and other changes may be resorted to without departing from the spirit of my invention, it being my intention to claim and protect, broadly herein, the novel features of construction and arrangements of parts hereinbefore described.

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

1. In an elastic-fluid turbine operating by stage expansion, the combination with two sets of supply-nozzle passages for the turbine and independent sets of movable buckets coöperating respectively with said sets of nozzle-passages, of a single set of stage-nozzle passages and movable buckets coöperating therewith.

2. In an elastic-fluid turbine, the combination of movable buckets and coöperating nozzle-passages operating by stage expansion, said nozzle-passages and buckets for one or more of the high-pressure stages being arranged in independent coöperating sets designed to produce different speeds of shaft rotation, while the nozzle-passages and buckets for a low-pressure stage or stages are arranged in a single set which coöperates with either or both of the sets of nozzle-passages and buckets in the high-pressure stage or stages.

3. In an elastic-fluid turbine operating by stage expansion, nozzle-passages and movable buckets forming independent working passages, across the high-pressure stage or stages, which merge into a common working passage across the low-pressure stage or stages.

4. In a multicellular turbine, the combination of movable buckets and coöperating nozzle-passages operating by stage expansion, the buckets being arranged in independent sets at different distances from the shaft-center in one or more of the high-pressure stages only.

5. In an elastic-fluid turbine operating by stage expansion, a set of movable buckets and one or more coöperating nozzles for each stage, and a second set of movable buckets and one or more coöperating nozzles for a high-pressure stage.

6. In an elastic-fluid turbine operating by stage expansion, a bucket-bearing element for each stage, a double set of buckets for a high-pressure stage or stages and a single set for the other stage or stages carried by said elements, one or more nozzles coöperating with each set of buckets, and stationary intermediates between the rows of buckets comprised in one of the sets of buckets for a high-pressure stage or stages.

7. In an elastic-fluid turbine operating by stage expansion, the combination with two sets of nozzles for the high-pressure stage or stages which are disposed at different distances from the shaft, independent valve means to control each set of nozzles, two sets of buckets in said stages which coöperate with said nozzles to drive the turbine with equal efficiency at different speeds, and means to control the flow of motor fluid through said nozzles, of movable buckets and coöperating nozzles for the low-pressure stage or stages, and independent means to control the flow of motor fluid through said latter nozzles.

8. In a controller mechanism for an elastic-fluid turbine operating by stage expansion, the combination with fluid-actuated valve means to control the flow of motor fluid through the turbine, of a controller-chamber for the valves supplying motor fluid to the high-pressure stage or stages, a separate controller-chamber for the valves supplying motor fluid to the low-pressure stage or stages,

independent controller-valve means within said chambers, and means to transmit pressure from said chambers to said valve means, for the purposes described.

9. In an elastic-fluid turbine operating by stage expansion, the combination of two independent sets of coöperating nozzles and buckets for the first stages, of single sets of coöperating nozzles and buckets for the other stages, a fluid-pressure-controller means adapted to control the admission of motor fluid to one or the other, or both of said sets of nozzles in the first stages, and an independent controller means for regulating the flow of motor fluid through the other or low-pressure stages.

10. In an elastic-fluid turbine, the combination with coöperating nozzles and movable buckets operating by stage expansion, of fluid-pressure-actuated valve means for controlling the supply of motor fluid to the several stages, and fluid-pressure controller mechanism for one or more of the high-pressure stages, and an independent fluid-pressure-controller mechanism for the low-pressure stage or stages.

11. In a multicellular turbine, one or more nozzles and a coöperating set of buckets for one or more of the high-pressure compartments, a second nozzle or nozzles and set of coöperating buckets for said compartments, said nozzles and buckets being adapted to operate by stage expansion to produce forward motion at different speeds, a fluid-pressure-controller mechanism adapted, under normal load conditions, to regulate the admission of motor fluid against one of said sets of buckets, while cutting off the supply from the other set, and also adapted, under overload conditions, to simultaneously admit motor fluid against both sets of buckets, in combination with a set of nozzles and coöperating buckets for each of the other compartments, and an independent controller mechanism adapted to vary the volume of motor fluid discharged against the buckets in said latter compartments.

12. In an elastic-fluid turbine operating by stage expansion and adapted to drive a shaft in one direction at different speeds, the combination of buckets and nozzles forming full-speed working passages through one or more of the high-pressure stages, independent nozzles and buckets forming low-speed working passages through the same stage or stages, and nozzles and buckets forming a single set of working passages leading through the low-pressure stages and adapted to coöperate with either the full or low speed working passages or both, independent valves to control the said nozzles, a controller mechanism for the full and low speed nozzles, and means to open and close the nozzle-passages for the low-pressure stages independently of said controller mechanism.

13. In a controller mechanism for a turbine provided with two independent sets of working passages comprising each a set of movable buckets and one or more coöperating nozzles, fluid-pressure-actuated valves for said nozzles, conduits to conduct fluid-pressure to actuate said valves, and a controller-valve provided with two sets of ports adapted to admit high pressure to said conduits in one of the valve's operating positions, and ports in said valve communicating with exhaust-pressure and adapted to expose the conduits leading to the valves of one of said sets of working passages to said exhaust-pressure when the controller-valve is in either of its other operating positions.

14. In a controller mechanism, a controller-chamber formed in a movable casing, two sets of ports in said casing, means to admit high and low pressures to opposite ends of said chamber, a valve movable therein to control the admission of said pressures to said ports, two longitudinal passages formed in said casing and communicating with an exhaust-pressure, openings leading through the shell to said passages, and a plurality of conduits for communicating high or low pressure to fluid-actuated means within the turbine for controlling the flow of motor fluid, said conduits being so arranged that they may be all in communication with the ports in said casing or part in communication with said exhaust-openings, while the rest communicate with said ports.

15. In a controller mechanism for an elastic-fluid turbine operating by stage expansion, the combination of a pressure-supply chamber for the turbine, a controller-chamber communicating at two points with said pressure-chamber, a passage in said casing connecting with two ports and leading over a shoulder in said casing, a valve-seat formed in said shoulder and provided with a plurality of ports which communicate with conduits leading to the fluid-actuated means within the turbine, a valve movably mounted on said seat, and means to operate said valve.

16. In an elastic-fluid turbine operating by stage expansion, a fluid-pressure controller mechanism for the supply-valves in one or more of the high-pressure stages, and independent fluid-pressure controller mechanism for the supply-valves of the other or low-pressure stages, said mechanism comprising two controller-chambers formed in a common casing and communicating with a source of high pressure, and controller-valve means disposed within said chambers and adapted to be independently operated.

17. In an elastic-fluid turbine operating by stage expansion, two fluid-pressure controller mechanisms for the stage-supply valves, said mechanism comprising two controller-chambers disposed within a suitable

casing, ports admitting high pressure to said chambers, ports admitting low pressure to said chambers, a piston-valve movable in each chamber, and ports leading therefrom which are exposed to one or the other of said pressures by said pistons, and conduits adapted to communicate with said ports and with means for operating the turbine-valves.

18. In a compound turbine, the combination of a high-pressure forward-driving turbine, and a reversing turbine, with a motor-fluid-supply passage for the high-pressure turbine, a chamber communicating therewith, a plurality of conduits leading from said chamber and communicating with supply-nozzles for the reversing turbines, and valve means to control the admission of motor fluid to said conduits.

19. In a compound turbine comprising a forward-driving turbine and a reversing turbine, a controller-chamber for said forward-driving turbine, means to admit high pressure thereto, valve means therein to control the admission of said high pressure to valve-actuating means, a chamber communicating with said high pressure, ports therein, conduits connecting said ports with supply-nozzles for the reversing turbine, and a valve in said latter chamber for controlling the admission of high pressure to said ports for the purpose of regulating said reversing turbine.

20. In a compound turbine comprising a forward-driving and a reversing turbine, a controlling-casing comprising a controller-chamber for the forward-driving turbine and a supply-chamber for the reversing chamber, means to admit high pressure to said chambers, means to conduct said pressure from the supply-chamber for said reversing turbine to the supply-nozzles thereof, and means to control the volume of the motor-fluid supply to said reversing turbine.

21. In an elastic-fluid turbine, a nozzle-passage leading through a stationary part thereof, and means inserted into said nozzle-bearing part transversely to said nozzle-passage and adapted to form a stationary part of the rounded entrance to the discharge end of the nozzle-passage.

22. In an elastic-fluid turbine, a supply-head for a wheel-compartment, a nozzle-passage formed therein and comprising an admission end from which the nozzle proper leads obliquely through said head, and a plug fixed in said head transversely to said nozzle-passage and adapted to form the rounded entrance to the nozzle proper.

23. In an elastic-fluid turbine, a nozzle-passage formed in a stationary part, said passage comprising an admission end and a discharge end leading at an angle through said stationary part, and a valve controlling the flow of fluid through said passage the combination with an apertured plug inserted substantially radially into said stationary part, the aperture in said plug being adapted to form an intermediate part of said nozzle-passage.

24. In an elastic-fluid turbine, a supply-head for a wheel-compartment, a nozzle-passage leading in a curved direction through said head, an opening in said head intersecting said nozzle-passage, and a split plug inserted therein and adapted to form an intermediate part of the nozzle-passage.

25. In an elastic-fluid turbine, a plurality of nozzle-passages disposed at different distances from the shaft-center, a stationary element through which said passages lead, an opening in said element which intersects a plurality of said passages at an intermediate point, and means inserted in said opening to form an intermediate part of said nozzle-passages.

26. In an elastic-fluid turbine, a stationary element provided with two nozzle-passages at different distances from the shaft-center, an opening leading inwardly into said element and intersecting said two nozzle-passages at an intermediate point, and a plug provided with cut-away portions which is adapted to be inserted into said opening, the cut-away portions of said plug, forming intermediate parts of both nozzle-passages.

27. In an elastic-fluid turbine, a supply and an exhaust head for a wheel-compartment, a bucket-wheel disposed within said compartment and provided with a plurality of rows of buckets, a set of intermediate buckets and means to support said intermediates comprising a supporting portion or portions, and intersecting flanges carried by said heads between which said supporting portion or portions are held in place.

28. In an elastic-fluid turbine subdivided into stages by diaphragm-partitions, a supply-head, said supply-head and diaphragms being provided with peripheral flanges which are adapted to abut and which form the casing of the turbine, said flanges being cut away at their abutting portions to form recesses, and stationary buckets having a supporting portion disposed within said recesses and held in place between said flanges, in combination with movable buckets within the stages.

29. In a sectional elastic-fluid turbine having an inner casing, a shell surrounding said casing and carrying inwardly-disposed projections between which the sections of the casing are held together, and a dead-air chamber formed between said shell and casing to prevent the radiation of heat from the turbine.

30. In an elastic-fluid turbine, a diaphragm-partition therein, and a detachable element comprising a valve-bearing portion and motor-cylinder connected to said diaphragm.

31. In an elastic-fluid turbine having a diaphragm-partition, a nozzle leading there-

through, a valve-casing mounted on said diaphragm and communicating with said nozzle-passage, and a valve therein for cutting said nozzle out of service.

32. In an elastic-fluid turbine having one or more diaphragm-partitions, a plurality of nozzle-passages leading through each diaphragm, valves for controlling said nozzle-passages mounted in casings seated upon and detachably connected to said diaphragm or diaphragms.

33. In an elastic-fluid turbine having one or more diaphragm-partitions, a plurality of nozzle-passages leading through each diaphragm, valves for controlling said nozzle-passages mounted in casings seated upon and detachably connected to said diaphragms and means to control the independent operation of said valves.

34. In an elastic-fluid turbine having one or more diaphragm-partitions, a plurality of nozzle-passages leading through each diaphragm, valves for controlling said nozzle-passages mounted in casings seated upon and detachably connected to said diaphragms, and fluid-pressure means to open and close said valves independently.

35. In an elastic-fluid turbine operating by stage expansion, the combination with diaphragms and nozzle-passages leading therethrough, of means to control the flow of motor fluid through the stages comprising a plurality of valve and motor casings detachably connected to said diaphragms and disposed within the stages, fluid-pressure-actuated valves in said casings, and conduits to conduct controller-fluid pressure to said motors.

36. In an elastic-fluid turbine divided into stages by a diaphragm, a nozzle-passage leading through said diaphragm, a detachable valve-casing mounted on said diaphragm and provided with ports through which the stage-pressure enters said nozzle-passage, a valve in said casing to cut said nozzle out of service, and a fluid-motor, to operate in said valve, which is removable with said valve-casing.

37. In an elastic-fluid turbine operating by stage expansion, a diaphragm therein, nozzle-passages in said diaphragm, a plurality of compound valve and motor casings mounted on said diaphragm, valves in said casings to control the admission of motor fluid to said nozzles, and conduits to supply an actuating-fluid pressure to the motor-pistons.

38. In an elastic-fluid turbine, a diaphragm-partition therein provided with a nozzle-passage, a valve-casing mounted on said diaphragm and through which the motor-fluid pressure enters said nozzle-passage, a rotary valve in said casing, a stem for operating said valve, a piston connected to said stem and disposed within a cylinder formed integral with said casing, and means utilizing fluid-pressure to control the operation of said piston.

39. In an elastic-fluid turbine divided into stages by a dished diaphragm having a peripheral flange and provided with a nozzle-passage between stages, the combination therewith of a valve-casing, a valve therein, and a motor for actuating said valve detachably connected to said diaphragm at a point adjacent to said flange, a bucket-wheel for each stage between which and said diaphragm said valve and motor are disposed, and means to connect said motor with a controller mechanism.

40. In a set of turbines, the combination with a forward-driving turbine operating by stage expansion and having independent full and cruising speed working passages leading through the high-pressure stages, and a single set of working passages leading through the low-pressure stages and coöperating with either or both of said first-mentioned working passages, of a reversing turbine connected to the shaft of said forward-driving turbine.

41. An elastic-fluid turbine provided at its high-pressure end with two independent working passages comprising differently-arranged sets of buckets, and means to supply motor fluid thereto, in combination with a single working passage at the low-pressure end of the turbine comprising buckets and stationary guide devices which are supplied with the motor fluid after flowing through one or the other of said high-pressure working passages.

42. An elastic-fluid turbine provided with independent sets of buckets and means to supply fluid thereto, in combination with a working passage adapted to be supplied with the motor fluid after it has acted upon either or both of said sets of buckets, said sets of buckets being adapted to produce different driving effects.

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

JAMES WILKINSON.

Witnesses:

H. M. HARTON,

NOMIE WELSH.