

Oct. 26, 1926.

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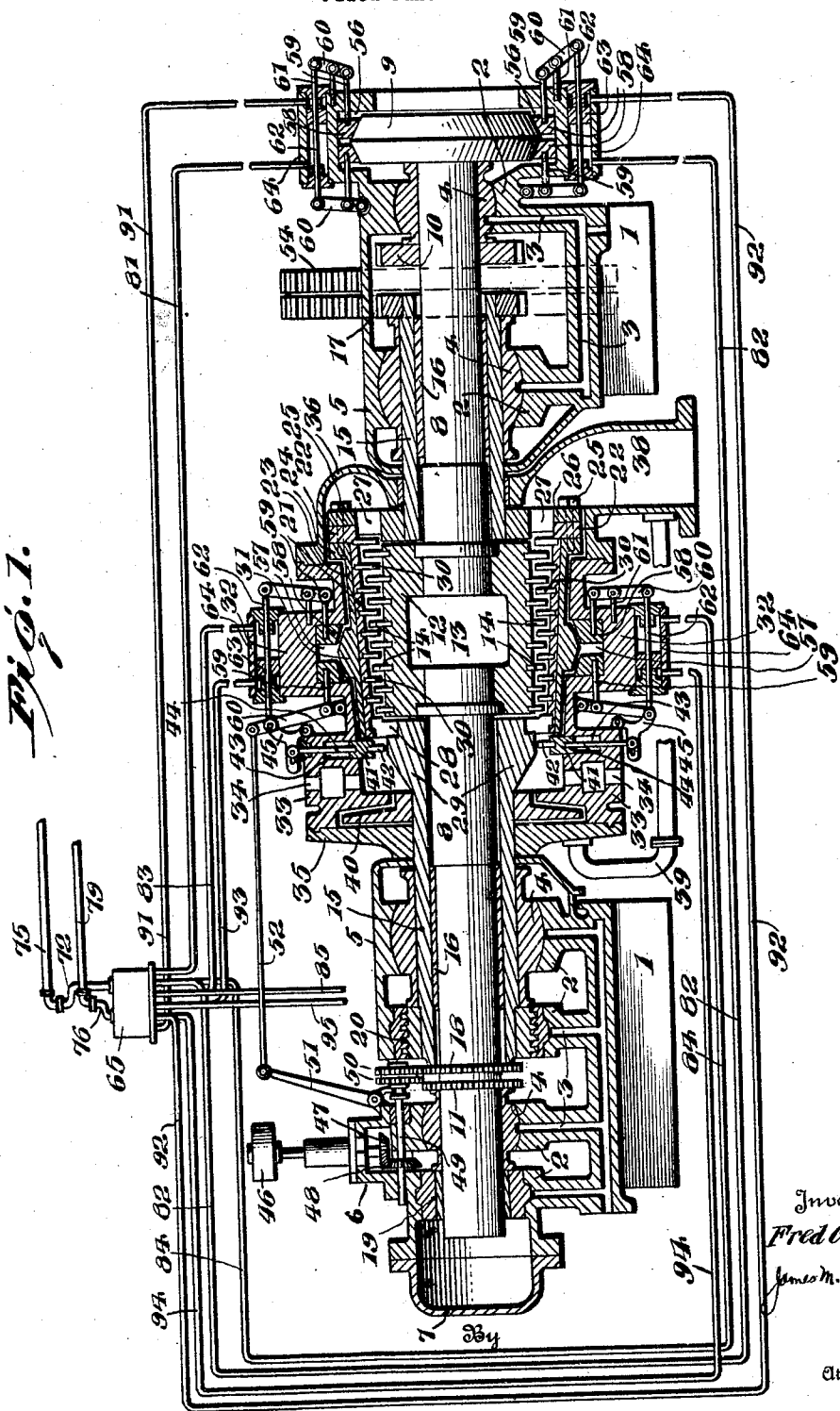
F. C. WEYER

REVERSIBLE STEAM TURBINE

Filed June 30, 1924

3 Sheets-Sheet 1

Fig. 1.



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3 Sheets-Sheet 2

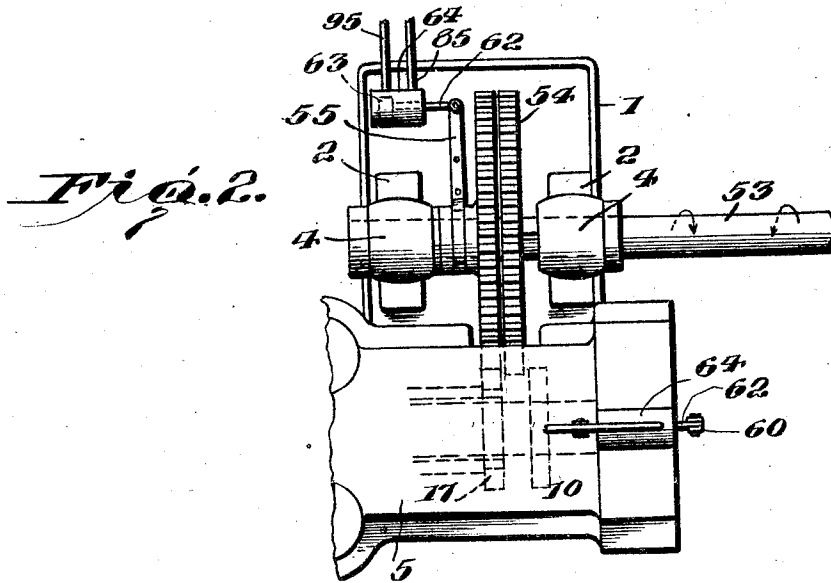


Fig. 3.

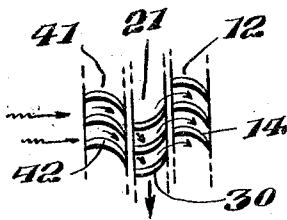
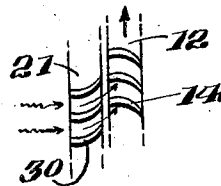


Fig. 4.



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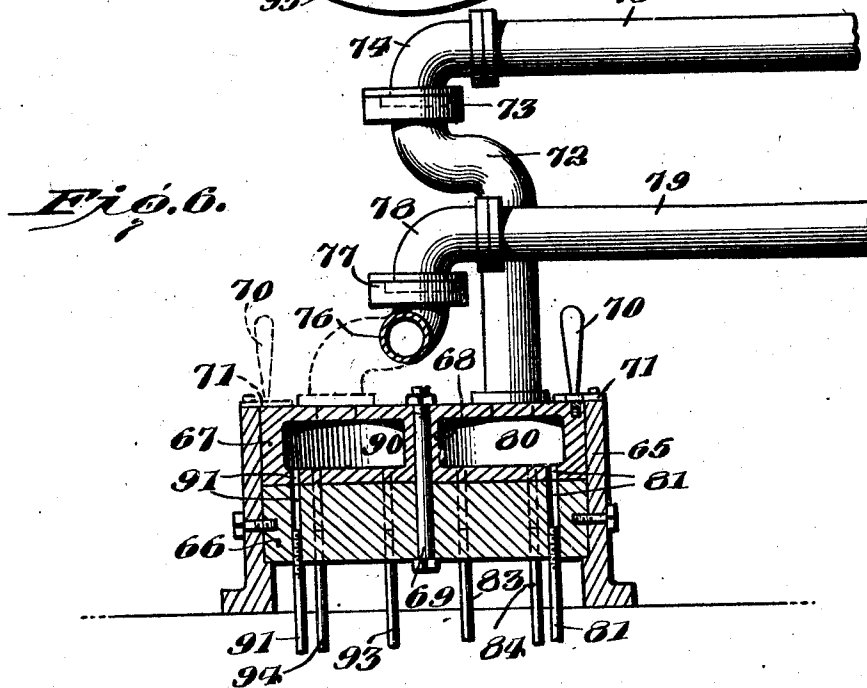
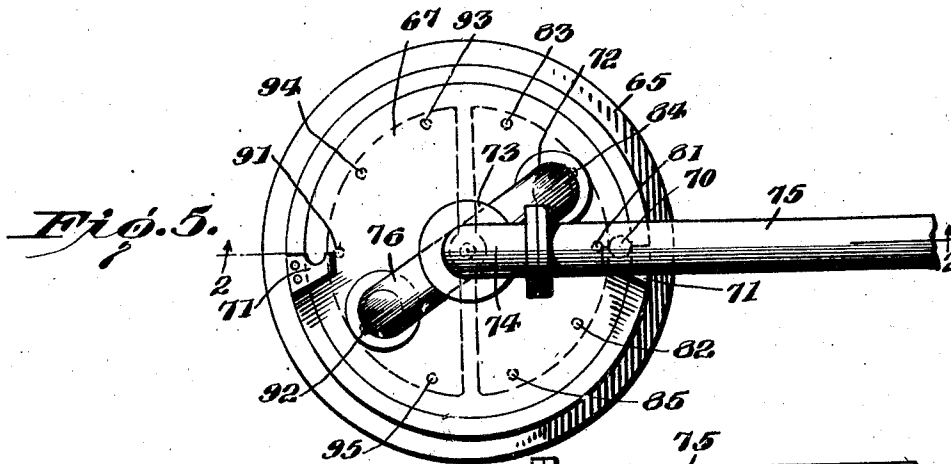
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE.

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REVERSIBLE STEAM TURBINE.

Application filed June 30, 1924. Serial No. 723,410.

This invention relates to a reversible steam turbine and has for one of its objects to provide a turbine of this character that is of horizontal type and provided with an inner sectional shaft upon which is secured an inner rotor having a plurality of circumferentially spaced rows of outwardly extending radial vanes or blades, and an outer sectional shaft upon which is secured an outer rotor having a plurality of spaced rows of inwardly extending radial vanes or blades, the outer shaft and rotor entirely surrounding the inner shaft and rotor in concentric relation and with the vanes or blades of the respective rotors being transversely concaved in opposite directions and alternately interfitting each other.

Another object of this invention is to provide a turbine of this character having a cylinder enclosing the respective rotors and provided with a steam chest at one end having therein a balance piston and a divided reciprocating vane or blade ring and an exhaust chamber at the other end, whereby the steam will travel from the steam chest to the exhaust chamber longitudinally through the turbine along the space between the rotors that is intercepted by the respective vanes or blades thereof, whereby to cause additional expansion of the steam when one or the other of the rotors is held inactive.

A further object of this invention is to provide one end of the inner shaft with a braking disk, and the exterior of the outer rotor with a circumferential braking ring and oppositely disposed pairs of reciprocating coacting brake shoes for engaging the disk and the ring for locking against rotation one or the other of said rotors, the brake shoes being actuated by reversible fluid pressure cylinders and pistons mounted respectively upon the frame and cylinder of the turbine.

A still further object of this invention is to provide one of the ends of the inner and the outer shafts with spaced oppositely disposed bevelled power gears adapted to alternately mesh with one or the other of the bevelled surfaces of an oppositely bevelled fixed shiftable gear wheel mounted upon a main power shaft at one side of the turbine, the shiftable gear wheel being thrown into mesh with either power gear through the medium of a reversible fluid pressure cylinder and piston located upon the frame of the turbine in proximity to the shiftable

gear wheel, and also to provide the opposite ends of the inner and the outer shafts with spaced oppositely disposed bevelled gears adapted to mesh with one of the bevelled surfaces of an oppositely bevelled gear pinion that is slidably mounted on the governor shaft, and which pinion is shifted to mesh with either of the last-mentioned bevelled gears by a connection with the piston rod of one of the reversible fluid pressure cylinders upon the steam cylinder of the turbine for operating the governor regardless of whichever rotor is in operation.

Still another object of this invention is to so connect the divided sections of the vane or blade ring with the piston rods of the reversible fluid pressure cylinders and pistons upon the turbine cylinder as to simultaneously reciprocate the blade ring sections in accordance with the movements of the brake shoes of the outer rotor.

And a still further object of this invention is to provide each of the reversible fluid pressure cylinders with a dual pipe connection with a single universal valve and body, the body comprising two compartments to one of which compartments is connected one set of the dual pipes while the other set of the dual pipes is connected to the other compartment, with a rotary valve in the valve body having one side thereof connected to a fluid pressure tank and the opposite side connected to a fluid release or fluid receiving tank, whereby a half revolution of the rotary valve in either direction will alternately convert one set or the other of the respective dual pipes into fluid pressure pipes or fluid release pipes and vice versa for reciprocating the pistons of the fluid pressure cylinders for actuating the brake shoes, shifting gears and blade ring sections in accordance with the desired direction of rotation of the turbine.

These and other objects will more fully appear and the nature of the invention will be more clearly understood from the description in the following specification, the subject-matter of the appended claims and the views illustrated in the accompanying drawings in which,

Figure 1 is a vertical, longitudinal sectional view through the turbine showing the general construction thereof;

Figure 2 is a top, plan view of the right hand end of the turbine, on a reduced scale, showing the power driven shaft, the shift-

able gear wheel thereon and the reversible fluid pressure cylinder and connections for shifting the gear wheel and which are located at one side of the turbine;

5 Figure 3 is a detailed fragmentary view of a portion of the vanes or blades of the blade ring, the outer or reversely driven rotor and the inner or forwardly driven rotor showing the course of the steam there-
10 through when the blade ring is in operation and the inner rotor is held stationary and the outer or reversible rotor is being driven in the direction of the arrow;

Figure 4 is a detailed fragmentary view
15 of a portion of the vanes or blades of the outer or reversely driven rotor and the vanes or blades of the inner or forwardly driven rotor with the vane or blade ring sections withdrawn from operation showing the
20 course of the steam therethrough when the outer rotor is held stationary and the inner rotor is being driven in the direction of the arrow;

Figure 5 is a top plan view of the valve
25 and valve body showing its pipe connections with the fluid pressure and fluid release or receiving tanks; and

Figure 6 is a vertical sectional view on
30 line 2—2 of Figure 5 showing the detailed construction of the universal valve and the valve body.

Referring to the drawings, wherein like reference characters denote corresponding parts throughout the several views, 1 denotes
35 the base frame of the turbine provided with preferably eight bearing supports 2 formed with suitable lubricating channels or ducts 3 leading to the main bearings 4 in the supports 2 and which are preferably two-part
40 bearings though other suitable forms of bearings may be employed. The frame of the turbine is further provided with the main caps 5, a smaller cap 6 and the end cap 7 to enclose and protect the bearings 4 and
45 other working parts within the frame and its housings.

Extending through the longitudinal center of the turbine and revolving in the bearing blocks 4 is the sectional or two-part inner or forward drive shaft 8, though this
50 may be a continuous solid shaft if desired, and secured upon one end of the shaft 8 is a brake disk 9 having its periphery formed with transversely inclined diverging faces.
55 Suitably secured upon the shaft 8 in proximity to the brake disk 9 is an inwardly inclined bevelled forward drive gear 10, and likewise secured upon and adjacent to the opposite end of the shaft 8 is an inwardly
60 inclined bevelled governor driving gear 11.

Secured upon the contiguous ends of the inner shaft 8 is the cylindrical inner or forward drive rotor 12 which may be a solid rotor but is preferably hollowed out as at
65 13, and upon the periphery of the rotor 12

is suitably secured a plurality of equi-spaced circumferential rows of outwardly extending radial vanes or blades 14 which gradually increase in length from the steam intake end to the exhaust end of the turbine 70 and are transversely concaved and slightly inclined in one direction as clearly shown in Figs. 3 and 4 of the drawings.

Surrounding the inner or forward drive shaft 8 and revolving therearound in certain
75 other of the bearing blocks 4 is the sectional or two-part outer or reverse drive shaft 15 having interposed between itself and the inner shaft 8 the two spacing and bearing sleeves 16. There is secured upon
80 the outer end of the right hand section of the outer shaft 15 an inwardly inclined bevelled reverse drive power gear 17 in slight spaced relation to the forward drive power gear 10 and also secured upon the opposite outer end
85 of the left-hand section of the outer shaft 15 is an inwardly inclined bevelled governor driving gear 18 also in slight spaced relation to the opposing bevelled governor driving gear 11. In proximity to the governor
90 driving gears 11 and 18, the inner shaft 8 is provided with the thrust bearing 19, and the outer shaft 15 is provided with the thrust bearing 20 for preventing any undue lateral or longitudinal movements of the shafts 8
95 and 15.

Connecting the inner ends of the outer sectional shaft 15 and surrounding the inner or forward drive rotor 12 is the outer or reverse drive rotor 21, consisting of a cy-
100 lindrical body divergently tapering from the steam inlet end towards the exhaust end and provided thereat with an annular flange 22 and being snugly surrounded by a similar shaped shell or sleeve 23 also provided with
105 an annular flange 24 in juxtaposition to the flange 22 and through which flanges 22 and 24 project the screw bolts 25 for securing the rotor 21 and its sleeve 23 to the circular plate or disk 26 having its hub portion rigidly
110 secured to the right-hand section of the outer or reverse shaft 15 and provided with a plurality of exhaust steam outlet openings 27 adjacent its periphery. At the inner end of
115 the outer rotor 21 there is a row of spaced inwardly extending flat plates or struts 28 set edgewise to the course of the steam and having one of their ends mortised or seated in the inner wall of the rotor 21 and their
120 opposite ends likewise mortised or seated in the inner end of the hub 29 formed at the inner end of the left-hand section of the outer shaft 15. Secured upon the inner surface of the outer rotor 21 is a plurality of
125 equi-spaced rows of radial or inwardly extending vanes or blades 30 which gradually increase in length from the steam intake end to the exhaust end of the turbine allowed by the taper of the rotor 21. The vanes 30
130 are transversely concaved and slightly in-

clined but in a direction opposite to that of the vanes 14 of the rotor 12 into which they operatively interfit and are preferably the same in number. Formed upon the shell or sleeve 23 of the rotor 21 is the centrally located circumferential brake ring 31 having oppositely disposed inclined braking surfaces. The construction set forth in the foregoing paragraph constitutes the outer or reverse rotor 21 and its mountings upon the respective outer or reverse shaft sections 15.

Surrounding the inner and outer rotors and the inner end portions of the inner and outer shafts is the turbine cylinder 32 provided with the steam chest 33 having the steam inlet ports 34, the head 35, the exhaust chamber 36, exhaust pipe 38 and the by-pass 39 leading from the steam chest 33 to the exhaust pipe 38 to provide for the proper functioning of the balance valve 40 mounted upon the outer shaft 15 within the steam chest 33. Also operatively mounted in the steam chest 33 is a divided vane or blade ring 41 provided upon its inner surrounding surface with a row of spaced inwardly projecting radial vanes or blades 42 which are also transversely concaved and slightly inclined in a direction similar to the vanes 14 of the inner rotor 12 as clearly shown in Fig. 3. The sections of the blade ring 41, when not required for use, are capable of being withdrawn in opposite directions from the steam chest 33 and into the housings 43 formed in the wall of the steam chest 33 through the medium of the rods 44 secured thereto and having their outer ends loosely connected to an arm of the bell crank levers 45 pivotally mounted upon the steam chest 33.

Mounted upon the smaller cap 6 is a reversible governor or governor operating device 46 of any well-known design having upon the lower end of its vertical shaft the bevelled pinion 47 meshing with a bevelled pinion 48 on a horizontal shaft 49 upon which is slidably keyed a double faced bevelled gear pinion 50 adapted to be shifted into mesh with either of the bevelled gears 11 or 18 as desired by the shifting lever 51 attached to the actuating connecting rod 52 to be later described.

Revolubly mounted in the bearings 4 upon the base frame 1 at one side of the turbine is the main power driven shaft 53 (see Fig. 2) upon which is slidably keyed or splined the double bevelled faced main power gear wheel 54 adapted to be shifted into mesh with either of the beveled power gears 10 or 17 of the inner and outer shafts 8 and 15 by the shifting arm 55 operatively attached to the hub of the gear wheel 54 and actuated in a manner to be later described.

In order to cause the turbine to become a forward drive motor or a reverse drive motor there are employed four brake shoe

housings, two oppositely disposed on the right hand end of the turbine frame and designated 56 and two oppositely disposed on the turbine cylinder and designated 57. As the brake shoes and their operating devices are substantially the same, description of one will suffice for all. Operatively mounted within each of the housings 56 and 57 is a pair of oppositely disposed inclined faced brake shoes 58 having secured thereto one end of the operating stems 59 which slidably project through the side walls of the housings 56 and 57, the projecting ends of the stems 59 being pivotally connected to the oppositely disposed links 60 at either side of the housings 56 and 57. The links 60 at the left of the housings having their inner ends pivotally mounted adjacent the housings with the operating stems 59 pivotally connected to these links at a point slightly remote from their pivotal mountings, while in the case of the links 60 at the right of the housings 56 and 57 the operating stems 59 are pivotally connected to the inner ends of these links while these last-mentioned links are pivotally mounted at points slightly remote from their connections with the stems 59 upon the studs 61 secured in the side walls of housings 56 and 57. The reason for so arranging the links 60 is that as all of the links 60 have their outer ends pivotally connected to the ends of the piston rods 62 and are moved simultaneously thereby in one direction or the other, the brake shoes 58 will be moved towards or away from each other as the case may be for causing the brake shoes 58 to either grip or be released from the braking disk 9 of the inner or forward drive shaft 8 or to either grip or be released from the braking ring 51 on the outer or reverse rotor 21. The end links 60 upon the left side of the turbine cylinder are connected to a second arm of the bell crank levers 45 having a third arm pivoted to the steam chest 33, the uppermost of the links 60 being slightly elongated and having its extreme end pivotally connected to the connecting actuating rod 52 of the shifting lever 51 of the shifting gear 50 of the governor.

Secured upon the piston rods 62 are the pistons 63 designed to be reciprocated in the fluid pressure cylinders 64 of which there are five in number, two upon the right end of the turbine frame 1, two upon the turbine cylinder 32 and one upon the frame 1 at one side of the turbine.

Located at a convenient point to the turbine is a controlling valve consisting of a preferably circular valve body 65 having rigidly secured therein by any suitable means a block or valve seat 66 formed with ten bores or conduits therethrough. Also within the upper portion of the body 65, and adapted to rotate upon the seat 66 is a

hollow disk-shaped valve 67 formed with a diametrical partition 68 therein to divide the valve 67 into two compartments, each having five openings through their bottom walls or ten in all and adapted to register with the ten boxes or conduits of the valve seat 66. There is a central bore through the partition 68 and the seat 66 through which passes a bolt 69 for rotatably mounting the valve 67 upon the seat 66, and for rotating the valve 67 there is provided at one edge thereof the operating handle or stem 70 adapted to abut against one or the other of the stop plates 71 secured at diametrically opposite points upon the valve body 65 in accordance with the direction of rotation of the valve 67.

Communicating with the right hand compartment of the valve 67 is the elbow 72 connected by the universal joint 73 to the elbow 74 of the fluid pressure pipe 75 leading from a fluid pressure tank (not shown), and communicating with the left hand compartment of the valve 67 is the elbow 76 connected by the universal joint 77 with the elbow 78 of the fluid release or return pipe 79 leading to a fluid-receiving tank (also not shown).

For the sake of convenience, brevity and clearness, the remaining details of the construction will be combined with the description of the operation, and as the ten bores or conduits of the valve structure and the ten pipe lines connected thereto each forms a separate continuous fluid conducting means either from or to the valve structure, reference characters in a selected sequence will be employed in a manner as to render reading of the invention more complete and discernible, as follows:

The turbine is shown in all the views in the drawings with the parts set for operating the same as a reversely driven rotor and in this instance, the fluid pressure, preferably oil, flows through pipe 75 and its connections into the compartment 80 of the valve 67 and through pipes 81, 82, 83, 84 and 85 to one end of the pressure cylinders 64 as shown in Figs. 1 and 2, whereby to force the pistons 63 and piston rods 62 towards one end of the cylinders as shown, the fluid that was previously in the cylinders 64 being forced out through the release or return pipes 91, 92, 93, 94 and 95 attached to the ends of the cylinders 64 and onto the compartment 90 of the valve 67 and through the return pipe 79 to the receiving tank, and through the mechanisms before described cause two sets of the brake shoes to engage the brake disk 9 on the inner shaft 8, thereby locking this shaft and its inner rotor 12 against rotation. At the same time the two other sets of brake shoes will be held free from the brake ring 31 of the outer rotor 21, the bell crank lever 45 will force the blade section into the steam chest 33 while the actuating rod 52 of the shifting lever 51 will

shift the double gear pinion 50 into mesh with the bevel gear 18 upon the outer shaft 15, and at the same time the piston rod 62 at one side of the turbine will actuate the arm 55 to cause the double main drive gear wheel 54 to mesh with gear 17 upon the outer shaft 15 for driving the main power shaft 53 in a reverse direction as shown by the full line screw. The outer or reverse rotor 21 now being free to rotate, steam from the steam chest 33 will strike the vanes 42 of the blade ring 41 and from there exert force against the vanes 30 of the rotor 21 and rebounding against the vanes 14 of the now stationary rotor 12 will be expanded and the expansion will be continuous throughout its course from the steam chest 33 to the exhaust chamber 36, this being illustrated in Figure 3.

Should it be desired to convert the turbine into a forward drive rotor, the operator or attendant of the turbine will grasp the handle 70 and rotate the valve 67 a one-half revolution until the handle strikes the stop 71 at the opposite side of the valve body 65 as shown in dotted lines. This movement will cause the fluid under pressure to flow through the pipe 75 and its connections into the compartment 90 of the valve, the elbow 76 of the pipe 79 being transferred to the compartment 80 of the valve, and thence through the pipes 91, 92, 93, 94 and 95 secured to the opposite ends of the cylinders 64, which pipes now become fluid pressure pipes, and thence onto the pressure cylinders 64. The pipes 81, 82, 83, 84 and 85 now become the release or return pipes through which the fluid, previously under pressure, returns to the compartment 80 of the valve and on through pipe 79 to the fluid-receiving tank. At this juncture, the pistons 63 and the rods 62 are shifted to the opposite ends of cylinders 64 or, opposite to the positions shown in the drawings as will be understood, whereby the brake shoes will grip the brake ring 31 of the outer rotor 21 to lock the same and its shaft 15 against rotation, withdraw the blade ring sections 41 from within the steam chest 33 and shift the shifting lever 51 to bring the double gear pinion 50 into mesh with the gear 11 on the inner shaft 8, and in the meantime the other sets of brake shoes release the brake disk 9 of the inner shaft 8 while the shifting arm 55 at the side of the turbine shifts the double power gear wheel 54 into mesh with the bevel power gear 10 on the shaft 8. The inner rotor 12 and its shaft 8 are now free to rotate and the turbine now becomes a forward drive rotor, the steam from the steam chest 33 first striking the vanes 30 of the locked outer rotor 21 rebounding against the vanes 14 of the inner rotor 12, thus causing an expansion of the steam successively from the steam chest 33 to the exhaust chamber 36 in the manner illustrated in Fig. 4. The main

power shaft 53 will now become a forwardly driven shaft as indicated by the dotted line arrow in Fig. 2.

While I have herein shown and described the preferred embodiment of my invention, I may resort to numerous variations and alterations in the general as well as the specific constructions thereof from time to time as I may deem expedient and which will neither depart from the spirit of the invention or the scope of the claims.

What I claim is:

1. In a reversible steam turbine, the combination with a forwardly driven rotor, of a reversely driven rotor, braking mechanisms for each of said rotors, fluid-actuated means for applying and releasing said braking mechanisms for permitting the operation of either of said rotors selectively, and a single universal valve for controlling the flow of the fluid to and from said fluid-actuated means.

2. In a reversible steam turbine, the combination with a forwardly driven rotor, of a reversely driven rotor, braking mechanisms for each of said rotors, fluid-actuated means for applying or releasing said braking mechanisms for preventing or permitting the operation of either of said rotors, a single universal valve for controlling the flow of the fluid to and from said fluid-actuated means, a shaft for each of said rotors, a main drive shaft, and a fluid actuated shiftable gear connection between said rotor shafts and said main drive shaft for driving the latter in either a forward or reverse direction.

3. In a reversible steam turbine, the combination with a forwardly driven rotor, of a reversely driven rotor, braking mechanisms for each of said rotors, fluid-actuated means for applying and releasing said braking mechanisms for checking or permitting the operation of either of said rotors, a single universal valve for controlling the flow of the fluid to and from said fluid-actuated means, a shaft for each of said rotors, a main drive shaft, a shiftable gear connection between said rotor shafts and said main drive shaft for driving the main shaft either forwardly or reversely, and fluid-actuated means controlled by said single universal valve for actuating said shiftable gear connection simultaneously and in accordance with the operation of the fluid actuated means of said braking mechanisms.

4. In a reversible steam turbine, the combination with a forwardly driven rotor, of a reversely driven rotor, braking mechanisms for each of said rotors, fluid-actuated means for applying or releasing said braking mechanisms for checking or permitting the

operation of either of said rotors, a single universal valve for controlling the flow of the fluid to and from said fluid-actuated means, a shaft for each of said rotors, a main drive shaft, a shiftable gear connection between said rotor shafts and said main drive shaft, fluid-actuated means controlled by said single universal valve for actuating said shiftable gear connection, and a reversible governor operating device shifted by that one of the fluid-actuated means which operates the brakes of the outer rotor.

5. In a reversible steam turbine, the combination with a forwardly driven rotor, of a reversely driven rotor surrounding said forwardly driven rotor, braking mechanisms for each of said rotors, fluid-actuated means for applying and releasing the braking mechanisms of either of said rotors, a shaft for each of said rotors, a main drive shaft, a shiftable gear connection between said rotor shafts and said main drive shaft, fluid-actuated means for actuating said shiftable gear connections, a reversible governor operating device shifted by that one of the fluid-actuated means which operates the brakes of the outer rotor, a pressure tank, a fluid tank, fluid conduits connecting said pressure tank and said fluid tank with the respective fluid-actuated means, and a single universal valve interposed in said fluid conduits for controlling the fluid to and from said fluid-actuated means.

6. In a reversible steam turbine, the combination with a forwardly driven inner rotor, of a reversely driven outer rotor surrounding said inner rotor, braking mechanisms for each of said rotors, fluid pressure cylinders having pistons therein for actuating said braking mechanisms, fluid conduits leading to said fluid pressure cylinders, and a single universal controlling valve interposed in said fluid conduits for selectively operating said braking mechanisms for preventing the rotation of either of said rotors, whereby to permit the rotation of the other.

7. In a reversible turbine, the combination with an inner rotor, of an outer rotor surrounding said inner rotor, shafts for said rotors, a brake disk upon the inner rotor shaft, a brake ring upon said outer rotor, brake shoes for said disk and ring, pistons for operating said brake shoes, cylinders encompassing said pistons, fluid pressure conduits leading to said cylinders, and a single rotary valve interposed in said conduits for controlling the flow of the fluid to and from said cylinders, whereby to brake one or the other of said rotors to permit the other to operate.

In testimony whereof I affix my signature.
FRED C. WEYER.