

J. PROCNER.
TURBINE.

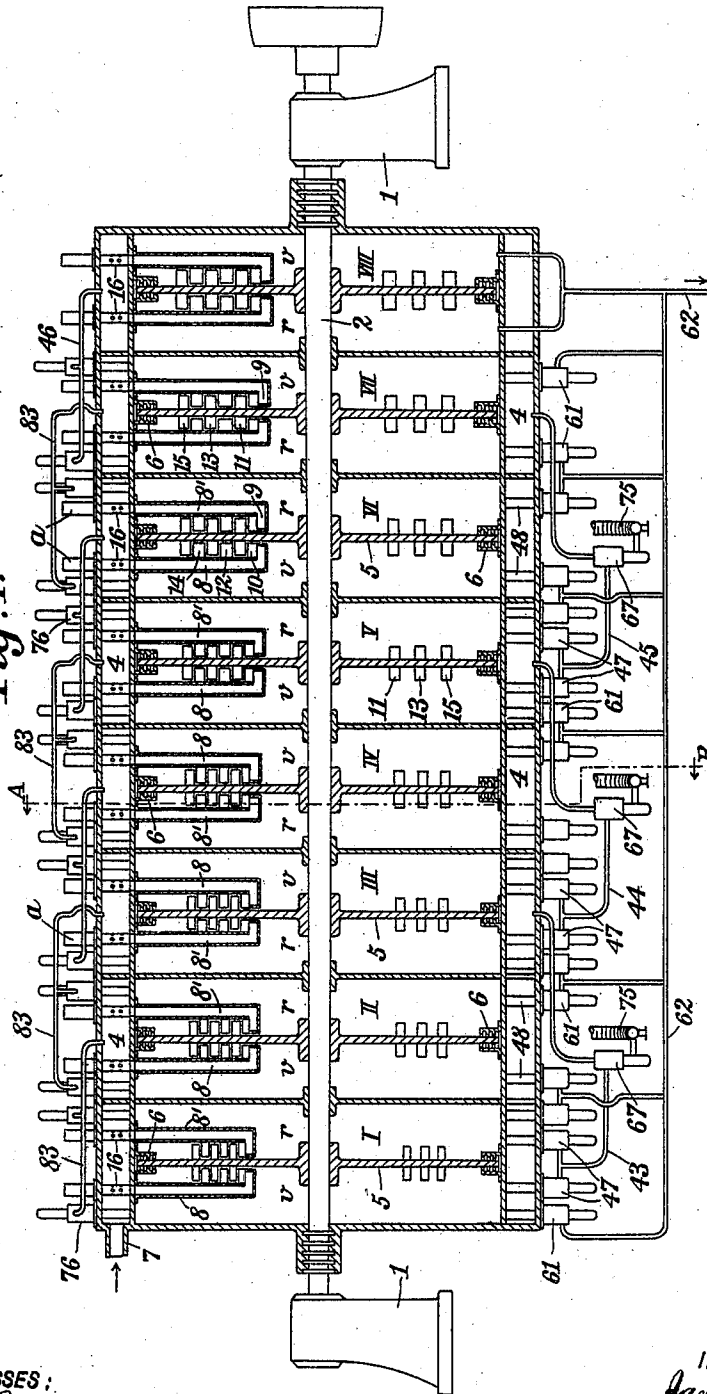
APPLICATION FILED MAY 28, 1909.

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5 SHEETS—SHEET 1.

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Fig. 1.



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5 SHEETS—SHEET 2.

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Fig. 2.

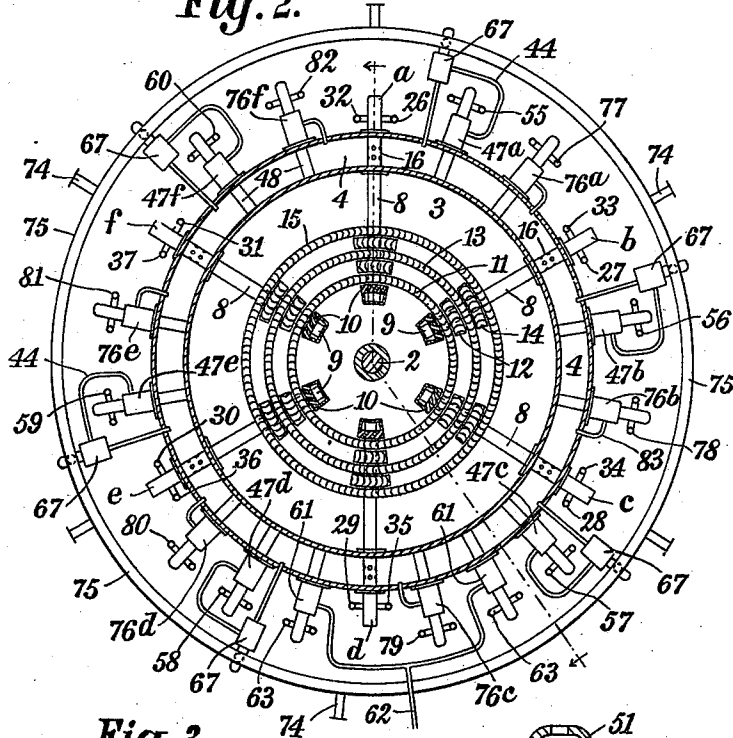


Fig. 3.

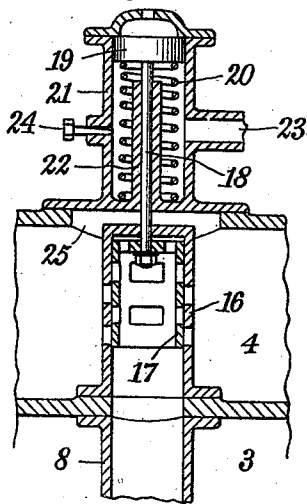
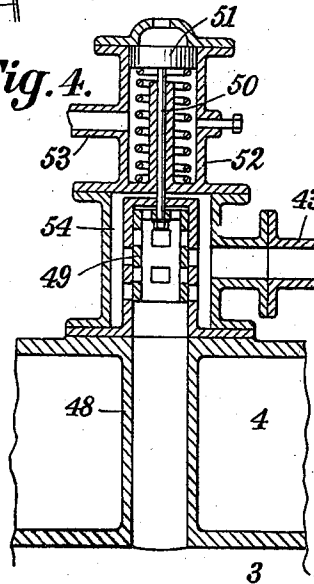


Fig. 4.



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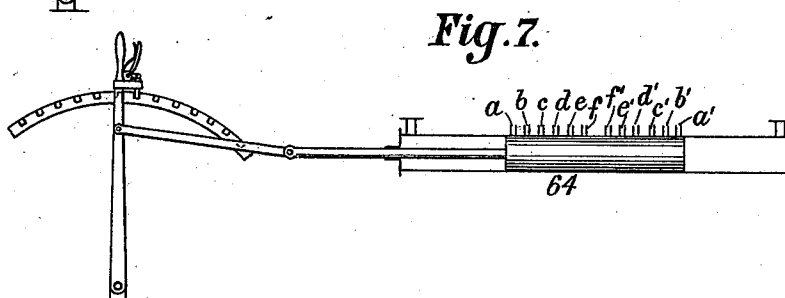
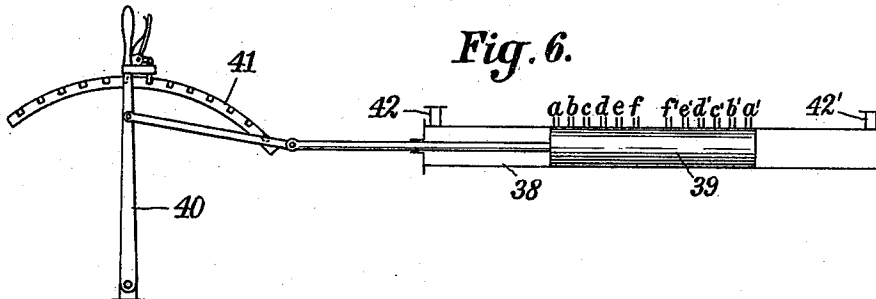
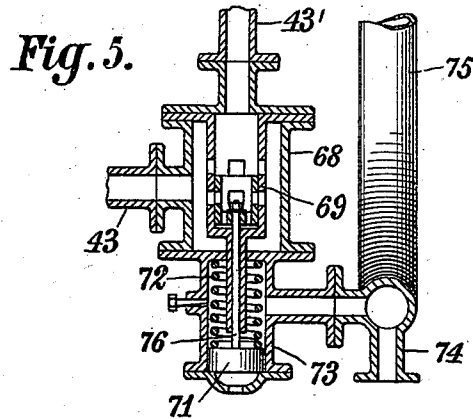
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6 SHEETS—SHEET 3.



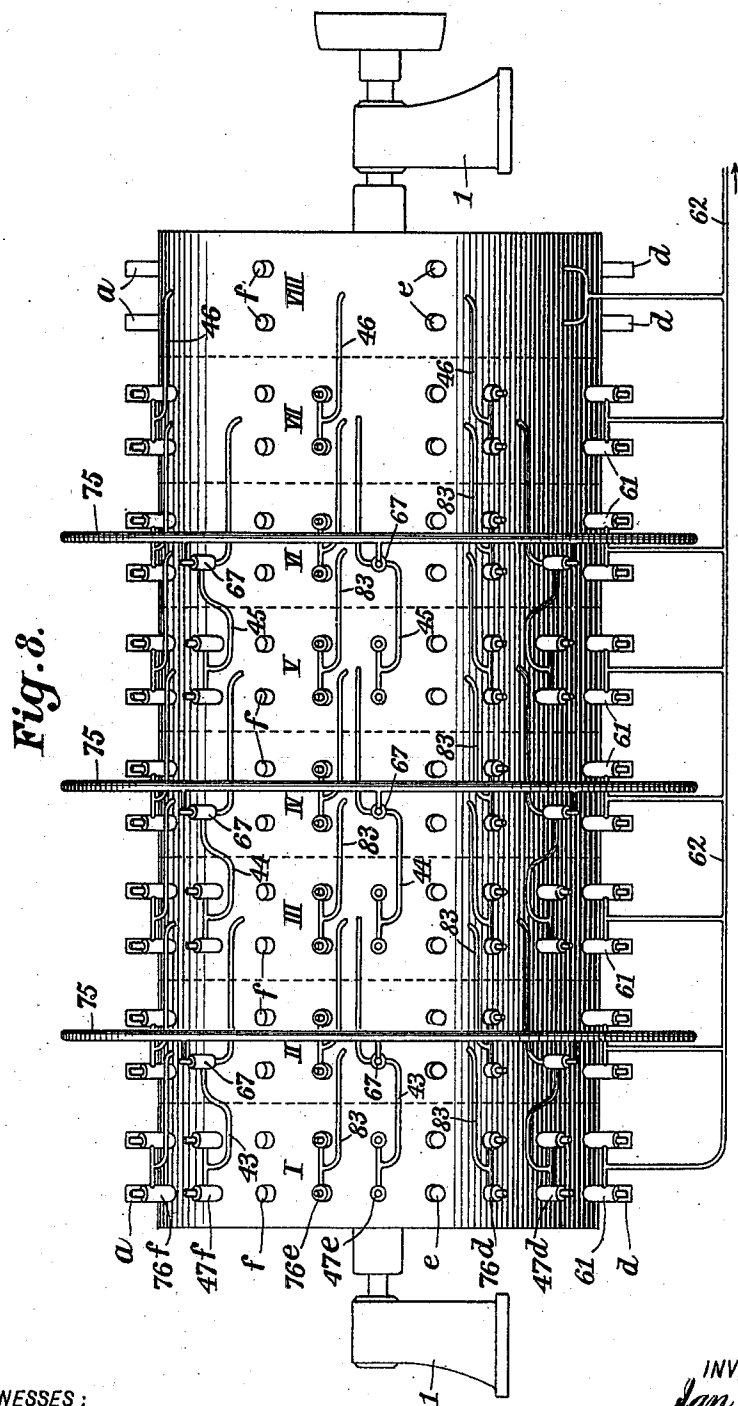
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UNITED STATES PATENT OFFICE.

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TURBINE.

977,899.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, JAN PROCNER, a subject of the Czar of Russia, and residing at Pabianice, in the Empire of Russia, have invented certain new and useful Improvements Relating to Turbines, of which the following is a specification.

The present invention has for its object a reversible turbine which may be constructed in substantially the same way for use as a steam turbine and as a gas turbine and in which the motor of each turbine chamber is provided in the known manner with moving blades on both sides in such a manner that according as the steam or the motor gas is supplied to one side or the other forward or reversed running may be obtained.

The turbine which forms the object of the present invention presents the important advantage as compared with turbines of the known kinds that either as a steam turbine or as a gas turbine it can be operated and regulated with great simplicity and within wide limits both in forward and in reversed running. With this object in view the improved turbine is in accordance with my present invention provided with an annular steam or combustion chamber located concentrically with the turbine chamber a number of radially arranged nozzle tubes varying in accordance with the power of the turbine proceeding from the said steam or combustion chamber; these tubes supply the steam or motor gas to the rims of blades mounted in the rotor in such a manner that the admission to the turbines is radial from the interior to the exterior. When the turbine is constructed as a steam turbine a larger or smaller number of pressure stages is used according to the method of operation desired. The inoperative turbine chambers are then preferably placed under vacuum in order to increase the efficiency. In the case of gas turbines in accordance with the number of nozzle tubes that are operative for the time being the fuel valves, a number of which are distributed throughout the entire combustion chamber and to which a ready prepared explosive mixture is preferably supplied are more or less opened, the extent of the aperture increasing with the number of open nozzle tubes so that the regulation is strictly quantitative. Both in the case of gas turbines and in the case of steam turbines the nozzle tubes are provided with

separate admission valves connected with a distributing slide common to them all and they are acted upon by vacuum, compressed air or other gas or electrically according to circumstances.

The invention is illustrated as applied to a steam turbine and also to a gas turbine in the accompanying drawing in which:

Figure 1 is a vertical section through a steam turbine comprising eight pressure stages for forward and reversed running. Fig. 2 is a section on the line A—B— looking in the direction indicated by the arrow. Fig. 3 is a section through the admission valve on the connecting tube for the pressure stages. Fig. 4 is a section through the exhaust valve on the connecting tube for the pressure stages. Fig. 5 is a section through the valve in the circulation conduit of the pressure stages. Fig. 6 shows the main distributing valve for rendering the various nozzle of each pressure stage operative or inoperative. Fig. 7 is similar distributing slide valve for influencing the separate pressure stages which are normally inoperative. Fig. 8 is a side elevation of the casing, parts being omitted, and Fig. 9 is a diagrammatic view of the valves, nozzles, and their connections.

In the reversible steam turbine illustrated in Figs. 1 to 9 a number of casings are mounted on a shaft 2 arranged in and supported by two bearings 1; these casings are passed upon the shaft from its end and are connected one with the other preferably by means of flanges and bolts and they constitute the various pressure stages I, II, III, IV, V, VI, VII, VIII of the turbine. Instead of the construction illustrated in the drawing which comprises eight pressure stages obviously any other suitable number of pressure stages may be employed without affecting the principle of the invention. Of these eight pressure stages shown in the drawing only five are operative in normal running that is to say the stages I, III, V, VII, VIII while the pressure stages II, IV, and VI are only rendered operative when this appears to be necessary for a given purpose such for instance as modifying the number of revolutions with an unaltered power of the turbines say when a ship provided with such a turbine is to travel slowly for a long time for the purpose of economizing steam. Each of these various casings consists of the inner turbine chamber 3 and

the outer annular steam chamber 4 concentric to the chamber 3. Inside the casing a rotor 5 is mounted on the shaft 2 its edge extending almost to the inner periphery of the turbine chamber where by means of a labyrinth packing 6 it subdivides the turbine chamber in such a manner that in each pressure stage two halves or sides are formed one of which together with the blades on the rotor 5 is intended for forward running while the other is intended for reversed running. In order to produce a uniform distribution of pressure on the shaft throughout the entire turbine the front side and the rear side in the various pressure stages are arranged alternately right and left of the rotor. Thus in the pressure stages I, II, V, VI, the side for forward running is located on the left hand and in pressure stages III, IV, VII and VIII on the right hand of the corresponding rotor as indicated by the letters *v* and *r* in the drawing which indicate the forward and reversed running. The steam which enters the turbine at 7 in pressure stage I is conducted toward the moving blades of the rotor in each pressure stage and on each side of the rotor by means of a number of radial hollow nozzle tubes 8 and 8' all the nozzle tubes 8 being located in the forward side of each pressure stage and the nozzle tubes 8' in the rear side of the pressure stage. As shown in Fig. 2 a suitable number of these nozzle tubes is provided in each pressure stage this number being dependent upon the power required of the turbine. The number of these tubes is the same in all the pressure stages and preferably the various nozzle tubes in the several pressure stages are arranged in the same radial plane. The ends of these nozzle tubes located radially inward relatively to the moving blades open into cavities 9 from which the steam supplied passes through nozzles 10 on to the blades 11 of the rotor 5 after leaving which it is conducted by reversing blades 12 likewise provided on the nozzle tubes 8 and 8' into a second series of moving blades 13 and then eventually by means of additional reversing blades 14 into a third series of moving blades 15 in such a manner that the admission to the turbine is in the radial direction from the interior to the exterior. At the end opening into the annular chamber 4 however each nozzle tube 8 or 8' is provided with a piston slide valve which as shown in Fig. 3 consists of the outer stationary perforated or slotted casing 16 and of the inner and likewise perforated or slotted slide 17. The latter is connected by a rod 18 with a piston 19 arranged outside the turbine casing and subjected to the action of a spring 20; it is mounted in a separate casing 21. The rod 18 passes through a spindle guide 22 arranged inside the cas-

ing 21 this guide likewise forming a stop for the piston 19. Through the cover the upper side of this piston communicates with the atmosphere while its lower side can be placed in communication with a vacuum conduit through a tubular socket or branch pipe 23 so that under the influence of the vacuum the piston 19 and the piston slides 17 move downward so that the latter is opened. When the vacuum conduit connected with the branch pipe 23 is closed a screw 24 enables an equalization of pressure to take place slowly in the casing 21. When the casing 21 has been removed an opening 25 in the turbine casing gives access to the piston slide valve 16, 17. In so far as these admission valves of the various nozzle tubes 8 or 8' follow in the same direction of rotation and are located in the same radial plane they are in connection with a vacuum conduit common to them all. Thus the admission valves of the six nozzle tubes 8 shown in Fig. 2 are marked *a, b, c, d, e, f* in correspondence with their various radial positions are in communication with the common vacuum conduit 26, 27, 28, 29, 30 and 31 so far as the nozzle tubes for forward running are concerned. The admission valves for the nozzle tubes 8' which are located in the same radial plane as the nozzle tubes 8 on the front side of the corresponding pressure stage are likewise each connected with a common vacuum conduit 32, 33, 34, 35, 36 and 37. These vacuum conduits 26, 27, 28, 29, 30, 31 and 32, 33, 34, 35, 36, 37, lead to the main distributing slide valve (illustrated in Fig. 6) consisting of a casing 38 and of a piston 39 movable therein. Here the various vacuum conduits open at different places in the casing and are marked *a, b, c, d, e, f* in correspondence with their admission valves and as regards the rear side of the pressure stages *a', b', c', d', e', f'*. Thus the vacuum conduit 26 of all the valves *a* proceeds to the mouth *a* in the distributing slide valve 38 in Fig. 6 and so forth. The admission valve marked *b* may be arranged opposite the valve *a*; the following valve behind *b* can be marked *c* and the opposite valve *d* so that with such an arrangement the opposite valves are rendered operative and inoperative and the steam pressure does not act one-sidedly on the blade wheels. In the case of steam turbines of large size in order to obtain a perfectly uniform central loading of the blade wheels the admission valves may be arranged in such a manner that every time two opposite admission valves of each socket *a, b, c, d, e, f a', b', c', d', e', f'* on the distributing slide valve are opened and closed in one operation. The valves can then be operated in series but on the periphery of the turbine chamber double the number of admission valves must be provided as com-

pared with the number of sockets *a*, *b*, *c*, *d*, *e*, *f*, or *a'*, *b'*, *c'*, *d'*, *e'*, *f'* on the distributing slide valve. The piston 39 is adjustable by a rod which is actuated by means of an adjusting lever 40 and notched sector 41. The cylinder 38 is connected at both ends by sockets 42 and 42' with the vacuum chamber of the turbine so that normally there is a vacuum in the chamber 38. The admission valves are normally closed under the influence of their springs 20. As soon, however, as the adjusting lever 40 has been displaced over the adjusting sector 41 from the middle position shown in the drawing into the right or left hand position say into the right hand position the outlets *a*, *b*, *c*, *d*, *e*, *f* of the vacuum conduits 26, 27, 28, 29, 30 and 31 are exposed in succession so that through these conduits a vacuum is produced in succession in the cylinder 21 in all admission valves located in the same radial plane, the result being that the corresponding piston 19 is displaced downward and the openings of the two piston slide valve members 16, 17 thereby placed in communication so that the steam entering the annular chamber 4 of the pressure stage I at 7 is able to enter the nozzle tube 8 through the corresponding valve *a* and by impinging on the rotor cause it to rotate. This steam which has been operative in the forward side of the pressure stage I must then be conducted in succession to the other pressure stages operative with the pressure stage I, that is to say, the pressure stages III, V, VII, VIII. This is effected through what are called the circulating pipes 43, 44, 45 and the connecting pipe 46. These circulating pipes are connected at one end with exhaust valves 47 of the corresponding preceding pressure stages and at the other end with the annular chamber 4 of the pressure stage of the turbine to which the steam is next to be admitted. Thus the connecting pipe 43 is connected with the exhaust valve 47 of the pressure stage I and proceeds to the annular chamber 4 of the pressure stage III.

Only one circulation conduit need be used for connecting each pair of pressure stages but in this case the cross section of the tube must be relatively large and this when all the nozzle tubes of each pressure stage are not operative would necessarily cause an expansion of the steam inside the circulation pipe 43. In order to prevent this, preferably as many circulation pipes 43 and exhaust valves 47 are used as there are admission valves and nozzle tubes 8 and 8' in each pressure stage and invariably as soon as an admission valve or a nozzle tube is rendered operative in a pressure stage a circulation conduit 43 and an exhaust valve 47 are opened so that the total open cross section of the compartment is always in agreement

with the cross section of the steam supply. In order that this may be possible the various exhaust valves 47 are constructed in substantially the same manner as the admission valve. As shown in Fig. 4 the steam proceeds from the inner turbine chamber through a tube 48 and the annular passage 4 and reaches the interior of the piston slide valve 49 the movable member of which is likewise displaced by the spindle 50 of the spring controlled piston 51. By means of a socket or branch pipe 53 the casing 52 is in communication with a vacuum conduit while the annular chamber 54 surrounding the piston slide valve 49 comprises a socket for the circulating conduit 43. These exhaust valves 49 are likewise normally closed under the influence of their spring controlled piston and are opened as soon as the casing 52 is placed under vacuum. By reason of the fact that the various exhaust valves 47 lie in the same radial plane in the various pressure stages they are likewise connected with a vacuum conduit common to them all and in Fig. 2 the exhaust valves are marked 47^a, 47^b, 47^c, 47^d, 47^e, 47^f while the vacuum conduits for the exhaust valves lying in the same radial plane are marked 55, 56, 57, 58, 59, 60. Now if each time a nozzle tube 8 is rendered operative an exhaust valve 47 and a circulating conduit 43 is also to be rendered operative the corresponding vacuum conduits of the exhaust valves must be brought into appropriate relationship with the main distributing slide valve 38 39. This is effected in a simple manner owing to the fact that a vacuum is produced both in the conduit 26 and in the conduit 55 say by the conduit *a* of the main distributing slide valve by means of a branch pipe so that at the same time an admission valve and an exhaust valve are rendered operative in all the operative pressure stages that is to say instead of being closed the valve is opened. The same result is produced through the conduit *b* and through the vacuum conduits 27 and 56 in the case of the admission valve *b* and of the discharge valve 47^b and so forth. Accordingly when as already stated the main distributing slide valve 38, 39 is acted upon steam is first of all admitted to a nozzle tube 8 and at the same time the entire path for this steam through all the pressure stages that are to be operative is freed that is to say the steam which has finished its work in pressure stage I passes through the valve 47 and the conduit 43 into the annular chamber of pressure III there passes through the admission valve which is likewise open and through the nozzle tube 8 into the blades furnishes work and can then reach the pressure stage V through the open exhaust valve 47 and the conduit 44, furnish work in this pressure stage and then proceed to pressure stage VII through the circulation conduit

45; thence the steam proceeds through the pipe 46 into the low pressure stage VIII and then to the condenser. This path always remains the same no matter whether only a single nozzle tube or several of them or all of them are operative.

As already stated it is important for obtaining efficient operation that those pressure stages and those sides of the pressure stages which are not operative for the time being should be under vacuum. With this object on each side of each pressure stage one or more vacuum valves 61 are provided; they open into a vacuum conduit 62 common to them all. These valves present substantially the form illustrated in Fig. 4 but contrary to what is the case with the exhaust valves they are normally held open by their springs and can be closed through a vacuum conduit 63. This vacuum conduit 63 leads to all the vacuum valves 61 of the pressure stages I, III, V, VII and VIII which are normally operative in so far as they are located on the forward side while another conduit leads to all the valves of the same pressure stages which are located on the reverse side. This vacuum conduit 63 is likewise in communication by means of a branch pipe with the mouth α or in the same plane with a special opening of the main distributing slide valves 38, 39. Accordingly as soon as this distributing valve is adjusted in such a manner that the passage α is freed and the steam admission and exhaust valves thereby opened corresponding vacuum valves 61 are closed under the influence of the vacuum conduit 63 so that the corresponding sides of the pressure stages are closed. The other sides of the corresponding pressure stages for example on the reverse side of the pressure stages I, III, V, VII, VIII are under vacuum as before however.

As already stated the regulation of the force of the turbine is effected not only owing to the fact that a larger or smaller number of the radially arranged nozzle tubes are rendered operative or inoperative in each pressure stage but also owing to the fact that the number of pressure stages may be increased or decreased as desired. Also the five pressure stages I, III, VI, VII, VIII serve for normal running but the pressure stages II, IV, VI may also be rendered operative separately this being effected by acting upon the distributing slide 64 (Fig. 7) 65 (Fig. 8) and 66 (Fig. 9) the operating levers of these distributing valves being set upon their adjusting segments exactly in the same manner as the operating levers 40 of the main distributing slide valve 38, 39. If the pressure stage II is to be rendered operative for example it is first of all necessary to cut out the circulation conduit 43 which conducts the steam from pressure

stage I to pressure stage III. It is also necessary to cut off the forward side of pressure stage II from the vacuum and to allow the steam from pressure stage I to pass to pressure stage II and thence to pressure stage III. In order to render this possible in the first place each of the circulation conduits 43, 44, 45, is provided with a valve 67 of the form illustrated in Fig. 5. The steam passes through the pipe 43 into the cylindrical casing 68 and from there is able to pass through the piston slide valve 69 which is normally open into the tubular extension 43' in order to reach pressure stage III for example. The movable member of the piston slide valve 69 is acted upon by a spring 72 through the spindle 76 and the piston 71 while the casing 73 is connected with a vacuum conduit through a socket 74 this conduit being fitted to the first inlet of the piston slide valve 64 so that when this opening is freed by the displacement of the slide valve 64 the vacuum acts upon the piston 71 which closes the slide valve 69 and thus renders it impossible for the steam to pass from the tube 43 to 43' so that the circulation conduit is cut out.

If a number of circulation conduits 43 are used as mentioned above and as shown in Fig. 2 all the valves 67 of the circulation pipes are connected with an annular tube 75 common to them all and this tube 75 is in communication with the slide valve 64 (Fig. 7) so that all the circulation pipes 43 are cut out simultaneously. In place of these circulating pipes a corresponding number of connecting pipes may be interposed between the pressure stages I and II and here also the number of the connecting tubes to be interposed must correspond to the number of the nozzle tubes that are operative for the time being. Accordingly in addition to the valves already referred to each pressure stage and each side of the pressure stages is also provided with special exhaust valves 76 which are marked 76^a, 76^b, 76^c, 76^d, 76^e, 76^f in Fig. 2 in accordance with their respective radial positions. These exhaust valves 76 which present the form illustrated in Fig. 4 are in communication through vacuum conduits together with the exhaust valves 76 of the pressure stage II and the corresponding admission valves of the nozzle tubes 8 through vacuum conduits 77, 78, 79, 80, 81, 82 with the series of openings a , b , c , d , e , f , of the distributing slide valve 64. Accordingly when this distributing slide valve is reversed as compared with the position of the main distributing slide valve 38, 39 already existing, in the first place all the circulation conduits 43 are cut out and simultaneously as many nozzle tubes are opened in pressure stage II as are already open in pressure stage I. Similarly a corresponding number of connecting

pipes 83 are opened for connecting the exhaust valve 76 of pressure stage I with the annular chamber 4 of pressure stage II so that steam passes from pressure stage I to pressure stage II where it performs its work and is then able to pass through the exhaust valve 76 of pressure stage II through the connecting pipes 83 into pressure stage III and thence to enter the pressure stages V, VII, and VIII through the circulation conduit 44 and so forth. Obviously when the slide 64 is adjusted the corresponding vacuum valve 61 of pressure stage II is closed on its operative side. Similarly by means of the slide valves 65 (Fig. 8) and the slide valve 66 (Fig. 9) the pressure stage IV or VI is rendered operative in which case the corresponding circulation pipe 44 or 45 is cut out. As is known in proportion as the number of pressure stages in the turbine is increased its number of revolutions is diminished and economy obtained. The other sides of all the pressure stages which serve for reversed running are of course formed similarly to the forward sides it being only necessary in order to initiate reversed running to set the operating levers of the various distributing slides first of all back in their middle position and then with the construction here illustrated to move the operating levers toward the left hand, thereby exposing the openings *a'*, *b'*, *c'*, *d'*, *e'*, *f'* in succession and thus producing the distribution in the sense indicated above both as regards the separate nozzle tubes in the pressure stages and also as regards the pressure stages themselves.

In the case of ships' turbines a throttle valve is provided in the steam admission at 7 and this valve is under the direct influence of the automatic safety governor which cuts off the supply of steam to the turbine when the latter exceeds a given maximum number of revolutions. When the normal number of revolutions has again been reached the said throttle valve opens automatically. In order to prevent breakage of the steam pipes owing to the current of steam being confined by the momentary closing of the said throttle valve an ordinary spring controlled safety valve is arranged immediately in front of the throttle valve.

For a constant number of revolutions the turbine may of course be provided with the usual governor which automatically regulates the admission of steam by means of a distributing slide valve as shown in Fig. 6 with reference to single action only. Then in order to utilize the steam more efficiently not only can one low pressure stage VIII but also a second low pressure stage can be provided after the former in such a manner that the steam is simultaneously conducted to both low pressure stages from the pres-

sure stage VII through the conduit 46 in the same manner as is usual with low pressure piston engines. In order to start the turbine quickly with full power the middle pressure stages which are normally operative (in the present case the stages III, V and VIII) are supplied with fresh steam for a short time from a special branch steam pipe which can be cut off by hand.

In what has been stated it has been assumed that all the distributing valves are operated by vacuum as vacuum is necessary in a turbine and must be provided in any case. It need hardly be stated however that the valves may also be operated in some other manner electrically for example by providing conducting wires instead of tubular connections and in this case the distributing slide valves would be provided with contacts, relays, resistances and so forth for the purpose of operating the valves in the manner desired by means of electromagnets for example eventually by means of distant operating gear direct from the captain's bridge.

In order to place this turbine on the same footing as the hot steam engine as regards steam consumption hot steam is used for operating it and in addition the annular chambers 4 and the middle of the low pressure stages can be provided with heating coils through which hot steam is conducted. By this means what is called admission superheating (intermediate superheating) is produced.

In the pressure stages which are not constantly operative the supply of steam to the heating coils and its discharge may be cut off or established by means of cut off valves acted upon by the corresponding distributing valves (Figs. 7, 8 and 9).

In place of the steam heating coils electric resistances may be provided in the annular chambers for heating the operative steam and by this means the temperature of the steam in the several stages be better regulated. The operative steam may also be protected from cooling by providing the annular wall between the annular chamber and the inner turbine chamber with a layer of air that is to say making it with a double wall. The flat partitions between the several pressure stages can also be rendered non-conductive by means of a layer of air.

What I claim and desire to secure by Letters Patent is:

1. In a radial turbine, the combination with a housing having a plurality of pressure stages, a shaft passing through the housing, and a rotor having blades on both sides on said shaft in each pressure stage, of a plurality of radially arranged nozzle tubes in each side of each pressure stage for supplying a propellant radially from the interior to the exterior, means for sup-

plying a propellant to the nozzle tubes on the operative side of the first pressure stage, and means for supplying the propellant from the first pressure stage to the nozzle tubes on the corresponding sides of the additional pressure stages.

2. In a radial turbine, the combination with a housing having a plurality of pressure stages, a shaft passing through the housing, and a rotor having blades on both sides on said shaft in each pressure stage, of a plurality of radially arranged nozzle tubes in each side of each pressure stage for supplying a propellant radially from the interior to the exterior, means for supplying a propellant to the nozzle tubes on the operative side of the first pressure stage, and means for supplying the propellant from the first pressure stage to the nozzle tubes on the corresponding sides of an optional number of the additional pressure stages.

3. In a radial turbine, the combination with a housing having a plurality of pressure stages, a shaft passing through the housing, and a rotor having blades on both sides on said shaft in each pressure stage, of a plurality of radially arranged nozzle tubes in each side of each pressure stage for supplying a propellant radially from the interior to the exterior, means for supplying a propellant to an optional number of the nozzle tubes on the operative side of the first pressure stage, and means for supplying the propellant from the first pressure stage to a like number of the nozzle tubes on the corresponding sides of the additional pressure stages.

4. In a radial turbine, the combination with a housing having a plurality of pressure stages, a shaft passing through the housing, and a rotor having blades on both sides on said shaft in each pressure stage, of a plurality of radially arranged nozzle tubes in each side of each pressure stage for supplying a propellant radially from the interior to the exterior means for supplying a propellant to an optional number of the nozzle tubes on the operative side of the first pressure stage and means for supplying the propellant from the first pressure stage to a like number of the nozzle tubes on the corresponding sides of an optional number of the additional pressure stages.

5. In a reversible radial turbine, the combination of a shaft, a housing having a plurality of pressure stages on said shaft, a rotor having blade rims on both sides on said shaft in each pressure stage, each pressure stage comprising a turbine chamber and an annular propellant supply chamber arranged concentrically therewith, a plurality of radially arranged nozzle tubes on each operative side of each pressure stage

having nozzles on the ends opening radially inward relatively to the blade rims, said nozzle tubes opening into said supply chamber and being provided therein with admission valves, and means for operating together and in the same direction admission valves of the nozzle tubes located in the same radial plane in the various normally operating pressure stages.

6. In a reversible radial turbine, the combination of a shaft, a housing having a plurality of pressure stages on said shaft, a rotor having blade rims on both sides on said shaft in each pressure stage, each pressure stage comprising a turbine chamber and an annular propellant supply chamber arranged concentrically therewith, a plurality of radially arranged nozzle tubes on each operative side of each pressure stage having nozzles on the ends opening radially inward relatively to the blade rims, said nozzle tubes opening into said supply chamber and being provided therein with admission valves, a common operating mechanism, and means connecting said mechanism with groups of admission valves located in the same radial plane in the various normally operating pressure stages, said mechanism being adapted to operate the groups of valves in succession for forward and reversed running.

7. In a reversible radial turbine, the combination of a shaft, a housing having a plurality of pressure stages on said shaft, a rotor having blade rims on both sides on said shaft in each pressure stage, each pressure stage comprising a turbine chamber and an annular propellant supply chamber arranged concentrically therewith, a plurality of radially arranged nozzle tubes on each operative side of each pressure stage having nozzles on the ends opening radially inward relatively to the blade rims, said nozzle tubes opening into said supply chamber and being provided therein with admission valves, exhaust valves on each side of each normally operating pressure stage, circulating pipes connecting the exhaust valves of the corresponding preceding pressure stages with said supply chamber of the pressure stages to which the propellant is to be next admitted, and means for operating together and in the same direction admission valves of the nozzle tubes located in the same radial plane in the various normally operating pressure stages, and also a number of exhaust valves corresponding to the number of open admission valves in each pressure stage.

8. In a reversible radial turbine, the combination of a shaft, a housing having a plurality of pressure stages on said shaft, a rotor having blade rims on both sides on said shaft in each pressure stage, each pressure stage comprising a turbine chamber

and an annular propellant supply chamber arranged concentrically therewith, a plurality of radially arranged nozzle tubes on each operative side of each pressure stage having
 5 nozzles on the ends opening radially inward relatively to the blade rims, said nozzle tubes opening into said supply chamber and being provided therein with admission valves, exhaust valves on each side of each normally
 10 operating pressure stage, circulating pipes connecting the exhaust valves of the corresponding preceding pressure stages with said supply chamber of the pressure stages to which the propellant is to be next ad-
 15 mitted and means for operating together and in the same direction admission valves of the nozzle tubes located in the same radial plane in the various normally operating pressure stages; a number of exhaust valves
 20 corresponding to the number of open admission valves in each pressure stage, one or more normally open vacuum valves on each side of each pressure stage, and vacuum conduits, substantially as shown, connected with
 25 said vacuum valves and with said operating mechanism.

9. In a reversible radial turbine, the combination with a shaft, of a housing having a plurality of normally operative pressure
 30 stages and auxiliary pressure stages arranged between the same, a rotor having blade rims on both sides on said shaft in each pressure stage, a plurality of radially arranged nozzle tubes in each side of each
 35 pressure stage for supplying a propellant radially from the interior to the exterior, means for supplying a propellant to the nozzle tubes on the operative side of the first normally operative pressure stage and in
 40 succession to the nozzle tubes on the corresponding sides of the remaining normally operative and auxiliary pressure stages.

10. In a reversible radial turbine the combination with a shaft, of a housing having
 45 a plurality of normally operative pressure stages and auxiliary pressure stages arranged between the same, a rotor having blade rims on both sides on said shaft in each pressure stage, a plurality of radially
 50 arranged nozzle tubes in each side of each pressure stage for supplying a propellant radially from the interior to the exterior, means for supplying a propellant to the nozzle tubes on the operative side of the
 55 first normally operative pressure stage, means for supplying the propellant from the first pressure stage to the nozzle tubes on the corresponding sides of the additional pressure stages, and mechanism for operatively
 60 interpolating said auxiliary pressure stages singly between said normally operative pressure stages.

11. In a reversible radial turbine, the combination, with a shaft, of a housing having a
 65 plurality of normally operative pressure

stages and auxiliary pressure stages arranged between the same, a rotor having blade rims on both sides on said shaft in each pressure stage, a plurality of radially
 70 arranged nozzle tubes in each side of each pressure stage for supplying a propellant radially from the interior to the exterior, means for supplying a propellant to the nozzle tubes on the operative side of the first normally operative pressure stage, means for
 75 supplying the propellant from the first pressure stage to the nozzle tubes on the corresponding sides of the additional pressure stages, and mechanism for operatively interpolating said auxiliary pressure stages in
 80 groups between said normally operative pressure stages.

12. In a reversible radial turbine, the combination with a shaft, of a housing having
 85 a plurality of normally operative pressure stages and auxiliary pressure stages arranged between the same, each pressure stage comprising a turbine chamber and an annular propellant supply chamber arranged concentrically therewith, a rotor hav-
 90 ing blade rims on both sides on said shaft in each pressure stage, a plurality of radially arranged nozzle tubes in each side of each pressure stage having nozzles on the ends opening radially inward relatively to
 95 the blade rims, said nozzle tubes opening into said supply chamber and being provided therein with admission valves, special exhaust valves (76) on each side of each pressure stage, connecting pipes (83) con-
 100 necting the exhaust valves of the preceding normally operative pressure stage with the interposed auxiliary pressure stage and the exhaust valves of the latter with the succeeding normally operative pressure stage, a
 105 common operating mechanism, and means controlled by the latter for operating said exhaust valves.

13. In a reversible radial turbine, the combination of a shaft, a housing having a plural-
 110 ity of pressure stages comprising a main-pressure, middle-pressure, auxiliary and two low-pressure pressure stages on said shaft, a rotor having blade rims on both sides on said shaft in each pressure stage, each pressure stage
 115 comprising a turbine chamber and an annular propellant supply chamber arranged concentrically therewith, a plurality of radially arranged nozzle tubes on each operative side of each pressure stage having nozzles on the
 120 ends opening radially inward relatively to the blade rims, said nozzle tubes opening into said supply chamber and being provided therein with admission valves, and means for operating together and in the
 125 same direction admission valves of the nozzle tubes located in the same radial plane in the various normally operating pressure stages.

14. In a reversible radial turbine, the com- 130

combination of a shaft, a housing having a plurality of pressure stages comprising a main-pressure, middle-pressure, auxiliary and two low-pressure pressure stages on said shaft, a
5 rotor having blade rims on both sides on said shaft in each pressure stage, each pressure stage comprising a turbine chamber and an annular steam supply chamber arranged concentrically therewith, a plurality of radially
10 arranged nozzle tubes on each operative side of each pressure stage having nozzles on the ends opening radially inward relatively to the blade rims, said nozzle tubes opening into said supply chamber and being

provided therein with admission valves, 15 means for operating together and in the same direction admission valves of the nozzle tubes located in the same radial plane in the various normally operating pressure stages, and means in the steam supply chamber for superheating the steam therein. 20

In testimony, that I claim the foregoing as my invention, I have signed my name in presence of two subscribing witnesses.

JAN PROCNER.

Witnesses:

WLADYSLAW KRAJCIOSKI,
CYRIL TREDNICKI.