J. PROCNER.

STEAM TURBINE.

APPLICATION FILED MAY 20, 1910.

989,926.

Patented Apr. 18, 1911.

4 SHEETS—SHEET 1.

Fig. 3.

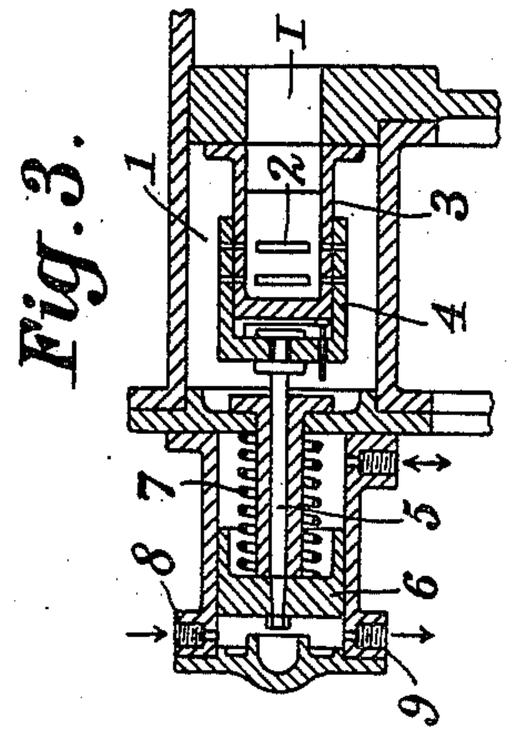


Fig. 4.

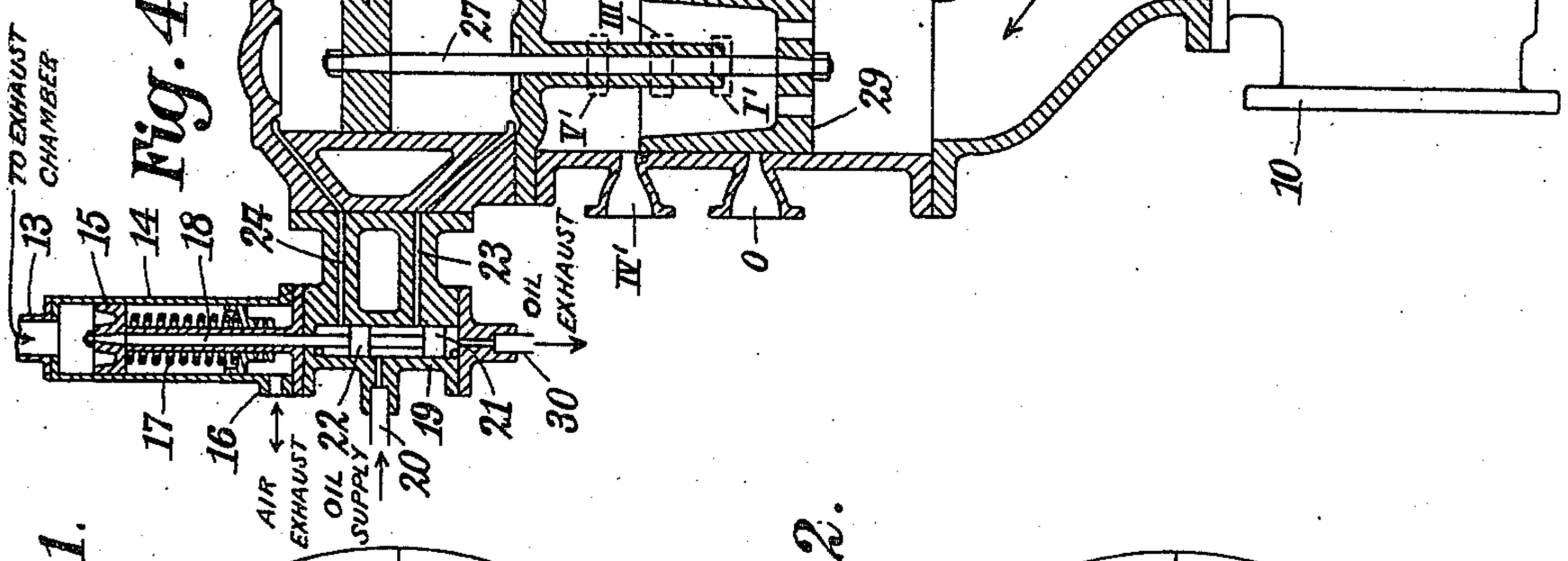


Fig. 1.

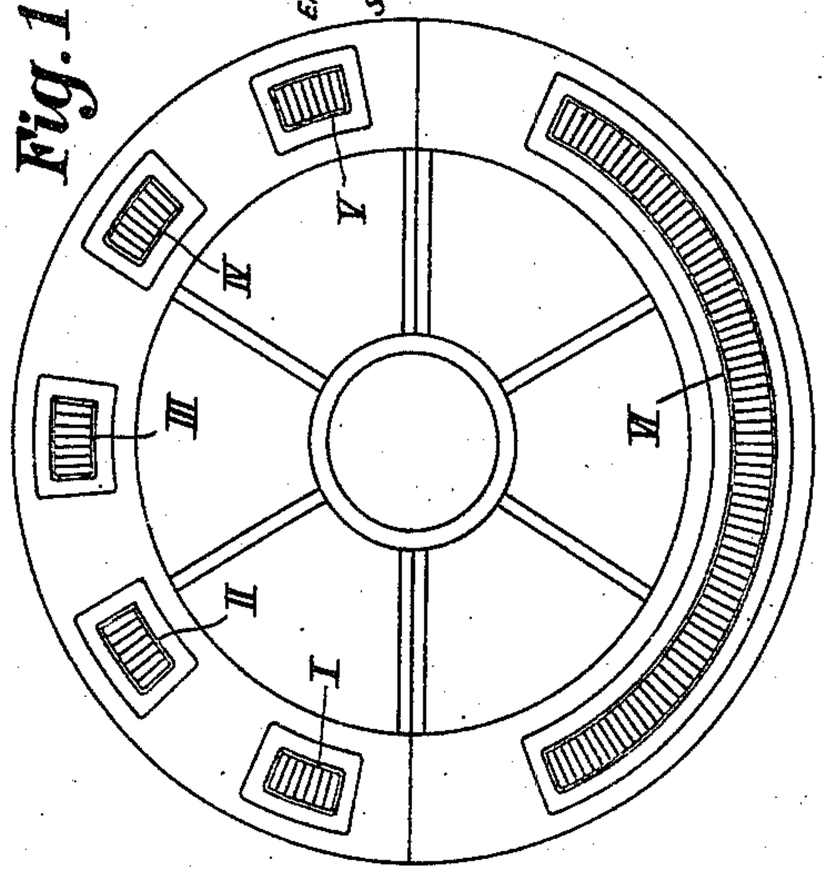
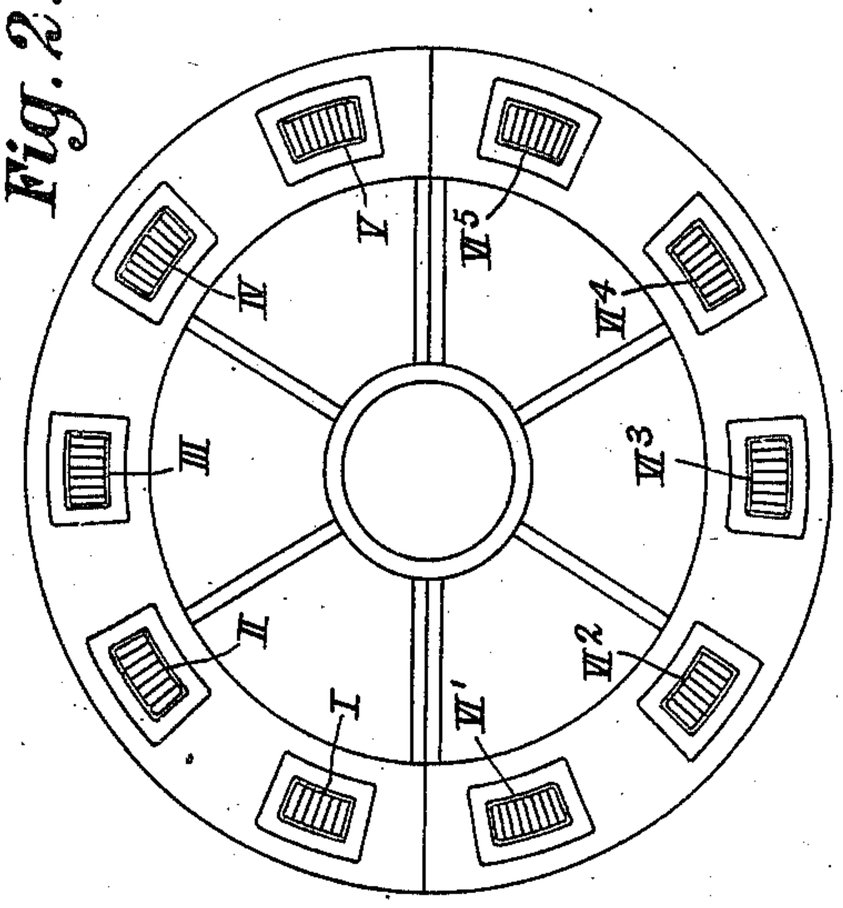


Fig. 2.



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4 SHEETS—SHEET 2.

Fig. 5.

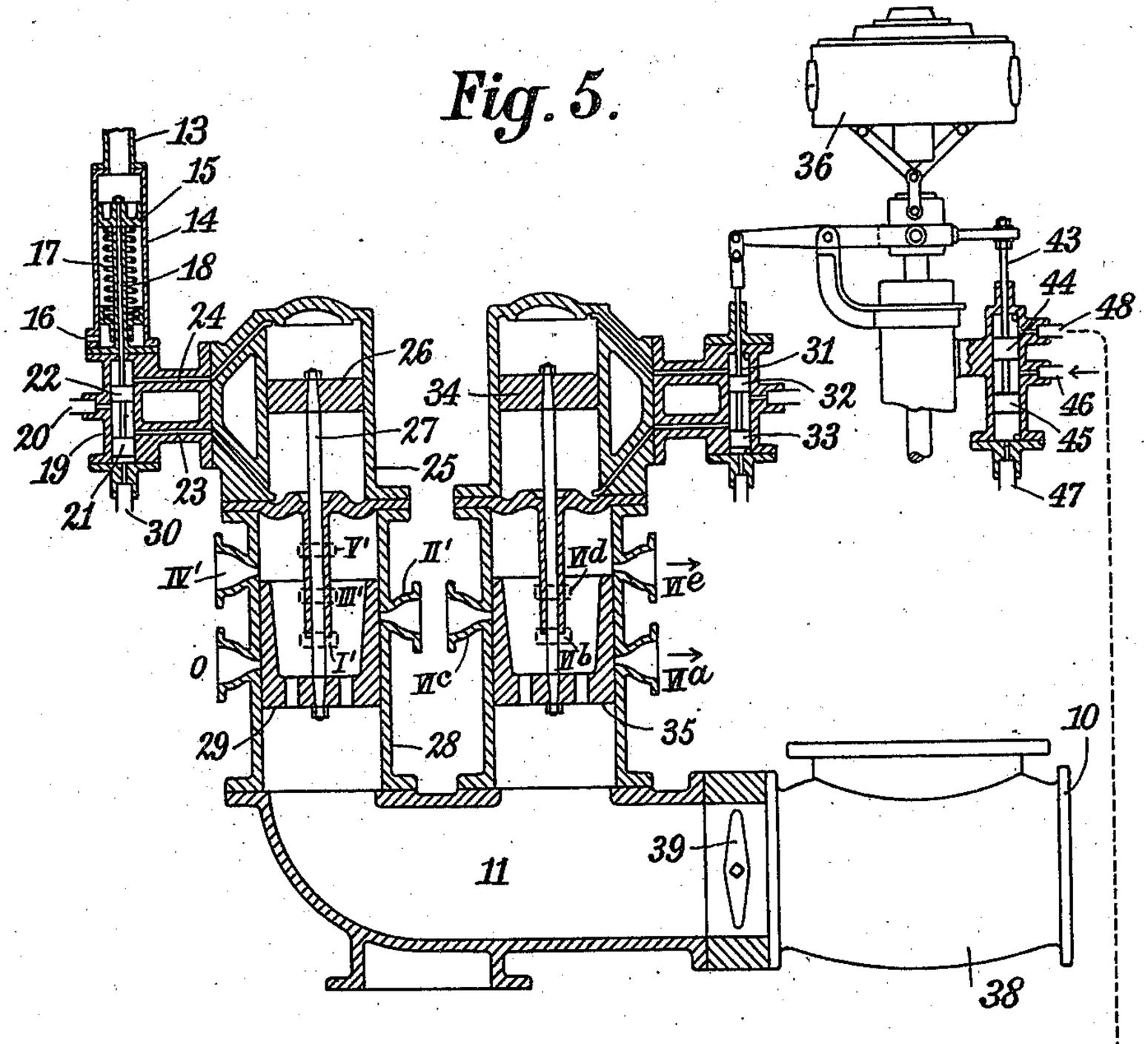
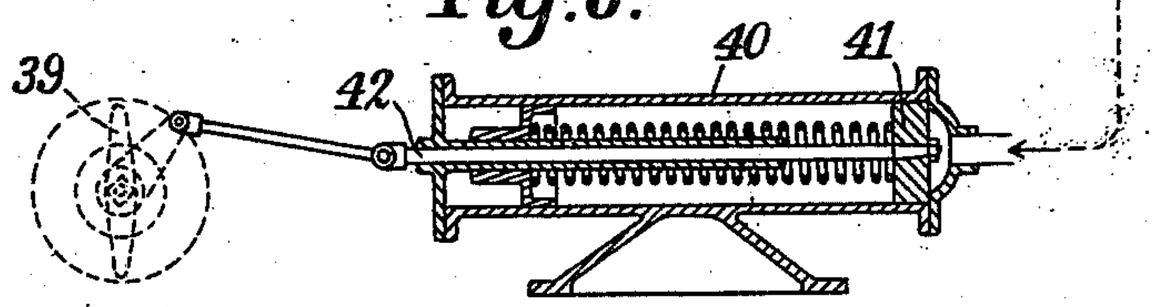


Fig. 6.



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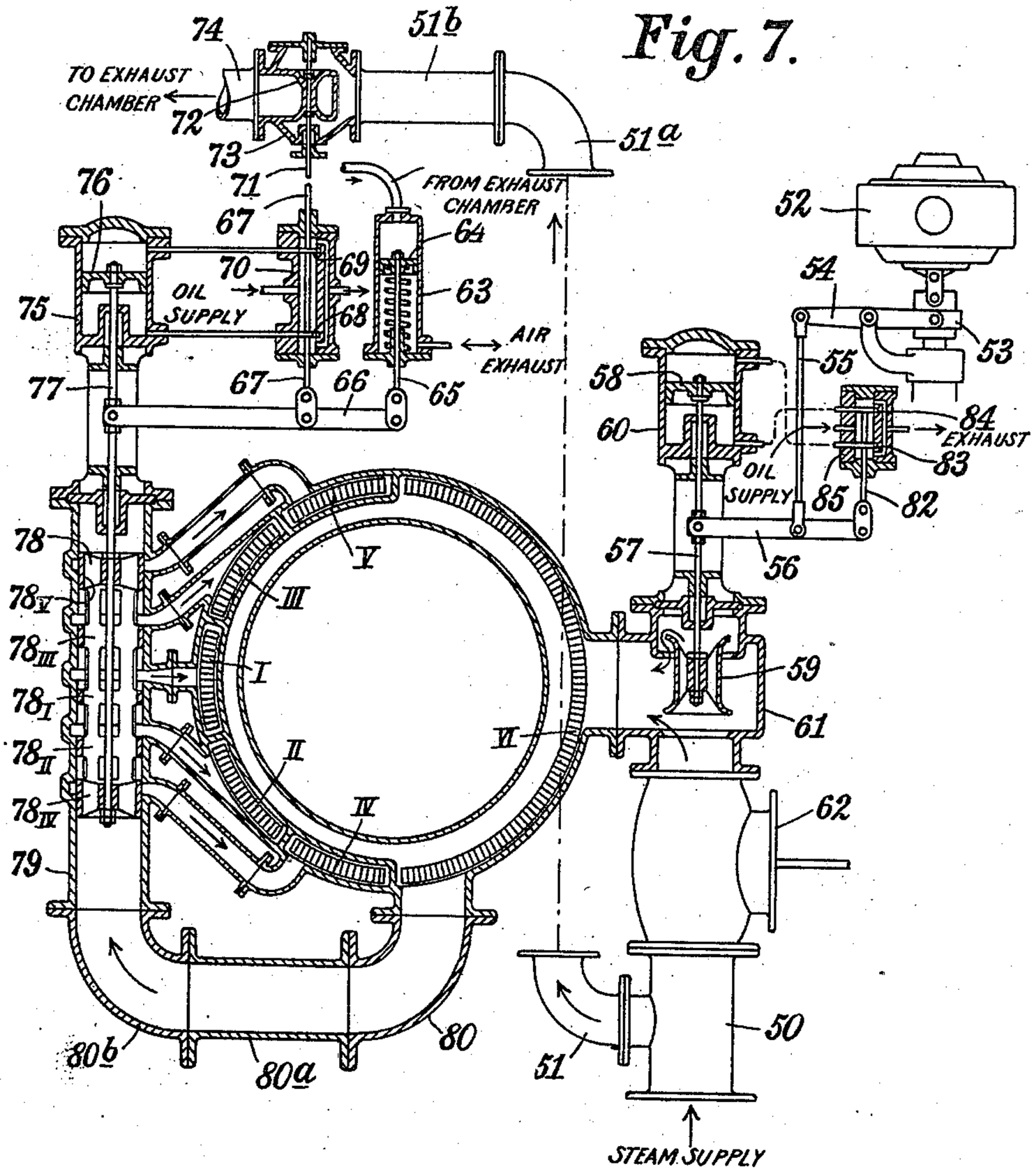
4 SHEETS—SHEET 3.

Fig. 7.



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4 SHEETS—SHEET 4.

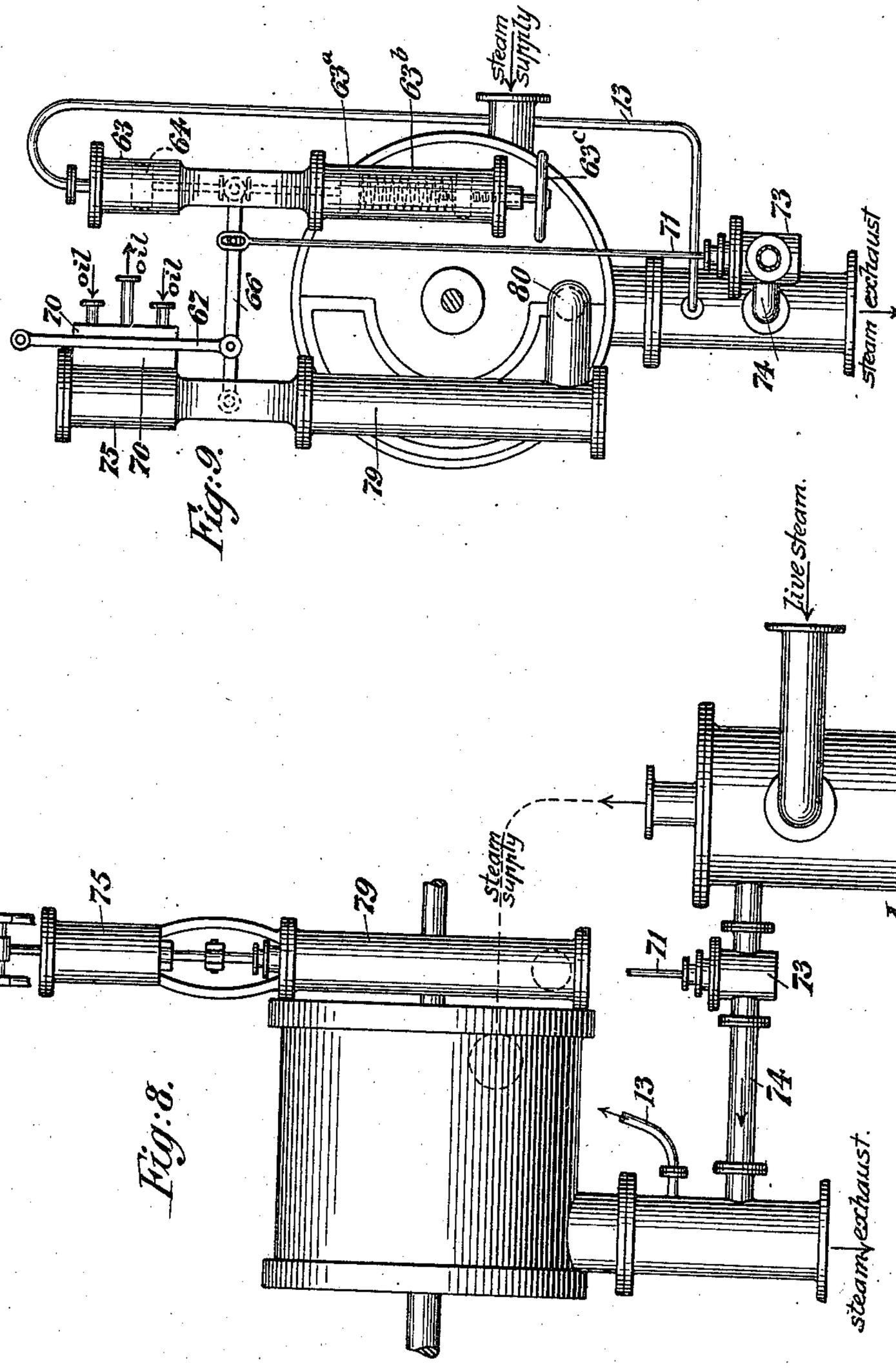

Fig. 9.

Fig. 8.

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UNITED STATES PATENT OFFICE.

JAN PROCNER, OF PABIANICE, RUSSIA.

STEAM-TURBINE.

989,926. Specification of Letters Patent. **Patented Apr. 18, 1911.**

Application filed May 20, 1910. Serial No. 562,351.

To all whom it may concern:

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

I, JAN PROCNER, of Pabianice, in the Empire of Russia, engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:

In my co-pending application for U. S. Letters Patent, Serial No. 513649, a final pressure steam turbine is described in which pressure stages are automatically rendered operative or inoperative in such a manner that the number of revolutions of the turbine remains constant while its output is variable or constant according to requirements and the quantity of steam passing through it variable. Consequently this prior case relates to turbines of the type in which the number of pressure stages is variable. The fundamental idea underlying my prior construction may however likewise be utilized in other turbines for example "Zoelly" turbines and the like in which it is required to maintain the number of pressure stages constant. In this case in accordance with the present invention the number of admission apertures to the first rotor is increased or reduced in dependence upon the final pressure due to the process of manufacture so that the work of the turbine is likewise absolutely and solely dependent upon the consumption of steam in the manufacturing operation so that the number of revolutions of the turbine may be maintained constant and its output either variable or constant as required. In this connection it has proved to be advantageous to divide the quantity of steam to be supplied to the turbine making one part of such a magnitude that it corresponds approximately to the minimum steam consumption in the manufacturing process so that this part may be regarded as approximately constant. The other part of the steam must however be variable and its quantity is determined by the final pressure of the turbine dependent upon the steam consumption in the process of manufacture. For this second portion of the steam it is consequently necessary to provide a final pressure regulator that is to say for example a device substantially as described in my co-pending application aforementioned and which determines the number of steam inlets to be kept open at any given time in dependence upon the final pressure. The constant quantity of steam on the other hand requires practically no special regulation but it appears to be desirable to subject it to the influence of the centrifugal governor (revolution governor) in such a manner that the maximum speed of the turbine cannot be exceeded. If such a tendency exists the centrifugal governor may either effect a qualitative regulation by throttling the portion of steam in question or else a purely quantitative regulation by utilizing a regulating device corresponding substantially to the final pressure governor.

The present invention is illustrated in the accompanying drawing in which by way of example:

Figure 1 is a front elevation of the steam admission device for the first rotor of a turbine operating with a constant number of pressure stages. Fig. 2 is a similar view showing a modified steam admission device. Fig. 3 is a section of a steam admission valve actuated or controlled by the final pressure governor. Fig. 4 is a section of a final pressure governor directly operating the steam supplied to the first pressure stage. Fig. 5 illustrates a similar form of regulating device in which, however, a quantitative regulation under the influence of a centrifugal governor is employed for the constant quantity of steam to be supplied to the turbine. Fig. 6 is a section through an operating device for a throttle slide or clack valve, which may likewise be subjected to the influence of the centrifugal governor. Fig. 7 shows diagrammatically a form of operating gear similar to that represented in Fig. 4 with combined qualitative and quantitative regulation. Figs. 8 and 9 show respectively side-view and end-view of a constructive form of the gear shown at the left of Fig. 7.

The present invention in the first place resides broadly in the fact that the fundamental idea of the reaction turbine described in my said co-pending application and which in this earlier case is only applicable to turbines of the kind in which the number of pressure stages can be modified, is applied to other kinds of turbines and in particular to those in which the number of stages must remain constant. In accord-

ance with the present invention the steam admission to the first pressure stage of the turbine is first of all subdivided in a manner known *per se* into a number of independent inlets I, II, III, IV, V and so forth to which the steam is supplied under the influence of a governor such as described in the main application that is to say in dependence upon the final pressure determined by the steam consumption of the manufacturing process this supply taking place in such a manner that when the final pressure in the process of manufacture increases the number of the steam inlets I, II, III, IV, V is reduced, while when the final pressure diminishes this number is increased presupposing that both the variable output of the turbine and also the variable quantity of steam utilized in the manufacture and from which the output results can be maintained approximately proportionate to each other (eventually by parallel connection or storing the temporary excess power in electric accumulators). With this object all the steam inlets may be located in a single annular chamber 1 (Fig. 3) and each aperture may be covered with a tubular socket 3 comprising slots 2. Above this tubular socket 3 a slide 4 likewise slotted is arranged; by means of a spindle 5 this slide is connected with a piston 6 acted upon by a spring 7 and also by oil under pressure admitted through an aperture 8 and discharged through an aperture 9. This oil under pressure comes from the aforesaid governor in which as is known a piston displaced under the influence of the final pressure of the turbine exposes one after the other a number of openings through which oil under pressure is able to flow. If with the governor suitably adjusted this oil reaches one side of the piston 6 (Fig. 3) this piston is displaced in opposition to the pressure of the spring 7, whereby the slide 4 is set in such a manner that the steam is able to pass from the annular chamber 1 through the slots in the slide 4 and socket 3 into the corresponding inlets I, II, III, IV, V so that it is suitably admitted to the turbine.

As already stated it has been found to be advantageous in turbines with an invariable number of pressure stages to divide the quantity of steam to be supplied to the turbine supplying a portion of it approximately corresponding to the minimum consumption of steam in the manufacturing process constantly to the turbine, while the other part is subjected to the influence of the governor so that it is variable. In this case a steam inlet (Fig. 1) of suitable size must be provided for the constant supply of steam. In the drawing it has been assumed that the constant supply of steam amounts approximately to 50% of the maximum quantity. Consequently the opening VI is of such a size that about one half of the guide wheel passages in the first pressure stage can be supplied by it. The steam inlets I, II, III, IV, V which serve for supplying the variable quantity of steam are arranged symmetrically on the other half of the wheel. As already stated these inlets are acted upon by the governor while the inlet VI for the constant quantity of steam is influenced by the centrifugal governor, the latter arrangement being adopted merely in order that the number of revolutions of the turbine should not exceed a maximum limit.

The means for dividing the steam and for automatically regulating the two portions of steam are represented in Figs. 4 and 7. In Fig. 4 the total quantity of steam supplied to the turbine is conducted through a socket 10 which opens into a branch 11 from which the constant quantity of steam is conducted to the inlet VI over the valve 12 which can be furnished with a throttle slide or clack valve acted upon by the centrifugal governor. The other half of the steam reaches a final pressure governor which differs from the governor used in my earlier construction of turbine to the extent that here it permits of distributing the steam directly. The final pressure acting upon the end of the turbine is conducted on to a piston 15 arranged in the cylinder 14 through a pipe 13. Air is exhausted from the under side of the piston 15 which is acted upon by a spring 17. The piston rod 18 is extended beyond the cylinder 14 and projects into a distributing slide valve 19 to which oil under pressure is supplied through the pipe 20. By means of two slide pistons 21, 22 mounted on the piston rod 18 two passages 23, 24 are controlled; these passages lead to the two ends of a cylinder 25 in which the piston 26 is mounted. The piston rod 27 of the piston 26 is prolonged beyond the cylinder 25 and extends into the steam distributing cylinder 28 proper; in this cylinder upon the end of this piston rod the balanced steam piston 29 is fixed. This piston 29 opens and covers a number of steam outlets O, I′, II′, III′, IV′, V′ which are connected with the steam inlets I, II, III, IV, V on the blade wheel directly by means of tubular conduits that is to say independently. The opening O communicates with the exhaust chamber of the turbine through a pipe. At the beginning of the operation the piston slides 21, 22 are arranged in the cylinder 19 in such a manner that oil under pressure from the passages 11 and 24 may act on the upper side of the piston 26 while from the lower side of the piston connection is established with the exhaust 30 by means of the passage 23. The oil under pressure is therefore able to depress the piston 26 so that the piston 29

frees all the openings O, I′, II′, III′, IV′, V′. The machine therefore begins to operate with full steam and by opening O live steam is able to flow to the exhaust chamber of the turbine and thence to the scene of the manufacturing operations. As at the same time steam is conducted into the turbine also through all the passages I′, II′, III′, IV′, V′ and all the openings I, II, III, IV, V the steam conduits for the manufacturing process are speedily filled with steam. As soon as the desired final tension has been attained the final pressure acts upon the piston 15 through which it displaces the piston slides 21, 22 in such a manner that the passage 23 is placed in communication with the supply passage 20 for oil under pressure while simultaneously the passage 24 is placed in communication with the exhaust 30 by a circulation conduit. By means of the oil under pressure which now acts on the lower side of the piston 26 this piston is lifted and the steam piston 29 first of all closes the branch O through which live steam flows into the exhaust chamber of the turbine, and then the pipes I′, II′, III′, IV′, V′ which conduct the steam into the guide wheel apertures I, II, III, IV, V which are adapted to be closed. By closing the upper half of the first guide wheel the power of the turbine is reduced by one half. If the final pressure should not then fall a safety valve located on the exhaust chamber of the turbine opens and conducts the whole of the steam to a hot water reservoir for example until the increased final pressure ceases. Even with the steam inlets I, II, III, IV, V entirely closed of course the steam inlets for the constant quantity of steam remain open as before except that eventually as already stated the steam may be throttled in the valve 12 by the centrifugal governor for regulating the number of revolutions. In view of the fact that such a quantitative regulation of this constant quantity of steam always causes considerable loss of power in final pressure turbines it may be advantageous to employ a purely quantitative regulation for this constant quantity of steam passing through the turbine. A construction of this kind is illustrated by way of example in Figs. 2 and 5. In this case it is first of all necessary to employ a number of separate openings VI′, VI^2, VI^3, VI^4, VI^5, etc., for the constant quantity of steam instead of the large steam inlet VI shown in Fig. 1. For quantitative regulation even under the influence of the centrifugal governor a regulating device is employed (Fig. 5) which substantially corresponds to the final pressure governor except that here the rod 31 which by means of slide pistons 32, 33 distributes the oil under pressure which acts above the piston 34 on the steam piston 35 is acted upon by the centrifugal governor 36 in the usual manner. In the cylinder 37 of the steam piston 35 a number of branches VI^a, VI^b, VI^c, VI^d, VI^e corresponding to the subdivision of the steam inlet VI are arranged; these branches are connected by conduits with the several openings VI′, VI^2, VI^3, VI^4, VI^5 (Fig. 2). Here also the piston 36 renders the several openings operative or inoperative in correspondence with the distribution of the oil under pressure produced by the centrifugal governor and thus produces a purely quantitative regulation. Finally it may also be advantageous to provide a throttle slide or clack valve 39 in the steam conduit 10 behind a cut off valve 33, said valve being likewise acted upon by the centrifugal governor 36. With this object a distributing cylinder 40 is employed (Fig. 6); in this cylinder a spring-controlled piston 41 is arranged its rod 42 being connected with and displacing the throttle slide or clack valve 39. Oil under pressure distributed from the centrifugal governor by means of a rod 43 acts upon the piston 41. Slide pistons 44, 45 are mounted on the rod 43 and between them the oil under pressure supplied through the opening 46 either remains steadily or flows to a passage 48 and thence is caused to act on the piston 41 in the distributing cylinder 40 in which case the throttle slide or clack valve 39 in the highest position of the governor cuts off the steam supply in order to prevent the turbine from racing; when the number of revolutions has fallen the steam cut-off device re-opens automatically.

In the construction in Fig. 2 the openings VI′, VI^2, VI^3, VI^4, VI^5 through which the constant supply of steam passes are likewise located on one half of the guide wheel only while the other openings I, II, III, IV, V through which the variable quantity of steam passes are located on the other half of the guide wheel. This construction is particularly advantageous for turbines with axial admission. It need not be insisted upon that with turbines of other form especially when the admission is radial the openings for the supply of the constant quantity of steam can be arranged alternately with the openings for the variable steam supply.

In cases where not only the variable steam supply but also the constant steam supply passing through the turbine are regulated purely quantitatively by the final pressure governor or centrifugal governor, in order to prevent the turbine from developing excessive power when this cannot be utilized it may be advantageous to connect a suitable number of distributing sockets of the final pressure governor directly through the circulation pipe with the exhaust chamber of the turbine instead of with the corresponding inlets in the first guide wheel so that the increased consumption of steam in

the manufacturing process is distributed in the so-called final pressure governor directly into the proper steam conduit and not over the turbine blades. The supply of live steam to the exhaust chamber can be effected from a separate live steam valve of the usual kind as in Fig. 7 instead of from the sockets O in Figs. 4 and 5. For example the oil distributing pistons 21, 22 may be furnished with prolonged slide rods thereby actuating a steam admission member (valve slide, clack or the like) which supplies live steam directly to the exhaust chamber. It is essential that the connection between this piston rod and the valve stem should be allowed a certain amount of play so that with normal small stroke of the oil piston slide valve the valve may not be influenced. It is only when the spring 17 is vigorously compressed which only occurs when all the cross sections of the first guide apparatus are fully open or if the regulating steam piston 29 should have stuck owing to defective operation that the valve would become operative.

When both the load on the turbine and also the quantity of steam passing are subjected frequently to considerable fluctuations in running when there would be danger of unsteady operation of the turbine if the valve gears shown in Figs. 4 and 5 were used the gear shown in Fig. 7 can be employed. In one extreme case, with a small load and small steam consumption, this gear furnishes the admission to the first blade wheel with throttled steam likewise by the quantitative regulation effected by the final pressure governor; in the other extreme case (with a small load and large consumption of steam) a separate live steam valve is opened by the final pressure governor through which unthrottled steam can conveniently flow into the exhaust chamber of the turbine. With a heavy load and a large consumption of steam both the governors supply unthrottled steam to the first guide wheel while with a heavy load and small steam consumption the steam is temporarily conducted into a hot water reservoir from the exhaust chamber as in Figs. 4 and 5 through a safety valve.

The operation of the valve gear illustrated in Fig. 7 is as follows: At the beginning of operations the sleeve 53 of the centrifugal governor 52 occupied its lowest position so that by means of the lever 54 the rod 55 is lifted, by this means the lever 56 lifts the valve rod 82 with the piston 83, 84 and oil under pressure issues from the oil valve 85 into the oil cylinder 60 beneath the piston 58, presses it and the piston rod 57 and the throttle valve 59 upward so that the latter remains open and as soon as the cut-off valve 62 is opened by hand for starting the turbine, live steam leaves the socket 50 through the valve casing 61 and passes to the chamber VI for admission to one half of the first blade wheel. The final pressure governor 63 communicates with the exhaust chamber of the turbine through the steam pipe 13. At the beginning of operations there is no steam pressure in this pipe and the steam piston 64 is pressed upward by spring pressure. By means of piston rod 65, lever 66 and slide rod 67, this piston acts upon the two slide pistons 68, 69 in the oil slide valve 70 in such a manner that in the upper position of the steam piston 64 oil under pressure flows toward the cylinder 75 over the oil piston 76 and depresses it. By means of the piston rod 77 this oil piston is connected with the steam distributing slide valve 78 for quantitative regulation. The lowest position of the oil piston 76 also corresponds with the lowest position of the steam slide 78 in which all five operative faces 78^{I}, 78^{II}, 78^{III}, 78^{IV}, 78^{V} afford a free passage for the steam to the chambers I, II, III, IV, V for admission to the other half of the first blade wheel. The steam flows toward the chambers I, II, III, IV, V from the chamber VI through the tubular connections 80, 80^{a}, 80^{b} and the slide valve casing 78. In addition at the beginning of operations the exhaust chamber of the turbine is filled with live steam by means of the final pressure governor. In the uppermost position of the governor piston 64 the oil slide spindle 67 presses with its upper end on the valve spindle 71 and lifts the balanced live steam valve 72 so that the live steam flows from the socket 50 through the branch 51, 51^{a}, 51^{b} into the valve casing 73 and through the open valve 72 and pipe 74 to the exhaust chamber. As soon as the turbine has exceeded its normal speed the governor sleeve 53 rises in the known manner, the steam is throttled in the valve casing 61 and valve 59. As soon as the normal final pressure of the turbine is exceeded the piston 64 is depressed whereby the steam inlets to the admission chambers I, II, III, IV, V are obturated in succession. With a normal number of revolutions unthrottled steam passes through the regulating valve 61, 59.

Fig. 7 shows the various parts of the gear arranged diagrammatically for the proper understanding of the same. Figs. 8 and 9 show a constructional form corresponding to Fig. 7, in which the individual parts appear different in location but are essentially the same. In Fig. 9 the piston 64 is divided and one half located in the cylinder 64 and the other half in cylinder 64′, and the spring 63^{b} is regulated by the hand wheel 63^{c}. The cylinder A is supplied with live steam and acts as a water separator.

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

1. In an apparatus of the kind described, the combination of a fluid pressure motor,

an inlet-pipe for said motor divided into a pair of branches, an exhaust-pipe, a valve in each of the branches for regulating the amount of fluid passing therethrough into the motor, a movable means operated by the pressure of the fluid in the exhaust-pipe and operatively connected to one of said valves for varying the admission of fluid to the motor, and a governor operated by the speed of the motor and operatively connected to the other valve.

2. In an apparatus of the kind described, the combination of a fluid pressure motor, an inlet-pipe for said motor divided into a pair of branches, an exhaust-pipe, a valve in each of the branches for regulating the amount of fluid passing therethrough into the motor, a movable means operated by the pressure of the fluid in the exhaust-pipe and operatively connected to one of said valves for varying the admission of fluid to the motor, a governor operated by the speed of the motor and operatively connected to the other valve, an additional pipe for conducting fluid under pressure to the exhaust-pipe, a valve in said additional pipe, and an operative connection between the said movable means and said last-named valve.

3. In a system for regulating the final pressure and number of revolutions of a steam-turbine, the combination, with the steam-turbine, of inlet-pipes for conducting live steam to the turbine at different points, valves in said inlet-pipes for regulating the amount of steam flowing through said inlet-pipes, a movable means operated by the pressure of the exhaust of the turbine and operatively connected to the valve in one of said pipes for operating said valve, and a governor operated by the rotation of the turbine and operatively connected to the valve in the other inlet-pipe.

4. In a system for regulating the final pressure and number of revolutions of a steam-turbine, the combination, with the steam-turbine, of inlet-pipes for conducting live steam to the turbine at different points, valves in said inlet-pipes for regulating the amount of steam flowing through said inlet-pipes, a movable means operated by the pressure of the exhaust of the turbine and operatively connected to the valve in one of said pipes for operating said valve, a governor operated by the rotation of the turbine and operatively connected to the valve in the other inlet-pipe, an additional pipe for conducting live steam into the exhaust, and a regulating valve in said additional pipe and operatively connected to said movable means.

5. In an apparatus of the kind described, the combination, with a steam-turbine, of conduits for introducing steam to various points of the turbine, means controlled by the final pressure of the turbine and the speed thereof for regulating the amount of steam passing through certain of said conduits, the steam passing other of said conduits being free from regulation.

6. In an apparatus of the kind described, the combination of a steam-turbine, a plurality of inlet-conduits for conducting pressure steam to the turbine, a sliding means for successively uncovering a number of said conduits for permitting the passage of the steam, a movable part adapted to be pressed upon by the exhaust steam of the turbine, and an operative connection between the movable part and the sliding means and adapted to be operated by the movable part and to move the sliding means.

7. In an apparatus of the kind described, the combination of a turbine having an exhaust-pipe and an admission-gear, an exhaust pressure cylinder, a spring-pressed piston therein, a pressure medium cylinder, a pressure medium distributing valve operatively connected to the spring-pressed piston and having conduits leading to the pressure medium cylinder, and a piston in the pressure medium cylinder operatively connected with the admission-gear.

8. In an apparatus of the kind described, the combination of a steam-turbine having an admission-conduit, a throttling valve and an admission-gear for said conduit, a pair of pressure medium valves, a pair of cylinders having connection with said valves respectively and adapted to operate said throttling valve and said admission-gear respectively, a centrifugal governor operated by the turbine and operating one of the pressure medium valves and means for operating the other pressure medium valve and operated by the pressure of the exhaust of the turbine.

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

JAN PROCNER.

Witnesses:
HENRY HASPER,
WOLDEMAR HAUPT.