C. R. WALLER.

ELASTIC FLUID TURBINE.

APPLICATION FILED JUNE 10, 1909.

971,092. Patented Sept. 27, 1910.

6 SHEETS—SHEET 1.

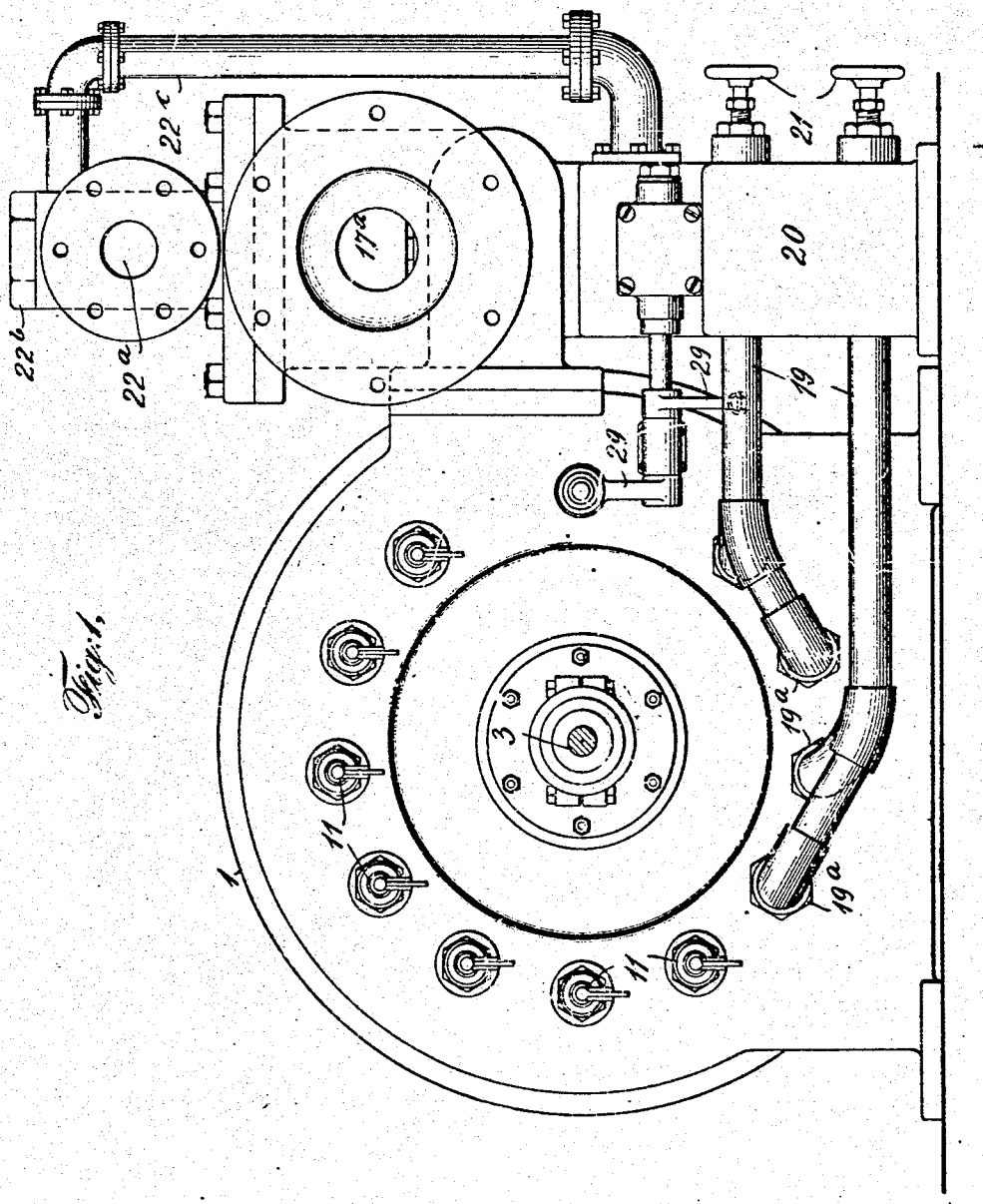

Fig. 1.

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6 SHEETS—SHEET 2.

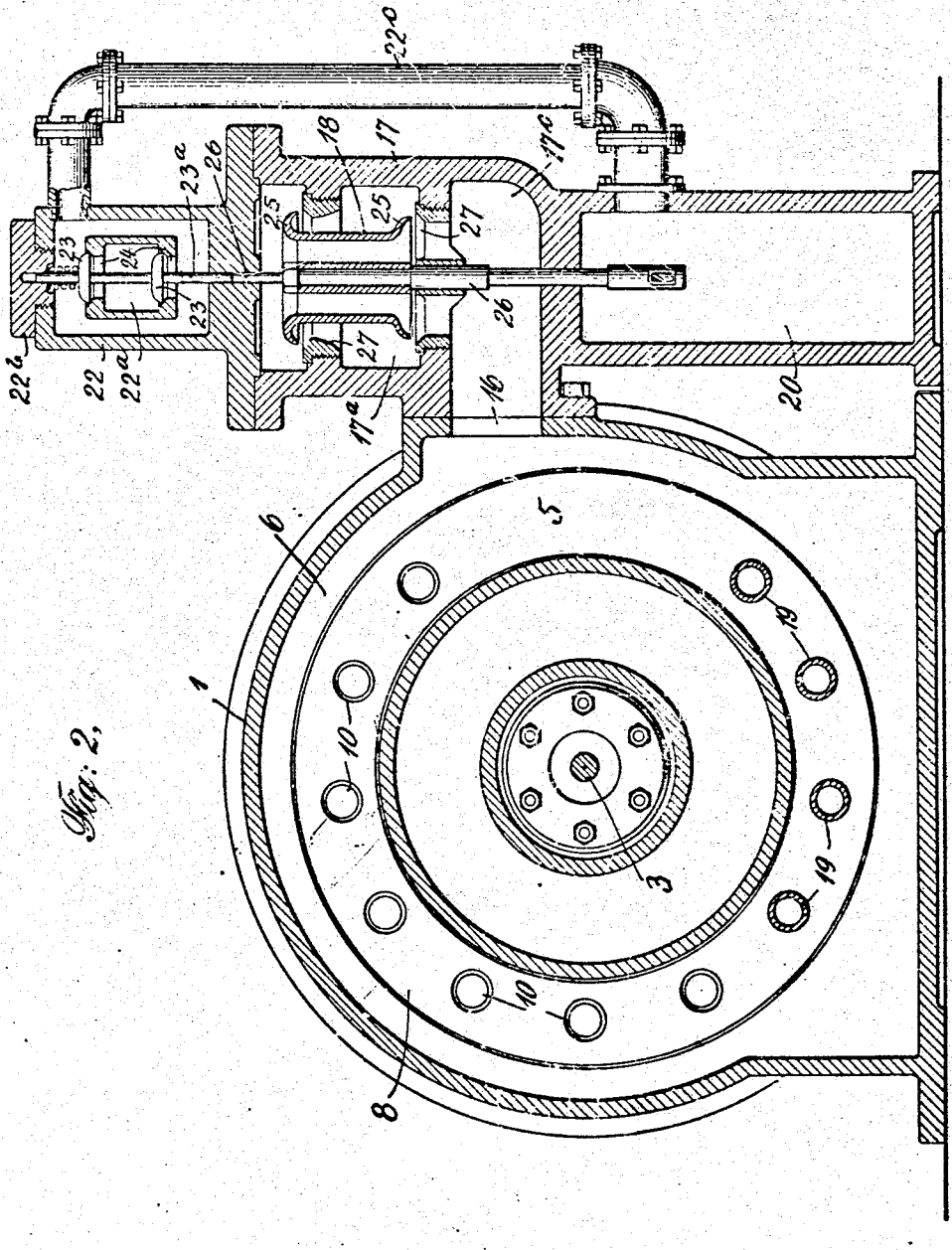

Fig. 2.

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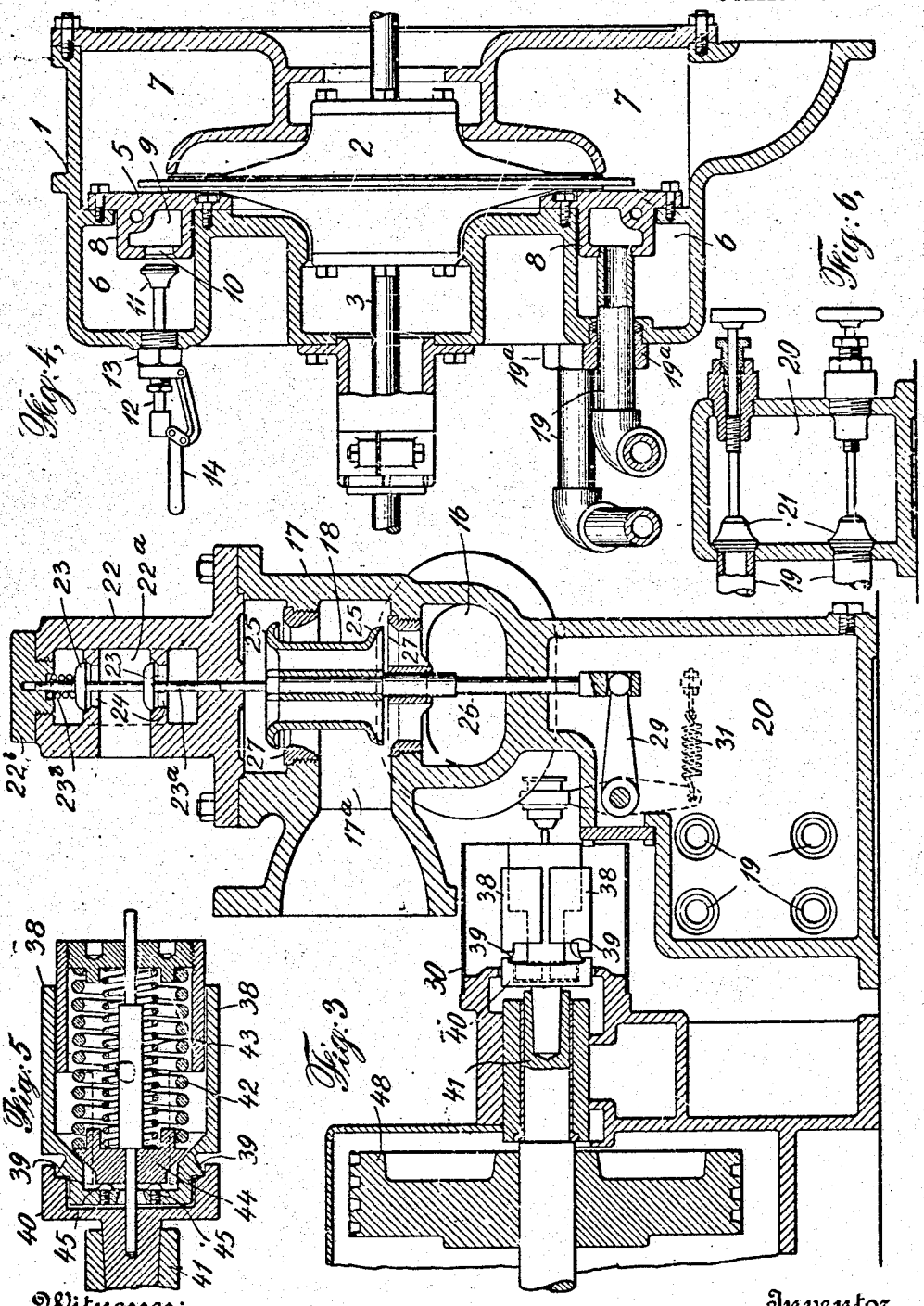
6 SHEETS—SHEET 3.



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6 SHEETS-SHEET 4.

Fig. 9.

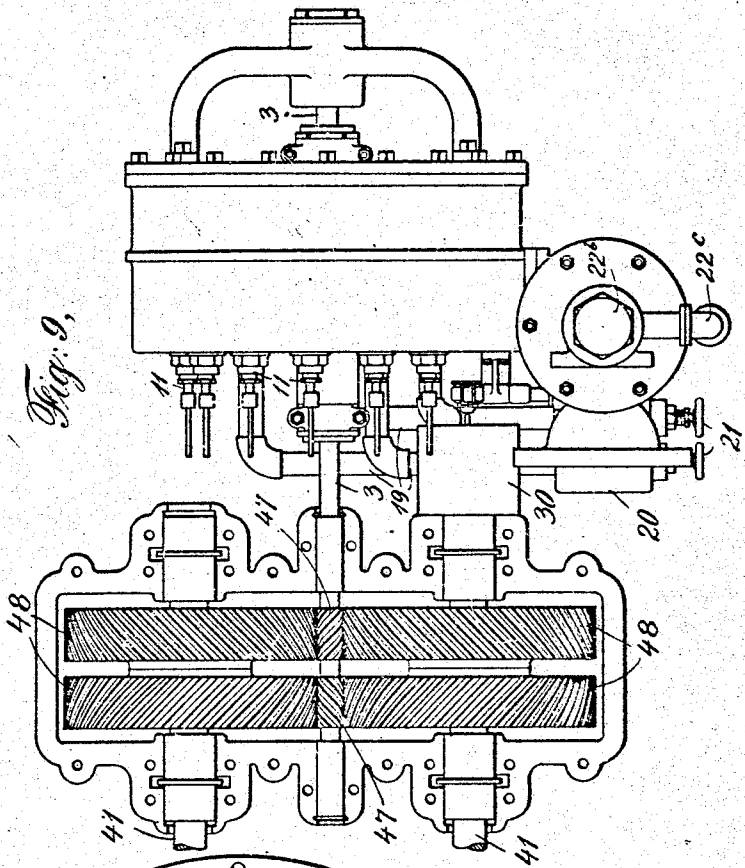


Fig. 7.

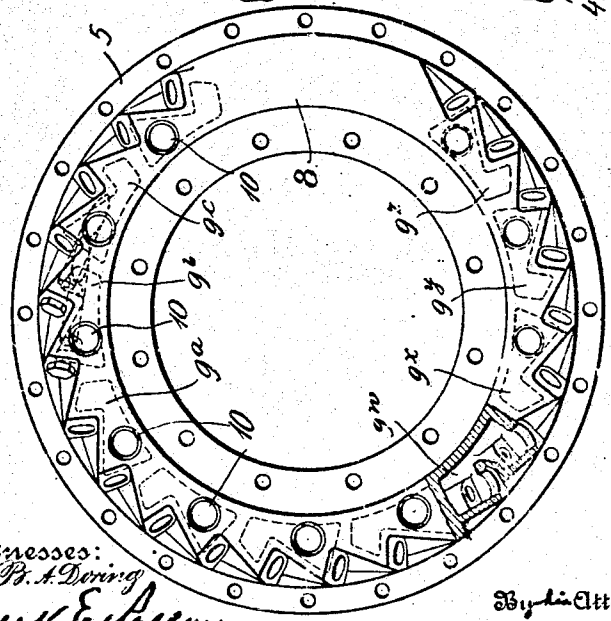
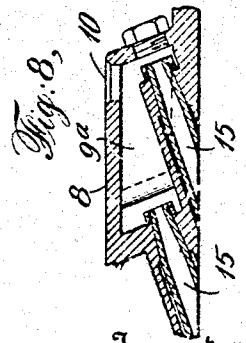


Fig. 8.



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6 SHEETS—SHEET 5.

Fig. 11.

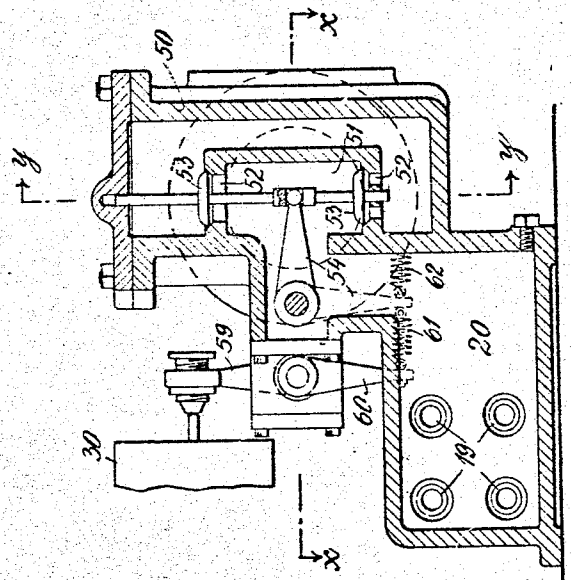
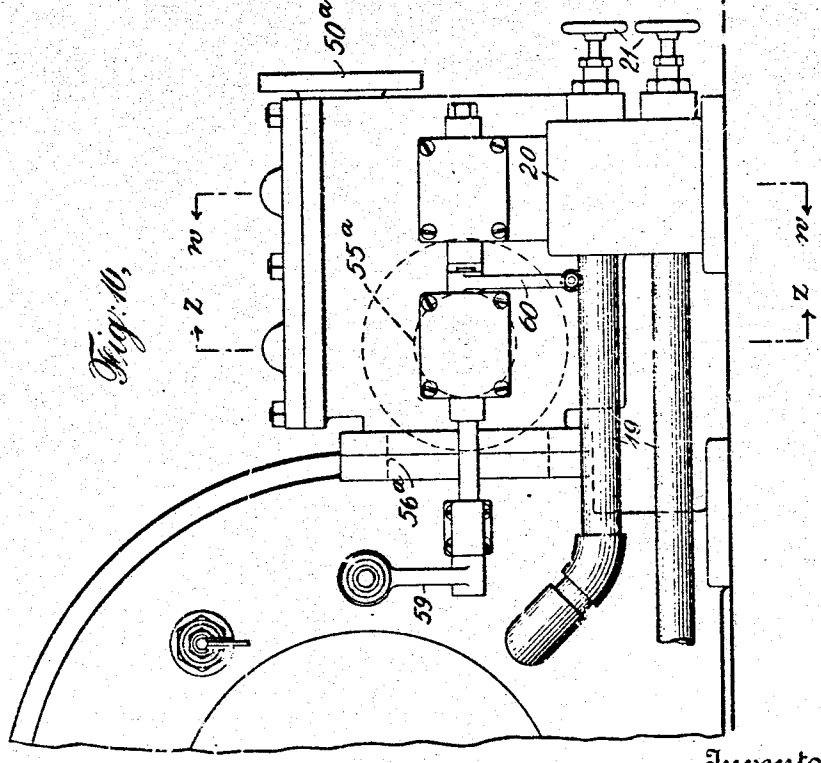


Fig. 10.



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ELASTIC FLUID TURBINE.

APPLICATION FILED JUNE 10, 1909.

971,092.

Patented Sept. 27, 1910.

6 SHEETS—SHEET 6.

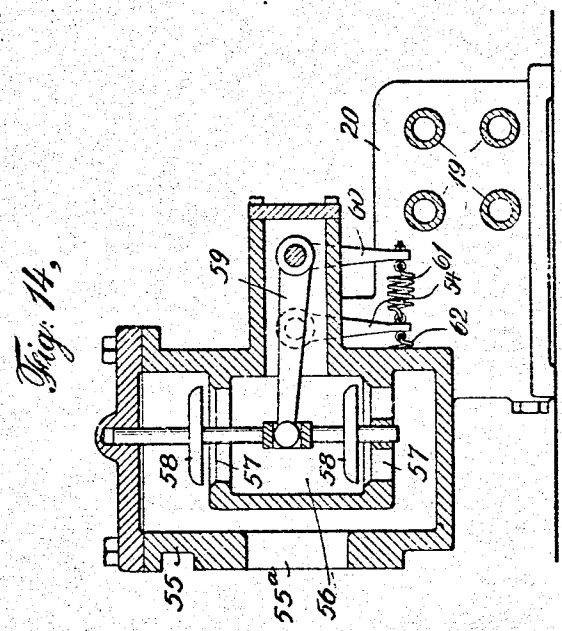

Fig. 14.

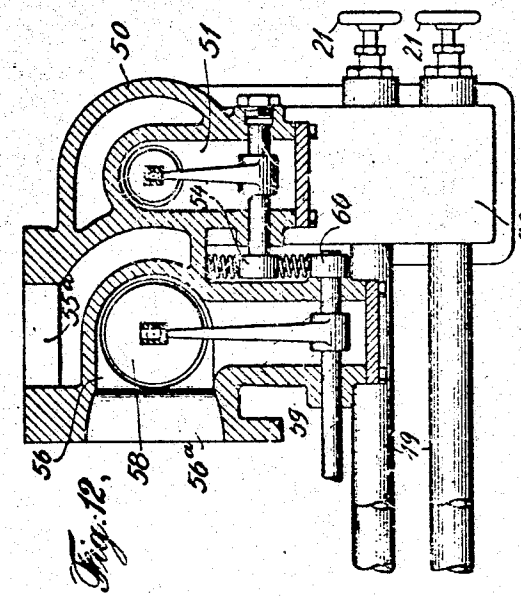

Fig. 12.

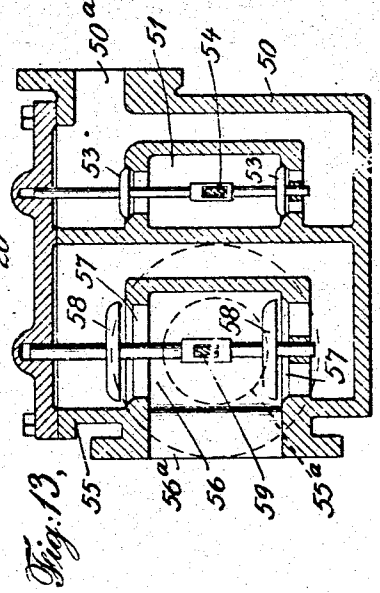

Fig. 13.

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UNITED STATES PATENT OFFICE.

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ELASTIC-FLUID TURBINE.

971,092. Specification of Letters Patent. Patented Sept. 27, 1910.

Application filed June 10, 1909. Serial No. 501,298.

To all whom it may concern:

Be it known that I, CARL RICHARD WALLER, a subject of the King of Sweden, and a resident of Trenton, county of Mercer, and State of New Jersey, have invented certain new and useful Improvements in Elastic-Fluid Turbines, of which the following is a specification.

This invention relates to improvements in elastic fluid turbines, and particularly to improvements in turbines designed to be operated simultaneously upon steam of a plurality of different pressures, derived from a corresponding plurality of sources. An example of such turbine is, a turbine designed to be operated simultaneously upon high pressure steam derived from a boiler or other suitable source, and upon exhaust steam derived from some other engine.

It is highly desirable, in the case of exhaust turbines, that as great a proportion of the load on the turbine shall be carried by means of the exhaust steam as possible, the high pressure or boiler steam being used only to supplement the action of the exhaust steam. Since the load on the turbine may be variable, and since the supply of exhaust steam to the turbine may be variable, I have found that it is desirable to provide automatic governing means which shall admit to the turbine only that amount of boiler or high pressure steam required to supplement the action of the low pressure or exhaust steam; and in the governing mechanism herein described, two valves are provided, one controlling the supply of exhaust or low pressure steam, the other controlling the supply of boiler or high pressure steam, these valves being operated by suitable mechanism so that, in regulating the supply of steam to the turbine, the high pressure valve remains closed altogether until the low pressure steam proves insufficient to enable the turbine to carry its load, and then such high pressure valve is opened to such extent only as is required to enable the turbine to carry its load; such mechanism being further so arranged that, upon decrease of load of the turbine, the high pressure valve regulates the supply of high pressure steam to the turbine, the low pressure valve remaining wide open; until high pressure steam is no longer required, and then said high pressure valve is closed entirely, and further regulation of the action of the turbine is effected, for lower loads, by adjustment of the low pressure valve. In this way all of the low pressure steam available is utilized, and only so much high pressure steam is employed as is required to enable the turbine to carry its load.

In the specific embodiment of my invention herein illustrated and described, I have shown a turbine of well known type, comprising a single rotary blade-carrying member, and a plurality of nozzles arranged to project steam against the blades of said rotary member, certain of these nozzles being understood to be of a shape adapting them for efficient use of low pressure steam, and other of said nozzles being understood to be of a shape adapting them for efficient use of high pressure steam; and I have further illustrated separate valves for regulating the supply of steam separately to these two classes of nozzles, and a centrifugal governor, and means operated thereby controlling separately the high pressure valve and the low pressure valve to such extent that the high pressure valve is not opened until the low pressure valve is practically wide open, and said high pressure valve is closed before any material closing of the low pressure valve has occurred.

In a companion application of even date herewith Serial No. 501,297, I illustrate and describe other turbine regulating means embodying the broad invention likewise embodied in the turbine herein illustrated and described, but specifically different in, among other features, that two governors are employed, one for the high pressure valve and the other for the low pressure valve, said governors being adjusted so that the high pressure valve is opened after the low pressure valve is opened and is closed before the low pressure valve is closed. I do not, in the present application, claim the features common to the two engines, as such features in common are claimed in my said application Serial No. 501,297.

The objects of my invention are to improve turbines intended to be operated simultaneously by the working fluid derived at different pressures from a plurality of sources; to operate successively a plurality of valves controlling supply of working fluid from a plurality of different sources; to carry as great a proportion of the load as possible by working fluid of one pressure,

admitting only such proportion of working fluid of the other pressure or pressures as may be required to carry the load; to control the supply of both working fluids by means of a single governor; and to make the turbine relatively simple, compact, efficient and reliable.

I will now proceed to describe my invention with reference to the accompanying drawings.

In said drawings: Figure 1 shows an end elevation of one construction of turbine embodying my invention, the gearing of the type of turbine illustrated and centrifugal governor of such turbine, being omitted. Fig. 2 shows a vertical transverse section of the turbine through the primary steam chest and the valve chambers. Fig. 3 shows a vertical section through the center of the valve chambers, taken on a plane at right angles to that of Fig. 2. Fig. 4 shows a vertical axial section of the turbine. Fig. 5 shows a detail axial section of the centrifugal governor employed for adjusting the valves. Fig. 6 shows a detail section through the high pressure steam chest on a plane at right angles to Fig. 3. Fig. 7 shows a detail elevation and partial section of the nozzle ring, and Fig. 8 shows a detail transversa fragmentary developed section through said ring and one of its nozzles. Fig. 9 shows a plan view of the turbine. Fig. 10 shows a detail fragmentary end elevation of a portion of the turbine embodying an alternative arrangement of valves, and Fig. 11 shows a detail vertical section through the valve chamber on the line w—w of Fig. 10. Fig. 12 shows a detail horizontal section through the valve chamber on the line x—x of Fig. 11. Fig. 13 shows a detail vertical section through the valve chamber on the line y—y of Fig. 11, and Fig. 14 shows a detail vertical section through the valve chamber on the line z—z of Fig. 10.

Referring now to the drawings, and at first to Figs. 1–9 inclusive, 1 designates the casing of the wheel chamber of the turbine, 2 designates the rotary bucket-carrying wheel within said casing, and 3 designates the shaft upon which said wheel is mounted. I do not in the drawings show the buckets themselves in detail, but it will be understood that the same are arranged upon the periphery of the wheel 2, in the ordinary manner. 5 designates a nozzle ring such as employed in this class of turbine, and 6 designates a low pressure primary steam chest constituting an annular chamber within the casing 1. The nozzle ring 5 separates this low pressure steam chest 6 from the wheel chamber 7, said nozzle ring comprising an annular portion 8 projecting through a corresponding annular space formed in the casing 1, and in this annular portion 8 of the nozzle ring there is a secondary steam chest 9. For convenience in governing, this secondary steam chest is customarily divided into a plurality of separate chambers 9^a, 9^b, 9^c, etc., and in the wall of the annular portion 8 of the nozzle ring opposite certain of the chambers 9^a, 9^b, 9^c, etc., are a plurality of valve seated openings 10, one for each such chamber; and for each such opening there is a corresponding valve 11; the stems 12 of these valves, in the construction shown in the drawings, extending outward through suitable stuffing boxes, being arranged to be operated by suitable hand levers 14. As many expansion nozzles 15 may lead from one of these chambers 9^a, 9^b, etc., as found convenient. In the construction shown, two nozzles lead from each such chamber, as indicated particularly in Fig. 7, but this number is not material and will be varied, as convenience of design makes desirable.

The low pressure primary steam chest 6, is provided with an admission port 16, Fig. 2, to which is connected a low pressure valve chamber 17 having in it a suitable regulating valve 18. The valve openings 10 above referred to, serve to lead the low pressure or exhaust steam from the primary steam chest 6, to the corresponding nozzles 15. The supply of this pressure steam to the primary steam chest 6 is controlled by the regulating valve 18, adjusted by a suitable centrifugal governor, as hereinafter described. The particular form of low pressure regulating valve 18 shown, is a hollow, double seated, balanced puppet valve, comprising two valve edges 25 seating against corresponding ported seats 27, this valve being mounted upon a stem 26. Low pressure steam is admitted to an intermediate space 17^a and, when valve 18 is open, passes directly past the lower edge 25 of valve 18 and through the port of the lower valve seat 27 into the chamber 17^c of valve chamber 17, and also passes through the port of valve seat 27 and past the upper edge 25 of the valve 18 into a chamber 17^c and thence through the interior of the hollow valve 18 and the port of the lower valve seat 27 into the lower chamber 17^c of low pressure valve chamber 17, and thence into the low pressure primary steam chamber 6.

Above the low pressure valve chamber 17 is a high pressure valve chamber 22 to the intermediate portion 22^a of which high pressure steam is supplied. This intermediate chamber 22^a has ported valve seats 24, for a balanced regulating valve 23 comprising two valves mounted upon the same stem 23^a, which stem is mounted to slide in bearings in the lower wall of the high pressure valve chamber 22 and in the bonnet 22^b of that valve chamber. The upper portion of the stem 26 of the low pressure regulating valve 18 is reduced and also works through the bearing orifice in the lower wall of the high

pressure valve chamber 22, being directly beneath the high pressure valve stem 23^a. When the valves 23 are seated, and valve 18 is also seated, there is a slight space between the low pressure valve stem 26 and high pressure valve stem 23^a; but when the low pressure valve 18 has opened somewhat, its valve stem 26 abuts against valve stem 23^a, and further raising of valve 18 raises the high pressure valves 23 against the pressure of a spring 23^b. Therefore, one movement of the stem 26 serves to open both valve 18 and valve 23, valve 18 opening first and after it valve 23; and in closing, the two valves move together until the valve 23 has closed, after which valve 18 continues its downward motion alone. When valve 23 is opened high pressure steam admitted into the chamber 22^a passes through the ported seats 24 into the main portion of high pressure valve chamber 22, and thence passes through a conduit 22^c into a high pressure steam chest 20, from whence pipes 19 lead to certain high pressure nozzles connected to corresponding chambers 9^w, 9^x, 9^y, etc., in the nozzle ring 5; these pipes 19 passing through suitable stuffing boxes 19^a in the front of casing 1. In the high pressure steam chest 20, suitable valves 21 (Fig. 6) are provided for regulating independently the supply of high pressure steam to the several pipes 19.

The valve stem 26 passes through a suitable guide orifice in the lower wall of the low pressure valve chamber 17, into the high pressure steam chest 20, and is there connected to one arm of a bell crank lever 29, the other arm of which is outside of the high pressure steam chest 20 and is arranged to be actuated by a centrifugal governor 30; a governor spring 31 acting upon this bell crank and tending to cause the bell crank to follow the stem of the governor when the same is retracted.

I do not limit myself to any particular type of governor for adjusting the valves, but the particular governor illustrated in Figs. 3 and 5 is convenient for the purpose, and comprises centrifugal weights 38, having knife edges 39 bearing against a disk 40 mounted upon a shaft 41, and springs 42 and 43 pressing against a disk 44 itself pressing against the heads of screws 45 carried by the inner end of the governor weights 38. It will be obvious that as the shaft 41 rotates, these governor weights 38 tend to fly out, such tendency being resisted by the springs 42 and 43, and also by the spring 31 shown in Fig. 3.

As shown particularly in Fig. 9 this turbine comprises, as is usual in turbines of the particular type illustrated, pinions 47 mounted upon the turbine wheel shaft 3 and intermeshing with gears 48 on opposite sides of the pinions 47, and themselves mounted upon two shafts 41. From either of these shafts 41 power may be taken off. On one of these shafts 41 the speed governor 30 above mentioned, is mounted. In the operation of this turbine, as already described, the governor so adjusts the valves that as great a portion of the total power developed as possible, is developed from the low pressure steam; such regulation being automatic. But the operator may, and will customarily, control the operation of the turbine more or less, by hand, by cutting various of the high pressure and low pressure nozzles into and out of action, by means of the valves 21 and 11, respectively, so that if the load carried is materially less than the low pressure steam alone is able to carry, only a part of the low pressure nozzles will be in service; or if the load carried is such as to require some, but not all, of the high pressure nozzles, some of these high pressure nozzles will be out of service; the purpose being to avoid throttling and wire drawing as much as possible, by having only those nozzles in service which are absolutely required for carrying the load; the low pressure regulating valve being therefore, customarily, wide open, and the high pressure regulating valve on the point of opening; though when the load conditions, or the supply of high pressure and low pressure steam, are very variable, a greater working margin may be provided, by leaving open more nozzles than are absolutely required by conditions existing at the moment.

As shown in my companion application Serial No. 501,297, I may provide an emergency valve and suitable pipe connections for permitting a portion of the high pressure steam to flow into the low pressure steam chest 6, and thence to the low pressure nozzles; this high pressure steam being either throttled down to or above the pressure intended to be maintained normally in the low pressure steam chest, or, if excessive over-load is to be carried, so that economy of operation is not so important, steam may be admitted to the low pressure steam chest at much higher pressures, the supply of low pressure steam being cut off altogether.

It will be apparent that the turbine may be started either with low pressure steam or with high pressure steam, as may be most convenient; and that if the machine is in operation, the governor will automatically adjust the valves so that as great a proportion as possible of the load will be carried by the low pressure steam.

It will, of course, be apparent that, should there be any occasion for doing so, the valve mechanism can be rearranged so that as much as possible of the load is carried by the high pressure steam, and the low pressure steam is used only to supplement the action of the high pressure steam. It will also be understood that, in the case of a turbine of

proper capacity with respect to the load to be carried, the turbine can carry its full load at normal speed if operated either with low pressure steam alone, or with high pressure steam alone, or if operated partly with high pressure and partly with low pressure steam.

In Figs. 10–14 inclusive, I illustrate an alternative type of valve gear, in which the high pressure and low pressure valves, instead of being one above the other, are arranged side by side in separate valve chambers. In these drawings, 50 designates the high pressure valve chamber into which high pressure steam is admitted through a port 50^a. Figs. 13 and 51 designates an intermediate space in said chamber and communicating through ported valve seats 52 with the interior of valve chamber 55. This chamber 51 communicates with high pressure steam chest 20, from which the pipes 19 lead to the high pressure nozzles. The high pressure regulating valve 53 is a double balanced puppet valve, and is operated by a bell-crank lever 54, one arm of which is within the high pressure steam chest 20 and chamber 51, the other arm of such bell-crank being outside of the high pressure steam chest and connected high pressure steam spaces. The low pressure valve chamber 55 is at the side of the high pressure valve chamber 50, and is provided with a port 55^a for the admission of low pressure steam to its interior. Within it is an intermediate chamber 56 having ported valve seats 57 connecting it with the interior of valve chamber 55. This interior chamber 56 communicates by a port 56^a with the low pressure steam chest 6 of the turbine. The low pressure regulating valve 58 is a double balanced puppet valve, and it is operated by a bell crank lever 59, one arm of which is within the space 56 and the other arm of which is outside of the low pressure steam chest, and is arranged to be actuated by the stem of the governor 30. This bell crank has secured to it another arm, 60, which is directly in front of the external arm of the high-pressure-valve bell crank 54; and a spring 61 connects these two arms, and another weaker spring 62 is connected to bell crank 54 and to some fixed portion of the machine. In the operation of the turbine, as speed rises above normal and the governor operates accordingly, the arm 60 is moved to the left of Fig. 11, the motion of such arm being transmitted through spring 61, with little or no extension of that spring, to bell crank 54, the high pressure valves 53 being thereby moved toward their seats, and, finally, closed: and if the speed rises still further, the governor moves arm 60 still farther to the left and since bell crank 54 is no longer able to move in that direction, valves 53 being seated, motion is communicated to the low pressure valve 58 only, until finally said valve may be closed nearly or completely. As speed falls, valves 58 open first, owing to the greater stiffness of spring 61, and if such valves be open wide, further decrease in speed causes opening of the valves 53.

It will be obvious that numerous mechanisms may be devised for the joint control and successive opening and closing, of high pressure and low pressure valves, by the action of a single governor, the mechanism herein illustrated and described being only two of the many which might be devised.

What I claim is:—

1. An elastic fluid turbine comprising a rotor, high-pressure-working-fluid supply means and lower-pressure-working-fluid supply means therefor, and governing means controlling the supply of both such working fluids and arranged to begin the supply of one such fluid after the supply of the other fluid is begun, and to discontinue the supply of one such fluid before the supply of the other fluid is discontinued, comprising separate high pressure and low pressure puppet valves in line with one another and arranged to be actuated one by the other, but disconnected one with respect to the other and arranged to seat independently, and a single governor and connecting devices connecting said governor to one of said valves, the valve so connected to the governor being arranged to be moved from its seat before it encounters the other valve and moves said latter valve from its seat in turn, the said latter valve being arranged to seat, during closing of the valves, before the seating of that valve which is connected to the governor.

2. An elastic fluid turbine comprising in combination a rotor, high pressure and low pressure nozzles for supplying working fluid thereto, and governing means controlling the supply of working fluids to such nozzles comprising separate high pressure and low pressure puppet valves in line with one another and arranged to be actuated one by the other, but disconnected one with respect to the other and arranged to seat independently, and a single governor and connecting devices connecting said governor to one of said valves, the valve so connected to the governor being arranged to be moved from its seat before it encounters the other valve and moves said latter valve from its seat in turn, the said latter valve being arranged to seat, during closing of the valves, before the seating of that valve which is connected to the governor.

3. An elastic fluid turbine comprising a rotor, high-pressure-working-fluid supply means and lower-pressure-working-fluid supply means therefor, a high pressure valve chamber and a low pressure valve chamber and puppet valves therein for controlling flow of high pressure working fluid and low

pressure working fluid respectively, said valves arranged in line with one another and one arranged to open the other when itself open, and after it has been opened somewhat, and a single governor arranged to actuate that valve which is arranged to open the other.

4. An elastic fluid turbine comprising a rotor, a high pressure valve chamber and a low pressure valve chamber, and high pressure and low-pressure puppet valves located therein and in line with one another, the low pressure valve disconnected from the high pressure valve but arranged to lift the high pressure valve from its seat after said low pressure valve has been lifted from its seat, said valves arranged to seat independently, a centrifugal governor driven by the turbine and a pivoted lever actuated by said governor and connected to the stem of the low pressure valve and arranged to move said valve from and toward its seat.

5. An elastic fluid turbine comprising a turbine casing having in it a rotor chamber, a rotor therein having a series of buckets, a plurality of separate steam chests in said casing and expansion nozzles extending from said steam chests to the rotor chamber and arranged all to direct working fluid directly against the same series of buckets, the nozzles of certain of said steam chests of different expansion ratio than the nozzles of others of said steam chests, independent working-fluid-supply-means for the steam chests having expansion nozzles of different ratios, independent puppet supply valves for said independent working-fluid-supply-means, and a speed governor and means operated thereby for operating said valves arranged to open said valves successively and to permit same to close in reverse order to their order of opening.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

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