No. 760,003. PATENTED MAY 17, 1904.

T. G. E. LINDMARK.

REGULATOR FOR ELASTIC FLUID TURBINES.

APPLICATION FILED JUNE 27, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

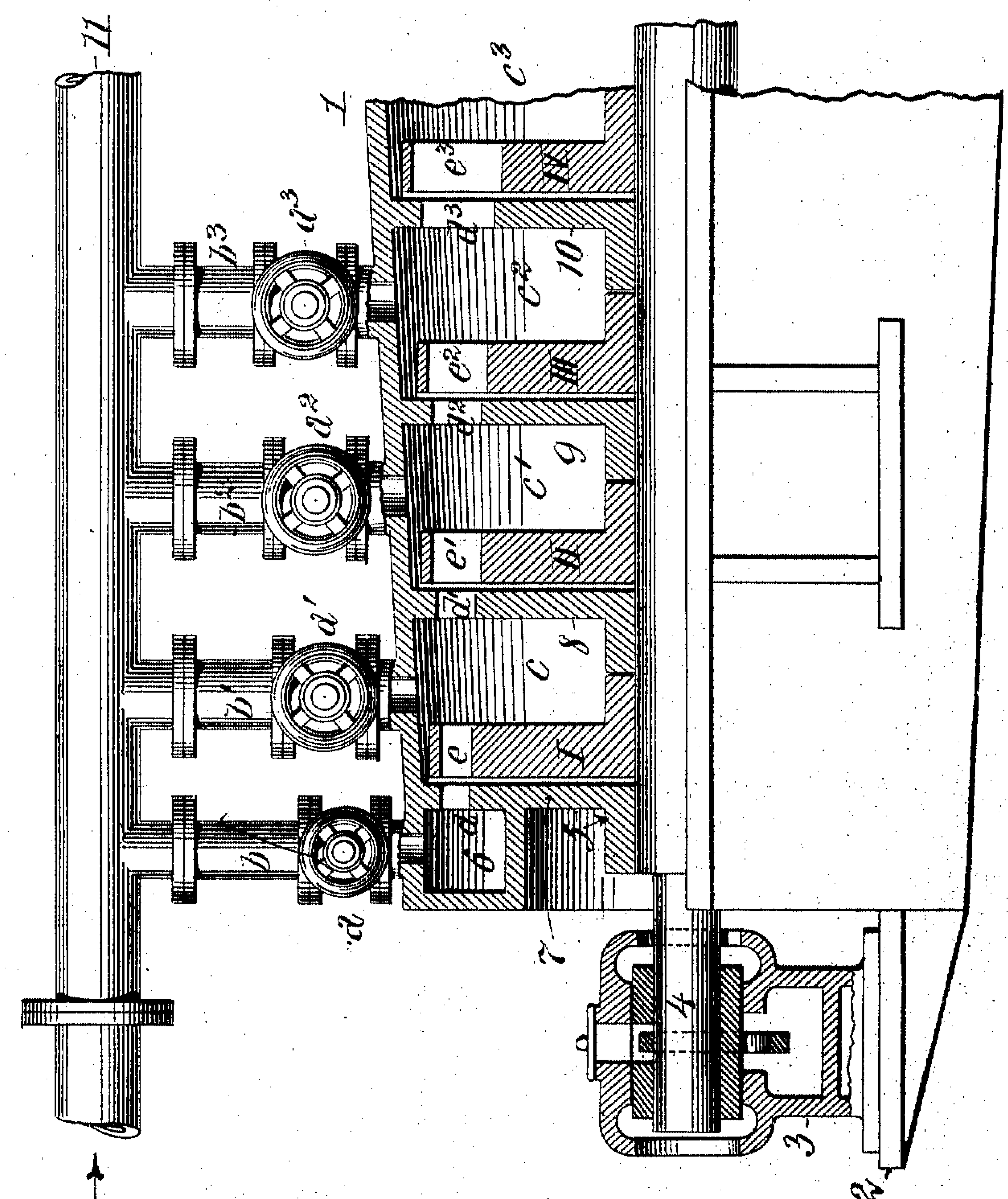

Fig. 1.

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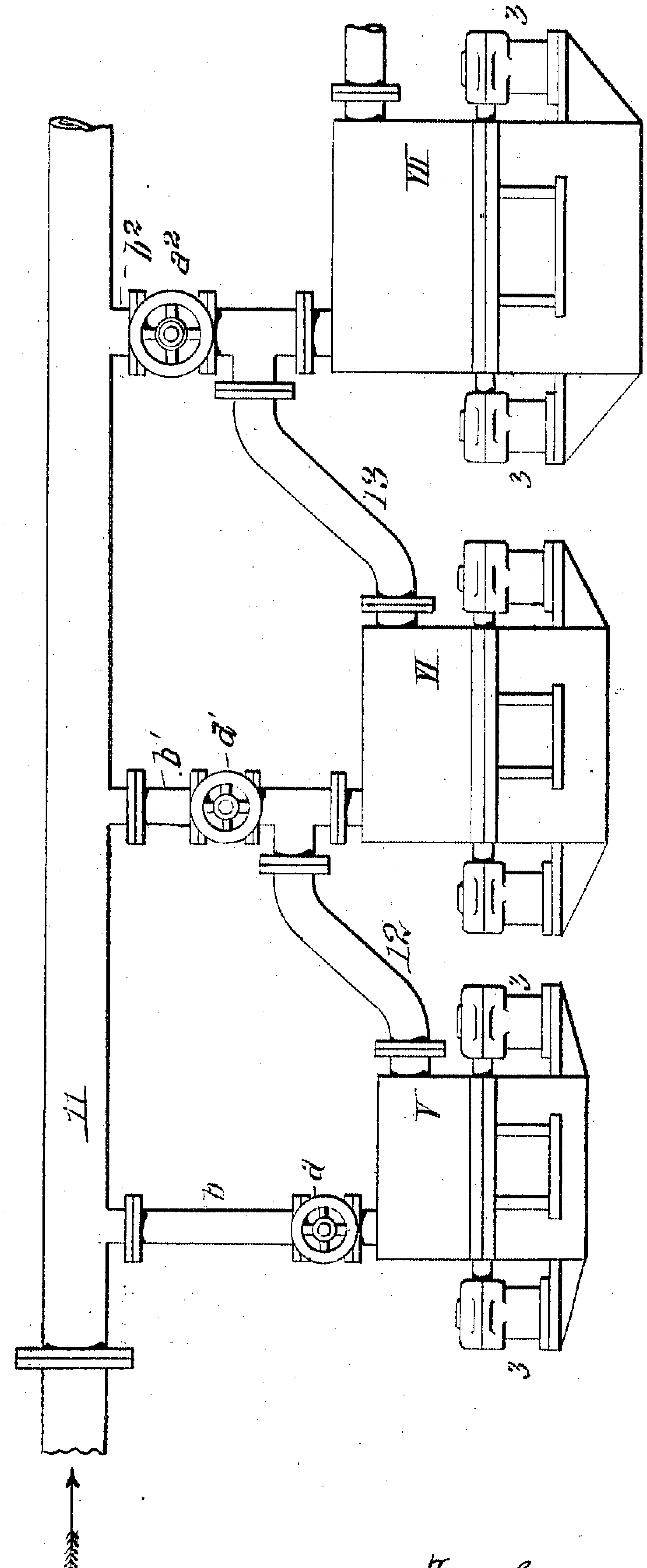
NO MODEL. 3 SHEETS—SHEET 2.

Fig. 2.



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NO MODEL. 3 SHEETS—SHEET 3.

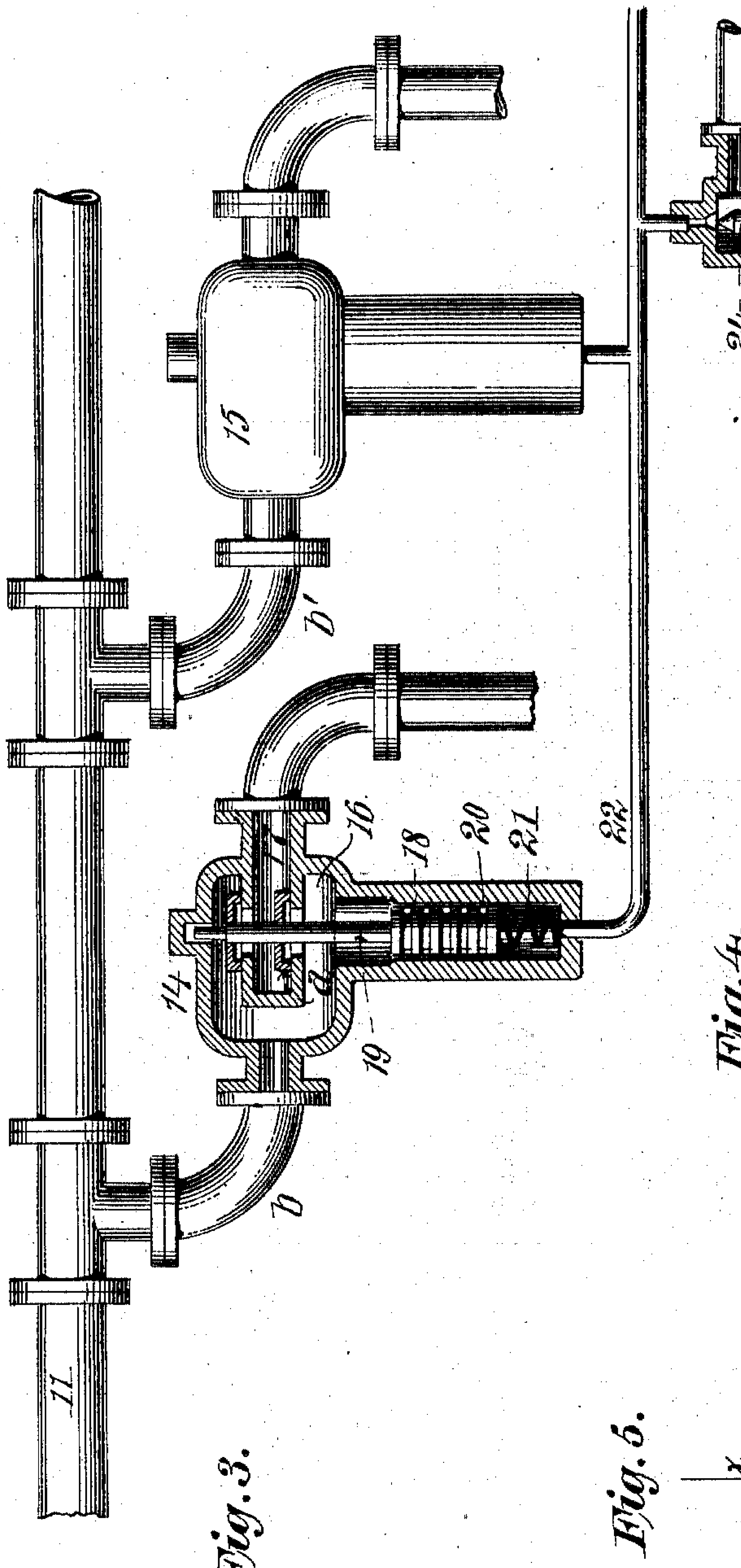

Fig. 3.

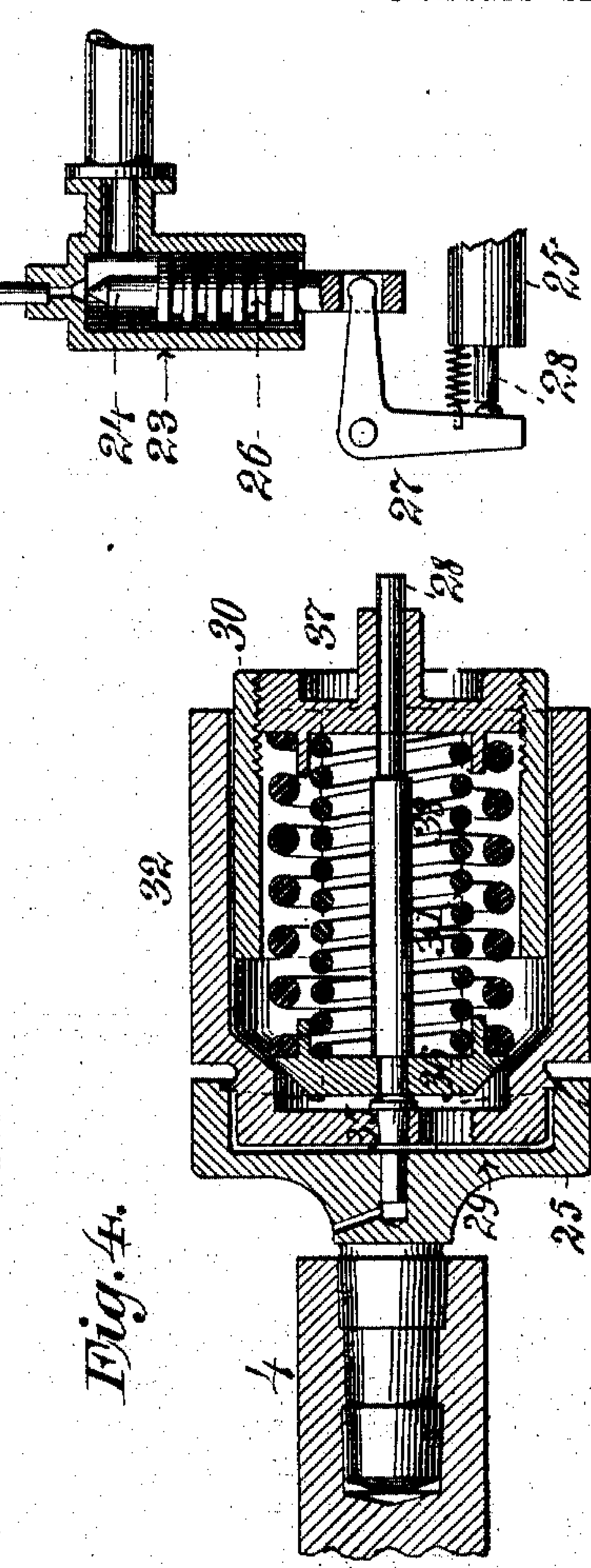

Fig. 4.

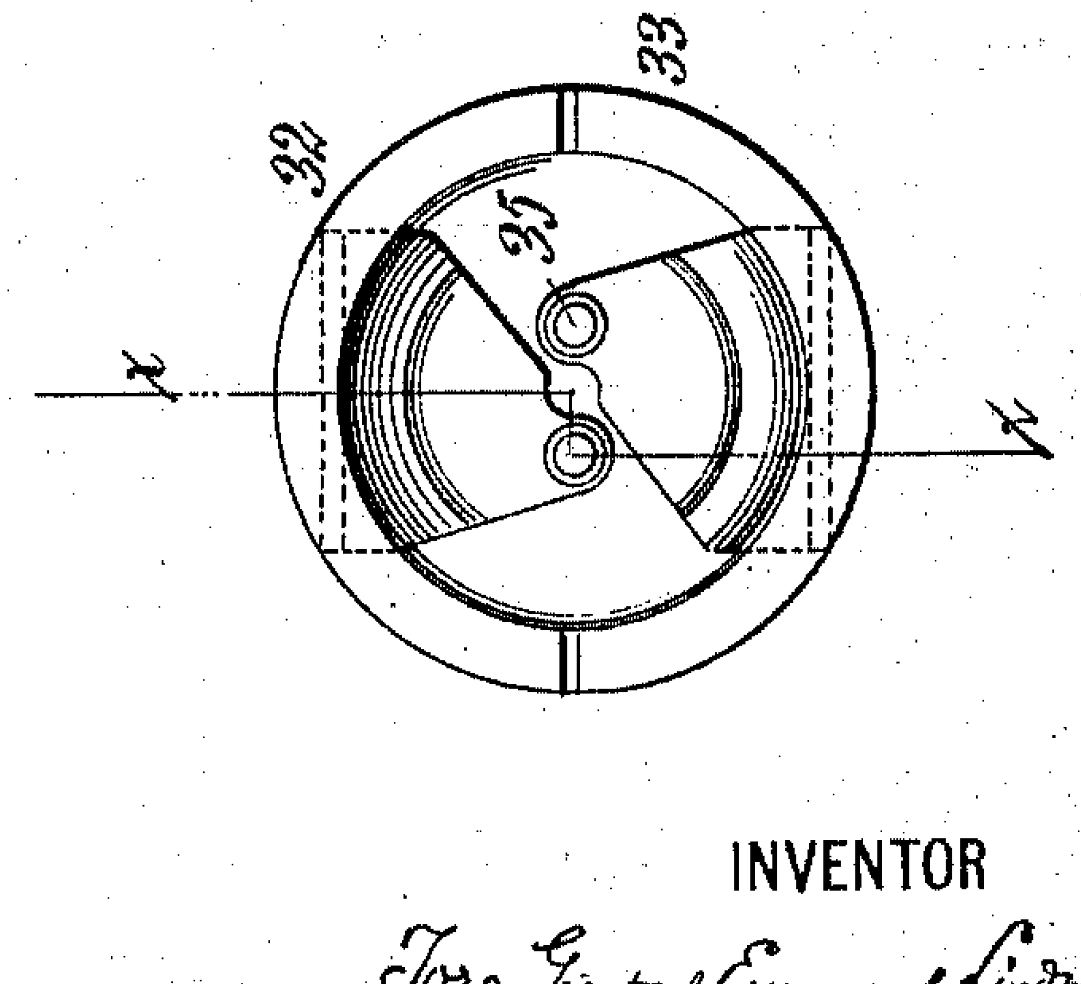

Fig. 5.

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No. 760,003. Patented May 17, 1904.

UNITED STATES PATENT OFFICE.

TORE GUSTAF EMANUEL LINDMARK, OF STOCKHOLM, SWEDEN.

REGULATOR FOR ELASTIC-FLUID TURBINES.

SPECIFICATION forming part of Letters Patent No. 760,003, dated May 17, 1904.

Application filed June 27, 1902. Serial No. 113,530. (No model.)

To all whom it may concern:

Be it known that I, TORE GUSTAF EMANUEL LINDMARK, a subject of the King of Sweden and Norway, and a resident of Stockholm, Sweden, have invented a new and useful Improvement in Regulators for Elastic-Fluid Turbines, of which the following is a specification.

The invention relates to a regulating device for elastic-fluid turbine-wheels, and has for its object to regulate the quantity of fluid supplied to the turbine according to the load without corresponding throttling of the admission-pressure.

The invention consists in the combination, with an elastic-fluid turbine-wheel, of means for admitting live working fluid from a source of supply to both inlet and outlet of said wheel, also of means for regulating the flow of live working fluid so admitted, also of means for effecting this regulation automatically.

The invention also consists in the construction, as herein set forth, whereby the said invention is applied to a compound turbine wherein the fluid undergoes progressive expansions in successive wheels.

In the accompanying drawings, Figure 1 is a partial longitudinal section of a compound turbine embodying my said invention. Fig. 2 illustrates a modification wherein the successive units are disposed in separate casings. Fig. 3 is a view, partially in section, illustrating the devices for automatically operating the admission-valves. Fig. 4 is a longitudinal section of a governor adapted for use with my said invention on the line x x of Fig. 5, and Fig. 5 is an end view of the weights in said governor of Fig. 4.

Similar numbers and letters of reference indicate like parts.

Referring first to Fig. 1, 1 represents the wheel-casing, preferably made in two parts secured together in any suitable way. On the lower half of the casing are the bed-plates 2, which support the shaft-standards 3, in which standards the shaft 4 is journaled. 7 is the casing-head on the inlet side, said head being provided with an annular chamber 6 and flanged at 5. The interior of the casing is divided by partitions into as many chambers c c' c^2 c^3 as there are wheel-bodies on the shaft 4. Three flanged partitions 8, 9, and 10 are shown in Fig. 1, and in the chambers thus formed are located the wheel-bodies I II III IV, which are fast on shaft 4. The wheels here illustrated are of the axial-flow type, provided, as usual, with buckets suitably arranged in an annular opening of the body formed near the circumference thereof. Thus in wheel-body I there is an opening e, in wheel-body II an opening e', in wheel-body III an opening e^2, and in wheel-body IV an opening e^3. In the head 7 and partitions 8 9 10 are openings d to d^3, registering with the openings e to e^3. The successive annular openings d' to e^3 progressively increase in width. 11 is the main supply-pipe for steam or other elastic fluid (which passes in the direction of the arrow) provided with branches b b' b^2 b^3, which branches communicate, respectively, with the chamber 6 and the chambers c c' c^2, containing wheels I II III. The said chambers are therefore connected in parallel relation to the source of supply of live working fluid. The chamber c^3 is not connected by branch to pipe 11 nor is any chamber succeeding c^3 connected to said pipe. In each branch b b' b^2 b^3 is a throttle-valve a a' a^2 a^3.

The operation of the device of Fig. 1 is as follows: Assume valves a to a^3 to be open. The motor fluid passes at full pressure to the several chambers; but as it enters on both sides of wheels I II III there will be no flow through the bucket-openings e to e^3 of said wheels, and in them the fluid will do no work; but there will be a flow through opening d^3 to wheel IV, and this will be the first working wheel of the compound turbine. As its opening e^3 is larger than that of any of the preceding wheels, this wheel will work (as compared with said preceding wheels) with the maximum of motor fluid, and therefore with a maximum efficiency, the fluid being admitted at full pressure to said wheel. Assume valve a^3 to be throttled. Pressure on the discharge side of wheel III will be lower than that on the inlet side, and hence a flow will take place through wheel III, which will begin to do work. The more valve a^3 is closed the larger the amount of fluid which will pass through wheel III, and, finally, if said valve be completely closed, then all the fluid will traverse wheel III before actuating wheel IV; but inasmuch as the openings d^2 e^2 are smaller than d^3 e^3 wheel III works with a smaller volume of motor fluid than did wheel IV. Hence the efficiency of the compound motor is less. If now in like manner valve a^2 be throttled or closed, then wheel II can be made the first working wheel, and, similarly, if valve a' be throttled or closed wheel I will become the first working wheel, the wheel and inlet-openings, however, becoming progressively smaller. It will therefore be obvious that in each instance every degree of work can be obtained by suitably regulating or closing the valves a to a^3—that is to say, the pressure of the motive fluid coming to the wheels I II, &c., can be increased or decreased, the flow increased or decreased, and the work of the whole machine increased or decreased.

In Fig. 2 I show a modification in which instead of mounting all the wheels upon a single shaft they are arranged on separate shafts and inclosed in separate casings V VI VII. A pipe 12 leads the exhaust from casing V to branch b' between valve a' and casing VI, and a similar pipe 13 leads the exhaust from casing VI to branch b^2 between valve a^2 and casing VII.

In Fig. 3 I illustrate means for operating the throttle-valves a a', &c., automatically. Two valve-casings interposed, respectively, in branches b b' are indicated at 14 and 15, casing 14 being shown in section to exhibit the internal construction, which is the same in all the casings of the series. The upper portion of the casing is enlarged at 16 to form a chamber into which projects the conduit 17, having a closed end and openings in the walls which are covered by the double valve a. The valve-stem 19 is connected with a piston 18, movably arranged in the cylindrical portion 20 of the casing. The cylindrical space below the piston 18 contains a helical spring 21 and communicates, through a pipe 22, with the similar space in casing 15 and other casings of the series and also with the cylindrical chamber 23 of a throttling-valve 24, which is controlled by the governor 25 on the shaft 4 of the compound turbine. Valve 24 is conical and carries on its stem a piston 26, which is operated by means of a bell-crank lever 27 from a pin 28, which is moved to the right or left of the drawing by the governor 25. Pipe 22, on the other side of the throttling device, may lead to the atmosphere or as desired. The operation of this automatic apparatus is as follows: The motive fluid flows through the main pipe 11 into the valve-casing 14. The piston 18, fitting loosely in its cylinder 20, allows of a certain leakage of fluid to the cylindrical space below said piston, and hence to pipe 22. The amount of pressure of the motive fluid in said space and pipe is determined by the position of the throttle-valve 24. If said valve is completely opened by the governor, (which occurs at the greatest speed of the turbine,) then the fluid-pressure above piston 18 will overcome the fluid-pressure below it and that of the spring 21 and the valve a will be closed. If, however, the throttle-valve 24 is more or less closed or shut, then the pressure below it, added to the pressure of the spring 21, overbalances the pressure of the motive fluid above the piston 18, and the valve a will be opened. The position of said valve a, therefore, is dependent upon the position of the throttle-valve 24, or, in other words, upon the speed of the compound turbine.

The valve in casing 15 and other casings in the branches of the main pipe 11 are similarly constructed to the above-described valve. Their springs 21, however, are relatively weaker, so that the valve (say a^3) having the weakest spring is closed first and then the valve a^2, then the valve a', and at last the valve a. The cutting off of the motive fluid occurs gradually, according to the position of the throttle-valve 24, and hence a gradual regulation of the motive fluid according to the load is obtained.

A form of governor 25, adapted to actuate the pin 28, is represented in Figs. 4 and 5. It is provided with a tapered shank 25*, inserted in a recess in the turbine-shaft 4 and carrying the body portion, which consists of a recessed circular portion 29, a ring portion 30, and connecting-arms 31, one of which is indicated by dotted lines in Fig. 4. 32 and 33 are two arc-shaped weights surrounding the ring 30 and of bell-crank form, each having a knife-edge 34, by which it is fulcrumed in the circular portion 29 of said body, and each having a pin 35, which bears against the disk 36. Said disk is carried by the pin 28. Within the ring 30, which is threaded, is a nut 37, through which the pin 28 passes. A helical spring 38 is interposed between disk 36 and nut 37. By operating the nut the pressure of said spring is regulated, and said spring also serves to keep the weights closed in upon the body. When the limit of speed of the turbine, and hence of the shaft 27, is exceeded, the weights 32 33 spread apart by centrifugal force and in so doing move their pins 35 against the disk 36, and the latter moves the pin 28 outwardly and to an extent proportionate to the speed. When the speed diminishes, the pin 28 is moved inwardly by the action of the spring 38.

I do not limit myself to a multiple steam-turbine of the specific type herein illustrated, since other forms of multiple steam-turbines are known.

I claim—

1. In combination with an elastic-fluid turbine-wheel, a device controlling the admission of live working fluid to the inlet of said wheel,

and a device controlling the admission of live working fluid to the outlet of said wheel, substantially as described.

2. In combination with an elastic-fluid turbine-wheel, a casing for said wheel, a device controlling the admission of live working fluid to said casing on the inlet side of said wheel, a device for controlling the admission of live working fluid to said casing on the outlet side of said wheel, and means for independently operating said devices to vary the steam-pressure exerted by said fluid respectively on the opposite sides of said wheel, substantially as described.

3. In combination with an elastic-fluid turbine-wheel, a device for controlling the admission of live working fluid to the inlet of said wheel, a device for controlling the admission of live working fluid to the outlet of said wheel and means controlled by said wheel for operating said devices to vary the steam-pressures exerted by said fluid respectively on the opposite sides of said wheel, substantially as described.

4. In a compound elastic-fluid turbine of the type wherein said fluid undergoes progressive expansions in a series of successive wheels, means controlling the admission of live working fluid to the opposite sides of each of said wheels, substantially as described.

5. In a compound elastic-fluid turbine of the type wherein said fluid undergoes successive expansions in a series of successive wheels, means for controlling the admission of live working fluid to the opposite sides of each wheel of a number of wheels less than all in said series, substantially as described.

6. In a compound elastic-fluid turbine of the type wherein said fluid undergoes successive expansions in a series of successive wheels, means for controlling the admission of live working fluid to the opposite sides of each wheel of a number of wheels less than all in said series; the said selected wheels being disposed successively at one end of the compounded series, substantially as described.

7. In combination with an elastic-fluid turbine-wheel, means for admitting live working fluid simultaneously to both sides of said wheel, and a device governed by the speed of said wheel for regulating the admission of said fluid to the exhaust side of said wheel, substantially as described.

8. In combination with an elastic-fluid turbine-wheel and its inclosing casing, a valve for admitting live working fluid to the inlet side of said wheel, a valve for admitting live working fluid to the exhaust side of said wheel, and means controlled by said wheel for governing the said valves, substantially as described.

9. In combination with an elastic-fluid turbine-wheel and its inclosing casing, a valve for admitting fluid to the inlet of said wheel, a valve for admitting fluid to said casing on the exhaust side of said wheel, and means controlled by said wheel for governing said valves, the said means being constructed and arranged to throttle the valve communicating with the exhaust side prior to throttling said inlet-valve, substantially as described.

10. In combination with an elastic-fluid turbine-wheel of the axial-flow type, means for controlling the admission of live working fluid to both sides of said wheel, substantially as described.

11. In a compound elastic-fluid turbine, a casing having a series of successive wheel-chambers and in the walls of said chambers inlet-openings of progressively larger area, a series of wheels in said chambers having bucket-openings of progressively larger area communicating respectively with said inlet-openings, means for connecting said chambers in parallel relation to a source of working fluid, and means for regulating the admission of said live working fluid to each of said chambers, substantially as described.

12. In a compound elastic-fluid turbine, a casing having a series of successive wheel-chambers and in the walls of said chambers inlet-openings of progressively larger area, a series of wheels in said chambers having bucket-openings of progressively larger area communicating respectively with said inlet-openings, means for connecting said chambers in parallel relation to a source of working fluid, and means controlled by said turbine for regulating the admission of said live working fluid to each of said chambers, substantially as described.

13. The combination with a compound elastic-fluid turbine having a plurality of wheels disposed in successive communicating chambers, means for connecting said chambers in parallel relation to a source of live-steam supply, valves for regulating the flow of said steam in said connecting means, and a governor controlling said valves and itself actuated by said turbine, substantially as described.

14. The combination with an elastic-fluid turbine-wheel, of the inlet-pipe *b*, casing 14, in said pipe, valve *a* in said casing, valve-stem 19 and piston 18 thereon, throttle-valve chamber 23, pipe 22 communicating with said casing 14 and said chamber 23, valve 24 in said chamber, turbine-shaft 4, and means for controlling said valve 24 relatively to the speed of said shaft, substantially as described.

15. The combination with an elastic-fluid turbine-wheel of the inlet-pipe *b*, casing 14 having cylindrical extension interposed in said pipe, valve *a* in said casing, valve-stem 19, piston 18 on said stem and within said cylindrical extension, spring 21 below said piston, throttle-valve chamber 23, pipe 22 communicating with said cylindrical extension below said piston, and with said chamber 23, valve 24 in said chamber, turbine-shaft 4 and means for controlling said valve 24 relatively to the speed of said shaft, substantially as described.

16. The combination with a compound elastic-fluid turbine, having a plurality of wheels disposed in successive communicating chambers of the inlet-pipes *b b'*, casings 14, 15 interposed in said pipes, valves *a*, *a'* in said casings, valve-stems 19 and pistons 18 thereon, springs 21 in said casings below said pistons, pipe 22 communicating with said casings and said chamber 23, valve 24 in said chamber, turbine-shaft 4 and means for controlling said valve 24 relatively to the speed of said shaft; said springs 21 in said casings 14, 15, being of different elastic strengths, substantially as described.

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

TORE GUSTAF EMANUEL LINDMARK.

Witnesses:
WALDEMAR BOMAN,
H. RIDDERSTOLPE.