No. 749,476. PATENTED JAN. 12, 1904.

C. G. CURTIS.

APPARATUS FOR GOVERNING ELASTIC FLUID TURBINES.

APPLICATION FILED JUNE 17, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

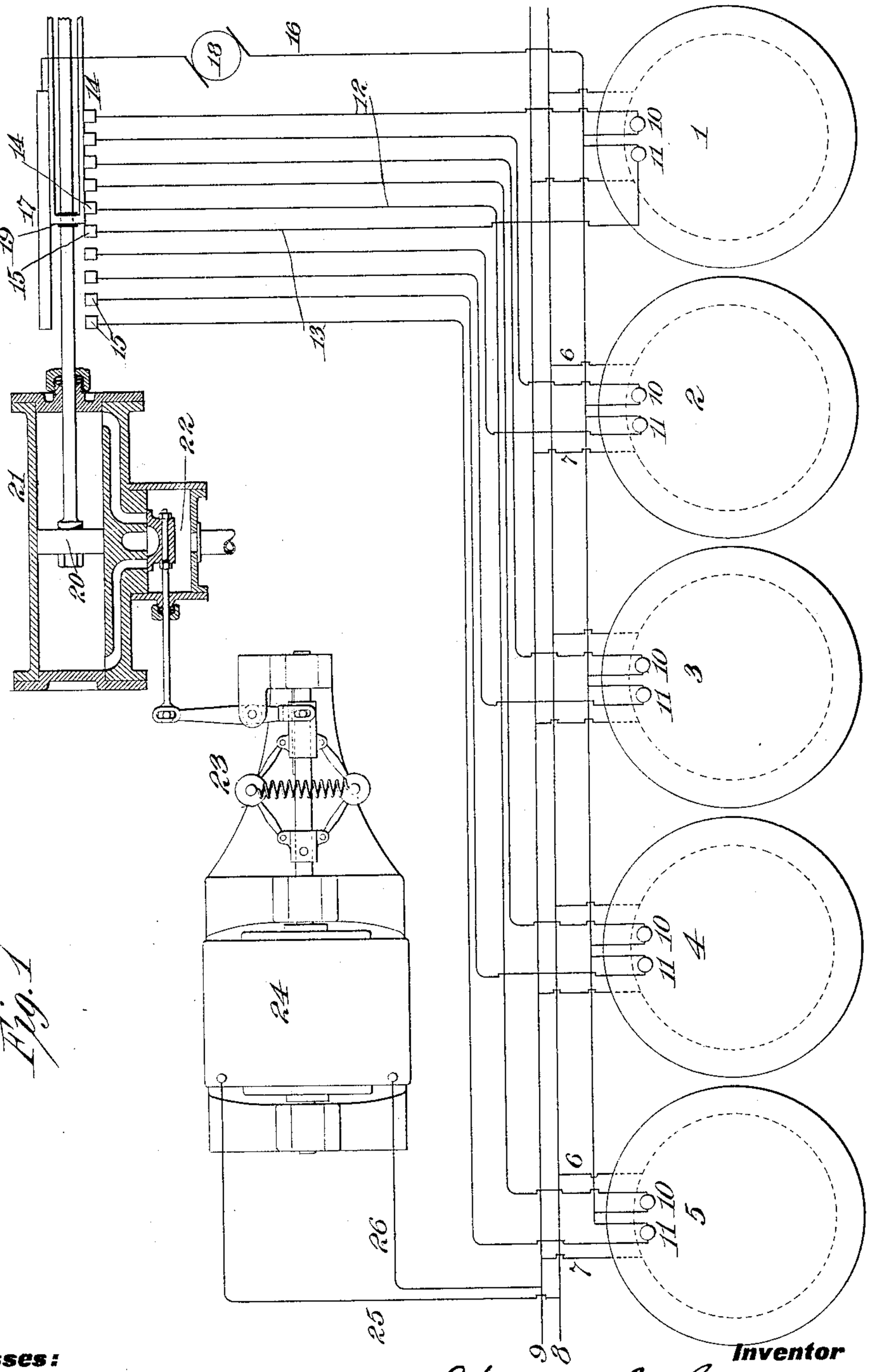

Fig. 1.

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NO MODEL. 3 SHEETS—SHEET 2.

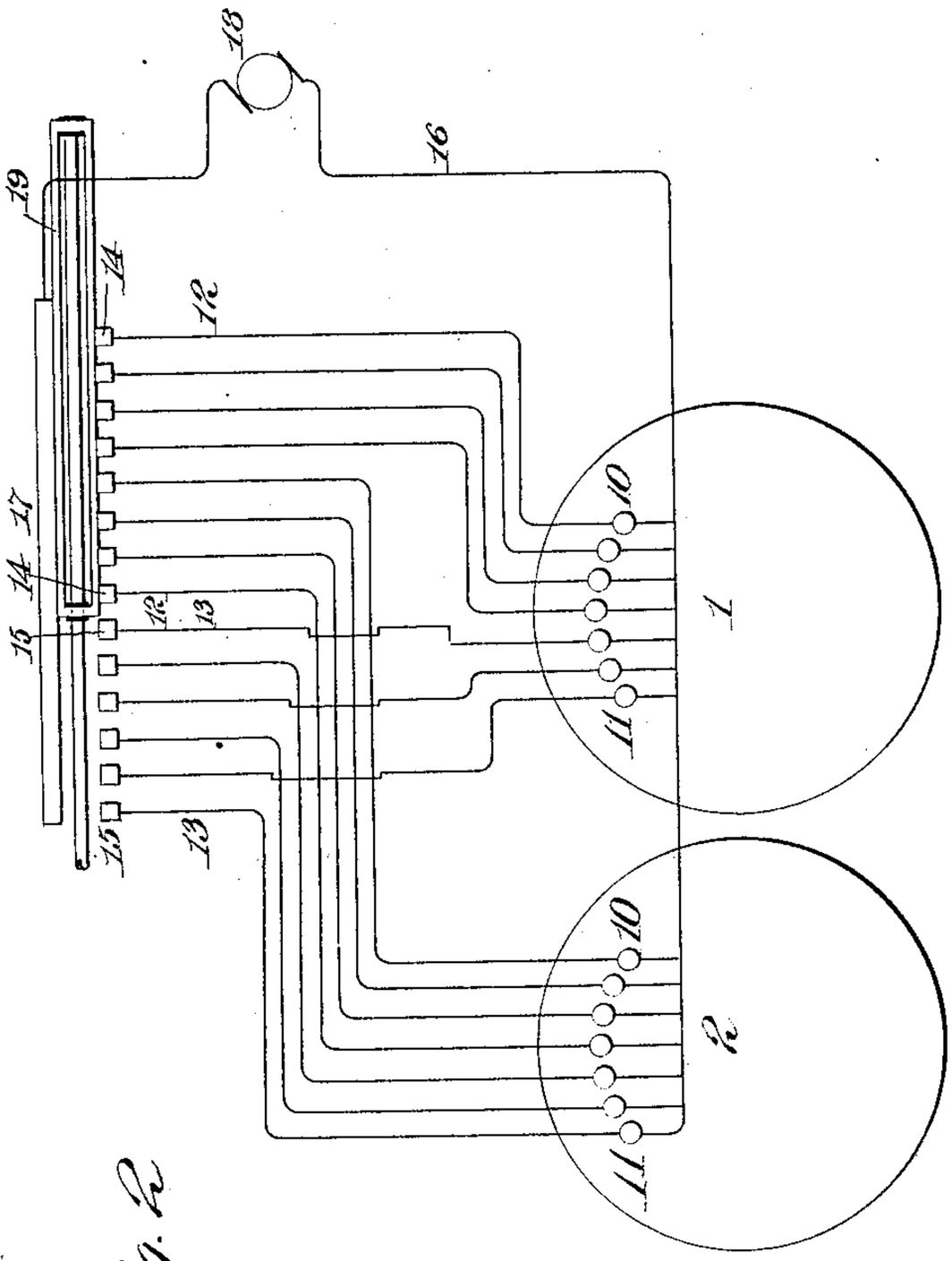

Fig. 2.

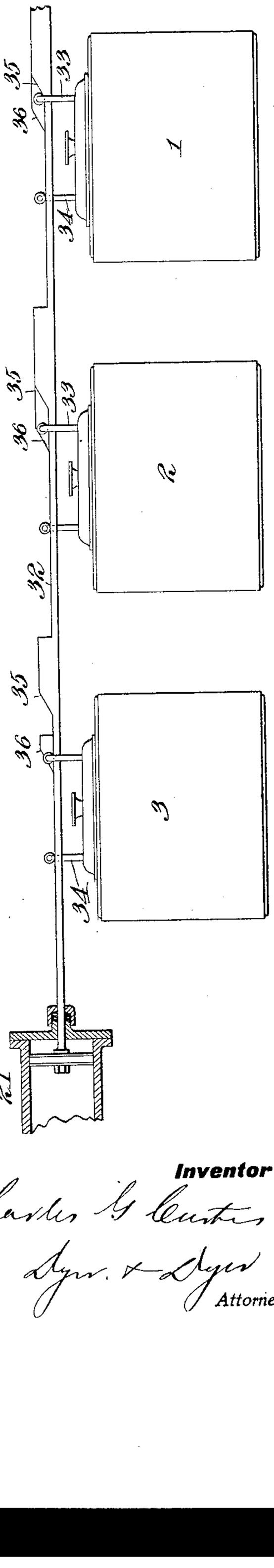

Fig. 4.

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NO MODEL. 3 SHEETS—SHEET 3.

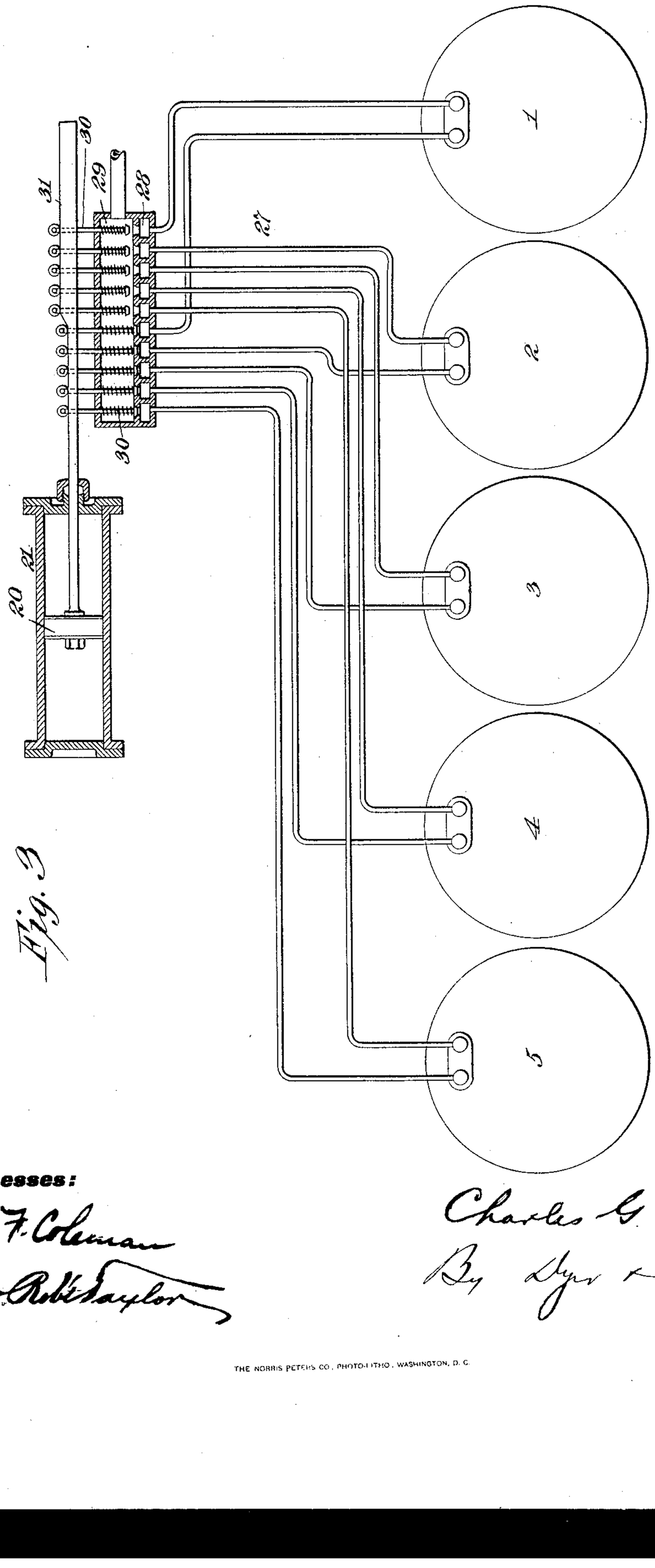

Fig. 3

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No. 749,476. Patented January 12, 1904.

UNITED STATES PATENT OFFICE.

CHARLES G. CURTIS, OF NEW YORK, N. Y.

APPARATUS FOR GOVERNING ELASTIC-FLUID TURBINES.

SPECIFICATION forming part of Letters Patent No. 749,476, dated January 12, 1904.

Application filed June 17, 1903. Serial No. 161,839. (No model.)

To all whom it may concern:

Be it known that I, CHARLES G. CURTIS, a citizen of the United States, residing in the borough of Manhattan, city of New York, State of New York, have invented a certain new and useful Improvement in Apparatus for Governing Elastic-Fluid Turbines, of which the following is a description.

The object I have in view is to produce means for automatically governing a battery of elastic-fluid turbines, so as to maintain the most efficient conditions of operation of the turbines themselves and of the apparatus, such as dynamo-electric machines, which is driven by them.

In carrying out the invention I provide as the controlling element of the apparatus a centrifugal governor, which may be mounted upon or driven from the shaft of the first turbine of the battery, or in case the turbines are used to drive alternating-current dynamo-electric machines this centrifugal governor may be driven by a synchronous motor connected with the bus-bars to which the dynamos are connected. This centrifugal governor serves to open and close a valve admitting water, oil, or other suitable liquid to opposite ends of the cylinder, in which moves a piston, and the piston by its movement opens and closes directly or indirectly and in proper order the valves controlling the supply of elastic fluid to the turbines. These valves preferably control the supply of the elastic fluid to sectional nozzles, such as are described in my Patent No. 700,744, dated May 27, 1902, each valve by its opening admitting the elastic fluid to a chamber with which one or more of the sections of the nozzle are connected, as described in my application, Serial No. 114,357, filed July 5, 1902. The controlling-valves of the several turbines are operated by the governing apparatus, so as to govern the turbines progressively in the following manner: Enough of the valves of the first turbine are opened in succession as the load increases to produce the full-load condition of the dynamo driven by that turbine. As the load increases further the controlling-valves of the second turbine are opened successively until the full-load condition of the dynamo driven by that turbine is reached, and so on for the third, fourth, and any greater number of turbines which the battery may contain. After the full-load condition of all the dynamos of the battery has been reached the governing apparatus puts on part of the overload on the first turbine and then successively on the other turbines of the battery until all the dynamos are carrying the same amount of the overload, when a further fraction of the overload is added, first to the first turbine and then to the second turbine, and so on, and this operation of adding the overload to the turbines in succession fractionally is repeated until the full overload condition is reached. Instead of having the control of each turbine divided between a number of valves, both for the full-load condition and for the overload condition, the number of valves for each turbine may be reduced and the regulation for each turbine made dependent to a greater extent upon the throttling action of the valves. Indeed, this may be carried to the extent of providing only two valves for each turbine, one for the full-load and one for the overload, each of these valves controlling the admission of the elastic fluid to a large number of sections of the sectional nozzle. In this case the governing apparatus will act to first open the full-load valve of the first turbine, depending upon the throttling action of the valve at intermediate positions to control the turbine for less than full load. The governing apparatus will then in the same manner open the full-load valve of the second turbine, and so on until the full-load valves of all the turbines of the battery are open. For the overload the governing apparatus will apply the overload fractionally to the turbines by first partially opening the overload-valves of the turbines in succession and then returning to the first turbine and opening the overload-valves in succession still further, and so on until the overload-valves of all the turbines are entirely open. The loss in efficiency which will result from depending upon the throttling action of the valves will not be very great in the case of a battery containing a number of turbines, since the effect produced by throttling will be for most of the

time confined to a small fraction of the whole effect.

In the accompanying drawings, forming a part hereof, Figure 1 is view, largely in diagram, illustrating an apparatus embodying my invention. Fig. 2 is a diagram illustrating more in detail the relative control of the full load and overload valves of the apparatus of Fig. 1, and Fig. 3 is a view illustrating the employment of compressed air for operating the turbine-valves, and Fig. 4 is a view illustrating a governing apparatus of simpler form and with a single full-load and overload valve for each turbine.

Referring particularly to Fig. 1, 1, 2, 3, 4, and 5 represent turbine units, including elastic-fluid turbines and alternating-current dynamo-electric machines, the dynamos being cennected by wires 6 7 to the bus-bars 8 9. 10 and 11 are magnets controlling the valves of the turbines. For simplicity of illustration only two of such magnets are shown in Fig. 1 for each turbine, the magnets 10 controlling the full-load valves and the magnets 11 controlling the overload-valves; but since each valve is either wholly opened or closed there will be a number of valves for the full load and overload of each turbine, as will be presently explained in connection with Fig. 2. The magnets 10 and 11 are connected by separate wires 12 and 13 with the separately-insulated contacts 14 15, while a return-wire 16, common to all the magnets, is connected with a plate 17 and includes a source of direct current 18. A contact-plate 19, having a length equal to all of the contacts 14 15, slides over the contacts 14 15 and plate 17. The contact-plate 19 is carried by a rod from a piston 20, which moves in a cylinder 21. The piston 20 is moved in one direction or the other by liquid under pressure admitted to opposite sides of the cylinder 21 and exhausted therefrom through suitable entrance and exhaust ports controlled by a valve 22. The valve 22 is moved by a centrifugal governor 23, which is driven by a synchronous motor 24, connected by wires 25 26 with the bus-bars 8 9. As already suggested, the centrifugal governor 23 may be mounted on the shaft of the turbine 1.

It will be understood that the usual switches are placed in the several circuits for opening and closing them and also that the steam-supply pipes leading to the turbines will be provided with the usual throttle-valves for turning on and off the steam. When the turbines are not running, these throttle-valves will be closed and the switches will be opened, the piston 20 will stand at the left-hand end of the cylinder 21, and the plate 19 will cover all the contacts 14 15. To start up the plant, the circuit to the magnets 10 11 will be closed, thus opening all the turbine-valves controlled by the various branches of that circuit. Steam will then be turned on the first turbine by opening its throttle. When the dynamo operated by the turbine has acquired the proper speed, it will be connected with the bus-bars and the circuit to the synchronous motor will also be closed. The motor will at once acquire the speed of the dynamo and will operate the centrifugal governor, which will move the valve 22 to the right and cause the piston 20 to move to the right until the contact-plate 19 covers the proper number of contacts 14 15. If the load is greater than the capacity of the first dynamo, the throttles of one or more of the other turbines will be opened. Preferably at least one turbine in addition to that required to carry the load should have its throttle opened, so as to be ready to instantly respond to any sudden increase in load, and, indeed, the throttles of all the turbines of the battery may be opened irrespective of the amount of load. Such of the turbines as are not receiving steam through the valves controlled by the magnets 10 and 11 will be run as motors by current from the bus-bars, or, if desired, each turbine may have a nozzle which is always open when the throttle is open and with sufficient capacity to turn the turbine and dynamo and produce an electromotive force which will approximately balance the electromotive force of the bus-bars.

Assuming that the throttles of all the turbines are open and that all the dynamos are connected with the bus-bars and are turning, the operation of the governing apparatus will be as follows, starting with a light load on the first dynamo: It is assumed that contact-plate 19 rests only on the contact 14 at the extreme right, thus opening the full-load valve of the first turbine. As the load is increased the first dynamo will reduce in speed, and this will cause the synchronous motor to reduce in speed, causing the governor 23 to move the valve 22 to the left, opening the right-hand end of the cylinder 21 to the liquid-pressure and the left-hand end of that cylinder to the exhaust. The piston 20 will be moved slowly to the left, drawing the contact-plate 19 upon the second contact 14 and opening the full-load valve of the second turbine. This will cause the second turbine and the dynamo driven by it to take a part of the load, and the synchronous motor will regain its speed and will move the valve 22 to a central position, covering both pressure-ports to the cylinder. As the load further increases a similar sequence of operations will take place, and the contact-plate 19 will be drawn farther to the left, covering in succession the contacts 14, connected with the full-load valves of the third and subsequent turbines. A still further increase of load will cause a continued movement of the contact-plate 19 to the left, so that it will cover in succession the contacts 15 and will successively open the overload-valves of the several turbines. The reverse operation takes place as the load decreases.

As illustrated in Fig. 2, each turbine is provided with four magnets 10 for controlling the full load of the turbine and three magnets 11 for controlling the overload of the turbine. The wires 12 and 13, running from the full-load and overload magnets 10 and 11 to the contacts 14 15, are so arranged, as illustrated in Fig. 2, that the four full-load magnets 10 of the turbine 1 are first energized successively, then the four full-load magnets 10 of the second turbine, and so on throughout all the turbines of the battery. After all the turbines are operating on the full load the overload is applied fractionally to the turbines in succession by first closing the circuit to the first overload-magnets 11 of the several turbines successively and then successively to the second overload-magnets of the several turbines, and so on.

In Fig. 3 the employment of compressed air for operating the valves is illustrated instead of electrical energy. The pipes 27 for carrying the air-pressure to the valves are connected with compartments 28, which have valve-openings leading into the pressure-box 29. Valves 30 close the openings between the separate compartments 28 and the pressure-box 29. These valves are closed by springs and are retracted by a cam-slide 31, which is carried by the rod from the piston 20, this piston being operated as already described. The valves 30 in closing operate in a manner well understood to open vents in the pipes 27, so as to release the pressure in such pipes when they are disconnected from the pressure-box 29.

As illustrated in Fig. 4, the turbine-valves are operated directly by a movement of the piston 20 through a cam-rod 32, connected with the piston. This figure also illustrates the arrangement wherein each turbine is provided with only a single full-load valve 33 and a single overload-valve 34. The inclines upon the cam-rod 32 are so formed and coördinated that the full-load valves 33 of the several turbines wil be opened in succession, each valve being opened gradually and acting to throttle the elastic fluid when partially open. The full-load valves are opened by the inclines 35, carried by the rod 32. Other inclines 36 are employed to open the overload-valves. These inclines 36 are preferably so coördinated that after the full-load valves of all the turbines are open the overload-valves of the several turbines will be opened in succession fractionally—as, for instance, the overload-valve of the turbine 1 will be open only part way when the overload-valve of the turbine 2 will begin to open, and before the overload-valve of the turbine 1 is wholly open the overload-valve of the last turbine of the battery will begin to open.

What I claim is—

1. The combination with a battery of elastic-fluid turbines, of an automatically-acting governor controlling the turbines in succession, substantially as set forth.

2. The combination with a battery of elastic-fluid turbines, of an automatic governor acting to apply the full load to the turbines in succession, substantially as set forth.

3. The combination with a battery of elastic-fluid turbines, of an automatic governor acting to apply the overload to the turbines in succession, substantially as set forth.

4. The combination with a battery of elastic-fluid turbines, of an automatic governor acting to apply the full load to the turbines in succession and to apply the overload to the turbines in succession after all the turbines have received the full load, substantially as set forth.

5. The combination with a battery of elastic-fluid turbines, of an automatic governor acting to apply the overload to the turbines in succession fractionally, substantially as set forth.

6. The combination with a battery of elastic-fluid turbines, of an automatic governor acting to apply the full load to the turbines in succession and to subsequently apply the overload to the turbines in succession fractionally, substantially as set forth.

7. The combination with a battery of turbines, of a centrifugal governor whose speed is synchronous with the speed of the turbines, a power device controlled by said governor, and connections from said power device to the valves of the turbines for controlling the turbines in succession, substantially as set forth.

8. The combination with a battery of elastic-fluid-turbine units including alternating-current dynamos, of a synchronous motor driven by the current from said dynamos, a speed-governor driven by said motor, a power device controlled by said speed-governor, and connections from said power device to the valves of the dynamos for controlling the turbines, substantially as set forth.

This specification signed and witnessed this 8th day of June, 1903.

CHARLES G. CURTIS.

Witnesses:

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JOHN LOUIS LOTSCH.