No. 822,324. PATENTED JUNE 5, 1906.

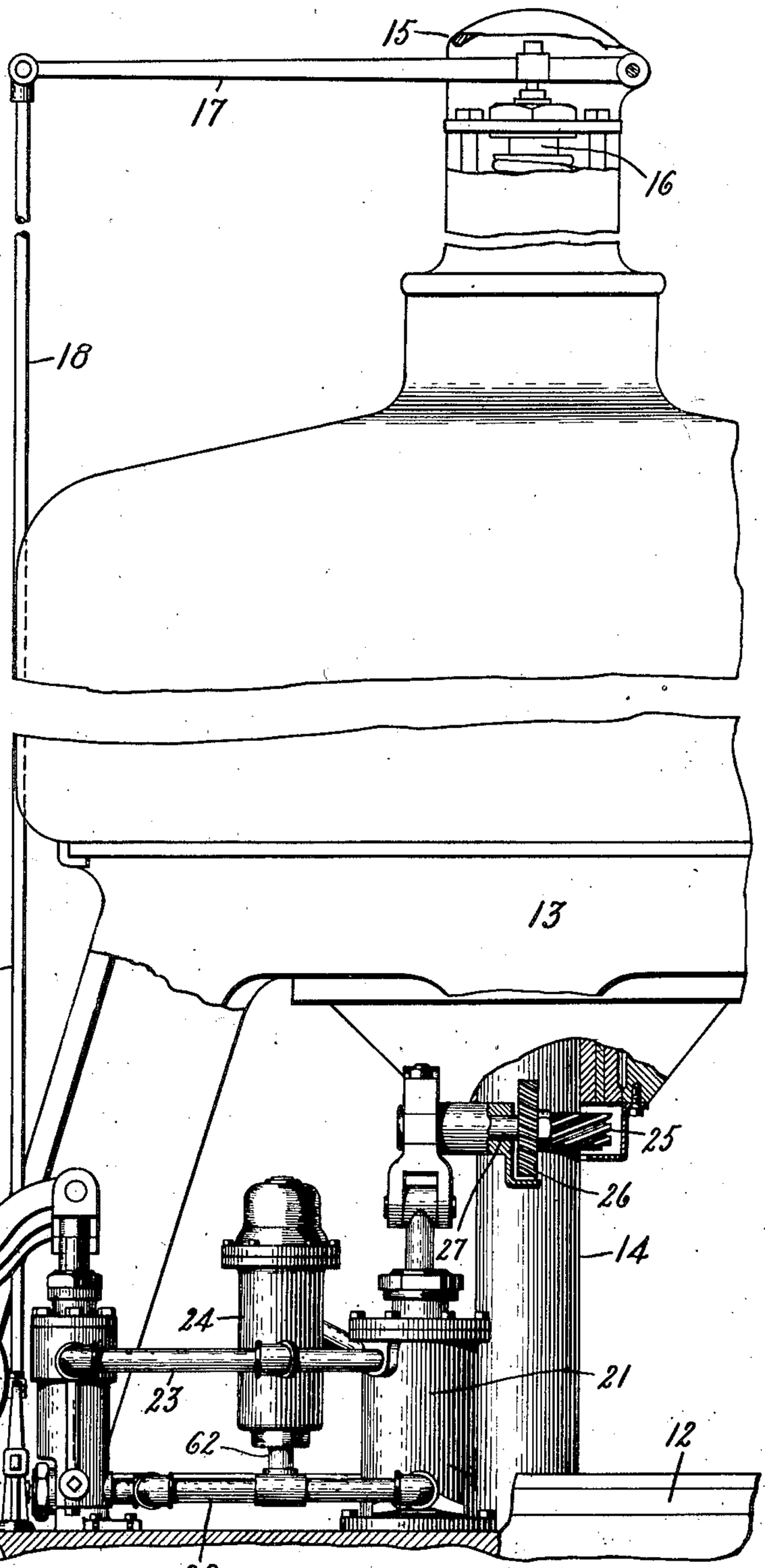
E. THOMSON.

GOVERNING MECHANISM FOR ELASTIC FLUID TURBINES.

APPLICATION FILED SEPT. 30, 1905.

6 SHEETS—SHEET 1.

Fig. 1.



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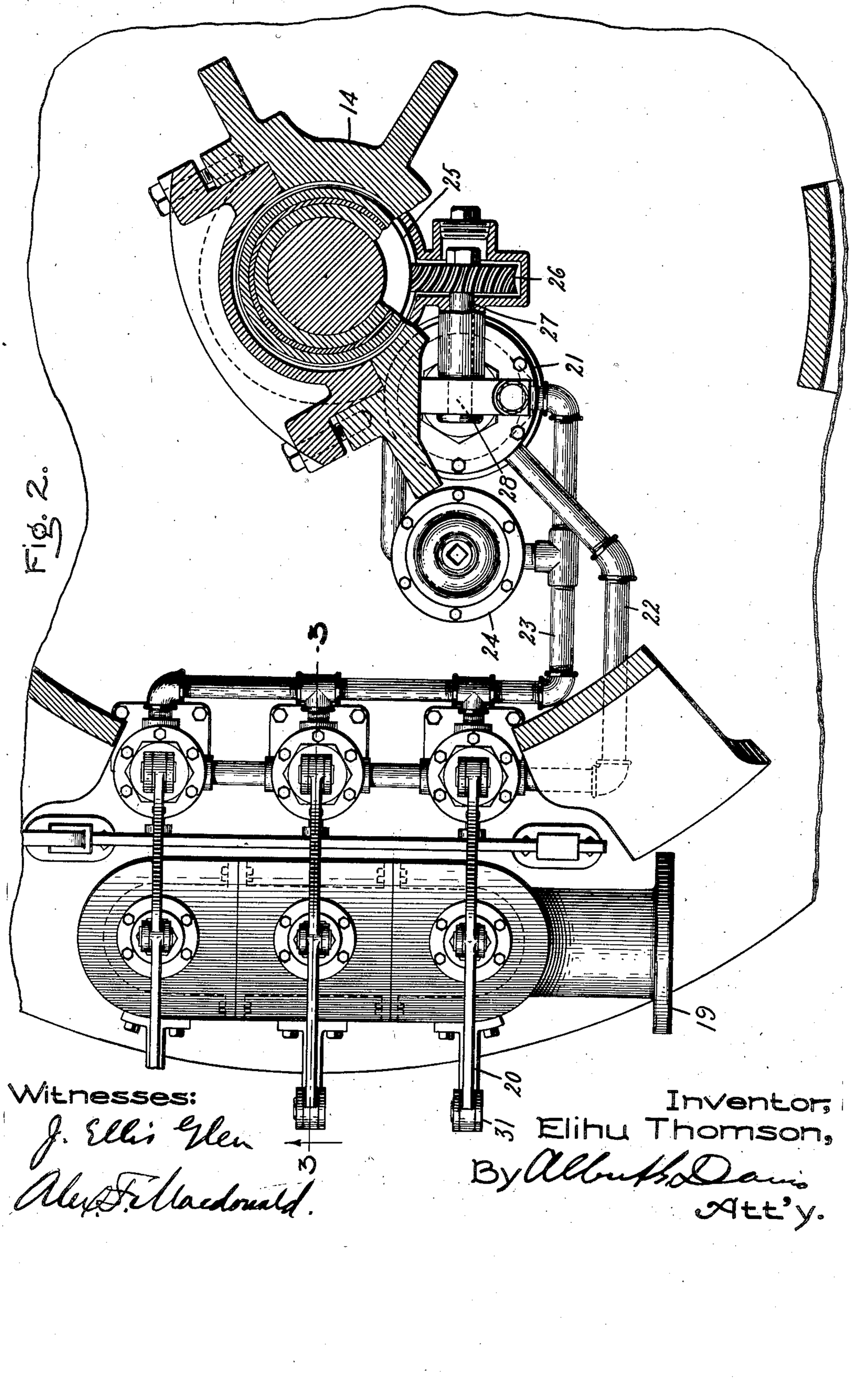

Fig. 2.

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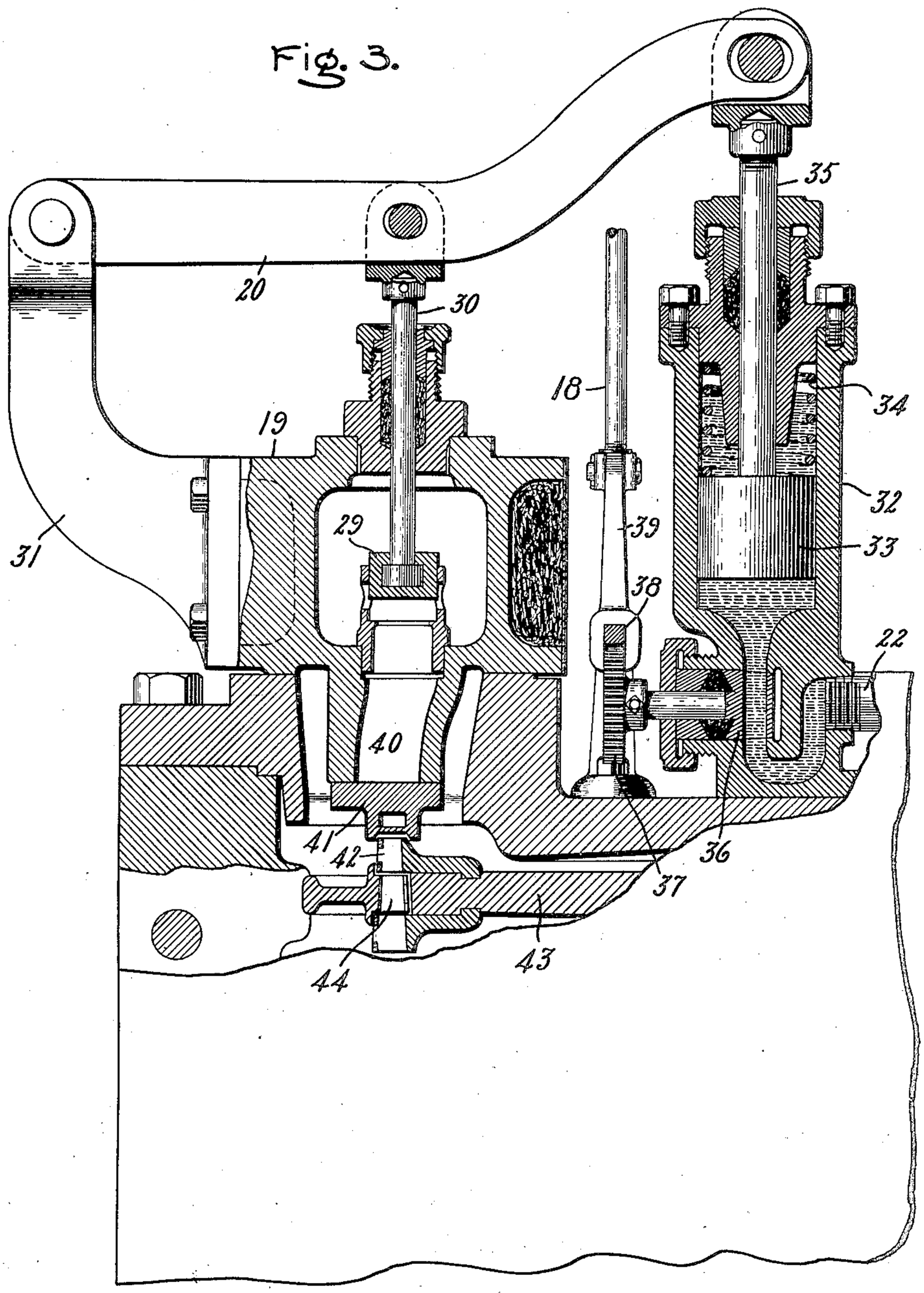
6 SHEETS—SHEET 3.

Fig. 3.



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6 SHEETS—SHEET 4.

Fig. 4.

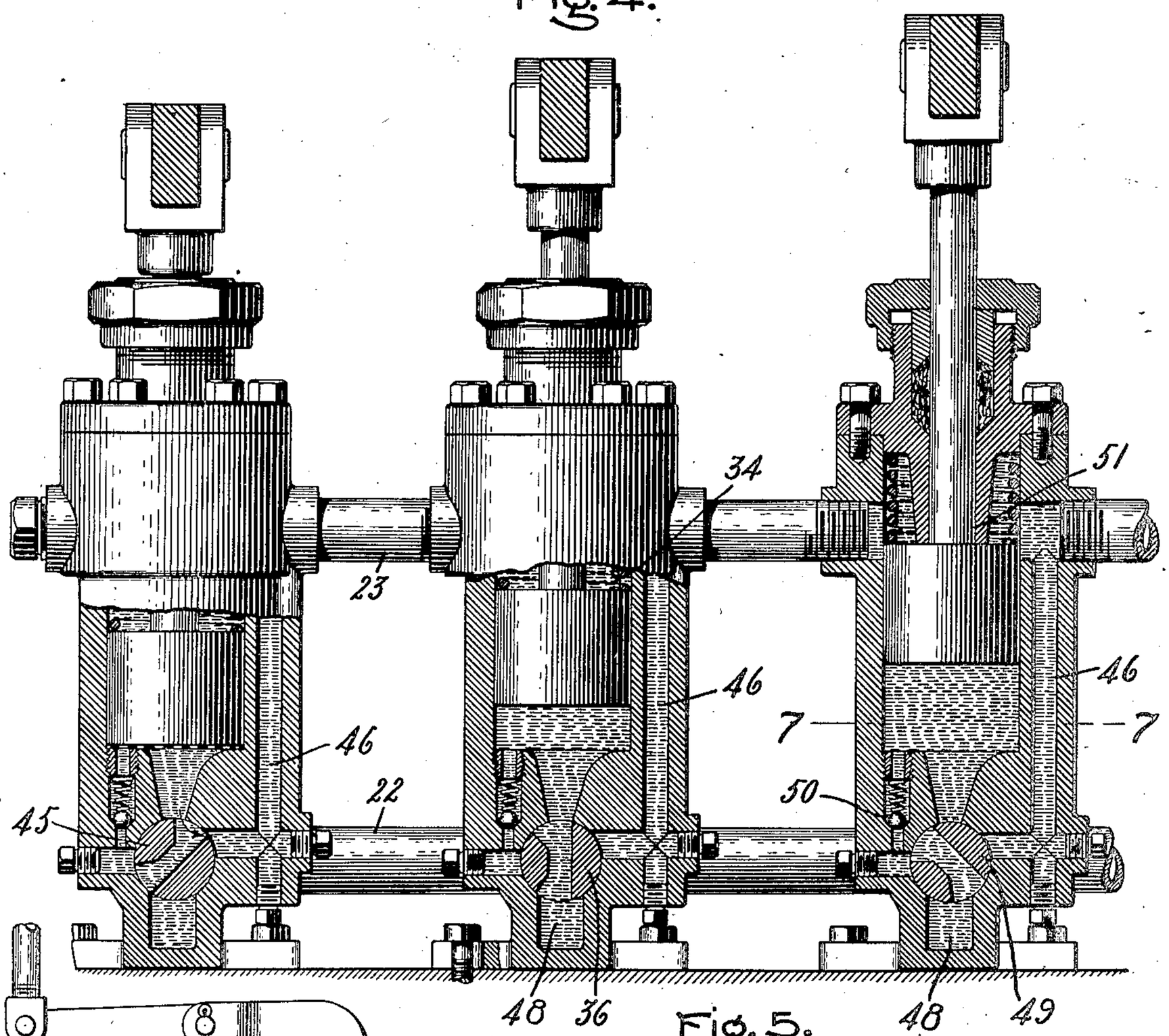
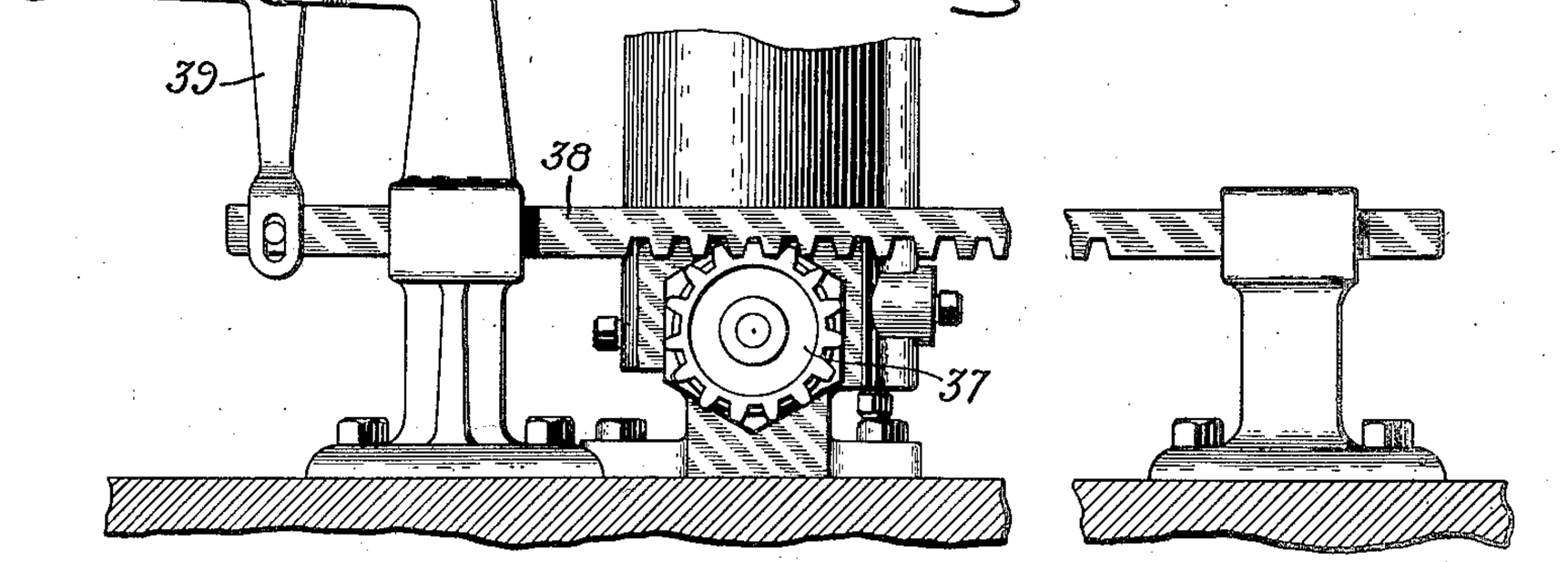


Fig. 5.



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6 SHEETS—SHEET 5.

Fig. 6.

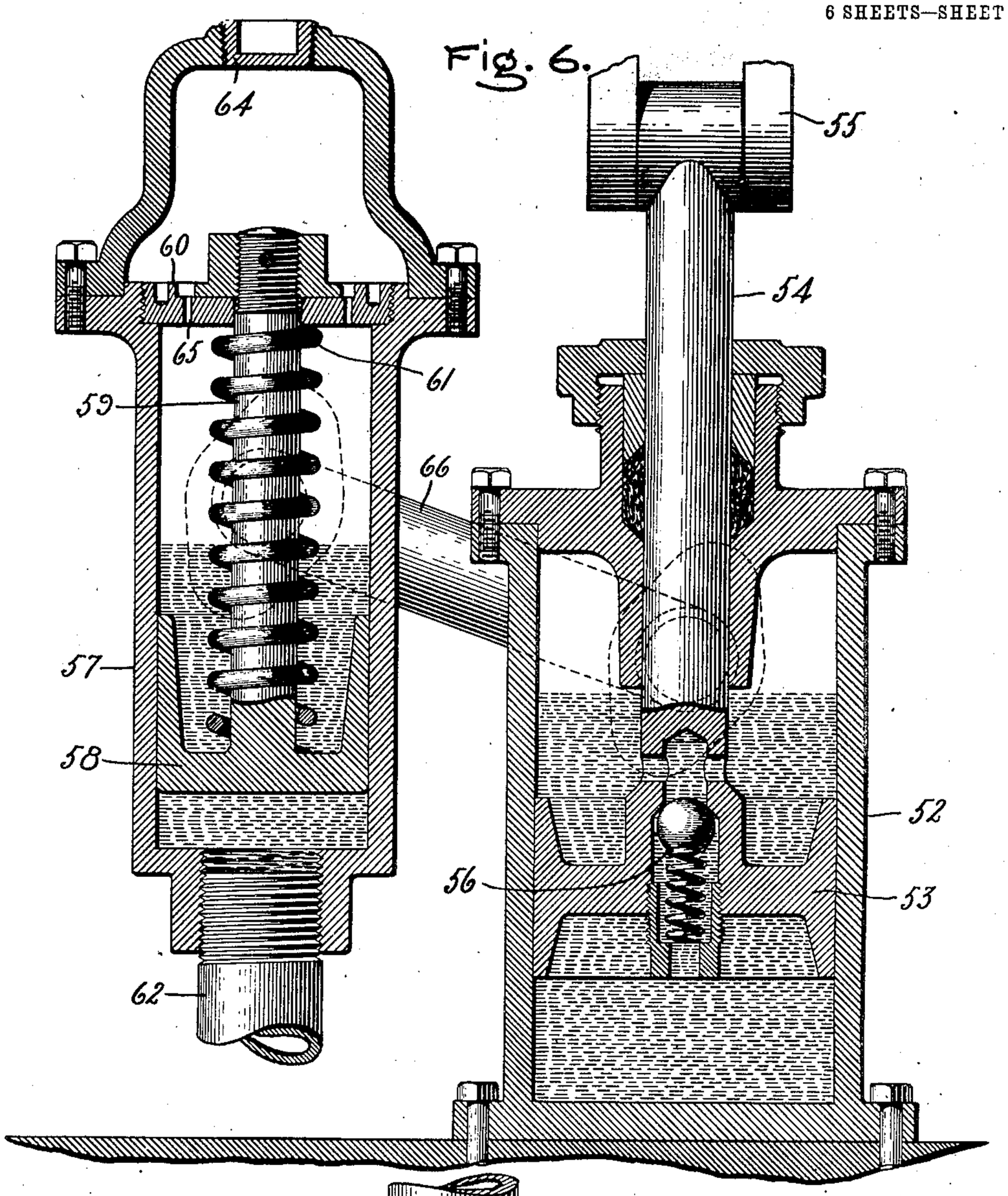
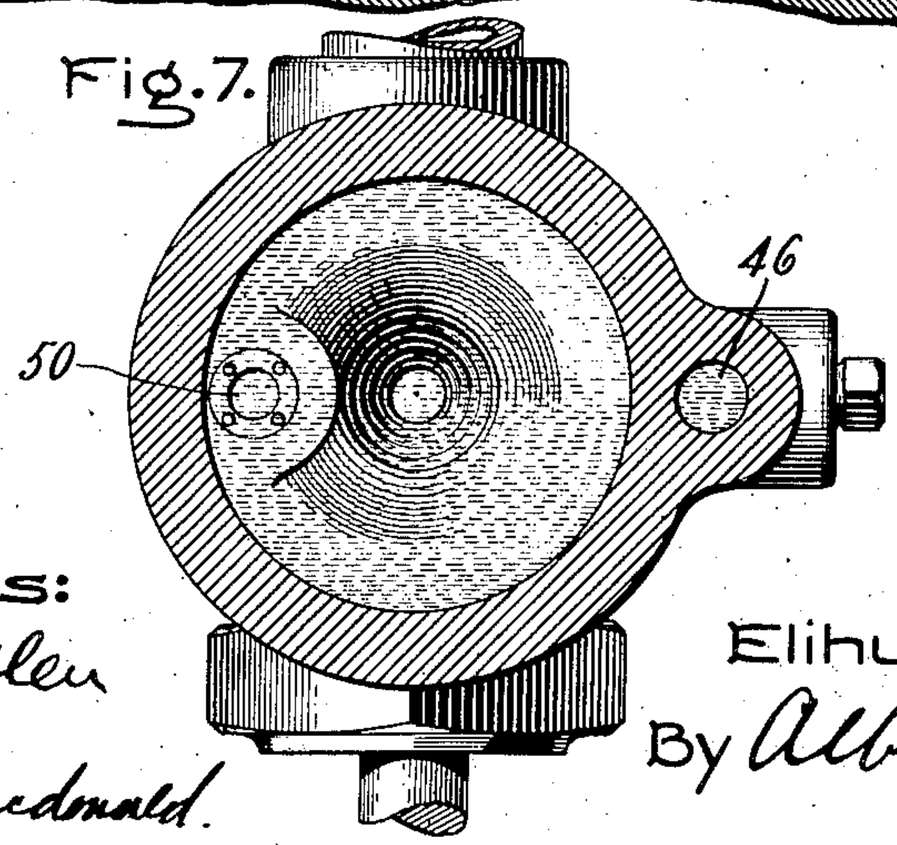


Fig. 7.



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6 SHEETS—SHEET 6.

Fig. 8.

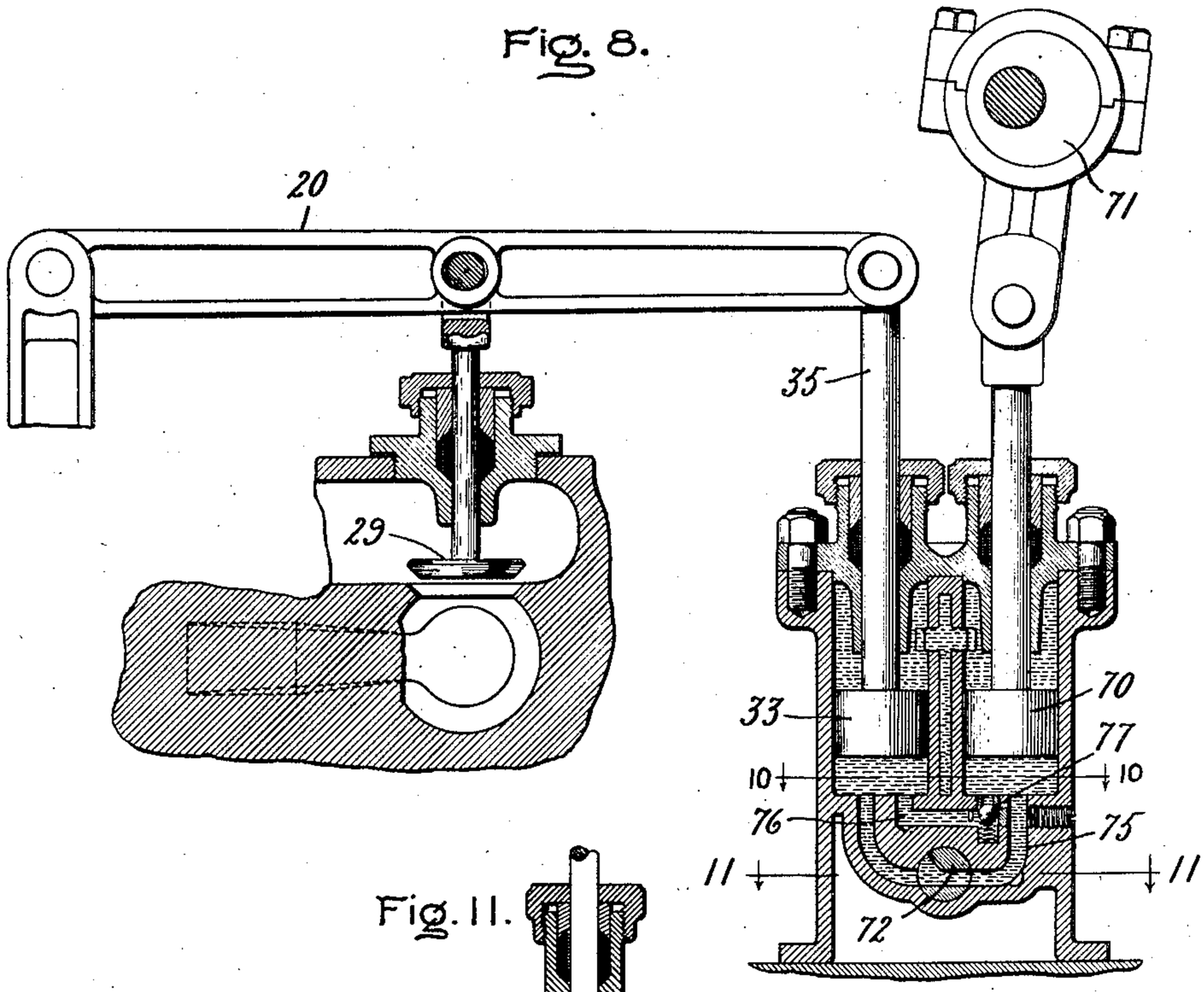


Fig. 11.

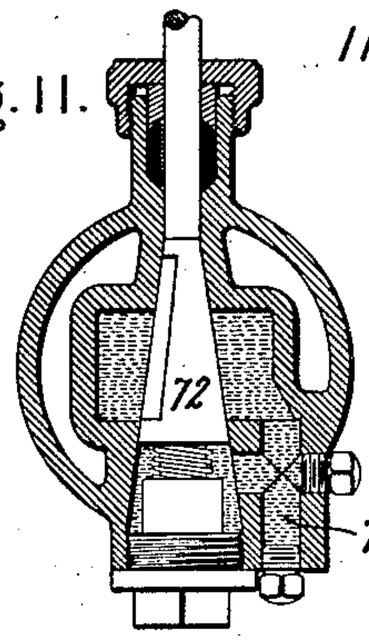


Fig. 9.

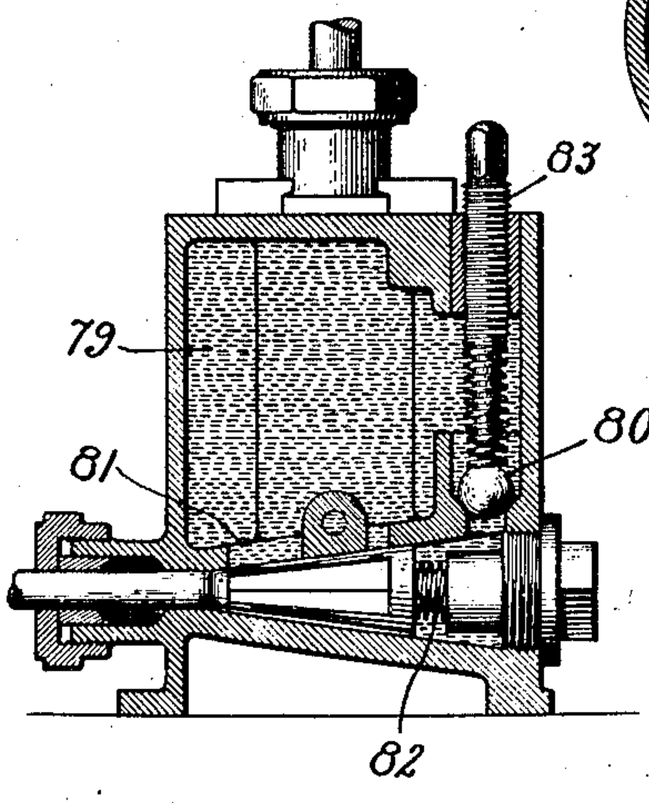
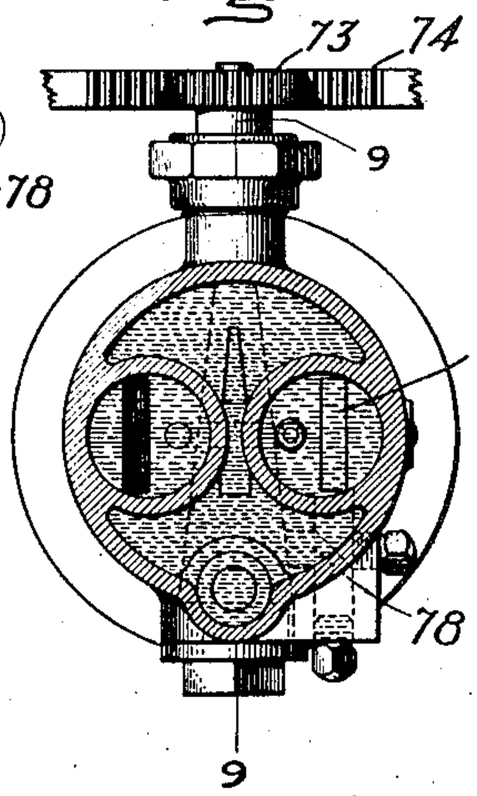


Fig. 10.



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UNITED STATES PATENT OFFICE.

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GOVERNING MECHANISM FOR ELASTIC-FLUID TURBINES.

No. 822,324. Specification of Letters Patent. Patented June 5, 1906.

Application filed September 30, 1905. Serial No. 280,764.

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing at Swampscott, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Governing Mechanisms for Elastic-Fluid Turbines, of which the following is a specification.

The present invention relates to governing mechanisms for elastic-fluid turbines, and more especially to those mechanisms wherein the controlling-valves are successively actuated by hydraulic pressure.

The present invention has for its object to provide a governing mechanism of improved construction, which will effectively control the admission of motive fluid to a turbine by varying its volume without varying its velocity.

In carrying out my invention as many nozzle-valves are provided as are necessary to control the passage of motive fluid through the turbine. These valves may admit fluid to the turbine, or they may control the passage of motive fluid from one stage to another in a multistage-turbine, or some of the valves may be employed for admitting fluid and others for regulating the passage of fluid between stages. Each valve is actuated by a hydraulic motor comprising a suitable piston and cylinder, and the admission of fluid under pressure to each of the several motors is controlled by a pilot-valve, and these pilot-valves are in turn actuated by a speed-responsive device or other means. Under ordinary conditions of operation a shaft-governor is provided that is mounted directly on or connected to the main shaft of the turbine, and between it and the pilot-valves is a connection whereby the latter may be operated one after the other both in opening and closing in order that the nozzle-valves may open and close successively as the load on the turbine varies. When for any reason it is desired to multiply the power or the motion between the piston of a hydraulic motor and a nozzle-valve, a suitable lever is provided that is pivotally supported by a stationary part of the turbine and is connected to the nozzle-valve and the piston of the motor.

Suitably mounted with respect to the motors is a pump of suitable construction—for example, of the plunger type—which is constantly kept in motion at any predetermined rate and discharges fluid in a pulsatory manner as distingushed from a continuous flow. By preference the pump is driven through suitable speed-reducing gearing from the main shaft of the turbine, since in this manner ample power is available at all times, and the parts can be made relatively compact. The pump preferably has sufficient capacity to open one or more of the valves at a time in order to compensate for substantial load changes. Since the pump is constantly in operation and the pistons of the motors are normally stationary, either in a position to hold the nozzle-valves open or closed, it follows that some means must be provided to take care of the pulsatory discharge of the pump when it is unnecessary to move one or more of the valves. For this purpose I provide an accumulator which may be constructed in a variety of ways. For example, it may be of the dead-weight type, or a tank containing a body of elastic fluid under an initial pressure, or it may contain an abutment, which is constantly urged in one direction by a spring. The last-mentioned arrangement is very desirable on account of its extreme simplicity.

Where the nozzle-valves are unbalanced and have a tendency to at all times close, this tendency may be utilized in closing them; but where the valves are unbalanced and have a tendency to remain open I employ springs or equivalent means for closing them. These springs may be located inside of the cylinder of each of the motors and act on the piston therein or they may be arranged to act on the valves directly or through their actuating means. Preferably the springs are located outside of the steam-space.

The cylinders of all of the motors are connected to the high-pressure side of the pump and in circuit with the accumulator, the latter being common to all of the motors. The cylinders are also connected to the low-pressure side of the pump, and the connection is so arranged that a given level may be constantly maintained in the cylinders of the motors. A conduit also connects the accumulator with the pump-chamber, so as to return any fluid to the system which may leak past the movable abutment.

My invention is particularly applicable to turbines having a plurality of regulating-valves. It can, however, be applied to tur-

bines having only one valve which is pulsated or vibrated to admit varying amounts of motive fluid per unit of time. Where a number of valves are employed, I prefer to so arrange the parts that for normal load conditions one or more of the nozzle-valves are open, one or more of the nozzle-valves closed, and at least one valve pulsating or vibrating in synchronism with the strokes of the pump for regulating.

In the accompanying drawings, which illustrate one embodiment of my invention, Figure 1 is a view in partial elevation, with certain of the parts broken away, of the valve mechanism applied to a vertical-shaft turbine of the Curtis type. Fig. 2 is a plan view of the mechanism with certain of the parts of the turbine in section. Fig. 3 is an enlarged section taken on line 3 3 of Fig. 2. Fig. 4 is a detail view showing the motors for operating the valves, together with the pilot-valves that control the motors. Fig. 5 is a detail view illustrating the connection between the shaft-governor and the pilot-valves of the motors. Fig. 6 is a detail sectional view of the pump and the spring-weighted accumulator. Fig. 7 is a cross-section on line 7 7 of Fig. 4. Fig. 8 is a detail view of a modified arrangement more especially intended for turbines having only a single nozzle-valve. Fig. 9 is a vertical section taken on line 9 9 of Fig. 10. Fig. 10 is a cross-section taken on line 10 10 of Fig. 8, and Fig. 11 is a cross-section taken on line 11 11 of Fig. 8.

12 represents the casing of a vertical-shaft turbine of the Curtis type. The invention, however, is applicable to turbines of other construction, either of the jet or other types. Mounted on top of the turbine is a generator 13, the revolving element of which is carried by the upright turbine-driven shaft 14. The upper end of the generator is provided with a dome 15, that incloses a shaft-governor 16. Pivotally supported by the dome is a lever 17, that transmits motion from the shaft-governor to the pilot-valves of the motors through the connecting-rod 18. Steam or other elastic fluid is supplied to the turbine by a valve-chest 19, containing one or more nozzle-valves. Each valve is provided with a stem that extends through a suitable stuffing-box and is connected to a lever 20. These levers are pivoted on one side of the valve-chest and are connected to the piston-rods of the hydraulic motors.

21 represents a pump of the reciprocating plunger type that supplies the necessary fluid under pressure to actuate the motors.

22 represents the high-pressure or supply pipe, and 23 the low-pressure or return pipe. Connected to the high-pressure pipe is an accumulator 24, the construction of which will be described later.

Referring to Fig. 2, the arrangement of the parts, together with the driving mechanism for the pump, will be readily seen. 14 represents the main shaft of the turbine, and mounted thereon is a spiral gear 25, the latter being situated just below the middle or guide bearing and inclosed by a suitable casing. Meshing with the gear 25 is a pinion 26 on the horizontal shaft 27. The left-hand end of the shaft is provided with an eccentric 28 for driving the plunger of the pump.

Referring now to Fig. 3, the construction and arrangement of the mechanism employed for actuating each of the nozzle-valves will be described, it being understood that all of the valves and their actuating mechanisms are similar in construction. 19 represents the steam or valve chest containing a plurality of nozzle-valves 29, each valve being suitably guided in its vertical movement. The valve-chest is made in sections and the several sections bolted together. By reason of this arrangement it is a comparatively simple matter to change the size of the chest. The valve-stem 30 extends through the upper wall of the steam-chest and is suitably packed to prevent leakage. The upper end of the valve-stem is connected to the horizontal lever 20 by a pin-and-slot connection. The lever is pivotally attached to a bracket 31, that is bolted to the side of the valve-chest. Situated at the right of the valve-chest is a hydraulic motor comprising a cylinder 32, supported by the head of the turbine, and a reciprocating piston 33. Situated above the piston and tending at all times to force it downward and close the valve is a coil compression-spring 34. The piston-rod 35 passes through a suitable packing and is connected at its outer end by a pin-and-slot connection with the lever 20. Fluid under pressure from the pump is supplied to the motor by the conduit 22, and the passage of fluid to the cylinder is controlled by the pilot-valve 36. The outer end of the stem of the pilot-valve is provided with a gear 37, Figs. 3 and 5, that meshes with a rack 38, the latter being reciprocated by a bell-crank lever 39 and link 18, Figs. 2 and 5. Fluid from the valve-chest is admitted to or cut off from the passage 40, leading to a nozzle or other fluid-discharging device, by the nozzle-valve, the said passage being arranged to supply one or more sections of a sectionalized nozzle 41. The valves may be so arranged that a single stroke of the pump will cause them to open, or they may be so arranged that it requires two or more strokes of the pump to fully open them, in which case a slight throttling action of the motive fluid may take place. Situated below the nozzle 41 and in line therewith are buckets 42, carried by the wheel 43, mounted on the main shaft. In the present illustration of my invention a multistage-turbine is shown with each stage provided with two rows of wheel-buckets, be-

tween which are located stationary intermediate buckets 44 for reversing the direction of steam or other elastic fluid in passing from one row of wheel-buckets to the other. Instead of using two sets of wheel-buckets per stage a greater or less number may be employed, depending upon the requirements. The nozzle 41 is shown as being of the expanding type; but it is within the scope of my invention to use a non-expanding nozzle or other fluid-discharging devices and either associate them closely or space them apart, as desired.

Referring to Fig. 4, I have shown three motors with their pilot-valves; but it is to be understood that a greater or less number of motors can be employed, according to the requirements. These motors are shown as being located in the same plane; but it is evident that they can be located in different planes, and, in fact, one of the great advantages of my improved governing mechanism resides in the fact that these motors can be placed wherever most convenient and connected by suitable piping to the pump and accumulator. In this respect the arrangement is exceedingly flexible, and it is a simple matter to install or take off one of the motors and the valve-actuating mechanism. In this figure the piston of the left-hand motor is in its lowest position, which means that the nozzle-valve actuated thereby is closed. The piston of the central motor is in a mid-position, which means that the nozzle-valve actuated thereby is partially open, and the piston of the right-hand motor is shown in its extreme upper position, which means that the nozzle-valve actuated thereby is wide open. Fluid is supplied to the motors by the high-pressure pipe 22, leading from the pump. The pilot-valve 45 of the left-hand motor is in such a position that fluid is permitted to escape from the under side of the piston to the vertically-extending passage 46 that communicates with the upper end of the cylinder and with the return and equalizing pipe 23. The pilot-valve 36 of the middle motor is so positioned by the shaft-governor that fluid under pressure is permitted to flow from the pipe 22 through the chamber 48, thence through the passage in the valve into the cylinder-space below the piston. With the pilot-valve in this position the vertical passage 46 is closed. Each downward stroke of the pump-plunger will cause the piston to be raised, and during the suction-stroke the compression-spring will force the piston downward, and in this manner an opening and closing or pulsating effect will be given the nozzle-valve actuated by the motor. The pilot-valve 49 of the right-hand motor is so positioned by the governor that fluid from the supply-pipe 22 can pass through the bottom chamber 48, through the passage in the valve, and past the spring check-valve 50 to the under side of the piston. When the pilot-valve is thus arranged and the plunger of the pump is of such capacity that it requires more than a single stroke to open the valve, the first discharge-stroke of the pump will cause a certain amount of fluid to pass to the under side of the piston through the check-valve 50, the latter serving to prevent the passage of fluid in the opposite direction. The next discharge-stroke of the pump-plunger will raise the piston an additional amount, and so on until the piston is moved to the position shown, where it engages a stop 51, formed on the under side of the cylinder-head. With the valve in this position the by-pass 46 is closed. Ordinarily, however, I prefer to make the capacity of the pump such that a single discharge-stroke is sufficient to raise a motor-piston and fully open a nozzle-valve and in this manner prevent throttling of the motive fluid. Assuming that the load increases, the governor will move the pilot-valve 36 of the central motor to the same position as that of the right-hand pilot-valve 49, and at or about the same time the pilot-valve 45 will assume the position now occupied by the valve 36. This means that there will be two nozzle-valves open and the third valve opening and closing in synchronism with the strokes of the pump. In event of the amount of fluid discharged by the pump in a given stroke being greater than that required to actuate one or more of the motor-pistons the balance will flow into the accumulator and cause the abutment therein to rise and fall. I may so arrange the accumulator that when the pressure below the abutment exceeds a certain amount the latter will permit a certain amount of the fluid to be by-passed back to the pump or to a receiver connected therewith.

Referring to Figs. 6 and 7, the construction and arrangement of the pump and the accumulator will be described. The pump comprises a cylinder 52, that is attached to the head of the turbine or other suitable support, and a reciprocating piston 53, connected by the rod 54 to the fork 55, the latter being attached to the eccentric-strap surrounding the eccentric of the shaft 27, Fig. 2. Located within the piston is a spring-actuated valve 56, which closes on the discharge-stroke and opens more or less on the suction-stroke. The pressure at which this valve will open is dependent upon the stress of the spring located directly beneath it. The tension on this spring can be adjusted at will. Situated at the left of the pump is an accumulator, comprising a cylindrical casing 57 of suitable diameter, and mounted therein and arranged to slide vertically is a piston or abutment 58. The piston is provided with a rod 59, that extends upwardly through a perforated head 60, the latter being threaded to the casing and acting as a stationary abut-

ment for the compression-spring 61. The spring urges the piston downward at all times against the pressure in the pipe 62, supplied from the high-pressure pipe 22 of the pump. The upper end of the accumulator is provided with a detachable cover 63, whereby the parts may be removed. In the upper part of the cover is a screw-threaded plug 64, and by removing it fluid can be supplied to the interior of the accumulator and the pump and the various motors connected therewith. By making the head 60 with perforations 65 any fluid admitted to the casing will readily flow into the piston-chamber and thence to the proper point. On the back side of the accumulator is an orifice which is connected by the pipe 66 with the cylinder of the pump, so that any fluid located on the upper side of the piston and above the level of the discharge-orifice will be carried into the pump-cylinder. There should be sufficient difference in level of these two devices to cause this action to take place. It is evident that when the piston 53 of the pump descends and there is no outlet in the motors for the fluid thus discharged the pressure in the pipe 22, Figs. 1 and 4, will increase, and this increase causes the abutment in the accumulator to move upward and compress the spring; but on the suction-stroke of the pump-plunger the abutment of the accumulator will descend under the action of the spring 61 or its equivalent and return to the pump the fluid which it received on the preceding stroke. This action will be repeated until one or more of the pilot-valves change their position, when the fluid discharge from the pump will open one of the valves.

I prefer to keep the various cylinders, accumulator, pump-cylinder, &c., filled, or substantially filled, with liquid. The fluid displaced at one side of a piston is compensated for by the increased space on the other.

I have described the nozzle-valves as being opened by hydraulic motors and closed by springs; but it is evident that my invention is not in all its aspects limited to this feature, since I may both open and close the nozzle-valves by means of hydraulic motors.

In Fig. 8 I have shown a slight modification of a mechanism employed for actuating the valves. 20 represents the actuating-lever, and 29 the nozzle-valve, as before, 33 the motor-piston, and 35 the piston-rod that connects it to the lever 20. In this modification each nozzle-valve is provided with a motor and also a pump for actuating the motor. The pump-plunger 70 is moved by an eccentric 71, driven by a suitable source of power. The pistons 33 and 70 are mounted in a casing that is common to both, and the piston-rods are provided with suitable packings that are carried by a detachable head. Situated at the bottom of the casing is a pilot-valve 72, of the plug type, that is adapted to control the movements of the motor-piston 33. The pilot-valve is provided with a suitable stem, the end of which is provided with a pinion 73, meshing with a rack 74, actuated by the shaft-governor. Formed in the base of the casing and controlled by the pilot-valve 72 is a passage 75, which connects the cylinders of the pump and motor. As the piston 70 moves downward it discharges the fluid beneath it through the passage 75 against the under side of the piston 33, which causes it to rise and at the same time lift the nozzle-valve away from its seat. On the other hand, when the plunger 70 rises, it withdraws the fluid from the under side of the piston 33 and the latter falls, due to the action of the spring or otherwise, and causes the nozzle-valve to close. Thus it will be seen that each stroke of the piston 70, assuming the parts as shown, will cause the nozzle-valve to open and close, and for this reason the eccentric 71 should revolve at a low rate of speed,

Assuming that a shaft-governor or other device moves the pilot-valve 72 to a position where it interrupts the continuity of the passage 75, fluid discharged by the pump-piston 70 will then pass into the conduit 76 past the check-valve 77 to the under side of the piston 33. This will open the nozzle-valve and the check-valve will hold it. The parts may be so arranged that a single downward stroke of the plunger 70 will fully open the nozzle-valve 29, or it may take several strokes of the pump to accomplish this, and the check-valve 77 will prevent the fluid from being withdrawn from the motor-cylinder. Assuming that the nozzle-valve is wide open and that the pilot-valve 72 has closed the continuity of the passage 75, there must be some relief provided for the pump. This is found in the passage 78. (Best shown in Fig. 10.) This passage 78 opens into the space at the right of the plug-valve, Fig. 9, and passes up into the chamber 79 and past the spring-seated check-valve 80. The pump can be arranged to pump a slight vacuum, or the pilot-valve 72 may be so arranged that a certain amount of fluid will pass from the chamber 79, through the port 81, thence through the passage in the valve into the passage 75. The plug-valve is normally held in engagement with its surrounding walls by the adjustable compression-spring 82. The tension on the spring controlling the check-valve 80 may be adjusted by the screw 83.

Instead of operating each valve by a motor, two or more valves may be connected to and operated by the same motor. This arrangement is particularly useful where it is desired to control both the admission and stage valves by the governor.

In accordance with the provisions of the patent statutes I have described the principle of operation of my invention, together

with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by equivalent means.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a governing mechanism for elastic-fluid turbines, the combination of a regulating-valve, a hydraulic motor for operating the valve, a constantly-running pump which supplies the fluid for actuating the motors, and an accumulator that receives the fluid discharged by the pump after the regulating-valve is moved to a given position.

2. In a governing mechanism for elastic-fluid turbines, the combination of a regulating-valve, a hydraulic motor, a lever for transmitting motion from the hydraulic motor to the valve, a constantly-running pump that supplies fluid to the motor for actuating it, and an accumulator that is permanently connected to the discharge side of the pump and receives fluid after the motor is actuated.

3. In a governing mechanism for elastic-fluid turbines, the combination of two or more regulating-valves, a hydraulic motor for actuating each of the regulating-valves, a constantly-running pump that supplies fluid under pressure for actuating the motors, an accumulator in circuit with the pump that is common to the motors, and pilot-valves controlling the action of the motors and the regulating-valves.

4. In a governing mechanism for elastic-fluid turbines, the combination of a regulating-valve, a hydraulic motor for actuating the valve, a pump having a pulsating discharge which vibrates the valve in synchronism with its strokes, and a pilot-valve controlling the action of the pump on the plunger.

5. In a governing mechanism, the combination of a regulator, a hydraulic motor for actuating it, a pump having a pulsating discharge for actuating the motor, a pilot-valve which regulates the pulsating action of the pump on the motor, and a device for moving the pilot-valve.

6. In a governing mechanism, the combination of a regulator, a hydraulic motor for actuating it, a pump having a pulsating discharge for actuating the motor, a check-valve between the pump and the motor, a pilot-valve which regulates the action of the pump on the motor, and a speed-responsive device for moving the pilot-valve.

7. In a governing mechanism for elastic-fluid turbines, the combination of a plurality of regulating-valves, a hydraulic motor for actuating each of the regulating-valves, a source of hydraulic pressure which is fluctuating in its nature, for actuating the motors, and pilot-valves for controlling the action of the pulsating source of pressure on the motors.

8. In a governing mechanism for elastic-fluid turbines, the combination of a plurality of regulating-valves, a separate motor for actuating each valve, a source of fluid under pressure that is fluctuating in its nature, pilot-valves for regulating the action of said source on the motors, and a speed-responsive device for adjusting the pilot-valves so that one or more of the regulating-valves will be in the open position, one or more closed and one valve opening and closing in accordance with the pulsations of the said source.

9. In a governing mechanism for elastic-fluid turbines, the combination of a regulator, a hydraulic motor for actuating the regulator, a source of fluid under pressure which is fluctuating in its nature for actuating the motor, and a means that determines whether or not the motor shall vibrate with the fluctuation in pressure of the source of power.

10. In a governing mechanism for elastic-fluid turbines, the combination of a regulating device, a motor for actuating the device, and a source of fluid under pressure which makes a predetermined number of fluctuations in pressure per unit of time, the motor and source being so arranged that the former is caused to vibrate in accordance with fluctuations in pressure of the source.

11. In a governing mechanism for turbines, the combination of an unbalanced regulating-valve, a source of fluid for moving the valve in one direction, the pressure of which fluctuates, a spring for moving the valve in the opposite direction, and a means for controlling the effective action of the said source on the valve.

12. In a governing mechanism for turbines, the combination of an unbalanced regulating-valve, a source of fluid for moving the valve in one direction, the pressure of which fluctuates, a spring for moving the valve in the opposite direction, a means for controlling the effective action of the said source on the valve, and an accumulator in circuit between the source of supply and the valve.

13. In a governing mechansim for turbines, the combination of a regulating-valve, a hydraulically-actuated motor, a lever for transmitting motion from the motor to the valve, a pulsating source of fluid for the motor, a pilot-valve for regulating the effective action of the said source on the motor, and a speed-responsive device that adjusts the pilot-valve as the load changes.

14. In a governing mechanism for turbines, the combination of a plurality of regulating-valves, a pulsating source of fluid for actuating the motors, and a means intermediate the said source and motors arranged to hold one or more valves open and to permit one or more valves to vibrate from the closed to the open

position in accordance with the pulsations of the said source.

15. In a governing mechanism for turbines, the combination of a plurality of regulating-valves, a motor for actuating each of the valves, a pump having a pulsating delivery for actuating the valves one after the other, valve mechanism between the pump and the motors arranged to hold one or more valves in the open position and permit one or more valves to vibrate in synchronism with the strokes of the pump, and a speed-responsive device that controls the action of the said valve mechanism.

16. In a governing mechanism for turbines, the combination of a plurality of regulating-valves, a motor for actuating each of the valves, a pulsating source of fluid for actuating the motors, a means intermediate the said source and motors arranged to hold one or more valves open and to permit one or more valves to vibrate from the closed to the open position in accordance with the pulsations of the said source, and an accumulator in circuit with the source which receives fluid when the regulating-valves are held in a given position.

17. In a governing mechanism for turbines, the combination of a plurality of regulating-valves, a motor for actuating each of the valves, a pump having a pulsating delivery for actuating the valves one after the other, valve mechanism between the pump and the motors arranged to hold one or more valves in the open position and permit one or more valves to vibrate in synchronism with the strokes of the pump, a speed-responsive device that controls the action of the said valve mechanism, and an accumulator in circuit with the pump and the motors which receives fluid from the pump when its action does not affect the motors.

In witness whereof I have hereunto set my hand this 28th day of September, 1905.

ELIHU THOMSON.

Witnesses:

JOHN A. McMANUS, Jr.,

HENRY O. WESTENDARP.