No. 680,677. Patented Aug. 13, 1901.

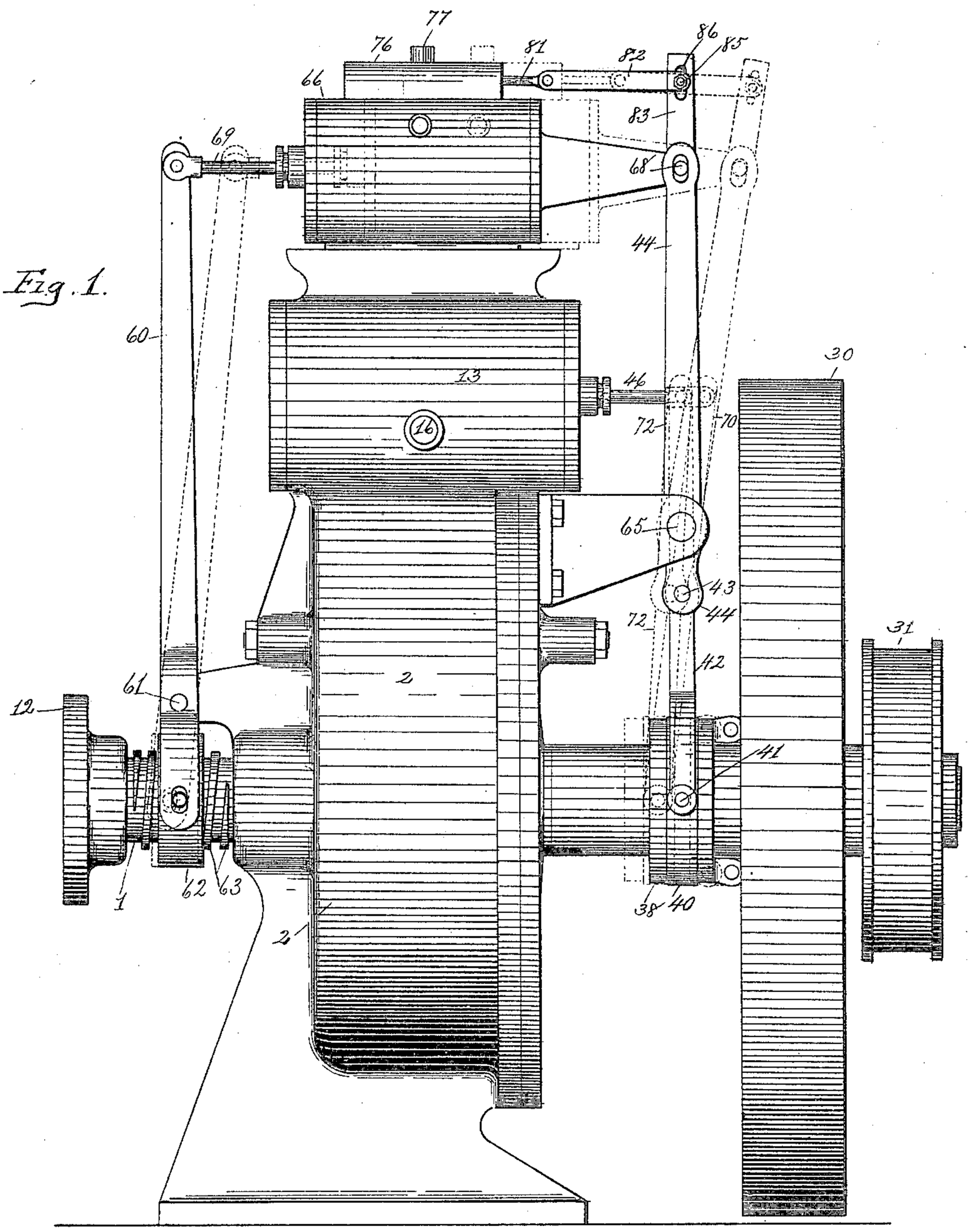
J. STURGESS.

SPEED REGULATOR.

(Application filed June 4, 1900.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.



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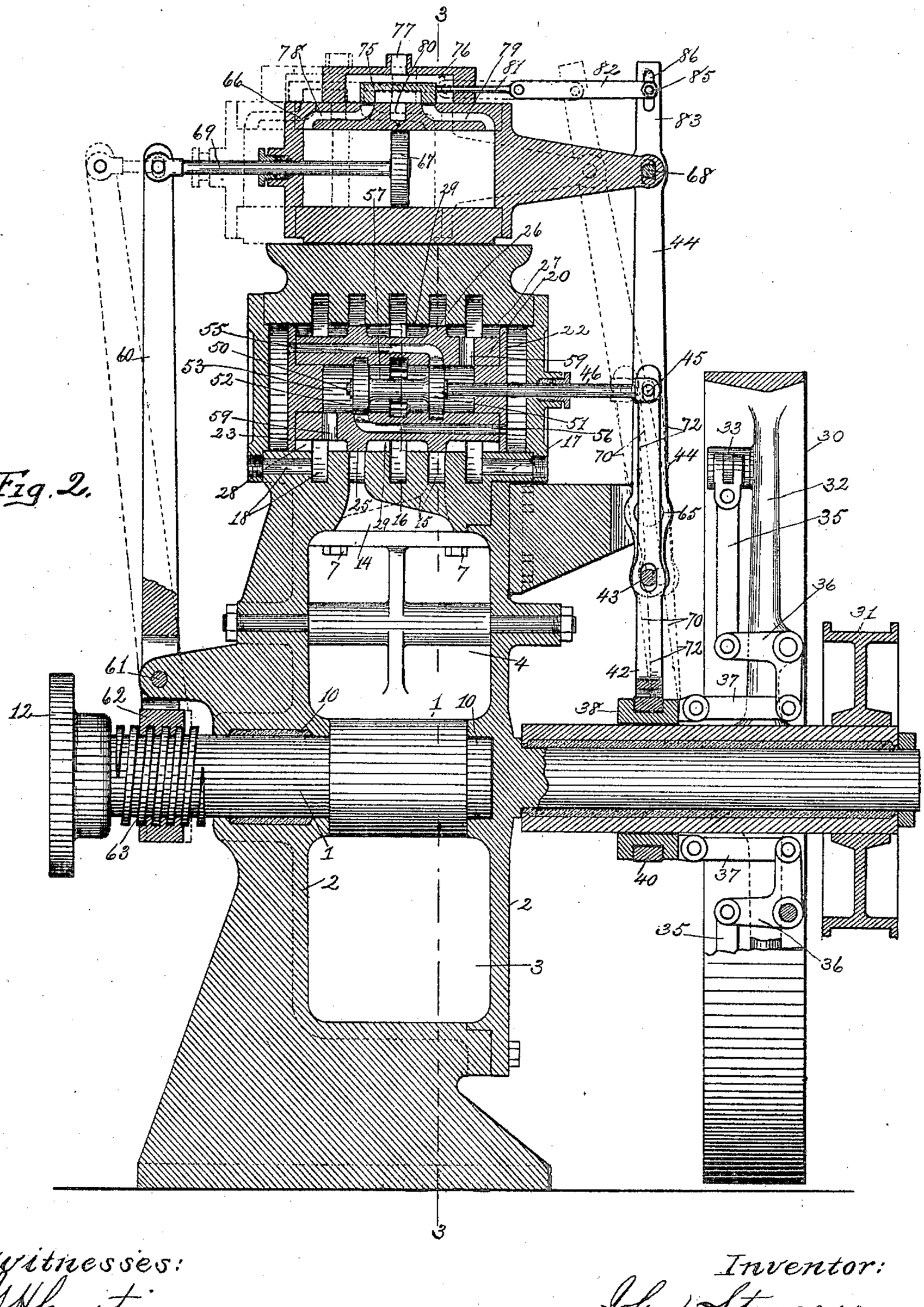
(No Model.) 4 Sheets—Sheet 2.

Fig. 2.



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(No Model.) 4 Sheets—Sheet 3.

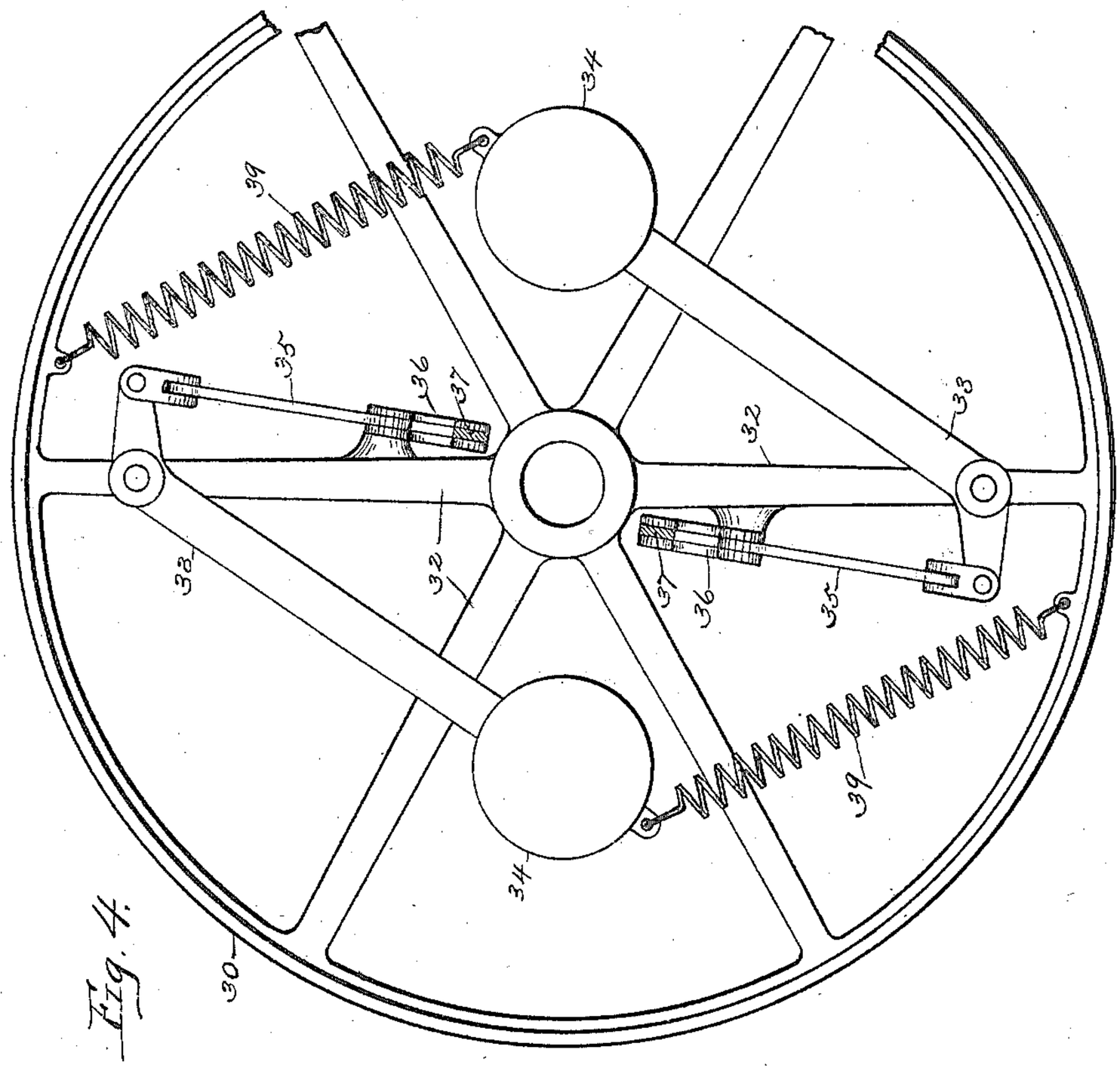

Fig. 4.

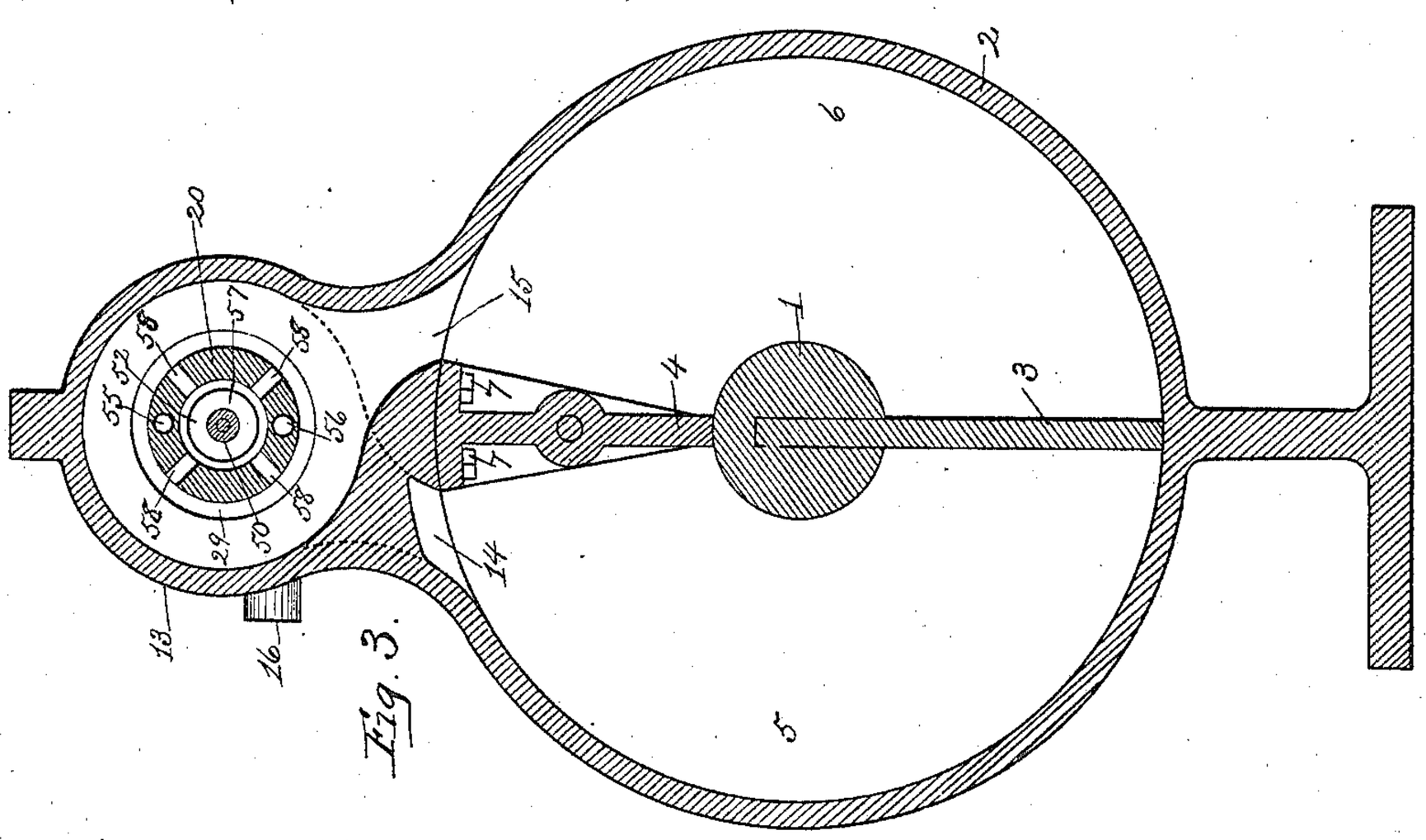

Fig. 3.

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(No Model.) 4 Sheets—Sheet 4.

Fig. 5.

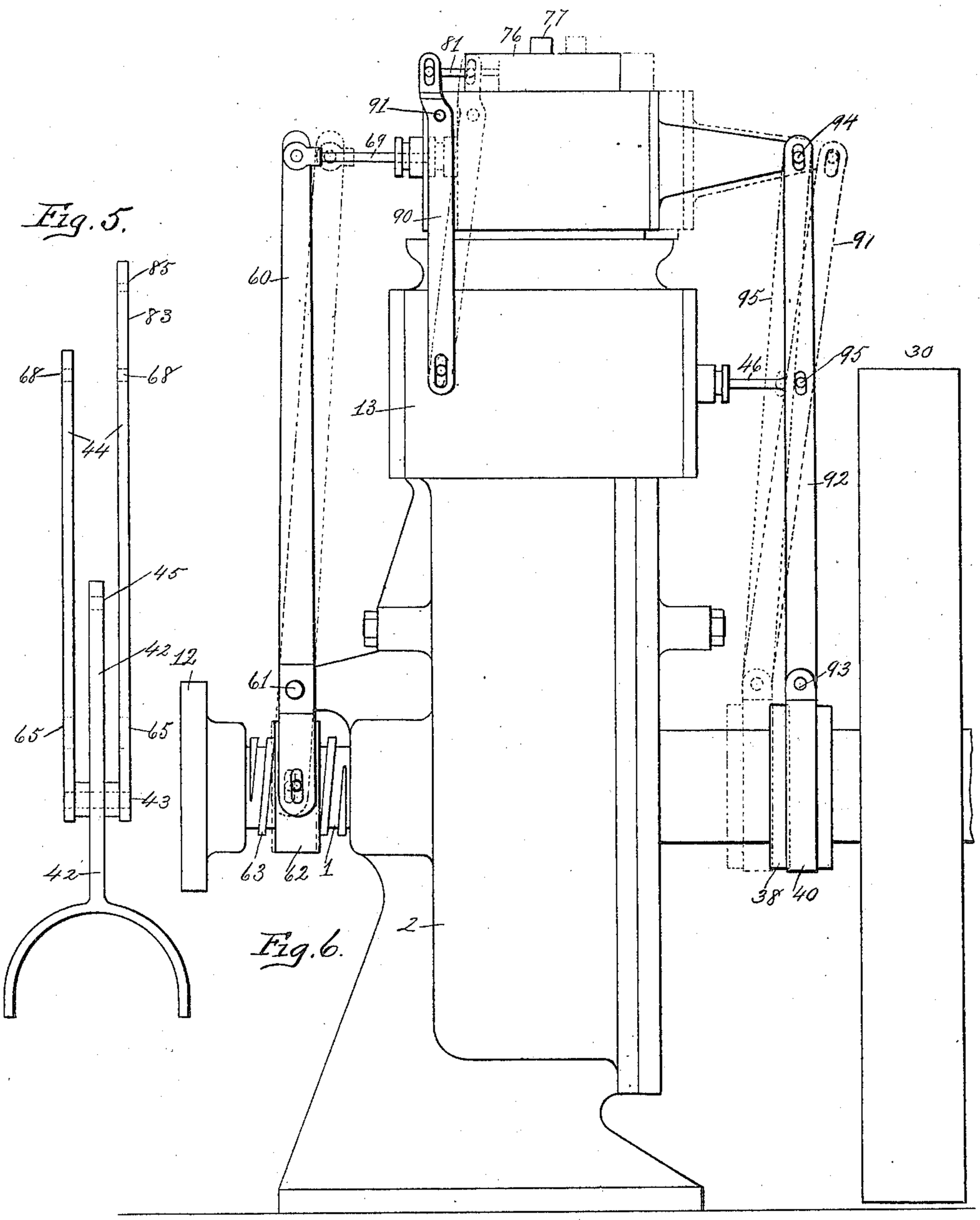

Fig. 6.

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UNITED STATES PATENT OFFICE.

JOHN STURGESS, OF TROY, NEW YORK, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO THE STURGESS GOVERNOR ENGINEERING COMPANY, OF SAME PLACE.

SPEED-REGULATOR.

SPECIFICATION forming part of Letters Patent No. 680,677, dated August 13, 1901.

Application filed June 4, 1900. Serial No. 18,985. (No model.)

To all whom it may concern:

Be it known that I, JOHN STURGESS, a subject of the Queen of Great Britain, residing at Troy, county of Rensselaer, and State of New York, have invented certain new and useful Improvements in Speed-Regulators, of which the following is a specification.

The invention relates to such improvements; and it consists of the novel construction and combination of parts hereinafter described and subsequently claimed.

Reference may be had to the accompanying drawings and the reference characters marked thereon, which form a part of this specification.

Similar characters refer to similar parts in the several figures.

My invention relates to that class of speed-regulators adapted to automatically maintain and control the speed of a prime mover at a uniform rate and prevent variations due either to load changes or power fluctuations.

My invention is applicable more particularly to that class of prime movers operated by water-power—such as turbine, reaction, and impulse wheels—and it may be advantageously used with other prime movers, more especially when the mechanism for controlling the volume or amount of working fluid passing to the prime mover requires appreciable efforts to move it.

The object of my invention is to produce a regulator which is highly efficient in operation, easily and cheaply constructed, and so organized that the chances of failure from breakdown are reduced to a minimum.

The essential features of a speed-regulator for water-wheels and the like are a controller consisting of mechanism for controlling the movements of the gate which regulates the supply of water to the wheel, fluid-pressure for actuating the controller, a valve for distributing the fluid-pressure to the controller, a centrifugal governor for opening the distributing-valve, controller-actuated mechanism for closing such valve, and means for restoring to their normal or midway position parts of the mechanisms acting upon the distributing-valve.

Figure 1 of the drawings is a side elevation of my improved speed-regulator. Fig. 2 is a vertical longitudinal central section of the same. Fig. 3 is a vertical cross-section taken on the broken line 3 3 in Fig. 2. Fig. 4 is a side elevation of the centrifugal governor detached. Fig. 5 is a side view of governor-actuated and valve-actuating levers detached. Fig. 6 is a side view showing my invention embodied in a modified form.

The controller of my improved speed-regulator comprises a rock-shaft 1, contained in a cylindrical inclosure 2, having its axial line coincident with the axial line of the cylindrical inclosure and provided with a radial leaf-piston 3, fixed thereon and extending from the shaft to the cylindrical wall of the inclosure. The inclosure is also provided with a fixed partition 4, radial to the shaft and extending from the shaft to the cylindrical wall of the inclosure, so that such partition, together with the leaf-piston and shaft, divides the inclosure into two chambers 5 and 6. The fixed partition is secured to the wall of the inclosure by means of the bolts 7. The shaft is provided with suitable bearings 10 in the end walls of the inclosure. One end of the shaft projects through the end wall beyond its bearings and is provided with a flange 12 for connecting the shaft with the gate of the water-wheel (not shown) in the usual well-known manner. The wall of the cylindrical inclosure is projected on one side, as at 13, to form an inclosure for a distributing-valve 20, the valve-inclosure being connected with chamber 6 through the port 15 and with chamber 5 by a similar port 14 (indicated partly by dotted lines in Fig. 3) and with an inlet-port 16, leading from a fluid-pressure supply (not shown) and extending around the valve 20, also with exhaust-ports 17 and 18, leading from the valve-inclosure. When fluid under pressure is admitted through port 14 into chamber 5, the fluid-pressure upon the piston 3 causes the piston and rock-shaft to oscillate, the piston traveling in a direction toward the right hand, as seen in Fig. 3, the fluid contained in chamber 6 being forced from such chamber through the other port 15 into the valve-inclosure and from thence through the exhaust-port 17 out-

side of the inclosure, and when fluid under pressure is admitted through port 15 into chamber 6 the piston is caused to oscillate and travel in the opposite direction, the fluid in chamber 5 being forced back through port 14 into the valve-chamber and out through the exhaust-port 18, thereby causing the piston to act as a rock-lever on the rock-shaft to impart to the shaft an oscillatory motion adapted to move the gate of a water-wheel or the like in either of two opposite directions to open or close the same, and thereby increase or diminish the water-supply to the water-wheel. As a means for thus distributing fluid under pressure to the opposite sides of the oscillatory piston I provide within the valve-inclosure the cylindrical valve 20, adapted to be given a reciprocating longitudinal movement therein. This valve-inclosure is adapted to receive and closely fit the piston-heads 22 and 23, which are constructed to make a fluid-tight joint between the piston edge and the casing. The body of the valve between the piston-heads is also provided with annular flanges 25 and 26, forming cut-offs to close the openings of the ports 14 and 15, respectively. As will be seen in Fig. 2 the body of the valve is provided with annular spaces or channels 27 and 28, formed between the piston-heads and the cut-off flanges, each open to an exhaust-port, and with an annular space or channel 29, which forms a pressure-chamber open to the supply-port 16 when the valve is closed in the position shown in Fig. 2, in which position the cut-off flanges are shown covering the ports 14 and 15. By sliding the valve from the closed position (shown in Fig. 2) to the left the port 14 is opened to the port 16 through a channel 29, and the fluid under pressure is forced into chamber 5, which causes the fluid in chamber 6 to flow out through port 15 and channel 27 to the exhaust-port 17, and when the valve is moved in the opposite direction the fluid passes from port 16 through channel 29 and port 15 into chamber 6, the fluid in chamber 5 passing out through port 14, channel 28, and exhaust-port 18. As a means for automatically operating the valve I provide a centrifugal governor 30, which may be of any known form and connected with some part of the machinery operated by the water-wheel by means of a belt (not shown) passed over the pulley 31. Inside the rim of the governor and pivoted to the spokes 32 are levers 33, provided with weights 34 on one arm and links 35 on the other arm, connected, respectively, with one arm of the bell-crank levers 36, and the other arms of the bell-crank levers being connected by links 37 with the sleeve 38, rotary with the governor. The outward throw of the weights 34 may be controlled by means of coiled springs 39. The sleeve 38 is provided with an annular channel adapted to receive a ring 40, having on its opposite sides pivot-studs 41, upon which is pivoted the bifurcate end of lever 42. The other end of lever 42 is pivotally connected at 45 with the valve-stem 46, and the lever is pivotally connected intermediately of its ends at 43 with the short end of lever 44. Where the centrifugal governor can be made sufficiently large and mounted directly upon the main shaft of the water-wheel, this valve may be of the ordinary piston-valve construction, having an inlet-space in the middle and exhaust-spaces at either end. In some cases, however, the centrifugal governor cannot conveniently be made sufficiently large for this purpose, and if an ordinary piston-valve of the requisite diameter were used in this case the effort required to move it would interfere considerably with the sensitiveness of the governor. As a means for obviating this difficulty and affording a sensitive quickly-responding mechanism for controlling the movements of the gate I provide a smaller valve 50, adapted to control the movements of the larger valve, and which is easily and quickly operated by the centrifugal governor. The smaller valve is provided with two annular flanges 51 and 52, located, respectively, on the ends of the body part of the smaller valve. These flanges are adapted to fit the cylindrical bore or chamber 53, extending longitudinally through the central portion of the larger valve. The body portion of the larger valve is provided with two passages, one passage 55 leading from the chamber of the larger valve located outside of the piston-head 23 to the chamber containing the smaller valve and a similar passage 56 leading from the chamber of the larger valve outside of the piston-head 22 to the chamber containing the smaller valve. The body part of the smaller valve is provided with an annular space or channel 57 between the two flanges 51 and 52, forming an inner pressure-chamber, which is connected through ports 58 with the outer pressure-chamber 29, which is open to the supply-port 16. The chambers 53 of the inner valve, located outside of the flanges 51 and 52, are connected by ports 59 with the exhaust-ports 17 and 18, respectively, so that when the valve is moved toward the left hand as viewed in the drawings the passage 56 is uncovered and open to the inner pressure-chamber 57, which permits the fluid contained therein under pressure to travel through the passage into the end chamber of the larger valve outside of the piston-head 22 to act thereupon, which forces the larger valve in the direction taken by the smaller valve, the fluid in the end chamber of the larger valve outside the piston-head 23 being forced through passage 55, which is uncovered by flange 51, through port 59, to the exhaust. When the smaller valve is moved in the opposite direction, as toward the right hand, fluid under pressure passes from the inner chamber 57 through passage 55 and acts upon piston-head 23, which forces the larger valve toward the right hand, the fluid contained in the end chamber of piston 22 passing through

passage 56, which is then uncovered by flange 52, through port 59 to exhaust 18, whereby the fluid-pressure is caused to move the larger valve, it only being required to exert a comparatively small force upon the smaller valve, sufficient to open and close the annular ports leading from the chamber of the smaller valve to the passages 55 and 56, respectively. The smaller valve is connected with the governor-actuated lever 42 by the valve-stem 46, whereby a very small force exerted through the weights of the centrifugal governor will serve to move the comparatively small valve sufficiently to open and close alternately the ports leading to the passages 55 and 56, thereby operating the comparatively large valve and causing a distribution of the fluid under pressure to the rock-lever piston to oscillate the rock-shaft and operate the gate which controls the supply to the water-wheel. I am thus able to accomplish this result in a very simply and direct manner without the use of plate-gears, pinions, or springs for actuating the controller mechanism in either direction.

Fluid-pressure for operating the controller mechanism may be obtained in most instances from the supply which operates the water-wheel or prime-motor, or it can be obtained in any known manner, as by pumping fluid up into a stand-pipe or reservoir.

It should be borne in mind that the movements of the larger valve are identical with those of the smaller valve in either direction and that when the smaller valve comes to a rest the larger always does the same, and in the relative position shown in Fig. 2, with the passages 55 and 56 closed by the flanges 51 and 52. If the machinery attains a rate of speed above the normal, the governor-weights acting through the connecting mechanism open the valve to distribute the fluid-pressure upon that side of the controller-piston, which causes it to rock or oscillate the rock-shaft in a direction to close or partially close the gate of the water-wheel, which will eventually cause the machinery and governor to travel at a slower rate of speed; but the excess of speed above the normal is not immediately eliminated, on account of the inertia of the fluid and the moving parts. It is necessary, therefore, to provide some means for closing the distributing-valve before the controller has acted upon the gate a sufficient length of time to close it altogether or farther than is necessary to reduce the speed of the machinery to the normal. As such a means for closing the distributing-valve independently of the movements of the governor I provide valve-actuating mechanism which is operated by the movements of the controller, consisting of a lever 60, fulcrumed upon a fixed support 61, a lever-actuating connection, as threaded sleeve 62, and screw-threads 63 on the rock-shaft of the controller, between one end of the lever and the controller mechanism, and a valve-actuating connection between the other end of the lever and the valve, which serves to close the valve as soon as the controller has been in action long enough to give the gate the desired movement. The connections which unite the controller-actuated mechanism with the valve consist of the lever 44, which is fulcrumed upon the fixed support 65 and pivotally connected at one end with the governor-actuated lever 42, and the expansible and contractible link, comprising the fluid-filled cylinder 66 and the piston 67, reciprocatory in such cylinder, which link connects the other end of lever 44 with the lever 60. The cylinder is pivotally connected with the lever 44 at 68, and the piston is pivotally connected with the lever 60 through the piston-rod 69. The cylinder being filled with a comparatively non-compressible fluid, as water, the piston remains immovable therein so long as the contained fluid cannot escape or pass from one side of the piston to the other, in which case the connecting-link, consisting of the piston and cylinder, acts as a rigid connection, and when the lever 60 is forced by the rocking movement of the rock-shaft 1, through the agency of the screw-threaded portion 63 and the screw-threaded sleeve 62, from the position shown by solid lines to the position indicated by dotted lines the rigid piston-and-cylinder link will force the lever 44 from the position shown by solid lines to that indicated by dotted lines in said Fig. 2; but the lever 42 was previously forced by the action of the governor from its position shown by the solid lines to the position indicated by the dotted lines 70 in said Fig. 2, which movement served to open the valve, which opening of the valve started the controller in motion, giving a rocking movement to the rock-shaft, and thereby forcing the levers 60 and 44 from their respective positions shown by solid lines to the positions indicated by the dotted lines, as before explained, at the conclusion of which movements the governor occupies an approximately fixed position, and the pivotal connection at 41 between the sleeve 38 and the lever 42 becomes an approximately fixed fulcrum for the lever 42, so that the action of the lever 44, pivoted at 43, thereupon forces that end of the lever 42 which is connected with the valve-stem from the position indicated by the dotted lines 70 to the position indicated by the dotted lines 72, which movement serves to restore the valve to its original and closed position.

The solid lines of the drawings represent the movable parts in the normal midway positions which they occupy when the water-wheel or other motor is running at the rate of speed previously determined upon as the most desirable and which may be termed the "normal" rate. Since the movements indicated by the dotted lines are caused by the abnormal speed of the machinery and governor, which abnormal speed will in time be overcome by the consequent increase or diminution of supply to the water-wheel which

has been effected by the movements of the controller, it is obvious that the governor should be permitted to return gradually to its normal rate of speed without further action upon the distributing-valve and that the valve-actuating connections both with the controller mechanism and with the governor should be permitted to return to their normal or midway positions. As a means for accomplishing this result without changing the position of the valve to open the same I provide means for contracting or expanding the piston-and-cylinder link which connects the levers 60 and 44, consisting of a cut-off valve 75, reciprocatory in the chamber 76, which is connected, as by inlet 77, with a supply of fluid under pressure (not shown) and provide the cylinder-case with fluid-passages 78 and 79, leading from the pressure-chamber 76, one to the piston-chamber on one side of the piston and the other to the chamber on the opposite side of the piston. The chamber 76 is provided with exhaust-port 80. The cut-off valve 75 is connected by a stem 81 and link 82 with a projection 83 of lever 44. It will be seen that when the lever 44 is forced from the position shown by solid lines to that indicated by dotted lines in Fig. 2 the cut-off valve 75 will be opened, so as to admit fluid under pressure from chamber 76 through the passage 79 into the piston-chamber to develop pressure upon the right-hand side, as viewed in Fig. 2, of piston 67, and the cut-off valve, which also controls the exhaust-port 80, at the same time opens the piston-chamber on the opposite or left-hand side of the piston to the exhaust through the passage 78, thus permitting a movement of the piston in the cylinder, which movement expands or lengthens the piston-and-cylinder link. Since the lever 60 is held in a fixed position by the controller, which is now at rest, the lengthening of the link causes the lever 44 to swing from the position indicated by the dotted lines to that shown by solid lines in Fig. 2, which is the normal or midway position of such lever. During these latter movements of the lever 44, induced by the expansion of the contractible and expansible link, the governor has been gradually returning to its normal rate of speed, and consequently to its normal or midway position, (shown by the solid lines in Fig. 2;) but the rate of speed of the lever 44 is proportioned to the rate of speed of the governor, so that the valve is not affected or moved by the movements of the governor while returning to its normal position. This will be understood upon examination of the lever connections with the valve and the fulcrums of the levers. When the governor-actuated lever 42 opens the valve, that lever has its fulcrum at 43, and when the controller mechanism acts upon levers 44 and 42 to close the valve the governor or its connecting-sleeve 38 is the fulcrum for lever 42; but while the two levers 44 and 42, as well as the governor, are returning to their normal positions under the influence of the expansible and contractible link the lever 42 has its fulcrum at 45, which is its pivotal connection with the valve-stem, which point remains stationary while the two levers 44 and 42 are being restored to their normal midway positions. It will thus be seen that the lever 42 is a triple-fulcrum lever having fulcrum-points at each end of the lever and a third fulcrum-point located intermediately of its ends and that the fulcrum shifts from one of these points to another.

The rate of movement of lever 44 under the influence of the piston and cylinder of the expansible and contractible link can be varied or adjusted as desired to cause the movements of the lever 44 to harmonize with the movements of lever 42 while the governor is returning to its normal rate of speed by varying the distance between the pivotal connection of the cylinder portion of the link with lever 44 at 68 and the pivotal connection at 85 between the valve-stem link 82 and the projection 83 of lever 44, since the movement of the valve 75 depends upon the distance between these two pivotal points of connection. It should be observed that the rate of movement of lever 44 due to the action of the contraction or expansion of the piston-and-cylinder link continually varies, the speed being diminished toward the end of the movement by reason of the gradual closing of the ports leading to passages 78 and 79 by the valve 75, which retards the flow of fluid through such ports. This retarding influence, capable of adjustable control, greatly facilitates the successful operation of my improved speed-regulator, inasmuch as the sleeve of the centrifugal governor under the influence of the governor-weights returns to its normal mid-position at a gradually-diminishing rate of speed due to the restoration of equilibrium between the energizing and resisting forces, and if the expansible and contractible movements of the piston-and-cylinder link do not harmonize with the natural movements of the governor mechanism while returning to its normal position the valve will be partially opened during such return movement and impart to the gate an objectionable movement. The pivotal connection of link 82 with the projection 83 of lever 44 may be adjusted relatively to the pivotal connection 68 in any known manner, as by slot 86, formed in the projection 83 to afford a slideway for a pivot-bolt and means for securing the bolt in an adjusted position therein.

The modified construction shown in Fig. 6 differs from that shown in the other figures in that the mechanism for operating the cut-off valve that controls the expansion and contraction of the piston-and-cylinder link is transferred to a fixed support and to the cylinder and consists of the lever 90, pivoted upon the stationary valve-case 13 upon one end, upon the valve-stem at the other end,

and intermediately of its ends, as at 91, upon that part of the link which is pivoted upon the valve-actuating lever. Such change permits of a modification also in the lever mechanism for actuating the distributing-valve. Instead of two levers, as 42 and 44, a single lever 92 is employed, connected, one end with the governor-actuated mechanism at 93 on sleeve 38 and the other end with the controller-actuated mechanism, as the piston-and-cylinder link at 94, the intermediate portion being connected at 95 with the valve-stem 46. When the governor actuates the lever to open the distributing-valve, the lever assumes the position indicated by the dotted lines 95, the connection 94 being its fulcrum-point, and when the controller mechanism actuates the same lever through the link to close the distributing-valve the lever assumes the position indicated by the dotted lines 97, the connection 93 being its fulcrum-point, the fulcrum being reciprocal and shifting from one end of the lever to the other. When the valve-actuating lever and governor are returning to their normal midway positions, the connection 95 becomes the fulcrum-point of the lever, the opposite ends of the lever traveling in opposite directions being actuated by the expansion or contraction of the link, as before explained, and by the governor. The movements of the governor and governor-actuated mechanism (indicated by dotted lines in Fig. 2) are in a direction such as would be caused by an extreme reduction of the load, which largely increases the speed of the machinery and the governor, and a sufficient movement is shown to wholly open the ports of the distributing-valve on that side which would actuate the controller mechanism to partially close the gate for the water-wheel. When the load is greatly increased, the speed of the machinery and the governor is greatly reduced and the governor-actuated mechanism would be moved in the opposite direction from that shown in Fig. 2 to open the ports of the distributing-valve, which would actuate the controller mechanism to open the gate for the water-wheel. Such a movement of the governor-actuated mechanism and also the corresponding movements of the controller-actuated mechanism and the connections which actuate the valve are shown by dotted lines in Fig. 1.

The description of the movable parts and movements (indicated by dotted lines in Fig. 2) will apply equally well to the movements shown in Fig. 1 by the dotted lines, except that the expansible and contractible link would be contracted and shortened to produce the movements indicated by the dotted lines in Fig. 1 by admitting fluid under pressure from chamber 76 through passage 78 to the left-hand side of piston 67 instead of through passage 79 to the right-hand side of said piston.

What I claim as new, and desire to secure by Letters Patent, is—

1. In a speed-regulator, the combination with a centrifugal governor; of a gate-controller having an inclosed oscillatory piston fixed upon a rock-shaft; means for connecting such rock-shaft with the supply-gate, or the like, means for providing fluid-pressure; a relatively large valve for distributing the fluid-pressure to the gate-controller; and a relatively small valve, operated by the centrifugal governor, for actuating the larger valve, substantially as described.

2. In a speed-regulator, the combination with a piston-inclosure provided with an inner cylindrical surface; a rock-shaft projected through one end of the inclosure with its axial line coincident with the axial line of the cylindrical surface; a rock-lever piston, consisting of a piston-blade radially secured to the shaft and oscillatory in the inclosure; a stationary partition radial to the shaft which together with the radial piston divides the interior of the inclosure into two chambers each having an opening for receiving and discharging fluid; and means for operatively connecting the shaft with a supply-gate, or the like; of a fluid-pressure-supply pipe; valve mechanism with ports and connections between such supply-pipe and the chamber-openings, whereby fluid under pressure may be admitted alternately on opposite sides of the leaf-piston to rock the shaft; a centrifugal governor; and operating connections between the valve mechanism and governor, substantially as described.

3. A speed-regulator for water-wheels, and the like, consisting of a gate-controller adapted to be operated by fluid-pressure; a relatively large valve for admitting fluid under pressure to said controller; a relatively small valve contained within and supported by the larger valve and arranged to cause the fluid-pressure to communicate to the larger valve movements identical with those of the smaller valve; a centrifugal governor and actuating connections between such governor and such small valve, substantially as described.

4. In a speed-regulator, the combination with a centrifugal governor; of a controller for water-wheel gates, and the like, operated by fluid under pressure; a valve inclosure having an inlet for fluid-pressure and exhaust and distributing ports leading from and to the controller; a relatively large piston-valve, movable in such inclosure for controlling such ports and having an inner pressure-chamber open to the fluid-pressure and fluid-passages leading from the inner pressure-chamber to the ends of the valve inclosure respectively; and a relatively small piston-valve within the larger valve operated by the centrifugal governor for controlling the fluid-passages leading from the inner pressure-chamber to the ends of the inclosure of the large valve, whereby the fluid-pressure forces the larger to follow the movements of the smaller valve, substantially as described.

5. In a speed-regulator, the combination with a centrifugal governor; a controller for water-wheel gates, and the like, operated by fluid under pressure; a valve for distributing such pressure to the gate-controller; and a valve-actuating and governor-actuated lever having a shiftable fulcrum; of a controller-actuated cut-off mechanism for closing the distributing-valve independently of the movements of the governor, whereby the movement of the gate-controller serves to close the distributing-valve before the speed of the governor is appreciably affected, substantially as described.

6. In a speed-regulator, the combination with a centrifugal governor; a controller for water-wheel gates, and the like, operated by fluid under pressure; a valve for distributing such pressure to the gate-controller; and a valve-actuating and governor-actuated lever having a shiftable fulcrum; of controller-actuated cut-off and returning mechanisms for inclosing the distributing-valve and returning the valve-lever and shiftable fulcrum to their normal positions, consisting of a contractible and expansible connection between such lever and the gate-controller; and means for expanding and contracting such connection, substantially as described.

7. In a speed-regulator, the combination with a centrifugal governor; a controller for water-wheel gates, and the like, operated by fluid under pressure; a valve for distributing such pressure to the gate-controller; valve-operating mechanism and a connection between said mechanism and the governor; of controller-actuated mechanism; connections between said controller-actuated and valve-operating mechanisms having an expansible and contractible link; means for expanding and contracting said link by fluid-pressure; a controlling-valve for said fluid-pressure and mechanism whereby said valve is opened by the movement of the controller-actuated mechanism and closed by the expansion or contraction of the link, substantially as described.

8. In a speed-regulator, the combination with a centrifugal governor, a controller for water-wheel gates and the like, operated by fluid under pressure; a valve for distributing such pressure to the gate-controller; of connections between the governor and valve; connections between the controller and valve comprising in part a piston and cylinder, pivotally secured, one to the remaining part of the connections on the controller side and the other to that on the valve side; means for supplying fluid-pressure to such cylinder; a cut-off valve for regulating the pressure in such cylinder; a link connecting such cut-off valve with some part of the connection on the valve side of the piston and cylinder which has a rate of travel differing from that of the pivotal connection between that part and the piston and cylinder, substantially as described.

9. In a speed-regulator, the combination with a centrifugal governor, a controller for water-wheel gates, and the like, operated by fluid under pressure; and a valve for distributing such pressure to the gate-controller; of a reciprocal fulcrum-lever; and pivotal connections between the lever and the governor, controller and valve, respectively, substantially as described.

10. In a speed-regulator, the combination with a centrifugal governor, a controller for water-wheel gates, and the like, operated by fluid under pressure; and a valve for distributing such pressure to the gate-controller; of a triple fulcrum-lever; an expansible and contractible connection between the lever and controller; means for expanding and contracting such connection; and pivotal connections between the lever and the governor and valve, respectively, substantially as described.

11. In a speed-regulator, the combination with a centrifugal governor, a controller for water-wheel gates, and the like, operated by fluid under pressure; a valve for distributing such pressure to the gate-controller; connections between the valve and governor for opening the valve; connections between the valve and controller for closing the valve independently of the position of the governor and retaining the valve in a closed position during the movements of the governor in resuming its normal position having an expansible and contractible link comprising a fluid-filled cylinder and piston and means for positively operating the piston by fluid under pressure, substantially as described.

12. In a speed-regulator, and in combination a centrifugal governor; a gate-controller operated by fluid under pressure; a valve for distributing the pressure to the controller; connections between the governor and gate for opening the valve; and connections between the controller and gate for closing the valve, having a contractible and expansible link consisting of a fluid-filled cylinder and a piston operated in such cylinder by fluid under pressure, a cut-off valve for distributing the fluid-pressure to the piston, and means for operating the cut-off valve at a varying rate of speed, substantially as described.

13. In a speed-regulator, the combination with a centrifugal governor; a controller for water-wheel gates, and the like, operated by fluid under pressure and having an inclosed oscillatory leaf-piston radially fixed upon a rock-shaft which together with a stationary partition radial to the shaft divides the interior of the piston-inclosure into two chambers, each having an opening for receiving and discharging fluid under pressure; means for operatively connecting the shaft with a supply-gate or the like; a relatively large valve for distributing the fluid-pressure to the piston; a relatively small valve contained within and supported by the larger valve for distributing fluid-pressure to the larger valve;

a lever connected with the governor to be actuated thereby and connected with the smaller valve to actuate both valves; a cut-off lever connected with the valve; another lever having an actuating connection with the gate-controller; an expansible and contractible connection between the controller-actuated lever and the cut-off lever; and means for expanding and contracting such connection at a varying rate of speed, substantially as described.

14. In a speed-regulator, the combination with mechanism for controlling the supply to a fluid-operated motor, and means for causing movement of said motor at abnormal speed to induce action of said mechanism; of an expansible and contractible link, for inducing inaction of said mechanism, comprising a fluid-filled cylinder, piston and rod, movable as a rigid element in response to the movement of said mechanism and expansible or contractible during the return of the motor to normal speed; and means for positively expanding and contracting said link by fluid under pressure, substantially as described.

In testimony whereof I have hereunto set my hand this 28th day of May, 1900.

JOHN STURGESS.

Witnesses:
GEO. A. MOSHER,
FRANK C. CURTIS.