No. 625,337. Patented May 23, 1899.

S. N. KNIGHT.

WATER WHEEL REGULATING APPARATUS.

(Application filed Dec. 11, 1897.)

(No Model.) 4 Sheets—Sheet I.

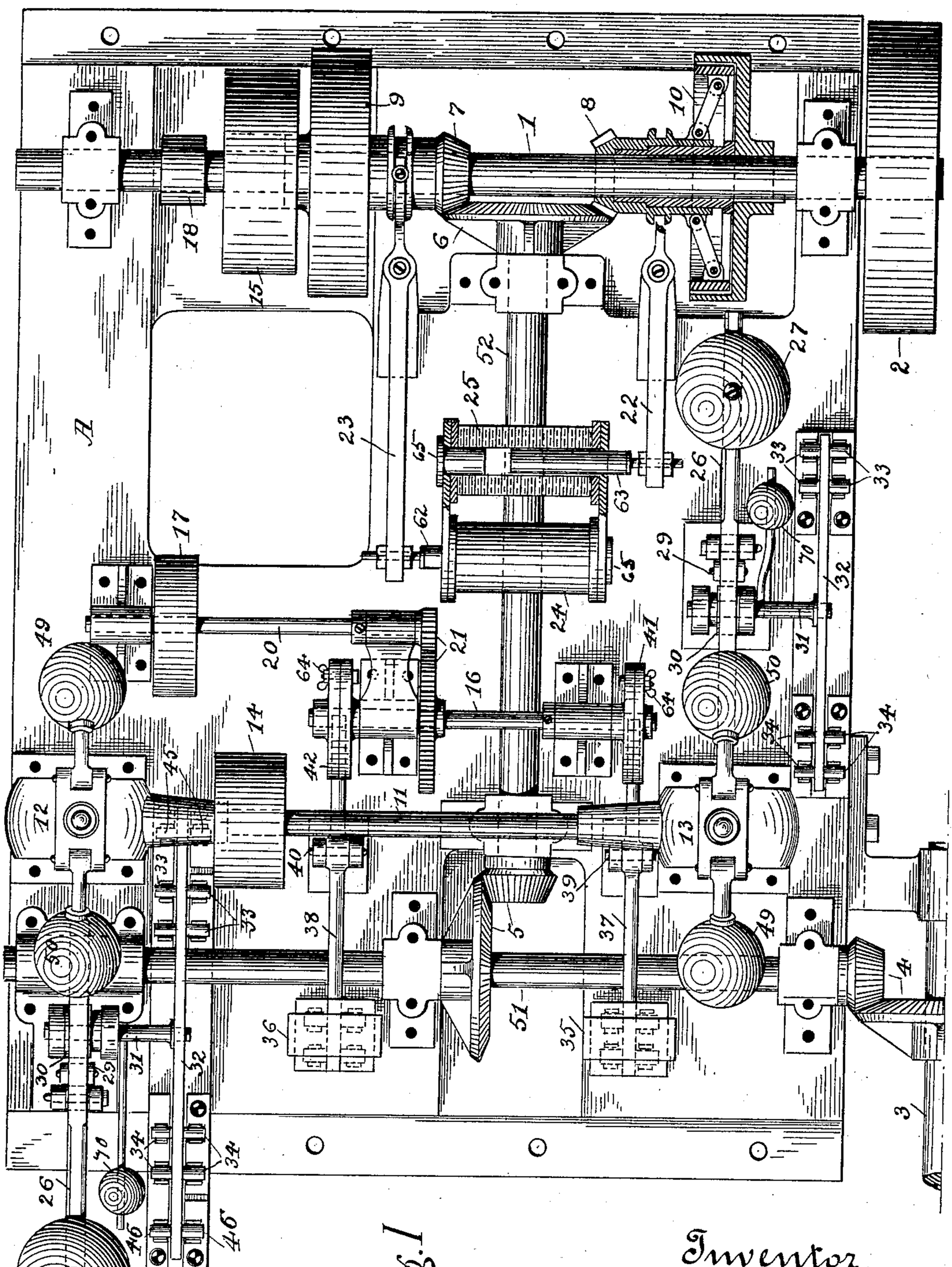

Fig. 1.

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Fig. IV.

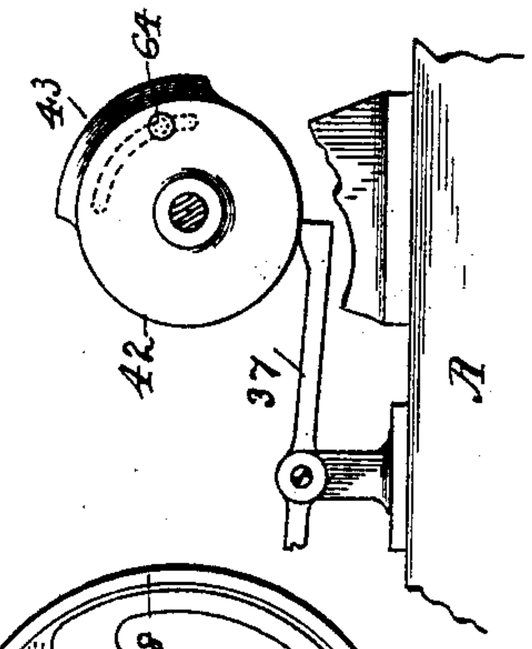

Fig. III.

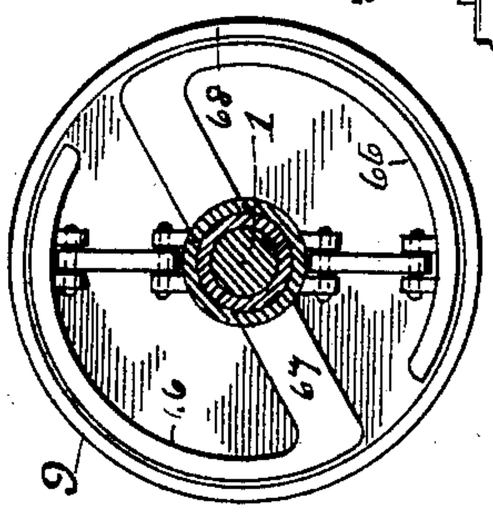

Fig. II.

Witnesses.

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WATER WHEEL REGULATING APPARATUS.

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(No Model.) 4 Sheets—Sheet 3.

Fig. V.

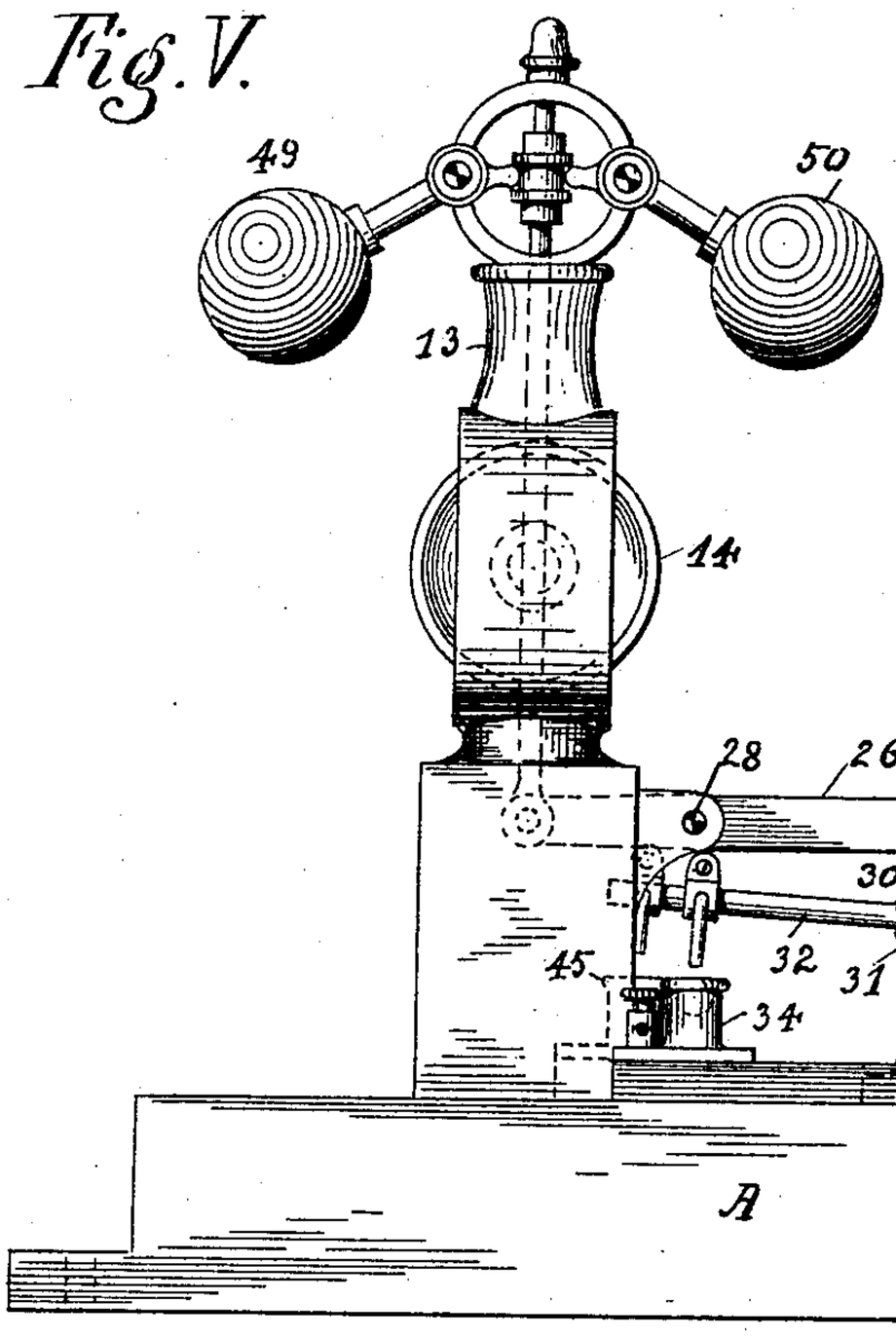


Fig. VII.

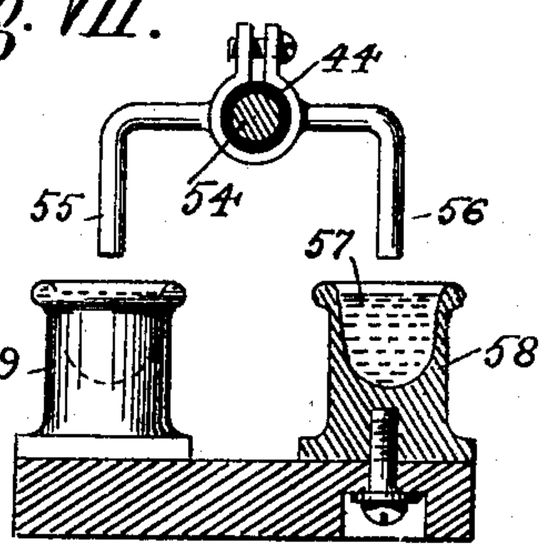
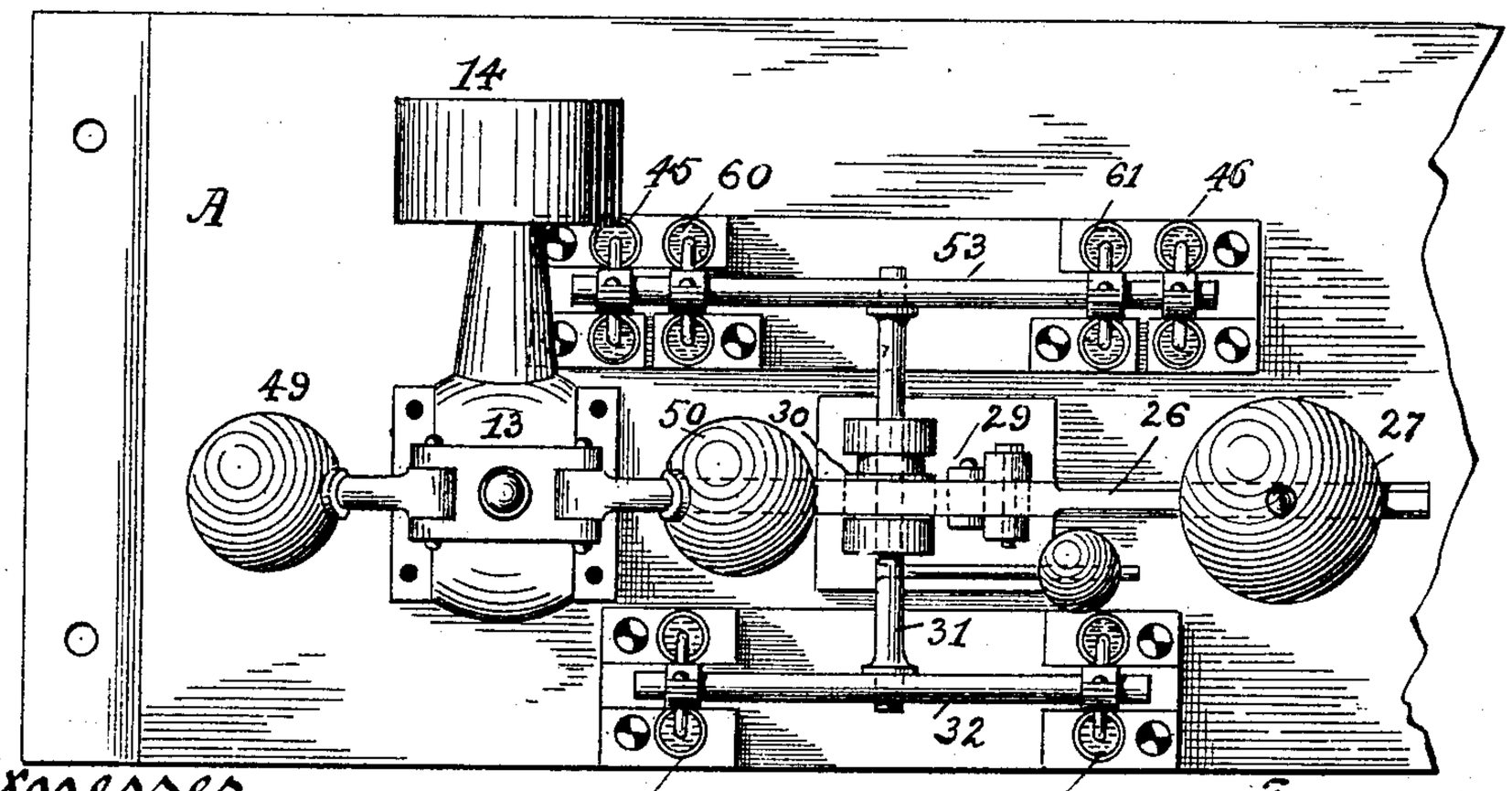


Fig. VI.



Witnesses.
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No. 625,337. Patented May 23, 1899.

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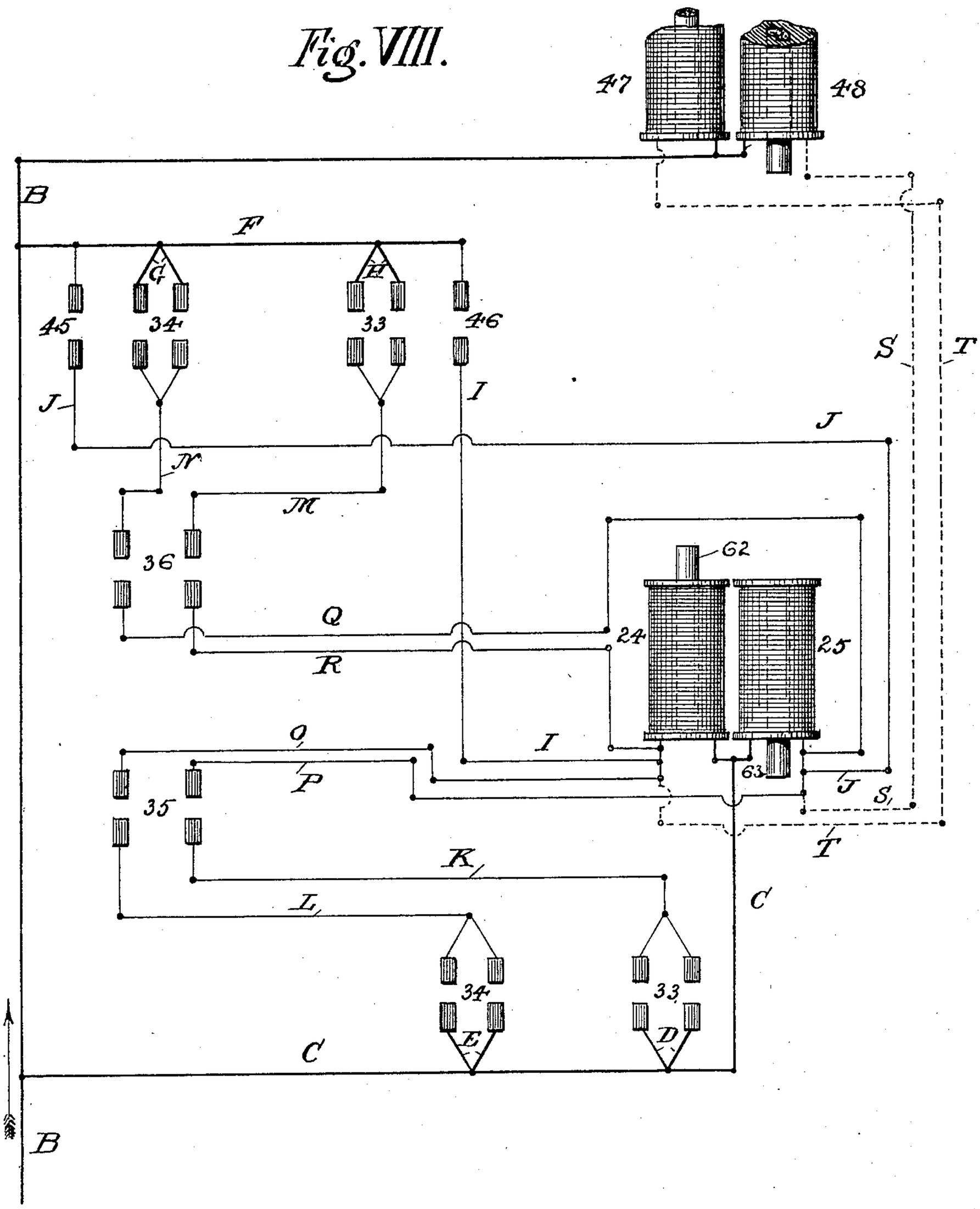
WATER WHEEL REGULATING APPARATUS.

(Application filed Dec. 11, 1897.)

(No Model.) 4 Sheets—Sheet 4.

Fig. VIII.



Witnesses.

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Atty.

UNITED STATES PATENT OFFICE.

SAMUEL N. KNIGHT, OF SUTTER CREEK, CALIFORNIA.

WATER-WHEEL-REGULATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 625,337, dated May 23, 1899.

Application filed December 11, 1897. Serial No. 661,555. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL N. KNIGHT, a citizen of the United States, residing at Sutter Creek, county of Amador, and State of California, have invented certain new and useful Improvements in Water-Wheel-Regulating Apparatus; and I hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to a method and apparatus for regulating the speed of motive machinery, especially of water-wheels, when the resistance or load is variable and the motive force has to be changed cumulatively or by degrees.

My improvements consist in engaging and disengaging clutches that transmit motion from the driven machinery to the controlling gearing and apparatus, solenoids to operate the clutches, and a centrifugal governor to operate contacts and produce electric currents whereby the solenoids are energized; in supplementary or relay contacts, mechanically operated, that intermittently open and close the circuit to the solenoids over predetermined periods or ranges; in the interoperation and combination of two governors and sets of contact or controlling devices to act upon and regulate a single water-wheel or a number of water-wheels collectively or to regulate their speed relatively; in a series of successively-operating liquid electrical contacts whereby the circuits to the solenoids can be controlled by a single centrifugal governor; also consists of various features of a constructive and operative nature to be hereinafter particularly pointed out in connection with the drawings herewith, forming a part of this specification.

The particular object of my invention is to secure uniformity of the speed of water-wheels and of electric generators driven thereby when the amount of electric current consumed or the resistance is variable.

Referring to the drawings, Figure I is a plan view of a regulating or controlling apparatus constructed according to my invention. Fig. II is a side elevation of the same. Fig. III is a side view of one of the clutches for engaging and disengaging the regulating-gearing. Fig. IV is a side view of a cam for intermittently opening and closing the electric current to the solenoid and is a detail of Figs. I and II. Fig. V is a side view of one of the centrifugal governors arranged to operate fluid instead of metallic electrical contacts. Fig. VI is a plan view of Fig. V. Fig. VII is an enlarged detail of Fig. V, showing the construction of the fluid contacts. Fig. VIII is a chart to indicate in plan the wiring between the electrical elements of the apparatus.

Like letters and numerals of reference indicate corresponding parts in the different figures of the drawings.

In regulating apparatus of the class to which my invention belongs the arrangement, proportions, and to some extent the manner of operating have to be modified to meet the circumstances of different cases—as, for example, when there is but one water-wheel and generator, when there are two or more of each, when these operate independently or in series, when the impelling-water is taken from long pipes and its momentum will not permit sudden changes of flow, where the surplus water beyond what is required for power can be wasted and the flow be uniform, and when the water is valuable and must all be applied on the water-wheels. These circumstances demand modification of any kind of regulating apparatus and amplify its mechanism and the drawings required to illustrate it; but the mode of operating remains practically the same, and may be said to consist, essentially, in an adjustment of the gates or valves that supply water to the wheels, by stages or at intervals, positively determined by the mechanism.

In the regulation of the speed of water-wheels an increase or decrease of the amount of water applied to a wheel does not, as in the case of steam or air, produce almost instant change in the speed of motors driven thereby. The rate of flow for liquids being less than a tenth that of gases under ordinary pressures, a correspondingly longer period of time is required for the action of regulating apparatus.

I am aware that in regulating apparatus for water-wheels the action on gates, valves, or other devices to control the amount of water supplied operates with intervals, but not at

determined or positive intervals or stages, but cumulatively at irregular intervals, determined by change of the speed of the water-wheels. In my method of operating the intervals of change in the water-supply are determined positively by stages, proceeding at a rate that permits the effect to take place and then repeats, if such effect is not sufficient, and, finally, if the action by stages fails to produce the desired change in speed of the water-wheels, continuous action of the regulating apparatus begins and continues until the whole available amount of water is applied or is shut off.

Referring to the drawings, especially to Fig. I, all the various parts constituting the regulating apparatus are integrally mounted on a base-plate, (marked A in the drawings.) 1 is a shaft driven from the water wheel or wheels by means of a belt to the pulley 2. 3 is a shaft extending to a valve, gate, or other device to regulate the quantity of water admitted to the water wheel or wheels. The valve, gate, or other device to regulate the amount of water can be of any suitable construction, not necessary to be illustrated, and is opened and closed by the shaft 3, which revolves in either direction, as will be hereinafter explained. This shaft 3 is driven by the gear-wheels 4, shaft 51, the gear-wheels 5, and shaft 52, which latter is driven by one or the other of the bevel-pinions 7 or 8, meshing into the wheel 6, as the motion requires to be right or left and as the clutches 9 or 10 may be engaged. The shaft 11 drives the centrifugal governors 12 and 13 and derives motion from a belt passing around the pulleys 14 and 15, the latter being keyed on the shaft 1. The shaft 16 is also driven from the shaft 1 by means of the pulleys 17 18, the shaft 20, and gear-wheels 21, so that all motions mechanically derived are from the shaft 1 and primarily from the water wheel or wheels to be regulated. The friction-clutches 9 and 10, the construction of which is further shown in Fig. III, drive the bevel-pinions 7 and 8 and are engaged and disengaged by the levers 22 and 23, operated by the electric solenoids 24 and 25, that are energized in the manner hereinafter explained.

Supplementary parts, such as the bearings for shafts, fastenings, and supports, also the proportions of pulleys and gear-wheels, will be understood from the drawings without particular description.

Referring now to the centrifugal governors 12 and 13 and the operating parts connected directly therewith, these are the same and in most cases bear like references except as to certain electrical contacts hereinafter described. These governors, which are of the usual construction, are attached to the levers 26, which latter are pivoted at 28, as shown in Figs. II and V, and are provided with adjustable weights 27, that can be moved out or in upon the levers 26 to regulate resistance to the centrifugal force of the governor, and thus determine its rate of revolution, and thereby the speed of a water-wheel to be regulated in the common manner of adjusting such centrifugal apparatus. On these levers 26, between the fulcra 28 and the weights 27, are attached toothed racks 29, that engage and turn the pinions 30, as seen in Fig. II. These pinions 30 are fastened upon and turn the spindles 31, on the ends of which are fastened the levers 32, the latter bearing electrical contacts 33 34, that open and close indirectly an energizing electric circuit to the solenoids 24 and 25, as hereinafter explained. The contacts 33 34 are made double or in pairs to insure their action, and the movable electrodes are insulated from the levers 31 32 by collars 44, as shown enlarged in Fig. VII.

To prevent play or backlash in the teeth of the pinions 30 and rack 29, I employ a small weight 70, that keeps the teeth in contact and produces true movement of the levers 32.

By the position of the fulcra 28 of the levers 26 and multiplied movement caused by the small pinion 30 it will be seen that the slightest movement of the centrifugal governors 13 will move the levers 32 throughout their operating range and engage one or the other of the contacts 33 or 34 as the levers 32 are moved right or left or as the motion of the governor 13 is increased or diminished. These contacts 33 34, which will be further explained in connection with the connecting-wires illustrated in Fig. VIII, do not close directly on energizing electric current to the solenoids 24 25. Such current passes from the contacts 33 34 first through the relay-contacts 35, or in other case through the relays 35 and 36 now to be described. These relay-contacts 35 36, which are interposed between the contacts 33 34 and the solenoids 24 25, consist of electrodes mounted on the levers 37 and 38, that are pivoted at 39 and 40 and are given an intermittent vibratory motion by means of the trip or cam wheels 41 and 42. (Shown enlarged in Fig. IV.) These wheels 41 42 are mounted on the shaft 16, driven from the shaft 1, as before described, and are provided with cams 43, as seen in Fig. IV, that come in contact at each revolution with the levers 37 38, and by depressing the free ends of these close upward the contacts 35 and 36 for a period corresponding to the length of arc of the cams 43. These cams 43, however, have not the same length of arc, those on the wheel 41 being, for example, sixty degrees of arc in length and on the wheel 42 one hundred and twenty degrees of arc, so that the relay-contacts 35 will be closed one-sixth of the time and the relay-contacts 36 closed one-third of the time, the electric current acting on the solenoids 24 25 in the same proportion.

The cam-wheels 41 42 are divided into two parts, one of which is adjustable about the axis and is held by the screw-bolts 64. In this manner the length of the cam-face 43 can by adjustment be made longer or shorter,

altering in proportion the time that the contacts 35 36 are engaged. The difference in the periods or time of contact in the relay devices 35 and 36 and the functions resulting therefrom demands the two governors 12 and 13, which act consecutively, as will be explained in connection with the electrical elements and their operation.

Referring to the conducting-wires, B is the main line connecting directly to the solenoids 24 25 by the wire C, to the contacts 33 by wires D, and to the primary contacts 34 by the wires E; also, connects to the second contacts 33 34 by the wires F, G, and H. This forms the main-line connections with one exception—that to the extra contacts 45 46 in the second series. These latter contacts, as will be hereinafter explained, connect direct from the main wire B to the solenoids 24 25 by the wires I and J, as seen in Fig. VIII. The first set of primary contacts 33 34, operated by the governor 13, as seen in Figs. I and II, connect to the relay 35 by the wires K and L, and the second primary contacts 33 34, operated by the governor 12, connect to the relay 36 through the wires M and N. The first relay 35 connects to the solenoids 24 25 by the wires O and P, and the second relay 36 connects to the solenoids 24 25 by the wires Q and R. This makes up the connections for one water-wheel or to operate one shaft 3, which may control gates or valves for two or more water-wheels. The electrical elements just described are, however, capable of regulating any number of water-wheels in series by means of separate solenoids and their gearing, as indicated at 47 48 in Fig. VIII, the only electrical connection required being two connecting-wires, (indicated by dotted lines S and T.) This produces coincident action throughout a number of solenoids and operating-gearing connected therewith, so the controlling mechanism heretofore described can be applied to any number of water-wheels operating together or at constant speeds relatively.

Referring to the solenoids 24 25, I find, besides the usual coils, the static cores 65, that intensify cumulatively the action upon the movable cores 62 63 as the inner ends approach, thus providing an increasing force, such as is demanded in engaging the friction-clutches 9 and 10.

Referring now to mechanical elements and their movements and supposing the water wheel or wheels and the governors 12 and 13 to be moving at their normal rate, all the electrical elements will be inert; but if the water-wheels and the governor 13 increase in speed even to a small extent, estimated in practice at one revolution in a hundred, the weights 49 50 rise, and the lever 26 is depressed at its inner or shorter end and rises at its outer end, so that the rack 29 turns the pinion 30, thus depressing and engaging the primary contacts 34, sending current through the line L to the relay-contacts 35, and through these, by the line O, to the solenoid 24, energizing that and causing an inward movement of the piston or core 62, and by the lever 23 engaging the friction-clutch 9 setting in motion the bevel-pinion 7, and by the interposed gearing, heretofore described, turning the shaft 3, shutting off a portion of the water from the wheels. These operations are not, however, continuous. The electric current is interrupted by the relay 35, the movable electrodes of which are separated and the current broken one-sixth of the time, or as the length of the cam 43 on the wheel 41, which depresses the lever 37 and makes the contact, as before described, so that movement of the water-controlling mechanism progresses in stages and at regular intervals corresponding to revolutions of the shaft 16. The reverse operation, that of increasing the amount of water applied to the water wheel or wheels, follows through a like series of operations affecting the solenoid 25.

If the water-wheels and the shaft 1 move too slow, the governor-weights 49 50 will fall for a short distance, the lever 32 will be moved in the opposite direction, so that the primary contacts 33 will engage, as seen in Fig. II, and the circuit will pass through the wire K to and through the relay 35 and by the wire P to the solenoid 25, thereby causing the bevel-pinion 8 to be set in motion, and the clutch 10 and the shafts 52, 51, and 3 will be turned to further open a gate or valve and admit more water to the wheel or wheels, the relay-contacts 35 closing the circuit between the wires P and K at intervals, or during one-sixth of the time, the same as before described. This describes the operation of the regulating mechanism so far as the action of the centrifugal governor 13; but it will be obvious that when sudden changes of load or resistance occur, as is common in generating electric currents and for many other kinds of service, the range of controlling action that has been described will fail to meet such emergencies, and the second centrifugal governor and the second relay devices 36 are provided. Supposing the range of variation to which the first governor 13 is adjusted to be for one revolution in a hundred or one per cent. variation of speed and the second governor 12 to be adjusted so as to engage the contacts 33 34, right or left, by a change of two revolutions in a hundred, then as soon as such variation exceeds that to which the governor 13 is adjusted and reaches two per cent. the governor 12 substitutes the one 13, and the relay 36 comes into operation with its longer periods of contact, and the solenoids 24 and 25 are operated for double the time or with twice the range each time the electric current is closed, so the distinction between the governors 12 and 13 is that the latter is half as sensitive in respect to indication, and the relay-contacts 36, connected therewith, maintain the electric current during intervals twice as long. There is, however, another contingency to be provided for—that of the changes of load or re-

sistance being so sudden and extensive as to demand full and continuous action of the solenoids 24 and 25. This I provide for by extra contacts 45, one at each end of the lever 32. The inner contacts 33 34 are elastic—that is, can slide together after contact—or they may be of the fluid kind shown in Fig. VII, so that after the first ones, 33 or 34, are engaged the lever 38 can go on and contact the electrodes at 45 or 46 either right or left, as the speed of the governor 12 is increased or diminished, thus establishing connection and a continuous circuit between the main wire B and one of the wires I or J, which pass direct to the solenoids 24 25 and not through the relays 35 36. This provides for every emergency in regulation, and may be said to consist of three cumulative methods of operating the solenoids 24 25 and the water-controlling gearing set in motion thereby—namely, an electric circuit maintained one-sixth of the time, an electric circuit maintained one-third of the time, and a continuous circuit.

In cases where regulation does not require the precision attained by the mechanism heretofore described I employ a single centrifugal governor, as shown in Figs. V, VI, and VII, and by preference fluid contacts to close the electric circuits. In these figures parts corresponding to Figs. I and II are marked with corresponding numerals of reference. The method of constructing the fluid contacts is illustrated in Fig. VII, which is intended to explain the manner of operating and not parts of the preceding figures. 54 is an oscillating shaft. 55 56 are contact-points or electrodes insulated from the shaft 54 by the collar 44 and adapted to dip into the liquid 57 in the cups 58 59. This liquid 57 may be mercury, salt water, solution, cyanid of potassium, or any fluid of high conductivity that will close an electric circuit between two cups spanned by the electrode 55 56.

Referring to Figs. V and VI, all the various parts correspond to Figs. I and II, except as to the contacts, which are made single instead of double, because there is no uncertainty in their action that would be avoided by a dual construction, and the operative and conducting wires are the same; but the functions of the centrifugal governor are extended to cover the office performed by both governors in Figs. I and II. The electric circuits pass through the relays 35 36 in the same manner, but are closed differently, as will now be described. The contacts on the right, 33, 61, and 45, close the circuit to the solenoid 25, and those on the left, 34, 60, and 46, close the circuit to the solenoid 24. The circuit from the contacts 33, 34, 60, and 61 pass through the relays 35 36; but the circuit from the contacts 45 46 is direct and continuous. The shaft or spindle 31 is provided with two levers 32 and 53, and the contacts thereon act cumulatively. For example, on the left the contact 34 engages first, then by farther movement in the same direction contact 60 engages, and by still farther movement contact 45 engages. This successive action is attained by making the electrodes 55 56 of different lengths, so that one will first come in contact with the fluid 57, then another, and so on, to the third, the electrodes being immersed in the liquid at different depths accordingly. In this manner it will be seen that by permitting a wider range of variation in speed for the centrifugal governor 13 it can perform the functions of the two shown in Figs. I and II, but not with the same precision or within so small a range for variation of speed. The contacts or electrodes to open and close the electric circuits can be in any case of either of the types shown, metallic or fluid, the latter being most convenient constructively in the case of a single centrifugal governor adapted to operate over the whole range of variation in speed, but subject to change in the position of contact by the evaporation or loss of the fluid in the cups 58 59.

Referring again to the clutches 9 and 10, these are of peculiar construction, as shown in Fig. III. The sections 66 are made integral with the driving-bar 67 and are sprung outward to engage the rim 68 by the usual toggle-gearing. (Shown in section in Fig. I.) These sections 66 are in tension when engaged and when released by the toggle-gearing react so as to move the levers 22 23 and retract the movable cores 62 63 of the solenoids 24 25. This dispenses with the use of withdrawal-springs or other devices to readjust the clutch mechanism after its disengagement.

Having thus described the nature and objects of my invention, what I claim, and desire to secure by Letters Patent, is—

1. In water-wheel-regulating apparatus, a gate or other means to control the amount of water applied to the water wheel or wheels, reversible gearing connecting the same to the water-wheel shaft, clutches to engage and disengage the reversible gearing and electric solenoids to operate the clutches, a centrifugal governor to open and close the electric circuit to the solenoids, relay-contacts in this circuit to interrupt it at predetermined intervals, and means to adjust the intervals or periods of such interruption, operating substantially as described.

2. In water-wheel-regulating apparatus, a gate or other means to control the amount of water supplied to the water-wheel, gearing to open and close the gate inversely as the speed of the water-wheels is increased or diminished, clutches to connect the gearing with the water-wheel shaft and to reverse the motion as required, electric solenoids to operate the clutches, means to supply electric current to the solenoids, and two relay-contacts to interrupt in succession the electric circuits to the solenoids with different periods of closure, substantially as specified.

3. In water-wheel-regulating apparatus, the centrifugal governors 12 and 13 operating together at like speed, primary electric contacts 33 and 34 operated by the governors consecutively, closing electric circuits to the solenoids 24 25 that engage and disengage the clutches 8 and 9 as the shaft 3 is to be turned right or left, substantially as specified.

4. In water-wheel-regulating apparatus, the centrifugal governors 12 and 13 operating together at like speed, primary contacts 33 and 34, opened and closed by the governors consecutively, electric currents controlled by said contacts, intermitting relays 35, 36 operated by the opening and closing of said circuits, and solenoids 24, 25 in circuit with said intermitting relays, and energized by the same, substantially as specified.

5. In water-wheel-regulating apparatus; the intermitting electrical relays 35 36 connecting to primary contacts 33 and 34 and to the solenoids 24 and 25, the levers 37 38, shaft 16, and cam-wheels 41 and 42 and adjustable cams 43 to open and interrupt the electric circuit to the solenoids, for different periods, relatively.

6. In water-wheel-regulating apparatus, centrifugal governors 12 and 13, primary contacts 33 34, relays 35 and 36 connecting thereto, and to the solenoids 24 25, the oscillating levers 37 38, shaft 16, and cams 43 to operate the levers intermittently, and close the electric circuit through the relays 33 34 for different periods of time, relatively.

7. In water-wheel-regulating apparatus, centrifugal governors 12 and 13, connected to and operating the oscillating shafts 31 and levers 32, the latter having contacts 33 and 34 moving right or left, and closing electric circuits to the solenoids 24 25, as the speed of a water-wheel and of the governors driven thereby is increased or diminished, the governors and the contacts adjusted to act successively, one substituting the other at some predetermined speed.

8. In water-wheel-regulating apparatus, centrifugal governors 12, 13, primary contacts 33, 34, opened and closed by said governors consecutively, electric circuits controlled by said contacts, intermitting relays 35, 36 operated by the opening and closing of said circuits, solenoids 24, 25 in circuit with the said intermitting relays, and energized by the same, and contacts 45, 46, operated by governor 12, placed in a circuit including the main wire B and the solenoids, substantially as specified.

In testimony whereof I have hereunto affixed my signature in the presence of two witnesses.

SAMUEL N. KNIGHT.

Witnesses:

K. LOCKWOOD-NEVINS,

H. SANDERSON.