No. 719,283. PATENTED JAN. 27, 1903.

R. WEBER.

SPEED GOVERNOR.

APPLICATION FILED JULY 13, 1901.

NO MODEL. 3 SHEETS—SHEET 1.

FIG. 1.

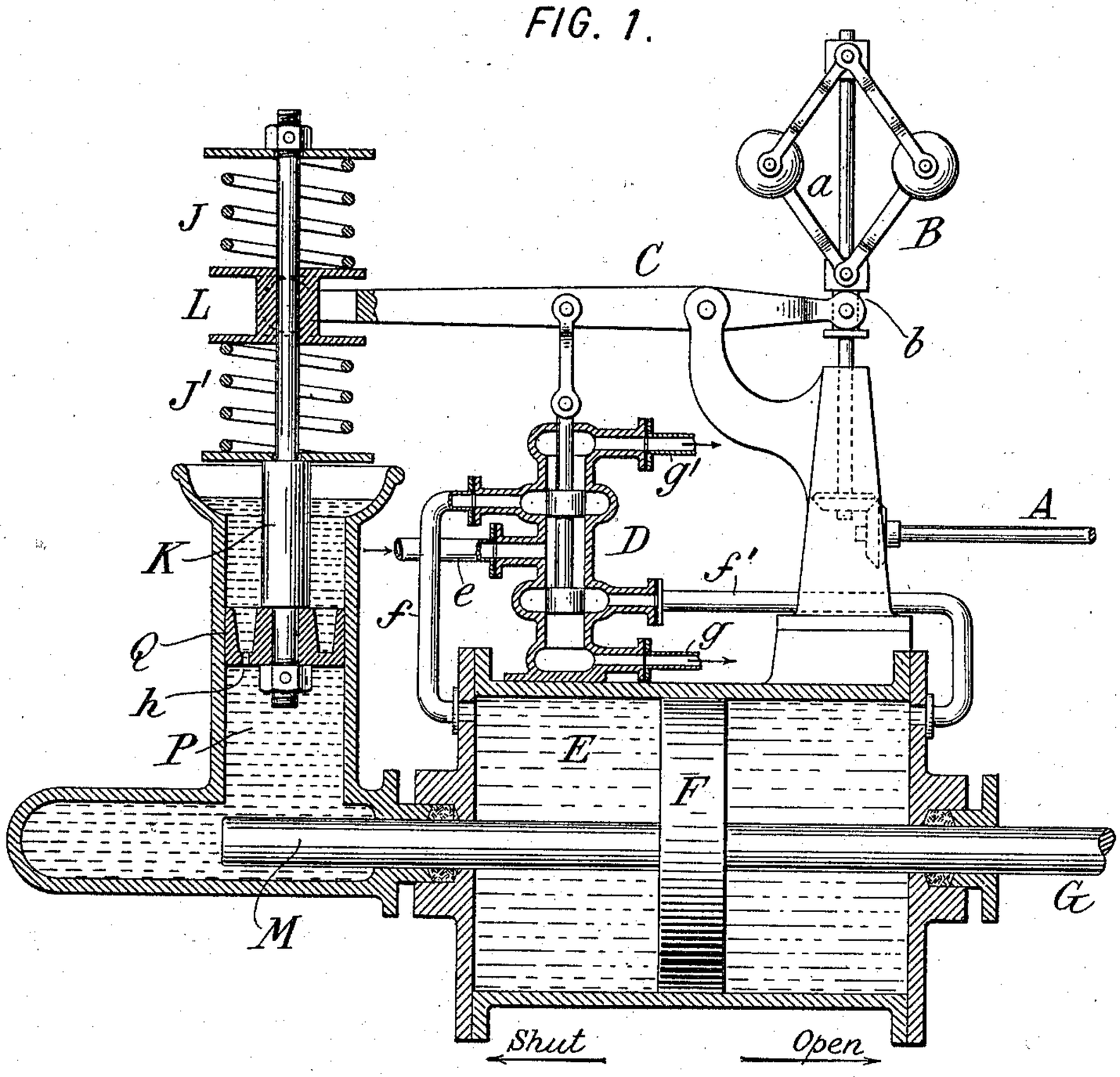


FIG. 2.

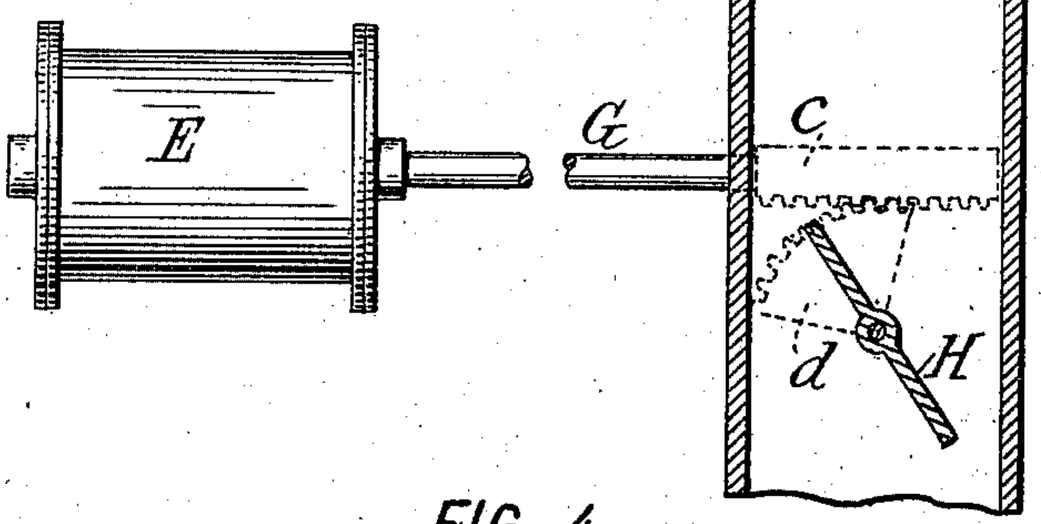


FIG. 3.

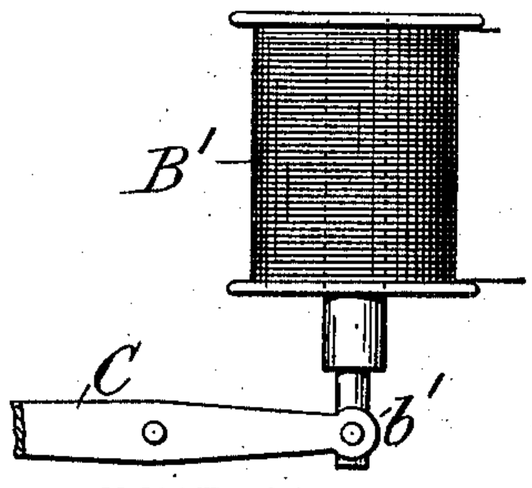
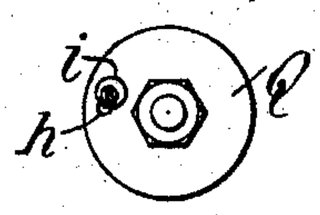


FIG. 4.



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NO MODEL. 3 SHEETS—SHEET 2.

FIG. 5.

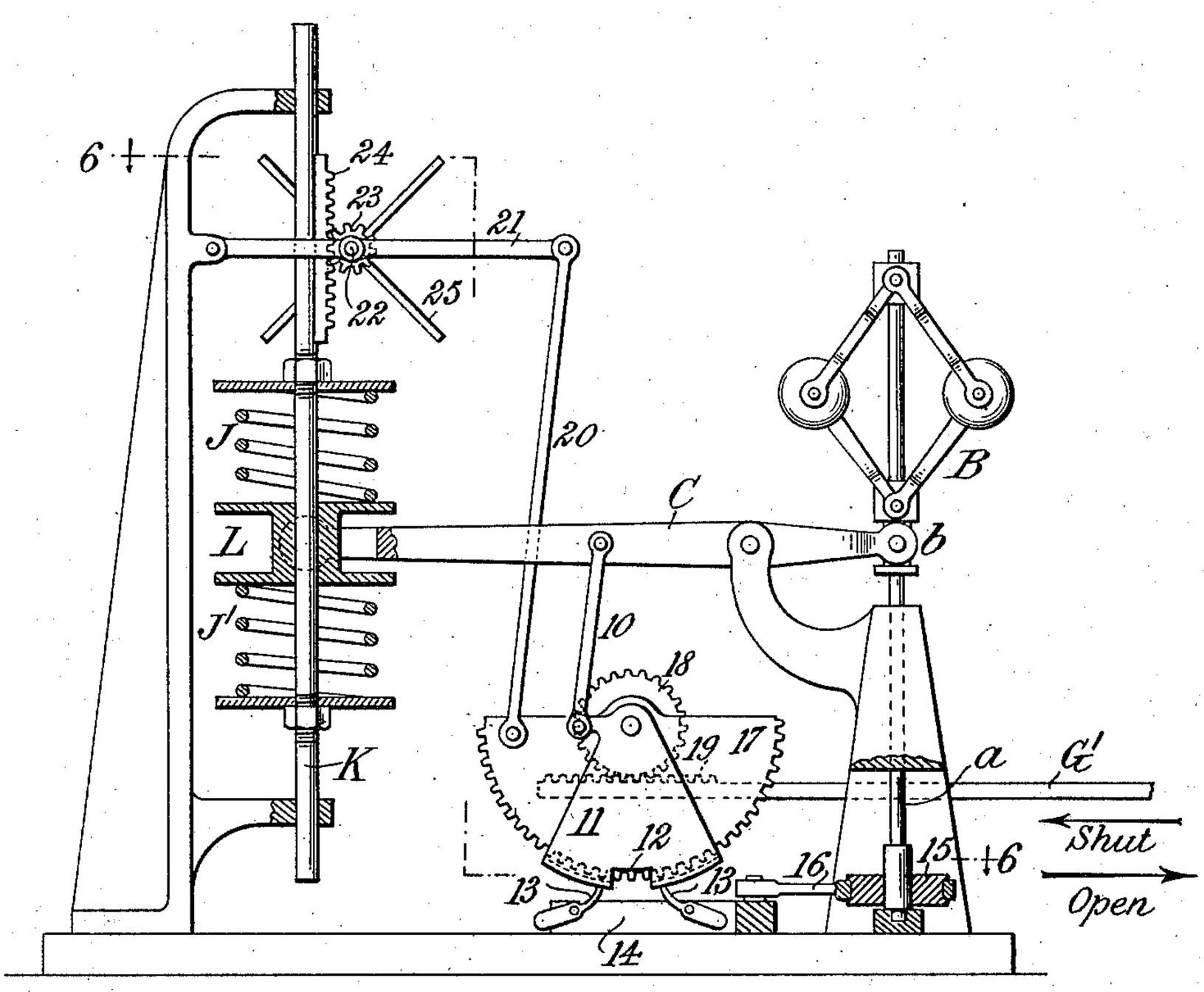
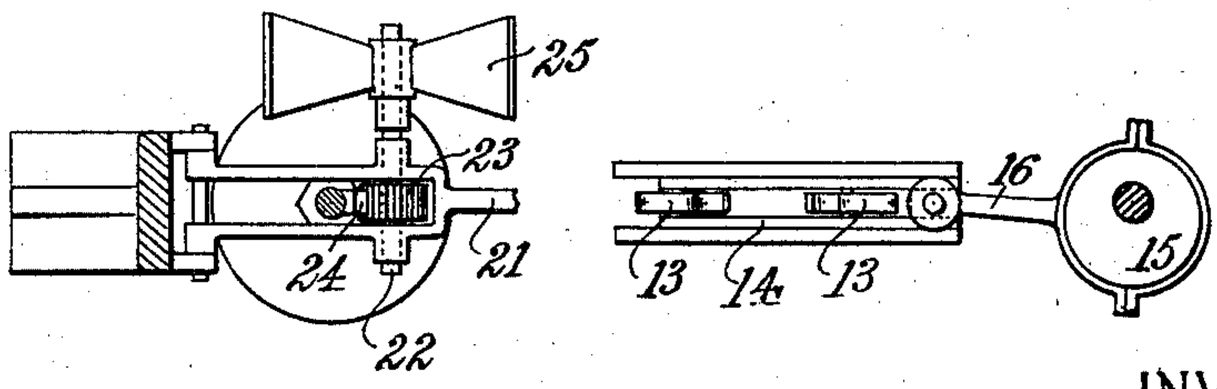


FIG. 6.



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NO MODEL. 3 SHEETS—SHEET 3.

FIG. 7.

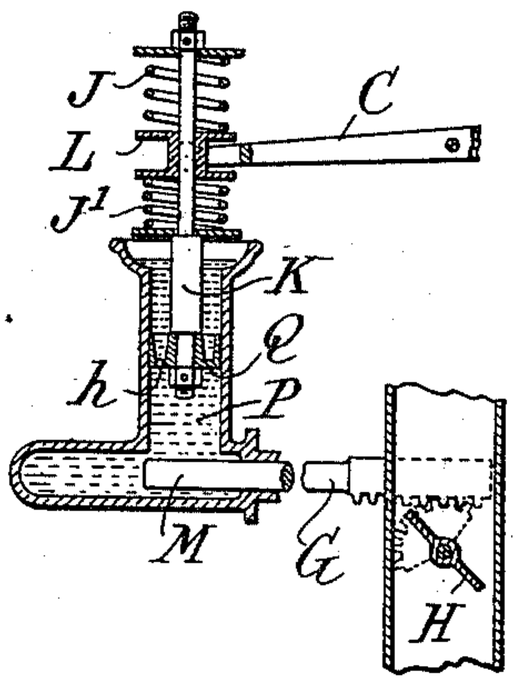


FIG. 8.

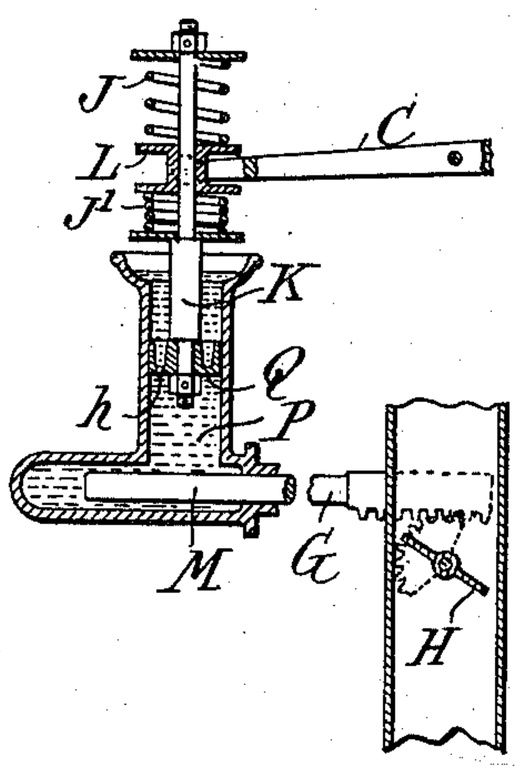


FIG. 9.

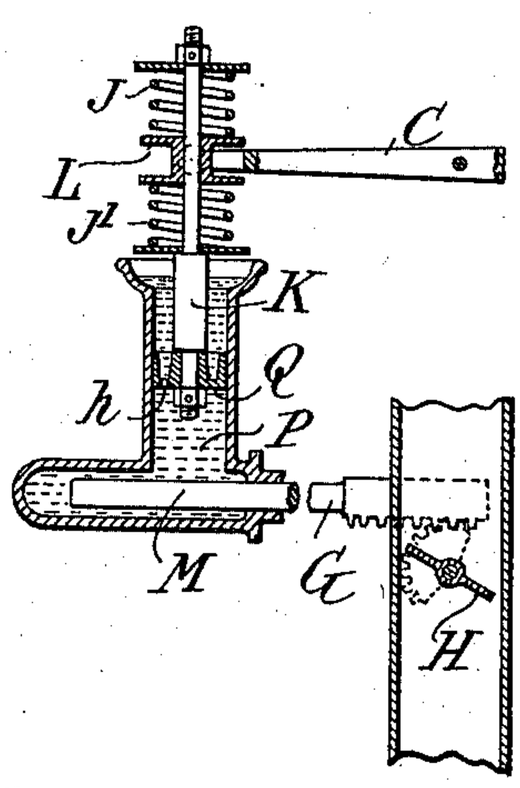


FIG. 10.

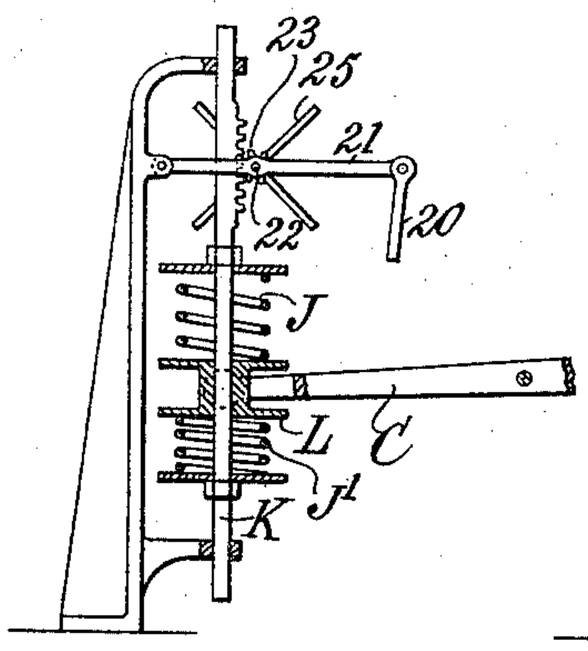


FIG. 11.

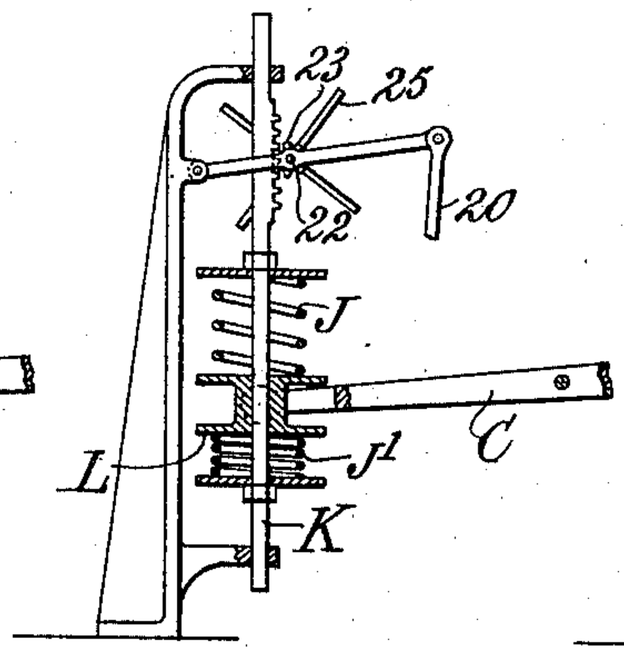
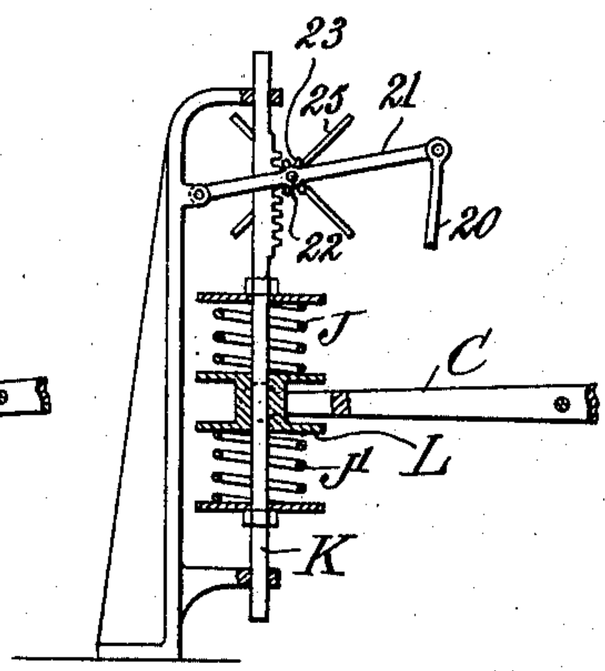


FIG. 12.



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UNITED STATES PATENT OFFICE.

RUDOLF WEBER, OF ZURICH, SWITZERLAND, ASSIGNOR TO ESCHER WYSS & CIE., OF ZURICH, SWITZERLAND, A CORPORATION.

SPEED-GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 719,283, dated January 27, 1903.

Application filed July 13, 1901. Serial No. 68,190. (No model.)

To all whom it may concern:

Be it known that I, RUDOLF WEBER, a citizen of the Republic of Switzerland, residing at Zurich, Switzerland, have invented certain new and useful Improvements in Speed-Governors, of which the following is a specification.

This invention relates to governors for controlling the speed of machinery and ordinarily of prime movers, such as water-wheels, steam-engines, or other motors. It pertains most particularly to governors which operate indirectly to control the admission of power or pressure to the prime mover or to what are known as "relay-governors." In such governors the action of the governing device (of which the ordinary centrifugal balls or weights constitute an example) communicates movement not to the main control device, (as a gate-valve or throttle,) but to an intermediate mechanism—such, for example, as a valve controlling a hydraulic cylinder and piston—and the movements of this intermediate device are communicated to the main control device, whereby the admission of power or pressure is determined. The peculiar and harmful accompaniment of relay-governors is the action known as "racing." An increase of speed of the motor causes the balls to fly outward, and this movement in turn actuates the relay-controller, whereby the relay device is set in motion to close the main power-controller, (gate or throttle valve.) During the time required for this operation the accelerated speed continues, and by the time that the main power-controller has been so shifted as would cut down the speed to the proper amount the momentum of the moving parts maintains the abnormal speed to an extent sufficient to prevent stopping the motion of the relay at the precise instant that it should be stopped in order to accomplish the required speed regulation and nothing more. The result is an excessive movement or overcompensation whereby the main controller is carried too far and the valve or other device is closed too much, so as to cut down the supply of power to less than is required to maintain the normal speed. It follows from this that the speed falls off and an opposite action of the governor then takes place, although to less extent, bringing about a second overcompensation. This in turn is followed by an acceleration of speed, and this through the action of the governor by a retardation, so that there ensues a series of speed fluctuations continually diminishing in amount until finally the mechanism is restored to its proper or normal speed; but this is accomplished only after a series of continually-diminishing accelerations and retardations of speed instead of the normal speed being restored promptly and by a single movement.

It is the object of my invention to avoid the overcompensations, and hence the racing and fluctuation, that are peculiar to relay-governors, and to cause the governor to act promptly to compensate for any fluctuation in speed, but without overcompensating therefor, in order to bring the power-controlling device or valve by a single movement to the appropriate position for adapting the prime mover to any change of condition (either of power or load) which affects its speed. To attain this end, I provide means by which the movement which is begun by the action of the governor generates a pressure or force which acts in opposition to that of the governor, and consequently tends to oppose the original force acting upon the governor, and in order to prevent this opposing pressure, acting in conjunction with the variation in the supply of power, from moving the governor an abnormal distance, and so producing overcompensation in the opposite direction, I provide means for permitting the dissipation of said opposing pressure before the governor shall have got back to its original position. Therefore when the engine is running steadily the only external forces acting on the governor are the power-supply and the load, and the relation of power to load may be so regulated that after each change of load the governor changes the power-supply to such an extent as to return the governor to its previous position. The means for permitting dissipation of the pressure opposing the first movement of the governor is operative as soon as the governor takes its new position under a change of load; but the dissipation preferably takes place gradually during the returning movement of the gov-

ernor, so that when the latter shall have got back to its original position there is no pressure acting to carry it beyond. In the specific form of apparatus which I have devised for carrying this invention into practice I employ, preferably, a means for varying the stress of the springs which resist any movement of the governor from its position corresponding to the normal speed, this means being operated through the movement of the relay device by which the main power-controller is operated. I prefer to communicate this movement through a column of fluid and to permit a gradual dissipation of the opposing force of the springs by means of a minute leakage, whereby after any displacement the parts may gradually assume their normal position of equilibrium.

My invention is applicable to various types of governors—either the ordinary centrifugal governor in any of its many forms or in lieu thereof any device which is sensitive to fluctuations in speed or in special cases to fluctuations in load. Thus electromagnetic or dynamometric governors may be applied in connection with my present invention. Also any form of relay device may be applied. Various relay devices are now known, some operating on the step-by-step principle—as, for example, by the application of pawls to propel the ratchet-wheel or rack in one direction or the other, such wheel or rack being connected to the power-controller or speed-gate; but the best form of such relay device is that wherein a valve is operated by the governor which controls the flow of liquid to and from a hydraulic cylinder in which moves the piston or plunger connected to the power-controller.

In Figure 1 of the accompanying drawings is shown in vertical mid-section a suitable and the preferred form in which I have embodied my invention, the view being a vertical mid-section of a centrifugal hydraulic relay-governor adapted for controlling the speed-gate of a turbine water-wheel. Fig. 2 is a sectional elevation, on a smaller scale, showing the connection of the apparatus to operate a hydraulic gate. Fig. 3 shows an electromagnetic governor to replace the centrifugal governor. Fig. 4 is an under side plan of the piston. Fig. 5 is a sectional elevation of a modified construction. Fig. 6 is a horizontal section of parts thereof. Figs. 7, 8, and 9 and Figs. 10, 11, and 12 are diagrams illustrating the operation of the devices of Figs. 1 and 5, respectively.

Referring to Fig. 1, let A designate a shaft the speed of which is to be maintained uniform and from which is driven the governor B, which is here shown as an ordinary centrifugal governor mounted on a shaft *a*, which is geared to and driven from the shaft A, and the outward or inward movements of the balls or weights being communicated in usual manner to a collar *b*, which is caused to move longitudinally on the shaft *a* and the movement of which is communicated, through a lever C of any suitable kind and arrangement, (or by any other communicating mechanism,) to the relay device. The relay device is here shown as of the type of a hydraulic cylinder and its controlling-valve, D being the valve as a whole, E the cylinder, and F the piston, the latter being connected, through a rod G, to the power-controller. The connection may be made, for example, in the manner shown on a smaller scale in Fig. 2, where H is the gate controlling the flow of water to a turbine-wheel, being connected through a toothed rack *c* and sector *d* to the piston-rod G; but any other intermediate operating means may be substituted and any other type of gate or other control valve or other means of controlling the power-supply may be substituted for the gate H. The relay-valve D is shown as a balanced hydraulic piston-valve, receiving water under pressure through a port or passage *e*, admitting it to one end or the other of a cylinder through passages *f f'*, and discharging the waste or exhaust water through passages *g g'*; but any other type or kind of valve may be used instead, it being of course preferable to use some form of balanced valve. The governor is caused in any suitable or usual way to act against resistant forces or pressures tending to bring it to the position corresponding to the normal or prescribed speed of rotation. The means commonly employed for this purpose are oppositely-acting springs, one of which is put under stress as the balls fly out under an excessive speed, while the other is put under stress as the balls move in under a reduced speed. These opposite springs are shown at J J', and instead of acting directly upon the governor-balls are shown as arranged to act upon them through the lever C. One of these springs may be additional to or take the place of the spring usually employed in centrifugal governors for drawing the balls in in opposition to centrifugal force. The springs are shown as arranged to react against projections on a movable part K and to exert their stress against a separate movable part L, which is shown as a collar, which may be freely slid along the part K, which is shown as a shaft or rod. The movable collar L is shown as engaged by the forked end of the lever C. The movable part K constitutes a means through which the springs J J' may be forced up or down in order to increase or diminish their respective stresses against the governor. The part K is accordingly connected to the relay itself in any suitable manner, so that the movement of the relay or, in other words, the movement by which the power-controlling gate or valve is opened or closed shall cause a corresponding movement of the part K and shall correspondingly increase the stress of one of the springs J or J' and relax the stress of the other. A convenient and suitable means for this purpose is that shown, wherein the piston F carries a plunger M, (which may be a continuation of

the rod G,) which plunger enters, through a suitable stuffing-box, a closed chamber P, containing any suitable liquid, preferably oil, and which is formed, preferably, as a cylinder, in which cylinder moves a piston Q, which piston is connected in any suitable manner with the movable part K. Through the piston Q is formed a small leak-hole *h* of an area which may be calculated for any prescribed case or may be readily ascertained by experiment. If desired, means may be provided for varying the area of this leak-orifice—as, for example, by partly covering it by an eccentric plate *i*, as shown in Fig. 4, which plate can be turned to cover more or less of the orifice and then set in position by a screw. With this arrangement it is apparent that any movement of the piston F causes the plunger M to move into or out of the chamber P, and thereby through the liquid in this chamber to force the piston Q up or down, thereby compressing one of the springs J J′ and relaxing the other, whereupon the compressed spring will act upon the piston Q to force it back to the normal position at a rate which is modified and controlled by the rate at which the liquid can flow through the leak-orifice *h*, so that the piston Q is slowly restored to such position that the force of the spring which was compressed is dissipated. As in all governors, it will be understood that the driving-shaft A is connected to the prime mover or to shafting therefrom or machinery driven thereby, so that it has imparted to it the speed of the apparatus which it is desired to govern. In the case of a turbine, for example, the shaft A is driven by suitable gearing from the power-shaft of the turbine-wheel, and the gate H controls the flow of water to the turbine.

The operation is as follows, referring especially to Figs. 1, 7, 8, and 9: So long as the apparatus runs at a uniform speed the governor is not affected and the parts remain unmoved; but assume, for example, an increase in speed which causes the governor-balls to fly outward. This movement of the governor is communicated through the lever C to the sliding collar L, which is forced downward, so as to compress the spring J′ and relax the stress of the spring J. The position of the parts immediately after the movement of the governor is shown in Fig. 7. The rod K has not yet moved appreciably, nor have the plunger M and gate H. The only variation from the position of Fig. 1 is in the angle of the lever C and the downward movement of collar L and consequent compression of the spring J′. The same movement of the governor has acted through the valve D to admit water to the right-hand end of the cylinder E, at the same time permitting it to escape from the left-hand end of said cylinder, and the water-pressure effects a movement of the plunger M, and with it the gate H, moving these parts to the position of Fig. 8 and forcing upward the piston Q, so as to further compress the spring J′. Thus the spring J′, which acts upon the governor to oppose the effect of centrifugal force, has its opposing pressure augmented by the movement of the plunger M. In any event the closing of the gate H would by shutting off the power tend to reduce the speed and cause the governor-balls to fall in; but this result of moving the governor-balls inward is accelerated by the compression of the spring J′, so that the governor is forced back to its normal position sooner than would be the case but for this provision. From the first moment that the governor took up its new position, Fig. 7, and an opposing pressure was generated in the spring J′ this spring has exerted a downward thrust upon the piston Q, and after the increased compression caused by the inward movement of the plunger M, Fig. 8, the force of the spring J′ is continuously dissipated by a gradual downward movement of the piston Q (the liquid passing up through the leak-hole *h*) and by a slow upward movement of the collar L. While this dissipation of the opposing pressure is occurring the effect of the closing of the gate H is being transmitted to the balls, so as to reduce their speed. During this returning movement of the governor to its original position there is a still further slight closing movement of the gate H and inward movement of the plunger M, which movement, however, is stopped as soon as the balls reach substantially their original position and close the valve D. The pressure of the spring J′ having been dissipated in the meantime by the upward movement of the collar L and the downward movement of the piston Q, there is no tendency of the governor to depart from its original normal position. The engine therefore runs with the governor in the same position which it occupied with its original load, Fig. 1, only the positions of the gate H and the plunger M having been changed in the meantime to the positions shown in Fig. 9.

With an ideal governor the closing movement of the gate induced by an acceleration of speed should be just sufficient to neutralize this acceleration and restore the apparatus to the normal speed. Commonly in relay-governors there has been an overcompensation, the gate or control-valve having been carried too far, with the result that the speed is reduced below the normal, which action produces a counter operation, so that several successively-diminishing fluctuations of speed occur before the apparatus is finally restored to its normal speed. In other types there has been an opposing force set in operation to resist too great movement of the governor; but on the return of the governor this force acts to carry it beyond its original position, thus moving the supply-gate in the opposite direction back toward its original position, and so back and forth by successive diminishing fluctuations to a position of rest, and this position of rest assumed after a change of load is not the same as the original

position of rest, since the new force opposing the governor continues to act—that is to say, besides the load and the power the governor is influenced by a third external force, the opposing force referred to, and this third force is variable for changes of speed. My invention, however, by providing for a prescribed increase in the force which acts in opposition to the governor and tends to restore it to its normal position so far hastens the closing of the relay-valve and the stoppage of the movement of the relay as to stop the closing movement of the gate at the proper instant to effect the required compensation for the variation in speed and, furthermore, by then dissipating this opposing force avoids such a continuation of the opposing force as would cause an opposite fluctuation in speed. This result is attained by a suitable proportioning of the parts—namely, the stress of the springs J J′, the size of the plunger M, the diameter of the piston Q, and the area of the leak-orifice *h*—which should be so proportioned or adjusted as to make the dissipation of the opposing force approximately coincide with the movement of the gate to the position necessary to restore the normal speed.

In case of a diminution of speed below the normal the operation is precisely the inverse of that above described. After any operation the piston Q assumes after a sufficient interval its original position, only the plunger M being in a new position corresponding to the new position of the piston F and the power-controlling valve or gate which serves as a starting-point for the next succeeding operation.

My governor need not necessarily be controlled directly by the speed, but may be controlled through other agencies—as, for example, in the driving of dynamos, where varying speed is required in order to maintain a given potential under varying loads, the centrifugal governor B may be substituted by an electromagnetic governor. This modification is shown in Fig. 3, where B′ is an electromagnetic governing device, shown as a solenoid, the core of which engages at *b*′ with the lever C in the same manner that this lever is engaged by the centrifugal governor, the effect being the same, except that instead of resulting in a uniform speed it results in such varying speed as generates a uniform electromotive force or, according to requirements, a uniform current. Any known form of dynamometric governor may be substituted.

My invention is not confined to any particular type of relay device, a hydraulic cylinder and piston being shown only as a suitable example to be substituted by any other form of such device, according to requirements or individual preference.

My invention is susceptible of other modifications and is not confined to the specific details shown. The employment of a hydraulic intercommunication between the relay device or gate motion and the movable part K, against which the springs react, is not necessary to my invention, although a convenient and probably the best means for embodying the same. Such hydraulic intercommunication greatly facilitates the restoration of the normal stress or equilibrium of the springs after each operation, this being very easily accomplished by reason of the leak-orifice *h*, whereas with any purely mechanical intermediation a relatively much more complicated provision would be required to permit the dissipation of the power of the compressed spring by the gradual return of the part against which the springs react to its original position after each operation.

An example of a mechanical means for applying my invention is illustrated in Figs. 5 and 6. In Fig. 5 the same type of governor is shown as in Fig. 1, with the same lever C, springs J J′, intervening collar L, and movable part K, against which the springs react. The means for opening the gate is of well-known type, wherein the motion is obtained by a ratchet-and-pawl device. The lever C operates through a link 10 a sector 11, having a notch 12, the rim of the sector serving normally to hold out of action two pawls 13 13, carried on a reciprocating slide 14, which is shown as reciprocated by an eccentric 15 on the governor-shaft *a* through the medium of a connecting-rod 16. When the sector 11 is in the normal position shown corresponding to the normal speed, its rim keeps the pawls from engaging the teeth of a wheel or toothed sector 17; but upon the notch 12 being moved to either side by a rise or fall of speed one or the other of the pawls is permitted to engage the teeth of the wheel 17 and turn it forward or backward, whereby movement is communicated through a pinion 18 fixed to it to a rack 19 on the gate-rod G′, which corresponds to the rod G in Figs. 1 and 2. Motion is communicated from the gate-operating mechanism to the spring-carrier or moving part K through a connecting-rod 20 and lever or other connecting part 21, which carries a spindle 22, on which is fixed a pinion 23, which meshes with a rack 24 on the moving part K. The shaft 22 is provided with some sort of retarding device—preferably a fan 25—which may be of the character used in the speed-governors of music-boxes or the like. By reason of this fan or retarding device the movements communicated through the rod 20 and lever 21 are at first transmitted bodily to the sliding part K, after which the unbalanced stress of the springs J J′ is dissipated by rotating the fan until the part K moves back to a position of equilibrium. Thus the rack and pinion, with the fan or retarding device, serves the purpose that in the hydraulic construction is served by the leak-orifice *h*. The hydraulic apparatus first described, however, is much to be preferred. Figs. 10, 11, and 12 show positions of this apparatus corresponding with the positions of

the hydraulic apparatus shown in Figs. 7, 8, and 9. Starting from the position of Fig. 5 the first effect of a reduction of load is to throw downward the collar L and compress the spring J'. As the effect of the new position of the governor is transmitted to the gate there is a simultaneous upward movement of the rod 20, which carries with it the rod K and further compresses the spring J', as shown in Fig. 11. After this the reduced power applied to the engine tends to return the collar L, and the spring J' pushes upward on this collar and downward on the rod K, so as to restore these parts to their original position. The fan-brake 25 permits a gradual downward movement of the rod K, although the rod 20 and the arm 21 move a short distance farther upward to the position of Fig. 12, where they remain for the new conditions of load and power.

What I claim is—

1. The combination with a governor having a determined normal position, of means set in operation by its movement therefrom in either direction and adapted to generate a pressure acting against the governor and tending to return it toward its normal position, and means for permitting the dissipation of said pressure as the governor returns to its normal position so as to prevent overcompensation.

2. The combination with a governor having a determined normal position, of a relay device controlled thereby, a power-controller operated by the relay device, a means actuated by said relay device and adapted to generate a pressure acting against the governor and tending to return it toward its normal position, and means for permitting the dissipation of said pressure as the governor returns to its normal position so as to prevent overcompensation.

3. The combination with a governor having a determined normal position, of yielding means continually opposing the movement of the governor from said normal position, and means set in operation by its movement therefrom adapted to generate a pressure acting against the governor and tending to return it toward its normal position and hasten the termination of the compensating effect, to prevent overcompensation in the direction in which it has moved, and means for permitting the dissipation of said opposing force as the governor returns to its normal position so as to prevent overcompensation in the opposite direction.

4. The combination with a governor, of a relay device controlled thereby, a power-controller operated by the relay device, opposite springs adapted to oppose a pressure against any movement of the governor from its normal position, a movable part against which said springs react connected to the relay device whereby the operation of the latter displaces said movable part and adds to the stress of the spring already put under stress by the movement of the governor, whereby to hasten the termination of the compensating effect and prevent overcompensation, and means for permitting the dissipation of said opposing pressure.

5. The combination with a governor, of a hydraulic relay device controlled thereby, a power-controller operated by the relay device, a plunger operated by the relay device, a hydraulic cylinder in which said plunger moves, a piston in said cylinder, opposite springs adapted to oppose a pressure against any movement of the governor from its normal position, the moving part against which said springs react connected to said piston, whereby the operation of the relay device causes a movement of said piston and adds to the stress of the spring already put under stress by the movement of the governor, and a contracted passage for permitting a restricted flow of liquid from one side to the other of said piston, whereby to permit the dissipation of said opposing pressure.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

RUDOLF WEBER.

Witnesses:

ARTHUR C. FRASER,

FRED WHITE.