(No Model.)

2 Sheets—Sheet 1.

A. LAWRENCE.

SPEED GOVERNOR.

No. 335,228. Patented Feb. 2 ,1886.

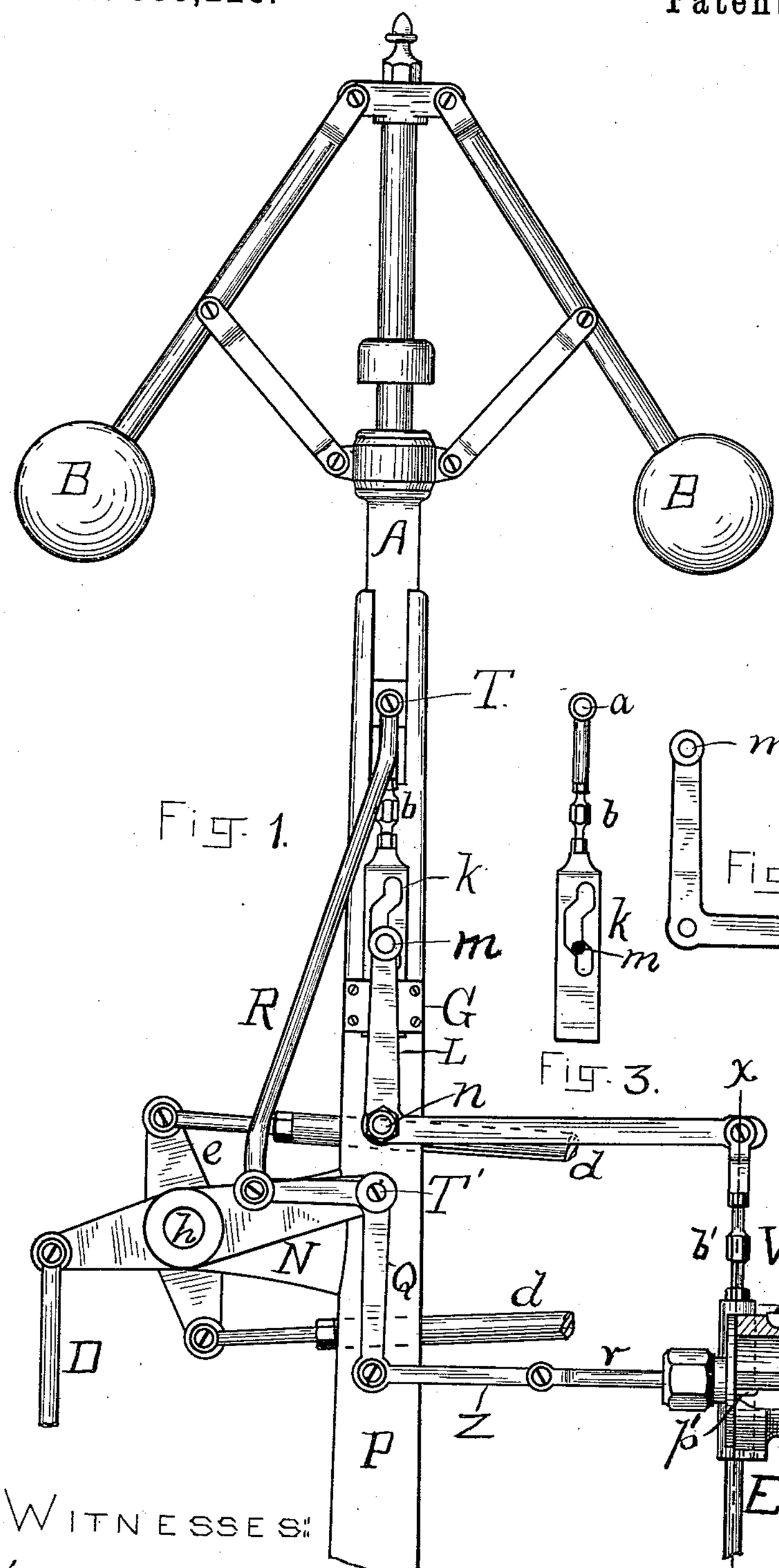

Fig. 1.

Fig. 3.

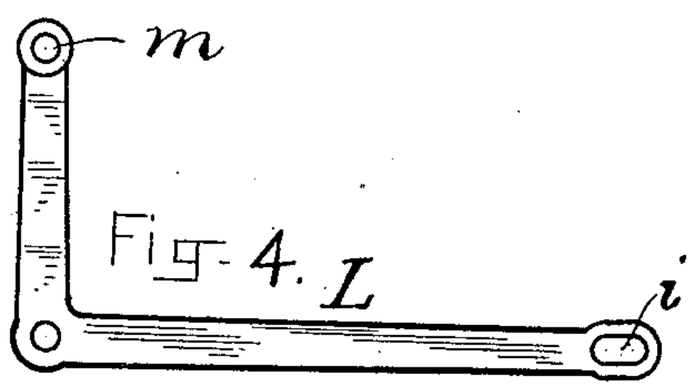

Fig. 4.

WITNESSES:

Wm. H. Anderson

Grant Patmer

INVENTOR:

Alvin Lawrence

(No Model.)

2 Sheets—Sheet 2

A. LAWRENCE.

SPEED GOVERNOR.

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Patented Feb. 2 ,1886.

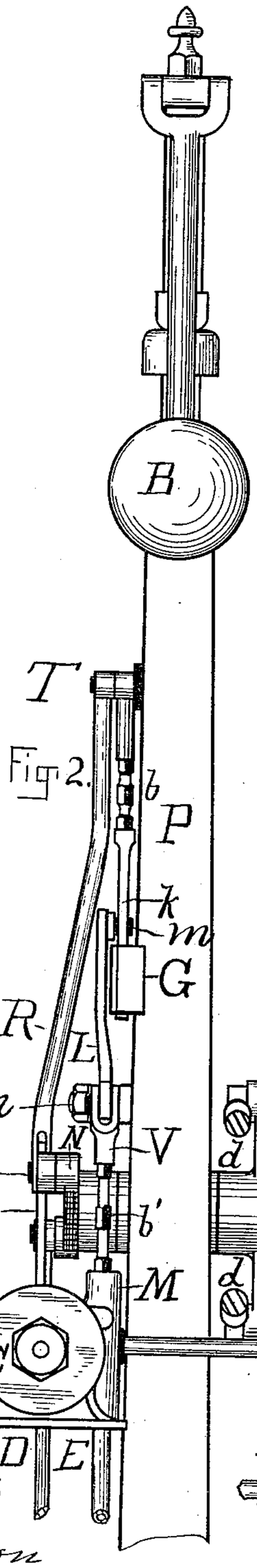

Fig 2.

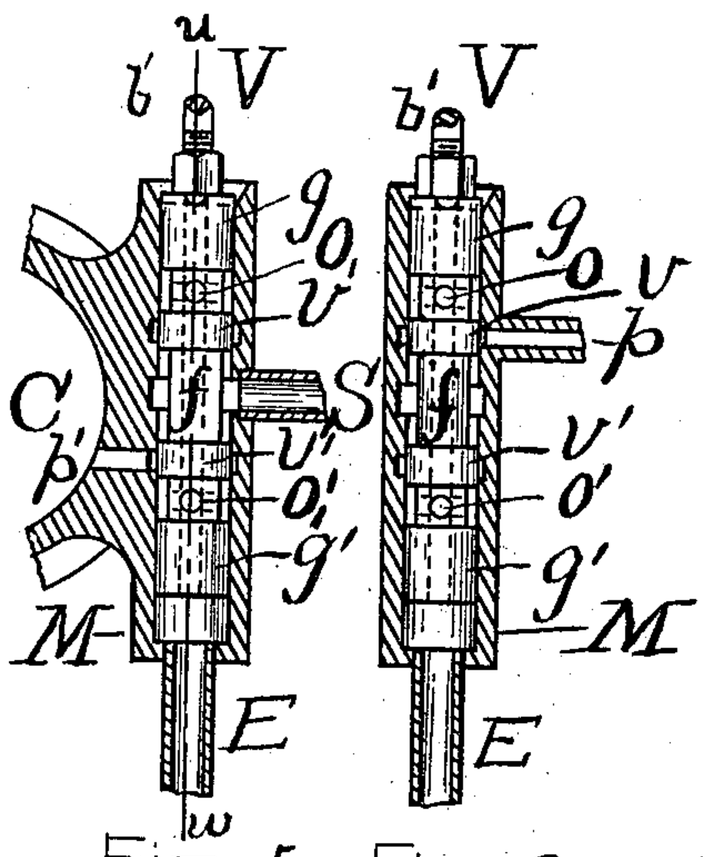

Fig. 5.

Fig. 6.

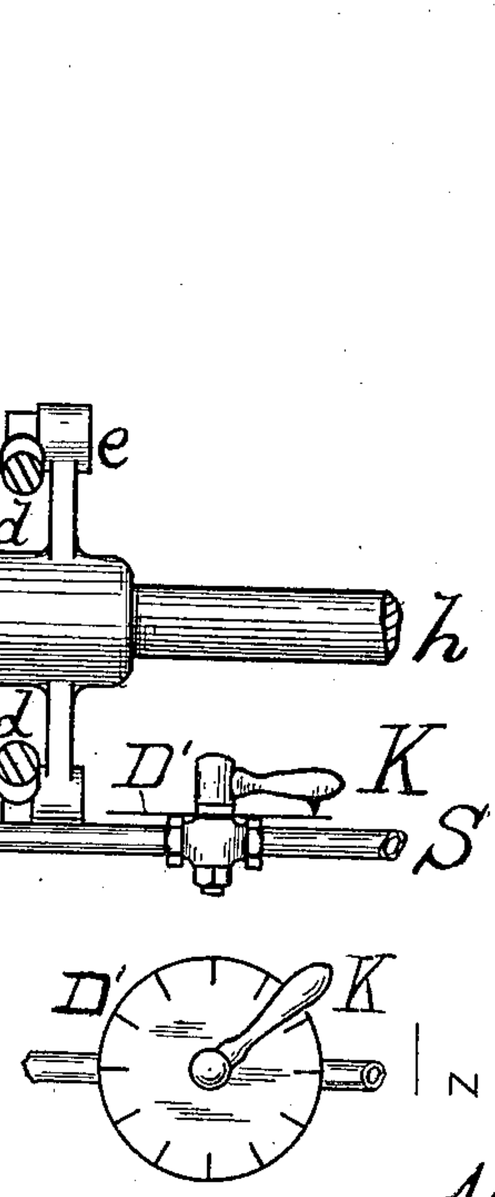

Fig. 7.

WITNESSES:

Wm. H. Anderson

Grant M. Belmet

INVENTOR:

Alvin Lawrence

UNITED STATES PATENT OFFICE.

ALVIN LAWRENCE, OF LOWELL, MASSACHUSETTS, ASSIGNOR OF ONE-HALF TO CHANNING WHITAKER AND CHARLES H. FISHER, OF SAME PLACE.

SPEED-GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 335,228, dated February 2, 1886.

Application filed September 9, 1885. Serial No. 176,680½. (No model.)

To all whom it may concern:

Be it known that I, ALVIN LAWRENCE, a citizen of the United States, residing at Lowell, in the county of Middlesex and State of Massachusetts, have invented a new and useful Improvement in Speed-Governors for use upon Steam-Engines and other Motors, of which the following is a specification.

My invention is intended to more perfectly effect the regulation of the speed of the motor to which it is applied than is now commonly the practice, as well as to provide a more convenient method of varying the mean speed of the motor than has hitherto been available. It is also intended to prevent injury to the engine or its surroundings in case the belt or other mechanism which drives the governor should fail of operation by breakage or otherwise, which it does by stopping the motor until the trouble is rectified. I attain these objects by the use of mechanism illustrated in the accompanying drawings of a governor adapted for use in connection with a steam-engine furnished with an automatic cut-off device, and in which—

Figure 1 is a side elevation of portions of the improveed speed-governor, including all the new and useful improvements, and is the view to which reference is always made in this specification when the right or left hand end of the cylinder C is mentioned. Fig. 2 is an elevation of the same as seen from the cylinder end of the engine. Fig. 3 is a side elevation of a cam which I sometimes use in the mechanism. Fig. 4 is a side elevation of a bell-crank lever sometimes used in the mechanism, and is drawn to show the slot *i* in its end. Fig. 5 is a section at the line *x y* in Fig. 1. Fig. 6 is a section at the line *u w* in Fig. 5. Fig. 7 is a plan of the cock K drawn in Fig. 2, showing an attached graduated disk.

Similar letters of reference refer to similar parts throughout the several views.

A B B represent an ordinary centrifugal regulator of approved construction, the driving portions of the same being omitted, because such portions are now well known. This regulator is of such construction that certain of its movable parts will be found at a certain definite position when the regulator is rotating at a suitable speed, while they will be in some other equally well-defined position when running at any other speed within the limits of speed where the regulator is designed to be used. Other forms of centrifugal regulators than that shown in the drawings satisfy equally well the requirements of my invention. This one is chosen for illustration simply because it is an excellent form of such regulators. With this form of regulator a pin, T, serves as the point of application to the centrifugal regulator of other portions of the mechanism, and this pin rises above the position corresponding to the proper speed of rotation of the regulator when that speed is increased, and it falls below that position when that speed is diminished. The amount of this rising or falling depends upon the amount of the change of speed. Similar action takes place in some portion of the mechanism of all other centrifugal regulators.

Working upon the pin T is a piece furnished with an eye, *a*, as is shown detached in Fig. 3, connected by a stud, *b*, to the cam-plate *k*. This cam-plate *k* is guided by a guide, G, so that it can in the case illustrated move only in a vertical direction.

For convenience of adjustment, the stud *b*, which is interposed between the eye *a* and the cam-plate *k*, is furnished with a right-handed screw at one end and a left-handed screw at the other, both screws being furnished with check-nuts. By the use of this stud *b* the said cam-plate may at any time be easily adjusted with reference to the pin T.

Within the cam in the cam-plate *k* there works a pin, *m*, which is rigidly fastened in one end of the bell-crank lever L. The lever L rocks upon the pin *n*, and is furnished at one end with the slot *i*. Through the slot *i* there passes a pin, which is in the end of the valve-rod V, and which causes the latter to rise or fall with the slotted end of the lever L when the pin *m* is moved by the cam in the cam-plate *k*.

The slot *i* in the lever L is used as a simple equivalent of a link for the purpose of connecting the valve-rod V with the lever L. This lever L is not an essential part of my invention, since I sometimes dispense with it and al-

low a pin in the valve-rod V to work directly in the cam in the plate *k*. In this case the valve-casing M would be horizontal, instead of vertical, as in the drawings. The cam-plate *k* may also be sometimes advantageously omitted, and the valve-rod V be directly connected to the pin T, or connected to the pin T through the intervention of a suitable lever.

The valve-rod V is furnished with a stud, *b'*, which is, like the stud *b*, furnished with a right-handed screw at one end and a left-handed screw at the other, each being furnished with a check-nut. By means of this stud *b'* the position of the valve *g f g'* may at any time be readily adjusted with reference to the lever L.

Upon the end of the valve-rod V is the valve *g f g'*, which is shown in detail as a piston-valve, and in its middle position in Figs. 5 and 6. This valve consists of a cylinder having an internal passage, *f*, which communicates with the interior of the valve-casing M at *o*, *o'*, *o*, and *o'*. It also has the exterior projections, *v* and *v'*, which control the motion of a fluid through the passages *p* and *p'*. The projections *g* and *g'* upon the valve serve to aid in guiding the valve within its casing M, and in guiding the fluid through the passages *p* and *p'*. These projections are sometimes grooved circumferentially in a way well known to makers of this class of pistons, in order to diminish the escape of fluid by leakage between the projections *g* and *g'* and the casing M. This exact construction of the valve is not essential to the successful use of my invention, since some other forms will answer the purpose.

The supply-pipe S, is filled with a fluid under pressure, and is furnished with a cock, K, which may be used as a throttle-valve, by means of which the pressure in the pipe S between the cock K and the cylinder C may be reduced to any desired amount when motion of the fluid is taking place. D' is a graduated disk attached to the body of the cock K, and serves as a guide for the proper adjustment of the handle of the same. The fluid in the supply-pipe S may be either liquid or gaseous; but I usually prefer to use water in the liquid state. When the valve *g f g'* is raised by the rod V, the fluid in the pipe S is allowed to flow through the passage *p* to the right-hand end of the cylinder C, while at the same time any fluid which might be in the left-hand end of the cylinder is allowed to flow out through the passage *p'*, the holes *o' o'*, the central passage, *f*, of the valve and the exhaust-pipe E. The piston F will then of course move to the left with a speed and force dependent upon the condition of the fluid in the supply-pipe S between the cylinder C and the cock K. Should the valve *g f g'* be depressed in its chest M, the flow of fluid would be through the passage *p'* to the left-hand end of the cylinder C, the fluid in the right-hand end passing out through the passage *p*, the holes *o o*, the central passage, *f*, and the exhaust-pipe E. In this case it is evident that the piston F will be driven toward the right-hand end of the cylinder C with a speed and force dependent upon the condition of the fluid in the supply-pipe S, as in the first case.

The cylinder C is shown as being horizontal and cast in one piece with the valve-chest M; but this method of construction is not essential, since the same may be arranged in any equivalent and convenient manner. For instance, the valve-chest M may be cast by itself and connected to the cylinder C, placed at a considerable distance from it, by means of pipes. The cylinder C is usually secured in a firm manner to some portion of the frame-work of the motor with which the regulator is to be used.

The piston F is furnished with the rod *r*, which in the example illustrated in the drawings is constrained to move in a straight line by passing through stuffing-boxes on each head of the cylinder C. This may, however, be effected by other well-known means, such as a cross-head or other guide outside the cylinder C.

The connecting-rod *z* serves to transfer the motion of the piston-rod *r* to one end of the equalizing-lever Q. A slot in the end of the lever Q, within which might work a pin in the end of the piston-rod *r*, is a simple equivalent to this rod *z*, which I sometimes use. This lever Q is shown as a bell-crank lever, and has some advantages when made in that form; but it may be made straight or of any other suitable shape if the cylinder C is only placed in the proper position. To one end of this lever Q is attached the rod R, which connects it with the centrifugal regulator at the pin T. This rod R may sometimes be advantageously omitted, and the equalizing-lever Q directly connected with the centrifugal regulator by means of the pin T, working in a slot in the lever Q, or other equivalent method. The lever Q is also connected with that mechanism, which serves at all times to determine how much energy shall be expended upon the motor by the driving agent, in order that the proper speed of the motor may be maintained. This mechanism, which may be called the "power-regulator" of the motor, is the throttle-valve of a throttling-engine, the cut-off mechanism of an automatic cut-off engine, or the supply-gate of a water-wheel. With other motors equivalent devices are in use.

In the governor shown in the accompanying drawings the power-regulator is the cut-off mechanism of an automatic cut-off engine of the well-known Corliss type. In this case the power is regulated by the angular position of the shaft *h*, to which are fixed the levers *e* and N. The lever *e* carries the rods *d d*, which control the tripping-cams that cause the steam to be cut off at the proper position in the stroke of the engine. The lever N is connected by the rod D with a dash-pot regulator, which serves to modify any tendency to a too sudden change of the point of cut-off. The other end of the lever N is with the ordinary governor directly connected with the centrifugal regu-

lator A B B by means of a rod having an eye at one end working upon the pin T′, and another at the other end working upon the pin T. The action of the ordinary governor is for the balls B B to separate and rise with an increase of speed of the engine, thus raising the pin T, and with it the directly-connected pin T′. By this means the shaft *h* is rotated slightly, carrying with it the lever *e*, and shortening the cut-off of the engine. When the speed of the engine diminishes, the reverse action takes place, and the steam follows the piston in the cylinder an increased distance before being cut off.

With my improved governor the rod R, instead of being attached at its lower end directly to the pin T′, is attached to the equalizing-lever Q. In consequence of this method of construction the lever N or the power-regulator in any different case is capable, when the dimensions of the parts are properly chosen, of being under the direct control of the centrifugal regulator A B B by means of the rod R, just as if the same were connected to the pin T′ in the manner which has hitherto been common. This is what would actually happen when a liquid is used in the cylinder C if the cock K should be fully shut off at any time, since the piston F would then be locked in position by the liquid on each side of it in the cylinder C; but the action is different when the cock K is open and the supply-pipe full of liquid under pressure. In this case the piston F is locked in the cylinder by the liquid when the valve *g f g′* is in the central position, as shown in Figs. 5 and 6.

When the motor to which this governor is attached is running at its proper speed, the studs *b* and *b′* must be so adjusted that the pin *m* is in the position in the cam in the cam-plate *k* shown in Fig. 3. When the pin *m* is in this position in the cam, a very slight increase of speed of the centrifugal regulator and consequent raising of the pin T and the cam-plate *k* will cause the valve *g f g′* to move downward. The piston F will then be driven to the right, and the pin T′ will be raised exactly as it would have been raised by a much greater increase of speed of the centrifugal regulator had the rod R been directly connected to it in the usual manner. If the speed of the centrifugal regulator should diminish slightly from its proper amount, the reverse action would occur. The valve *g f g′* would be thrown upward, the piston F would be driven to the left, and the pin T′ would be depressed exactly as it would have been depressed by a much greater diminution of speed in the case where the rod R is directly connected to the pin T′. It will thus be seen that the entire regulation of the cut-off of the engine can be controlled within the extreme limits of its variation by a very slight change of speed of the engine, and it is entirely practicable to adjust the mechanism so that this change is hardly to be detected by ordinary means. In this case the action of the governor will be to keep the speed of the engine practically unchanged, no matter what changes of load may occur. This is what cannot possibly happen when the rod R is directly connected to the pin T′ in the usual manner, since in that case the engine must run at a different speed for every different load.

The action of my invention upon the power-regulator described above is entirely similar to its action upon the power-regulator of other motors, the power-regulator in those cases being attached to the equalizing-lever Q in a way similar to that above described. It will be observed that the lever Q rocks upon the pin T′, which passes through it at a point intermediate between the points of connection between *z* and Q and R and Q. This is not an invariable way of attaching the lever Q to the pin T′, since, if the other parts are suitably adapted to it in a way similar to that above described, the pin may, without detriment to the successful use of my invention, pass through the lever at some point in it not intermediate between these points.

The adjustable cock K serves to regulate the time occupied by the changes of the position of the piston F, thus putting it in the power of the attendant to adjust his governor in the most advantageous way to meet the changes of load to which the motor is usually to be subjected.

The cam in the cam-plate *k* is shown as being so made that when the regulator A B B drops much below its normal position for any reason—such as the slowing down of the motor or the failure of the mechanism which drives the centrifugal regulator—the cam will move the valve *g f g′* so as to drive the piston F to the right. Thus the power-regulator will be placed in such a position as to stop the motor, and also to prevent it from being again started until the piston F is replaced near the middle of the cylinder C. This portion of the cam thus forms a safety attachment to the governor, and is so styled in my claims, and it prevents the motor to which it is connected from ever running too fast in consequence of the failure of the centrifugal regulator to turn at the proper speed on account of breakage or for other reason. This construction of the cam in the cam-plate *k* is not always necessary, since, if the safety element in the governor is not required, a straight inclined slot in the cam-plate will be all sufficient for the proper control of the valve *g f g′*.

The action of the governor in placing the power-regulator in such a position that the motor cannot be again started whenever the motor is purposely stopped may be prevented by closing the cock K before stopping the motor. By this means the piston F will be retained by the fluid in the cylinder C in the position which it at that moment occupies, and the rod R will place the power-regulator in such a position that the motor can be again started without trouble.

The graduated disk D′ on the cock K, in

connection with the pointer shown on the handle of the cock, gives the operator of the motor a means of accurately setting the cock and of quickly resetting it when it has for any reason been displaced.

The necessity of displacing the handle of the cock K may be obviated by placing in the supply-pipe S a second cock, which may be closed at the pleasure of the operator without disturbing the adjustment of the cock K.

From the above description of this governor it will be seen that when the speed of the motor, and consequently the speed of the centrifugal regulator is exactly right, the valve *g f g'* will be in its middle position. The power-regulator will have been previously placed by the piston F in the proper position to maintain that speed with the existing load upon the motor, and very slight changes of load will be provided for by the direct action of the centrifugal regulator upon the power-regulator through the rod R. This latter action is caused by the projections *v v'* being made of such size that they will slightly lap by the edges of the ports in the casing M when they are in their middle position, and consequently the valve *g f g'* does not cause any change in the position of the piston F for minute changes of speed of the centrifugal regulator.

To adjust the improved governor so that it will cause the motor to which it is attached to run at a different speed from the one at which it is found to be running, it is only necessary to properly adjust either one or both of the studs *b b'* so that the valve *g f g'* will be in its middle position and the pin *m* in the proper working position in the cam, as shown in Fig. 3, when the pin T is in the position due to the desired speed of the centrifugal regulator.

Such being a description of the construction and methods of working of my improved speed-governor, what I claim as new, and desire to secure by Letters Patent, is—

1. A centrifugal regulator, in combination with a cylinder having a piston that is driven by fluid-pressure, a valve that controls the motion of the said piston, and a cam that is connected with the said centrifugal regulator and which fixes the position of the said valve, substantially as described, and for the purposes specified.

2. A centrifugal regulator, in combination with a cylinder having a piston that is driven by fluid-pressure, a valve that controls the motion of the said piston, and a cam that is slotted as shown, and which is connected with the said centrifugal regulator and which fixes the position of the said valve, substantially as described, and for the purposes set forth.

3. A centrifugal regulator, in combination with a cylinder having a piston that is driven by fluid-pressure, a valve that controls the motion of the said piston, a cam that fixes the position of the said valve and that is connected with the said centrifugal regulator, a power-regulator of a motor, and an equalizing-lever that is connected with the said piston, the said centrifugal regulator, and the said power-regulator, substantially as described, and for the purposes specified.

4. A centrifugal regulator, in combination with a cylinder having a piston that is driven by fluid-pressure, a valve that controls the motion of the said piston, a cam that is slotted as shown, and that fixes the position of the said valve and which is connected with the said centrifugal regulator, a power-regulator of a motor, and an equalizing-lever that is connected with the said centrifugal regulator, the said piston, and the said power-regulator, substantially as described, and for the purposes set forth.

5. A centrifugal regulator, in combination with a cam that is connected thereto, a cylinder having a piston that is driven by fluid-pressure, a valve that controls the motion of the said piston and whose position is fixed by the said cam, and a motor power-regulator which is connected with the said piston, substantially as described, and for the purposes set forth.

6. A cylinder having a piston that is driven in both directions by fluid-pressure, a valve that controls the motion of the said piston, a centrifugal regulator that is connected with the said valve and which actuates the same, a power-regulator of a motor, and an equalizing-lever that is connected with the said piston, the said power-regulator, and the said centrifugal regulator, substantially as described, and for the purposes specified.

7. A cylinder having a piston that is driven by fluid-pressure, in combination with a valve that controls the motion of the said piston, a centrifugal regulator, a cam that is connected with the said centrifugal regulator and that fixes the position of the said valve, an adjustable means of regulating the supply of fluid that drives the said piston, a power-regulator of a motor, and an equalizing-lever that is connected to the said power-regulator, the said piston, and the said centrifugal regulator, substantially as described, and for the purposes specified.

ALVIN LAWRENCE.

Witnesses:
WM. H. ANDERSON,
GRANT M. PALMER.