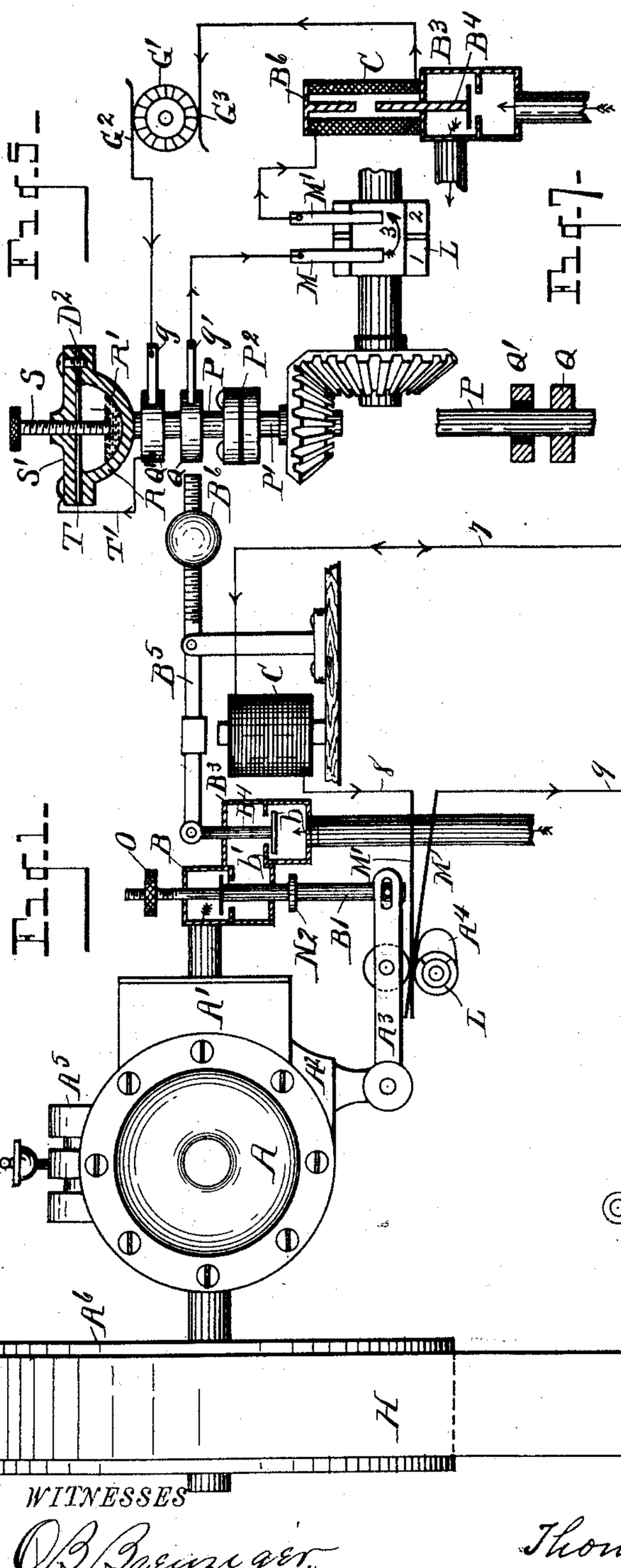
No. 632,716. Patented Sept. 12, 1899.

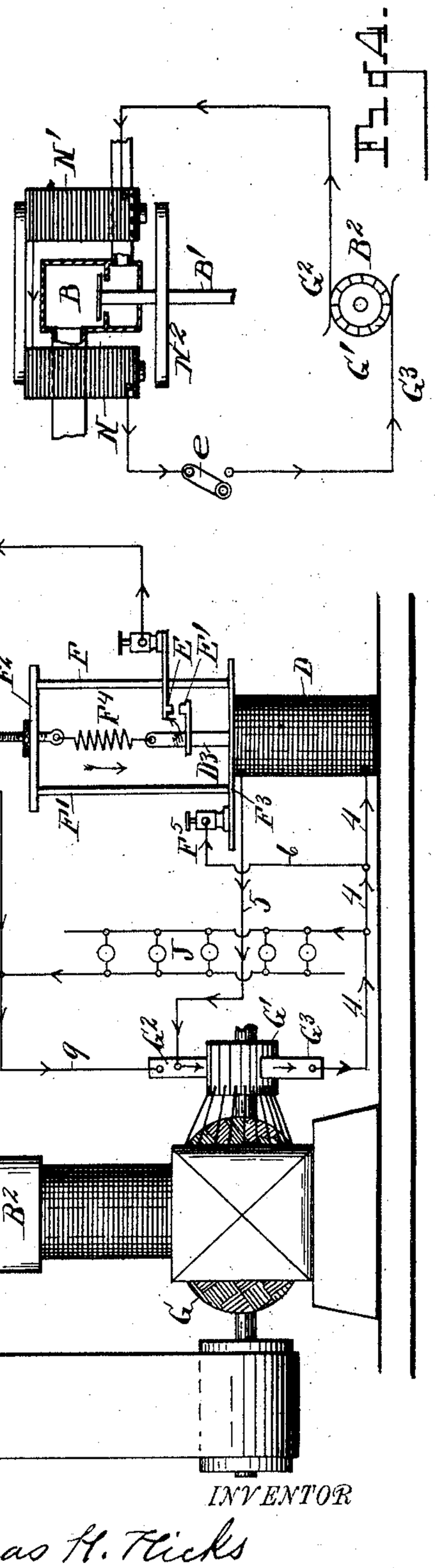
# T. H. HICKS.

## CONTROLLING AND REGULATING MECHANISM FOR ENGINES.

(Application filed Oct. 21, 1895. Renewed Apr. 3, 1899.)

(No Model.) 2 Sheets—Sheet 1.







WITNESSES

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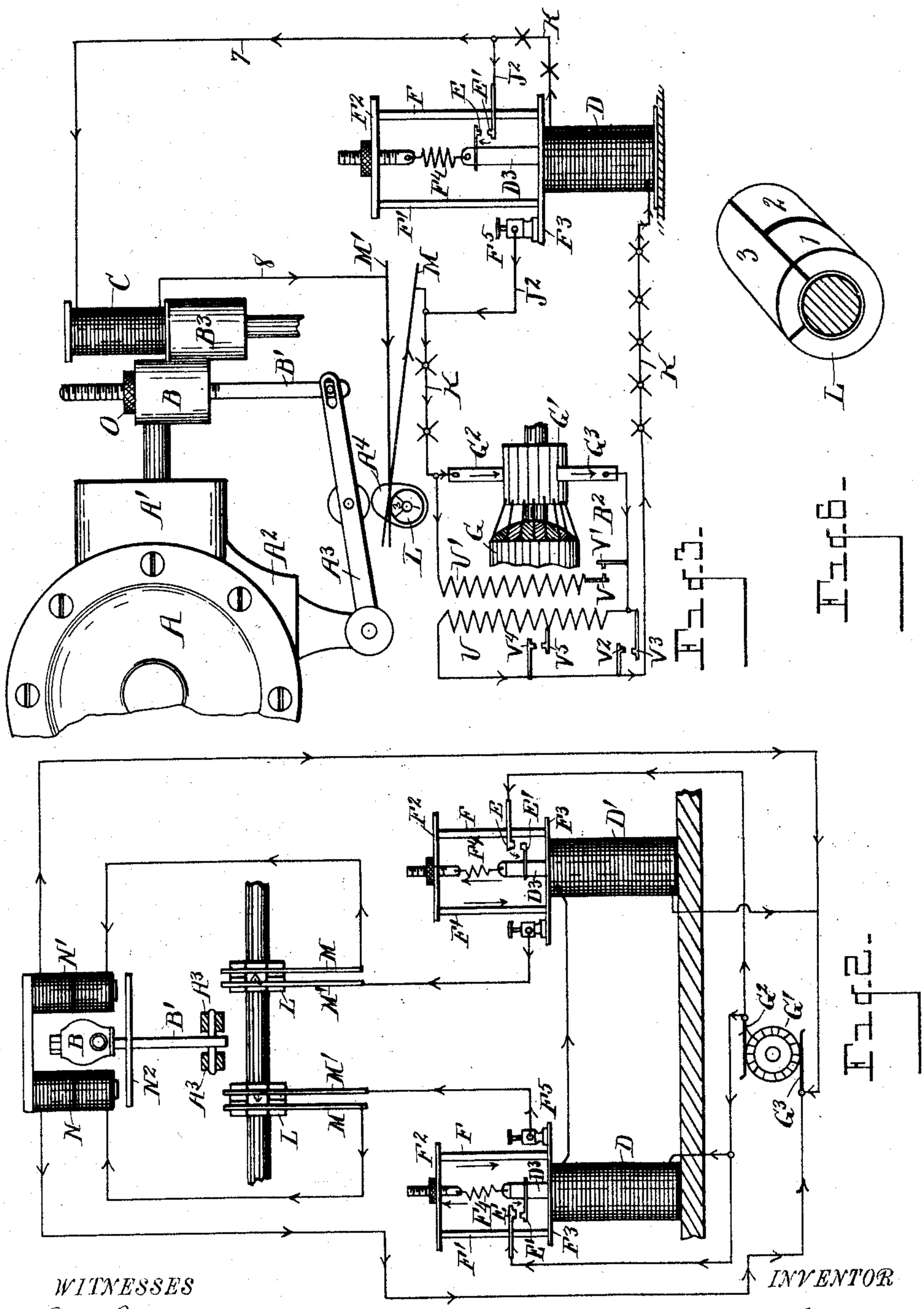

FIG. 1.



FIG. 6.



FIG. 2.

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## CONTROLLING AND REGULATING MECHANISM FOR ENGINES.

SPECIFICATION forming part of Letters Patent No. 632,716, dated September 12, 1899.

Application filed October 21, 1895. Renewed April 3, 1899. Serial No. 711,610. (No model.)

*To all whom it may concern:*

Be it known that I, THOMAS H. HICKS, a subject of the Queen of Great Britain, residing at Fort Wayne, county of Allen, State of Indiana, have invented a certain new and useful Improvement in Controlling and Regulating Mechanism for Engines; and I declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, which form a part of this specification.

This invention relates to new and useful improvements in controlling and regulating parts of engines, and more particularly of gas-engines for driving electric generators. By the term "gas-engine" I include all engines which are operated by explosive mixtures for producing power.

My invention is especially intended to produce a gas-engine which will be automatic in its regulation and at the same time be suitable for driving either constant-potential or constant-current electric generators.

My invention admits of and includes certain modifications to suit both constant-potential and constant-current systems of electrical generation and electrical and electrocentrifugal governors, and that, too, without departing from the spirit of the invention. In the drawings I illustrate the application of my invention to both constant-current and constant-potential systems, and I also illustrate both electrical and electrocentrifugal governors. In one application of my invention the engine will maintain constant speed up to its maximum power, and in another application the speed of the engine will vary with the load on the electric generator. This latter application is especially suitable for arc-lamp systems of electric lighting; but it will also prove to be equally useful in application to constant-potential systems where the field-magnets of the generators are only shunt-wound—*i. e.*, not compound wound. The constructive parts embodied in my invention may also be changed to suit engines having either one, two, or any number of explosions of gas to each cycle of the engine-piston, and also to suit engines having either one, two, or any number of separate cylinders and their pistons. My scheme may also be applied to steam-engines, and the various parts may also be changed in form to suit various conditions, which will be readily understood by any person skilled in this art.

To these ends my invention consists of the construction, combination, arrangement, and application of the various parts which are illustrated in the accompanying drawings, and hereinafter described and claimed.

The drawings are largely diagrammatic, various part not embodied in my invention and unnecessary to the full understanding thereof being omitted—such, for example, as brush-holders, journal-bearings, &c.; but they will be readily understood by persons skilled in these lines of art.

In the accompanying drawings, Figure 1 is a view in diagram showing in combination an engine, electrical generator, and my controlling and operating devices as applied to a constant-potential system, the case of the valves B and $B^3$ being shown in section. Fig. 2 is also a diagam view showing a modification of some parts of Fig. 1, together with other parts. Fig. 3 is a diagram view showing parts of Fig. 1 and the application of my scheme to a constant-current system. Parts of the engine and electrical generator are shown to be cut away in this figure. Fig. 4 is a view, partly in diagram, showing a modification of a part of my invention which may be applied to engines operating either system of lighting. Fig. 5 is a diagram view showing parts in section. This figure shows also a modification in which I use an electrocentrifugal governor as a means of regulation instead of solenoids, as shown in Fig. 1, 2, and 3. Fig. 6 is a perspective view of a short-circuiting commutator, which is shown also in a different view in Figs. 1, 2, 3, and 5. Fig. 7 is a detail view in section, showing the rings Q Q′ in section upon the shaft P.

The parts in detail are indicated as follows:

A indicates one cylinder-head of a gas-engine.

A′ is the explosion-chamber for the engine.

$A^2$ is a support, preferably cast with the cyl-

inder, for supporting a hinged arm $A^3$, which is actuated in its movements by a rotatable cam $A^4$.

$A^5$ indicates the top of the crank-shaft of the engine.

$A^6$ is the engine's drive-wheel.

B is a starting-valve which is operated through the plunger B'. This valve B is only intended to be in use until the electric generator $B^2$ becomes generative of sufficient electric pressure, after which the valve is thrown out of commission, which I further explain hereinafter. $B^3$ is a similar kind of valve to B; but instead of being operated by electromagnetic means which may be varied in the form of construction, as I show in Figs. 1 and 5, the valve $B^3$ is provided with a plunger $B^4$, carrying a valve-disk *b* for opening and closing a valve-seat *b'*.

$B^5$ is a lever fulcrumed intermediate its ends, having a counter-pulling weight $B^6$ attached to one of its ends.

C is an electromagnet for operating the valve $B^3$.

D and D', Fig. 2, are solenoid-governors for actuating the movements of the valve B through its electromagnets N N'. $D^2$, Fig. 5, is an electrocentrifugal governor for performing the same function as the solenoids D and D'. The solenoid-governors D and D' are constructed alike in Figs. 1, 2, and 3; but they operate differently. In Figs. 1 and 2 the plunger $D^3$ of the solenoid throws the electromagnet C into action when the plungers ascend far enough to make contact between the contact-points E and E', which closes the circuit through the electromagnet C; but in Fig. 3 the plunger performs the same function when it descends far enough to make contact between the points E E'. Thus the movements of the plungers in the two cases are in reverse directions to perform the same function.

F, F', $F^2$, and $F^3$ are four metallic pieces forming a frame-support for the plunger $D^3$ of the solenoid.

$F^4$ is a spring for supporting the solenoid-plunger.

$F^5$ is a binding-post in metallic contact with the frame of the solenoid.

G is an armature of the dynamo $B^2$. G' is its commutator.

$G^2$ and $G^3$ are brushes.

H is a driving-belt.

J, Fig. 1, is a constant-potential work-circuit, and K, Fig. 3, is a constant-current work-circuit.

L is a "closing-circuit" commutator for causing the electromagnet C to become operative in opening the valve $B^3$ when the piston of the engine is in a favorable position for receiving an explosion of gas. The valve $B^3$, therefore, is a timing-valve and operated conjointly by the commutator L and solenoid D, or solenoids D and D', if two explosions are to occur instead of one. The commutator L, as shown in Fig. 6, consists of three segments 1, 2, and 3. There are two brushes M and M', forming sliding contacts on the commutator L; but current only flows from one brush to the other when the two brushes are on the segment marked 3. The valve $B^3$ is only open to admit gas to the engine while the brushes M and M' are on the segment 3.

N and N' in Fig. 2 are two sets of electromagnets for operating the valve B electromagnetically. When these magnets N and N' are used, then the valve $B^3$ will not be necessary. The engine will operate the valve B by the cam $A^4$ until the dynamo picks up. Then by suitable means the cam can be released from acting upon the plunger of the valve B and the latter thereafter be operated by the solenoids D and D', Fig. 2, the solenoid D controlling gas for one end of the cylinder and the solenoid D' controlling gas for the other end of the cylinder or for two separate cylinders.

$N^2$ is a bar of iron attached to the plunger B' of the valve B for lifting the plunger through the influence of the magnets N N'; but instead of using these electromagnets N and N' for said purpose they may be used for the purpose of holding the valve B open after the dynamo picks up. I show this arrangement in Fig. 4, where the magnets are connected in a closed circuit with the generator $B^2$. In such a case these electromagnets N N' would simply take the place of the nut O upon the plunger B', Figs. 1 and 3, which is for the same purpose of holding the valve B open after the valve $B^3$ begins to work, by screwing the nut O down so as to lift the plunger B' and arm $A^3$ up above the action of the cam $A^4$, as I show in Fig. 3. When the plunger is thus held up, the valve B is out of commission; but instead of arranging the magnets N N' in a closed circuit with the dynamo for the purpose of lifting the valve B automatically as soon as the valve $B^3$ begins to become operative the circuit may be closed manually by the switch *e*.

In Figs. 1, 3, and 4 I show the valve B for use in starting the engine only. Thereafter the valve $B^3$ becomes the timing and only operating valve to control the supply of gas for the engine.

In Fig. 5 I show what I designate an "electrocentrifugal" governor $D^2$. Any suitable kind of a centrifugal governor can take the place of the one I show. So long as the circuit through the electromagnet C is opened and closed by the centrifugal action, to take the place of the solenoid D, then the spirit of this part of my invention is manifest. This governor $D^2$ consists of a rotatable shaft divided into two portions P P', the two parts being insulated from each other, as I show at $P^2$. Upon the shaft P are two rings Q Q', Q being in metallic contact with the shaft P; but Q' is insulated therefrom, as shown in Fig. 7.

R is a mercury-cup, and R' indicates mercury.

S is an adjustable screw passing through the cover S′, which latter is insulated from the lower part of the cup R.

T is the insulation for separating the two named parts of the cup.

The cover of the cup S′ is connected to the ring Q′ by the conductor T′. During rotation of the governor the mercury recedes from the center of the cup when the speed is sufficient, and thereby breaks the circuit between the lower end of the screw S and the mercury, and when the speed slows down sufficiently the circuit is again closed in a manner which will be readily understood. A governor of this kind has no other work to perform than to simply make and break contact through the mercury, and it is therefore very sensitive as compared with a centrifugal governor which would be required to operate the valve $B^3$ directly.

In Fig. 5 I show a different kind of electromagnet C for operating the valve $B^3$ to that shown in Fig. 1, in Fig. 5 it being a combination of a solenoid and an electromagnet, the plunger $B^4$ being divided into two portions, $B^6$ being a fixed portion thereof and the coil being shown in section.

In Figs. 1, 4, and 5 I show the case of the valves B and $B^3$ in section, so as to expose the interior of the valves. The casings of two valves B and $B^3$ can either be formed of one casting, as I show in Figs. 1 and 3, or they can be made of separate parts suitably connected together.

In Fig. 3, U and U′ indicate two field-magnet windings for the armature G, the coil U′ being a differential winding for demagnetizing the field-magnets when necessity demands it. The differential coil U′ may be cut out of circuit by suitable contacts V and V′, and the coil U may be short-circuited, either in all or in part, as I indicate by the contacts $V^2$ $V^3$ and $V^4$ $V^5$.

Having thus referred to the various parts shown in all of the figures, I will now explain the manner in which my scheme may be operated to suit both constant-potential and constant-current systems.

In an application for United States Letters Patent filed by me September 13, 1895, Serial No. 562,370, I disclosed a scheme for throwing a valve similar in function to my present valve B out of commission to prevent gas-explosions in the engine. In that case I operated the valve by throwing the plunger of the valve in or out of connection with the arm operated by the cam; but in this my present case I throw both the plunger B′ and the arm $A^3$ out of action together when I wish to throw the valve B out of commission for the purpose of having the valve $B^3$ control the supply of gas thereafter. It may thus be seen that the two cases differ widely from each other, for in that case the valve B was used continuously to operate the engine; but in this case it is only used to start the engine, unless I resort to the scheme which I disclose in Fig. 2, which, however, is also different from the scheme disclosed in the application referred to, inasmuch as in that case the valve B was operated by the engine, while in this case the valve is to be operated by electromagnetic means. In that case, also, I show two sets of magnetic devices, one being for sensitiveness and the other for power, as I do in my present case; but in that case the solenoid, which was marked G in the drawings, closed the circuit through the second magnet when the potential of the electric current became sufficiently increased, while in this my present case the reverse occurs, the plunger of the solenoid closing the circuit of the magnet as it ascends by the potential of the current becoming weaker, and the valve K′ in that case (B in this case) was only out of commission when the circuit was closed by the governing solenoid. Therefore if anything went wrong, so as to throw the dynamo out of use, the engine would then receive the maximum number of explosive charges, which would cause the engine to begin at once to race, and damage to the engine would also be likely to result. Of course the former scheme could be supplemented with extra devices to cut off the gas in case the current gave out; but that means trouble and expense. Now from what has been said the constant-potential system which I show in Fig. 1 will be readily understood from the following description:

To start the engine, if the valve B has been held open by the nut O, as shown in Fig. 3, then the nut O must be turned toward the end of the plunger, so as to bring the arm $A^3$ in a favorable position for being acted upon by the rotating cam $A^4$, as I show in Fig. 1; but if the valve B be thrown out of use by electromagnets, which I show in Fig. 4, then the engine will always be ready to start without requiring to first arrange the valve B. We will suppose that the engine is supplied with a proper ignition device. Then when a charge of gas and air has been forced into the ignition-chamber by turning the drive-wheel $A^6$, which will open the valve at the proper moment for admitting gas to the engine, an explosion will occur, which will start the engine running by its own power, and explosions will then continue to occur at every proper cycle of the engine-piston until the dynamo $B^2$ gives out sufficient pressure to operate the solenoid D, after which the solenoid will throw the electromagnet C into use, so as to open the valve $B^3$ automatically by the current and also allow it to become closed by the counter-pulling weight $B^6$ when the speed of the engine has increased sufficiently. The valve B is then to be thrown out of use either by the magnets N N′, or by the nut O, or in any other equivalent manner. When starting the engine, the valve $B^3$ must be held open until the magnet C becomes operative, after which the counterweight $B^6$ and said magnet will open and close

the valve; but the time when the valve $B^3$ must be opened to admit a charge of gas to the engine is governed by the act of the closing-circuit commutator L, which of course operates in conjunction with the solenoid D, the solenoid-plunger $D^3$ closing the circuit of the electromagnet C by the contact-points E E′ when the voltage of the generator $B^2$ has fallen sufficiently to allow the plunger to rise far enough to bring the contact-points together. Of course the contact-points are always together when the current is off from the solenoid D, so as to be ready for operation when the current is turned on. By properly constructing the solenoid D it will open and close the circuit of the electromagnet C whenever the current rises in pressure one-fourth of a volt. I am thereby enabled by this combination scheme to hold the voltage of the work-circuit J within a very small electric pressure variation, and if the dynamo $B^2$ be compound-wound the speed of the engine will then remain practically constant.

When operating an electric generator, the voltage will always drop proportionally to the heat of the field-magnet windings, and this is where my scheme beautifully counteracts such a defect, for when the voltage drops the valve $B^3$ will be kept open until the voltage rises to suit the adjustment of the solenoid D. Therefore my scheme is well adapted to operate electric generators which are only shunt wound when supplying constant-potential work-circuits or generators supplying arc-lamps where the potential rises proportionally to the number of lamps arranged in series. I show this latter application in Fig. 3. In this case the current of the work-circuit K flows through the coil of the governing-solenoid D, thereby causing the solenoid D to be operated by variations in the volume of current instead of by variations in the current-pressure. In this case the circuit of the electromagnet C is always closed, except when it is opened by the timing closing-circuit commutator L, the current being only diverted from the said magnet by a by-pass shunt $J^2$, Fig. 3. When the volume of current increases, the solenoid-plunger $D^3$ is thereby drawn down, so as to make contact between the points E E′, which diverts all the current principally through the shunt $J^2$. In this way the said magnet is thrown out of use, so as to allow its plunger to descend, and thereby close the valve $B^3$.

In the application of my scheme to a system of arc-lighting in which the work-circuit is traversed by a current of ten amperes if only one lamp be turned on the engine will then run just fast enough to generate the needed pressure suitable for the one lamp. If, however, ten lamps be then thrown on, the speed of the engine will then increase enough to generate an electric pressure sufficient for the ten lamps, and in this way it will vary in speed to suit any number of lamps. It may therefore be seen that I need no other governing devices to operate a constant-current work-circuit than the solenoid D and magnet C. However, in case the work-circuit should become short-circuited I provide the field-magnets with a differential coil U′, which may be cut in or out of circuit by any suitable automatic device, or instead of using the coil U′ the exciting field-coil U may be cut out by suitable portions, as I indicate at $V^2$ $V^3$ and $V^4$ $V^5$. V and V′ indicate where the differential coil U′ may be cut out or in circuit.

The speed of the engine will vary inversely proportional to the variations of potential in a constant-potential system; but in a constant-current system the speed of the engine will vary inversely proportional to any variations in the volume of current. This is due to the fact that in either case of increase the valve $B^3$ will always become closed and thereby cut off the supply of gas from the engine. Changing the speed of the engine to suit the electric pressure of the work-circuit is therefore a novel feature and constitutes an important feature of my invention.

In Figs. 1 and 3 I have shown the magnet C to be operated by a solenoid D; but in Fig. 5 I show how the solenoid may be dispensed with and a centrifugal governor be used in place thereof. If the centrifugal governor be used, then the current would flow through the governing parts as follows: From the brush $G^2$ to the brush *g* to ring Q′, thence through conductor T′, cover S′, screw S, mercury R′, shaft P, ring Q, brush *g*′, brush M, segment 3, brush M′, helix of magnet C, thence to dynamo $G^3$ in the direction of the arrow-head. In the system shown in Fig. 1 the current flows as follows: From dynamo-brush $G^3$ through conductor 4, thence through the coil of solenoid D, conductor 5 to dynamo-brush $G^2$. This constitutes the circuit of the solenoid D. Starting again at brush $G^3$ the current flows through conductor 4, thence through conductor 6, frame F′ and spring $F^4$, plunger $D^3$, contact-points E E′, conductor 7, thence through the coil of the electromagnet C, thence through conductor 8, brush M′, segment 3, brush M, conductor 9, back to dynamo through brush $G^2$. In Fig. 3 the current starts from brush $G^3$, field-coil U, work-circuit K, thence through the helix of the solenoid D, and thence through either the conductor 7, helix of magnet C, conductor 8, brush M′, segment 3, brush M, and back to dynamo through the brush $G^2$, or else from the helix of D, through the contacts E E′, spring $F^4$, frame $F^2$ and F′ and conductor $J^2$ to brush $G^2$ to armature again. When my devices are used on an engine having two explosions to one cycle of the piston, as I show in Fig. 2, then the two solenoids D D′ are adjusted so that one of the solenoids does not begin to operate the contacts E E′ until after the other solenoid is doing its maximum amount of work.

As regards the two electromagnets C C

(shown in Figs. 1 and 5) I will add: The construction of the magnet C (shown in Fig. 5) requires no stuffing-box to be attached to the valve for the plunger to pass through. Therefore this form of combination of the magnet C with the valve $B^3$ is decidedly better as regards friction with the stuffing-box.

Having thus described my invention, and in accordance therewith, I claim as new and desire to secure by Letters Patent—

1. In a system of power operation and regulation, the combination with a gas-engine provided with a gas-supply valve, of a magnetic device for controlling said valve, a source of electricity for supplying said magnetic device with current to operate said valve, and a centrifugal governor for throwing said magnetic device in and out of electrical circuit to operate said valve for controlling the speed of said engine, substantially as described.

2. In a system of gas-engine operation and regulation, the combination with a gas-engine, of two gas-valves, and electromagnetic means, one of said valves being operated by said electromagnetic means, said electromagnetic means being thrown out of action to check the speed of said gas-engine, the other of said valves being used to operate the engine until the valve, which is operated by electromagnetic means, becomes operative, substantially as described.

3. In a system of power operation and regulation, the combination with a gas-engine provided with two gas-supply valves, one of said valves being used only to operate the engine until the second of said valves becomes automatically operative, of electrically-operated means for automatically throwing the starting-valve out of action when the second valve becomes operative, substantially as described.

4. In a system of gas-engine operation and regulation, the combination with a gas-engine and a source of electric supply, of a valve for controlling the amount of gas for said engine, an electromagnetic device for operating said valve to admit gas to said engine, a close-circuiting commutator for timing the action of said valve to suit the requirements of the engine, and means for supplying said electromagnetic device with a current of electricity in a manner suitable to the speed of the engine, substantially as described.

5. In a system of gas-engine operation and regulation, the combination with a gas-engine provided with a valve for regulating the supply of gas to operate said engine, and with a source of electric supply, of an electromagnetic device for opening said valve to admit gas to the engine, and mechanical means for closing the valve when the said electromagnetic device ceases to become effective, substantially as described.

6. In a system of gas-engine operation and regulation, the combination with a gas-engine and a source of electricity, of a valve $B^3$ for controlling the supply of gas to operate said engine, an electromagnetic device to operate said valve, and an electrocentrifugal governor for regulating the current of electricity from said source to operate said electromagnetic device, substantially as described.

7. In a system of gas-engine operation and regulation, the combination with a gas-engine, of a valve B for starting the engine into action, a valve $B^3$ for operating the engine thereafter, and electromagnetic means for automatically throwing the valve B out of use when the valve $B^3$ becomes operative in a manner substantially as described.

8. In a system of power operation and regulation, the combination with a power-engine, of a valve $B^3$, an electromagnetic device to operate said valve, an electric generator for supplying said electromagnetic device with current, a by-pass circuit $J^2$, and an electric device for throwing said electromagnetic device in and out of circuit by diverting the current through said by-pass circuit $J^2$, substantially as described.

9. In a system of power operation and regulation, the combination with a power-producing engine, of an engine-controlling valve $B^3$, an electromagnetic device for operating said controlling-valve, an electric generator provided with field-magnet coils, means for cutting said coils in or out of circuit to control said electric generator, and means for cutting said electromagnetic device in and out of circuit to control the speed of said power-producing engine, said engine being caused to vary in speed according to the work it performs, substantially as described.

In testimony whereof I sign this specification in the presence of two witnesses.

THOMAS H. HICKS.

Witnesses:

THOS. A. PARISH,

FLORENCE BUCKHURST.