(No Model.) 4 Sheets—Sheet 1.

M. C. BULLOCK.

GOVERNING DEVICE FOR COMPOUND ENGINES.

No. 504,691. Patented Sept. 5, 1893

Fig. 1.

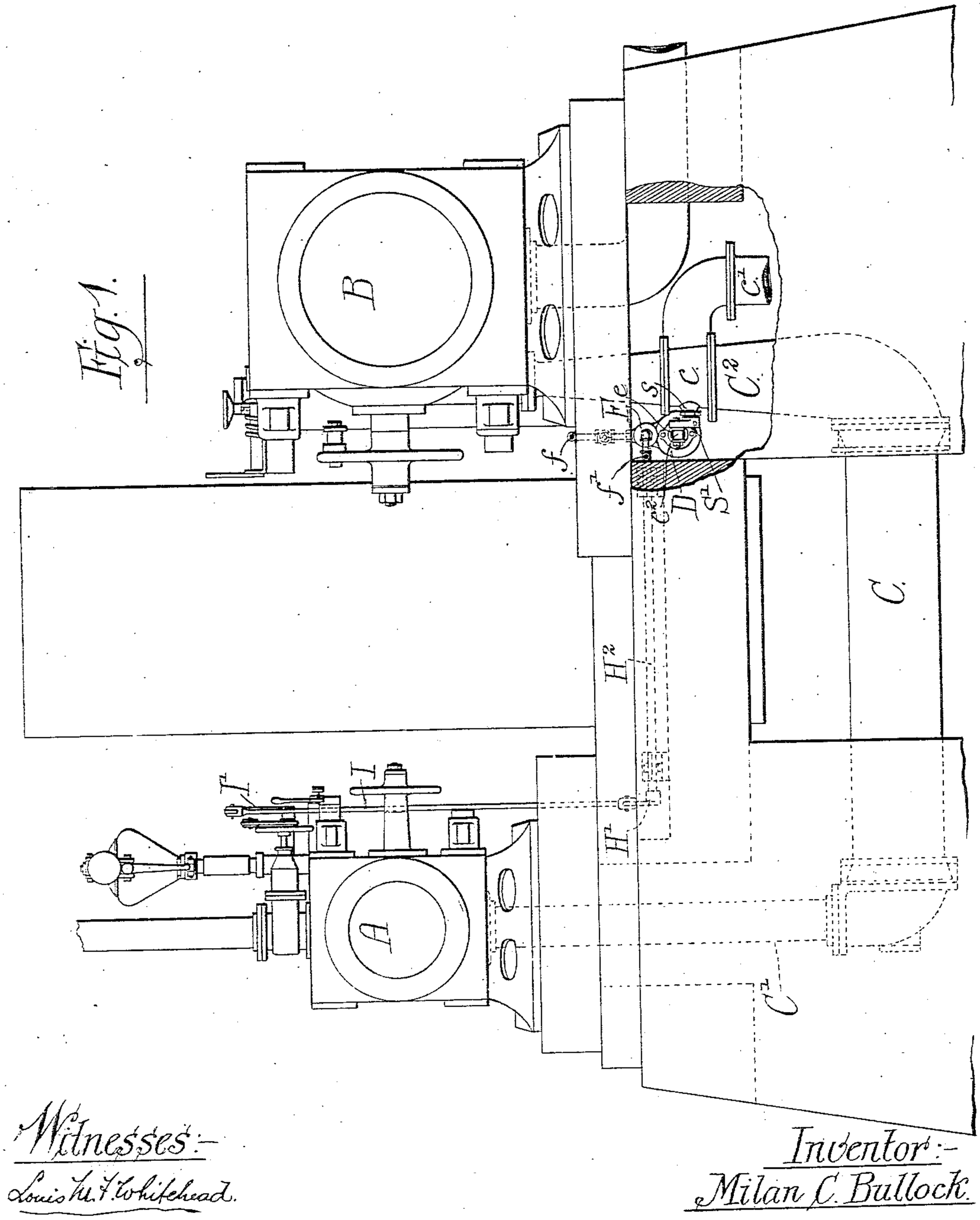

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Fig. 2.

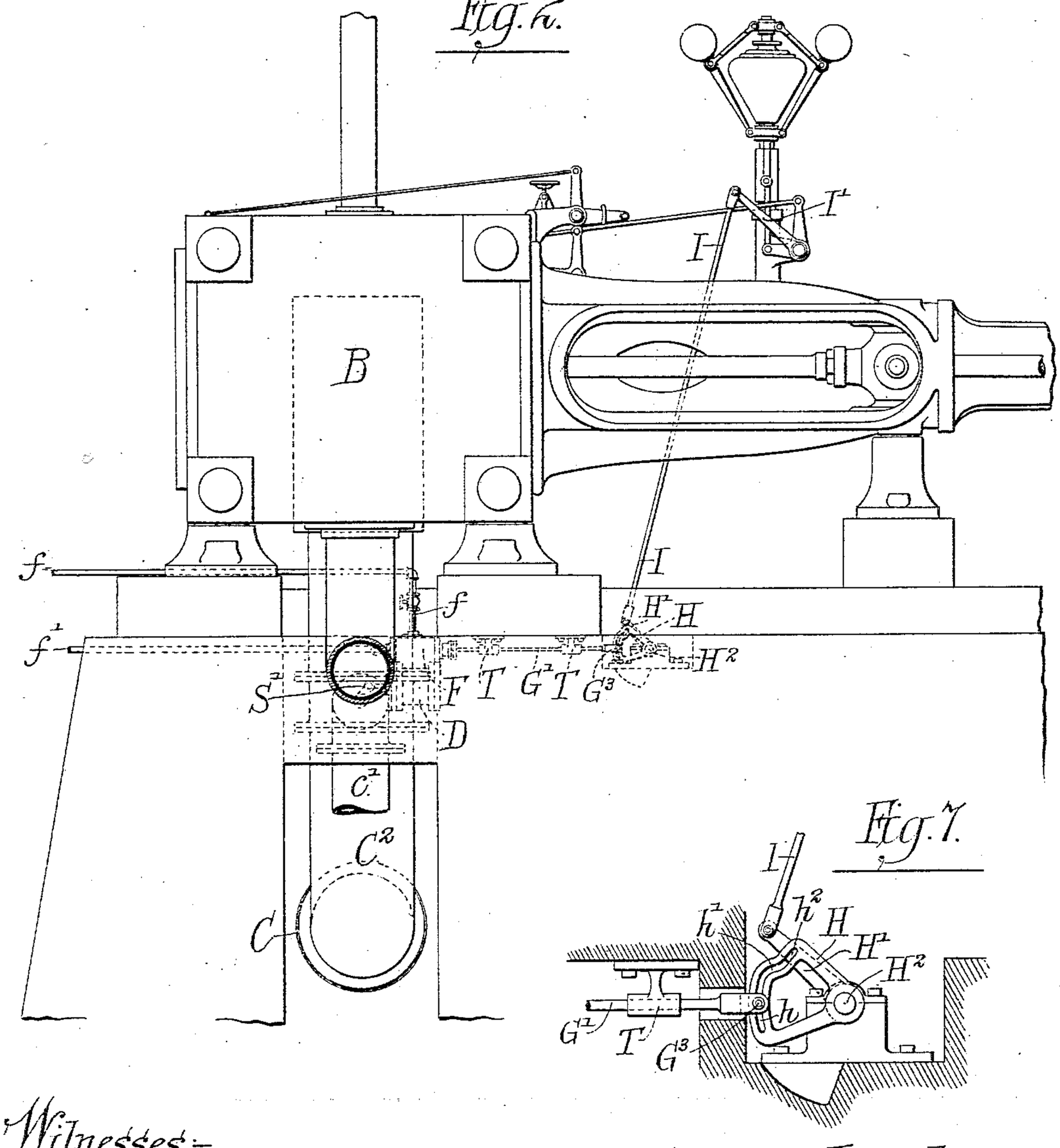

Fig. 7.

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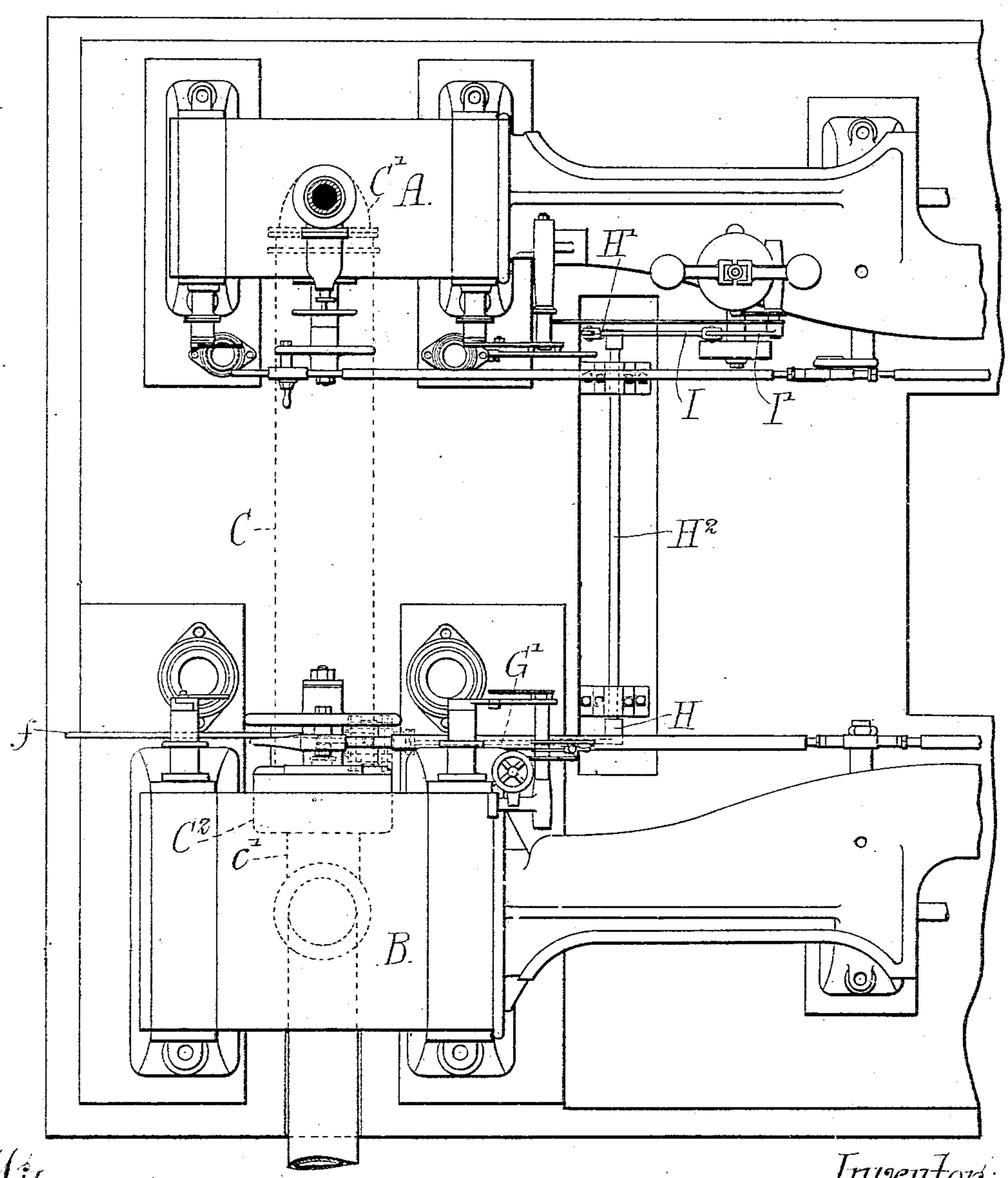
Fig. 3.



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M. C. BULLOCK.

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No. 504,691. Patented Sept. 5, 1893.

Fig. 4.

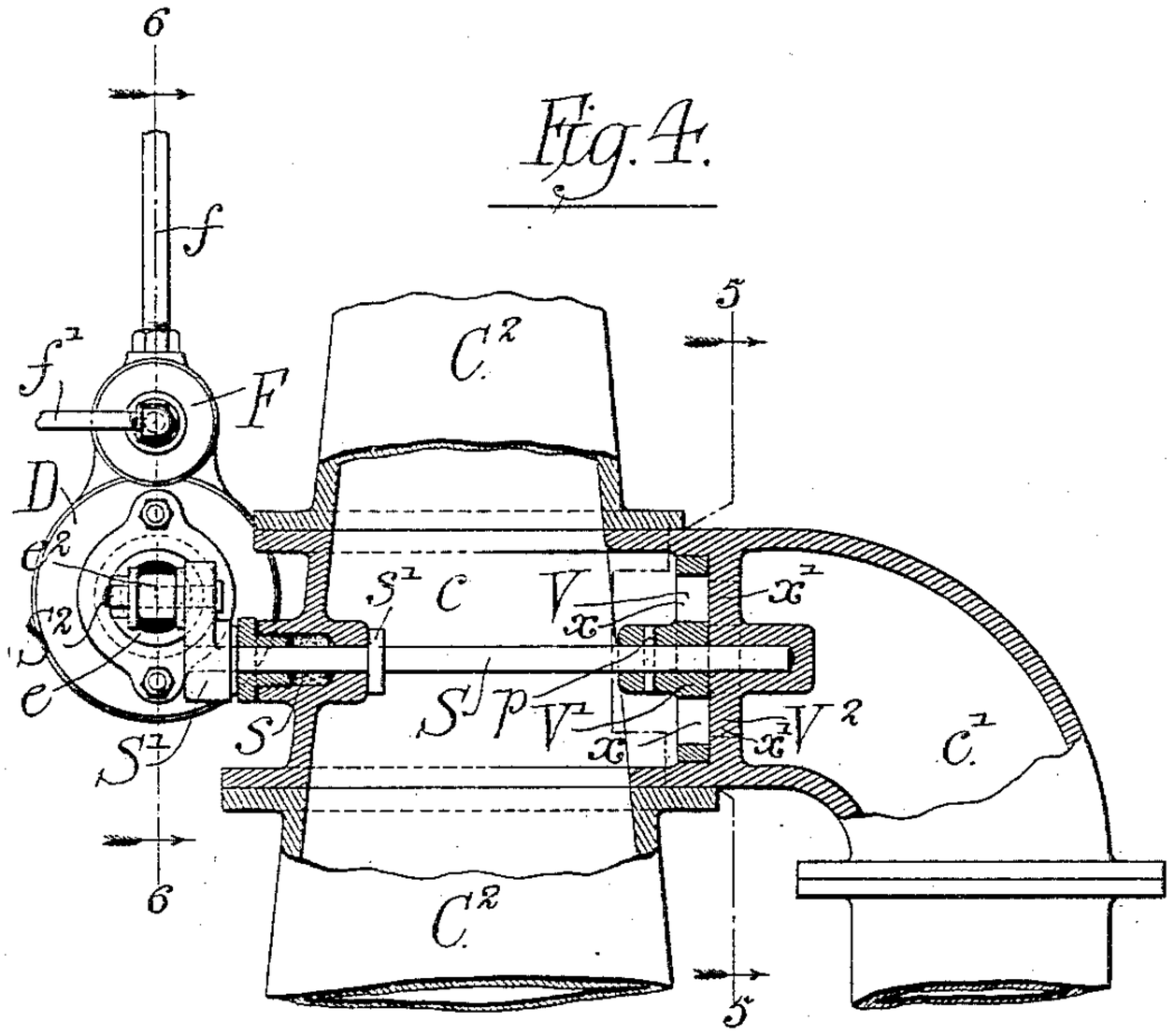


Fig. 5.

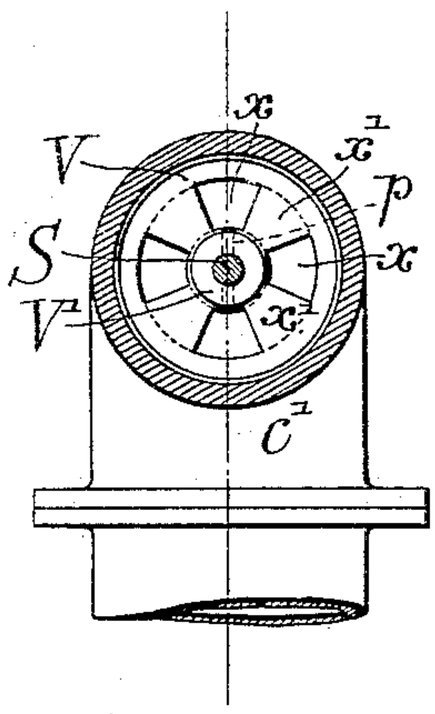
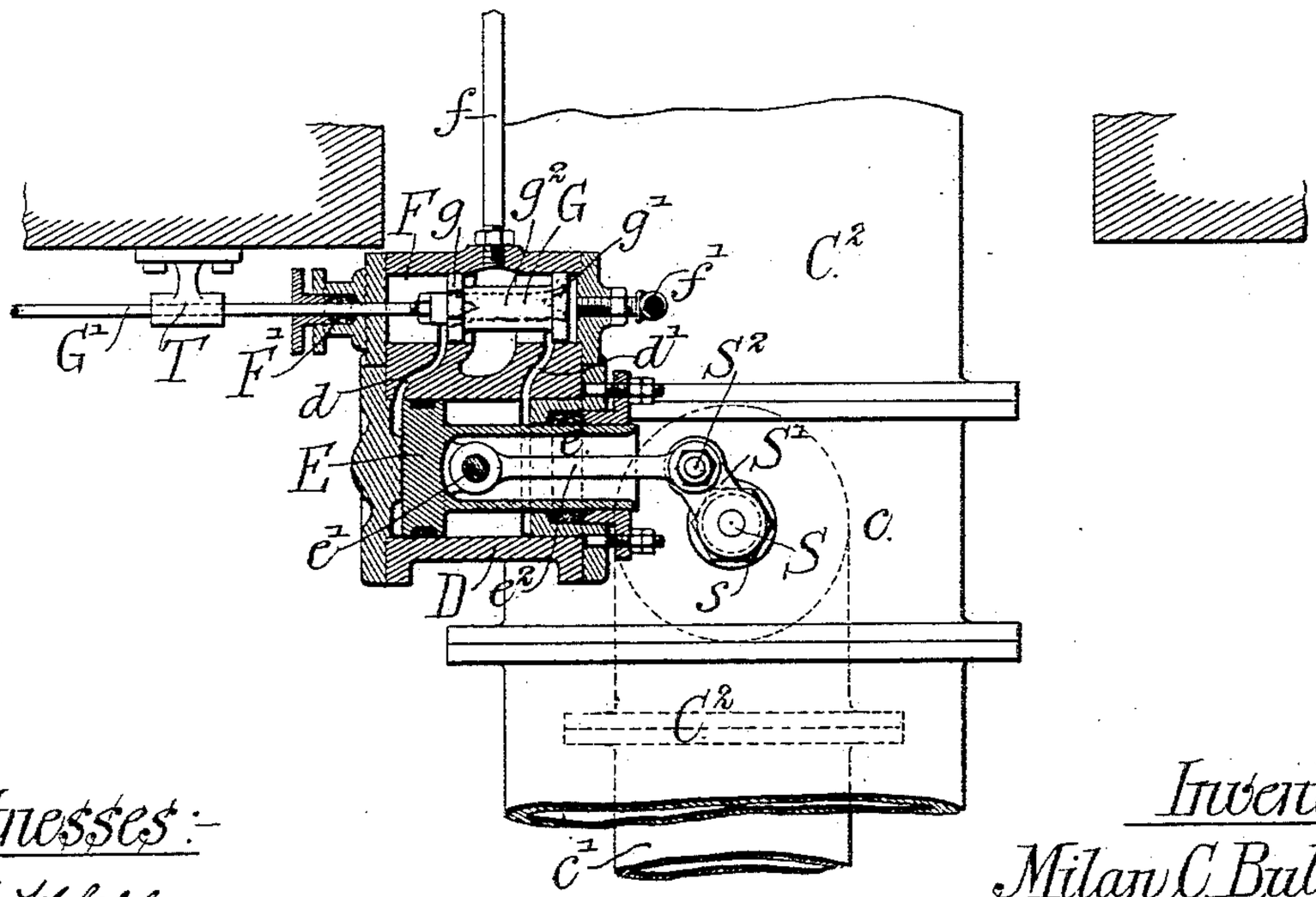


Fig. 6.



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UNITED STATES PATENT OFFICE.

MILAN C. BULLOCK, OF CHICAGO, ILLINOIS.

GOVERNING DEVICE FOR COMPOUND ENGINES.

SPECIFICATION forming part of Letters Patent No. 504,691, dated September 5, 1893.

Application filed October 11, 1892. Serial No. 448,533. (No model.)

To all whom it may concern:

Be it known that I, MILAN C. BULLOCK, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Governing Devices for Compound Steam-Engines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to improvements in governing devices for compound steam engines and is adapted for two cylinder, triple or quadruple expansion, or any other type of multiple cylinder expansion engine.

Hitherto great difficulty has been experienced in governing closely engines of the class referred to owing to the fact that after the governing devices have completely cut off the steam supply from the high pressure cylinder, the low pressure cylinder or cylinders must still use up such steam as has already entered and is then contained in the high pressure cylinder and in the exhaust passages leading from the same to the low pressure cylinder before the engine is entirely relieved from the effective pressure tending to accelerate its velocity. As it necessarily takes considerable time for this steam to work out through the low pressure cylinder or cylinders, the compound engine is sluggish in responding to the action of the governing devices and to such an extent that in cases of widely and suddenly varying loads, as, for example, in the operation of electric railways, the best results obtained with compound engines involve a fluctuation of speed of from two and one half to three per cent., while with single engines under the same conditions, such fluctuations may be controlled to never exceed one half of one per cent.

The object of my invention is to provide improved devices by which a closer regulation of compound engines is effected, and to this end it consists in the matters hereinafter set forth and pointed out in the appended claims.

In the accompanying drawings: Figure 1 is an end elevation of a cross compound engine provided with my improvements. Fig. 2 is an elevation of the low pressure cylinder side of the same. Fig. 3 is a general plan view. Fig. 4 is a detail sectional elevation of the valve and its immediate operating mechanism. Figs. 5 and 6 are similar views, taken respectively on lines 5—5 and 6—6 of Fig. 4. Fig. 7 is a detail of the cam mechanism.

My improvements are shown in this instance as applied to that type of engine commonly known as the "cross compound" in which the high and low pressure cylinders are placed side by side and parallel with each other. Said engine may be provided with any preferred form of valve gear, that shown in the drawings being of the well known Corliss type, and may be controlled by any preferred form of governor, the one illustrated being the common ball governor usually used in connection with the Corliss valve gear. The exhaust steam from the high pressure cylinder A is conducted to the low pressure cylinder B by a suitable pipe or passage, usually made of considerable capacity and constituting what is known as the "receiver," the form shown in this instance being that usually employed in this type of engine, consisting of a large pipe or chamber C, placed transversely between and beneath the cylinders and connected at one end with the lower end of the high pressure exhaust pipe C′, at the other with the lower end of the low pressure steam supply pipe C^2, the upper ends of said pipes C′ and C^2 being connected with their respective cylinders A and B in any preferred manner, in this instance, to the under sides of the same.

At any suitable point on the receiver or passages conducting the high pressure exhaust to the low pressure cylinders, I provide a valved passage communicating with the open air, and I also provide connections between the valve in said passage and the governor whereby the former may be operated by the latter, as hereinafter described. In this instance such valved passage is provided in the form of a branch pipe *c′*, opening out of the removable section *c* of the low pressure steam supply pipe C^2, and leading to any suitable point of discharge, the said section *c* and branch pipe *c′* being preferably made integral and serving as a casing for the valve V, by which the passage is maintained normally closed. Said valve V in the form shown, is

of oscillating disk form, and normally comprises a circular valve plate V′, rotatably mounted in close contact with a fixed transverse seat V^2, connected at its edges with the side walls of the passage and in this instance made integral therewith. Both the valve plate V′ and seat V^2 are provided with radial openings *x*, preferably of sector shape separated by solid portions *x′* of similar shape and slightly greater area, by which construction the passages may be closed completely or opened to its greatest extent by a relatively slight oscillatory movement of the valve plate V. In the form shown said valve plate is suitably mounted, as stated, by being affixed in any suitable manner, as a dowel pin *p*, to a shaft S, one end of which is journaled in a socket in the seat V^2 and the other end of which passes out through a stuffing box *s* in the side wall of the section *c* and has affixed to its end a crank-arm S′, by means of which the shaft S and valve plate V′ are oscillated. The valve plate may be held down to its seat in any suitable manner, as by a collar *s′* attached to the shaft S and engaging the adjacent wall of the section *c*. Said valve V may be operated by the governor directly, but in order to avoid the sluggish action which would possibly result from loading the governor with so much additional resistance, I provide, in this instance, an auxiliary motor for operating the valve; the action of said motor being controlled by the governor, as hereinafter set forth. Said motor, in the form shown, comprises an auxiliary steam cylinder and piston having a valve connected with the governor and serving to admit steam to one side of the piston or the other according to the position of said governor; the piston moving the one way or the other under the pressure of the steam so admitted and being suitably connected with the crank arm S′ to oscillate the same and thereby open or close the valve V. In the form shown such auxiliary cylinder and piston, designated in the drawings as D, and E, respectively, are of the ordinary trunk engine type; said piston E being provided with a trunk *e* within which is pivoted at *e′* a connecting rod e^2, the other end of said connecting rod being journaled on a wrist-pin S^2, projecting from the crank arm S′. Steam is admitted to the opposite sides of the piston E through suitable ports *d* and *d′*, provided at each end of the cylinder and is, in this instance, exhausted through the same ports, the connection between the ports and the steam supply and exhaust being controlled by any suitable valve G. The valve shown in this instance is of the well known hollow piston type consisting of two short cylindric pistons *g g′* accurately fitting the interior of the cylindric valve chest F and rigidly connected by an integral body portion g^2 of smaller diameter, the length of said body portion being such that the distance from the inner edge of either cylinder and piston *g g′* to the outer edge of the other of said end portions equals the distance between the ports *g g′* at their valve chest ends. A suitable steam supplying pipe *f* entering the valve chest about midway between its ends admits steam to the annular space surrounding the body portion g^2 of the valve piston, the larger end portions *g* and *g′* preventing it from entering the spaces at the end of the piston. The latter spaces are connected with the exhaust, in the instance shown, by means of an exhaust pipe *f′*, leading from one end of the valve chest, in connection with a suitable port affording free communication between said end spaces provided, in the form shown, by making the valve piston hollow.

Attached to the valve G is the usual valve rod G′ passing out of the valve chest through a suitable stuffing box F′, and supported at its outer end by suitable bracket bearings T, connections being provided between the valve rod and the governor by which the latter in its movement serves to operate the valve G and thereby, through the operation of the intermediate mechanism just described, to open and close the valve V. In the present form of my invention I provide said connections of such nature that the ordinary fluctuations of the governor do not affect the position of the valve G, no movement of the latter taking place until the governor has exceeded, in its movement, a predetermined limit. The full freedom and delicacy of action of the governor is thus preserved during the continuance of normal conditions. Said connections are, however, further constructed to rapidly move the valve rod and valve in one direction whenever the governor exceeds said predetermined limit of movement and in the other direction whenever said governor returns within the same.

Various connections producing the above described action may be devised, but in this instance, I have shown a cam mechanism comprising a pivoted cam H, provided with a cam slot engaging a pin G^3, projecting from the outer end of the valve rod G′. Said cam slot is composed of a concentric part *h* having at one end a relatively short eccentric portion *h′*, beyond which, in the instance shown, is a second concentric portion h^2, the radial distance beyond the extremities of said eccentric portion *h′*, being equal to the desired travel of the valve G. Said cam is connected with the governor to oscillate with the fluctuation of the same, such connection being in the present instance provided in a connecting rod I, pivoted at its upper end to a lever I′, fixed to any oscillating part of the governor and at its lower end to the cam H or to some part rigidly connected to oscillate therewith, in this instance to a lever H′ affixed to one end of a shaft H^2, which serves as the pivot of the cam H and is rigidly connected therewith. In the form shown the lever I′ is made of considerably greater length than the lever H′ in order that a relatively slight fluctuation of the governor may produce a considerable oscillation of the cam H for a pur-

pose hereinafter set forth. The parts of the cam mechanism thus described are so arranged that normally the pin G^3 engages the concentric portion *h* of the cam slot, the length of which portion is such that the ordinary movement of the governor will not swing the cam far enough to engage said pin with the concentric portion *h'* and it is obvious that until this is done the valve rod will remain stationary. Thus under ordinary circumstances no extra load is put on the governor beyond the slight amount required to oscillate the same and its freedom and delicacy of action are consequently not interferred with. When, however under an unusual decrease of load, the movement of the governor exceeds a predetermined limit, the cam H will be swung so far as to cause the pin G^3 to pass the eccentric portion *h'* of the slot and thereby shift the valve G. Further movement of the governor and cam in the same direction would only cause the pin G^3 to enter farther into the concentric continuation h^2 of the slot without affecting the position of the valve G, but a reverse movement would return the pin G^3 through the eccentric portion *h'* of the slot and carry the valve G back to its first position.

It will be observed that by so constructing the parts that a slight movement of the governor will cause a considerable oscillation of the cam H, as hereinbefore set forth, and by making the eccentric portion *h'* relatively very short, as previously stated, only a very slight movement of the governor will suffice, after the proper point is reached, to move the valve G the full length of its stroke. The movement of the latter, therefore, will occur at substantially the same point in the return movement of the governor that it did in the original movement of the same.

In the normal position of the valve G, *i. e.* its position under normal conditions with the cam as shown in Figs. 2 and 7, one of the ports, the port *d* in the drawings, is open to the exhaust and the other port, the port *d'*, is open to the steam supply and admits steam freely to one side, in this instance the trunk-side, of the piston D, holding said piston by positive pressure at that end of the cylinder opposite to the port by which steam is then admitted and thereby holding the connected valve V in its closed position. When the valve G is moved to the other end of its stroke under an expansive movement of the governor, as hereinbefore explained, the port *d'* will in turn be opened to the exhaust while steam will pass through the port *d* to the other side of the piston D, forcing the same to the other end of the cylinder and thereby opening the valve V. The ports will be held in this position until as the engine resumes its normal action, the valve G returns to its first position, as above explained, when steam will be again admitted to the port *d'* and will force back the piston and close the valve V.

It will be obvious that the shifting of the piston and connected parts under the pressure of the steam will be practically instantaneous and coincident with the shifting of the valve G, by the governor, and this latter action being accomplished very suddenly and at a predetermined point in the movement of said governor, as hereinbefore set forth, it follows that as the governor passes such predetermined point in its movement the valve V will be instantly opened or closed as the case may be.

The operation of that embodiment of my improved governing devices, set forth in the foregoing, is as follows: Normally the valve V, is held closed in the manner hereinbefore described, the exhaust steam from the light pressure cylinder passing through the exhaust-passages to the low pressure cylinder in the usual manner, while the governor fluctuates as usual under the slight variations of load. When, however, the movement of the governor becomes so great as to exceed a predetermined limit, the said governor operates in the manner previously described to instantly throw open the valve V, thereby permitting the steam contained in the high pressure cylinder and exhaust-passages to escape into the open air and relieve the low pressure cylinder of all of future actuating pressure. Such predetermined limit of movement of the governor will usually be the point at which said governor operates to completely cut off the steam supply from the light pressure cylinder the engine being thus permitted to operate in the ordinary manner controlled by the usual governing devices applied thereto until they shall have reached the limit of their effectiveness whereupon the additional governing devices constituting my improvements come into play to still further control the engine, as hereinbefore set forth. The low pressure cylinder remains thus practically in operation until the governor (owing either to a decrease in speed or an increase in the load of the engine), repasses in its retrograde movement, the point at which the valve V was opened whereupon said governor operates in the manner described, to instantly close the said valve V and the engine then resumes its normal action.

It is obvious that my improvements do not in any way depend upon the type of governor employed, being equally useful in connection with any type whether ball or shaft, load or speed nor is it material whether the same is a throttling or an automatic cut off governor. My improvements are moreover, equally as applicable to the tandem or other forms of compound engine as to the "cross compound," and to marine as well as stationary engines. Indeed they are particularly adapted for marine screw engines, tending when so used, to reduce to a minimum the racing of the screw whenever the stern of the vessel rises out of water, a serious and hitherto unavoidable difficulty common to all screw engines.

I do not desire to limit myself to any spe-

cific construction for carrying out my invention, for as before stated, various devices, other than those herein set forth, may be designed all embodying the same general principle and all of which I consider as falling within the scope of my broad invention.

What I claim is—

1. A governing device for compound engines comprising an exhaust steam outlet in the steam passage leading from the high to the low pressure cylinder, a valve maintaining said outlet normally closed and a governor connected with said valve and acting to open the same whenever said governor passes a predetermined point in its movement, substantially as described.

2. A governing device for compound engines, comprising an exhaust steam outlet communicating with the exhaust passages of the high pressure cylinder, a valve maintaining said outlet normally closed, an auxiliary motor connected with the said valve, and connections between the motor and a governor for throwing the motor into action whenever the governor passes a predetermined point in its movement, substantially as described.

3. A governing device for compound engines, comprising an exhaust steam outlet, communicating with the exhaust passages of the high pressure cylinder, a valve maintaining said outlet normally closed, an auxiliary steam cylinder with its piston connected with the said valve, a valve controlling the admission of steam to the auxiliary cylinder, and connections between the latter valve and a governor for shifting the valve as the governor passes a predetermined point in its movement, substantially as described.

4. A governing device for compound engines comprising an exhaust steam outlet communicating with the exhaust passages of the high pressure cylinder, a fixed transverse seat in said outlet having radial openings therein, an oscillating disk in contact with said seat, provided with similar openings, an actuating shaft for said disk, provided with a crank-arm, and mechanism connected with a governor for oscillating the crank arm whenever the governor passes a predetermined point in its movement, substantially as described.

5. A governing device for compound engines comprising an exhaust steam outlet communicating with the exhaust passages of the high pressure cylinder, a fixed transverse seat in said outlet having radial openings therein, an oscillating disk in contact with said seat, provided with similar openings, an actuating shaft for said disk, provided with a crank-arm, an auxiliary motor connected with said crank arm and connections between the motor and a governor for throwing the motor into action whenever said governor passes a predetermined point in its movement, substantially as described.

6. A governing device for compound engines comprising an exhaust steam outlet communicating with the exhaust passages of the high pressure cylinder, a fixed transverse seat in said outlet having radial openings therein, an oscillating disk in contact with said seat, provided with similar openings, an actuating shaft for said disk, provided with a crank arm, an auxiliary steam cylinder with its piston connected with the crank arm, a valve controlling the admission of steam to said auxiliary cylinder, and connections between the latter valve and a governor for shifting the valve whenever the governor passes a predetermined point in its movement, substantially as described.

In testimony that I claim the foregoing as my invention I affix my signature in presence of two witnesses.

MILAN C. BULLOCK.

Witnesses:

C. CLARENCE POOLE,

HENRY W. CARTER.