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M. C. BULLOCK.

GOVERNING DEVICE FOR COMPOUND ENGINES.

No. 547,242. Patented Oct. 1, 1895.

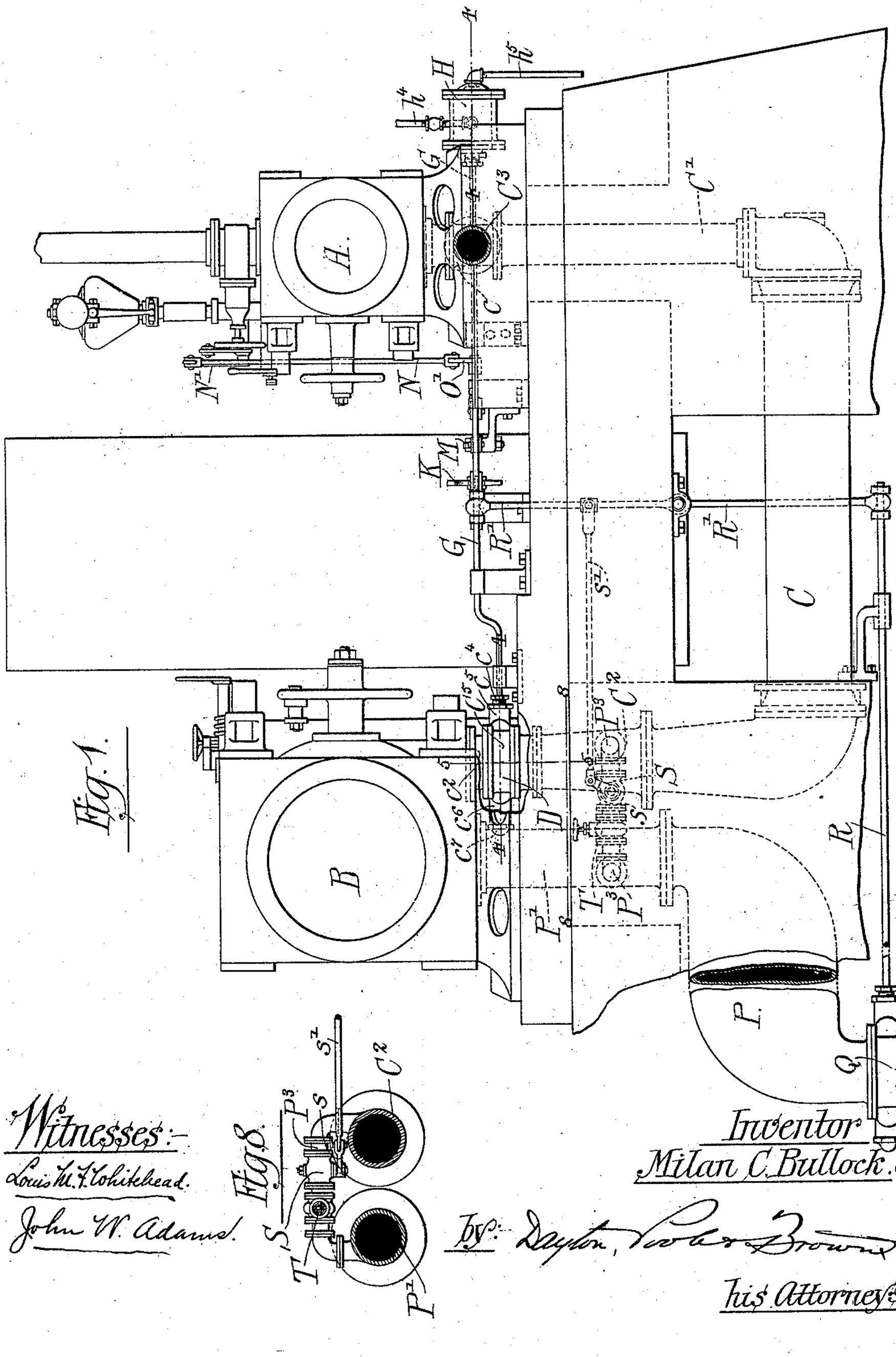

Fig. 1.

Fig. 8.

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Fig. 2.

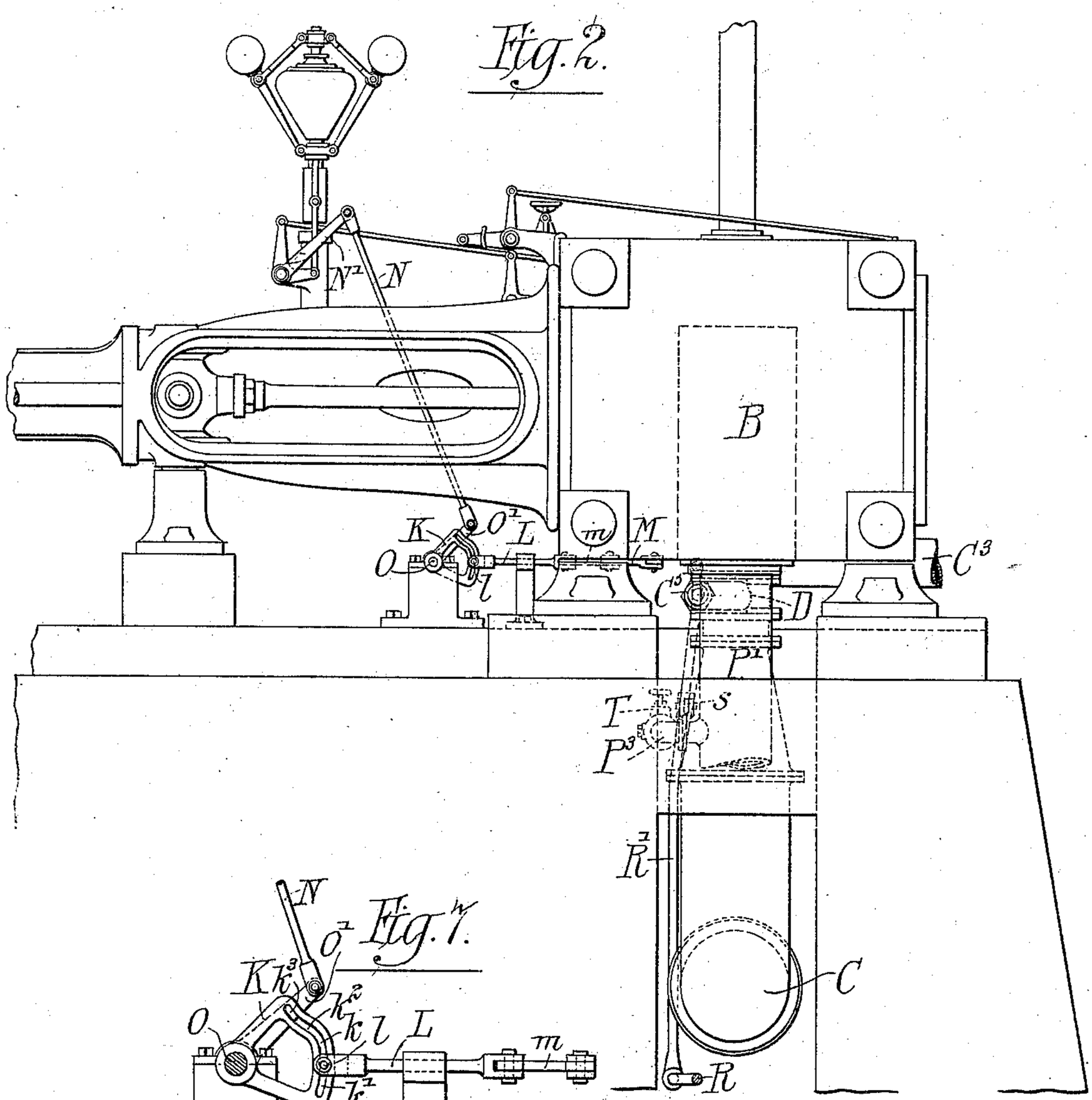

Fig. 1.

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M. C. BULLOCK.

GOVERNING DEVICE FOR COMPOUND ENGINES.

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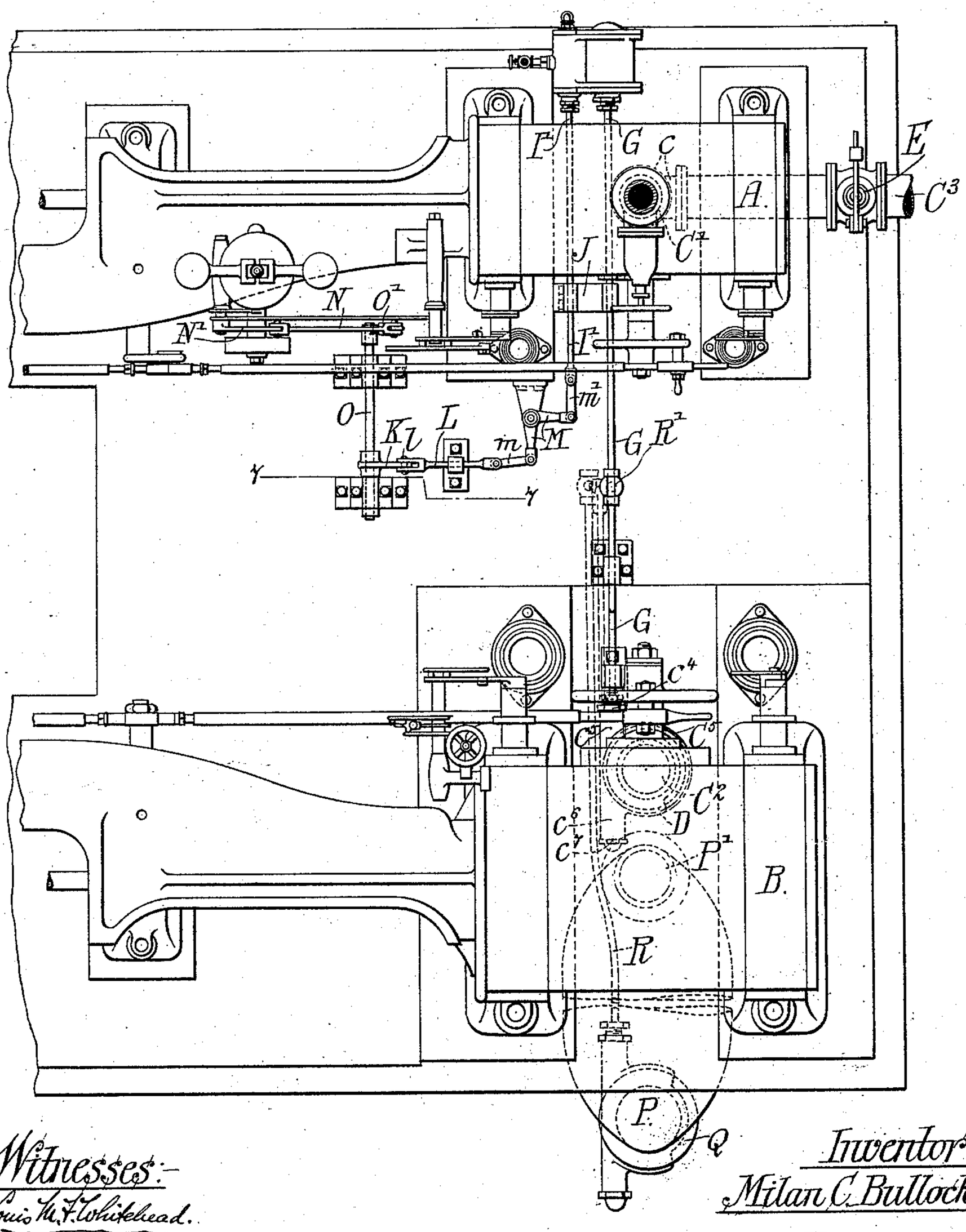
Fig. 3.



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M. C. BULLOCK.

GOVERNING DEVICE FOR COMPOUND ENGINES.

No. 547,242. Patented Oct. 1, 1895.

Fig. 4.

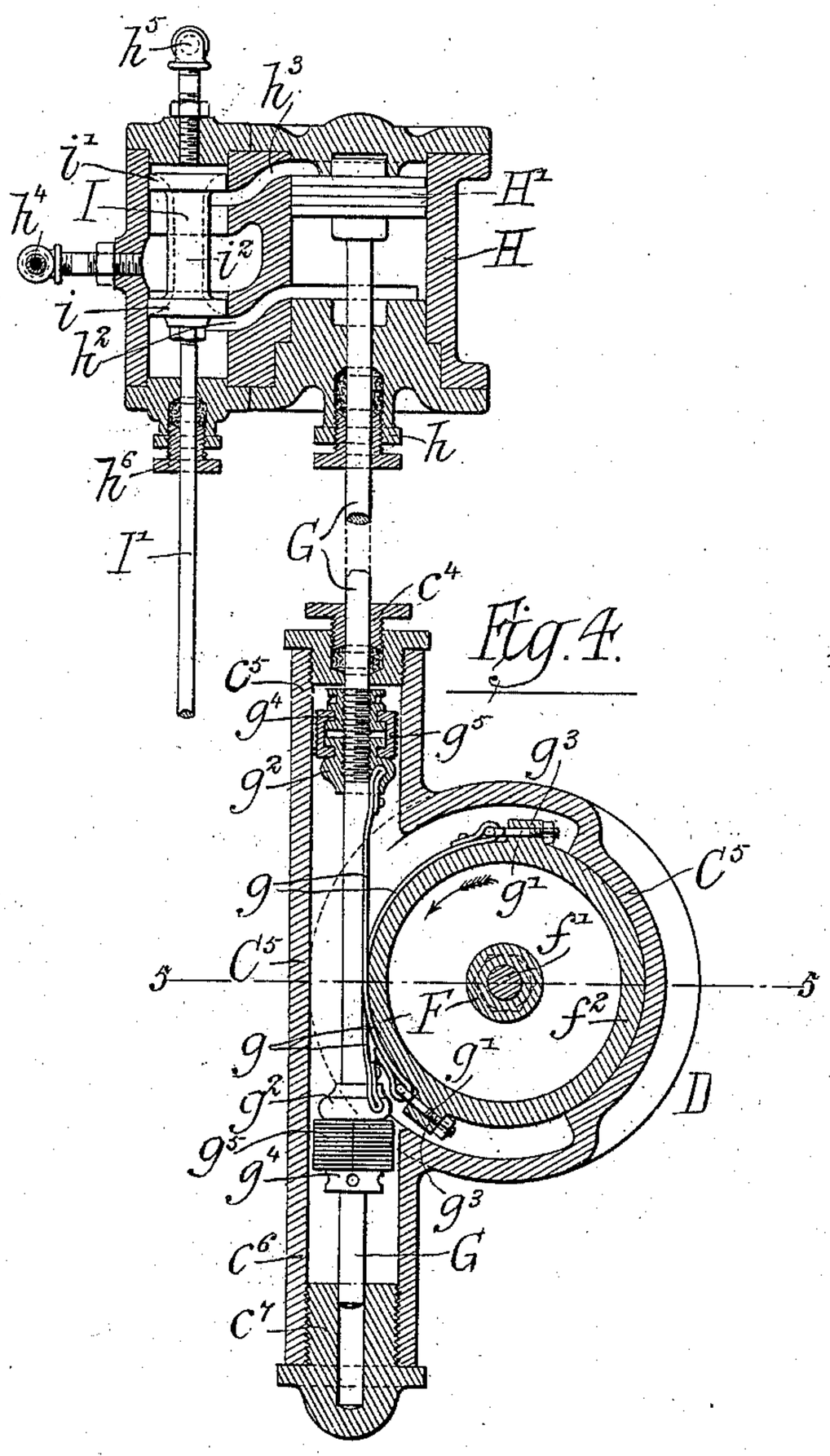


Fig. 6.

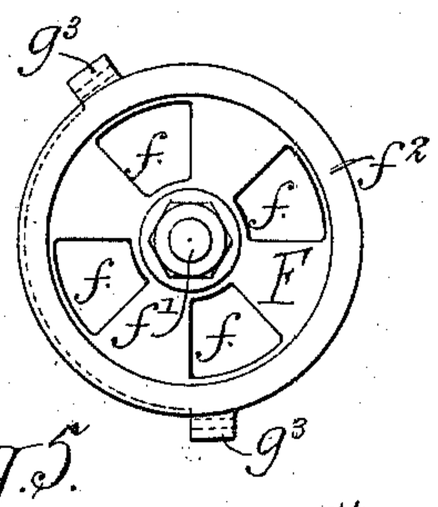
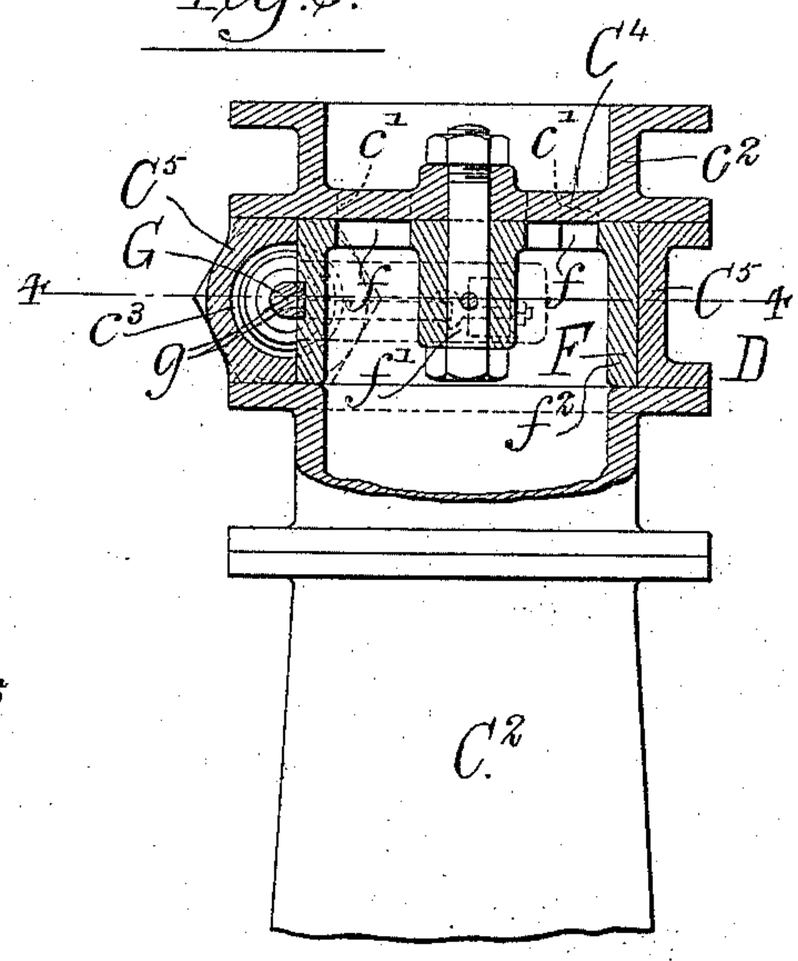


Fig. 5.



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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. 547,242, dated October 1, 1895.

Application filed September 6, 1893. Serial No. 484,881. (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 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 it embraces, among other features, improvements in governing devices of that class shown and described in a prior patent granted to me September 5, 1893, No. 504,691, wherein the steam-passage leading from a high to a low pressure cylinder is provided with an exhaust-steam outlet provided with a valve, which acts to maintain said outlet normally closed, but which is open to permit the escape of exhaust-steam from the high-pressure cylinder whenever the speed of the engine reaches a predetermined limit, and to thereby prevent such exhaust-steam from acting on the piston of the low-pressure cylinder until the engine again resumes its normal speed.

The invention consists in the matters hereinafter described, and pointed out in the appended claims.

While my invention is herein shown as applied to a two-cylinder cross-compound engine, yet the principles of the invention may be applied to triple or quadruple and to other forms or types of multiple-cylinder expansion-engines.

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 engine. Fig. 3 is a general plan view of the engine. Fig. 4 is a detail horizontal section showing the valve at the outlet of the receiver and its immediate operating mechanism, said section being taken on line 4 4 of Fig. 5. Fig. 5 is a vertical section through the same valve, taken on line 5 5 of Fig. 4. Fig. 6 is a bottom plan view of the valve-disk. Fig. 7 is a detail view of a cam mechanism through the medium of which the movement of the valves is controlled. Fig. 8 is a detail section on line 8 8 of Fig. 1.

My improvements are shown in this instance as applied to that type of engine commonly known as the "cross-compound," or that in which the high and low pressure cylinders are placed side by side or 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. The engine, furthermore, may be controlled by any preferred form of governor, the one herein shown being the common ball-governor usually used in connection with a Corliss valve-gear.

A is the high-pressure cylinder of the engine and B the low-pressure cylinder thereof, exhaust-steam being conducted from the high to the low pressure cylinder by a pipe or passage C, which will usually be made of considerable capacity and which constitutes what is known as the "receiver." The form of the receiver in this instance is that usually employed in this type of engine, consisting of a large pipe or chamber placed transversely between and at a lower level than the cylinders, and connected at one end with the lower end of the high-pressure exhaust-pipe C', and at the other end with the lower end of the low-pressure steam-supply pipe C^2. The upper ends of said pipes C' and C^2 are connected with the cylinders A and B in any preferred manner; said pipes being shown in this instance as attached to the under sides of the said cylinders. At the exit end of the receiver C, in the instance shown in the pipe C^2, I provide a valve D for closing said pipe, and in connection with said valve operative connections by which the valve may be operated by the engine-governor. In the passage leading from the high-pressure cylinder to the receiver, in this instance in pipe C', I provide an exit-passage C^3, communicating with the open air or with a condenser, and in said exit-passage is placed an outwardly-opening relief-valve E, adapted to open automatically when a predetermined pressure is reached. This construction enables the exhaust-steam from the high-pressure cylinder to be discharged into the open air or into the condenser when the desired limit of speed is reached, and the closing of the valve D at the exit end of the re-

ceiver acts to cut off steam-supply from the low-pressure cylinder and at the same time to confine the steam in the receiver until the pressure therein becomes so great as to overcome the resistance of the relief-valve E, when the latter opens and allows escape of steam from the receiver in quantity sufficient to prevent the pressure therein being in excess of that at which the relief-valve is set to open, steam held in the receiver under such pressure being retained therein until the engine resumes its normal speed, when it passes to the low-pressure cylinder. In this instance the exhaust-passage C^3 is in the form of a branch pipe forming part of a removable section c of the high-pressure steam-exhaust pipe C′, and the relief-valve E has the form of an ordinary weighted "pop" safety-valve, the weight of which may be adjusted to allow the escape of steam at any desired pressure. The said relief-valve will preferably be set to open at such pressure as to maintain in the receiver approximately the same pressure that exists therein during the usual or normal action of the engine, the object being to maintain such steam-pressure in the receiver during the time that the valve D is closed, so that when it is opened and the low-pressure cylinder resumes its work steam will be admitted to said low-pressure cylinder at normal working pressure only, and great or dangerous strains on the engine at such times will thereby be prevented.

The valve D at the exit end of the receiver is shown in detail in Figs. 4, 5, and 6, and is constructed as follows: In the pipe C^2, which leads from the receiver to the low-pressure cylinder, is located a diaphragm C^4, provided with segmental ports c' c'. The diaphragm is shown as made integral with a section c^2 of the pipe C^2, which is directly secured to the low-pressure cylinder. Beneath and in contact with the said diaphragm is an oscillatory valve-disk F, having ports f f of segmental form which operate in connection with the correspondingly-shaped ports c' c' to permit the passage of steam from the receiver to the low-pressure cylinder. Said valve-disk is supported in contact with the said diaphragm by a pin f', which is secured to the disk and passes through the diaphragm and is provided with a head or nut at its upper end and acting to hold the disk in contact with the diaphragm. Said valve-disk being below the diaphragm, it is pressed against the same by the steam-pressure within the receiver, so that leakage of steam is prevented at the time the valve is closed. The oscillating valve described may be operated in any suitable manner, but as herein shown it is actuated through the medium of a horizontally-movable rod G, which passes through the walls of the pipe C^2 and is connected with the valve-disk by means of two flexible strips or strands g g, each of which is attached at one end to the disk and at its opposite end to the rod, and which rest for part of their length upon the outer cylindric surface of the disk in the manner illustrated. Said rod G is shown as extending through a horizontal slot c^3 formed in the casing C^5 of the valve, within which slot the strands g g are located. Said strands are shown as connected with the valve-plug by means of lugs g^3, through which pass bolts g', engaged with loops on the ends of the strands, and as connected with the rod by means of sliding-sleeves g^2, to which the strands are directly attached and which are connected with adjusting-nuts g^4 on the rod by means of collars g^5, having inwardly-extending flanges which engage grooves on both of the sleeves g^2 and nuts g^4, so as to permit the nuts to be turned for tightening the strands without turning the sleeves to which the strands are attached.

In the particular construction illustrated the valve-disk F is provided at its margin with a cylindric flange f^2, which fits within the valve-casing, the purpose of said flange f^2 being to afford a cylindric bearing-surface of suitable width for the strips g g, which connect the valve-disk with the rod. In this instance the rod is shown as passing through a stuffing-box c^4, secured upon the outer end of the tubular extension c^5, which is formed on the valve-casing C^5 for the purpose of receiving the end of the strand g and the attaching devices by which the strand is secured to the rod. A similar tubular extension c^6 of the valve-casing receives the end of the rod G at the opposite side of the valve and is provided with a closing plug c^7, having a central guide-aperture within which the rod slides.

It is obvious that when the valves E and D are both closed the steam within the receiver will be "bottled up" or imprisoned therein, so that not only may any excess of exhaust-steam from the high-pressure cylinder escape into the open air through the relief-valve and thus be prevented from reaching the low-pressure cylinder, but steam already within the receiver is restrained from acting on the low-pressure cylinder and is confined within the receiver for subsequent use as soon as the low-pressure cylinder shall again come into action.

For the general purposes of the invention the rod G may be moved for actuating the valve D by any suitable connection with the governing device of the engine. I have, however, herewith shown a steam-actuated operating mechanism in the form of an auxiliary motor for the valve-rod, which is constructed as follows: Said motor in the form shown comprises an auxiliary steam-cylinder having a steam-valve connected with the governor and serving to admit steam to one side or the other of the piston within the cylinder, according to the position of the governor, said piston being suitably connected with the rod G to give reciprocatory motion to the same and to thereby open and close the receiver-valve. In the form shown H is the auxiliary cylinder and H′ the piston therein, said piston

being attached directly to the end of the rod G, which enters the cylinder through the stuffing-box h in the usual manner. Steam is admitted to the opposite sides of the piston H′ through suitable ports h^2 h^3 and is in this instance exhausted through the same ports, the steam supply and exhaust being controlled by a suitable valve I. The valve shown in this instance is of the well-known hollow piston form, embracing two short pistons i i' at the end of the tubular body portion i^2, of smaller diameter. A steam-supply pipe h^4 admits steam to the annular space surrounding the body portion of the valve-piston, the spaces at the ends of the piston are connected by a central passage in the valve, and an exhaust-pipe h^5 communicates with one of said spaces. Attached to the valve I is the usual valve-rod I′, which passes through a suitable stuffing-box h^6 and is supported near its outer end by a suitable bracket-bearing J, Fig. 3. Suitable connections are provided between the valve-rod and the governor, by which the latter operates the said valve, and thereby, through the operation of the auxiliary motor described, serves to open and close the receiver-valve.

In the present form of my invention I provide connections between the governor and the valve of such nature that the ordinary fluctuations of the governor do not affect the position of said valve, and no movement of the latter takes 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 its normal conditions. Said connections are, however, so constructed as to quickly move the valve-rod and valve in one direction whenever the governor exceeds such predetermined limit of movement and in the other or opposite direction when the said governor returns or repasses such limit of movement.

Various connections capable of producing the above-described action may be devised; but in this instance I have shown for actuating the valve a cam mechanism comprising a pivoted cam K, Figs. 2 and 7, which is provided with a cam-slot k, engaging a pin l in one end of the sliding rod L, the opposite end of which is connected with the valve-stem I′ by means of a bell-crank lever M and two connecting-links m m', Fig. 3. The cam-slot k of said cam is provided with a concentric part k', with which the pin l is normally engaged, at the end of which concentric part is a relatively-short eccentric portion k^2, beyond which, in the instance shown, is formed a second concentric portion k^3, the radial distances between the two eccentric portions being sufficient to give a desired travel to the valve. The cam K is connected with the governor so as to oscillate with the fluctuations of the same, such connections being in the present instance shown as provided by means of a connecting-rod N, pivoted at its upper end to a lever N′, which is fitted to any oscillating part of the governor. Said rod N is connected at its lower end with the cam K or some part rigidly connected to oscillate therewith, in this instance to an arm O′, which is affixed to one end of the shaft O, to which the cam is rigidly secured and which serves as a pivotal support for the said cam. In the form shown the lever N′ is made of considerably greater length than the arm O′, in order that a relatively-slight fluctuation of the governor may produce a considerable oscillation of the cam. The concentric portion k' of the cam-slot is of such length that the ordinary movements of the governor will not swing the cam far enough to engage the pin l with the eccentric portion k^2, and it is obvious that unless this is done the valve-rod will remain stationary. Thus, under ordinary circumstances no extra work is done by the governor beyond the slight force required to oscillate the cam, and consequently its freedom and delicacy of action are not interfered with. When, however, under an unusual decrease of load or increase of steam-pressure, the movement of the governor exceeds the predetermined limit, the cam K will be swung so far as to cause the pin l to pass the eccentric portion k^2 of the slot and thereby shift the valve I. Further movement of the governor and cam in the same direction will merely cause the pin to enter farther in the eccentric continuation of the slot without affecting the position of the valve, but a reverse movement of the cam will return the pin through the eccentric portion of the slot and thus carry the valve back to its first position.

By so constructing the parts that a slight movement of the governor will cause a considerable oscillation of the cam, as hereinbefore stated, and by making the eccentric portion of the cam-slot relatively short, a slight movement only of the governor will be required after the proper point has been reached to move the valve I the full length of its stroke. In the normal position of the valve the latter is in position to admit steam to that side of the piston H by which the main valve-ports leading from the receiver are held open. When the valve is moved to the other end of its stroke by an excessive movement of the governor in the manner hereinbefore explained, live steam will be admitted to the opposite end of the cylinder, while at the same time exhaust-steam escapes from that end of the cylinder filled with the same, so that the piston will be carried in a direction to move the receiver-valve, thereby closing the exit of the receiver, the surplus exhaust-steam from the high-pressure cylinder escaping through the exit-passage C^3. The valve I will be held in this position until, as the engine resumes its normal speed said valve will return to its first position, when steam will be admitted to force back the piston and again actuate the receiver-valve to bring it to its normal or

working position. It will be obvious that the shifting of the piston of the auxiliary motor under the pressure of steam will be practically instantaneous and coincident with the movement of the valve I by the governor, and the latter action being quickly accomplished at a predetermined point in the movement of said governor, it follows that as the governor passes such predetermined point in its movement the receiver-valve D will be instantly opened or closed, as the case may be. Normally the valves D will be held open in the manner hereinbefore described, the exhaust-steam from the high-pressure cylinder passing through the exhaust-passage thereof and the receiver to the low-pressure cylinder in the usual manner, while the governor fluctuates as usual under slight variations of load or steam-pressure. In case, however, the movement of the governor is so great as to exceed the desired limit of speed, the governor operates in the manner previously described to instantly move said valves, thereby cutting off the passage of steam already in the receiver to the low-pressure cylinder, so as to relieve the same of further actuating-pressure, and confining the steam within the receiver for subsequent use when the engine returns to its normal speed. In cases where provision is made for heating the receiver, as by a steam-jacket, as is the case in the engine herein illustrated, the steam thus imprisoned within the receiver will be maintained at a sufficiently-high temperature and pressure to do effective work as soon as admitted to the low-pressure cylinder.

The limit of movement of the governor at which the same will operate to actuate the receiver-valve D will usually be at the point at which the said governor operates to completely cut off the steam-supply from the high-pressure cylinder, so that the engine will be permitted to operate in the ordinary manner and will be controlled by the usual governing devices until such time as such governing devices shall have reached the limit of their effectiveness, whereupon the additional governing devices, herewith described, will come into play to further and more effectively control the engine. The low-pressure cylinder will obviously, after the cutting off of its steam-supply in the manner described, practically remain inoperative until the governor repasses the point at which the receiver-valves were closed, but owing to the fact that the steam-supply passage of said low-pressure cylinder will then be entirely closed, the piston of said low-pressure cylinder will at such time act against a vacuum, which will tend to lessen the speed of the engine and thus aid in quickly bringing the engine to the desired limit of speed.

The relief-valve E being set to open at a pressure approximately equal to or not greatly in excess of the normal pressure within the receiver, it follows that when the valve D is again opened, after having been closed, steam will be admitted at normal pressure to the low-pressure cylinder at such time. In the absence of said relief-valve, it is obvious that under some circumstances the steam-pressure in the receiver might become very great, the inertia of the fly-wheel and other rapidly-moving parts of the engine being commonly sufficient to force so much steam into the receiver as to establish a high pressure therein; but in the construction proposed any excess of the exhaust-steam will escape through the relief-valve and the receiver will remain filled with steam at a normal or moderate pressure only. It will be noted, furthermore, that inasmuch as the exhaust-valves of the high-pressure cylinder are open at the time the piston reaches the end of its stroke in each direction, steam thus confined in the receiver will rush into the cylinder as soon as said exhaust-valves are open, so as to give a back-pressure on the piston, and that the piston in its backward movement will force such steam back again into the receiver, and in doing so will compress the steam and restore it to its original pressure, or nearly so. Steam thus entering the cylinder through the exhaust-valves will act by its backward pressure on the piston to retard the engine, and will thus tend to quickly lessen its speed—in other words, the work done by the piston during its back stroke, in forcing the steam back into the receiver and compressing it to its original bulk, will tend to quickly retard the speed of the parts and to thus more promptly bring the engine to its normal speed. It is to be further noted that this action will continue during every stroke of the piston until the speed of the engine is properly reduced and steam is again admitted to the low-pressure cylinder, it being obvious that steam from the receiver will enter each end of the cylinder and will be forced from the same back into the receiver at every stroke, so that the same receiver full of steam is compressed again and again until, by the reduced speed of the engine, normal working conditions are restored.

Inasmuch as the steam-pressure in the receiver when made of sizes ordinarily employed will be considerably reduced when the steam therein expands into the high-pressure cylinder, it will usually be preferable, in order that the back-pressure of steam in the piston may act more efficiently in retarding the engine, to set the relief-valve to open at a pressure somewhat above the normal pressure in the receiver. This will not, under usual conditions, produce objectionable pressure on the low-pressure cylinder at the time of opening the valve D, owing to the large size of said low-pressure cylinder as compared with the receiver. The relief-valve will, however, be so set that the effective pressure in the low-pressure cylinder at the time referred to will not be materially greater than that which obtains when the governing devices are not in operation.

As a further and separate improvement, I propose to apply to the exhaust-passage of the low-pressure cylinder of a compound engine a receiver the exit-opening of which is provided with a valve which is opened and closed by the operation of the engine-governor in the same manner as is the valve D, herein shown as applied to the receiver C, or that between two cylinders. By the use of such receiver and valve upon the low-pressure cylinder I am enabled to secure the same retarding effect on the piston of said low-pressure cylinder by back-pressure on said piston and repeated compression of exhaust-steam within the receiver as is obtained in the construction hereinbefore described by the use of the receiver C and valve D. In the use of such receiver and valve applied to the exhaust of the low-pressure cylinder, the valve may be controlled by the governor of the engine or by a separate governor, and, furthermore, the valve may be operated by the same devices used to operate the corresponding valve of the receiver between the cylinders or by separate actuating mechanism. Commonly both valves will be actuated by the same governing devices, because both valves are desirably actuated at the same time. A construction of this latter kind is shown in the drawings, in which P is the receiver, and which is connected at one end of the exhaust-pipe P′ of the low-pressure cylinder B, and its opposite end with an exit-pipe P^2, leading to the open air or to a condenser. Q indicates a valve at the exit end of the receiver, said valve being like the valve D and being operated from the rod G by means of a valve-rod R and a centrally-pivoted lever R′, engaging the rods G and R, as shown. The receiver P and valve Q act in the same manner as do the receiver C and valve D as far as the retarding of the moving parts is concerned, the closing of said valve Q establishing a back-pressure in the low-pressure cylinder and resulting in the steam confined in the receiver repeatedly expanding into the cylinder and being compressed again into the receiver. An important advantage is gained by applying the retarding force of the steam from a receiver to both the high and low pressure cylinders of a compound engine or to all the cylinders of a triple or quadruple expansion engine, for the reason that by this construction are avoided torsional strains on the shaft and other dangerous strains which must necessarily come on the parts when retarding pressure is applied to one cylinder only or to less than all of the cylinders.

In connection with the use of a second receiver applied to a low-pressure cylinder, as above described, and as a still further improvement, I propose to provide a valved passage leading directly from the first receiver to the second receiver, said passage being normally closed, but adapted to be thrown open simultaneously with the closing of the valves at the exits of the two receivers to admit steam directly from the first receiver into the second receiver and thus increase the back-pressure on the low-pressure piston and add greatly to its retarding action. Obviously, however, if the pressure in the second receiver is suddenly increased to equal that of the first receiver, the retarding force resulting on the great area of the low-pressure piston may, in some instances, produce dangerous strains upon the driving-shaft and other parts of the engine. I therefore, also, preferably provide the passage connecting the receivers with a suitable reducing-valve by which the pressure in the second receiver may be limited, as desired. Such reducing-valve may, if desired, be combined with the valve, by which the passage is opened and closed by the governor, a single valve in this case accomplishing both the controlling of the passage and the limiting of the pressure in the second receiver. In this instance, however, I have shown the two valves as independent of each other, the construction being as follows: Connecting the low-pressure steam-pipe C^2 with the low-pressure exhaust-pipe P′ is a short passage or pipe P^3, which is provided with a controlling-valve S of any suitable type adapted to open and close the passage, said valve being, in this instance, shown as an ordinary plug-valve operated by a lever *s* and connecting-rod *s*′ from the oscillatory lever R′ and normally held closed thereby. The pipe P^3 is also provided in this instance, at a point between the low-pressure exhaust-pipe P′ and the valve S, with any suitable reducing-valve T, preferably of the ordinary type, capable of being adjusted or set at will to maintain any desired pressure in the second receiver when the valve S is open. With such construction it is obvious that the action of the engine will nominally remain unchanged, as before. When, however, the variation in speed becomes so great as to close the valves D and P^2 in the manner hereinbefore described, the valve S will simultaneously open and permit the flow of steam through the pipe P^3. The pressure of steam in the second receiver will obviously thereby be raised to the extent permitted by the reducing-valve, previously adjusted as desired, and exert a correspondingly greater back-pressure on the low-pressure piston, tending to restore the engine to its normal speed. This feature of improvement is of great value for use on condensing-engines, inasmuch as in such structures the vacuum ordinarily maintained by the condenser, and necessarily existing in the second receiver at the time the valves at the exits of the receivers are closed, will ordinarily prevent the comparatively small amount of steam which remains to pass through the low-pressure cylinder after the closing of the said valves from producing sufficient back-pressure to effect the desired degree of retarding action in the absence of a supply of higher-pressure steam from another source than by the way of the low-pressure cylinder.

The improvements herein illustrated are

obviously equally useful in connection with any type of governor, and may be used either with a ball or shaft load or speed motor or automatic cut-off governor. The improvements described, moreover, are not only applicable to all forms of compound engines, but to marine, as well as stationary engines. They are, indeed, particularly adapted for marine engines, because of a character to act quickly and positively in checking the speed of the engine and thereby preventing racing of the propeller when lifted out of the water.

I desire not to be limited to the details of construction shown or to any specific details of the devices for carrying out my invention, it being obvious that various forms of mechanism may be designed which will embody the general principles of construction and operation embraced in my invention.

Some of the advantages obtained by the use of the features of construction described in the passage connecting the high and low pressure cylinders, may be secured by the use of a valved discharge opening or outlet, permitting the escape of steam from the high-pressure cylinder, in connection with a single valve located at any point between the said outlet and the low-pressure cylinder and operated by the governor in the same manner as hereinbefore described, in cases where the exhaust-pipe of the high-pressure cylinder leads directly to the low-pressure cylinder and where there is practically no receiver, or, in other words, where the receiver is so small that the quantity of steam contained therein is insignificant. In such case steam from the high-pressure cylinder will be allowed to escape therefrom, while at the same time access of steam to the low-pressure cylinder will be prevented, so that the piston of the latter will work against a vacuum and thus tend to quickly retard or diminish the speed of the engine in the same manner as hereinbefore stated, although such a structure would not possess the advantage of storing or holding the steam in the receiver for repeated compression and subsequent use.

I claim as my invention—

1. A governing device for compound engines comprising a normally closed outlet in the steam passage which leads from the high to the low pressure cylinder, said outlet being provided with a relief valve and a normally open valve controlled by the engine governor, located in said steam passage between said outlet and the low pressure cylinder, substantially as described.

2. A governing device for compound engines comprising a normally closed outlet in the steam passage which leads from the high to the low pressure cylinder, said outlet being provided with a relief valve, a normally open valve in the said steam passage between the outlet passage and the low pressure cylinder, and a governor acting to close said last mentioned valve when the engine reaches a predetermined limit of speed, substantially as described.

3. The combination with high and low pressure cylinders and an intermediate receiver, of a relief valve applied to the receiver, a normally open valve at the exit of the receiver and a governor acting to close said valve when the engine reaches a predetermined limit of speed, substantially as described.

4. The combination with high and low pressure cylinders of a receiver between the cylinders, a receiver connected with the exhaust passage of the low pressure cylinder, normally open valves at the exit ends of both receivers, a governor acting to open and close both of said valves when the engine reaches a predetermined limit of speed, and a relief valve applied to the receiver between the cylinders, substantially as described.

5. A governing device for compound engines comprising a normally open valve adapted to close the low pressure exhaust pipe, a normally closed passage for admitting an auxiliary steam supply between the cylinder and valve, and means controlled by the governor for simultaneously closing said valve and opening said passage, substantially as described.

6. A governing device for compound engines comprising a normally open valve in a low pressure exhaust pipe, a passage leading from the low pressure steam pipe to the low pressure exhaust pipe between the cylinder and valve, a valve normally closing said passage and means controlled by the governor for simultaneously closing the valve in the exhaust pipe and opening the valve in the passage, substantially as described.

7. A governing device for compound engines comprising a normally open valve adapted to close the low pressure exhaust pipe, a normally closed passage leading from the low pressure steam pipe to the low pressure exhaust pipe between the valve and cylinder, a reducing valve in said passage and means controlled by the governor for simultaneously closing the valve in the exhaust pipe and opening the passage, substantially as described.

8. A governing device for compound engines comprising a receiver between the high and low pressure cylinder, a normally closed valve at the outlet of said receiver, a normally open valve in the low pressure exhaust pipe, a normally closed passage leading from a point on the receiver between the valve therein and the high pressure cylinder to a point on the low pressure exhaust pipe between the valve therein and the low pressure cylinder, and means controlled by the governor for simultaneously closing said valves and opening said passage when the engine reaches a predetermined limit of speed, substantially as described.

9. A governing device for compound engines comprising a receiver between the high

and low pressure cylinder, a normally closed valve at the outlet of said receiver, a normally open valve in the low pressure exhaust pipe, a normally closed passage leading from a point on the receiver between the valve therein and the high pressure cylinder to a point on the low pressure exhaust pipe between the valve therein and the low pressure cylinder, a reducing valve in said passage, and means controlled by the governor for simultaneously closing said valves and opening said passage when the engine reaches a predetermined limit of speed, substantially as described.

10. A governing device for compound engines comprising a receiver between the high and low pressure cylinder and provided with a relief valve, a normally closed valve at the outlet of said receiver, a normally open valve in the low pressure exhaust pipe, a normally closed passage leading from a point on the receiver between the valve therein and the high pressure cylinder to a point on the low-pressure exhaust pipe between the valve therein and the low pressure cylinder, a reducing valve in said passage, and means controlled by the governor for simultaneously closing said valves and opening said passage when the engine reaches a predetermined limit of speed, 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:
HENRY H. CARTER,
TAYLOR E. BROWN.