(No Model.) 2 Sheets—Sheet 1.

M. C. BULLOCK.

STEAM ENGINE.

No. 564,001. Patented July 14, 1896.

Fig. 1.

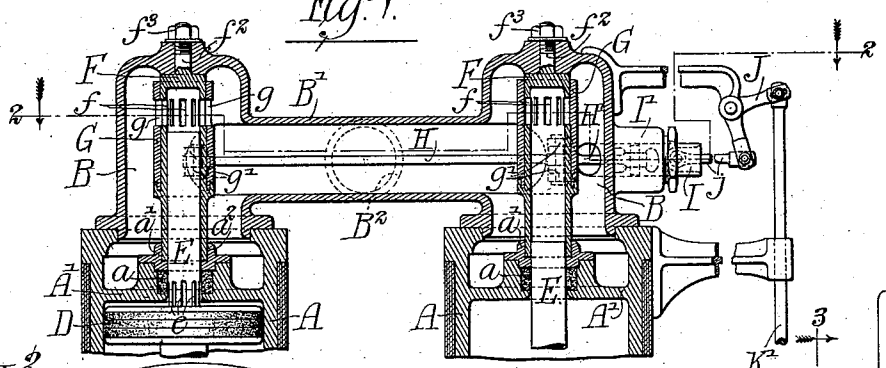


Fig. 3.

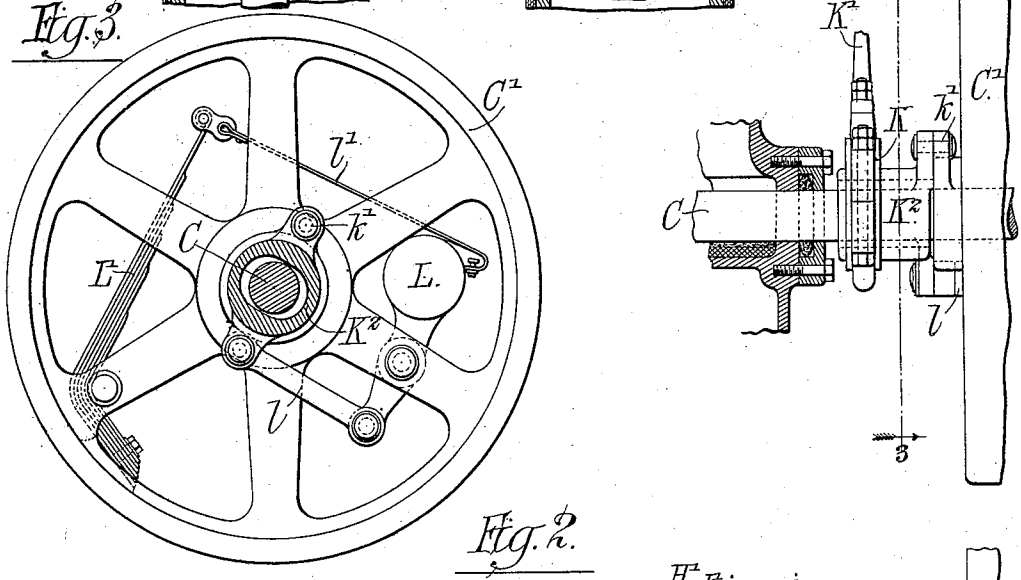
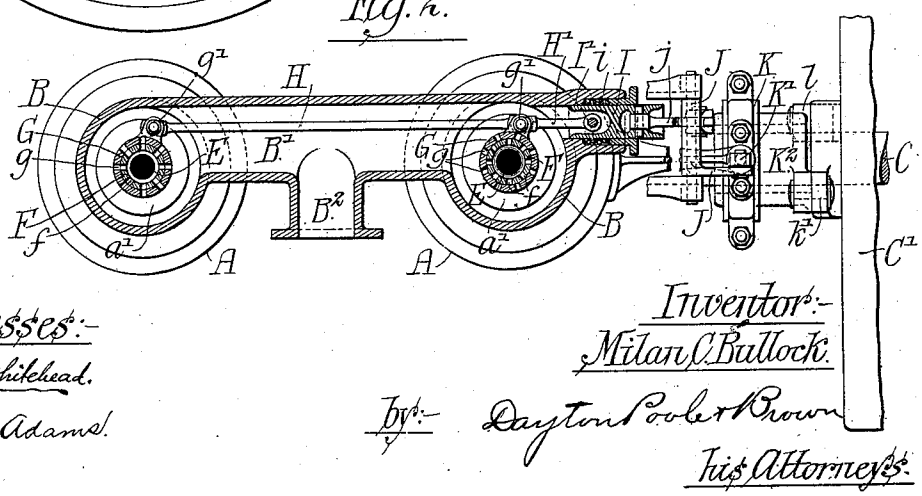


Fig. 2.



Witnesses:-
Louis M. Whitehead.
Jno. W. Adams.

Inventor:-
Milan C. Bullock.
by:- Dayton Poole Brown
his Attorneys.

(No Model.) 2 Sheets—Sheet 2.

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Fig. 4.

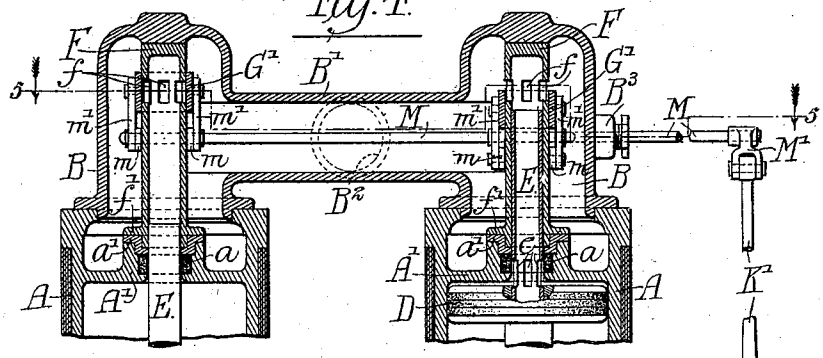


Fig. 6.

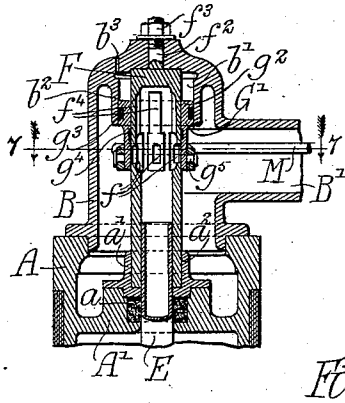


Fig. 7.

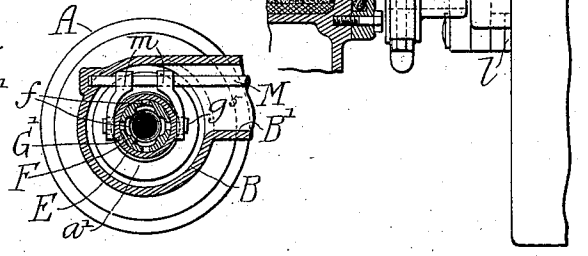


Fig. 5.

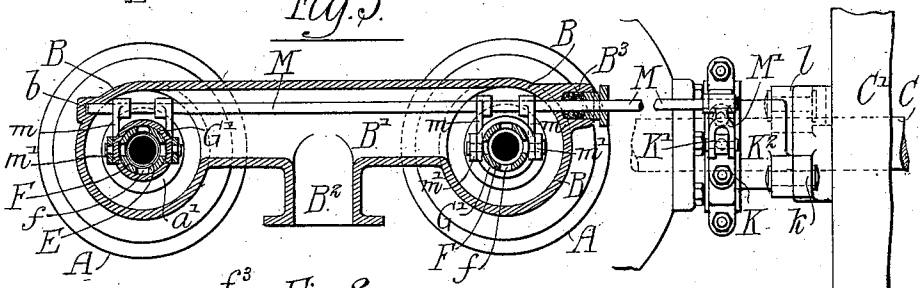
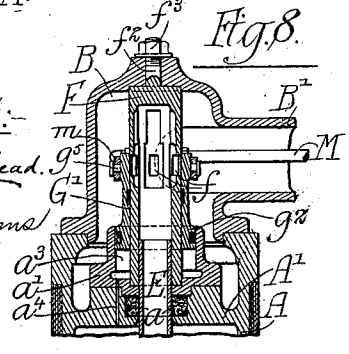


Fig. 8.



Witnesses:-

Louis H. Whitehead.

Jno. W. Adams

Inventor:-

Milan C. Bullock

by:- Dayton Poole & Brown

his Attorneys.

UNITED STATES PATENT OFFICE.

MILAN C. BULLOCK, OF CHICAGO, ILLINOIS.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 564,001, dated July 14, 1896.

Application filed February 7, 1894. Renewed April 29, 1896. Serial No. 589,606. (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 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 steam-engines of that kind having a hollow or tubular piston-rod through which steam is admitted to the steam-cylinder; and it consists in the matters hereinafter described, and pointed out in the appended claims.

The improvements constituting the invention are herein shown as applied to a single-acting engine having a plurality of cylinders arranged side by side, a single crank-shaft, pistons in the cylinders attached to piston-rods which severally engage the cranks of the shaft, and tubular piston-rods which enter the steam-chests and through which steam is admitted to the cylinders, the engine shown in respect to the features mentioned being generally similar to that illustrated and described in the prior patent to P. W. Willans, No. 339,242, dated April 6, 1886.

In the accompanying drawings, illustrating my invention, Figure 1 is a sectional view of the steam-chests and adjacent parts of the cylinders, together with a part of the crank-shaft with eccentric thereon, illustrating one embodiment of my invention. Fig. 2 is a sectional plan view of the parts shown in Fig. 1, taken on line 2 2 of the said Fig. 1. Fig. 3 is a detail section taken on line 3 3 of Fig. 1, showing features of construction in the fly-wheel governor illustrated. Fig. 4 is a view similar to Fig. 1, showing a vertically-sliding instead of an oscillatory steam-valve. Fig. 5 is a plan section taken on line 5 5 of Fig. 4. Fig. 6 is a sectional view of one steam-chest similar to Fig. 1, showing another form of vertically-reciprocating valve. Fig. 7 is a sectional plan view of the parts shown in Fig. 6, taken on line 7 7 of said Fig. 6. Fig. 8 is a view similar to Fig. 7 of a slightly modified construction.

As shown in the several figures of the drawings, A A indicate the engine-cylinders, B B the steam-chests attached thereto, C the crank-shaft, and C′ the fly-wheel, of an engine.

The cylinders A A may represent either the steam-cylinders of a simple single-acting two-cylinder engine or said cylinders may be the high-pressure cylinders of a single-acting double-tandem compound engine, such as is shown in said prior Willans patent, the features of this invention relating more especially to means for controlling the steam-supply to the hollow piston-rods of engines in which the steam is supplied through a hollow piston-rod, and being equally applicable to simple and compound engines.

The steam-chests B B are shown as connected by means of a steam-pipe B′, to which is connected a supply-pipe B^2. To the pistons D D of the cylinders are attached hollow or tubular piston-rods E E, which pass through the cylinder-heads A′ A′ into the steam-chests B B, in the same manner as in the said prior Willans patent.

Each of the hollow piston-rods E E is provided with ports *e e* adjacent to the piston D for the passage to the upper end of the cylinder A of steam, which enters the open upper end of the hollow piston-rod. Unlike the piston-rod of the Willans patent referred to, the piston-rod has no internal valve to control the passage of steam through the ports *e e*, and steam entering the open upper end of the rod is free to pass uninterruptedly to the cylinder through said ports.

No valve is herein shown for controlling the exit of exhaust-steam from the cylinder, and such valve may be of any suitable construction—as, for instance, it may be like that shown in said prior Willans patent, or it may be like that shown in a prior patent, No. 533,157, granted to me January 5, 1895. The cylinder-head A′ is provided with a packing or stuffing box *a*, closed by a gland or cap *a′*, by which the escape of steam past the piston-rod is prevented in the usual manner.

To now refer more particularly to the devices embodying the present invention and to the form thereof shown in Figs. 1, 2, and 3, F indicates a wall or tubular partition arranged vertically within the steam-chest B in axial alinement with the piston-rod E, and closed at its upper end, so as to constitute in

effect an inclosure or chamber within the steam-chest, in which the upper end of the hollow piston-rod moves during the stroke of the piston. Said tube F is provided with steam-ports *f f*, through which steam entering the steam-chest is allowed to pass to the open upper end of the hollow piston-rod, steam-tight connections being provided at the ends of the tube, so as to prevent passage of steam from the steam-chest to the hollow piston-rod, excepting through the ports *f f*. Any suitable construction may be provided for the purpose last mentioned, two of which I have shown in the accompanying drawings. As seen in Fig. 4, the tube F is closed at its upper end, and at its lower end is provided with an outwardly-extending annular flange *f'*, which rests on and is bolted to the ring *a'* of the stuffing-box. As shown in Fig. 1, the tube F is made cylindric at its lower end, and adapted to fit within an annular recess a^2, formed in the ring *a'*, while the upper end of the said tube is closed and provided with a central stem f^2, which passes through a central aperture in the top wall of the steam-chest, and is provided with a nut f^3, by which the tube is firmly clamped in place, and a steam-tight joint is made to prevent the escape of steam past the stem f^2. In this instance the tube F is made of an internal diameter approximately the same or only slightly greater than the external diameter of the piston-rod, so as to avoid clearance space, and the ports *f* are located at a point above the piston-rod when the same is at the upper end of its stroke. Said ports *f* are controlled by an oscillating valve ring or sleeve G, which surrounds the tube F, and is provided with ports *g*, corresponding in size and angular distance apart with said ports *f*. Said sleeve G is actuated from an eccentric on the crank-shaft C of the engine, so as to admit steam through the ports *f f*, and to thereby supply steam to the engine-cylinder at each stroke of the piston-rod. In connection with the actuating devices for operating the said valve-ring, I have provided a governing device of that kind known as an "automatic cut-off governor," which acts to control the movement of the said sleeve in such manner that the ports *f* will be opened at each stroke of the engine to admit steam to the cylinder to a greater or less extent, according to the work being done by the engine. Inasmuch as the steam enters the open upper end of the hollow piston-rod, and passes therethrough to the ports *e*, the admission of steam to the cylinder is controlled entirely by the valve-sleeve G.

The devices shown for actuating the sleeve G are of simple form, and are constructed as follows: H is a horizontal rod extending through the steam-pipe B' and connected with arms *g' g'* on the sleeve G. I is a piston which slides in an open-ended cylinder I', formed or attached to the wall of the steam-chest B at the right-hand side of the engine, which cylinder is open at its inner end to the steam pressure within the steam-chest and at its outer end to the air, and is provided with a packing *i* to prevent the escape of steam past the piston I. Said piston is therefore subject to steam pressure within the steam-chest, which tends to force the same outwardly. The piston I is connected at its inner end with the rod H by a connecting-rod H', and at its outer end is connected with and gives movement to a bell-crank lever J by means of a connecting-rod *j*. The engine crank-shaft C is provided with an eccentric K, the eccentric-rod K' of which extends upwardly to and is pivotally connected at its upper end with the horizontal arm of the bell-crank lever J. Said eccentric, through the medium of the bell-crank lever, gives reciprocatory motion to the piston I and rod H, whereby the valve-sleeve is oscillated. Pressure of steam on the inner end of the piston I holds the lower part of the eccentric-strap constantly in contact with the eccentric and all of the bearing-surfaces of other connected parts in contact with each other, notwithstanding looseness of the parts occasioned by wear, so that perfect smoothness of action and absence of lost motion is secured. The eccentric K is attached to a sleeve K^2, which has lateral movement relative to the shaft, and said sleeve is moved laterally to vary the throw of the eccentric by means of a governing device applied to the fly-wheel of the kind known as a "fly-wheel governor." As herein shown, the sleeve K^2 is connected by a pivot *k'* with the hub of the fly-wheel C', and is connected at its side opposite the pivot by a connecting-rod *l* with a governing-weight L, the outward movement of which is controlled by a spring L', the free end of which is connected with the weight by a strap *l'* in a familiar manner.

In Figs. 4 and 5 is shown a construction which is in all respects like that shown in Figs. 1, 2, and 3, with the exception that the admission of steam through the ports *ff* of the tube F is controlled by means of a sliding valve-ring G', instead of by an oscillating sleeve, and the valve-actuating devices are modified as necessary to give motion to the sliding ring. In this instance the ring G' is the form of a simple hollow cylinder surrounding the tube F, and adapted to slide downwardly on the tube to uncover or open the steam-inlet ports. For actuating the valve-ring G' a horizontal rock-shaft M extends through the connecting steam-pipe B' and passes through a stuffing-box B^3 in the wall of the steam-chest at the side of the engine at which the eccentric and governing devices are located. The said shaft is shown as being supported at one end by said stuffing-box and at its opposite end by a bearing aperture formed in the wall of the steam-chest. Said rock-shaft is actuated from the eccentric K by means of a horizontal arm M' on the outer end of the shaft, which arm is connected

with the upper end of the eccentric-rod K'. For communicating motion from the rock-shaft to the sliding valve-rings G'G', said rock-shaft is provided with rigidly-attached arms $m\,m$, which extend horizontally from the rock-shaft to points below the valve-ring and are connected with said valve-ring by upright links $m'\,m'$.

By the construction described motion is transmitted continuously from the eccentric to the ring-valves, and said rings are moved a greater or less distance to give admission of steam through a longer or shorter period, as determined by the action of the fly-wheel governor, which acts to vary the throw of the eccentric-rod in the same manner as heretofore common, and as hereinbefore described in connection with the mechanism shown in Figs. 1, 2, and 3.

In Figs. 6 and 7, I have shown a construction similar to but somewhat different from that shown in Figs. 4 and 5. In this instance the ports $f\,f$ of the tube F are located below the limit of the movement of the top of the piston-rod, and the walls of the tube are made considerably thicker than those of the tubes shown in Figs. 1 and 4. The upper part of the piston-rod fits closely within the said tube, but the tube is provided on its inner surface with longitudinal passages $f^4\,f^4$, which connect with the steam-inlet ports $f\,f$ and extend vertically upward to a point above the upper end of the piston-rod when the same is at its highest point, so as to afford communication from the steam-inlet ports f to the ports e of the piston-rod throughout the entire stroke of the latter. The construction described has the advantage of enabling the steam-chest as a whole to be made shorter or lower than is possible in the construction shown in Figs. 1 to 4, where the steam-inlet ports f are necessarily located at a point above the upper limit of the movement of the hollow piston-rod. When the construction shown in Figs. 6 and 7 is used, the hollow piston-rod may rise practically to the upper end of the surrounding tube F. Said Figs. 6 and 7 illustrate a further improvement, by which steam pressure within the steam-chest, acting on the vertical sliding valve-ring G', acts to thrust said valve-ring constantly in one direction and thus take up the lost motion which might otherwise arise from looseness in the joints of the several parts connecting the said ring with the fly-wheel governor. The ring G', in this instance, is adapted to slide upwardly on the tube F for uncovering the steam-inlet ports, and the upper end of the said ring fits closely within an annular chamber b', formed between the upper end of the tube F and the opposing part of the steam-chest, herein shown as consisting of a depending flange b^2 on the top wall thereof. The upper part of the ring G' is preferably provided with an annular enlargement g^2, forming in effect an annular piston. In said annular enlargement is inserted a suitable packing-ring g^3, and a similar packing-ring g^4 on the inner surface of the valve-ring makes a tight joint between said valve-ring and the tube F. The chamber b' is connected with the outer air by a small passage b^3 or otherwise. Steam-pressure within the steam-chest, acting on the part of the ring G' which slides in the annular recess b', tends to thrust said valve-ring upwardly, and thus maintains a constant pressure or tension on all the connecting parts, including the eccentric, whereby the parts of the pivotal and other joints are always in bearing against each other in one direction, and irregularity of action due to lost motion between the parts thereby entirely avoided.

The devices shown in Figs. 6 and 7 for giving motion to the valve-ring G' are like those illustrated in Figs. 4 and 5, with the exception that the arms $m\,m$ of the rock-shaft are in this instance connected with the ring G' by pins $g^5\,g^5$, engaging slots in the ends of the arms $m\,m$ instead of by connecting links.

The construction shown in Fig. 8 differs slightly from that shown in Figs. 6 and 7 in having the annular piston g^2 formed on the lower end of the ring G' and fitted within an annular chamber a^3 in the stuffing-box gland a', the chamber a^3 being placed in communication with the interior of the cylinder by a small passage a^4. The steam-pressure within the cylinder being at all times less than that within the chest, though the difference is but slight at the initial opening, a pressure in one direction only is maintained on the entire valve mechanism, with similar good results to those achieved by the construction shown in Figs. 6 and 7, although the direction of the pressure will obviously be reversed. The construction shown in Fig. 8, moreover, has the advantage of discharging any steam or water of condensation which may leak past the piston g^2 into the cylinder instead of into the open air.

It is obvious that the tubular partition or inclosure arranged as hereinbefore described constitutes in effect a stationary tubular extension of the hollow piston-rod, having sliding or telescopic connections therewith, and that by applying the steam-inlet valve to such tubular partition I avoid the necessity of using operative connections for driving the steam-inlet valve, embracing sliding and telescopic parts, such as are shown, for instance, in a prior application, Serial No. 478,148, filed by me June 9, 1893, or of using an eccentric on the crank-shaft of the engine, such as is shown in the prior Willans patent, it being obvious that by employing such tubular inclosure and placing the steam-inlet valve thereon said valve may be operated by connections of simple form from an eccentric on the crank-shaft or other moving part of the engine. One important advantage gained by the use of such stationary tubular partition arises, therefore, from the fact that it enables the valve to be actuated by connections of simple character

which can be easily and cheaply constructed and are not liable to derangement and of durable character.

An important feature of invention is embraced in the construction by which the valve arrangement as described is controlled by an automatic cut-off governing device applied to the crank-shaft or fly-wheel, in the manner common in other engines, this construction having the important advantage of obtaining all the benefits of a cut-off governor in an engine of the kind to which this invention relates without unduly increasing the number of parts or the expense of construction. By reason of these advantages, I desire to claim, as a means of controlling the steam supply to the engine-cylinder, the said tubular partition and a valve controlling the port or ports thereof, together with connections for driving said valve from a moving part of the engine, and an automatic cut-off governing device, without restriction to details of construction shown.

Certain of the details of construction herein shown are applicable to other forms of engines; such, for instance, as those in which the steam-valves are located in or carried by the hollow piston-rod, as shown and described in a separate application for patent, Serial No. 498,634, filed January 31, 1894, and as far as the claims on such features are concerned I do not desire to be limited to other features of construction shown.

I claim as my invention—

1. The combination with an engine-cylinder, a steam-chest, a piston, a hollow piston-rod extending into the steam-chest, said hollow piston-rod being provided with valve-ports for the admission of steam to the cylinder, of a wall or partition within the steam-chest forming an inclosure within which the piston-rod reciprocates and which is in constant open communication with the interior of said piston-rod, said wall or partition being provided with a steam-inlet port, a valve applied to said port for controlling the admission of steam to the cylinder, and operative connections between said valve and a moving part of the engine for actuating the valve, substantially as described.

2. The combination with an engine-cylinder, a steam-chest, a piston, a hollow piston-rod extending into the steam-chest, said hollow piston-rod being provided with valve-ports for the admission of steam to the cylinder, of a wall or partition within the steam-chest forming an inclosure within which the piston-rod reciprocates and which is in constant open communication with the interior of said piston-rod, said wall or partition being provided with a steam-inlet port, a valve applied to said port for controlling the admission of steam to the cylinder, and means for actuating said valve, embracing an automatic cut-off governing mechanism, substantially as described.

3. A multiple-cylinder, single-acting engine, embracing a plurality of steam-cylinders, steam-chests attached to the cylinders, pistons within the cylinders, hollow piston-rods extending into the steam-chests and provided with ports for the passage of steam to the cylinders, and walls or partitions within the steam-chests forming inclosures within which the piston-rods reciprocate and which are in constant communication with the interiors of said piston-rods, said walls or partitions being provided with steam-inlet ports, valves applied to said ports for controlling the admission of steam to the cylinders, and means receiving motion from a moving part of the engine for actuating said valves, substantially as described.

4. A multiple-cylinder, single-acting engine, embracing a plurality of steam-cylinders, steam-chests attached to the cylinders, pistons within the cylinders, hollow piston-rods extending into the steam-chests and provided with ports for the passage of steam to the cylinders, and walls or partitions within the steam-chests forming inclosures within which the piston-rods reciprocate and which are in constant communication with the interiors of said piston-rods, said walls or partitions being provided with a steam-inlet port, valves applied to said ports for controlling the admission of steam to the cylinders, and means for actuating said valves, embracing an automatic cut-off governing mechanism, substantially as described.

5. A multiple-cylinder single-acting engine comprising a plurality of steam-cylinders arranged side by side, steam-chests connected by a steam pipe or passage, pistons within the cylinders, hollow piston-rods extending into the steam-chests, walls or partitions within the steam-chests forming inclosures within which the piston-rods reciprocate, said walls or partitions being provided with steam-inlet ports, valves for controlling said ports, and means for actuating said valves, embracing an actuating-rod which extends through said steam pipe or passage and is connected with all of the said valves, and an eccentric on the crank-shaft of the engine connected with and actuating said rod, substantially as described.

6. The combination with a steam-cylinder, a steam-chest, a piston within the cylinder, and a hollow piston-rod extending into the steam-chest, of a wall or partition forming an inclosure in which the piston-rod reciprocates, said wall or partition being provided with a steam-inlet port, and a longitudinally-sliding valve-ring applied to the exterior of said tubular partition for controlling the passage of steam through said valve-port, substantially as described.

7. The combination with an engine-cylinder, a steam-chest, a piston within the cylinder, and a hollow piston-rod extending into the steam-chest, of a tubular partition located within the steam-chest and forming an inclosure in which the piston-rod reciprocates, said partition being provided with steam-in-

let ports, a valve applied to control said inlet-ports, operative connections between said valve and the crank-shaft of the engine by which the valve is actuated, and a piston subject to the steam-pressure within the steam-chest, and connected with the parts which operate the valve to take up lost motion therein, substantially as described.

8. The combination with an engine-cylinder, a steam-chest, a piston in the cylinder, and a hollow piston-rod extending into the steam-chest, said piston-rod being provided with steam-exit ports, and a tubular wall or partition forming an inclosure within which said piston-rod reciprocates, said wall or partition being provided with steam-inlet ports and with longitudinal spaces or passages at the sides of the hollow piston-rod affording constant open communication between said ports and the open upper end of the hollow piston-rod, and a valve controlling the admission of steam through said inlet-ports of the tubular wall or partition, substantially as described.

9. The combination with an engine-cylinder, a steam-chest, a piston in the cylinder, and a hollow piston-rod extending into the steam-chest, of a tube located within the steam-chest and forming an inclosure within which the piston-rod reciprocates, said tube being provided with annularly-arranged steam-inlet ports, a valve-ring surrounding said tube and adapted to slide endwise thereon, an annular piston connected with said ring, an annular recess surrounding the tube within which the said piston fits and slides and which is in communication with a space subject to lower pressure, and operative connections with the crank-shaft of the engine for actuating said valve-ring, substantially as described.

10. The combination with an engine-cylinder, a steam-chest, a piston in the cylinder, and a hollow piston-rod extending into the steam-chest, of a tube located within the steam-chest and forming an inclosure within which the piston-rod reciprocates, said tube being provided with annularly-arranged steam-inlet ports, a valve-ring surrounding said tube and adapted to slide endwise thereon, an annular piston connected with said ring, an annular recess surrounding the tube within which the said piston fits and slides and which is in communication with the cylinder, and operative connections with the crank-shaft of the engine for actuating said valve-ring, 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.