

4 Sheets—Sheet 1.

No. 510,256.

Patented Dec. 5, 1893.

Fig. 1.

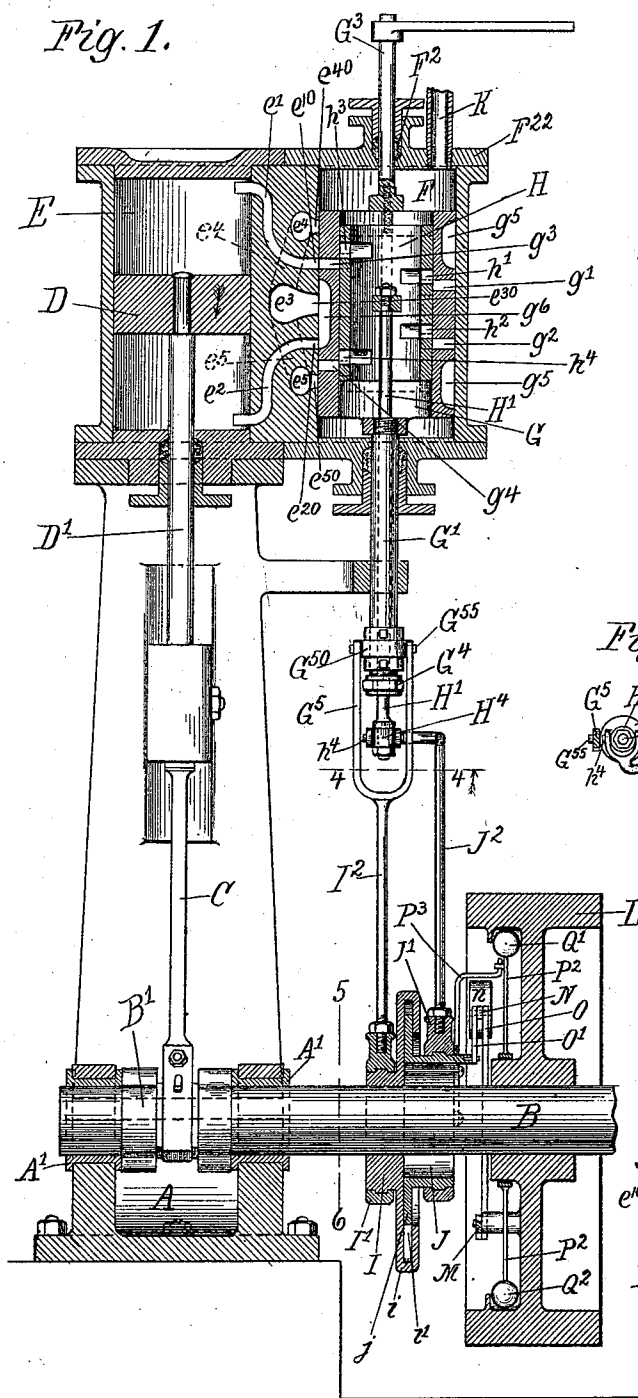


Fig. 2.

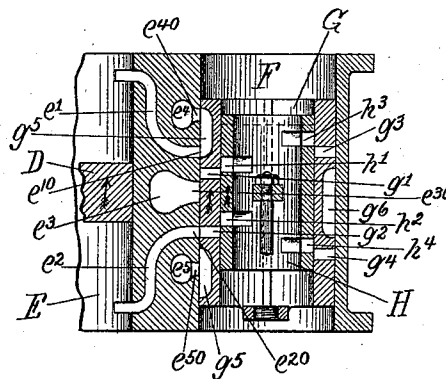


Fig. 4.

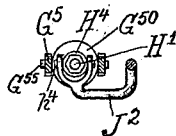
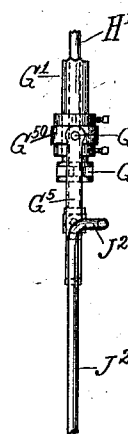
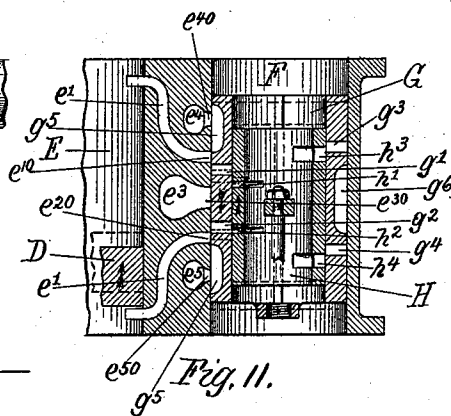


Fig. 3.



e⁵⁰ / Fig. 11.
g⁵



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(No Model.)

4 Sheets—Sheet 2.

C. HAMMEN.
REVERSING ENGINE.

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Fig. 8.

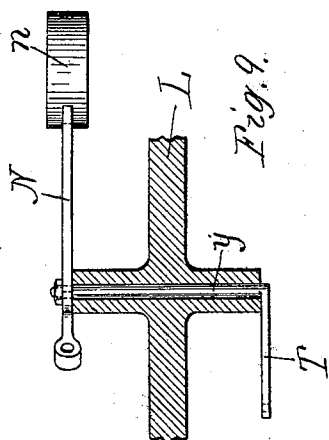
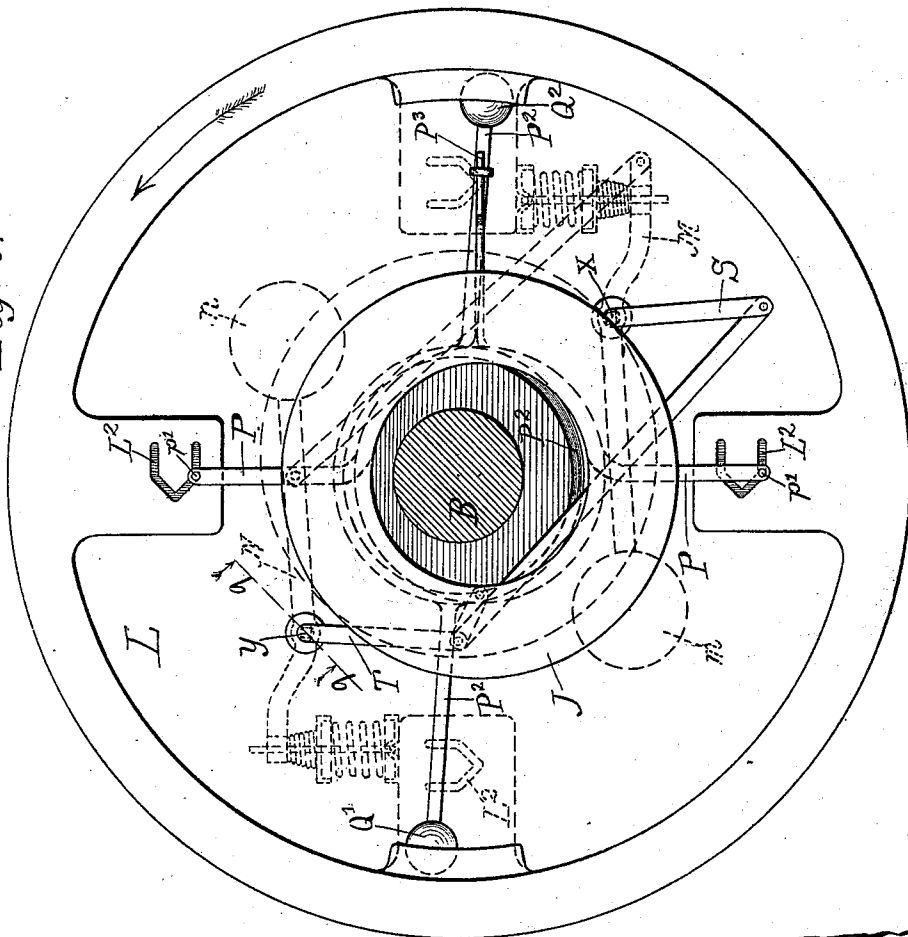
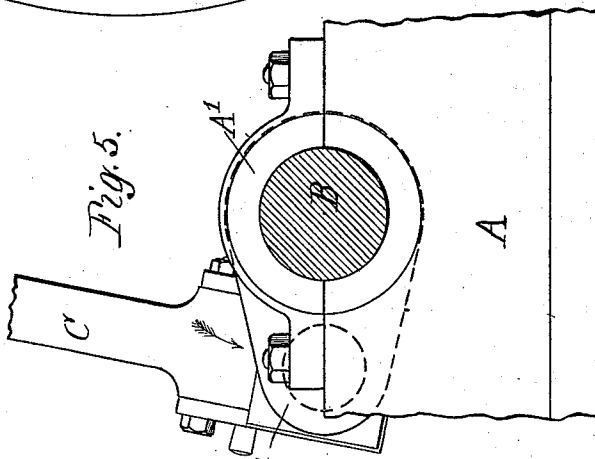


Fig. 9.

Fig. 5.



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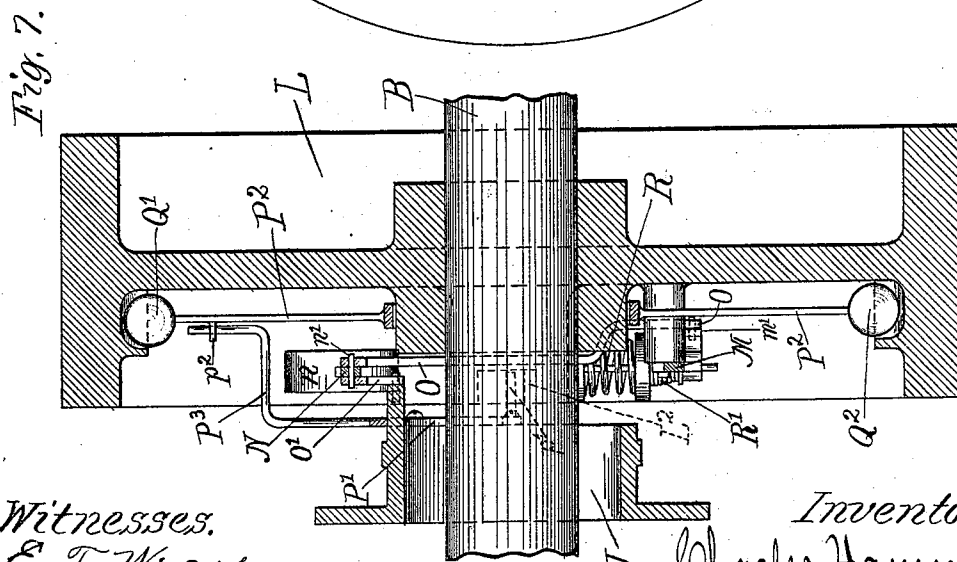
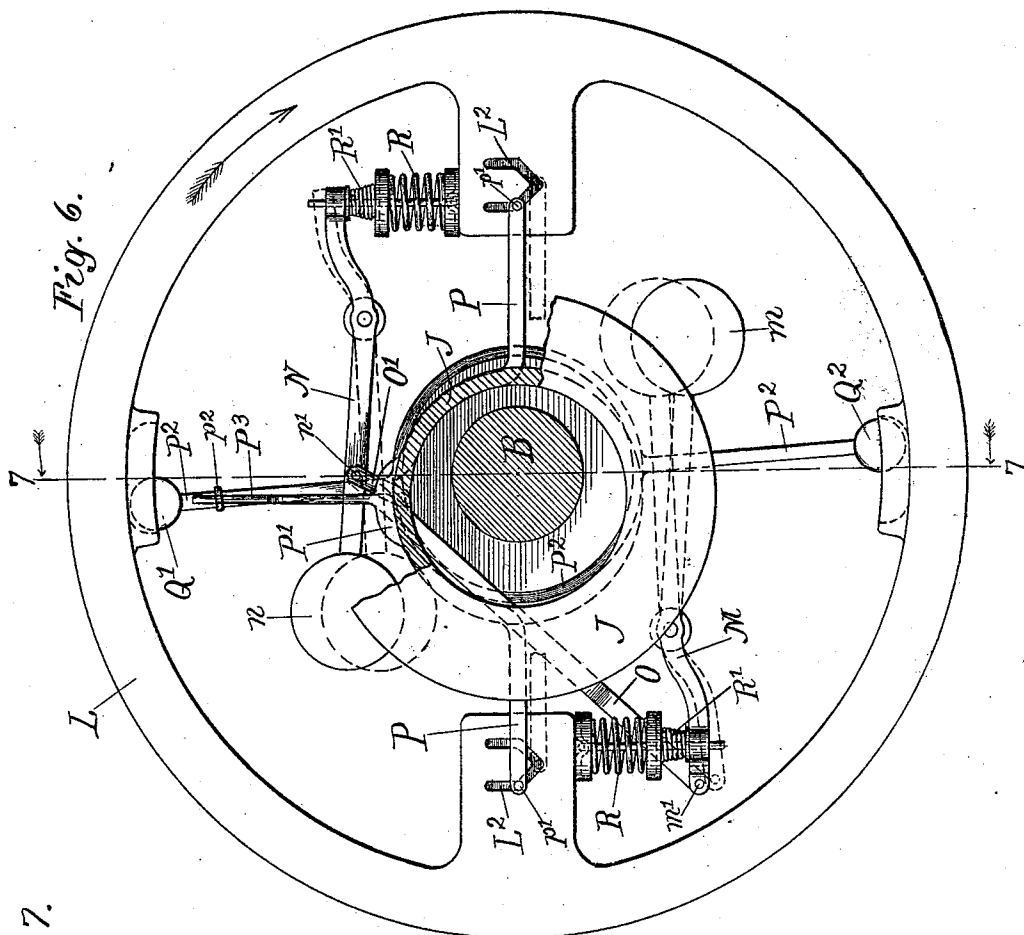
(No Model.)

4 Sheets—Sheet 3.

C. HAMMEN.
REVERSING ENGINE.

No. 510,256.

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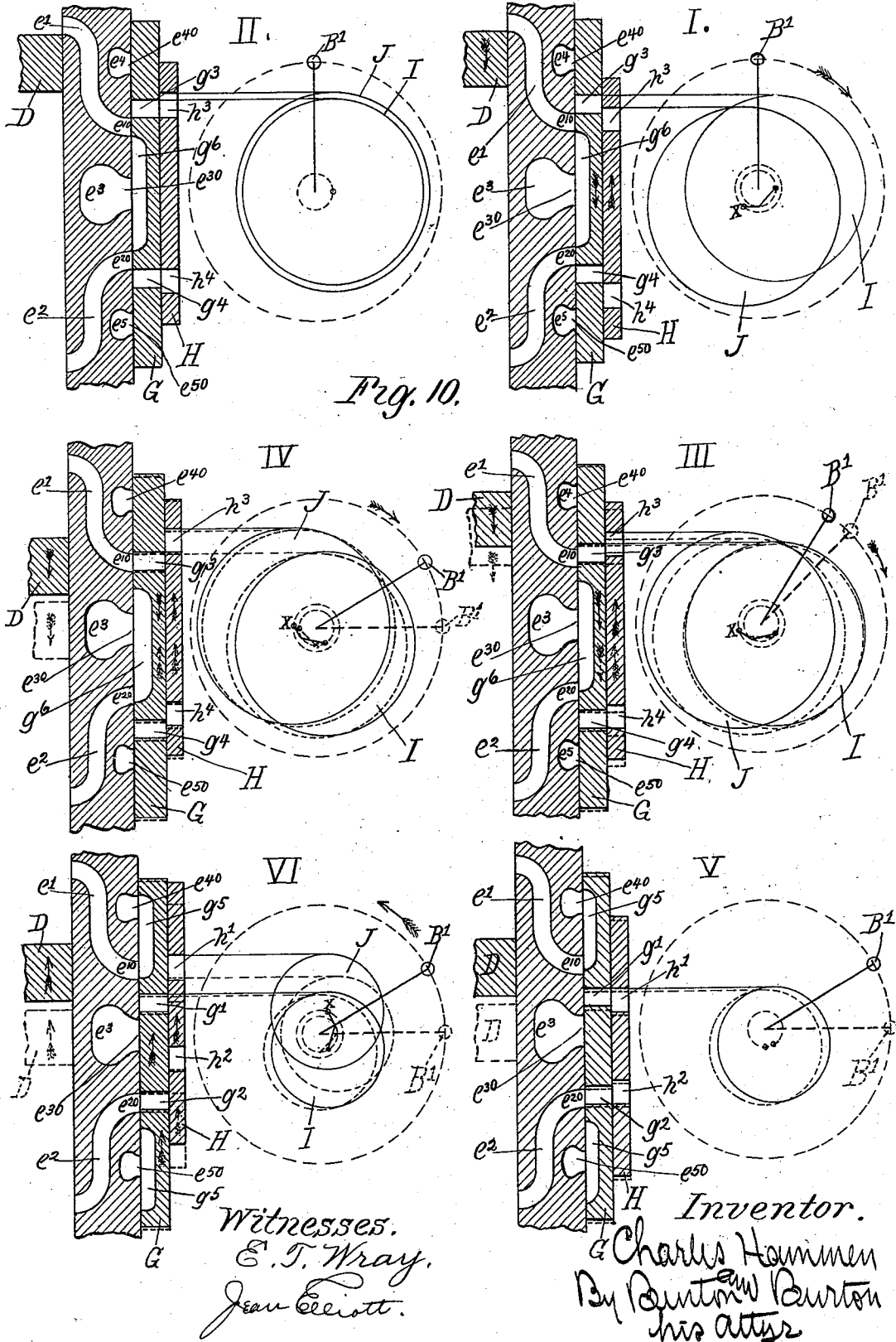
Witnesses.
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C. HAMMEN.
REVERSING ENGINE.

No. 510,256.

Patented Dec. 5, 1893.



UNITED STATES PATENT OFFICE.

CHARLES HAMMEN, OF CHICAGO, ILLINOIS.

REVERSING-ENGINE.

SPECIFICATION forming part of Letters Patent No. 510,256, dated December 5, 1893.

Application filed September 2, 1892. Serial No. 444,865. (No model.)

To all whom it may concern:

Be it known that I, CHARLES HAMMEN, a citizen of the United States, residing at Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Reversing-Engines, set forth in the following specification, reference being had to the accompanying drawings, forming part thereof.

10 This invention relates to the construction of steam engines, and its purpose is to provide means for reversing the direction of rotation by changing the position of the valve, dispensing with the familiar link motion for
15 that purpose.

It also comprises devices for suitably transposing the position of the cut-off valve with respect to the main valve when the direction of rotation is reversed.

20 In the drawings Figure 1 is a vertical section, in the plane of the axis of the cylinder, of an engine having my improvements, the position of the parts being that which corresponds to the half stroke of the piston moving
25 toward the crank end, the full lines showing the position when under motion, and the dotted lines showing the position when at rest at the same stage of movement of the piston. Fig. 2 is a detail of the cylinder and
30 valves, being a section in the same plane as Fig. 1, and the valves being reversed to reverse the direction of motion. Fig. 3 is a detail elevation of the connection of the eccen-
35 trics with their respective valves. Fig. 4 is a section at the line 4—4 on Fig. 3. Fig. 5 is a section at the line 5—6 on Fig. 1 looking toward the crank. Fig. 6 is a section at the
40 same line looking toward the governor wheel, the position of the parts shown in full lines corresponding to the full lines in Fig. 1, and the position shown in the dotted lines corresponding to the dotted lines in Fig. 1, the
45 main eccentric and the straps of both eccentrics being removed. Fig. 7 is a section at line 7—7 on Fig. 6. Fig. 8 is an elevation of the governor wheel on the opposite side from the view shown in Fig. 6 as the same would
50 appear when the invention is applied to a double cylinder engine. Fig. 9 is a detail section at the line 9—9 on Fig. 8. Fig. 10 is a diagrammatic representation of the relative positions of the crank, piston and valves in

several successive positions marked respectively I, II, III, IV, V and VI, which are hereinafter specifically explained. Fig. 11 is a
55 detail section similar to Fig. 2, showing a modification in the dimensions of certain parts of the valve for a specific purpose hereinafter explained.

This invention is adapted especially to en-
60 gines for operating hoisting or similar apparatus, in which the person managing the hoist reverses the engine to cause it to raise or lower the load, and which should therefore at
65 all times be prepared to take steam upon either side of the piston, and adapted to be stopped at any point while running in either
70 direction, and started again in either direction from that point; and, furthermore, should therefore be adapted to develop the maximum of power to overcome the inertia of the load
75 when starting from any position in either direction. The devices illustrated will therefore be most commonly applied to double engines, or engines having two cranks and two
80 cylinders, cranks being set ninety degrees apart on the shaft, so that when the one is at the center the other is at the position of greatest leverage; and some details of the construction are chiefly important in view of the
85 intention to adapt the engine to such use.

A is the base or frame of the engine, which is here represented as upright.

A' A' are the bearings of the crank shaft.
B is such shaft.

B' is the crank.

C is the pitman rod; D the piston, and D' the piston rod; E the cylinder.

F is the valve chamber, which is cylindrical; G the main valve, which is a tubular
90 cylindrical valve playing within the main valve.

I is the main eccentric, and J the cut-off eccentric; I' the strap of the main eccentric; I² the eccentric rod.

G' is the main valve stem, which is tubular to permit the stem H' of the cut-off valve to extend out through it and receive connection with the rod J², from the strap J' of the cut-off eccentric. The detailed construction of
100 these parts, and their relation to each other, will be more particularly explained after the explanation of the detailed construction of the valves and their operation.

KK are steam pipes or channels leading from the steam-chest to the valve chamber.

e^1 and e^2 are the steam passages from the valve chamber to the cylinder, the former leading to the head end and the latter to the crank end of the cylinder.

e^3 is the exhaust passage, to which there are two avenues, e^4 and e^5 , leading to the exhaust ports, e^{40} and e^{50} , in the valve seat. A third port, e^{30} , leads directly to the exhaust passage, e^3 .

e^{10} and e^{20} represent the steam ports at the valve seat.

The main valve has direct ports, g^1 and g^2 , on one side, and upon the other side, in the same diametric plane, ports g^3 and g^4 . The width of the valve ports is equal to the eccentricity of the main eccentric, or half the travel of the valve. The distance between the port e^{30} and the port e^{20} on the one hand, and e^{10} on the other, is a little more than the travel of the valve; that is, a little more than double the width of the ports, and the port e^{30} is at least once and a half the width of the other ports.

In addition to the two ports the main valve has the surface or by-pass exhaust passages g^5 g^5 outside the ports g^1 g^2 , and the by-pass exhaust passage g^6 between the ports g^3 and g^4 . The distances between the proximate edges of the ports g^1 and g^2 respectively, and the by-pass g^5 , and also the distances between the proximate edges of the by-pass g^6 and the ports g^3 and g^4 respectively, are equal to the width of the ports. The length of the by-pass passages g^5 g^5 , is equal to the distances between the extreme edges of the ports e^{10} and e^{40} at one end, and e^{20} and e^{50} at the other end, so that when the valve is in one position, for example that shown in Fig. 2, the by-pass g^5 makes a communication from the port e^{10} to the port e^{40} , and when it is at the opposite position, for example that shown in Fig. 1, the other by-pass g^5 similarly connects the ports e^{20} and e^{50} . In this construction the main eccentric is set at ninety degrees from the crank, and the main valve is therefore at one extremity of its path when the piston and crank are at mid position or "half stroke" as shown in Fig. 1. The main valve will therefore make half its travel while the piston is completing its stroke toward the head end, moving with the piston in that half, and bringing the ports g^1 and g^2 both into position where they are closed by the valve seat, the former being just beyond the port e^{20} , and the latter being just about to lap on to the port e^{10} . At this point, therefore, which is the end of the piston stroke, the main valve cuts off the steam from both sides of the piston. The continuing rotation of the shaft, while the piston is returning to the mid position, carries the main valve on toward its extreme outer position, and when the piston has again reached mid position on its return stroke, the port g^1 is registered with the port e^{10} , and the port g^2 is still closed against the seat between the

ports e^{30} and e^{50} ,—see Fig. 1. During the same movement the by-pass g^5 , at the upper end of the valve, has moved, first,—that is, while the piston is completing its stroke—out of registration with the port e^{10} , and the other by-pass g^5 has moved so that it is about to lap the port e^{20} , and during the half of the return stroke of the piston, the lower port g^5 laps the entire width of the port e^{20} , while the other upper by-pass travels farther from the port e^{10} . This action of the valve thus properly shifts the steam induction and exhaust from the one to the other side of the piston in the customary manner of a slide valve.

The main valve has a stem G^3 extending through the head end of the valve chamber F^{22} ; a proper stuffing-box F^2 being provided; and proper connections are made to this protruding stem G^3 , by means of which it may be rotated, to rotate the main valve in the seat, and by thus rotating the said valve one hundred and eighty degrees the ports g^3 and g^4 are brought over to the seat having the ports leading to the cylinder; and whereas the distance between the ports g^1 and g^2 is less than the distance between the ports e^{10} and e^{20} by the amount of the width of one port only, and the by-pass passages g^5 g^5 are outside of the ports at that side of the valve, the distance between the ports g^3 and g^4 is less than the distance between the ports e^{40} and e^{50} by the amount of the width of one port, and the by-pass passage g^6 is between the ports at the other side of the valve, so that when the valve is thus rotated ninety degrees, causing the ports and by-pass passages, on the side which has been in operative relation to the cylinder port, to be cut off against the blind side of the seat, and the other ports and by-pass to come into operative relation to the seat ports, the steam and exhaust communications are shifted to the opposite sides of the piston. Thus, considering the position shown in Fig. 1, if the valve G is rotated one hundred and eighty degrees, the port g^3 will register with the port e^{10} , and thereby admit steam to the cylinder at the head end, and the by-pass g^6 will lap the ports e^{30} and e^{20} , and thereby permit exhaust from the crank end of the cylinder. The breadth and distances between the valve ports are such relatively to the travel and to the seat ports, that the valve has neither lap nor lead; so that at the mid position of the main valve, the steam edges of the seat and valve ports are in conjunction and there is only one position,—and when the engine is in action, only one instant,—at which the steam is cut off from both sides of the piston.

When a double cylinder engine has this invention applied to it, the instant and position at which one cylinder is without steam at either end correspond to the instant and position at which the other cylinder has its ports wide open and its crank ninety degrees from the center, and is therefore in the best position, both as to steam supply and crank

leverage, for performing work. When the main valve is reversed at the mid position, or half stroke, as shown in Fig. 1, it is obvious that the steam pressure will be transferred by such reversion from the one side of the piston to the other, and the piston brought to rest in the shortest time possible. If the valve is reversed when the piston is at any position intermediate between middle and either end of its travel, the valve being at corresponding intermediate position between one extreme and the mid position of its travel, the steam opening given by the reversion, at the side which has been before the exhaust side, will be the same as the steam opening which is closed by such reversion. If the valve is reversed when the piston is at one limit of its travel, the valve being then at mid position, there will be at the instant of reversal no access of steam at either side, and by the reversal no access will be given either side, and no effect, therefore, will be produced until the crank passes the center and the piston commences its return movement, whereupon the steam port will be opened at the side toward which the piston commences to move, and the exhaust port will be opened at the other side, and the piston will thereupon be caused to reverse its movement. In the case of a double cylinder engine, as above stated, the extreme position of the one piston, corresponding to the mid position of the other, whenever the reversal occurs at such extreme position of one piston, the other piston will have its ports reversed with full openings, and the effect of the reversal will therefore be experienced without the delay which would occur, as above explained, in the case of the one cylinder when reversal is effected with the piston at the limit, and the action of the piston that is in mid position and which has its crank at the ninety-degree position, will control the shaft and cranks, and prevent the delay above described. But the reversal would be effective, nevertheless, with a single cylinder engine, although in case of slow movement and heavy work, the engine might thereby be brought to "dead center."

In order to permit the main valve to rotate through one hundred and eighty degrees about its axis, as described, its stem G' is swiveled to the eccentric rod I^2 , G^5 being the swivel yoke adapted to turn at the collar portion G^{50} on the stem G' , and being hinged at G^{55} , in a plane parallel with the shaft, to the eccentric rod I^2 .

As the operation has been thus far described, the engine is treated as having no cut-off valve, but only a main valve. It is adapted, however, to be employed with the cut off valve already partly described, and its operation with such valve will now be described. The cut-off valve H being a cylindrical valve, concentric with and located within the main valve, and having its exterior surface seating in the interior surface of

the main valve, has ports h' and h^2 , corresponding in the distance of their remote edges to the ports g' and g^2 , and the ports h^3 and h^4 corresponding, in respect to the distance between their proximate edges, to the ports g^3 and g^4 . These ports register circumferentially with the ports of the main valve to which they correspond respectively, and the cut-off valve is feathered to the main valve to prevent it from rotating with respect to the latter, and of causing it to rotate with it. The stem H' of the cut-off valve extends through the stem G' of the main valve, and a suitable stuffing-box G^4 is provided at the end of the tubular portion of the stem G' through which the stem H' emerges. Outside of that stuffing-box, the stem H' is swiveled to the eccentric rod J^2 , the latter being offset from the plane of the eccentric to pass by the swiveled yoke G^5 of the main valve stem and to reach the axial line of the valves, as seen in the drawings. The swivel collar H^4 has small trunnions h^4 projecting in the line parallel with the shaft, which form the pivots of the hinge connections of the stem H' to the opposite end of the eccentric rod J^2 .

I do not limit myself to the details above described for the connections between the eccentrics and their respective valves, but they are selected to represent and indicate the necessary movements of the parts. The cut-off eccentric is in the form of a flanged sleeve encircling the shaft, having its flange peripherally clasped by the introverted flange of the main eccentric, the diameter of the circular cavity i' , formed by the introverted flange i , being greater than the diameter of the flange j of the eccentric J by at least the amount of the maximum variation of the two eccentrics. The strap J' of the eccentric J operates upon the sleeve portion of the eccentric, as shown in the drawings. The position of the main eccentric is fixed with respect to the shaft being, as above stated, at right angles to the crank. The position of the cut off eccentric being, so far as above described, indeterminate, is determined by the connection which it has with the governor wheel L , which will now be described. This governor wheel is rigid with the shaft and has pivoted to it the arms M and N of the governor balls m and n , said arms being adapted to oscillate in a plane at right angles to the shaft. The arm N is fulcrumed on the wheel at the extremity opposite the ball, and the arm M is fulcrumed on the wheel at a point distant from the center of the ball equal to the distance of the fulcrum N from its ball, but is extended beyond said fulcrum to the point m' , where a link O is pivoted to it, which extends to the point n' on the arm N , distant from the fulcrum of said arm as far as the point m' is distant from the fulcrum of the arm M , but between the fulcrum of the arm N and the ball n . At the same point n' the link O' is connected. A bar P secured rigidly to the eccentric J is connected to the link O' at the

middle point of the bar. At the outer extremities of the bar are provided abutments, preferably in the form of a stud and roll, projecting toward the plane of the web of the wheel L, and said web is provided with two V-shaped cam grooves $L^2 L^2$ at diametrically opposite positions, in which said abutments are adapted to lodge and travel. The bar P extending, as described, diametrically across the face of the wheel L, is apertured about the shaft, the aperture being large enough to allow all the range of movement necessary for the bar in the operation hereinafter described. The portion which encircles the shaft may be referred to as the yoke P', and it is to one side of this yoke that the link O' is connected. On the hub of the wheel L, or on a shoulder concentric with the wheel, there is fulcrumed a lever P², having equal and similar arms extending in diametrically opposite directions from the eye or journal bearing by which it is fulcrumed on the hub as stated. Balls Q' and Q² are secured on the extremities of these arms respectively. From the yoke P', at the same side as the point of connection of the link O' an arm P³ extends alongside of one of the arms of the lever P², and passes loosely through an eye p^2 , rigid with the lever P², so that the arm P³ may slide and turn slightly in the eye but nevertheless make a practically close pivotal connection thereby with the lever P². Springs R R, connected to the lever arm M and N respectively, and to the wheel, tend to resist the movement of the balls m and n centrifugally.

The operation of this device will be as follows: Under the action of the springs R R, the bar P is normally held in such position that its abutments $p' p'$ are at the apexes of the cam grooves respectively in which they are guided. When the rotation of the wheel commences, the centrifugal tendency of the balls operates to pull the bar P laterally. The bar being guided by the abutments $p' p'$ in their respective cam grooves on the wheel, must move in a path determined by one slope or the other of the cam grooves. Which slope it will enter, and which direction it will move, would be matter of accident and wholly uncertain but for the control exercised by the balls Q' Q² on the lever P². This lever being pivoted freely on the wheel L tends, especially on account of the inertia of the balls Q' Q², to stand at rest when the wheel starts in either direction, until the friction or positive engagement of the wheel communicates motion to it. It will therefore lag behind the wheel, or move back over it when the latter starts, and in such movement being engaged at the eye p^2 with the lever arm p^3 of the bar P, it will tend to slide that bar so as to move the abutments $p' p'$ one way or the other from the apexes of their respective cam grooves, and will therefore determine which slope of the groove the abutments enter under the centrifugal influence of the gov-

ernor balls m and n . At rest,—that is, when the abutments $p' p'$ stand in the apexes of their cam grooves,—the main and cut-off eccentrics are concentric. The movement of the center of the cut-off eccentric will be obviously in a path parallel with the paths of the abutments $p' p'$; that is, with one or the other of the diverging slopes of the cam grooves, and, as shown, the slopes of the cam grooves being at right angles until they cross the circumference of a circle whose radius is the eccentricity of the main eccentric, the travel of the center of the cut-off eccentric, as controlled by these cam grooves, will bring it to that point of the arc which is the path of the center of the main eccentric, and at that position the cut-off eccentric will be either ninety degrees in advance of or ninety degrees behind the main eccentric, according to which slope of the cam groove is being followed. Since, as will be hereinafter explained, the cut-off valve will not cut off the steam until the cut-off eccentric is at least ninety degrees in advance of the main eccentric (the words "in advance" being construed with reference to the direction of rotation of the shaft, whether it be what is termed "forward" or the "reverse"), it is desirable that the cut-off eccentric should reach such position as quickly as possible after rotation of the shaft commences and with the least development of speed in such rotation, and I therefore prefer to construct the governor with the main governor springs R R of the desired tension to resist the centrifugal movement of the balls to a degree corresponding to the desired operation of the engine as to speed and work performed, and to supplement these main governor springs with lighter springs R' R' of sufficient force only to insure the return of the governor balls toward the center when the wheel is at rest, but with no greater tension than necessary for that purpose, and these supplemental springs are interposed between the governor arms and the main springs R R so that the main springs are not compressed or brought into action until the limit of compression of the supplemental springs is reached, or the main springs encountered after a certain movement of the arms compressing the supplemental springs. The main springs are thus encountered, or the limit of the compression of the supplemental springs is reached, at the point at which the cut-off eccentric has been moved ninety degrees from the point of coincidence with the main eccentric. This point will be reached, therefore, almost immediately after the wheel starts its rotation and before any considerable speed is developed. From this point on the main springs R R control the governor balls and enable the balls to regulate the action as usual in such governors, and from this point the two branches of the cam grooves may extend less divergently, and even parallel, without detracting from the effectiveness of the device, and with this advantage, that the cut-off eccentric will be ad-

vanced through a greater angle with a less increase in the throw of the eccentric valve than if the grooves continue to diverge at right angles throughout their entire extent.

5 As the speed of the shaft causes the governor to carry the abutments on the arm P farther out in the grooves, and so to advance the cut-off eccentric farther from the main eccentric, the point of cut-off is brought nearer and
10 nearer to the commencement of the stroke, and it may be made to cut-off as close as desired, as, for example, at one-quarter or one-fifth stroke, as will more clearly appear upon consideration of the action of the cut-off valve,
15 in connection with the main valve, under the control of the governing mechanism above described.

The direction of rotation which would result from the position of the main valve shown
20 in Fig. 1, may be considered as forward, and that which results from reversing the valve will be referred to as backward. The engine standing at rest, with the valves at the position shown in Fig. 1, the governing mechanism will be in the position shown in Fig. 6.
25 Steam being admitted, the piston moves toward the crank end, and the wheel commences to revolve in the direction shown by the arrow in Fig. 6, the action of the governor balls, influenced by the action of the balls Q' Q² on the lever arm P², causing the abutments p' p' on the arm P to take the left-hand slope
30 of the cam grooves, and move the cut-off eccentric away from its position of concentricity with the main eccentric toward a position ninety degrees ahead of the main valve, and when the cut-off eccentric reaches a position at right angles to the main eccentric, the governor coming into full action by reason of the
40 arms encountering the main governor springs R R will regulate the speed by causing the cut-off eccentric to still farther advance from the main eccentric as the abutments on the arm P move out farther in the right-hand slopes of their respective grooves, cutting off steam at less than half stroke to any limit provided for in the construction. Under an exceedingly slow rate of movement not sufficient to cause the governor balls to depart from the
50 center even against the slight resistance of the supplemental springs, the cut-off and main eccentrics will remain concentric and the two valves will travel together, and the action will be precisely the same as if there were no cut-off valve. But ordinarily the engine will cut-off at half stroke, as shown, and if while running at speed sufficient to cut off at half stroke, or earlier, the main valve is reversed, carrying with it the cut-off valve in the rotary
60 motion which effects such reversal, the introduction of steam to the opposite side of the piston causes the engine to come to rest for an instant before the reverse motion can be commenced, and at that instant the governor will cause the bar P to come to the position of rest with the abutments p' p' at the apexes of the cam grooves, and the cut-off eccentric

will be for that instant concentric with the main eccentric and the ports of the two valves will coincide, and will admit steam to their full capacity. This is the condition of affairs
70 always when the engine is at rest, and the valve having neither lap nor lead when the engine is one having two cylinders and cranks at right angles, there will be in one cylinder, 75 or the other, or in both together, the maximum steam portage, so that full benefit of the boiler pressure can be obtained through the engine to start the load, and only after considerable speed has been attained will the
80 steam be cut off at less than full stroke. When motion recommences, after the momentary halt due to reversing, the inertia of the balls Q' Q² operating on the lever P² will cause the abutments p' p' to enter the right-hand slope
85 of the cam grooves and shift the cut-off eccentric in the opposite direction from that in which it was shifted before, but, as before, in advance of the main eccentric, because that eccentric is now to revolve in the opposite direction. 90 The abutments now traveling in the right-hand slope of the cam grooves will operate just as when they were traveling in the left-hand slope, causing the steam to be cut-off at half stroke when very slight speed is attained, 95 enough to cause the governor balls to overcome the tension of the supplemental springs R' R', and afterward cutting off at less than half stroke, but under the restraint of the main governor springs, and therefore only 100 when the engine has attained the speed and is doing the work for which the governor is adjusted.

In diagram, Fig. 10, I have shown the relative positions of the eccentrics, and of the piston and crank, and of the main and cut-off valves. Position shown at "I" is with the crank on the center, piston at the crank end of the cylinder, the engine working "forward," the cut-off valve being in the position due to motion, the full line position being that which it would take with the speed such that the cut-off eccentric center were advanced to the point x, the dotted line showing the position it would take with the cut-off eccentric center at right angles to the main eccentric. Position "II" is the same as position I, except that the cut-off valve is shown in the position due to rest. This position, when the cam grooves L² are of the shape shown, brings the cut-off valve to the point of opening whatever the adjustment of the cut-off eccentric, provided the governor has brought it at least to a position ninety degrees in advance of the main eccentric. Position "III" shows the movement continued to the point at which the maximum opening is obtained, with the cut-off eccentric at the position x. Position "IV" shows the motion continued until full cut-off is obtained when the eccentric is advanced to x. This is about quarter stroke of the piston. Position "V" shows the parts as they would stand if the engine were reversed when position "IV" of the piston is

reached, that is, rest having occurred at that moment by reason of the reversion, and the cut-off valve having taken the position of rest. Position "VI" shows the parts at the same position as "V," except the cut-off and its eccentric, which are in the position due to reversal and full motion after reversal. This position would not be attained instantly after reversion at position "IV" because of necessity some movement of the piston would occur before the speed would bring the eccentric to the position shown, but for the sake of intelligent comparison of the positions, it may be thus described, and this would be the position at the end of one complete revolution from the point of reversal at position "V." Comparison of these various positions will make clear the operation of my invention, and will show that it affords a completely effective means of making a reversible engine with an automatic cut-off, that is, an engine which is governed by the cut-off valve and not by a throttle, and which notwithstanding this method of governing, is reversible. It will also be seen that this construction enables me to fix the main eccentric ninety degrees from the crank and so to have steam,—except as the cut-off may limit it,—at all points of the stroke except at the dead center, and since the cut-off and main valve ports coincide when the shaft is at rest, the cylinder always has steam at full pressure for starting its load except at dead center, and that therefore, when the invention is applied to an engine having two cylinders and cranks at right angles, when one is at dead center and has no steam, the other has its ports wide open and its crank at the best position for leverage, so that an engine thus equipped will be able to start any load which the maximum pressure of the boiler on the area of the piston can, and that it will do this from any point and in either direction. This adapts it peculiarly for purposes of hoisting, or operating loads horizontally alternately in opposite directions.

Another very valuable use for this invention consists in an adaptation of it to hoisting engines in such manner as to reduce to a minimum the use of steam during the descent of the load, and to cause the operation of the engine to produce a vacuum behind the piston as a restraint upon the engine, which, under such circumstances, wholly or in part is operated by the descending load. This is effected by making the ports of the cut-off valve which are the operative ports for steam induction when the engine is running in the direction to lower the load, only about half the width of the seat ports, the narrowing being made by advancing the steam edge of the port so that the cut-off will be effected almost immediately after the commencement of the travel of the piston in either direction when the engine is under full speed. This does not interfere with the stopping and starting if the load should not be sufficient to actuate the

mechanism, since at rest the steam passage will be open to the full width of the cut-off port, and although this width may be much less than the full width of the seat port, it will nevertheless admit steam and cause it to exert its maximum pressure on the piston and operate just as effectively to start the load as if the port were more widely open; and in any case the load, although insufficient to maintain the desired speed of descent, does nevertheless assist in that action, and the engine will take only enough steam to hasten the descent to the maximum speed desired, and will therefore waste no power which can be saved by utilizing the force of gravity operating upon the load. Such construction, that is to say, narrowing of the ports in the cut-off valve on one side is shown in Fig. 11.

Without detail explanation, the manner in which this invention would be applied to double cylinder engines will be obvious in all particulars except the connection of the governor with the cut-off eccentric pertaining to the valve of the cylinder which is on the opposite side of the governor wheel from that at which the governor balls are located. Figs. 8 and 9 illustrate the means by which this connection is effected, and the relation of the two sets of lever mechanisms pertaining to the two eccentrics. As shown in these figures, I cause the governor balls to operate both eccentrics by providing as the means of pivoting the lever arms M and N to the wheel, short rock-shafts *x*, *y*, which extend through suitable bosses constituting their bearings in the web of the wheel, and of lever arms S and T on the opposite side of the wheel from the arms M and N, but extending respectively at right angles to the planes which contain the arms M and N and their respective axes. The bar P, abutments *p'* *p'* thereon, cam groove for the abutments, the connection from the bar to the lever arms S and T are in all respects similar to those employed upon the opposite side, but all shifted ninety degrees around from the positions of the first described set of parts and bearings, therefore in the same relation to the second crank and main eccentric as the first set bears to the first crank and eccentric.

The description of the governing devices in detail is made in this specification, because otherwise the practicability of operating valves of the character described with the results stated would not be obvious. But the governing devices themselves are not the subject-matter of claims in this application but are the subject of my application Serial No. 469,008, filed April 4, 1893, as a division hereof.

I claim—

1. In a steam engine in combination with the cylinder having the ports leading thereto from the valve seat, the valve which controls such ports having two movements, one longitudinal with respect to the piston's travel, and the other transverse thereto and having two pairs of ports, the corresponding ports of

the two pairs being out of transverse line with each other a distance equal to the travel which the valve makes longitudinally to reverse the steam communication with the cylinder, whereby the transverse movement of the valve also reverses such communication, substantially as set forth.

2. In a steam engine in combination with the cylinder having the ports leading thereto from the valve seat, the valve which controls such ports being cylindrical and having a cylindrical seat and adapted to be both reciprocated and rotated in its seat, and having two pairs of ports at opposite sides, the corresponding ports of the two pairs being in transverse planes longitudinally separated a distance equal to the travel which the valve makes longitudinally to reverse the steam communication with the cylinder, whereby the rotation of the valve in its seat also reverses such communication substantially as set forth.

3. In a steam engine in combination with the cylinder having ports leading to the valve seat, the valve which controls such ports having two movements, one longitudinal with respect to the piston's travel, and the other transverse thereto, and having two pairs of ports in lines corresponding to two transversely separated positions, the corresponding ports of the two pairs being out of transverse line with each other a distance equal to the travel which the valve makes to reverse the steam communication with the cylinder, the ports of one pair being farther apart longitudinally than the ports of the other pair by an amount equal to twice said travel, substantially as set forth.

4. In a steam engine in combination with the cylinder having ports leading to the valve seat, the main valve which controls such ports having two movements, one longitudinal with respect to the piston's travel, and the other transverse thereto and having two pairs of ports, the corresponding ports of the two pairs being out of transverse line with each other a distance equal to the travel which the valve makes longitudinally to reverse the steam communication with the cylinder, whereby the transverse movement of the valve also reverses such communication, and a cut-off valve having with respect to the main valve longitudinal movement only, and adapted to be moved transversely with the main valve, and having ports corresponding to the ports of the main valve and the eccentrics which operate said valve respectively longitudinally, substantially as set forth.

5. In a steam engine in combination with the cylinder having ports leading to the valve seat, the main valve which controls such ports and a cut-off valve co-operating with said main valve, and the eccentrics which operate said valves respectively, and a governor which automatically adjusts the cut-off eccentric to vary the cut-off, the said valves being cylindrical and adapted to receive the

steam through the center and to be rotated in the seat of the main valve and having two pairs of ports at opposite sides of the axis, the corresponding ports of the said pairs being at a transverse line with each other a distance equal to the travel which the main valve makes to reverse the steam communication with the cylinder, whereby the rotation of said valves to change the pair of ports which co-operates with the seat ports, also reverses such communication, substantially as set forth.

6. In a steam engine the cylinder having the ports leading thereto from the valve seat, the valve which controls such ports having two movements, one longitudinal with respect to the piston's travel, and the other transverse thereto and having two pairs of ports, the corresponding ports of the two pairs being out of transverse line with each other a distance equal to the travel which the valve makes longitudinally to reverse the steam communication with the cylinder, whereby the transverse movement of the valve also reverses such communication, in combination with a cut-off valve having longitudinal movement with respect to the main valve to cut off the ports thereof, the eccentrics which operate said main and cut-off valves, and a governor which automatically adjusts the cut-off eccentric, whereby the engine is made reversible with an automatic cut-off, substantially as set forth.

7. In a steam engine, in combination with the cylinder having ports leading to the valve seat, the main valve which controls such ports having two movements, one longitudinal with respect to the piston's travel, and the other transverse thereto and having two pairs of ports, the corresponding ports of the two pairs being out of transverse line with each other a distance equal to the travel which the valve makes longitudinally to reverse the steam communication with the cylinder, whereby the transverse movement of the valve also reverses such communication, and a cut-off valve having with respect to the main valve longitudinal movement only, and adapted to be moved transversely with the main valve, and having ports corresponding to the ports of the main valve, and the eccentrics which operate said valves respectively longitudinally; the ports of the cut-off valve which correspond to that side of the main valve which co-operates with the seat ports for backward motion of the engine, being narrower than the ports on the other side, whereby cut-off is effected earlier in the backward movement, substantially as set forth.

8. In combination, substantially as set forth, the main eccentric and the cut-off eccentric located face to face a cylindrical main valve and a cut-off valve adapted to be rotated with said main valve, the main valve stem being tubular and the cut-off valve stem telescoping through it, and a stuffing box at the end of the tubular portion of the said main valve stem, a swiveled connection between the main

eccentric rod and the main valve stem comprising a yoke and a collar longitudinally stopped on the valve stem and adapted to rotate thereon between the stops and diametrically pivoted between the arms of the
5 yoke, a similar swivel connecting the cut-off eccentric rod with the cut-off valve stem, said swivel connection being located within the yoke of the main eccentric swivel, and having
10 ing the stem of its yoke deflected out of the

yoke of the main eccentric swivel, substantially as set forth.

In testimony whereof I have hereunto set my hand, in the presence of two witnesses, at Chicago, Illinois, this 20th day of August, 1892.

CHARLES HAMMEN.

Witnesses:

CHAS. S. BURTON,
JEAN ELLIOTT.