(No Model.) 3 Sheets—Sheet 1.

C. HAMMEN.

GOVERNOR FOR REVERSING ENGINES.

No. 514,187. Patented Feb. 6, 1894.

Fig. 7.

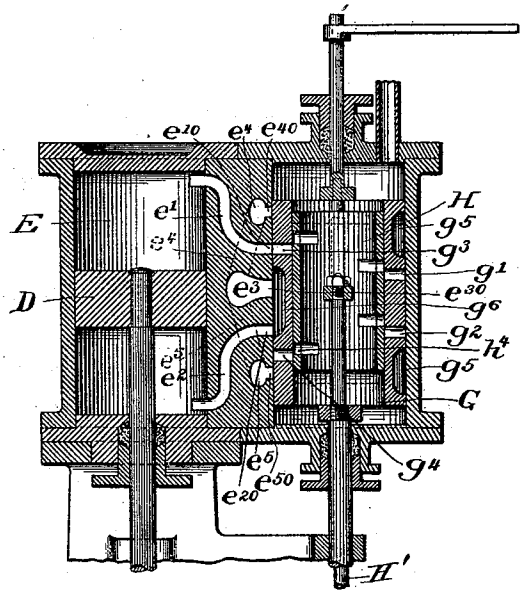
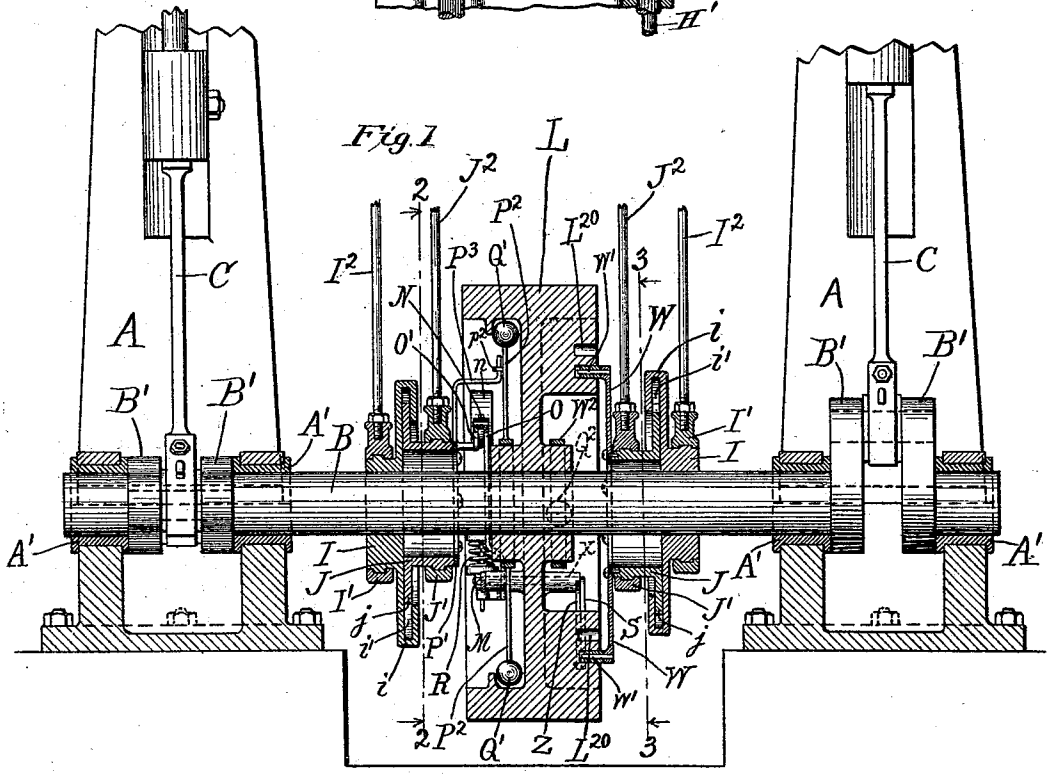


Fig. 1.



Witnesses.
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Fig. 2.

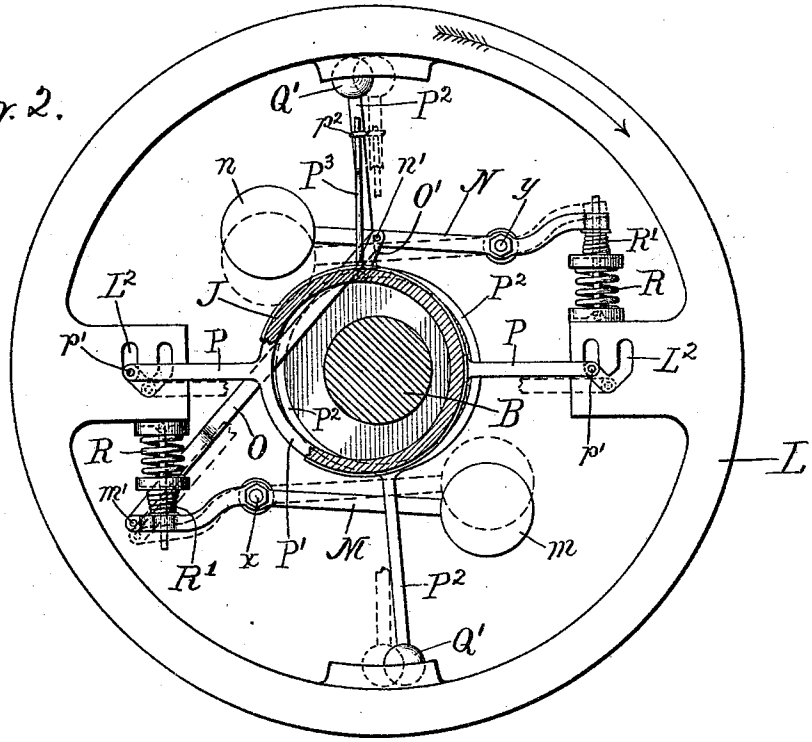

Fig. 3.

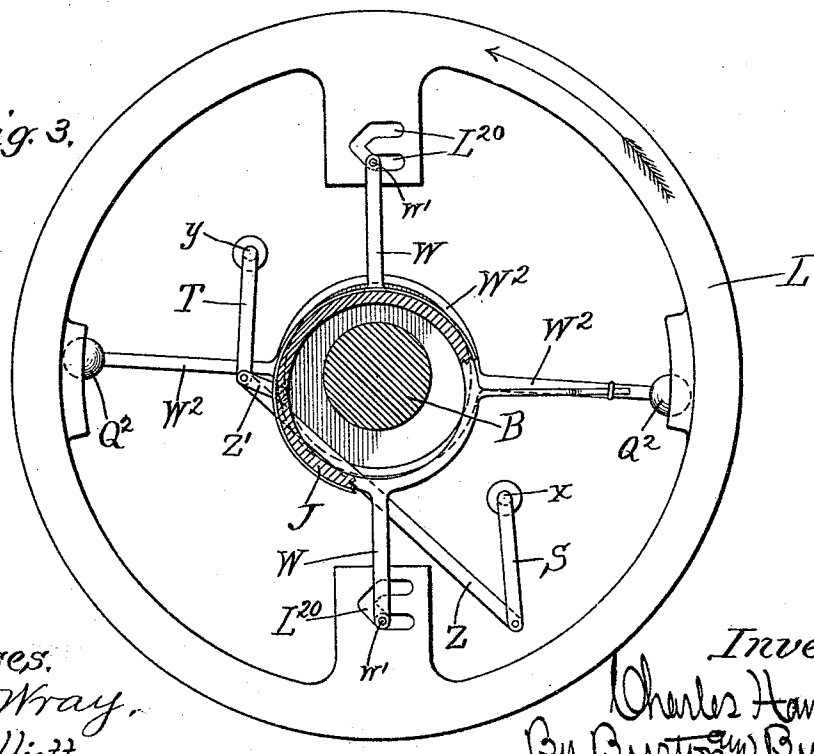

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Fig. 4.

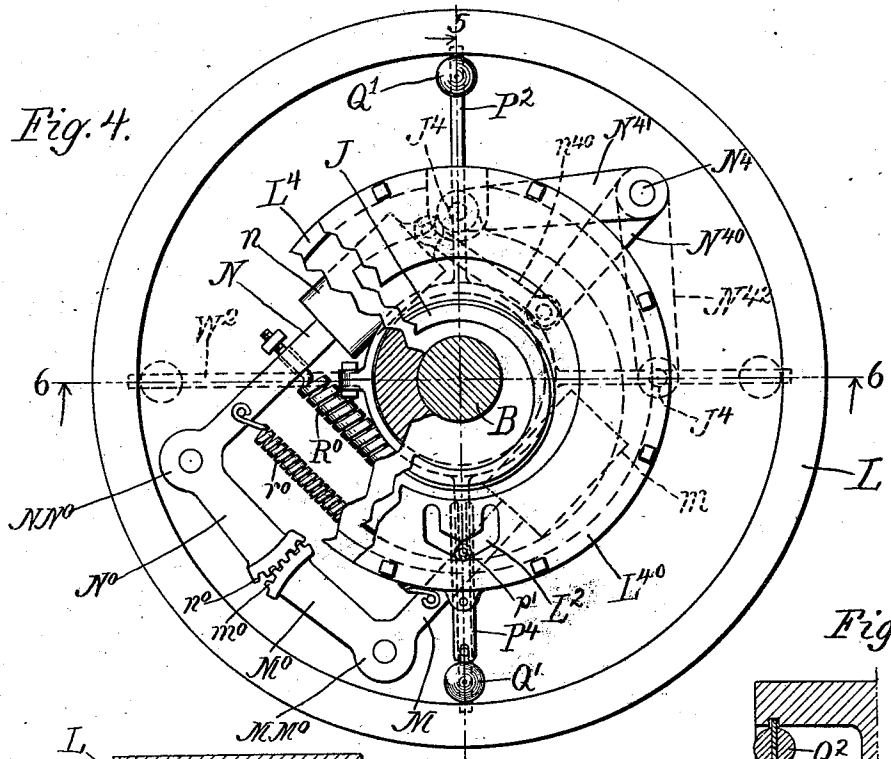


Fig. 5.

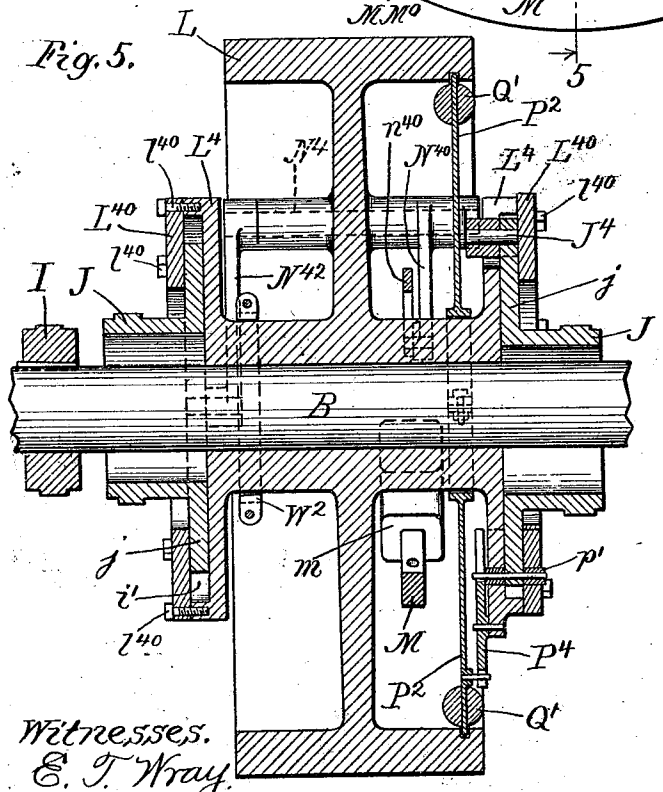
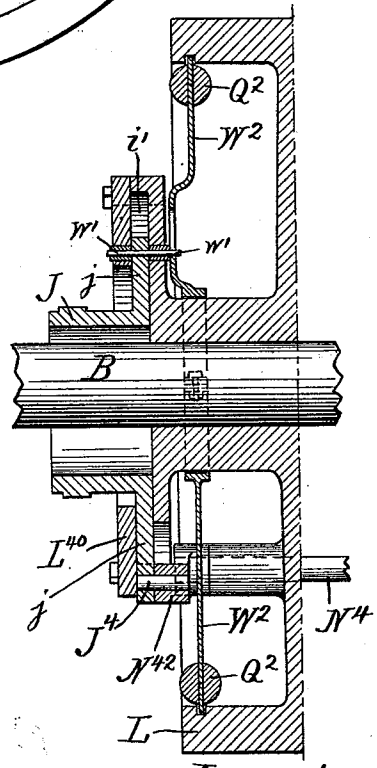


Fig. 6.



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THE NATIONAL LITHOGRAPHING COMPANY.
WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

CHARLES HAMMEN, OF CHICAGO, ILLINOIS.

GOVERNOR FOR REVERSING-ENGINES.

SPECIFICATION forming part of Letters Patent No. 514,187, dated February 6, 1894.

Original application filed September 2, 1892, Serial No. 444,865. Divided and this application filed April 4, 1893. Serial No. 469,008. (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 Governors for Reversing-Engines, which are fully set forth in the following specification, reference being had to the accompanying drawings, forming a part thereof.

This application is a division of my application Serial No. 444,865, filed September 2, 1892, and it relates to the features of the governor shown in that application.

In the drawings,—Figure 1 is a section, axial with respect to the main crank shaft, of a pair of engines embodying my invention, the section including, in addition to the crank shaft, the pitman rods from the two cranks and the fly wheel and the governing mechanism and eccentrics. Fig. 2 is a section at the line 2—2 on Fig. 1, showing the fly wheel in side elevation, some parts being partly broken away to disclose others more perfectly. Fig. 3 is a similar section at the line 3—3 on Fig. 1, showing the opposite side elevation of the wheel and governing mechanism. Fig. 4 is a similar sectional elevation of a wheel having governing mechanism somewhat modified. Fig. 5 is a section at the line 5—5 on Fig. 4. Fig. 6 is a detail section at the line 6—6 on Fig. 4. Fig. 7 is a section made axially through the cylinder and valves of one of the engines, the position of the parts corresponding to middle position of the piston on its return stroke at sufficient speed to bring the governor into action.

A A are the frames of the engines respectively.

A′ A′ are the bearings of the crank shaft.

B is such crank shaft.

B′ B′ are the two cranks.

C C are the pitman rods.

I I are the main eccentrics; J J, the cut-off eccentrics.

I′ I′ are the straps of the main eccentrics; I^2 I^2, the main eccentric rods.

J′ J′ are the straps of the cut-off eccentrics, and J^2 J^2 are the cut-off eccentric rods.

In each engine, the cut-off eccentric is in the form of a flanged sleeve encircling the shaft, having its flange *j* peripherally clasped by the introverted flange *i* 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 cut-off eccentric J, by at least the amount of the maximum variation of the two eccentrics. The strap J′ of the cut-off eccentric operates upon the sleeve portion of said eccentric, as shown in the drawings, the position of the main eccentric is fixed with respect to the shaft, being 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 and fly wheel L about to be described. This governor and fly 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 governor wheel near the end opposite the ball, and the arm M is fulcrumed on the wheel at a point distant from the center of gravity of the ball equal to the distance of the fulcrum of the arm N from its ball, but is extended beyond said fulcrum to the point *m′*, where the link O is pivoted to it, which extends to the point *n′* on the lever arm N distant from the fulcrum of said arm N as far as the point *m′* is distant from the fulcrum of the arm M, but between the fulcrum of the arm M and the ball *m*. At the same point, *n′*, the link O′ is connected to the arm N. 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, there are provided abutments, preferably in the form of a stud and roll, *p′ p′*, 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 groove 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 the entire range of movement necessary for the bar in the operation hereinafter described. The portion which encircles the shaft, bounding the aperture, may be referred to as the yoke P′, and it is to one side of this

yoke that the link O′ is connected, which is above described as being connected to the middle point of said bar P. On the hub of the wheel L, or otherwise concentric with the wheel, there is fulcrumed a lever P^2, having equal and similar arms extending in diametrically opposite directions from the eye or journal bearing by which it is fulcrumed as stated. Balls Q′ Q′ 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 P^3 extends alongside of one of the arms of the lever P^2, and passes loosely through an eye p^2, rigid on said lever, so that the arm P^3 may slide and turn slightly in the eye, but nevertheless make a practically close pivotal connection thereby with the lever P^2, being equivalent to a swivel eye. Springs R R, connected to the lever arms M and N, respectively, and to the wheel, so as to react between the wheel and said arms, tend to resist the centrifugal movement of the balls *m* and *n*.

The operation of this device will be as follows, considering it in relation to one engine only:—Under the action of the springs R R, the bar P is normally held in such position that the abutments p' p' are at the apexes of the cam grooves or tracks L^2 L^2, 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 tracks on the wheel must move in a path determined by one slot or the other of said cam tracks. Which slope the abutments would enter, and in which direction the bar would move, would be wholly uncertain but for the control exercised by the balls Q′ Q′ on the lever P^2. This lever being pivoted freely on the wheel L, about the center of the latter, tends, on account of the inertia especially of the balls Q′ Q′, to stand at rest when the wheel starts in either direction, until the friction or positive engagement of the wheel communicates motion to it. The bar will therefore lag behind the wheel and relatively 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 another from the apexes of their respective cam grooves, and will therefore determine which slope of the grooves the abutments enter under the centrifugal influence of the governor 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 of the cam grooves is being followed. The main and cut-off valves with which this governor is designed to open ate being so arranged, as shown in my said application Serial No. 444,865, that 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 "reverse," it is desirable that the cut-off eccentric should reach such position or whatever position in the particular construction of valve gives the latest maintainable cut-off, as quickly as possible after the rotation of the shaft commences and with the least development of speed in such rotation, so that the governing may be as complete as possible, the governor being as sensitive as possible to changes; and I therefore prefer to construct the governor with the main governing 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, and to supplement these 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 this purpose; and these supplemental springs are interposed between the governor arms and the main springs R R, so that the latter are not 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 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 commences 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 latter to regulate the action as usual in such governors; and from this point, the cam grooves may extend less divergently, and may even be parallel, without detracting from the effectiveness of the device, and with this advantage,—that the cut-off eccentric will be advanced through a greater angle with less increase in the throw of the eccentric valve than if the grooves continued to diverge at right angles through-

out their entire extent. 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 nearer to the commencement of the stroke, and it may be made to cut off as close as desired. The direction of rotation indicated by the arrow in Fig. 2 will be referred to as "forward," and the opposite direction as "backward." The engine standing at rest, with the eccentrics in the relative position shown in Fig. 1, the governing mechanism will be in the position shown in Fig. 2. The valves being in position so that the steam being admitted will give forward rotation to the shaft, the action of the governor balls, influenced by the action of the balls Q' Q' on the lever arm P^2, will cause the abutments p' p' on the arm P, to take the left-hand slope of the cam grooves, and move the cut-off eccentrics away from the position of concentricity with the main eccentric toward a position ninety degrees ahead of the main eccentric, and when the cut-off eccentric reaches a position at right angles to the main eccentric, the governor coming into action, by reason of the arms encountering the main governing 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 courses 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 center, even against the slight resistance of the supplemental springs, the cut-off and main eccentrics will remain concentric, and the main and cut-off 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, and if, while running at a speed sufficient to cut off thus or earlier, the valves are reversed, the introduction of the steam at the opposite side of the piston causes the engine to come to rest for an instant before reverse movement can commence; and at such instant, the governor will cause the bar P to come to the position of rest shown in Fig. 2 with the abutments p' at the apexes of the cam grooves, and the cut-off eccentric will be for that instant concentric with the main eccentric, and for the instant, therefore, the action of the engine will be precisely as if it had no cut-off valve,—that is, the full portage of the main valve will be operative to afford steam to the cylinder.

The construction of the valves with which the herein described governing mechanism and eccentrics are designed to operate, as shown in the parent application above mentioned and as seen in Fig. 1, is one in which the main valve has no lap nor lead, but has its ports so related to the ports of the valve seat that, operating alone, it would cause the steam to shift instantly from one side to the other of the piston at each end of the stroke, and so that there is practically no point, (although there is theoretically one point,) at which the main valve would not afford access of steam at one side or the other of the piston. This valve will be briefly described to indicate this feature:—E is the steam cylinder, and D, the piston therein. F is the valve chamber. G is the main valve. H is the cut-off valve which travels within the main valve, both being cylindrical. e' and e^2 are steam passages from the valve chamber to the cylinder, leading respectively to the head and crank ends of the latter. e^3 is the exhaust passage to which there are two avenues e^4 and e^5, which communicate with 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' and g^2 upon one side, and in the same diametric plane upon the other side, ports g^3 and g^4.

Reversing is effected by rotating the valve in the chamber to bring the ports upon one side or the other into operative relation with the ports of the valve seat. The width of the valve ports is equal to that of the ports of the seat, e^{20} and e^{10}, and also to the eccentricity of the main eccentric or half of the travel of the valve, so that the full travel of the valve is necessary to completely carry the port of the valve past the port of the seat. In addition to the two ports g^3 and g^4 upon one side, the main valve has the surface or by-pass exhaust passage G^6 located between them, and corresponding to this by-pass it has on the other side, outside the ports g' and g^2, by-pass passages g^5 g^5. The distances between the proximate edges of the ports g^3 and g^4 and the by-pass g^6, and also the distances between the proximate edges of the by-passes g^5 and the ports g' and g^2, respectively, are equal to the width of the ports. The length of the by-pass passages g^5 g^5 is equal to the distance between the extreme edges of the ports e^{10} and e^{40} at one end, and the equal distance between the extreme edges of the ports e^{20} and e^{50} at the other end, so that the valve, which in one position causes the by-pass g^5 to make communication from the port e^{40}, in an opposite position causes the by-pass g^5 similarly to contact the ports e^{20} and e^{50}. The main eccentric being set at ninety degrees from the crank, when the piston is at one end of its stroke the main valve is at the middle, and the steam port of the valve, g^3, for example, is just passing onto the port e^{10} of the seat, and it will make half its travel over that port and return while the piston is making its entire travel to the opposite end of the cylinder. At that position the

other port g^4 will be just passing onto the port e^{20} of the seat, and while the valve is completing half of its stroke in the other direction and returning to mid-position, its said port g^4 will pass over the port e^{20} and return while the piston is making its entire stroke in the opposite direction. So far as the main valve is concerned, therefore, it admits steam all the way at one side, and then instantly changes and admits steam all the way at the other side of the piston; that is to say, it is without lap or lead. This would be impracticable or undesirable in the absence of the cut-off valve, but with the cut-off valve operated by an eccentric controlled by the governing mechanism which at rest sets the cut-off eccentric coincident with the main eccentric, it affords the advantage that at whatever point of the stroke the mechanism is brought to rest by reversing, one engine or the other has the benefit of full boiler pressure to start the load; except at the exact middle point of one stroke which is the exact end of the other stroke, and at this point the one engine which does have full boiler pressure is operating most advantageously as to leverage, being at the middle point of its stroke, which compensates for the merely instantaneous lack of pressure in the other engine; this is a result which, so far as I am aware, has not been heretofore accomplished in a reversing engine. The full benefit of boiler pressure will thus be obtained to start the load from any position of rest, or from any position of reversal which is necessarily a position of rest. When motion recommences, after momentary halt due to reversing, the inertia of the balls Q′ and Q^2, operating on the lever P^2, will cause the abutments p' p' to enter the right hand slope 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. 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,—enough only 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 when the machine has attained the speed and is doing the work for which the governor is adjusted.

Thus far, the description of the governing mechanism has been confined to that of one side of the governor wheel operating upon one engine. The corresponding mechanism on the other side of the wheel and operating upon the other engine is shown in Fig. 3. The lever arms M and N are pivoted to the wheel upon short rock shafts x y, which extend through suitable bosses which constitute their bearings in the web of the wheel, and on the opposite side of the wheel from that at which said arms M and N are located, lever arms S and T are provided, rigid with said rock shafts, and extending respectively at right angles to the planes which cut the arms M and N and their respective axes. A bar W, precisely similar to the bar P, on the opposite side from the bar P, has similar abutments w' w', taking into cam grooves L^{20} L^{20} corresponding to the cam grooves L^2 L^2, and on the opposite side of the wheel from the latter; the position of said cam grooves and of the bar W, being ninety degrees around on the wheel from the positions of the corresponding parts P and L^2. And said parts W and L^{20} are therefore in the same relation to the crank and main eccentric of the second engine, as the parts P and L^2 are to the crank and eccentrics of the first engine. The link Z connects the arms S and T in the same manner as the link O connects the arms M and N, and a link Z′, from the pivotal connection of the link Z and arm T, makes connection at the other end with the yoke of the bar W, in the same manner as the link O′ makes a like connection from the lever N to the bar P. The centrifugal balls m and n, by means of the rock-shafts x and y, operate the connections upon both sides of the web of the wheel, and a lever W^2 like the lever P^2 and similarly fulcrumed on the opposite side of the wheel having at its extremities the inertia balls Q^2 Q^2, standing ninety degrees around from the balls Q′ Q′, co-operate with the governing devices on that side of the wheel in precisely the same manner as the balls Q′ Q′, already described, and both engines are thereby subject to precisely the same control, the operations of the controlling mechanisms of one being ninety degrees behind those of the other, as the position of the crank of one is ninety degrees behind that of the other.

In Figs. 4 and 5, I have shown a form of the governing mechanism which is somewhat preferred to that shown in the other figures; first, because both the centrifugal weights are controlled by the same spring, so that there can never be any inequality in their action; and second, because the radius of movement of said weights is the greatest possible within a given sized wheel, so that for a given distance of centrifugal movement, the path of the ball is most nearly a radial line with respect to the wheel, and so that the chord of the arc of the total range of such movement being strictly radial with respect to the wheel, the mean position of the weight is the nearest possible to the center of the wheel; and thirdly, because the connections whereby the governor balls operate the cut-off eccentrics are more simple and reliable.

The structure is as follows:—The weights m and n are secured to the extremities of the arms M and N, respectively, of bell-crank-levers M M^0 and N N^0, the arms M^0 and N^0 of

such bell-crank-levers being of equal length and having inter-engaging concentric segments m^0 and n^0. By reason of such connection, centrifugal or centripetal movement of either weight communicates precisely equal movement to the other weight. The lever arms M and N are connected by extensible springs R^0, corresponding to the main springs R R in the other construction, and by the supplementary lighter springs r^0, corresponding to the springs R′ in the other construction, the connection of the main springs R^0 being such as to permit some movement of the levers before the springs come into tension, the springs r^0 being under tension from the very commencement of such movement. The springs r^0 being nearer the fulcrums of the levers would operate with less tensional resistance, even though they were not lighter than the main springs, and by the term "lighter" as applied to these springs is meant merely that they are adapted to yield more easily, such adaptation being attained both by their position with respect to the fulcrums and also by their size and stiffness. The connections from the centrifugal balls and their levers to the other parts of the governing mechanism may be substantially the same in this construction as in the other, and it will be obvious to any mechanic how the same connections might be employed. But for the purpose of better balancing the governor wheel, and also, because of the longer radius of movement of certain of the parts, I prefer to employ as a means of communicating such motion, and also to transmit from one side to the other of the wheel, a rock-shaft N^4, journaled in the web of the wheel directly opposite a line connecting the fulcrums of the two bell-crank-levers. This rock-shaft has one lever arm N^{40}, which extends toward the center of the wheel, and is connected by a link n^{40} with the end of one of the centrifugal weights or its lever arm. At the same side of the web of the wheel, a lever arm N^{41} extends at an angle of forty-five degrees to the arm N^{40}, to a point from which a line substantially at right angles with said arm N^{40} will be radial with respect to the wheel, (the mean position of the rock-shaft and its lever arms being considered) at the opposite side of the wheel, a lever arm N^{42}, equal to the arm N^{41} extends in a plane at right angles to the latter. The ends of these lever arms N^{41} and N^{42} afford direct pivotal connection for the cut-off eccentrics respectively, at the studs J^4 J^4. The eccentrics in this construction are retained on the wheel hub instead of on the main eccentric, but in a manner essentially similar to that already described; the wheel hub having a flange L^4 with an introverted lip L^{40}, which clasps the eccentrics, the lip preferably being a separate piece secured by screws at l^{40}, as shown. One cam track, L^2, for each eccentric, is formed in the flange L^4 and the lip L^{40}, and one abutment taking into it is provided and the cut-off eccentric at a point diametrically opposite the pivotal connection or suspension of the cut-off eccentric to the lever arm N^{41} or N^{42}, as the case may be. The counterpoised lever P^2, fulcrumed on the wheel hub at the left-hand side will engage one arm of a lever P^4, fulcrumed on the wheel, and having its other arm engaging the stud of the abutment p', which engages the cam track L^2, said stud being extended through the eccentric for the purpose of engagement with the lever P^4. Both arms of the lever P^4 will be necessarily slotted at the connections respectively to the eccentric and to the counterpoised lever P^2. The operation of this device will be obvious by the description already given of the former device for the same purpose. At the opposite side of the wheel, the counterpoised lever P^2 will be slotted and will engage directly the eccentric on that side, the necessity for the lever P^4 to reverse the movement being wanting at that side.

I claim—

1. In a steam engine, in combination with the main shaft, the main eccentric and the governor wheel fixed on such shaft, the cut-off eccentric encircling the shaft; centrifugally acting weights and their levers fulcrumed on the wheel, and connections from the same to the cut-off eccentric through which the centrifugal movement of the balls operates the eccentric tending to move it in the line containing the shaft center and the main eccentric center; guides for the cut-off eccentric on the governor wheel adapted to divert the movement of said eccentric to the right or left from such path according as it is started to the right or left; a counterpoised lever fulcrumed concentrically with the shaft and connected to the cut-off eccentric and adapted by its inertia when the wheel starts to communicate to the cut-off eccentric movement relatively to the wheel to determine the direction of such divergence of the eccentric's path: substantially as set forth.

2. In a steam engine, in combination with the main crank shaft, the governor wheel and the main eccentric fixed on said shaft, the cut-off eccentric encircling the shaft; a lever arm fulcrumed on the wheel and pivotally connected to the cut-off eccentric at one side of the latter and adapted to vibrate at such pivotal connection substantially in the line of the shaft center and the main eccentric center; and a guide for the cut-off eccentric on the wheel at the opposite side from such lever connection adapted to divert the movement of the cut-off eccentric by causing it to swing to the right or left from the line of vibration of its pivotal connection, according as it is started to the right or left; a counterpoised lever fulcrumed concentrically with the shaft, and loose connections therefrom to the swinging side of the eccentric by which the movement of the counterpoised lever with re-

spect to the wheel starts the eccentric to the right or left: substantially as set forth.

3. In a steam engine, in combination with the main crank shaft, the governor wheel and the main eccentric fixed on said shaft, the cut-off eccentric encircling the shaft; a lever arm fulcrumed on the wheel and connected to the eccentric and adapted to vibrate at such connection substantially in the line of the shaft center and main eccentric center; a cam groove comprising symmetrically diverging portions having its guide walls rigid with the wheel; an abutment on the eccentric taking into such cam groove; and the counterpoised lever fulcrumed concentrically with the wheel, and loose connections therefrom to the eccentric; whereby the movement of the counterpoised lever relatively to the wheel tends to start the eccentric to cause its abutment to pass the apex of the cam groove: substantially as set forth.

4. In combination with two engines having a common crank shaft with its cranks ninety degrees apart, the main eccentric fixed on said shaft; the governor wheel also fixed on said shaft between the eccentrics; cut-off eccentrics encircling the shaft upon opposite sides of the wheel; centrifugally acting weights at one side of the wheel, and their lever arms fulcrumed on the wheel, and connections from the same to the cut-off eccentric at that side, said connections comprising an arm of a rock shaft, such rock-shaft extending through the wheel parallel with its axis, and having at the opposite side a like arm extending in a plane at right angles to the first, and like connections from such opposite lever arm to the cut-off eccentric at that side; said connections at both sides being adapted to move the eccentrics respectively in paths agreeing with the lines containing the shaft center and the main eccentric centers respectively; guides for the cut-off eccentrics respectively on the governor wheel adapted to divert the movement of the same to the right or left from such paths according as they are started to the right or left, and counterpoised levers P and W, fulcrumed concentrically with the shaft respectively at the opposite sides of the wheel and connected to the cut-off eccentrics respectively: substantially as set forth.

5. In a steam engine, in combination with the main crank shaft, the main eccentric and the governor wheel fixed to the shaft; a cut-off eccentric having an open center and encircling the shaft without bearing thereon; governing mechanism on the governor wheel, and connections therefrom to the cut-off eccentric, said eccentric being suspended in its position encircling the shaft by said connections, the wheel having a flange with an introverted lip which engages the flange of the cut-off eccentric to steady the latter and retain it in its position longitudinally with respect to the shaft: substantially as set forth.

6. In combination with the main shaft and the governor wheel thereon having the flange L^4 with an introverted lip and a cut-off eccentric retained by said flange and lip; the centrifugally operating balls and their lever arms on the governor wheels, and connections therefrom which tend to operate the cut-off eccentric in the line of the shaft center and main eccentric center; the cam groove or slot in the cut-off eccentric retaining flange of the main wheel having symmetrically diverging portions; an abutment on the eccentric taking into said cam slot or groove; and the counterpoised lever fulcrumed concentrically with the main wheel, and loose connections therefrom to the cut-off eccentric tending by inertia of the counterpoised lever to start the eccentric to cause its abutment to pass the apex of the cam groove: substantially as set forth.

7. In a steam engine, in combination with the governor wheel and the cut-off eccentric, the centrifugal governing mechanism and connections therefrom to the cut-off eccentric to operate the latter; the main spring which resists the centrifugal action of the governing mechanism, and a subsidiary spring adapted to yield more easily than the main spring and so connected that it is brought under tension before the main spring; whereby the cut-off eccentric is moved easily by the centrifugal governing mechanism to a pre-determined point before the governor main spring comes into operation to control its action: substantially as set forth.

8. In a steam engine, in combination substantially as set forth, a main valve and a cut-off valve, and a main eccentric and a cut-off eccentric to operate said valves respectively, the centrifugal governing devices and their controlling spring or springs, and connections from said governing devices by which they operate the cut-off eccentric said cut off eccentric having the same throw as the main eccentric, and being adapted to be coincident with the latter when the governing devices are at a position of rest, and the main valve having no lap; whereby the engine has the maximum power for starting at any point between the extremities of the stroke in either direction: substantially as set forth.

9. In a steam engine, in combination substantially as set forth, the main eccentric and the cut-off eccentric, centrifugal governing devices and their controlling spring or springs, the connections from the governing mechanism to the cut-off eccentric being such that the eccentrics are coincident at the position of rest of the governing devices, the cut-off eccentric being adapted to move away from such concentric position in either direction of rotation, whereby the cut-off action is produced similarly in forward and reverse running of the engine.

10. In a steam engine, in combination with a main shaft and the main eccentric and the

governor wheel fixed on said shaft; the cut-off eccentric encircling the shaft; centrifugally operating weights and their lever arms fulcrumed on the governor wheel and provided with inter-engaging segments to cause the centrifugal movement of the one to be communicated to the other in an equal degree; a spring connecting the lever arms adapted to be put under tension by their relative movement, and connections from said lever arms to the cut-off eccentric: substantially as set forth.

In testimony whereof I have hereunto set my hand, at Chicago, Illinois, this 22d day of March, 1893, in the presence of two witnesses.

CHARLES HAMMEN.

Witnesses:
CHAS. S. BURTON,
JEAN ELLIOTT.