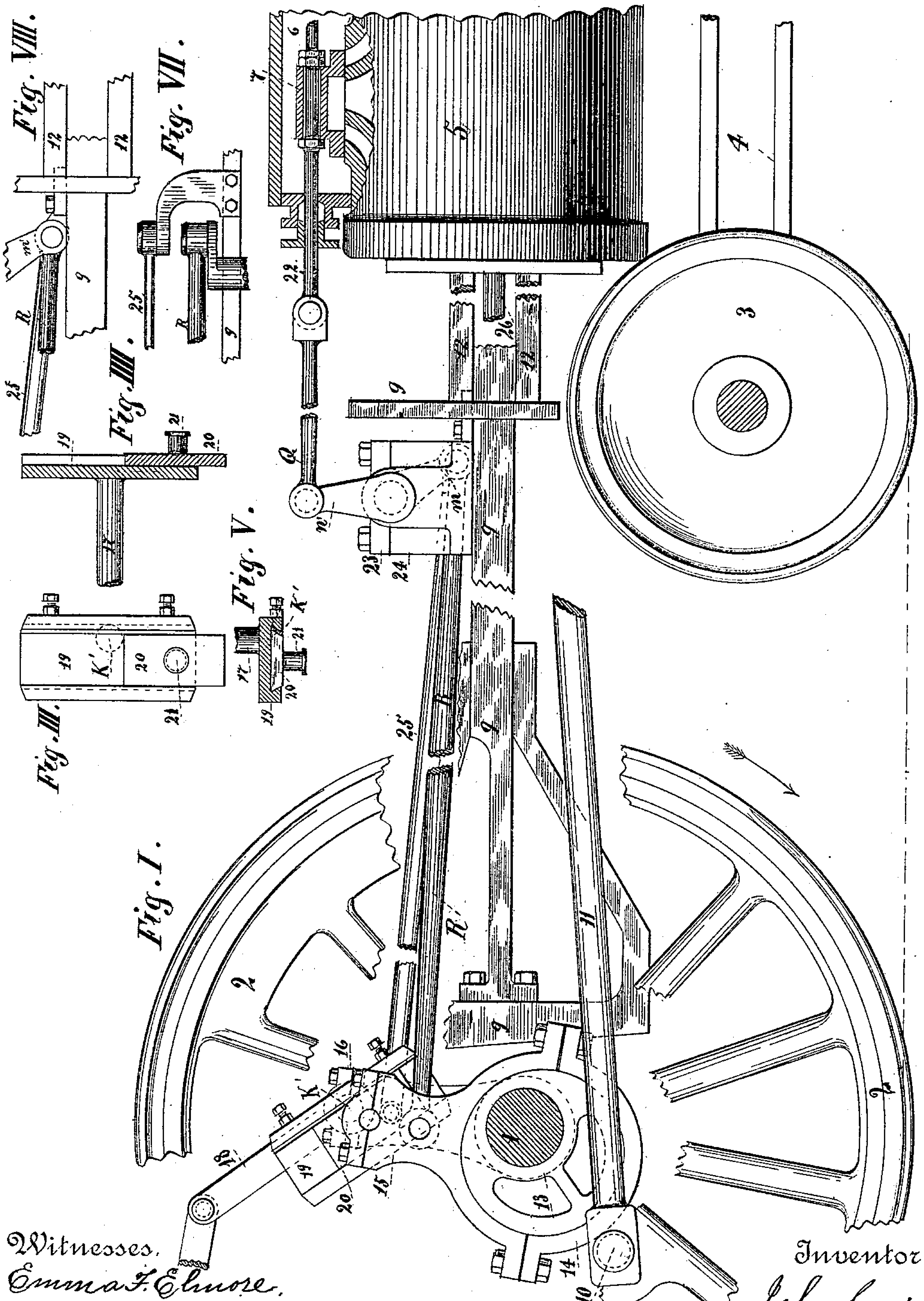
(No Model.) 3 Sheets—Sheet 1.

J. GRIME.

VALVE GEAR FOR ENGINES.

No. 389,382. Patented Sept. 11, 1888.



Witnesses.
Emma F. Elmore.
A. H. Opsahl.

Inventor,
John Grime,
By his Attorney
Jas. F. Williamson.

(No Model.)

3 Sheets—Sheet 2.

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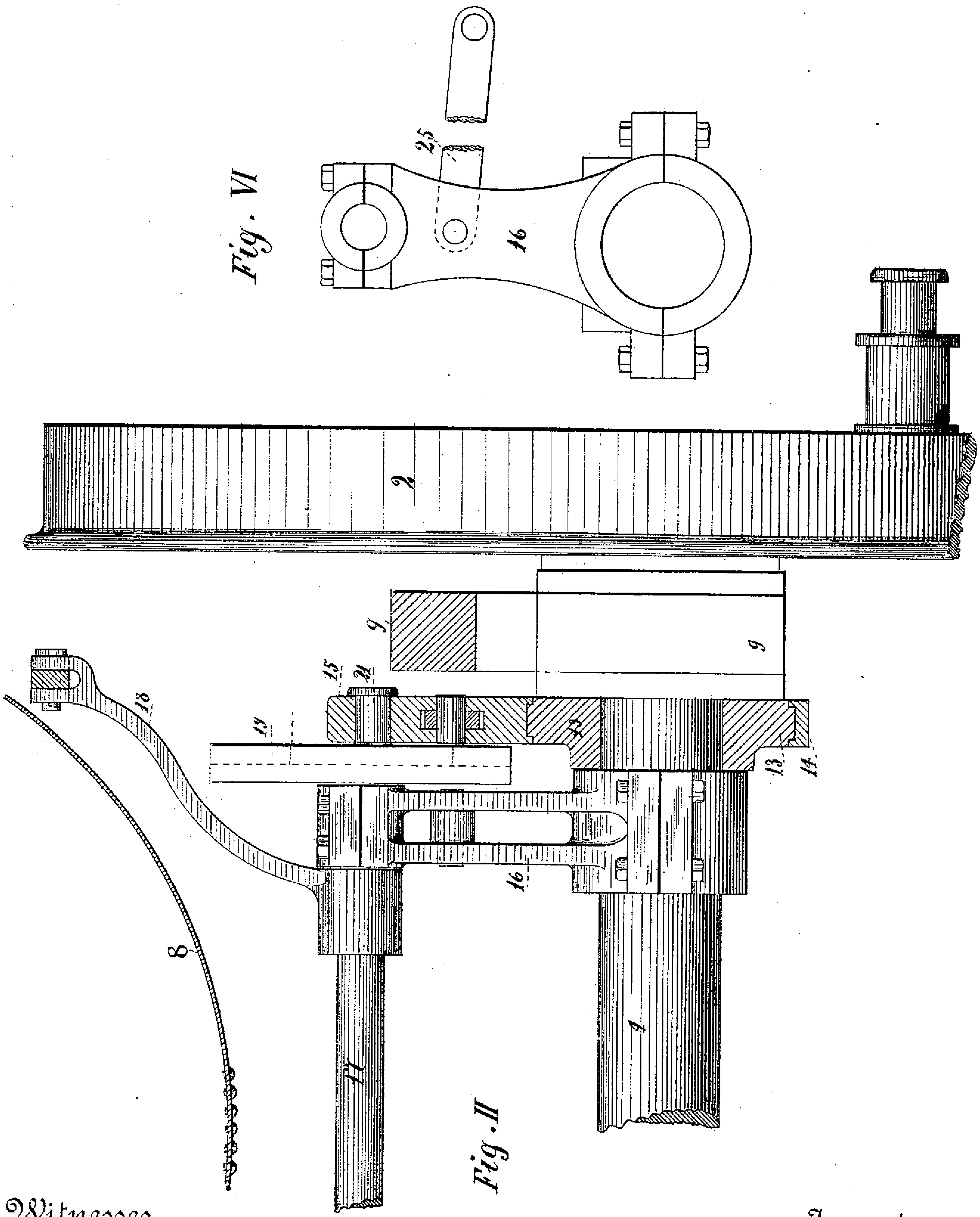

Fig. VI

Fig. II

Witnesses,
Emma F. Elmore,
A. H. Opsahl.

Inventor,
John Grime.
By his Attorney
Jas. F. Williamson.

N. PETERS, Photo-Lithographer, Washington, D. C.

(No Model.)

3 Sheets—Sheet 3.

J. GRIME.

VALVE GEAR FOR ENGINES.

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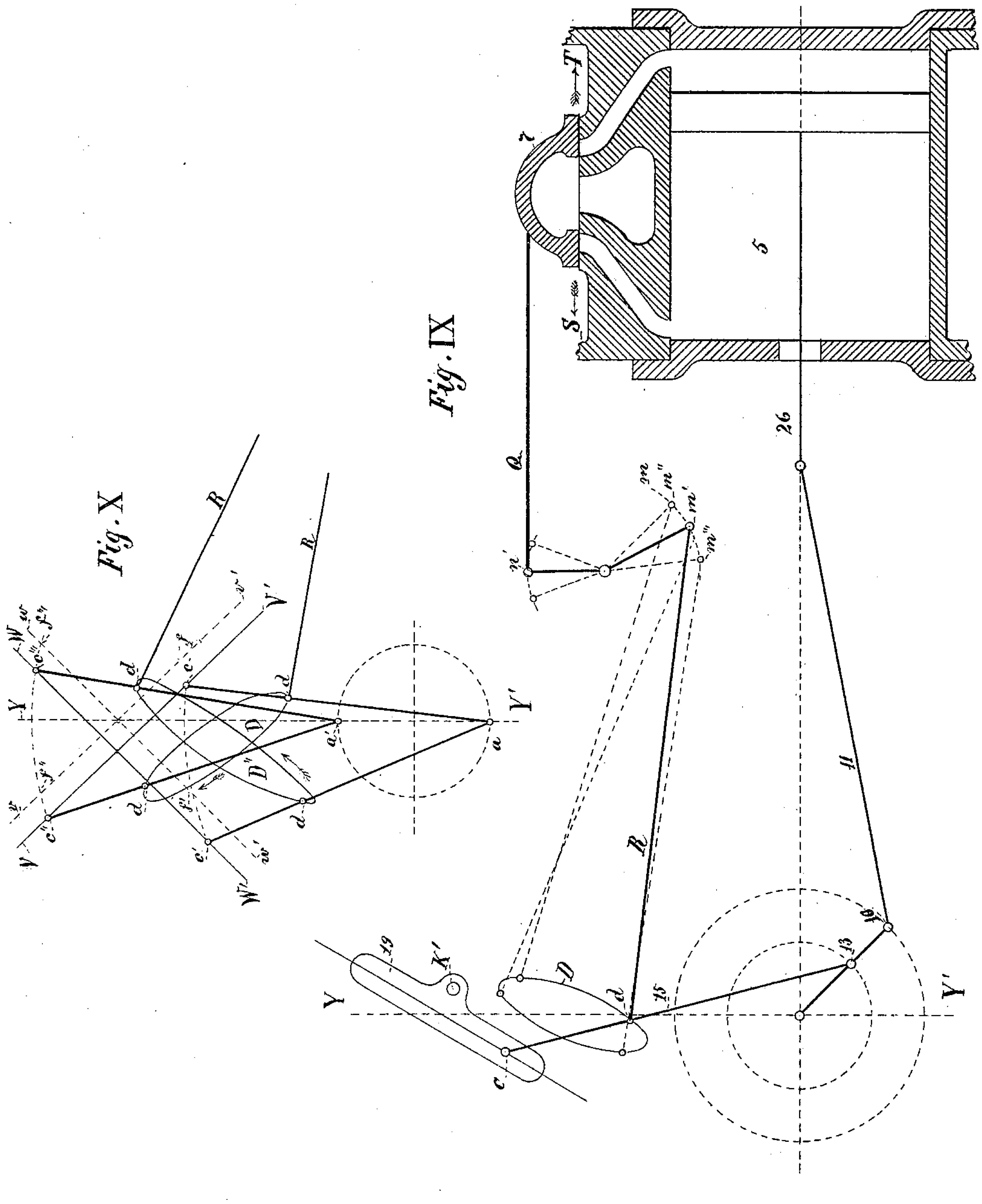

Witnesses.

Emma F. Elmore,

A. H. Opsahl.

Inventor,

John Grime.

By his Attorney

Jas. F. Williamson

UNITED STATES PATENT OFFICE.

JOHN GRIME, OF MINNEAPOLIS, MINNESOTA, ASSIGNOR, BY MESNE ASSIGNMENTS, OF ONE-HALF TO JAMES F. WILLIAMSON, OF SAME PLACE.

VALVE-GEAR FOR ENGINES.

SPECIFICATION forming part of Letters Patent No. 389,382, dated September 11, 1888.

Application filed December 19, 1887. Serial No. 258,299. (No model.)

To all whom it may concern:

Be it known that I, JOHN GRIME, a citizen of the United States, and a resident of the city of Minneapolis, county of Hennepin, State of Minnesota, have invented certain new and useful Improvements in Valve-Gear for Engines, of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to that class of valve-gear in which the valves are actuated from a single eccentric, and is in the nature of a radical improvement on the mechanism illustrated in Letters Patent No. 252,683, to Louis C. Lugmayr, of date January 24, 1882, and the Letters Patent granted to me under dates of February 9 and November 2, 1886, numbered 335,578 and 351,912, respectively.

The general object of my invention is to obtain the nearest possible approximation to an absolutely perfect valve movement; or, in other words, I seek to obtain a valve motion which will correspond absolutely to the motion of the piston or be the nearest practicable approximation to that perfect correspondence which is theoretically required between the two. More specifically, I aim to obtain the following results, viz: first, a variable cut-off which will take effect at equidistant points from the opposite end of the cylinder on the in and out strokes throughout a long range of variation and for both forward and back movements of the engine; second, comparatively uniform exhaust and uniform compression; third, a quick full-port opening and quick cut-off, avoiding wire-drawing of the steam; fourth, the admission of equal volumes of steam behind the piston on the in and out stroke, even in the cases where the cut-off is not uniform, in virtue of the compensation afforded by the inversely-related time or full-port opening, or, in other words, the port cut-off at the shortest distance is first wide open; fifth, a comparatively late exhaust for any given cut-off, thereby using steam very expansively. These results I seek to accomplish by the simplest possible construction.

To these ends my invention consists of the mechanism hereinafter fully described, and particularly pointed out in the claims.

Though of general application to various kinds of engines, my invention is especially well adapted for use on locomotives, and I have in the drawings shown it so applied.

Like references referring to like parts throughout, Figure I is a side elevation of a part of a locomotive embodying my invention. Fig. II is a rear view of the same, partly in elevation and partly in section, and some of the parts being broken away. Figs. III, IV, and V are details of the pivoted guide and its slide detached. Fig. VI is a view in side elevation of the standard for supporting the pivoted guide from the driver-axle, detached. Figs. VII and VIII are details showing points of attachments of radius-bar and eccentric-rod, and Figs. IX and X are diagrams illustrative of the action of the mechanism.

1 is the main driving-axle, 2 one of the main driving-wheels, 3 one of the forward truck-wheels, 4 part of the forward truck-frame, 5 one of the cylinders, 6 the steam-chest, 7 its valve, 8 a part of the boiler, 9 a part of the main supporting frame, 10 the crank-pin, 11 the connecting-rod, 12 the cross-head guides, and 26 the piston-rod, of an ordinary locomotive.

13 is an eccentric on the axle 1, lying directly together with the crank.

14 is the eccentric strap, and is provided with an extended arm, 15, having in its outer end a bearing for a pivot-pin.

16 is a standard mounted loosely on the axle adjacent to the eccentric, and provided at its outer end with a bearing for a rock-shaft.

17 is a rock-shaft supported at its opposite ends in the standards 16, and extending through the same outward toward the arms of the eccentric-straps.

18 is a crank-lever rigidly secured to the shaft 17, and is provided with suitable connections (not shown) extending to the engineer's cab.

19 is a slide-block guide rigidly secured to the outer end of the rock-shaft at a point in the guide-offset toward the cylinder from its longitudinal axis. This point is hereinafter designated K′, and constitutes the point of suspension in this valve-gear. The fact that this point of suspension is offset from the longitudinal axis is of great importance, as will be hereinafter made clear.

20 is a slide-block working in the guide 19, and provided at its center with an outwardly-projecting pivot-pin, 21, which rests in the bearing on the outer end of the eccentric-arm 15, and pivotally connects said slide-block and the eccentric strap. This point in the diagram is designated *e*.

22 is the valve-stem of the ordinary slide-valve, 7.

In a suitable bearing, 23, on the main frame is journaled a rock-shaft, 24, provided with the rocker arms *m'* and *n'*, rigidly attached thereto. To the rocker-arm *n'* is attached the valve-rod Q in such manner that they are at right angles or about at right angles to each other when the valve is in its mid-position. From some point on the arm 15 of the eccentric-strap, either below or beyond the pivot-pin 21, to the other rocker-arm, *m'*, extends the eccentric-rod R, said rocker-arm and eccentric-rod being always so attached to each other that they form with each other an oblique angle in mid-position of the valve. This feature has important functions, as hereinafter stated.

A radius-bar, 25, of exactly the same length as the eccentric-rod, is pivotally attached to the standard 16 and the main frame at points corresponding to the points of attachment of the eccentric-rod to the eccentric-arm and the rocker-arm, respectively. In other words, the respective pivot-pins attaching the eccentric-rod to the arm 15 and the radius-bar to the standard 16 are in the same axial line, and the respective pivot-pins attaching the radius-bar to the main frame and the eccentric-rod R to the rocker-arm *m'* are in the same axial line when the valve or said rocker-arm is in its mid-position. The object of this feature is to avoid distortions in the valve movement which would otherwise be produced by the movements of the main frame with reference to the driving-axle. As the point of suspension on the standard 16 is mounted on the axle and the support 23 for the rocker-arm shaft 24 is mounted on the main frame 9, the latter will rise and fall independently of the former, and would vary the relative position of the two were it not for the radius-bar 25. In virtue of this radius-bar and its points of attachment the centers of the eccentric-rod and the radius-bar are made to move in equal arcs, so far as the rising and falling of the frame with reference to the axle is concerned, and the point of suspension and the point of attachment of the eccentric-rod to the rocker-arm are kept in a constant relative position, regardless of the unevenness of the track and the rising and falling of the frame.

Operation: Having now described my construction as applied to a locomotive, I will endeavor to make clear the functions of my mechanism as applied to engines generally, reference being had to the diagrams. In brief, it may be stated that the function of connecting the rocker-arm *m'* and the eccentric-rod R so that they form with each other always an oblique angle (acute in construction shown) is to overcome the obliquity of the connecting-rod and effect a rate of valve movement in opposite direction in unison with the rate of piston movements in the opposite parts of its stroke, and the function of the offset point of suspension, or pivoting the guide 19 at the point K', is to correct an error or distortion which would otherwise be introduced at the extremes of the valve movements in opposite directions from mid-position; and the beauty of the construction is that the quantity of this correction varies in conformity to the error introduced (otherwise) by varying the length of the throw of the valve. In other words, the offset point of suspension is a constant corrective for a variable cut-off. That these are the functions of these features of construction may perhaps be rendered more explicit by the following considerations: It is a well-known fact that the motion of a piston does not correspond to the motion of the crank. The piston moves more rapidly in the half of the cylinder farthest from the crank-shaft on both the in and out strokes. That is owing to the obliquity of the connecting-rod. The motion of the crank being uniform, the crank-pin moves through like arcs in like times; but a greater arc must be described to move the piston through the half of the cylinder nearest to the crank-shaft on both the in and out stroke. In other words, the half-strokes farthest from the crank-shaft are made in the least time. The general principle involved is this, viz: In the movement of a point on the arc of a circle the horizontal movement, except at the limit and when exactly at right angles to the radius drawn from the point, does not correspond in length to the angular movement, but the two have an inverse relation dependent on the part of the circle and the direction of the movement. In other words, in all parts of the circle, with the exceptions stated, a constant angular travel will produce a variable horizontal travel, and, conversely, a constant horizontal movement will produce a variable angular movement.

In this valve-gear the above principle is employed to overcome the obliquity of the connecting-rod.

The rocker-arms *n'* and *m'* are rigidly attached to the rock shaft 24; hence whatever angular movement is given to the rocker-arm *m'* will also be given to the rocker-arm *n'*, and as the valve-rod Q is attached to the rocker *n'* exactly at right angles, when the valve is in mid-position, the length of valve movement will correspond very nearly to the angular movement of the rocker *n'*. Now, in virtue of the principle hereinbefore stated, the rocker *m'* may be given such a position with reference to the eccentric-rod R that equidistant throws of the rocker *n'* in the opposite directions from its mid-position will be made in unequal times. As shown, the two form with each other an acute angle when at mid-position, and as the rocker m' is moved up the arc m the acuteness of this angle is increased and the amount of angular movement for any given horizontal movement is correspondingly increased, and on the movement of m' down the arc m the reverse is true. In other words, the valve is made to move more rapidly toward S than toward T; but when the valve is moving toward S the piston is moving in the part of its stroke which is most rapid, and when the valve is moving toward T the piston is moving in the part of the cylinder nearest the crank-shaft, or in that part of its stroke where it moves most slowly. Relatively, therefore, the fast motions and slow motions of the piston and valve take place at corresponding parts of their travel. Now, the ratio of the mean velocities of the piston in the two parts of its stroke may be mathematically determined, inasmuch as they are to each other inversely as the arcs passed through by the crank, which are known quantities; hence the mean ratio of the valve from mid-position to its limit of travel in opposite directions may be given the same ratio as the mean velocities of the piston by simply varying the angle of the rocker m' to the eccentric-rod R; hence the valve not only moves fast when the piston moves fast, and conversely, but the two move at substantially the same rate; or, in other words, the two are in unison; but this is only true of the mean rates of motion, and the two would correspond only at certain parts of their respective paths. The valve would be thrown a little too far in one direction and not quite far enough in the other, and the actions—cut-off, exhaust, and compression—would take place a little too soon in one direction and a little too late in the other. For very short valve motions this error might not be material; but it is magnified as the travel of the valve is increased, for the length of valve travel is increased by increasing the horizontal movement of the eccenctric-rod, as hereinafter explained, while the angle of the rocker m' to the eccentric-rod at mid-position remains substantially constant; hence, as the angular movement corresponding to a given horizontal movement of the rod is greater the farther the point moves up the arc, the rocker would be moved too far toward m'' and not far enough toward m'''. Now, the offset point of suspension corrects this error by subtracting from the valve motion at one end and adding to it at the other.

It should be noted that in the construction as shown in the drawings the eccentric, the crank, and the axis of the crank-shaft lie in the same line on the same side of the shaft; hence the eccentric and crank may be treated as moving in the same circle if we conceive the crank to be shortened to the throw of the eccentric.

It must be further noted that, inasmuch as the eccentric-strap 13 rotates about the axis of the crank-shaft and the outer end of its extended arm 15 is constrained to follow a straight line—*i. e.*, the guide 19—any point, as d, on said arm will have a motion derived from said two motions. The eccentric-rod R is attached at such a point and takes such a motion, and its path, (*i. e.*, of point d,) when the guide is in position shown in Fig. IX, is the ellipse D. This would be back gear for a locomotive. In Fig. X the ellipses D' and D'' in oppositely-inclined planes would represent the path of the point d in forward and backward gear, respectively, for a locomotive. The full lines in both figures represent the respective positions taken by the axis of the guide—the point d and the point c—and the dotted lines show the corresponding positions which these same parts would occupy if the guide were pivoted at K—some point in its longitudinal axis.

On inspection it is evident that, whether the point of suspension be at K or K', the distance which the point d will be thrown to the opposite sides of the vertical, $Y Y'$, through the axis of the crank depends on the angle of the axis of the guide to the line $Y Y'$. In other words, this angle determines the horizontal motion given the eccentric-rod, and it is by varying the angle and horizontal motion that the valve travel is varied. But it is equally evident that in all positions of the guide except the vertical position the point d is thrown farther to the left, or away from the cylinder, when the guide is pivoted at K'. The effect is to restrain the rocker m' from moving as far up the arc m as it otherwise would, and to make it move farther in the direction m''', subtracting from the valve travel toward S and adding to its travel toward T. Now, it can be readily shown that the distance which d is thrown farther to the left or away from the cylinder in virtue of this offset point of suspension varies in proportion to the angle of the axis of the guide to the vertical, $Y Y'$. This is evident from the fact that when the axis is vertical the point c, and hence also the point d, is in exactly the same position as if the guide were pivoted on K; but as the guide is swung from the vertical the position which c does occupy is separated from the position it would occupy if the guide pivoted on K by an increasing distance measured on a horizontal line. When the guide is horizontal, for example, the two would be separated by an infinite distance. The possible variation in separation is therefore from zero to infinity. This is true for backward and forward gear, and is well shown in Fig. X, wherein the angles between the axes of the guides and the distance between K and K' are greatly magnified. In that figure $V V'$ represent the position of the guide for forward (locomotive) motion and $W W'$ for backward, while the dotted lines $v v'$ and $w w'$ represent corresponding positions which the guide would occupy if pivoted at K. When the eccentric is at a, the upper end of the arm 15 is at c' for forward motion and at c for backward motion, and when the eccentric is at a' the upper end of the arm 15 is at c'' for forward and at c''' for backward motion, while if the guide had been pivoted at K the corresponding positions of the outer end of the arm 15 when the eccentric was at a would have been f' for forward and f for backward motion, and when the eccentric was at a' the outer end of the arm would have been at f'' for forward and f''' for backward gear; but c and c' are much farther to the left than f'' and f'''. As d is a point on the arm 15, it is also moved farther to the left. In other words, as the error introduced by increasing the horizontal movement of the eccentric-rod to secure greater valve travel is increased the correction is increased in like proportion. The correction varies as the error varies.

Pivoting the point of suspension at K', connecting the rocker-arm m' and eccentric rod at an oblique angle to each other, and connecting the rod to the rocker at a point below the point of attachment of the rod to the eccentric-arm d, taken all together, have an additional function of advantage in preserving uniformity in a reversing engine. This combined function comes into play in shifting from forward to backward. As the tracing of this function is very difficult, requiring an abstruse mathematical discussion, it is not deemed essential in this specification.

There is a limit to the distance between K and K' and better and worse positions for this offset point of suspension to occupy. Its proper position for any given dimensions of all the co-operative parts of the valve-gear may be determined mathematically within a sufficiently near approximation for practical purposes.

The proper proportions and positions of the respective parts having been once determined, the importance of maintaining them in these relations is self-evident in view of the foregoing discussion. The radius-bar 25 accomplishes this function, as hereinbefore stated.

When all the parts are properly proportioned, this valve-gear gives a valve motion which is almost perfect, the actions—cut-off, exhaust, and compression—being very nearly uniform.

Modifications can be made in this construction without departing from the spirit of my invention.

What I claim, and desire to secure by Letters Patent of the United States, is as follows:

1. In a valve gear, the combination, with an eccentric, of an eccentric-strap provided with an extended arm, a guide for the outer end of said arm, constraining it to move in a definite path, a rocker provided with a pair of rigid arms, a valve-rod connected to one of said arms at or about right angles when the valve is in mid-position, and an eccentric-rod having one end attached to the extended arm of said eccentric-strap and the other end attached to the other rocker-arm at an oblique angle when the valve is in mid-position, substantially as and for the purpose set forth.

2. In a valve gear, the combination, with an eccentric-strap having an extended arm, of a guide for the outer end of said arm, pivoted at a point offset from its longitudinal axis, and an eccentric-rod for driving the valve, attached to said arm, substantially as and for the purpose set forth.

3. In a valve-gear, in combination, an eccentric-strap having an extended arm, a guide for the outer end of said arm, pivoted at a point offset from its longitudinal axis, a rock-shaft provided with a pair of rocker-arms, a valve-rod attached at or about right angles to one of said rocker-arms when the valve is at mid-position, and an eccentric-rod having one end attached to the other rocker-arm at an oblique angle when the valve is in mid-position and its other end attached to the extended arm of the eccentric-strap, substantially as and for the purpose set forth.

4. In a locomotive, an automatically-adjustable support for the point of suspension of a valve-gear, consisting of a standard boxed on the main driving-axle, in combination with a radius-bar attached at one end to said standard and at the other to a part of the main frame, as and for the purpose set forth.

5. In a valve-gear for locomotives, in combination with an eccentric on the main driving-axle and an eccentric-strap provided with an extended arm, a standard boxed on said axle, a guide for the outer end of said arm, pivoted to said standard, a rocker mounted on the main frame for communicating motion to the valve, an eccentric-rod from said arm to said rocker, and a radius-bar of same length as the eccentric-rod, attached to the standard and to a part of the main frame at points corresponding to the points of attachment of said eccentric-rod, substantially as and for the purpose set forth.

6. In combination with the driving-axle 1, the eccentric 13, the strap 14, having the arm 15, the standard 16, the rock-shaft 17, the guide 19, rigidly secured to said rock-shaft at a point offset from the longitudinal axis of the guide, the slide-block 20, to which the arm 15 is attached by pivot 21, the rocker-shaft 24, having rocker-arms m' and n', the valve-rod Q, attached to n' at or about right angles, and the eccentric-rod R, attached to m' at an oblique angle, and having its other end attached to the arm 15, all substantially as described.

JOHN GRIME.

In presence of—
E. BERGSTRESSER,
S. LESLIE LECROW.