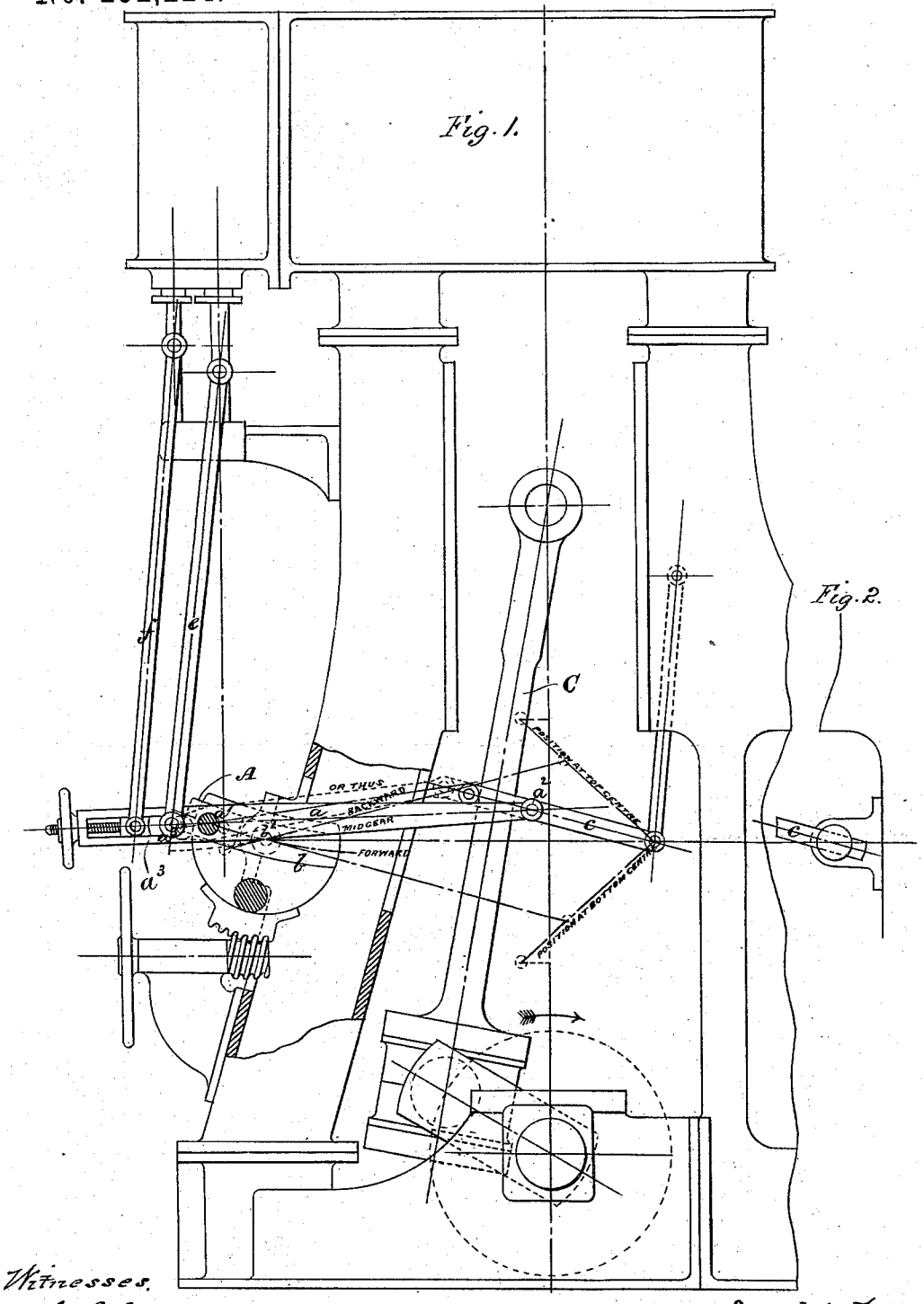
(No Model.) 4 Sheets—Sheet 1.

D. JOY.

STEAM ENGINE VALVE GEAR.

No. 252,224. Patented Jan. 10, 1882.



Witnesses.

J. A. Shumway.

Jos. C. Earle

David Joy Inventor

By atty Wm. C. Earle

(No Model.) 4 Sheets—Sheet 2.

D. JOY.

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Fig. 3.

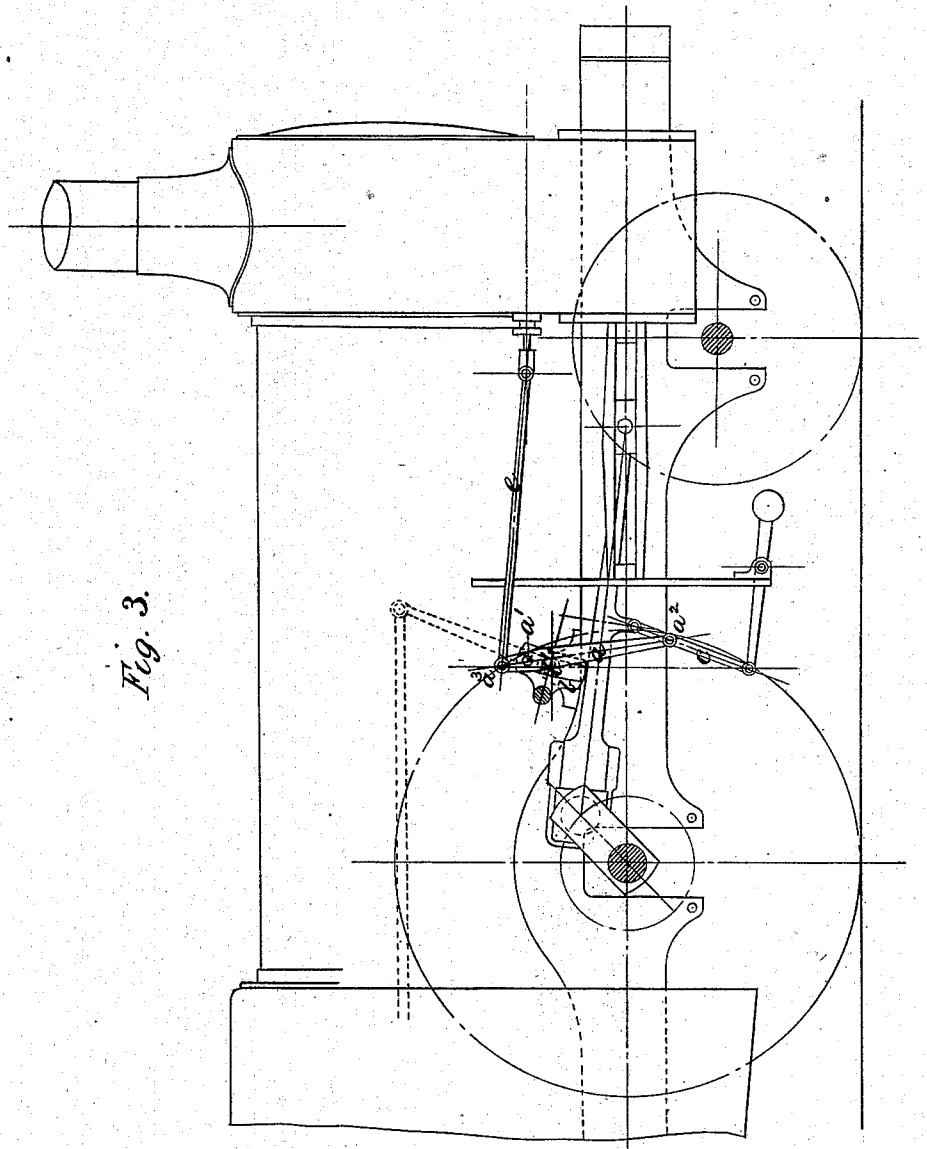
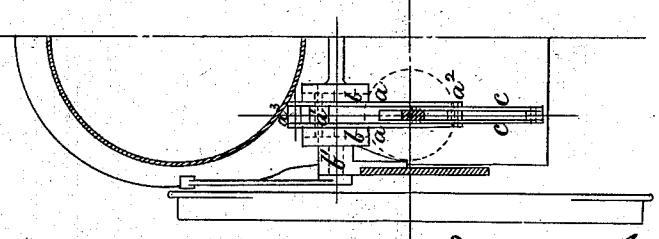


Fig. 4.



Witnesses
H. C. Shumway
Jos. A. Earle

David Joy
Inventor.
By atty
Thos. Earle

(No Model.) 4 Sheets—Sheet 3.

D. JOY.

STEAM ENGINE VALVE GEAR.

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Fig. 8.

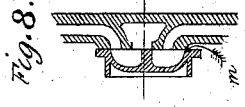


Fig. 7

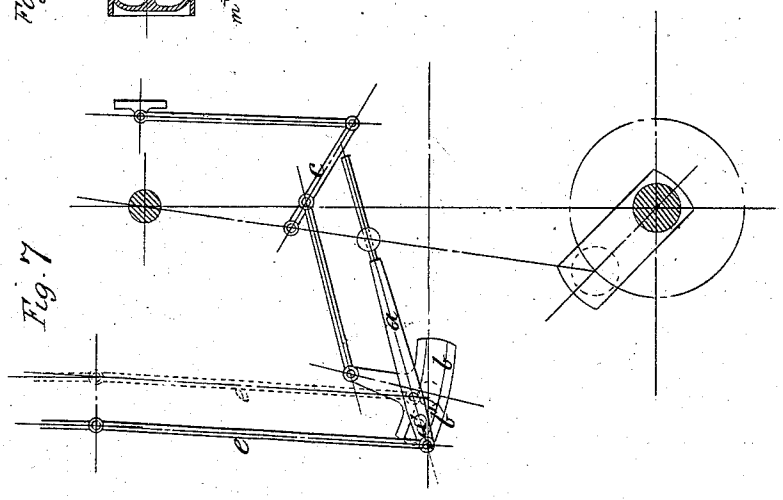


Fig. 6.

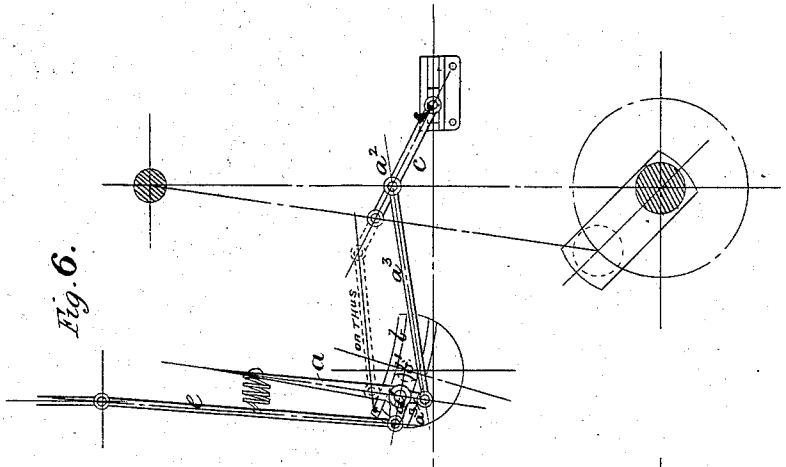
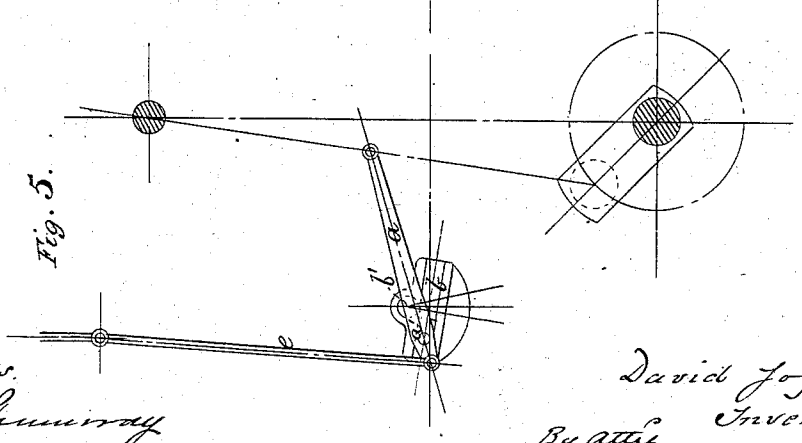


Fig. 5.



Witnesses.
J. H. Shumway
Jos. C. Earle

David Joy
Inventor
By attys
Wm. C. Earle

(No Model.)

4 Sheets—Sheet 4

D. JOY.

STEAM ENGINE VALVE GEAR.

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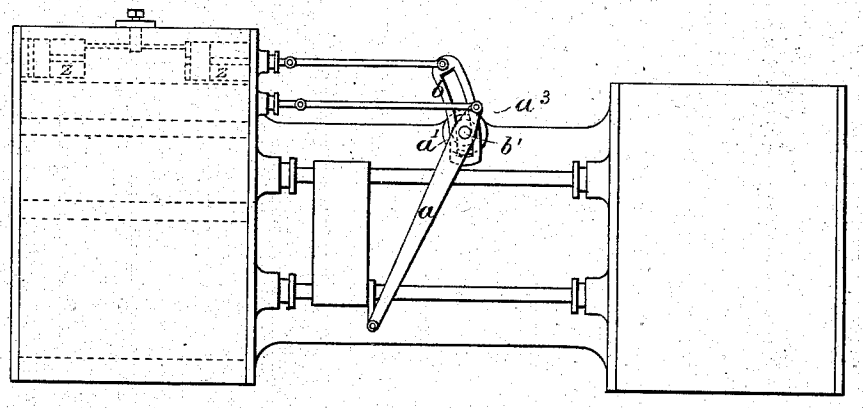
Fig. 9.



WITNESSES

Wm. A. Skinkle.

Wm. J. J. Tanner.

INVENTOR

David Joy.

By his Attorneys

Baldwin, Hopkins, Peyton.

UNITED STATES PATENT OFFICE.

DAVID JOY, OF BARROW-IN-FURNESS, COUNTY OF LANCASTER, ENGLAND.

STEAM-ENGINE VALVE-GEAR.

SPECIFICATION forming part of Letters Patent No. 252,224, dated January 10, 1882.

Application filed June 10, 1880. (No model.) Patented in England March 8, 1879.

To all whom it may concern:

Be it known that I, DAVID JOY, of Barrow-in-Furness, in the county of Lancaster, England, engineer, have invented certain new and useful Improvements in Steam-Engine Valve-Gear, of which the following is a specification.

My invention consists in the application and use of a simple form of valve-gear capable of giving expansive action or reversal to the valve or valves. The improved valve-gear in its preferred form is composed of a double lever the longer end of which is attached to any point of the connecting-rod. The fulcrum of this lever, instead of being fixed, traverses a slide which is centered at right angles, or nearly so, to the line of motion of the connecting-rod. This slide is capable of being angled to either side of the right angle. To the outer and shorter end of the said lever is attached the rod actuating the valve; or the center of the lever may be hung on a link centering at or about the position of the valve-spindle joint. It will thus be seen that the valve, being moved first by a lever attached to the connecting-rod, is partaking of the movement of the crank; but this motion is modified by the movement of the fulcrum of the lever in the slide according to the angle at which that slide is set, and by a combination of their movements in various proportions all the positions required for various degrees of cut-off and of reversal may be obtained.

This motion, from its simplicity, may be applied to any class of engine, whether stationary, marine, or locomotive. The slight inequality in the motion of the valve arising from the arc of the lever may be corrected by attaching the end of the lever (described above as attached to the connecting-rod) not directly to the connecting-rod, but part way along another lever, the one end of which is attached to the connecting-rod, the other end sliding in a guide on the opposite side and at right angles to the motion of the connecting-rod. The arcs made by these two levers crossing will correct each other and produce a perfectly equal action. By varying the proportion of the levers and the slide action, and by varying the proportion of motion transmitted to the valve by each, any combination of lap and lead may be obtained.

To apply this motion for working the valves of direct-acting pumps or engines where there is no rotary motion, a slight modification is required. In this case the lever, actuated by the connecting-rod in the rotating engine, is attached to the cross-head of the piston-rod, and has its fulcrum carried in a slide, as before; but the angle of the slide is changed over from side to side either by mechanical action, as by the changing of the motion of the rod, bringing a thrust on the slide and throwing it over, or by a small cylinder and piston connected to it, this small cylinder receiving steam from the large cylinder. Thus at each end of the stroke the steam admitted at lead to the large cylinder passes over to the small cylinder and reverses the position of the angled slide, or the small cylinder may have a special valve. The speed of the small cylinder may be controlled by a cataract-cylinder, or it may itself be made to constitute a cataract-cylinder by arranging that the steam-pressure shall act on the surface of two reservoirs of fluid, one for each end of the small cylinder, which shall transmit the pressure to the piston under the control of a checking-valve.

Figure 1 is an elevation, partly broken away, showing my improved valve-gear applied to an overhead marine engine. Fig. 2 is a detail view, showing the block in which the end of one of the levers pivoted to the connecting-rod slides. Fig. 3 is an elevation showing the improved valve-gear applied to another form of engine, and Fig. 4 is a half cross-section of the same. Figs. 5, 6, and 7 are detail views, showing modified forms of the gear. Fig. 8 is a detail view of one form of the valve which is used in connection with the modification shown in Fig. 7, and Fig. 9 is a view of a direct-acting pumping-engine with the improved valve-gear applied thereto.

Fig. 1 illustrates this valve-motion in its simplest and most perfect form as applied to an ordinary overhead marine engine. A lever, *a*, is centered at *a'* in a block, A, free to slide in a curved slot-link, *b*, which is centered at *b'*, and free to be set at various angles to the horizontal. This lever *a* receives motion from the connecting-rod C through a second lever or rod, *c*, pinned to the connecting-rod at a convenient point on its center line, up or down,

or away from it on either side, according to the position and amount of movement required; or this action may be taken direct from the crank. This rod *c*, at the other end, is either allowed to slide horizontally in a block and slide, as shown in Fig. 2, or it is suspended by a suspending-link, D, as shown in Fig. 1, and thus vibrates in a cross direction to the vibration of the connecting-rod. The point a^2 at which the end of the lever *a* is jointed to this rod or lever *c* is such as to correct the radial error of the lever *a* and to cause its fulcrum to traverse the slot-link *b* equally on each side of its center; but while correcting this action it does not reduce its amount. The lever *a* will therefore have imparted to it at the point a^2 a vertical action, while its fulcrum will also be traversed horizontally and equally in the slot-link *b*, partaking also of a motion due to the angle at which the slot-link may be set. The outer end, a^3, of this lever, to which the valve-rod *e* is attached, will therefore have a movement compounded of the up-and-down lever action of the lever *a* and of a similar motion, but timed differently, caused by the fulcrum sliding in the slot-link *b*, and in proportion to the predominance of either of these movements any lap, lead, or port and any point of cut-off may be arranged for.

It is evident that when the slot-link *b* is in the horizontal position the valve will be moved only for "mid gear," and in proportion as it is varied from this position either way—forward or backward—motion will be given to the valves with an opening of the ports of more or less duration and extent, according to the angle of the slot-link. Thus, with an action taken from the connecting-rod, movement is communicated direct to the valve, the radial action of the lever *a* being corrected by the rod *c* and the radial action of the valve-connecting link *e* being corrected by the curvature of the slot-link *b*, resulting thus in a correct action of the valve, giving equal leads, points of cut-off, and openings of port for both ends of the cylinder, each of which, however, may be varied at pleasure either way by altering the proportions of the parts and the point at which the center of the lever *a* crosses the center of the slot-link *b*. The position of the slot-link is controlled to govern the forward and backward motion or amount of expansion by means of a worm, as shown in Fig. 1.

Instead of the center of the lever *a* sliding in the slot-link, it may be hung by a suspending-link, the upper end of which is centered at such a distance and position as to cause the center of the lever *a* to traverse a similar path to what it would if governed by the slot-link, the point of suspension of such suspending-link being adjustable, so as to allow the curves formed by its vibrating end to be the same as the curves of the slotted link in its various positions or angles.

To work a cut-off valve on the back of the main valve, as is customary with an extra eccentric when the link-motion is employed, an additional lever, like *a*, and a slot-link, like *b*, may be employed, the slot-link of the expansion-valve being set at the reverse angle to that of the main slide-valve, and being more or less angled, according to the amount of expansion required; or the lever *a* may be lengthened at its outer end, (see Fig. 1,) and the expansion or cut-off valve-rod *f* may be attached to this, with an adjustment for lengthening or shortening the stroke according to the expansion required, as shown in the drawings.

This gear, which is specially adapted for actuating slide-valves under high-pressure steam and the large and heavy valves of marine engines, which have a long stroke or traverse, all of which require great force to move them, is suitable to all engines requiring reversal and expansive motion, such as is now usually gained by the link-motion, and modification of the parts will render it available wherever the link-motion obtains. Thus, for locomotive, rolling-mill, and winding engines, for agricultural and traction engines, where the diameter of the cylinder bears a small proportion to the length of the stroke, I connect the rod *c* to a point considerably outside the center line of the connecting-rod, as shown in Fig. 3, and thus I bring the center line of the valve-spindle into suitable relation to the center of the cylinder, while I also obtain an increased duration of the maximum opening of the port toward the end of its movement. In Fig. 4 is shown a half cross-section of the same engine.

Retaining the general principles of this gear, its arrangement may be modified, as in Fig. 5, where the lever *a* is pinned directly to the connecting-rod, a straight slot-link, *b*, is used, and the errors arising from such changes are balanced against each other by setting the center of support *b'*, on which the slot-link is angled, out of the center line of the slot-link, as shown; or the corrections of the radial action of the lever *a* and of the valve-rod *e* may be effected by carrying the center of the slot-link *b* in a horizontal slide and moving it backward and forward each stroke by the amount of the above-named radial errors; and again, as in Fig. 6, the lever *a* may be exchanged for a bell-crank lever and a connecting-link, a^3, the action of this bell-crank at each change of motion of the connecting-rod being controlled by a cataract-cylinder, or by a spring, as shown in the drawings; or again, as in Fig. 7, the center of the lever *a*, or of the bell-crank a^3, may be stationary in the slot-link, (its position therein governing the forward or backward motion and the amount of expansion,) and its inner end receives one motion from the connecting-rod, while the other motion is supplied by the slot-link itself being vibrated by its attachment to the cross-head or connecting-rod; or the slot-link may be a part of or may be fixed to the usual air-pump levers, which already have the required motion from the

cross-head; or if in any instance it is found convenient to attach the valve-rod within the fulcrum of the lever, as shown in dotted lines, Fig. 7, then as the action communicated to an ordinary slide-valve would be exactly opposite to that required, I employ in such case a double D-valve admitting the steam past the lip of the port-face at *m*, as shown at Fig. 8, instead of the usual slide-valve.

Other modifications may suggest themselves to those skilled in the art without departing from the spirit of my invention.

The application of the main features of this valve-gear to direct-acting pumping-engines is shown in Fig. 9. Here the lever *a* receives motion from the cross-head, both as a lever and as sliding its fulcrum in the slot-link *b*; but as both the inward and outward strokes of the cross-head are similar, it is necessary to change the angle of the slot-link for each opposite stroke. This is done by a small steam or water cylinder at *z*, controlled by a cataract-cylinder, which may be one with it, as shown; or the steam-cylinder may be made to serve both purposes by making its ports of such capacity that they will contain sufficient water or fluid to fill the cylinder at each stroke, and the water or fluid would then nearly all pass backward and forward through the cylinder and ports. The piston-rod of this small cylinder is connected to either end of the slot-link, as is convenient, and the steam may be admitted to it either by the main valve or by a small independent valve; or the slot-link may be pushed over by the thrust of the lever *a* on its return movement at each end of the stroke of the piston, a suitable locking-catch being provided to hold it over till the opposite end stroke is required, when the position of the lever *a*, unlocking this catch and reversing its pressure on the slot-link, would again push it over to its other position.

I am aware that English Letters Patent No. 3,170 of 1875 show an engine in which a valve-rod is pivoted to and operated by a lever which is actuated by an eccentric on the main shaft, the end bearing of said lever sliding in a grooved or slotted pivoted block. I make no claim, therefore, to the construction shown in such patent.

Having thus described the nature of my said invention and the manner in which it may be used or carried into effect, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination, in an engine, of the valve-rod, the vibrating operating-lever pivotally connected to the connecting-rod and to the valve-rod, the pivoted link in which said lever is fulcrumed, and mechanism for controlling the position of the link, substantially as and for the purpose set forth.

2. The combination, in an engine, of the connecting-rod, the valve-rod, a lever-connection between said rods, and a pivoted slot-link which carries the fulcrum of the lever-connection, substantially as and for the purpose set forth.

3. The combination, in an engine, of the connecting-rod, the valve-rod, the lever-connection *a* between said rods, the sliding fulcrum of the lever-connection, and the pivoted slot-link in which it moves, substantially as set forth.

4. The combination of the valve-rod, the connecting-rod, the lever *c*, pivoted thereto, the lever-connection *a*, its sliding fulcrum, and the pivoted slot-link in which the fulcrum slides, substantially as set forth.

5. The combination of the connecting-rod C, the valve-rod *e*, the cut-off valve-rod *f*, the lever-connection *a*, its sliding fulcrum, and the pivoted slot-link, substantially as and for the purpose set forth.

6. The improved valve-gear, consisting of the vibrating operating-lever pivotally connected to the reciprocating cross-head or connecting-rod of the engine at one end, and also to the valve-rod, and having a moving fulcrum, substantially as set forth, whereby the requisite movement of the valves is obtained by the combined motions of the parts, as described.

DAVID JOY.

Witnesses:
WILLIAM J. CORDNER,
JOHN SIMPSON,
Clerks, Barrow-in-Furness.