No. 786,060. PATENTED MAR. 28, 1905.

F. E. SMITH.

SLIDE VALVE MECHANISM FOR STEAM ENGINES.

APPLICATION FILED APR. 30, 1904.

4 SHEETS—SHEET 1.

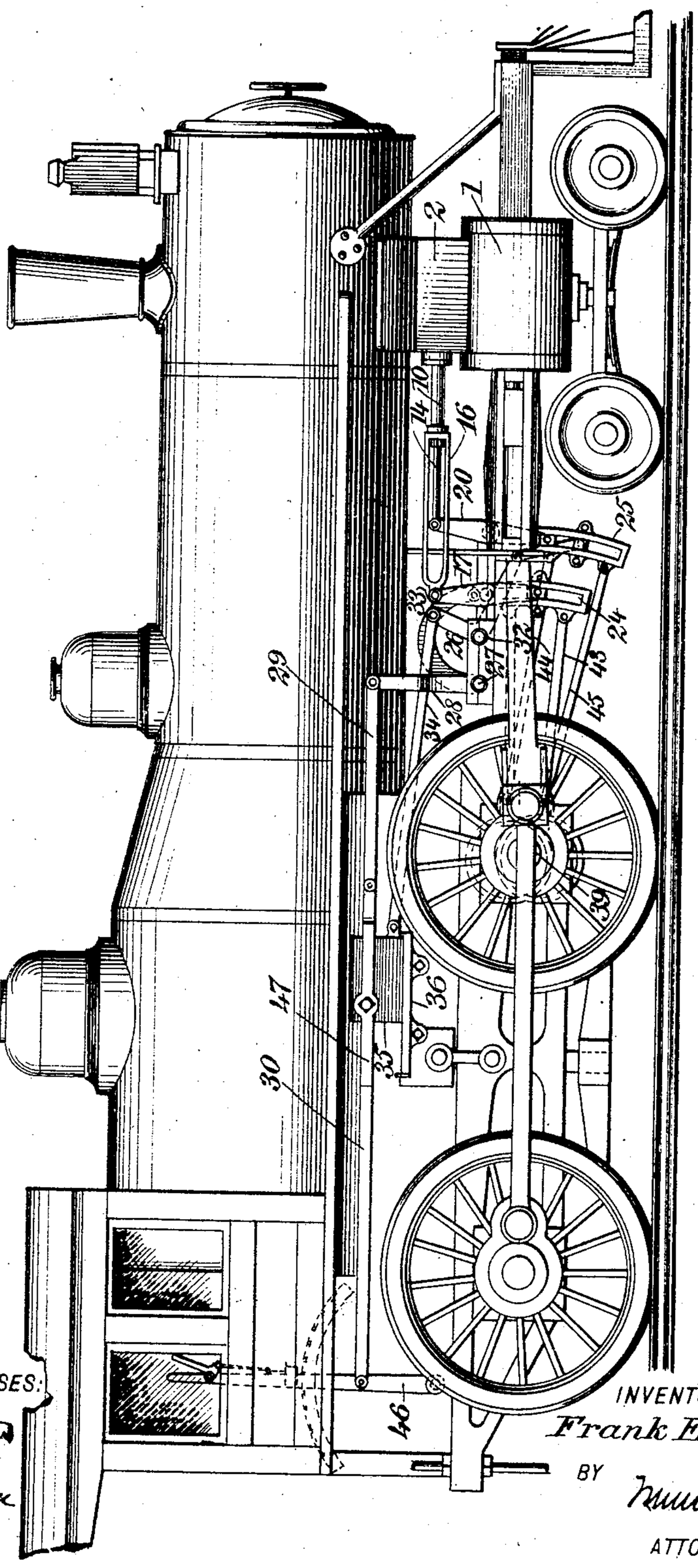

FIG. 1.

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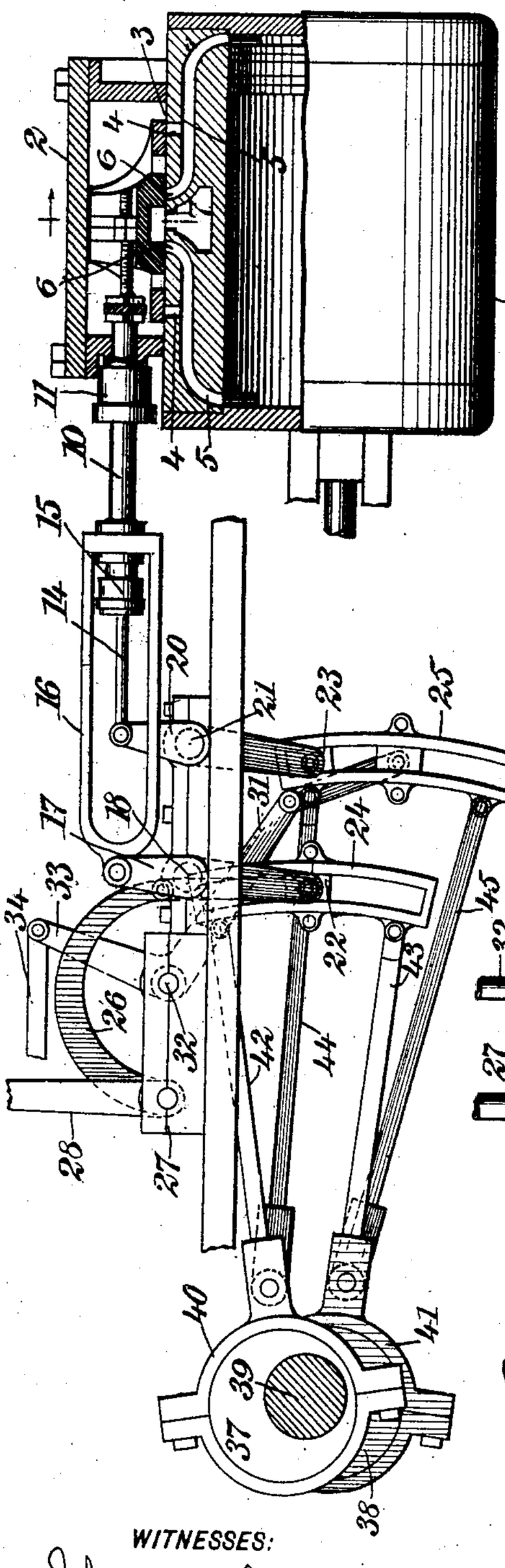

FIG. 2.

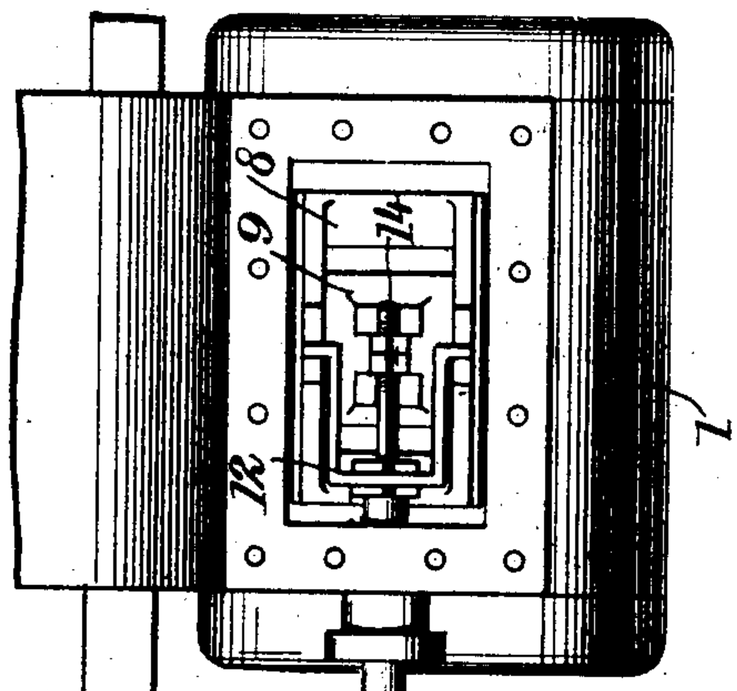

FIG. 1.

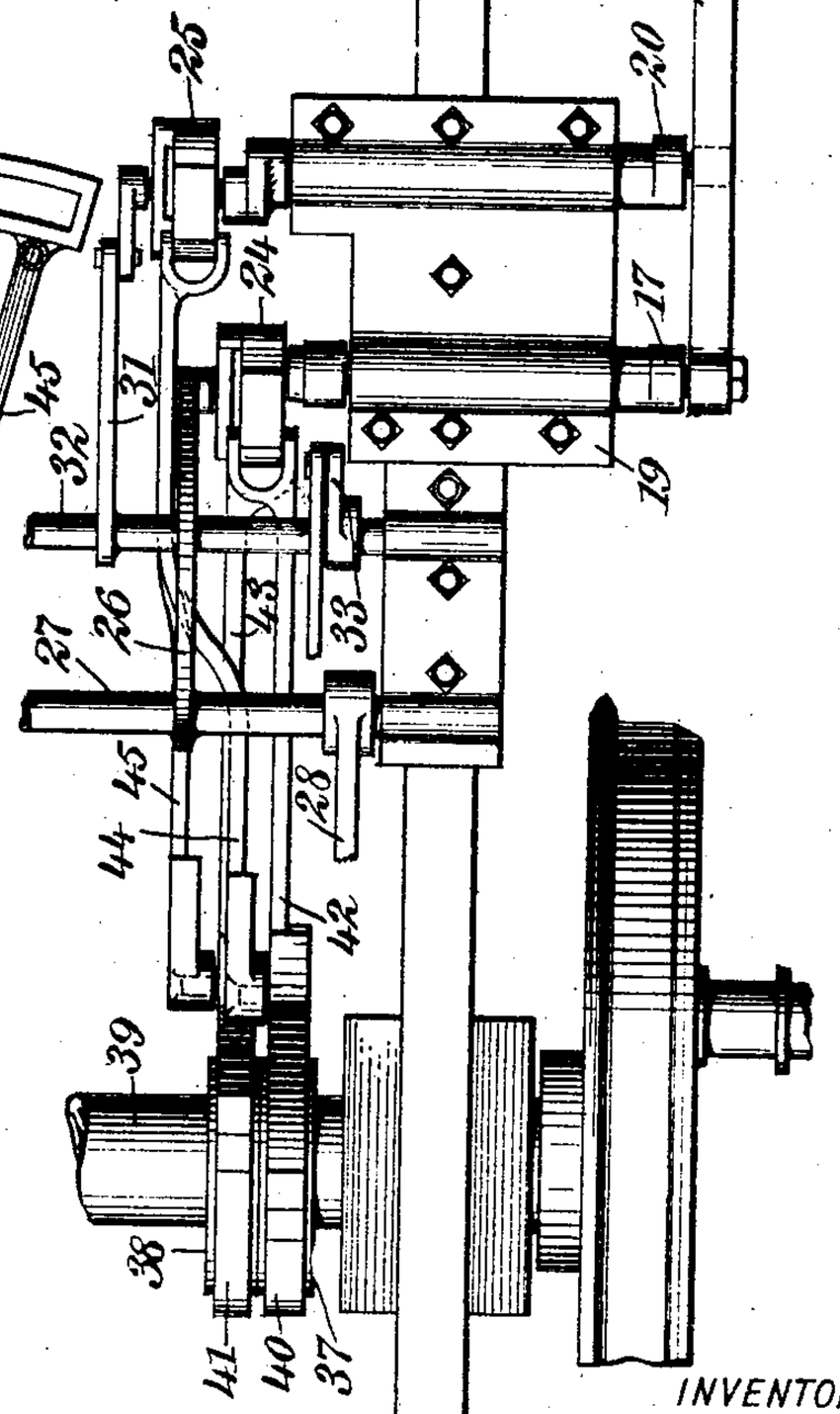

FIG. 3.

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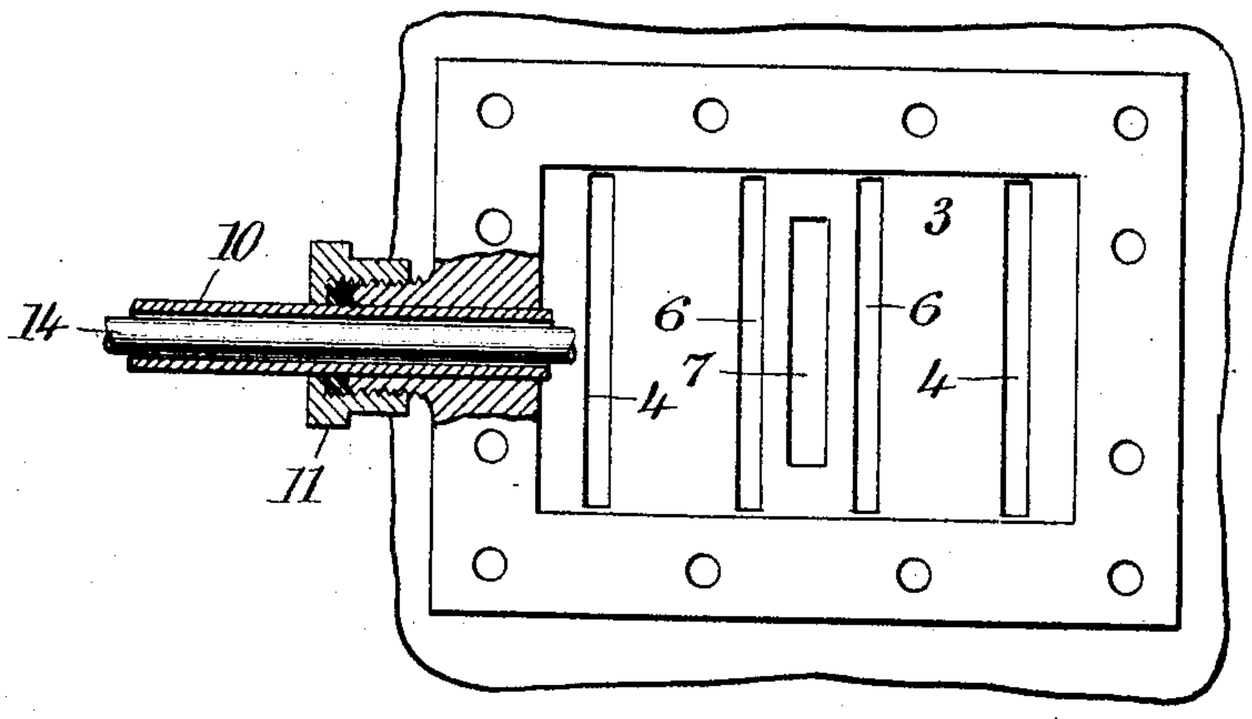

FIG. 4

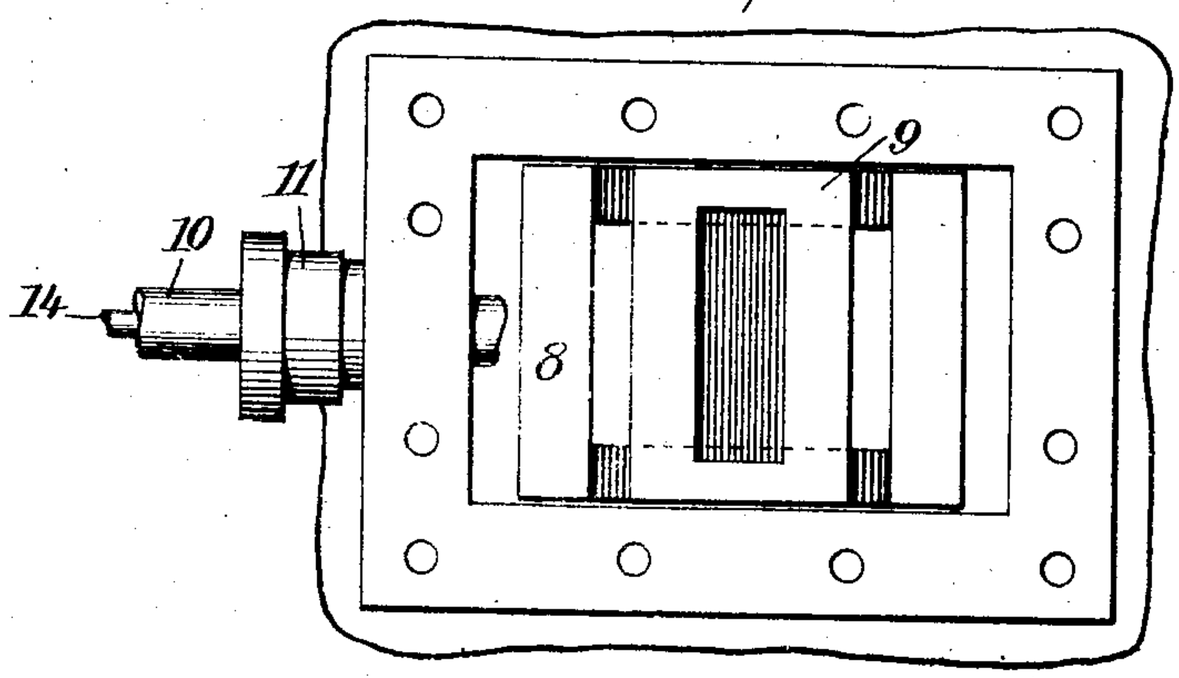

FIG. 5

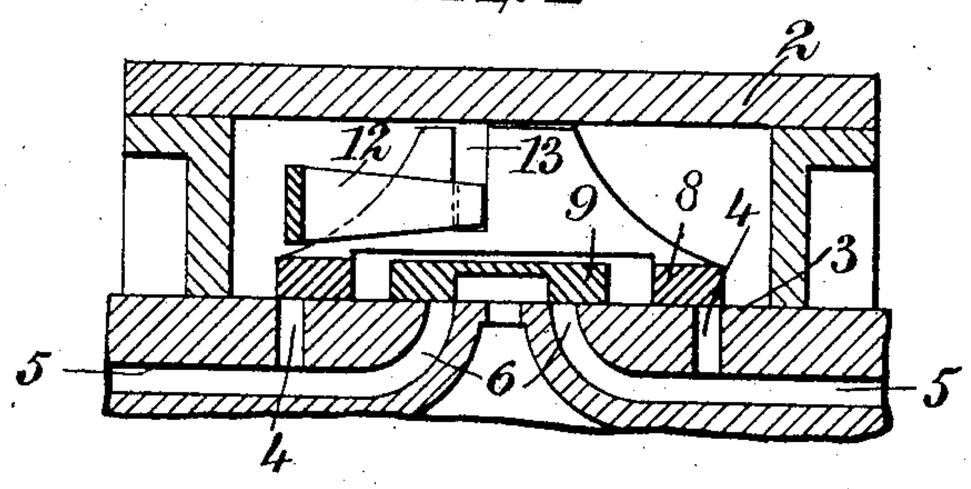

FIG. 6

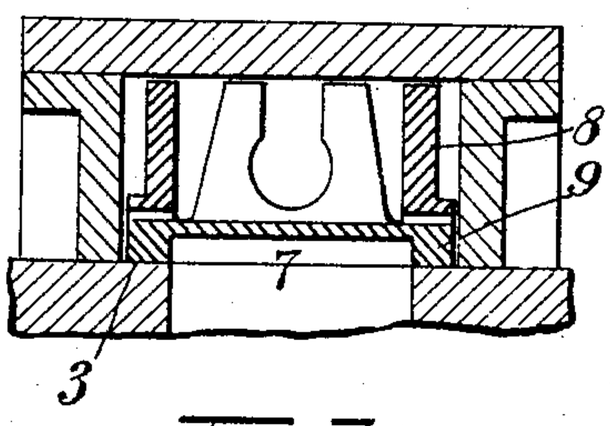

FIG. 7

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No. 786,060. PATENTED MAR. 28, 1905.

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APPLICATION FILED APR. 30, 1904.

4 SHEETS—SHEET 4.

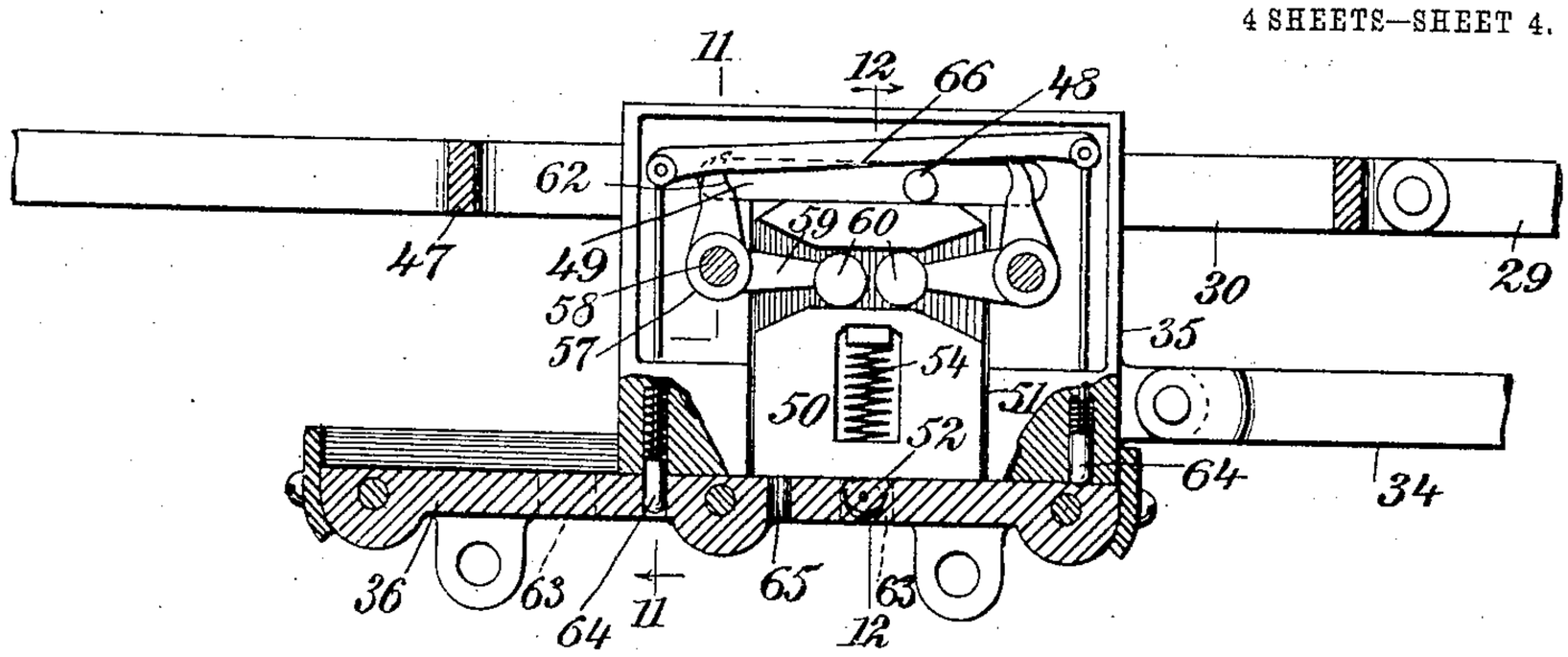

Fig. 8

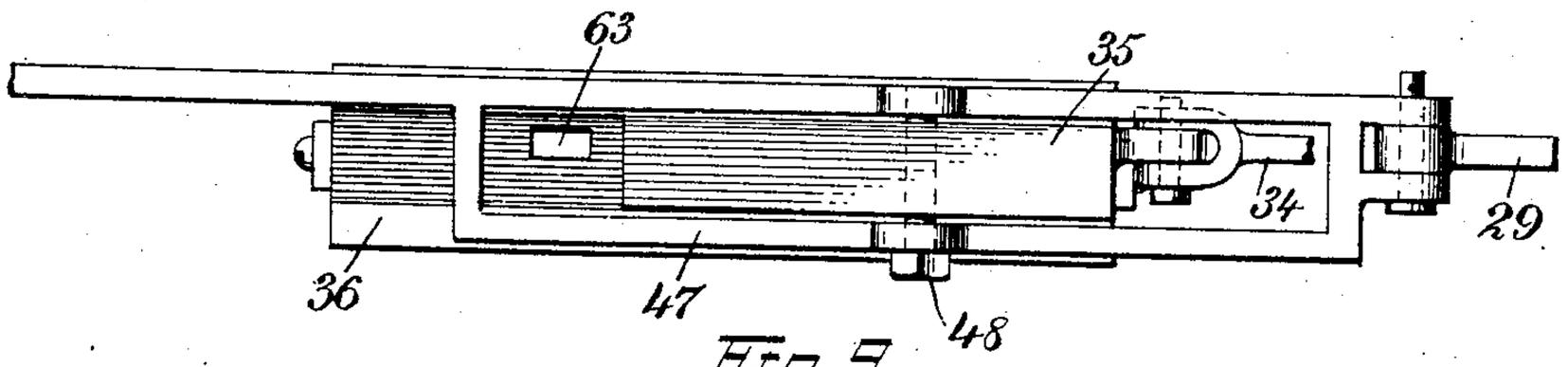

Fig. 9

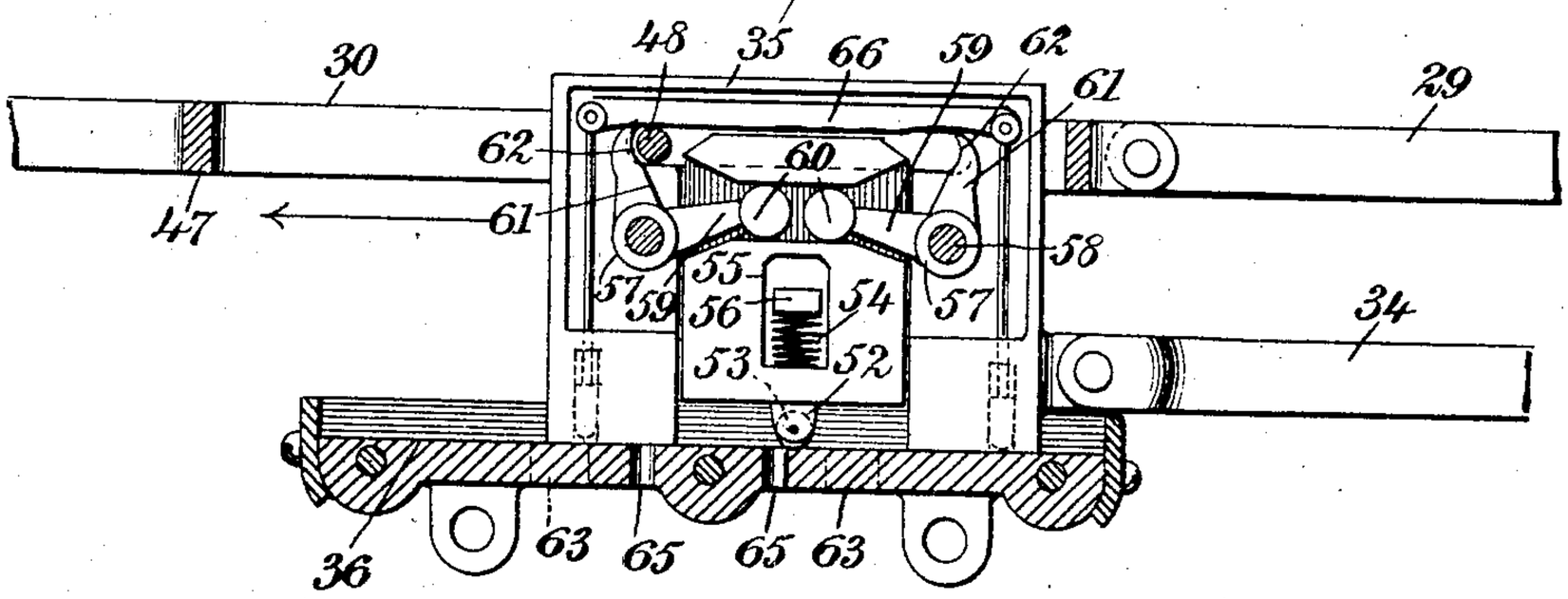

Fig. 10

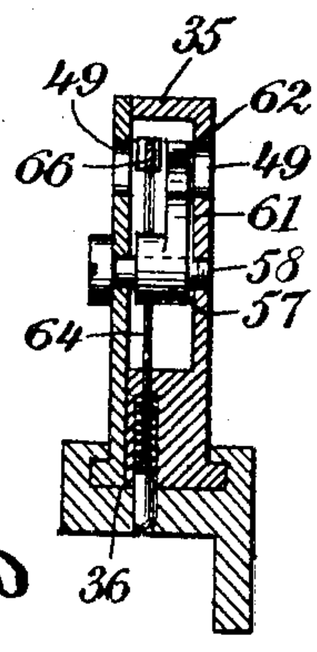

Fig. 11

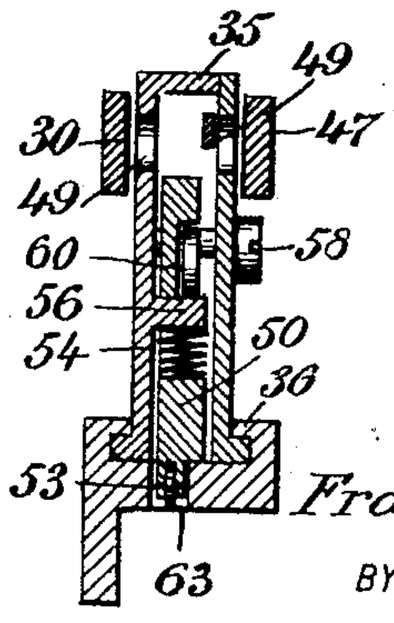

Fig. 12

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No. 786,060. Patented March 28, 1905.

UNITED STATES PATENT OFFICE.

FRANK ELI SMITH, OF MUNNSVILLE, NEW YORK.

SLIDE-VALVE MECHANISM FOR STEAM-ENGINES.

SPECIFICATION forming part of Letters Patent No. 786,060, dated March 28, 1905.

Application filed April 30, 1904. Serial No. 205,715.

To all whom it may concern:

Be it known that I, FRANK ELI SMITH, a citizen of the United States, and a resident of Munnsville, in the county of Madison and State of New York, have invented a new and Improved Slide-Valve Mechanism for Steam-Engines, of which the following is a full, clear, and exact description.

This invention relates to slide-valve mechanism for engines, but more especially to slide-valve mechanism for locomotive-engines.

The principal object of the invention is to provide a slide-valve mechanism comprising separate inlet and exhaust valves and means for reducing the stroke of the inlet-valve without diminishing the stroke of the exhaust-valve, and thereby reducing the rate of exhaust from the engine-cylinder.

As is well known to persons skilled in the art, it is customary in starting a locomotive-engine having a load attached thereto to set the inlet-valve for its full stroke, so as to admit to the cylinder of the engine upon each stroke of the valve the maximum amount of steam, this being necessary to overcome the inertia of the load and to set the engine and its load in motion. After the engine has developed some speed the stroke of the inlet-valve is gradually cut down, because the maximum amount of steam which is admitted by the valve when operating at full stroke is no longer necessary and is, in fact, objectionable, because it cannot be exhausted with sufficient rapidity to obtain the best effects from its expansion. In the engines now in general use upon railroads the mechanism by which the steam is admitted to the cylinder and allowed to escape therefrom is such that when the stroke of the inlet-valve is reduced to lessen the amount of steam admitted upon each stroke there is a similar reduction of the stroke of the exhaust-valve, and for any reduction of the amount of steam admitted to the cylinder there is a corresponding reduction of the exhaust.

The reduction of the exhaust when the inlet of steam into the cylinder is reduced is exceedingly undesirable, for the reason that the steam in front of the piston during its stroke opposes a considerable resistance to the movement of the piston under the influence of the steam behind it, and it is exceedingly desirable to reduce this resistance opposed to the piston by the unexhausted steam to an amount which is just sufficient to serve as a cushion between the piston and the cylinder-head. In the engines now in general use the resistance which the unexhausted steam opposes to the forward movement of the piston upon each stroke when the engine is traveling at a high speed is sometimes as high as thirty-five per cent. of the pressure of the steam expanding behind the piston, and hence only about sixty-five per cent. of the pressure of the expanding steam is effective upon the piston. Consequently if means were provided for effecting the complete exhaust of the steam in front of the piston, so as to allow the full effect of the steam behind the piston to be obtained, an increase of approximately fifty per cent. of the efficiency in the engine would result. It is, however, impossible with an engine having a reciprocating piston to dispense with all resistance from unexhausted steam in the cylinder, as it is necessary to provide a cushion between the piston and the cylinder-head to avoid injury to the cylinder-head from the violent and unopposed stroke of the piston; but the necessary cushion between the piston and cylinder-head is afforded by a much smaller quantity of unexhausted steam than now remains in the cylinder during its stroke, and it is desirable to provide for the exhaust of the steam to the minimum amount requisite to cushion the stroke sufficiently to prevent injury to the cylinder-heads.

The mechanism by which I accomplish the object above stated consists, essentially, of a separate inlet-valve and exhaust-valve for each engine-cylinder, independent mechanism, preferably comprising link-motion devices for reciprocating said valves, and mechanism for reversing the stroke of both valves simultaneously, which permits the reduction of the stroke of the inlet-valve without affecting in any way the stroke of the exhaust-valve.

One form in which the invention may be embodied is hereinafter described in detail,

and the novel features thereof are particularly pointed out in the appended claims, it being understood that changes in the form, proportions, and in the mode of assemblage of the elements described may be made without departing from the spirit of the invention or sacrificing the advantages thereof.

Reference is to be had to the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views.

Figure 1 is a view in side elevation of a locomotive-engine provided with the valve mechanism forming the present invention. Fig. 2 is a view, partly in elevation and partly in section, of one of the locomotive-cylinders, the inlet and exhaust-valves associated therewith, and the mechanism for imparting movement to the valves. Fig. 3 is a plan view of the structures shown in Fig. 2. Fig. 4 is a plan view of the valve-seat, showing the inlet and exhaust ports. Fig. 5 is a bottom plan view of the inlet and exhaust valves. Fig. 6 is a longitudinal sectional view through the valves and valve-seat, showing the relations of the separate inlet and exhaust valves. Fig. 7 is a transverse section through the inlet and exhaust valves and the valve-seat. Fig. 8 is a detail view showing the internal structure of the locking mechanism by which the exhaust-valve-reversing mechanism is held in fixed position during the adjustment of the inlet-valve-operating mechanism to reduce the stroke of the inlet-valve, the locking mechanism being shown in operative position. Fig. 9 is a plan view of the structures shown in Fig. 8. Fig. 10 is a view of the locking mechanism shown in Fig. 8, the mechanism being shown in inoperative position. Fig. 11 is a sectional view upon the line 11 11 of Fig. 8 looking toward the left, and Fig. 12 is a sectional view upon the line 12 12 of Fig. 8 looking toward the right.

Referring to the drawings, 1 designates a cylinder of a locomotive-engine having a steam-chest 2 at the top thereof, as usual.

3 designates the valve-seat within the steam-chest, and 4 4 designate the inlet-ports in the valve-seat 3, the inlet-ports 4 leading into the passages 5, which extend to the front and rear ends of the cylinder, as shown in Fig. 2. The passages 5 are continued upward and terminate in exhaust-ports 6 near the middle of the valve-seat 3, and extending transversely of the valve-seat between the exhaust-ports 6 from the cylinder is the usual opening 7, through which the exhaust-steam passes to the outer air.

The inlet-valve which coöperates with the inlet-ports 4 is designated 8 and has the interior thereof cut out to provide space for the reciprocation of the exhaust-valve 9, which coöperates with the exhaust-ports 6 and connects these ports alternately with the opening 7.

Motion is imparted to the inlet-valve 8 by the reciprocations of a hollow valve-rod 10, which works in a gland 11 in the end of the steam-chest and carries a U-shaped bracket 12, the ends of which engage with notches 13 in the sides of the inlet-valve, as best shown in Figs. 3 and 5. The exhaust-valve is reciprocated by means of a valve-rod 14, working through the hollow rod 10 and through a gland or stuffing-box 15, provided at the outer end of the said hollow valve-rod. The hollow valve-rod 10 is connected at its rear end with a frame 16, in which the gland 15 works, and the frame 16 is connected at its rear extremity with a rocker 17, carried by a shaft 18, journaled at the rear of the rock-shaft box 19. The valve-rod 14 is connected with a rocker 20, mounted on a shaft 21, journaled in the forward end of the rock-shaft box 19. The rockers 17 and 20 are connected with sliding blocks 22 and 23, respectively, said blocks being arranged for sliding movement in links 24 and 25, respectively. The saddle of the link 24 is connected with the curved arm 26 of a bell-crank lever mounted on a shaft 27 and having the other arm, 28, extended upward to connect pivotally with a link 29, which is connected at its other end with the reversing-lever rod 30. The saddle of the link 25 is connected with the arms 31 of a bell-crank lever mounted on the shaft 32 and having the other arms, 33, thereof pivotally connected with a link 34, which is connected at its other end with a sliding casing 35, mounted for reciprocation upon a bed 36 and containing locking mechanism, as hereinafter described. The arms 28 and 33 of the bell-crank levers, which serve as link-lifters, bear the ratio of two to one in length, for reasons that will hereinafter appear.

To give the desired rocking movement to the links 24 and 25, two eccentrics 37 and 38 are mounted upon the driving-axle 39 and eccentric-straps 37 and 38, respectively. The pivoted rods 42 and 43 connect the upper and lower ends, respectively, of the link 24 with the two eccentric-straps 40 and 41, respectively, and similar rods 44 and 45 connect the upper and lower ends of the link 25 with the same eccentrics. In consequence of this arrangement the two eccentrics 37 and 38 impart oscillatory movement in opposite directions to the links 24 and 25 simultaneously.

The casing 35, which is mounted for sliding movement upon the bed 36 and is connected, by means of the link 34, with the arm 33 of the bell-crank lever, by which the link 25 is raised and lowered, contains a novel locking mechanism, which is adapted to operate automatically when the casing 35 is moved to either end of the bed 36 by shifting the reversing-lever 46, to which the rod 30 is attached. The rod 30 has a frame 47 secured thereon, as best shown in Fig. 9, the frame 47 surrounding the casing 35 and affording space

for the movement of the frame for a considerable distance without causing it to engage the casing. Extending transversely through the casing 35 and secured in the frame 47 and rod 30 is a bolt or pin 48, and to provide for the movement of the bolt or pin 48 without shifting the casing 35 a slot 49 is formed in each side of the casing.

In the interior of the casing 35 a locking-block 50 is arranged for vertical sliding movement in ways 51 in the middle of the casing. This block 50 is provided at the bottom with a downward projection 52, which preferably contains a small roller 53, which is adapted to travel along the bed 36 to prevent wear of the projection when the casing 35 is moved to and fro upon the bed. The block 50 is normally depressed by a spring 54, arranged in an opening 55 in the block and abutting at its upper end against a stud 56, formed upon the rear wall of the casing, as best shown in Fig. 12. At either side of the locking-block 50 a small bell-crank lever 57 is mounted upon a shaft 58. These levers 57 are each provided with an approximately horizontal arm 59, terminating in a disk 60, which works in a recess in the face of the locking-block 50, as shown. Each bell-crank is also provided with an approximately vertical arm 61, presenting a concavity 62 for engagement with the pin or bolt 48. When either of the concavities 62 is engaged by the pin or bolt 48, the bell-crank lever upon which the concavity is formed will be tilted or rocked into the position shown in Fig. 10 and the locking-block 50 will be raised in the casing. When, however, the pin or bolt 48 does not engage with either of the bell-cranks 57, the locking-block is depressed by the spring 54 and the projection 52 at the bottom thereof will engage with one of two slots or recesses 63, formed for that purpose in the bed 36, over which the casing slides. These slots or recesses 63 are so placed in the bed 36 that when the projection 52 engages with either the casing must be at the limit of its movement toward one end of the bed, as clearly shown in Fig. 8.

In addition to the locking-block 50 and the parts coöperating therewith, as above described, the casing 35 contains two spring-pressed bolts 64, arranged at opposite ends of the casing and adapted to enter openings 65, provided in the bed 36, as best shown in Fig. 10. Each of the spring-pressed bolts 64 has the stem or shank thereof extended upward almost to the top of the casing 35, and a bar 66 is pivotally connected at its ends with each of the bolts 64. The dimensions of the spring-pressed bolts 64 are such that when the bar 66 is raised above the slots 49 throughout its entire length the two bolts 64 will be retracted into the casing 35 and will not engage with either of the openings 65, provided in the bed 36, upon which the casing slides.

To make the operation of the valve mechanism above described clear to persons skilled in the art, it may be assumed that the parts of the mechanism are in the position indicated in Fig. 1, the reversing-lever 46 being in vertical position in the middle of its range of movement and the inlet-valve having no movement in the steam-chest, it being disposed above the inlet-ports 4, as shown in Fig. 6. The engine is therefore standing still. If now it is desired to set the engine in motion in either direction, the reversing-lever will be thrown to the end of its range of movement in one direction or the other in order that the inlet-valve may make its full stroke and admit a maximum amount of steam to the cylinder upon each movement of the valve. If the reversing-lever is thrown forward, the rod 30, the frame 47, the link 29, and the arm 28 of the bell-crank carried by the shaft 27 will all travel forward. The link 24 will be lowered, so that the slide 22, which moves therein, will lie at the top of the link and the maximum throw will be given to the frame 16 by the rocker 17 and the inlet-valve 8 will have its full stroke. The casing 35, which is shown at the forward end of the bed 36 in Fig. 1, will not be disturbed by this movement of the reversing-lever 46, as the spring-pressed locking-bolt 64 at the rear end of the casing will continue to engage with the aperture in the bed provided for it. If, however, after the reversing-lever is thrown forward it is desired to swing it rearward to the other end of its stroke or if instead of throwing it forward from the position shown in Fig. 1 it is desired to throw it rearward to produce the opposite movement of the engine, the pin 48, carried by the frame 47 and the rod 30, will move rearward in the slots 49, provided therefor in the casing 35, and engaging the concavity 62 in the arm of the rear bell-crank 57 within the casing the said bell-crank will be turned upon its shaft 58 and the horizontal arm 59 of the bell-crank will be thrown upward, lifting the locking-block 50 against the resistance of the spring 54 until the lug 52 at the bottom of the locking-block is drawn out of the recess 63, with which the lug 52 had been in engagement. At the same time the movement of the pin 48 under the bar 66 will cause the elevation of the rear end of the said bar, and the spring-pressed bolt 64, attached to the rear end of the bar, will be drawn upward out of the recess with which it had previously been in engagement. This withdrawal of the lug 52 and the spring-pressed bolt 64 from engagement with openings in the bed 36 will occur as the reversing-lever passes the middle point of its swing, and after passing that point the casing 35 will travel rearward along the bed 36 with the rod 30 until the lever 46 reaches the end of its movement, at which time the spring-pressed bolt 64 at the forward end of the bar 66 will come into registration with the forward aperture 65 and

will automatically drop thereinto, so locking the casing 35 against any further movement. The movement of the casing 35 from one end of the bed 36 to the other during the swing of the lever 46 from the middle point of its range of movement to the rear limit thereof causes the link 34 to move rearward to the same extent, and the arm 33 of the bell-crank carried by the shaft 32 is swung through as great an arc as the arm 28 of the bell-crank upon the shaft 27 is turned during the entire swing of the lever 46, as the arms 28 and 33 bear the ratio of two to one in length.

From the foregoing description it will be seen that during one half of the swing of the lever 46 from one end of its range of movement to the other the pin 48 will move freely along the slot 49, provided therefor in the casing 35, without imparting movement to the casing 35, and during the other half of the swing of the lever 46 the casing 35 will travel rearward with the rod 30. It will also be noticed that one half of the swing of the lever 46 from either end of its range of movement to the middle point thereof is without effect upon the casing 35, but that the other half of its movement imparts to the casing 35 and to the bell-crank arm 33, connected with said casing by the link 34, a movement sufficient to raise the link 25 to change the position of the slide 23 from one end of the link to the other, thereby effecting a complete reversal of the movement of the exhaust-valve and giving it its maximum stroke in either direction. When the casing 35 has reached the rearward limit of its movement and the lever 46 begins to be moved forward toward the middle of its range of movement to cut down the stroke of the inlet-valve, the locking-block 50 will be depressed by the action of the spring 54 and the lug 52 will enter one of the openings 63 and supplement the action of the spring-pressed bolts 64 in retaining the casing 35 in position. As long as the casing 35 remains stationary no movement is imparted to the link 25 to vary the position of the slide 23 therein, and consequently there is no variation of the stroke of the exhaust-valve.

Briefly summarized, the connection of the reversing-lever 46 with the links 24 and 25 is such that the link 24 is moved up and down throughout the entire swing of the lever 46 to the rear or to the front, as the case may be, while the link 25 is moved only during the movement of the lever 46 from the center of its swing to one end thereof, and no movement is imparted to the link 25 by the lever as it moves from one end of its range of movement toward the middle thereof.

As the locking devices in the casing 35 are automatically operative when the casing reaches either end of its range of movement to hold the casing stationary until the lever 46 is swung in the opposite direction until it passes the middle of its swing, any variation in the stroke of the exhaust-valve is positively prevented, as the lever 46 is "hooked up" after the engine is started and a considerable degree of speed is developed.

As the reversing-lever is always thrown to the limit of its swing in starting the engine in either direction and is gradually hooked up toward the middle of its swing after its speed has been developed, it will be clear that the exhaust-valve is always set for its full stroke, and the reduction of the stroke of the inlet-valve as the lever is hooked up is not accompanied by a corresponding reduction in the stroke of the exhaust-valve with the cut-off of the exhaust. Hence while the amount of steam admitted to the cylinder upon each stroke of the inlet-valve is considerably reduced after the engine is started the exhaust is not correspondingly reduced, and much less resistance is offered to the advance of the piston under the influence of the freshly-admitted steam than is offered thereto when the same valve performs the functions of an inlet and an exhaust valve, making the stroke of the exhaust-valve always correspond to the stroke of the inlet-valve.

While I have described and illustrated an embodiment of my invention in which the strokes of the inlet and exhaust valves are controlled by link-motions, it is obvious that other devices for varying the strokes of the valves may be employed, and I do not, therefore, limit myself to the specific structure shown, but reserve the right to make changes therein such as lie within the scope of the appended claims.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. The combination with a cylinder having inlet and exhaust ports, of separate inlet and exhaust valves, a reversing mechanism for each valve, a reversing-lever common to both reversing mechanisms, and means whereby the reversing mechanism for the exhaust-valve will only be operated during the movement of said lever from the center of its movement to the end thereof.

2. The combination with the steam-engine cylinder having steam inlet and exhaust ports, of separate inlet and exhaust valves slidable over said ports, means for reversing the stroke of each of said valves, said reversing means comprising a movable lever which is constantly connected with said inlet-valve, and automatically-operative devices for connecting said lever with said exhaust-valve intermediate of the ends of the stroke of the lever.

3. The combination with a steam-engine cylinder having inlet and exhaust ports, of separate inlet and exhaust valves coöperating with said ports, and mechanism for reversing the stroke of both of said valves, said mechanism comprising a lever operative upon the inlet-valve throughout its entire stroke and connections between said lever and the ex-

haust-valve, whereby the reversal of the exhaust-valve is accomplished during the latter half of the stroke of the lever.

4. The combination with a steam-engine cylinder having inlet and exhaust ports, of separate inlet and exhaust valves coöperating with said ports, separate means for imparting reciprocatory movement to each of said valves, means for reversing the movement of each of said valves, said means comprising a crank-arm for each valve, the crank-arm for the inlet-valve being twice the length of the crank-arm for the exhaust-valve, and a lever for imparting movement to said crank-arms, said lever being connected directly with the crank-arm for the inlet-valve at all times, and being automatically connected with the crank-arm of the exhaust-valve during the latter half of its stroke only.

5. The combination in locomotive-valve mechanism, of separate steam inlet and exhaust valves, separate means for imparting reciprocatory motion to each of said valves, separate means for reversing the stroke of each of said valves, the reversing means for the inlet-valve being adapted to vary the stroke thereof, and connections between the reversing means of the inlet and exhaust valves automatically operative during the latter half of the stroke of the reversing means for the inlet-valve, whereby the reversal of the stroke of the exhaust-valve is accomplished during the latter half of the stroke of the reversing means for the inlet-valve.

6. The combination with a steam-engine cylinder having inlet and exhaust ports, of an inlet-valve coöperating with the inlet-ports, a separate exhaust-valve coöperating with the exhaust-ports, mechanism for imparting reciprocatory movement to the inlet-valve, means for reversing the stroke of the inlet-valve, said means being adapted to vary the stroke of the inlet-valve, mechanism for imparting reciprocatory movement to the exhaust-valve, and mechanism for reversing the stroke of the exhaust-valve, said reversing mechanism being adapted for automatic connection with the means for reversing the stroke of the inlet-valve substantially in the middle of its movement, whereby the reversal of the stroke of the exhaust-valve is accomplished during the latter half of the stroke of the reversing means for the inlet-valve.

7. The combination with a cylinder having inlet and exhaust ports, of separate inlet and exhaust valves for said ports, a reversing mechanism for each valve, said mechanisms having a common reversing-lever and means whereby the reversing mechanism for the exhaust-valve will be operated intermediate of the ends of the stroke of the reversing-lever.

8. The combination with a cylinder having inlet and exhaust ports, of separate inlet and exhaust valves, a reversing mechanism for each valve, said mechanism having a common reversing-lever, and a locking device for locking the exhaust-valve-reversing mechanism during the adjustment of the inlet-valve-operating mechanism to reduce the stroke of the inlet-valve.

9. The combination with a cylinder having inlet and exhaust ports, of separate inlet and exhaust valves, a reversing mechanism for each valve, said mechanisms having a common reversing-lever, a connection between the said lever and the exhaust-valve-reversing mechanism, whereby the said exhaust-valve mechanism will be operated intermediate of the ends of the stroke of the reversing-lever, and means for locking the said connection in position.

10. The combination with separate inlet and exhaust valves, of a reversing mechanism for each valve, said mechanisms having a common reversing-lever, a sliding member loosely connected with the reversing-lever, and means for locking said sliding member in position.

11. The combination with separate inlet and exhaust valves, of a reversing mechanism for each valve, said mechanisms having a common reversing-lever, a sliding casing having a loose connection with the reversing-lever, and a locking mechanism within the casing for locking the said casing in position at the ends of its movements.

12. The combination with separate inlet and exhaust valves, of a reversing mechanism for each valve, said mechanisms having a common reversing-lever, a sliding casing having a loose connection with the reversing-lever, and a locking mechanism within the casing and controlled by the connection between lever and casing, for locking said casing in position at the ends of its movements.

13. The combination with separate inlet and exhaust valves, of a reversing mechanism for each valve, said mechanisms having a common reversing-lever, a sliding casing, having slotted sides, a pin carried by the lever and working in the slots of the casing, a spring-pressed locking member in the casing, and bell-crank levers in the casing and each having one member engaging the locking member and the other extending into the path of the pin connecting the casing and lever.

14. The combination with separate inlet and exhaust valves, of a reversing mechanism for each valve, said reversing mechanisms having a common reversing-lever, a support provided with openings, a sliding casing on said support and having slotted sides, a pin carried by the reversing-lever and working in the slots of the casing, a spring-pressed block having a projection on its bottom for entering the openings of the support, and bell-crank levers in the casing and each having one member engaging the block and the other extending into the path of the pin connecting the lever and casing.

15. The combination with separate inlet and

exhaust valves, of a reversing mechanism for each valve, said mechanisms having a common reversing-lever, a support provided with openings, a sliding casing on the support and having slotted sides, a pin carried by the reversing-lever and working in the slots of the casing, a spring-pressed block in the casing and provided with a projection engaging openings in the support, bell-crank levers in the casing and each having one member engaging the block and its other member extending into the path of the pin connecting the casing and lever, spring-pressed bolts in the casing and entering openings in the support and a bar connecting the upper ends of the bolts.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRANK ELI SMITH.

Witnesses:
GEO. R. FRYER,
EDWIN J. BROWN.