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F. W. JOHNSTONE.

LOCOMOTIVE.

No. 331,973. Patented Dec. 8, 1885.

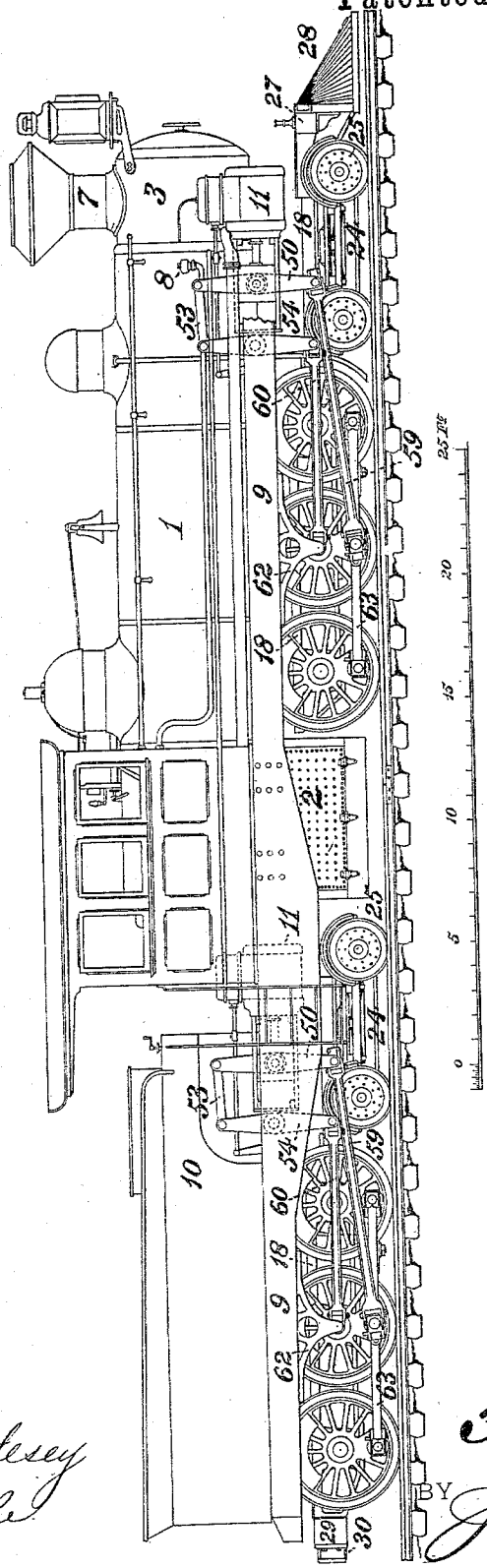

Fig. 1.

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(No Model.) 11 Sheets—Sheet 2.

F. W. JOHNSTONE.

LOCOMOTIVE.

No. 331,973. Patented Dec. 8, 1885.

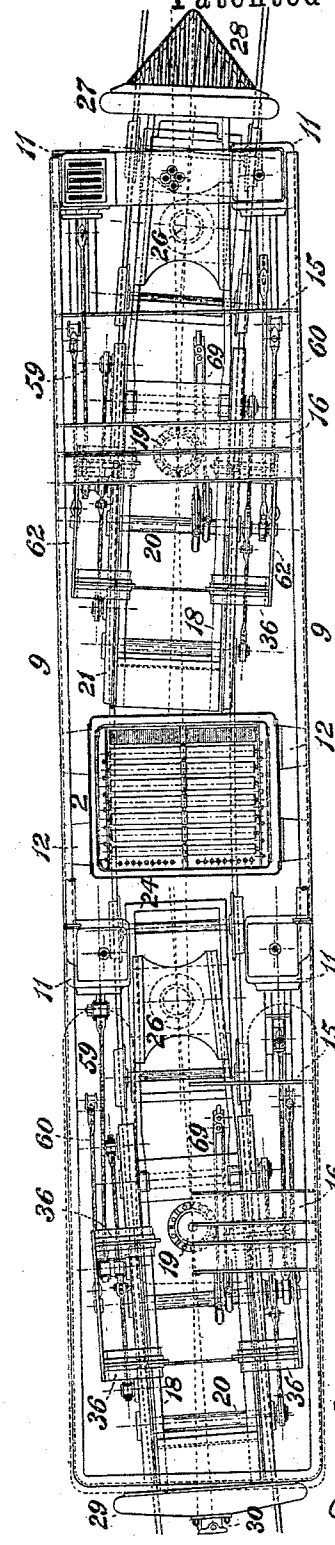

Fig. 2.

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F. W. JOHNSTONE.

LOCOMOTIVE.

No. 331,973. Patented Dec. 8, 1885.

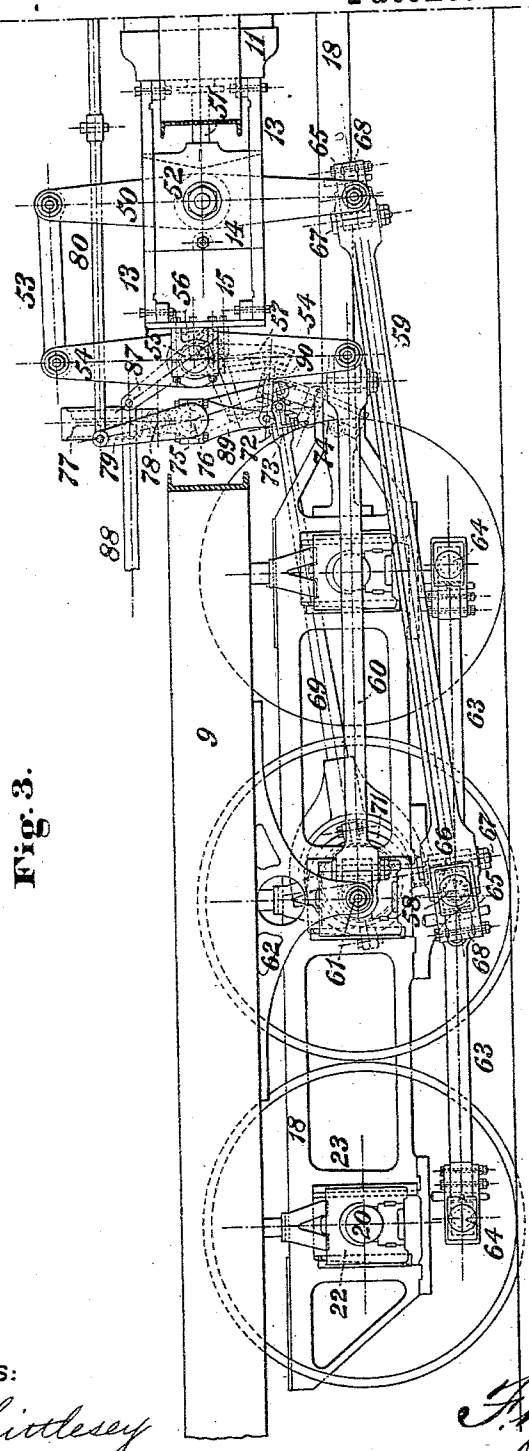

Fig. 3.

WITNESSES:

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(No Model.) 11 Sheets—Sheet 4.

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No. 331,973. Patented Dec. 8, 1885.

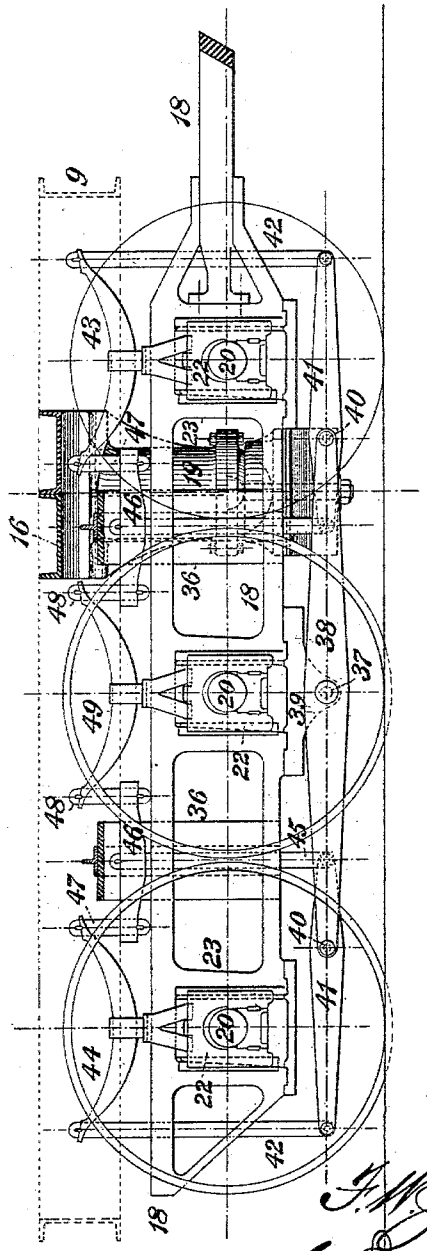

Fig. 4.

WITNESSES:

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(No Model.)

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No. 331,973. Patented Dec. 8, 1885.

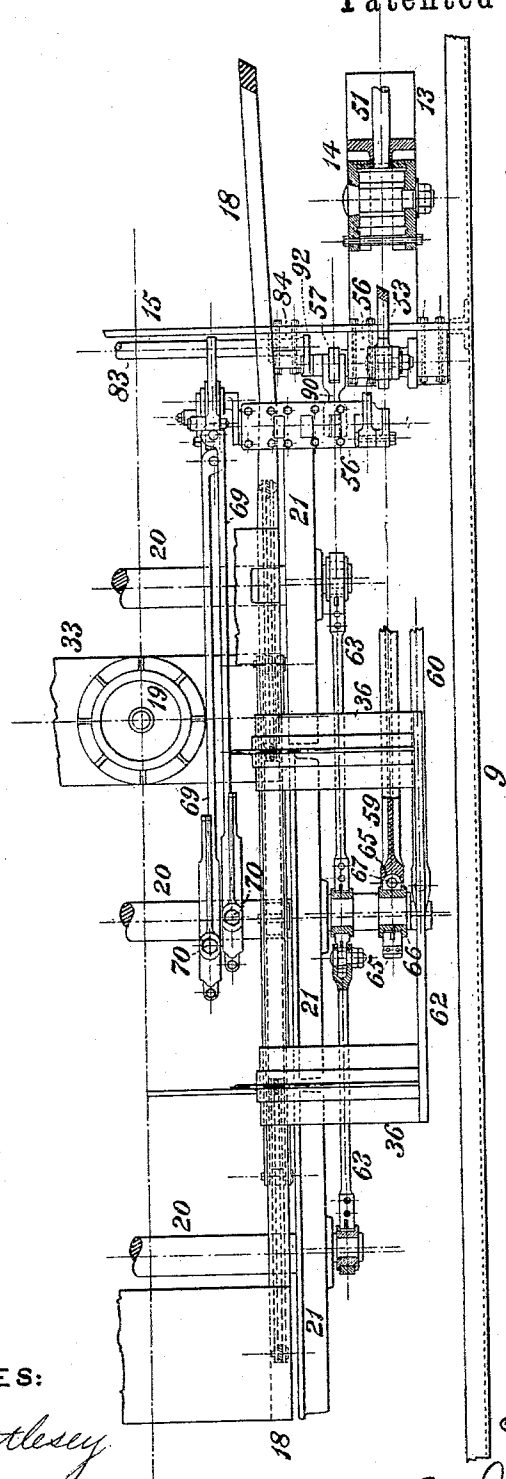

Fig. 5.

WITNESSES:

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(No Model.) 11 Sheets—Sheet 6.

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No. 331,973. Patented Dec. 8, 1885.

Fig. 7.

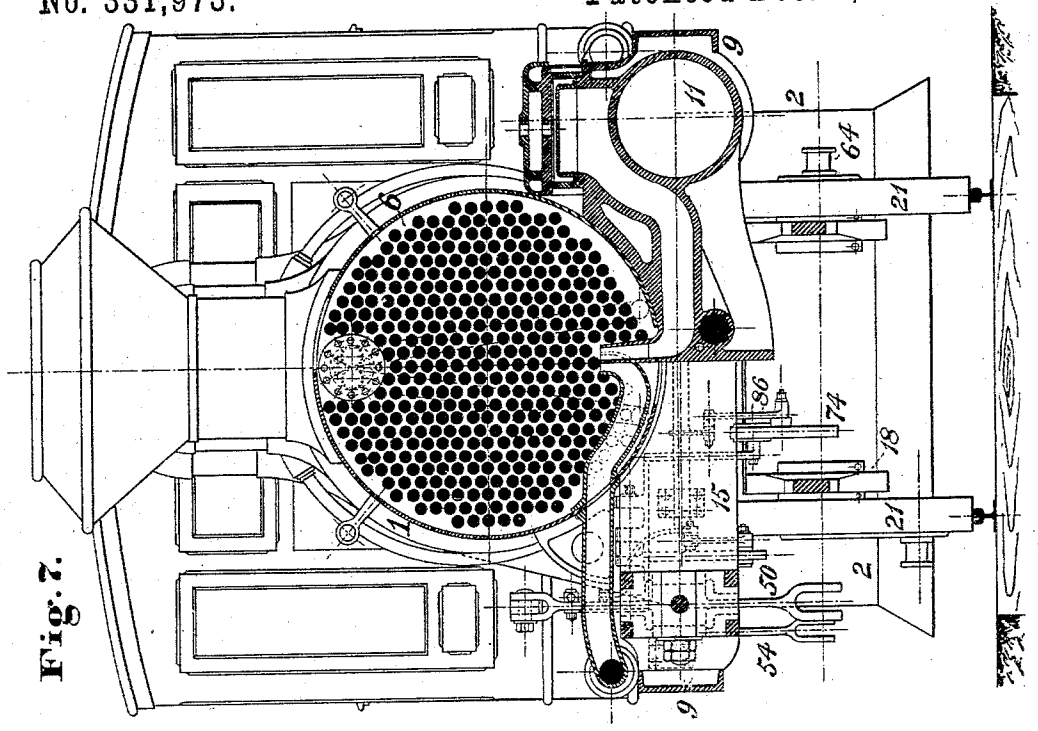
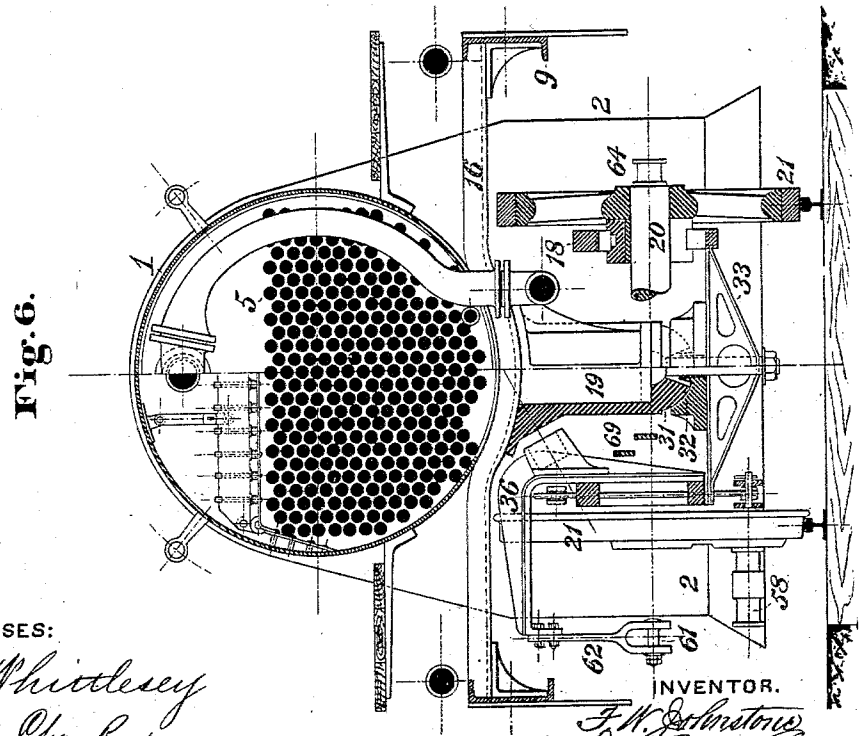


Fig. 6.



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(No Model.) 11 Sheets—Sheet 7.

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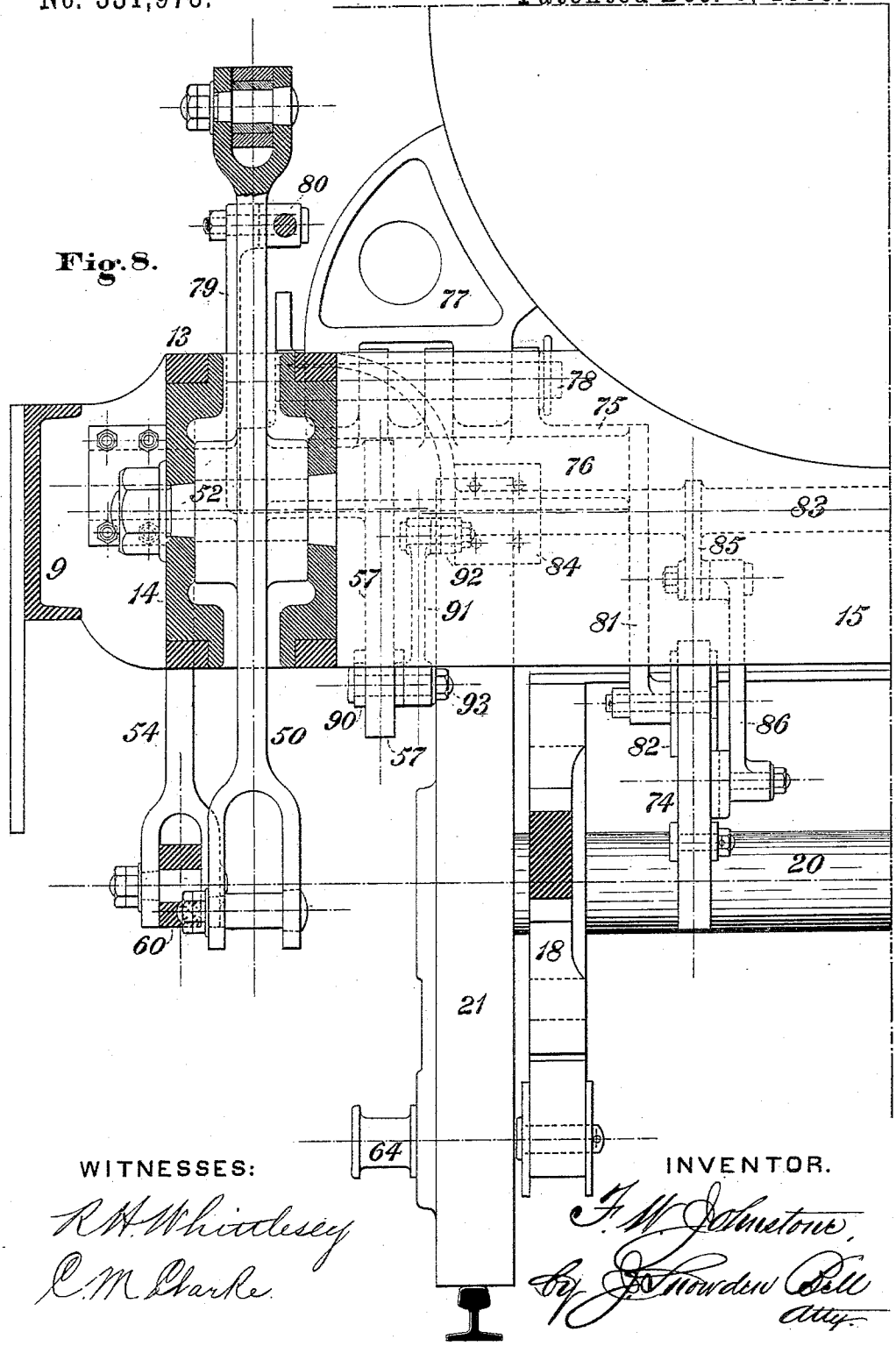
LOCOMOTIVE.

No. 331,973. Patented Dec. 8, 1885.

Fig. 8.



WITNESSES:

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(No Model.) 11 Sheets—Sheet 8.

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No. 331,973. Patented Dec. 8, 1885.

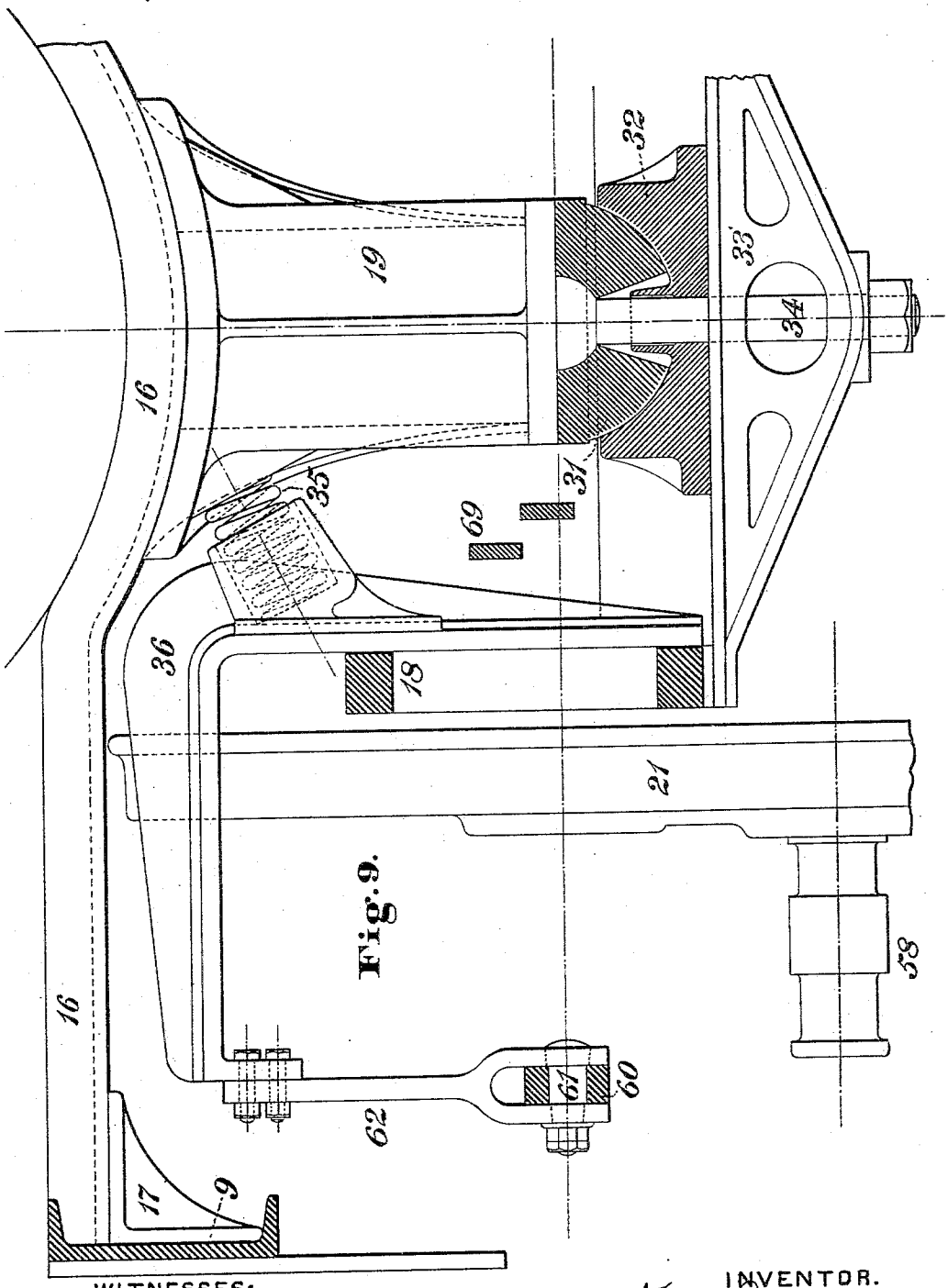

Fig. 9.

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(No Model.)

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No. 331,973. Patented Dec. 8, 1885.

Fig. 12.

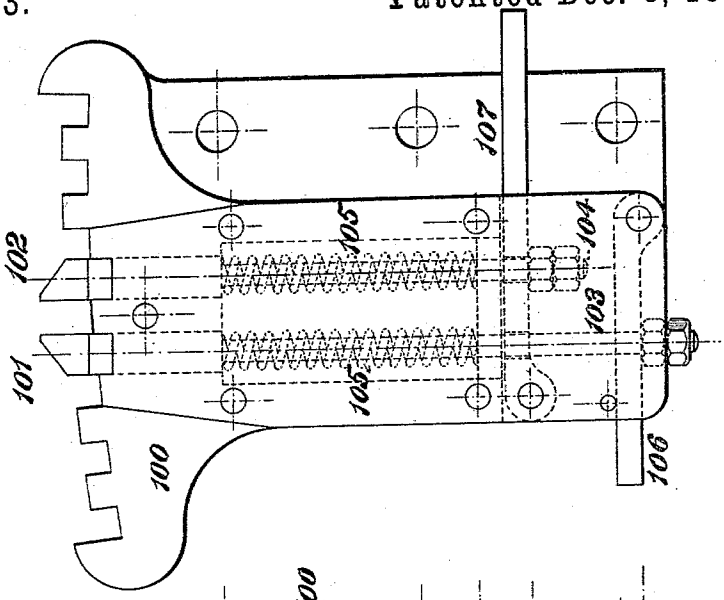


Fig. 13.

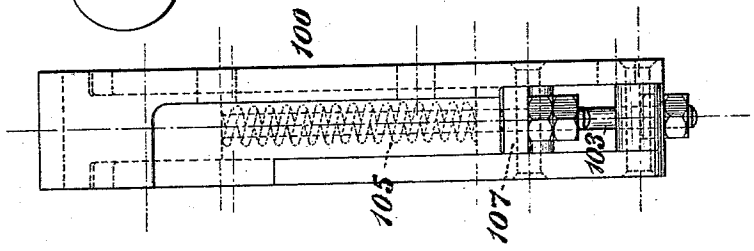


Fig. 11.

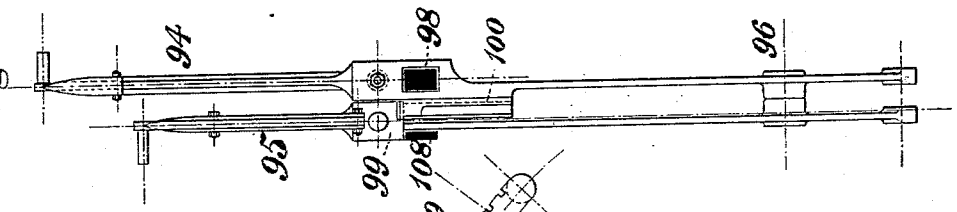
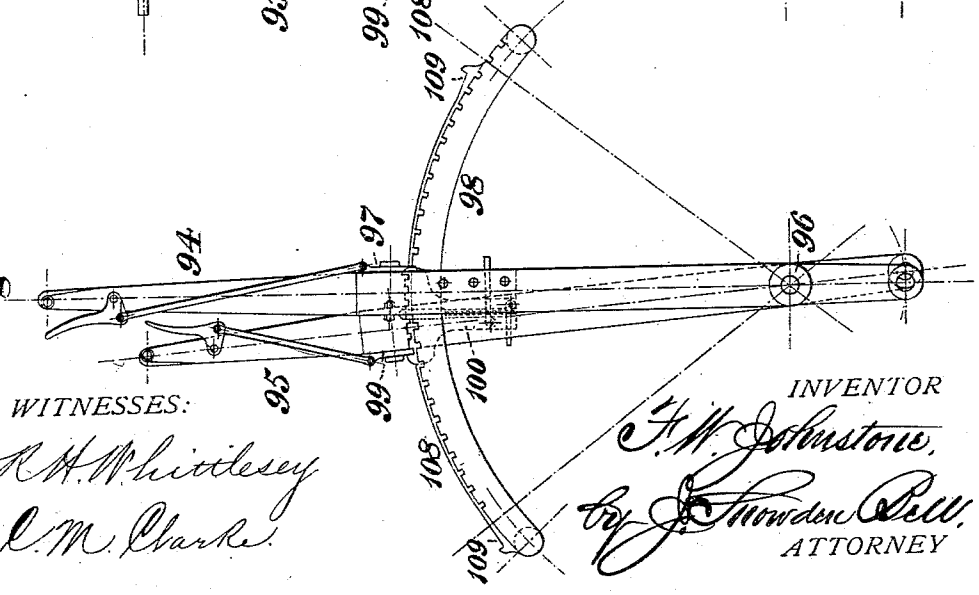


Fig. 10.



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(No Model.) 11 Sheets—Sheet 10.

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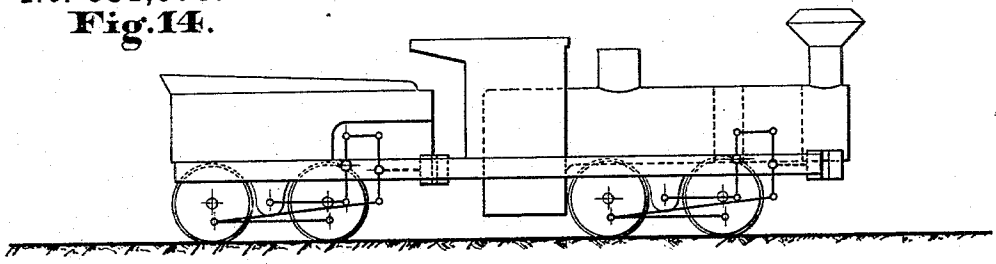
LOCOMOTIVE.

No. 331,973. Patented Dec. 8, 1885.

Fig. 14.



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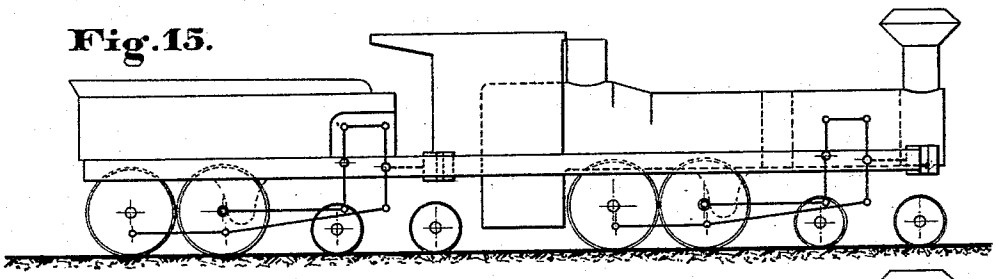

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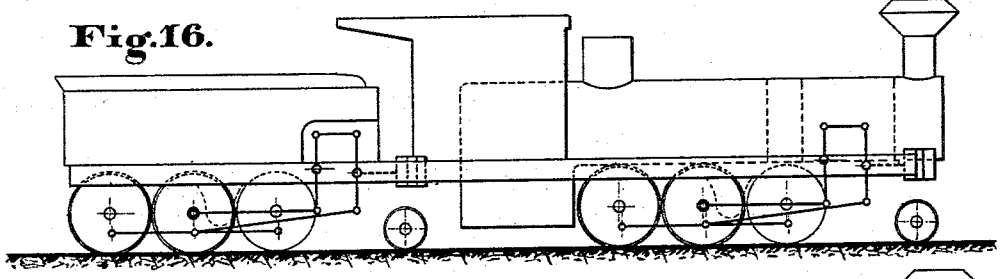

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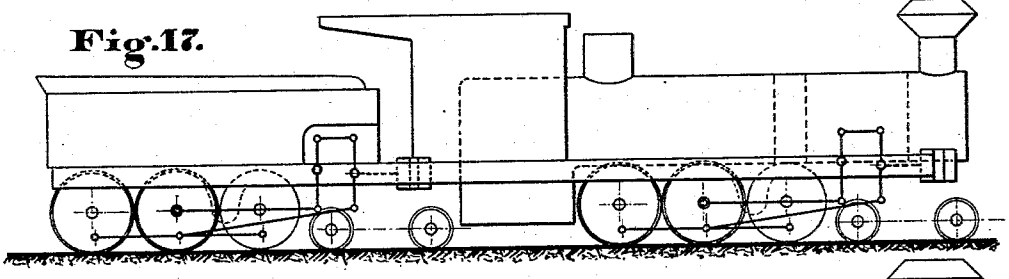
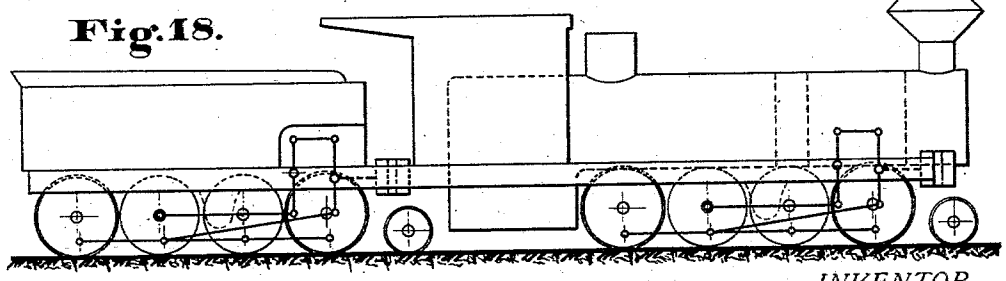


Fig. 18.



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No. 331,973. Patented Dec. 8, 1885.

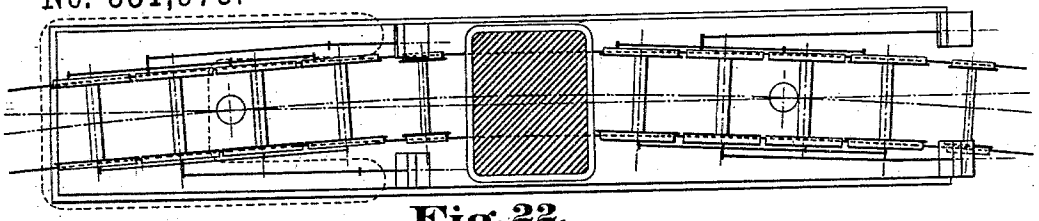
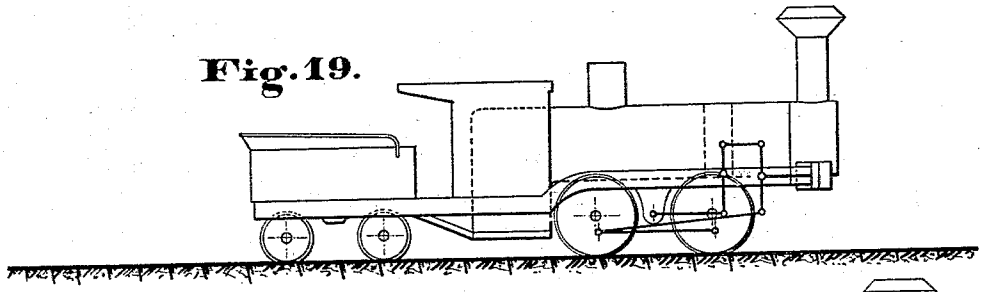


Fig. 22.

Fig. 19.



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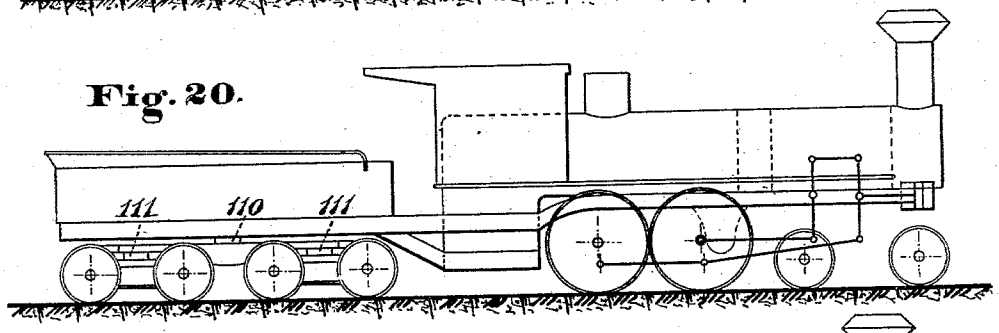

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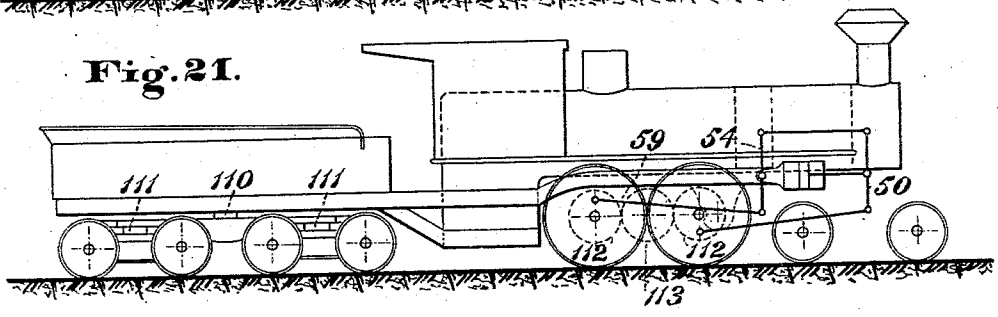

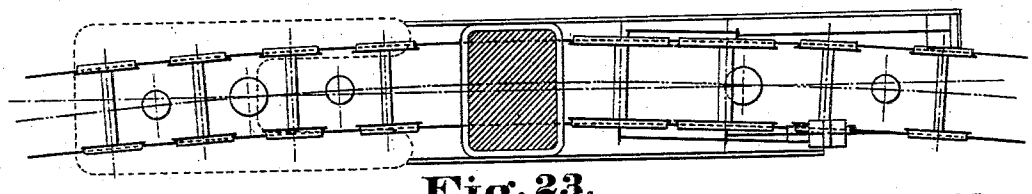

Fig. 23.

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by J. Snowden Bell,

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UNITED STATES PATENT OFFICE.

FRANCIS W. JOHNSTONE, OF MEXICO, MEXICO.

LOCOMOTIVE.

SPECIFICATION forming part of Letters Patent No. 331,973, dated December 8, 1885.

Application filed August 20, 1885. Serial No. 174,879. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS W. JOHNSTONE, a citizen of the United States, residing at the city of Mexico, in the State and Republic of Mexico, have invented certain new and useful Improvements in Locomotive-Engines, of which improvements the following is a specification.

The objects of my invention are to effect a material increase in the tractive force of a locomotive-engine without a proportionate increase in total weight and dead load relatively to constructions now and heretofore employed; to reduce as far as practicable the rigid wheel-base of the engine, in order to admit of passing freely curves of comparatively short radius, and to provide for the employment of a fire-box of ample capacity for steam-generating requirements under the maximum tractive force exerted by the engine.

To these ends my invention, generally stated, consists in a locomotive-engine having boiler and water-supply-tank and fuel-bin secured upon a rigid frame, one or more pairs of cylinders fixed to said frame, one or more systems of driving-wheels, each mounted in a truck or independent frame which is movable about a vertical axis relatively to the main frame, mechanism for transmitting power from the pistons to the driving-wheels, whereby the free movement of the trucks is permitted without affecting the normal action of the pistons upon the crank-pins, mechanism for effecting the rotation of the driving-wheels through crank-arms of greater length than half the stroke of the pistons, mechanism for controlling and maintaining the movement of the steam-distribution valves in proper relation to that of the other reciprocating parts under all conditions of traverse of the trucks, equalizing mechanism for uniformly distributing the load upon the driving-wheels, and mechanism for properly distributing the weight between the driving-wheels, and subsidiary guiding-trucks swiveling in the driving-wheel truck-frames.

The improvements claimed are hereinafter fully set forth.

Inasmuch as the weight which can be carried upon each driving-wheel of a locomotive-engine cannot, without involving undue wear and strain upon the road-bed and superstructure and upon the tires, be materially increased above that obtaining in the usual practice, increase of tractive force can be properly attained only by an increase in the number of driving-wheels, a limit to which is imposed, under ordinary constructions, by the necessity of adapting the engines to traverse curved portions of the lines. Increase of tractive force, together with capacity of passing short curves has been heretofore sought for in engines of the so-called "Fairlie" type, in which the driving-wheels have been grouped in one or more swiveling-trucks, which likewise carry the cylinders. Such construction involves the objection, which practice has indicated to be a material one, of necessitating unduly long steam and exhaust pipes and flexible joints therein, which are expensive and difficult to make and maintain.

Under my invention the engine and tender are mounted on a single rigid frame, to which the cylinders are likewise secured, while the driving-wheels are mounted in one or more swiveling trucks, thereby obviating the objection above stated, while retaining the advantage of the Fairlie construction as to facility of curving.

I further utilize the weight of the tender for adhesion by employing a pair of cylinders therein, and provide a system of lever-connections between the cross-heads and connecting-rods, whereby the piston speed is reduced relatively to a given speed of engine, and also a system of springs and equalizing-levers for properly distributing the weight, and means for insuring the normal and uniform operation of the pistons and valve mechanism, irrespective of the degree of swiveling movement of the trucks resultant upon the curvature of the line.

The detailed features of my invention, as embodied in an engine designed for heavy-freight service on lines having curves of comparatively short radii, will now be described.

In the accompanying drawings, Figure 1 is a side view, in elevation, of a four-cylinder, twelved riving-wheel locomotive-engine, illustrating the application of my invention; Fig. 2, a plan view of the same, with the boiler and tank removed, and shown as standing upon a curve of two hundred and eighty-eight feet,

radius (twenty degrees); Fig. 3, a side view, in elevation, illustrating the lever-connections between the cross-heads and crank-pins; Fig. 4, a similar view of the spring and equalizer arrangement; Fig. 5, a partial half-plan view, partly in section, showing the cross-head and eccentric-connections; Fig. 6, a vertical transverse section, the left-hand half being taken at the center of the pivot of the forward driving-wheel truck-frame and the right-hand half at a point in the combustion-chamber in advance thereof; Fig. 7, a similar section, the right-hand half being taken at the center of one of the forward cylinders and the left-hand half at a point in the smoke-box in rear thereof; Fig. 8, a half-vertical transverse section, on an enlarged scale, taken through one of the cross-heads and its guides; Fig. 9, a similar section through the pivot of the forward driving-wheel truck-frame; Figs. 10 to 13, inclusive, detailed views, in elevation, of the reversing-lever mechanism; Figs. 14 to 21, inclusive, diagrammatic side views, in elevation, illustrating the application of the invention in different types of engines, respectively; Fig. 22, a diagrammatic plan view of the engine shown in Fig. 18, and Fig. 23 a similar view of the engine shown in Fig. 21.

The engine selected as an illustration of the practical application of my invention is analogous, in the arrangement of its driving and truck wheels, to those of the ten-wheel type provided with six coupled driving-wheels and a four-wheeled leading-truck, which are here duplicated—that is to say, for the purpose of utilizing the weight of the tender for adhesion an additional pair of cylinders is placed thereon—and it is supported upon a supplemental set of six driving-wheels and a four-wheeled leading-truck, the engine thus having four cylinders, twelve driving-wheels, and two leading-trucks of four wheels each. The driving mechanism and running-gear of the engine and tender being similar in all particulars, those of the engine will only be described, the references thereto applying similarly to the corresponding numbers of the tender.

The boiler 1 is substantially of the usual locomotive type, having a fire-box, 2, at its rear end, a smoke-box, 3, at its front end, and an intermediate series of fire-tubes, 5, and may be of any approved and preferred construction within such type. The overhanging fire-box 2, being supported by the rearwardly-extending frame 9 and the rear truck-frame thereof, and not being confined between the driving-wheels, may be made of as ample dimensions as are necessary or desirable for required steam-generating capacity, and, as shown in Figs. 6 and 7, is extended laterally beyond the driving-wheels, such extension being practicable to a distance equal to the greatest distance permissible by the distance between tracks and width of cuttings and bridges of the line.

As herein shown, the major portion of the waist of the boiler, together with the space above the crown-sheet, constitutes a steam-generating chamber, through which a series of ordinary fire-tubes, 5, extends to a combustion-chamber. The forward portion of the waist, between the combustion-chamber and the smoke-box 3, serves as a feed-water heater-chamber, provided with a supplemental series of tubes, 6, through which the products of combustion pass to the smoke-box 3 and stack 7, the feed-water being supplied through the check-valves 8 to the heater-chamber, and thence to the main generating-chamber. Such construction, however, while of advantageous application in connection with the features about to be described, does not form an essential of my present invention, and being, moreover, fully set forth in another application for Letters Patent by me, filed January 15, 1885, Serial No. 156,148, need not be herein at length described.

The boiler 1 is secured to and supported upon a substantial continuous frame, 9, which is preferably formed of channel-iron members, as shown, and the water-tank and fuel-bin 10, equivalent to the ordinary tender, are likewise secured to the frame 9. A pair of cylinders, 11, each formed with a half-saddle casting in the usual manner, is bolted to the smoke-box 3 and to the forward ends of the frame-plates 9, and the fire-box 2 is connected by brackets 12 to the frame-plates, the bolts passing through elongated or slotted holes, to admit of the free expansion of the boiler. The supplemental cylinders of the tender are bolted to the frame-plates and to a substantial transverse casting, which connects the frame-plates, and likewise serves as a foot-plate for the fireman. The guide-bars 13 of the cross-heads 14 are bolted at their front ends to the cylinders and at their rear ends to guide-yokes 15, which are secured to the frame-plates 9, and which serve as the supports of the guides and of the boxes of the fixed fulcrum-levers and lifting-shafts, to be presently described. The frame-plates are likewise connected, between the main and forward pairs of each system of driving-wheels, by transverse girders or supports 16, each formed of two bars of channel-iron connected to the frame-plates by angle-plates 17, said girders carrying the main center plates of the truck-frames, in which the driving-wheels are mounted. The forward girder, 16, is curved centrally in conformity with the circle of the waist of the boiler, which rests upon without being fastened to the girder, thus supporting the latter vertically while being free to move horizontally upon it under the expansion and contraction induced by changes of temperature. The function of the girders 16 is to support the pivots of the driving-wheel truck-frames and to transmit the tractive force applied by the cylinders to the driving-wheels from said frames to the main frame 9 and draw-bar. The two systems of wheels which support, respectively, the boiler and tender are each mounted in bearings in a driving-wheel truck-

frame, 18, each of which frames is adapted to swivel or vibrate in a horizontal plane, independently of the main frame 9 of the engine, about the axis of a center bearing, 19, bolted to one of the transverse girders 16. The axles 20 of the driving-wheels 21 are fitted to rotate in boxes 22, which have a properly limited range of vertical movement in the pedestals 23 of the driving-wheel truck-frames 18, each of which frames is further provided at its forward end with a subsidiary leading or guiding truck, 24, of the usual type, having four truck-wheels, 25, and fitted to swivel about a center bearing, 26, independently of the truck-frame 18, with which it is connected. The driving-wheel truck-frame supporting the boiler extends to or near the front of the smoke-box, and carries the front buffer-beam, 27, and pilot 28, and the driving-wheel truck-frame, which supports the tender, carries on its rear end the back buffer-beam, 29, and draw-casting 30. The pilot and its front draw-bar and the rear draw-casting are thus brought as nearly as practicable to the center of track and to the center line of draft.

The girders 16, which carry the center bearings, 19, are so located relatively to the driving-wheel truck-frames 18 as to distribute in desired proportions the weight to be carried by the driving and the truck wheels, respectively, of said frames, these proportions being, for example, in the engine shown, about seventy thousand pounds on the driving-wheels to twenty-two thousand five hundred pounds on the truck-wheels of each driving-wheel truck-frame. Each of the center bearings, 19, is bolted at its upper end to one of the transverse girders 16 of the main frame 9, and has secured upon its lower end a ball-casting, 31, which fits into a corresponding socket-casting, 32, bolted to a transverse bearing-plate, 33, formed of wrought-iron plates with cast-iron filling-pieces, and bolted firmly at its ends to the driving-wheel truck-frame 18. A center pin, 34, connects the ball-and-socket joint thus formed and the bearing-plate 33. In lieu of employing side bearings, springs 35, fitting in sockets in brackets 36, bolted to the driving-wheel truck-frames 18, bear against each side of the center bearings, 19, thereby steadying the main frame 9 as against lateral movement, while admitting of the free vibration of the driving-wheel truck-frames about the axes of the center bearings in passing over curved portions of the line.

That portion of the weight supported by each driving-wheel truck-frame which is borne by the driving-wheels is transmitted thereto through a pair of bearing-pins, 37, passing through the centers of a pair of long equalizing-levers, 38, and pivoting the same to the pedestal-braces 39 of the main or center pairs of driving-wheels of the truck-frames 18. The equalizing-levers 38 are coupled by pins 40 to the shorter equalizing-levers 41 at points between the ends of the latter, and the levers 41 are in turn coupled at their ends farthest from the levers 38 to the outer hangers, 42, of the front and rear driving-wheel springs, 43 44, and at their ends nearest to the levers 38 to links 45, bearing at their upper ends against equalizing-beams 46, the opposite ends of which are coupled, respectively, to the inner hangers, 47, of the front and rear springs, 43 44, and to the hangers 48 of the main springs 49. It will be seen that by the above construction the distribution of weight may be uniformly effected throughout each system of driving-wheels, and, further, that the points of support 37 and 26 will not change their relation to the center bearings, 19, as all shocks upon the driving-wheels must be transmitted to the frames 18 through the bearing-pins 37.

Power is transmitted from the cylinders to the driving-wheels through a lever mechanism, under which construction the free vibration of the driving-wheels, with their truck-frames, is permitted without impairing the normal conditions of transmission, and which admits of the employment of a length of crank-pin stroke greater than that of the pistons, and consequently of a reduced piston-speed relatively to a given speed of the driving-wheels. In the engine illustrated the stroke of the pistons is eighteen inches and that of the crank-pins thirty-six inches.

Each of the cross-heads 14 carries a double-armed cross-head lever, 50, which is journaled at its center to the cross-head, in line with the piston-rod 51, by a pin, 52. The upper arms of the cross-head levers 50 are coupled by tension-rods 53 to the upper arms of a pair of double-armed fixed-fulcrum levers, 54, which are forged upon short shafts 55, journaled in boxes or bearings 56, bolted to the rear sides of the guide-yokes 15, each of the shafts 55 having also forged upon its inner end a downwardly-extending arm, 57. The lower arms of the cross-head levers 50 are coupled to the crank-pins 58 of the main driving-wheels by the main connecting-rods 59, and the lower arms of the fixed fulcrum-levers 54 are coupled by the tension-rods 60 to pins 61, fixed in supporting-plates 62, bolted to and extending downwardly from the outer ends of the brackets 36, secured to the driving-wheel truck-frames 18. The main crank-pins 58 are connected by side or coupling rods 63 to the crank-pins 64 of the front and rear driving-wheels in the ordinary manner.

The advance and recession of the bearing-pins 61 of the rear ends of the tension-rods 60 relatively to the cross-heads 14, which results from the swiveling movement in passing curves of the driving-wheel truck-frames 18, with which said pins are, as above stated, connected, effect corresponding movements of the fixed-fulcrum levers 54, which are transmitted through the upper tension-rods, 53, and cross-head levers 50 to the forward ends of the main rods 59; but inasmuch as the supporting-plates 62 are at a distance from the axes of the center bearings, 19, greater than that of the main crank-pins 58 therefrom, their

longitudinal movement in curving will be greater than that of said pins, and consequently of the rear ends of the main rods 59. Thus, for example, if in passing a curve, should the right hand driving-wheels change their position relatively to the center line of the boiler so far as to throw the center of their main pin 58 and main rod crank-pin brass forward, say, two inches, the right-hand bearing-pin 61 and the lower arm of the right-hand fixed-fulcrum lever 54 would be advanced, say, two and three-sixteenths inches, while the front end of the main rod 59 would of course require to be advanced only two inches. To compensate such difference of traverse and impart equal degrees of movement to the opposite ends of the main rods 59, the lower arms of the fixed-fulcrum levers 54 are made of greater length than the upper arms, proportionately to the difference of traverse of the bearing-pins 61 and main crank-pins 58, so that the movement of their upper arms may be equal to that of the main crank-pins and the movement of their lower arms to that of the bearing-pins. In the example above cited the traverse of the lower arms of the fixed-fulcrum levers being two and three-sixteenths inches, that of the upper arms will be two inches, which, transmitted through the upper tension-rod, 53, and cross-head lever 50, (the arms of which are of equal length,) imparts a movement of two inches to the forward end of the main rod 59, such movement being just equal to that of its rear end with the main crank-pin. It will be seen that such changes of position of the driving-wheels and main rods will be effected without tendency to vary the position of the cross-heads or to effect any appreciable change in their travel, either as to their length of stroke or location on the guides.

Assuming the pressure on the piston to be twenty thousand pounds, tending to move it toward the rear end of the cylinder, such pressure will be divided by the cross-head lever 50, ten thousand pounds acting on the main rod 59 to rotate the driving-wheels, and ten thousand pounds on the upper tension-rod, 53, and fixed-fulcrum lever 54. The upper arm of said lever being to the lower arm as, say, two to two and three-sixteenths, a pressure of, say, nine thousand one hundred and forty-three pounds will be exerted on the lower tension-rod; but as the bearing-pin 61, to which the rear end of the lower tension-rod is connected, is farther from the center of the driving-wheel truck-frame than the main crank-pin, in the proportion of two and three-sixteenths to two, the pressure of nine thousand one hundred and forty-three pounds exerted at the pin 61 and transmitted to the driving-wheels through the driving-wheel truck-frame will be equivalent to the pressure of ten thousand pounds in the opposite direction exerted by the main rod on the main crank-pin, and the opposing forces will be brought into the same vertical plane, thereby counteracting any tendency of the main rod to force the driving-wheels and their frames out of normal position. The forces acting on the driving-wheels and driving-wheel truck-frame are similar to those in engines of the ordinary construction having cylinders rigidly secured to their frames, the piston acting in one direction and the cylinder in the other, in the same vertical plane which passes through the center of the cylinder.

It will be observed that in passing curves the plane of motion of the crank-pin will be at a slight angle to the longitudinal center-line of the cross-head. To admit of the resultant change of position of the rear ends of the main rods and lower tension-rods, the boxes or brasses thereof are pivotally connected to their stub ends, as seen in Figs. 3 and 5. The straps 65, which carry the brasses 66, are open at their outer ends, and are pivoted at their inner ends by bolts 67 to the stub ends of the rods, the inner ends of the straps being curved concentrically with the bolts 67 and fitting corresponding recesses in the stub ends. Blocks 68 are secured in the outer ends of the straps to hold the brasses in position and fill up the straps. The rods are thus adapted to vibrate about the axes of the bolts 67, and the brasses may be filed and keyed up without disturbing the rods or affecting their free movement. To provide for the movement of the eccentric-rods 69 in the swiveling movements of the driving-wheel truck-frames, said rods are coupled by pivot-bolts 70 to the eccentric-straps 71, and their forward ends are coupled by pivot-bolts 72 to blocks 73, which are in turn coupled (by bolts at right angles to the bolts 72) to lugs on the backs of the shifting-links 74, in the usual manner.

In order to obviate interference with the regular and normal movement of the steam-distribution valves of the cylinders 11 by changes in the position of the eccentrics and links relatively to the cylinders and valves, resultant upon the movements of the main driving-axles which accompany the swiveling movements of the driving-wheel truck-frames, the following construction is provided: The boxes or bearings 75 of the valve rocker-shafts 76 are hinged to and suspended from brackets 77 by pins 78, passing through lugs on said brackets and on the rocker-shafts, the brackets 77 being bolted or riveted to the boiler and to the frame below the tank, respectively. The rocker-shafts 76 are mounted in their boxes 75 in the usual manner, and carry upper arms, 79, coupled to pins in the valve-stems 80, and lower arms, 81, coupled to the dies or blocks 82 of the links 74. The links are raised and lowered, as required, by the movements of lifting-shafts 83, journaled in bearings 84, secured to the rear sides of the guide-yokes 15, said lifting-shafts carrying lifting-arms 85, coupled to the link-hangers 86, and reverse-arms 87, coupled to reverse-bars 88, actuated by reverse-levers in the cab,

as hereinafter described. Downwardly-projecting arms 89 are fixed to the rocker-boxes 75, and said boxes are maintained in normal position by links 90, by which the arms 89 are coupled to the arms 57 of the shafts 55, which carry the fixed-fulcrum levers 54. The forward ends of the links 90 are also coupled by hangers 91 to short arms 92 on the lifting-shafts 83, the coupling-pins 93, by which the links 90, arms 57, and hangers 91 are connected, passing through blocks fitting curved slots in the lower ends of the arms 57.

Inasmuch as in the curving movements of the driving-wheel truck-frames the driving-wheels advance on one side of the engine and recede on the other, and with them the driving-wheel truck-frames, lower tension-rods, 60, and lower ends of the fixed-fulcrum levers 54, the eccentrics and links will be coincidently advanced and retracted through a degree of traverse proportionate to their distance from the center of the engine relatively to that of the lower tension-rods therefrom. If while, say, the right-hand links are in full-stroke forward motion, they are advanced, say, one inch by the curving of the driving-wheels with their frames, the lower ends of the right-hand fixed-fulcrum levers 54 will be also advanced, and with them the arms 57, which carry with them the lower ends of the arms 89, thereby swinging the right-hand rocker-boxes 75 on their suspending-pins 78, so that the centers of the right-hand rocker-shafts are advanced one-half an inch. Such movement permits the ends of the upper rocker-arms and the valves to remain in their normal positions, while the lower ends of the rocker-arms, coupled to the link-blocks, move forward in accordance with the advance of the links. The forward eccentric being on the outside, its change of position will be greater than that of the backing eccentric in curving, and therefore, in raising the links to any desired point of cut-off, it will be seen that the influence of the backing eccentric will be exerted more or less as the links are raised, and when in full-stroke back motion the valves will be practically entirely under the influence of the backing eccentrics, and the ends of the lower rocker-arms and the link-blocks will be, say, thirteen-sixteenths of an inch out of normal position, instead of one inch, as was the case when in full-stroke forward motion under the influence of the forward eccentrics. This varying difference in the positions of the link-block is compensated for by raising and lowering the blocks of the pins 93 in the curved slots of the arms 57 coincidently with the raising and lowering of the links, which is effected by the arms 92 of the lifting-shafts and the hangers 91, the hangers 91 being raised or lowered by the lifting-shafts 83 in raising and lowering the links through the lifter-arms 85 and link-hangers 86. As the forward ends of the connecting-links 90 are raised or lowered they, with the rocker-box arms 89, to which they are connected, are subjected to a shorter or a longer leverage, respectively, of the arms 57, the proportions being such as to always maintain the rocker-boxes in the position proper to admit of regular movement being imparted to the valves at all points of cut-off.

The lifting-shafts 83 are actuated to effect, by raising and lowering the links 74, the reversal of movement of the pistons, and to vary the point of cut-off by two reverse-levers, 94 and 95, pivoted, by a common bolt or stud passing through the bosses 96, to a suitable standard in the cab of the engine. The reverse-bar 88 of the link-motion of the forward cylinders is coupled to the lower end of the reverse-lever 94, and that of the link-motion of the rear cylinders to the lower end of the reverse-lever 95. A suitable counter-balance, either spring or weight, may be connected with the lifting-shafts or reverse-levers in the usual manner. The lever 94 causes a spring-latch, 97, engaging the notches of an ordinary fixed quadrant, 98, and the lever 95, a similar latch, 96, engaging the notches of a short supplemental quadrant, 100, bolted to and moving with the lever 94. Two spring-catches, 101 102, fixed, respectively, upon the upper ends of rods 103 104, are fitted to slide vertically in the quadrant 100 on opposite sides of its center, so as to form the sides of a center notch in said quadrant for the latch 99 of the lever 95. The spring-catches 101 102 are held up to their positions to engage the latch 99 by springs 105, and may be pressed downwardly, to enable the latch to clear them, by foot-levers 106 107, pivoted to the quadrant 100, and bearing against nuts or projections on the rods 103 and 104. A guide, 108, curved concentrically with the quadrant 98, is secured at its ends thereto, and is provided with end inclines, 109, adapted to raise the latch 99 of the lever 95 out of the notches of the quadrant 100, the latch 99 being made of sufficient width to project over the top of the guide 108. By moving the lever 94 the short quadrant 100 and lever 95 will be correspondingly moved, so that by placing the latch 99 in the center notch, between the spring-catches 101 and 102, the two levers can be moved coincidently, and the forward and rear pairs of valves handled at the same time. Should it be found desirable to work the rear cylinders somewhat lighter than the forward ones, by reason of diminution of weight on the rear driving-wheels, due to consumption of fuel and water, the lever 95 can be cut back a notch or two on the quadrant 100 without moving the lever 94, the engineer placing his foot upon the lever 106 and pressing the spring-catch 101 down, to allow the latch 99 of the lever 95 to pass. The latch can be raised sufficiently far to pass over the notches of the quadrant 100, but not far enough to pass over the spring-catches 101 102, so that the engine can be reversed, should it become necessary to do so suddenly, with the main reverse-lever 94, regardless of the position of the lever 95. If the lever 95 should stand in advance of the lever 94, the links of

the rear valve-motion would tend to strike their link-blocks before those of the forward valve-motion were fully reversed. Such tendency is obviated by the forward incline, 109, of the guide 108, which raises the latch 99 of the lever 95 out of the notch in the quadrant 100, and permits the lever 95 to remain stationary until overtaken by the lever 94, when the spring-catch 101 will pass under the latch 99, and the two levers will be held together during the remainder of the traverse requisite for reversing.

The application of my invention in engines of the several leading types of wheel arrangement is illustrated in the diagrams Figs. 14 to 23, inclusive. Fig. 14 shows an eight-wheel engine, for freight or switching service, having four cylinders and a front and a rear truck-frame, each supported on four driving-wheels; Fig. 15, a sixteen-wheel engine, for heavy passenger service, having four cylinders and a front and a rear truck-frame, each supported on four driving-wheels and a subsidiary four-wheeled leading or guide truck; Fig. 16, a sixteen-wheel engine, of the "Mogul" type, for freight service, having four cylinders and a front and a rear truck-frame, each supported on six driving-wheels and a subsidiary two-wheeled leading or guiding truck; Fig. 17, a twenty-wheel engine of the "ten-wheel" type, for freight service, which has been hereinbefore fully described; Fig. 18, a twenty-wheel engine, of the "consolidation" type, for freight service, having four cylinders and a front and a rear truck-frame, each supported on eight driving-wheels and a subsidiary two-wheeled leading or guiding truck, the same being shown in plan view in Fig. 22; Fig. 19, an eight-wheel engine, for switching service, having two cylinders, and four driving-wheels in a forward truck-frame, the rear of the frame and tender being supported on a four-wheel truck; and Fig. 20, a sixteen-wheel engine, for express-passenger service, having two cylinders, and a forward truck-frame supported on four driving-wheels, and a subsidiary four-wheel leading or guiding truck, the rear of the frame and tender being carried upon a truck-frame, which is adapted to swivel upon a center, 110, on the main frame of the engine, and is supported upon two subsidiary four-wheel truck-frames, each swiveling upon a center, 111, on the main truck-frame. In this engine, as in that of Fig. 15, it will be seen that the side rods are reduced to the minimum length.

The engine shown in Figs. 21 and 23 is of the same general type as that of Fig. 20, with the following modifications. The stroke of the piston is here of the same length as that of the crank-pins, and the piston-rods are carried out of the front ends of the cylinders. The usual side rods are dispensed with, and in lieu thereof two main rods, 59, are employed for each cylinder, one of said rods connecting the lower end of the cross-head lever 50 with the crank-pin of the forward driving-wheel, and the other connecting the lower end of the fixed-fulcrum lever 54 with the crank-pin of the rear driving-wheel. Inasmuch as the duty of transmission is divided between the two main rods, they, as well as the driving-wheel counterbalances, may be made correspondingly light.

In order to insure the maintenance of the two pairs of driving-wheels in normal relation one to the other, their axles may be coupled by wrought iron or steel cut gears 112 113. Each pair of driving-wheels being driven by equal forces exerted on the two main rods coupled to its crank-pins, the duty of the gears will be limited to that of checking any tendency of one pair of driving-wheels to advance by slipping relatively to the other, and in no case will the gears be required to transmit more than a small fractional part of the pressure acting upon the pistons.

I am aware that the employment of driving-wheels mounted in a truck or bogie frame, which is adapted to swivel or vibrate independently of the main frame of a locomotive-engine and carries directly the cylinders from which power is applied to the driving-wheels, was known at the date of my invention; and I am further aware that the utilization of the weight of a tender by providing the same with steam-cylinders whose pistons are connected to driving-wheels supporting the tender is not new. Such constructions, which differ in essential particulars from my invention, I therefore disclaim.

I claim as my invention and desire to secure by Letters Patent—

1. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a water and fuel receptacle, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a pair of steam-cylinders fixed upon the main frame and having their piston-rods secured to cross-heads working in guides thereon, and lever mechanism, substantially as described, whereby said cross-heads are coupled to pins fixed on the main frame and to crank-pins on the driving-wheels, respectively.

2. The combination, substantially as set forth, of a rigid main frame, a locomotive-boiler, and a water and fuel receptacle secured, respectively, upon the forward and rear portions of said frame, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame below the boiler, a pair of steam-cylinders fixed to the main frame and having their piston-rods secured to cross-heads working in guides thereon, lever mechanism, substantially as described, whereby said cross-heads are coupled to pins fixed on the main frame and to crank-pins on the driving-wheels, respectively, and a truck or bogie adapted to move about a center bearing fixed to the main frame below the water and fuel receptacle.

3. The combination, substantially as set

forth, of a rigid main frame, a locomotive-boiler, and a water and fuel receptacle, secured, respectively, upon the forward and rear portions of said frame, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame below the boiler, a pair of steam-cylinders fixed to the main frame and having their piston-rods secured to cross-heads working in guides thereon, lever mechanism, substantially as described, whereby said cross-heads are coupled to pins fixed on the main frame and to crank-pins on the driving-wheels, respectively, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame below the fuel and water receptacle, and a supplemental pair of steam-cylinders fixed to the main frame and having the cross-heads of their piston-rods coupled through lever mechanism, substantially as described, to pins fixed on the main frame and to crank-pins on the driving-wheels of the truck or bogie frame supporting the fuel and water receptacle.

4. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a water and fuel receptacle, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a pair of steam-cylinders fixed to the main frame and having their pistons connected to crank-pins on the driving-wheels, and a subsidiary leading or guiding truck adapted to move about a center bearing fixed to the driving-wheel truck-frame.

5. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a water and fuel receptacle, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a pair of steam-cylinders fixed to the main frame, a pair of cross-head levers, each journaled to the piston-rod cross-head of one of said cylinders, a pair of fixed fulcrum-levers journaled in bearings fixed to the main frame, tension-rods coupling the cross-head levers and fixed fulcrum-levers at their upper ends, tension-rods controlling the movements of the lower ends of the fixed-fulcrum levers, and main rods coupling the lower ends of the cross-head levers to crank-pins on the driving-wheels.

6. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a fuel and water receptacle, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a pair of steam-cylinders fixed to the main frame, a pair of cross-head levers, each journaled to the piston-rod cross-head of one of said cylinders, a pair of fixed-fulcrum levers journaled in bearings fixed to the main frame, tension-rods coupling the cross-head levers and fixed-fulcrum levers at their upper ends, tension-rods coupling the lower ends of the fixed-fulcrum levers to bearing-pins on the driving-wheel truck-frame, and main rods coupling the lower ends of the cross-head levers to crank-pins on the driving-wheels.

7. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a water and fuel receptacle, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a pair of steam-cylinders fixed to the main frame, a pair of cross-head levers, each journaled to the piston-rod cross-head of one of said cylinders, a pair of fixed-fulcrum levers journaled in bearings fixed to the main frame, tension-rods coupling the cross-head levers and fixed-fulcrum levers at their upper ends, and main rods coupling the lower ends of the cross-head levers and fixed-fulcrum levers, respectively, to crank-pins on the driving-wheels.

8. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a pair of long equalizing-levers, each pivoted centrally by a bearing-pin to and below one side of the truck-frame and coupled at each end to a shorter equalizing-lever, equalizing-beams coupled above the truck-frame by hangers at their ends to the driving-wheel springs, and links or hangers coupling one end of each of the short equalizing-levers to the end of a driving-wheel spring and the other end of said lever to the center of an equalizing-beam.

9. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, a subsidiary leading or guiding truck supporting one end of the driving-wheel truck-frame upon a center bearing, about which said subsidiary truck is free to move, and a spring and equalizer arrangement, as described, supporting the opposite end of the driving-wheel truck-frame upon a bearing-pin below each side thereof.

10. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler, a series of driving-wheels mounted in a truck or bogie frame, a center bearing secured to and projecting downwardly from a transverse girder connected to the main frame and having a spherical lower face, a correspondingly-recessed socket secured upon a transverse bearing-plate fixed to the truck-frame, and a center pin connecting the center bearing and the socket and its bearing-plate.

11. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler, a series of driving-wheels mounted on a truck or bogie frame, a center bearing secured to and projecting downwardly from a transverse girder connected to the main frame, a center casting or socket fitting the

lower end of said center bearing and secured to a transverse bearing-plate fixed to the truck-frame, and springs fitting in guides or sockets on the truck-frame and bearing against the sides of the center bearing of the main frame.

12. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a pair of steam-cylinders, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, and having crank-pins connected with the pistons of the steam-cylinders on the main frame, valve-operating eccentrics fixed upon one of the driving-axles, and eccentric-rods connected pivotally at one end to the straps of the eccentrics and similarly connected at the other end to valve-operating links suspended from a lifting-shaft journaled on the main frame.

13. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a pair of steam-cylinders, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, and having crank-pins connected with the pistons of the steam-cylinders on the main frame, fixed-fulcrum levers secured upon shafts journaled on the main frame and coupled at their opposite ends by tension-rods to pins on the truck-frame and to levers pivoted to the cross-heads, valve rocker-shafts mounted in boxes hinged to brackets, which are fixed relatively to the main frame, and links connecting arms on the rocker-boxes with blocks fitting slots in arms on the fixed-fulcrum-lever shafts, and with arms on the lifting-shaft of the valve-links.

14. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a pair of steam-cylinders, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, and having crank-pins connected with the pistons of the steam-cylinders on the main frame, a pair of cross-head levers each journaled to the piston-rod cross-head of one of said cylinders, a pair of fixed-fulcrum levers journaled in bearings fixed to the main frame, tension-rods coupling the cross-head levers and fixed fulcrum-levers at their upper ends, tension-rods connected by pivots to boxes or brasses fitting pins on the lower ends of the fixed-fulcrum levers and to boxes or brasses fitting pins on the truck-frame, and main rods connected by pivots to boxes or brasses fitting pins on the lower ends of the cross-head levers and to boxes or brasses fitting crank-pins on the driving-wheels.

15. The combination, substantially as set forth, of a rigid main frame carrying a locomotive-boiler and a pair of steam-cylinders, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame, and a pair of steam-cylinders fixed upon the main frame and having their pistons connected to crank-pins on the driving-wheels of stroke greater than that of the pistons.

16. The combination, substantially as set forth, of a rigid main frame, a locomotive-boiler, and a fuel and water receptacle, secured, respectively, upon the forward and rear portions of said frame, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame below the boiler, a pair of steam-cylinders fixed to the main frame and having their pistons connected to crank-pins on said driving-wheels, a series of driving-wheels mounted in a truck or bogie frame adapted to move about a center bearing fixed to the main frame below the fuel and water receptacle, a pair of steam-cylinders fixed to the main frame and having their pistons connected to crank-pins on said driving-wheels, a pair of reverse-levers adapted to swing upon a common pivot and connected, respectively, with the link-lifter shafts of the forward and the rear cylinders, and a quadrant secured upon one of the reverse-levers and serving to regulate the position of the other.

17. In a locomotive-engine of the type described, the combination, substantially as set forth, of a pair of link-motions and their operating-eccentrics mounted upon a forward truck or bogie, a pair of link-motions and their operating-eccentrics mounted upon a rear truck or bogie, a pair of reverse-levers adapted to swing upon a common pivot on the main frame of the engine, reverse-bars coupling said reverse-levers with the lifting-shafts of the forward and rear link-motions, respectively, a long fixed quadrant having notches receiving the stop-latch of one of said levers, a short quadrant secured to said lever and having movable stops to engage the stop-latch of the other lever, and a guide secured to the long quadrant and having an end incline adapted to raise the stop-latch of the lever last named from the notches of the short quadrant.

FRANCIS W. JOHNSTONE.

Witnesses:
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M. S. MCCAY.