(No Model.)

4 Sheets—Sheet 1.

W. L. JUDSON.

PNEUMATIC RAILWAY.

No. 409,205. Patented Aug. 20, 1889.

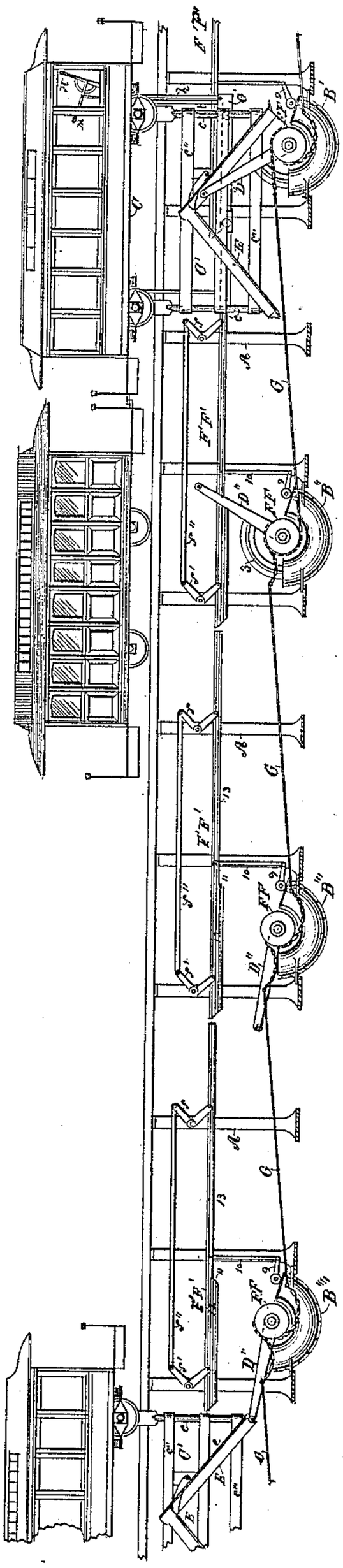

Fig. I.

Witnesses

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Emma F. Elmore

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By his Attorney

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(No Model.) 4 Sheets—Sheet 2.

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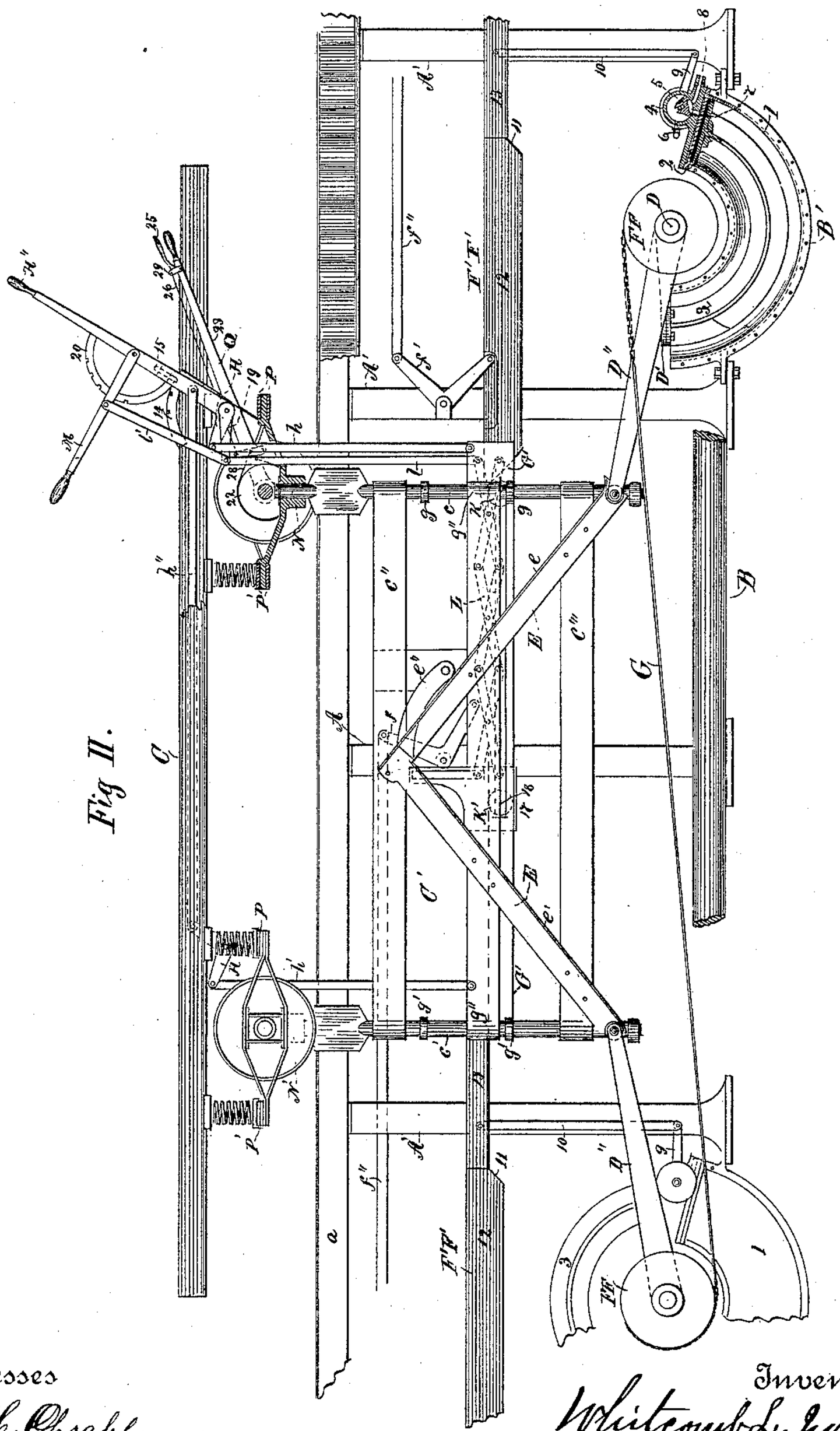

Fig II.

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(No Model.)

4 Sheets—Sheet 3.

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Fig. III.

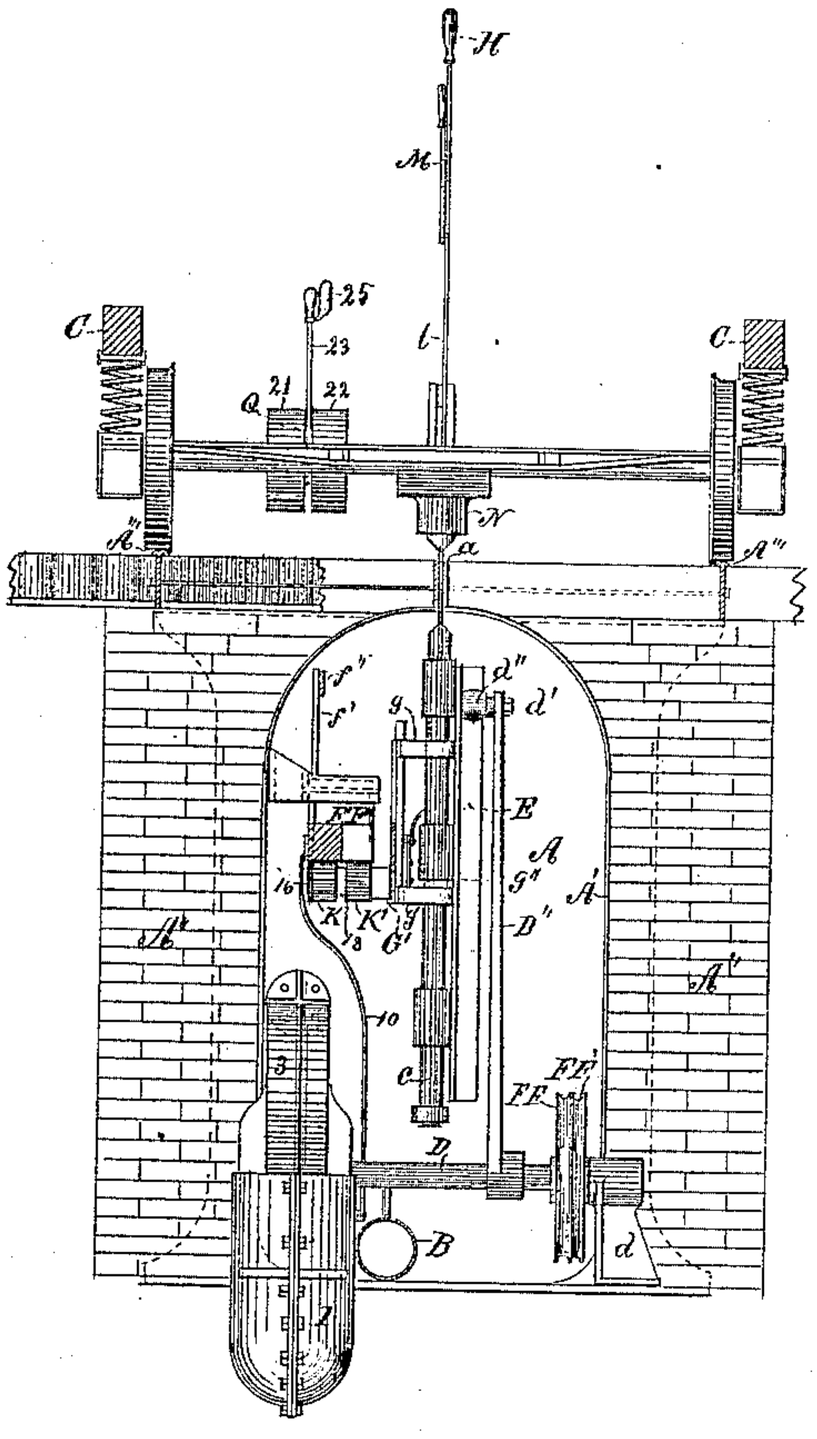
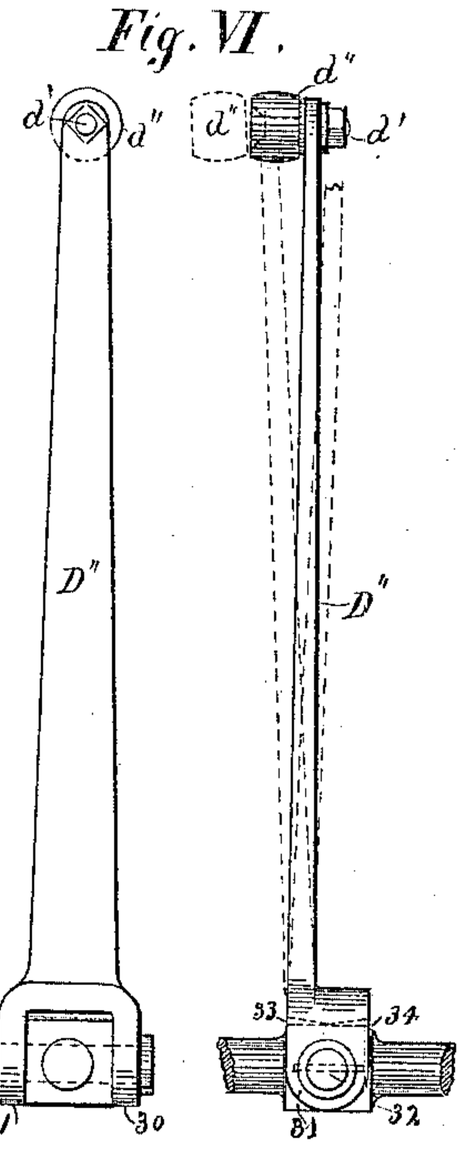


Fig. VI.



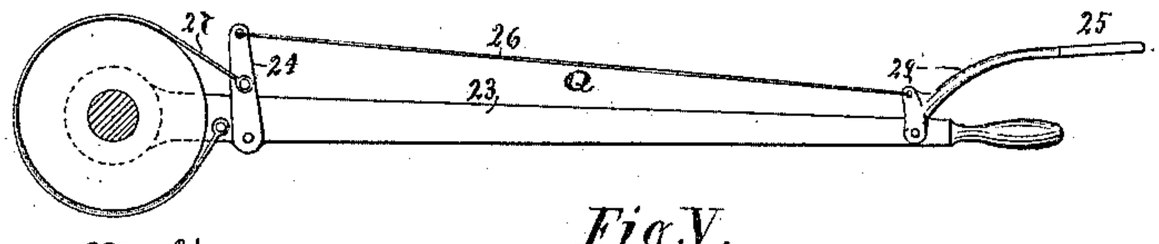
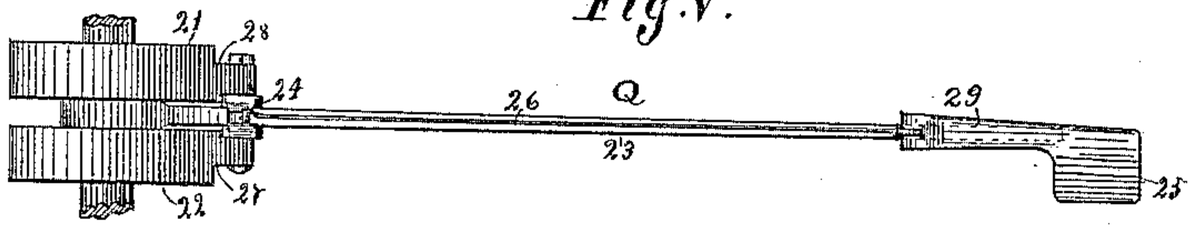


Fig. V.



Witnesses

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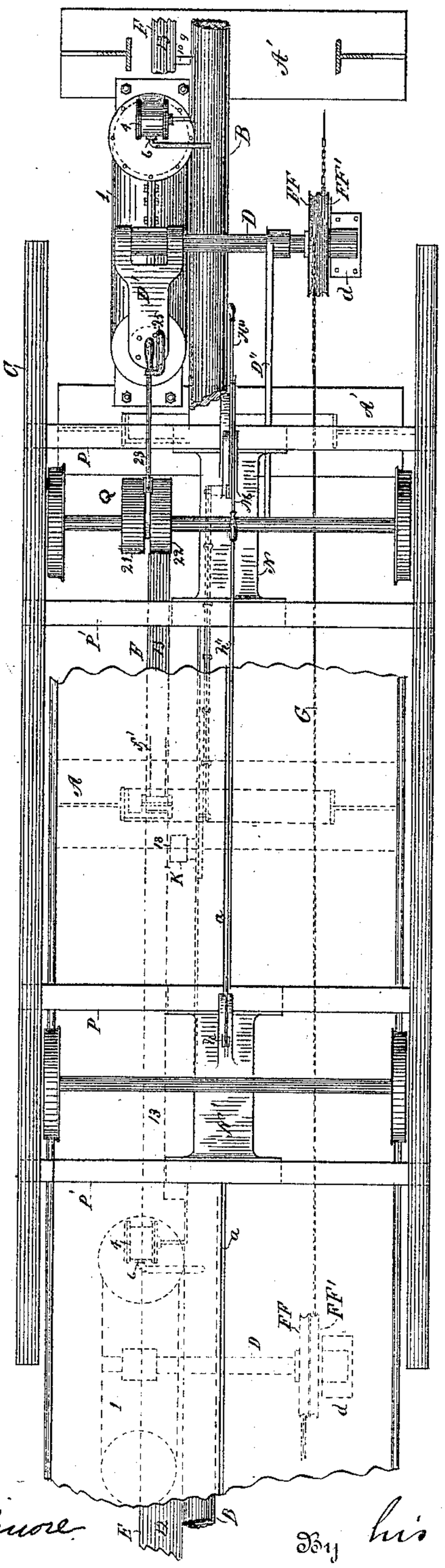
Fig IV.



Witnesses
A. H. Upsahl.
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By his Attorney
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UNITED STATES PATENT OFFICE.

WHITCOMB L. JUDSON, OF MINNEAPOLIS, MINNESOTA, ASSIGNOR TO THE JUDSON PNEUMATIC RAILWAY COMPANY, OF SAME PLACE.

PNEUMATIC RAILWAY.

SPECIFICATION forming part of Letters Patent No. 409,205, dated August 20, 1889.

Application filed April 2, 1888. Serial No. 269,325. (No model.)

To all whom it may concern:

Be it known that I, WHITCOMB L. JUDSON, a citizen of the United States, and a resident of the city of Minneapolis, county of Hennepin, State of Minnesota, have invented a certain new and useful Pneumatic Railway, of which the following is a specification, reference being had to the accompanying drawings.

My invention is designed more particularly for use in large cities and their thickly-populated urban districts as a substitute for cable lines and other systems for obtaining rapid transit on public streets, whether surface or elevated roads.

My invention consists in the system hereinafter fully described and in constructions for carrying out the system, part of which are fully set forth and claimed in this and another application of even date.

The system may be briefly outlined as follows, when constructed as a surface road, viz: An underground conduit provided with a central surface slot extends between the rails the whole length of the road, directly under the center of the road-bed, similar to the conduit used by the cable railways. Within and extending the whole length of this conduit is a motive-power main or conductor for supplying the motive power to the motors from a central station. This may be air from a compressor, a liquid under pressure, steam, (whether direct or from superheated water under pressure,) or even electricity, by the proper changes in the form of the motor; but I preferably use air. In the conduit, at definite short distances apart, are placed a series of motors each having a connection with the common motive-power conductor. To the under side of the car is attached a strong depending part, which passes through the slot and into the interior of the conduit. By suitable connecting mechanism the series of motors take hold of this dependent part in succession and thus propel the car. These motors and the mechanism for imparting their motion to the car are so arranged that one takes hold just as the other lets go. The motive force for driving the motors is supplied and cut off automatically by the car itself through suitable valve mechanism. Provision is made for traversing sharp curves, for preventing the escape of the car in either direction, and for instantly stopping the same in case of breakage. Provision is made for a variable cut-off and for the use of air expansively for a greater or less portion of the stroke, as desired. Automatic switch mechanism is provided for shifting the car to right or left side tracks at the will of the operator, the construction for the same being set out in full in the other application of even date herewith, under Serial No. 269,326, entitled "switch for street-railways."

Like letters referring to like parts, Figure I is a general view in side elevation with the walls of the conduit removed, illustrating the main features of the system, but designed more particularly to show the relation of the motors to each other. Fig. II is a view, partly in side elevation and partly in section, showing a pair of motors, the car-truck, and their connections, including the valve-controlling mechanism. Fig. III is a cross-section of the conduit and air-main, showing end elevation of the car-truck and propelling mechanism; and Fig. IV is a plan view with a part of the track-bed removed. Fig. V is a detail, and Fig. VI shows form of cam-lever used on curves.

A is the underground conduit, formed in any suitable way, but preferably composed of a series of arched metallic trusses A′ backed and overlaid by masonry A″. The top or arch of the conduit is provided with the customary longitudinal slot *a*.

A‴ are the rails of the track.

B is an air-main lying on the floor of the conduit and extending its entire length to a compressor at a central station. (Not shown.)

B′ B″, &c., are a series of air-motors fixed in the conduit at definite distances apart in line with each other, each having an independent connection with the main B.

C is the driving-car truck, of any suitable kind.

The motors are of a special construction designed for the purpose. The cylinder 1 is arc-shaped, being approximately a half-circle, and is closed at one end and open at the other. The piston 2 is provided with a strong rigid

stem 3, conforming exactly to the curvature of the cylinder and of the same or slightly greater length than the cylinder.

4 is an air-chest mounted on the cylinder, preferably on its closed end, and is provided with a seat for a rotary valve 5.

6 is a supply-pipe connecting the air-chest with the air-main.

7 is the port for passage of the air to and from the cylinder, and 8 is the exhaust-duct leading to the exterior of the chest and discharging in the direction opposite to the travel of the car.

The valve-stem projects through a stuffing-box to the exterior of the air-chest, and a crank-lever 9 is attached to the outer end thereof for operating the valve.

It is evident that if air under pressure be admitted behind the piston 2 the piston will be moved through the length of the cylinder, and that the outer end of the stem 3 will be moved through the supplementary arc of the same circle.

The converting and connecting mechanism.—The motion from the piston is converted and applied to the car as follows: In bearings on suitable supports, as *d*, within the conduit is placed a shaft D, arranged at right angles to the plane of the motor-piston's movement and in the center of that circle of which the cylinder is an arc. To this shaft is rigidly attached a strong crank D′, preferably in same vertical plane as the cylinder, of a length equal to the radius of the cylinder-circle. The outer end of this crank is secured to the outer end of the piston-stem 3. The shaft D will therefore be turned through a half-revolution (approximately) by a single stroke of the piston. On this shaft at a point to one side of its center is rigidly secured a strong cam-lever D″ of greater or less length, according to the distance through which it is desirable to move the car by a single stroke of the piston. To the outer end of the cam-lever is fixed a short arm *d′*, at right angles to its length, projecting toward the center of the conduit, which in turn is provided at its outer end with an anti-friction roller *d″*. To the under side of the car-truck C is attached, as before stated, a dependent portion C′, which projects through the slot into the interior of the conduit. This dependent portion within the conduit is in the form of a rectangular truss of a length equal to the distance between the forward and rear trucks of the car. The vertical parts consist of a pair of strong cylindrical steel bars *c c′*, flattened where they pass through the slot, attached by swiveled connections, respectively, to the front and rear trucks. These are tied together within the conduit and rigidly braced above and below by suitable horizontal metallic bars *c″* and *c‴*. To this dependent portion of the car (the truss *c c′ c″ c‴*) is rigidly secured a cam-track E, adapted to receive the head of the cam-lever D″. This track is in shape like an isosceles triangle with its base removed, having its apex at the top and center of the truss and the extremities of its legs at the lower corners of the same. This track is open at its ends and on the side facing the cam-lever, and is provided with a strong lateral flange *e*, projecting from the upper edge of the front leg, and with a similar lateral flange *e′*, projecting from the lower edge of the hind leg, to furnish the necessary resistance for the pull and push of the cam-lever. It may, if so desired, be provided with lateral flanges both above and below on both legs; but this is not necessary.

The normal position of the levers D″ is one of rest, their free ends entering the mouth of the cam-track in the forward movement of the car. The cam-lever and the dependent part of the car must be in different planes to afford the necessary clearance. To secure contact or engagement between the two, an angular projection must be provided either on the dependent part of the car or on the cam-lever, or on both. In the drawings I have, as before stated, shown such projections on both—viz., the lateral flanges *e e′* on the car and the arm *d′*, with its roller *d″*, on the lever.

A pawl *e″* is pivoted to a suitable support, as the top flange *e*, in proximity to the apex of the track in the proper position to fall behind the head of the cam-lever as it reaches the apex and force it to take the rear leg of the track through the rest of its stroke. This may be either a gravity or spring-actuated pawl. In the construction shown the flange *e* is provided with a slot, through which the free end of the pawl is allowed to rise and fall.

The angle made by the two legs of the cam-track to each other may be varied as desired. I have found the angle shown to be a good one for efficient work.

It has been noted that the piston 2 and consequently the cam-lever D″ only make a half-revolution. It is therefore necessary to return the piston and cam-lever to their normal positions after each stroke. This is done by coupling all the motors together in such manner that the motor in use doing work will restore the piston of the motor directly in its rear to its normal position. For this purpose a pair of independent sheaves F F and F′ F′ are fixed on all the cam-lever shafts D. From these sheaves to similar sheaves on the adjacent cam-shafts in front and rear, respectively, extend connections G, which are preferably chains, link belts, or chains and rods, as shown. These connections between the sheaves of two adjacent cam-shafts have just sufficient slack to allow one stroke of the piston without being drawn taut. Consequently, the slack in the connection between the motor just letting go and the one just taking hold of the car having been taken up, the stroke of the working-motor will restore the piston of the former (or idle) motor to its nor-

mal position, as is shown by motors B''' and B'''', Fig. I. Single sheaves with connections from different points on their peripheries will also do the work.

The valve mechanism.—For controlling the supply of air to the motors I use the following construction, viz: A series of independent valve-rails F' F'' corresponding in number to the number of motors are placed directly above the same within the conduit. Each rail is hung to the lower arms of vertical levers *f f'*, which, as shown, are bell-cranks pivotally secured at their elbows to the trusses of the conduit, and whose upper arms are tied together by a connecting-rod *f''*. These bell-cranks are attached to the valve-rails at points on the opposite sides of the center of the rail, preferably near its extremities. A link 10 connects the rail with the valve-crank 9. The valve-rail is provided on its under side with an offset or shoulder 11, the part 12 between the shoulder and the end of the rail first reached by the car being of greater depth than the part 13 between the shoulder and the other end. In other words, one part of the rail is larger (measured vertically) than the other. This shoulder marks the point of earliest possible cut-off. On the dependent portion C' of the driving-car is mounted a vertically-movable bar G'. It is preferably provided with pairs of keepers *g g'* at its opposite ends encirling the steel bars *c* and *c'*, on which, as guides, it is free to move up and down for a limited distance. Stops *g''*, fixed on the bars *c c'* between the upper and lower keepers *g* and *g'*, will answer for the purpose. To the front and rear ends of the car-truck are pivoted at their elbows a pair of vertical bell-crank levers H and H'. From the lower arms of these levers vertical links *h h'* extend through the slot in the conduit and are connected to the ends of the bar G'. The upper arms of the bell-cranks are tied together by a connecting-rod *h''*. The upper arm of the lever *h* is extended and provided with a handle H'' and is used as the operating-lever. It is evident that by throwing this lever H'' forward or backward the bar G' will be raised or lowered. It may be locked in any desired position in any suitable way, as by the notched segment 14, secured to the car-truck, and a pawl 15 on the lever for engaging with the same. To the forward end of the bar G' is fixed an arm 16, projecting laterally into the vertical plane of the valve-rails and provided at its outer end with an anti-friction roller K for engaging the lower surface of the same. On the bar G' is also mounted a sliding sleeve 17, having an arm 18, projecting laterally parallel with 16, and provided at its outer end with a similar anti-friction roller K'. A set of expansible toggle-levers L, on the lazy-tongs principle, are connected at their rear end to the sleeve 17 or arm 18. A pair of links *l l'* connect the forward end of the lazy-tongs to an operating-lever M, which is pivoted to the extended arm H'' of the bell-crank H. To keep the links *l l'* out of the way of the bell-crank H and its link *h*, they are both pivoted to the outer end of a short lever 19, which is pivoted at its other end to the bell-crank H. It is evident that by working the lever M the roller K'' may be brought near to or thrown away from the roller K.

20 is a notched segment on the lever H'' for engaging with a pawl on the lever M and locking the lever M in any desired position.

The operation of this valve mechanism is as follows: The normal position of the valve 5 is, as shown by motor B' in Fig. II, open for the exhaust and closed to the supply of air. As the car moves forward, the roller K first strikes the valve-rail and raises the same, carrying with it the link 10 and valve-crank 9, revolving the valve, closing the exhaust and opening to the supply. In case the rollers are both together, as soon as they pass the offset 11 the valve-rail will fall by its own weight far enough to cut off the supply, but not far enough to open the exhaust. The air in the cylinder will then be used expansively until both rollers pass the forward end of the rail, when the rail will fall to its normal position, opening the ports for exhaust. In case it is not desired, in the particular instance, to use the air expansively, the roller K' is simply thrown to its most remote position from K, and it will hold the inlet-port open through the whole stroke. By placing it at any intermediate position the cut-off may be made to take place earlier or later, at will. In case it should be found that it was never desirable to use the air expansively, the valve-rail would be made of uniform depth throughout, and the movable roller K' and its actuating mechanism would be discarded. This valve mechanism is adapted to all conditions of the road-bed and conduit. In curves, for example, the valve-rail is formed to the same curved line. Switching is readily done, as may be seen on reference to the other application of even date. To provide for the better traversing of sharp curves, the vertical bars *c c'* are swiveled in head-blocks N, attached to the car-truck, and also in the horizontal bars *c''* and *c'''*. The head-blocks N are not rigidly attached to the trucks, but are mounted on cross-bars P P', so as to be capable of a limited free lateral movement. This is to prevent breakage of the dependent portion C' in case the car should be thrown from the track.

Q is a combined brake and car-starter. On the front truck-axle I fix a pair of friction-wheels 21 and 22, with a clear space between the two. A strong drive-lever 23 is pivoted on the axle between the friction-wheels. A short brake-lever 24 is pivoted to the lever 23, normally standing at an angle to the same. A bell-crank foot-lever 25 is also pivoted to the lever 23. A rod 26 connects 24 and 25. A pair of friction-bands 27 and 28 encircle

the wheels 21 and 22, and are attached at one end to the drive-lever 23 and at the other to the brake-lever 24. By pressure on the foot-lever 25 the bands are tightened on the friction-wheels as much as may be desired. On the lever 23, near the handle of the same, is also a finger bell-crank lever 29, which is also connected to the lever 24. By throwing the lever 23 backward to its limit and tightening the friction-bands by the finger-lever 29 it may be used as a pinch-bar or hand-propeller to start the car or move it short distances in cases of necessity. This is a provision to meet the possible contingency of a stoppage or accident to some particular motor.

The general operation of the construction is deemed clear from the description already given. As to the propulsion of the car through the cam-track and cam-lever, it is evident that, inasmuch as the motors and cam-shaft are stationary and the car movable, when the head of the cam-lever traverses the fixed cam-track the car must be moved. The application is in the nature of a pull on the front leg and a push on the rear leg of the cam-track.

In all positions of the car at least one motor (supposing all to be in their normal working condition) has hold of it. The car may, therefore, be started from any position of rest. It may also be stopped in any position. By dropping the bar G′ the ports may be thrown open to exhaust, and the momentum of the car be readily overcome by the brake.

In respect to the movement on grades the car cannot escape backward in case a motor should fail to work, because the cam-lever in the rear leg of the cam-track would have to retraverse its path, which it could not do on account of the pawl *e″*. The car would therefore be instantly stopped when the rear cam-lever reached the apex of the cam-track; otherwise the truss or cam-lever would have to be broken, which could hardly happen under the necessarily small momentum of the car in reversing its path for so short a distance. The car cannot run away in going forward down a grade, unless the engineer should lose his head, because by throwing the bar G′ to an intermediate position (the normal expansion-point) he can close both exhaust and supply, and in that event there would be a vacuum behind the piston, and it would have to be moved against atmospheric pressure. To this, if necessary, he could add the hand-brake. Even if he should lose his head there would be a limit to the speed of the runaway car, which could be confined to the working limit on a level under full power, inasmuch as the air could only enter the cylinders as fast as permitted by the size of the inlet or exhaust duct, according to the accidental position in which the bar G′ happened to be left. If the momentum of the car should tend to make the piston move faster, it would be resisted by atmospheric pressure to a greater or less extent.

In order to better adapt the mechanism for traversing curves, the cam-levers of the particular motors located in the curves are not rigid on the cam-shafts, but are so connected as to have a limited lateral swing, as shown in Fig. VI. To this end the part of the shaft to which the cam-lever is attached is made square, and the lower end of the cam-lever is bifurcated. These bifurcated arms 30 and 31 embrace the square part of the shaft and are pivotally secured to the same by bolt 32. The swing to either side is limited by cutting the corners from the lever, affording a pair of inclined faces 33 and 34 from the center outward and upward. These faces meet the square top face of the shaft and stop the lever.

It will be readily understood that although I have herein shown my invention as applied to a surface road it is equally well adapted to elevated roads.

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

1. The combination, with a movable car, of a series of cam-levers along the line of travel, a cam on the car with which said levers engage in succession, and one or more motors for actuating said levers, substantially as described.

2. The combination, with a movable car, of a series of vibratory levers arranged along the line of travel adapted to successively engage a part of said car and one or more motors for actuating said levers, substantially as described.

3. The combination, with a movable car, of a cam-track connected with the car, a series of cam-levers along the line of travel adapted in their normal position of rest to engage with said cam-track in the movement of the car, and one or more motors for actuating said levers, substantially as described.

4. The combination, with a movable car, of a cam on the car, a series of levers along the line of travel, the relative lengths and positions of the cam and cam-levers being such that one lever will engage the cam before the preceding lever has left it, and one or more motors for actuating said levers, substantially as described.

5. The combination, with a movable car, of a cam-track connected thereto, a series of cam-shafts along the line of the car's travel, a corresponding series of cam-levers connected with said shafts, adapted to traverse said cam-track in succession and propel the car, and one or more motors for driving said shafts, substantially as described.

6. The combination, with a movable car, of a Λ-shaped cam-track connected thereto, a series of cam-shafts along the line of the car's travel, a corresponding series of cam-levers connected with said shafts, adapted to traverse said cam-track in succession and propel the car, and one or more motors for driving said shafts, substantially as described.

7. The combination, with a movable car, of

a cam-track connected thereto, a series of cam-shafts along the line of the car's travel, a corresponding series of cam-levers connected with said shafts, adapted to traverse said cam-track and propel the car, and a corresponding series of stationary motors for driving said shafts, substantially as described.

8. The combination, with a movable car, of a ∧-shaped cam-track connected thereto, a series of cam-shafts along the line of the car's travel, a corresponding series of cam-levers connected with said shafts, adapted to traverse said cam-track in succession and propel the car, and a corresponding series of stationary motors for driving said cam-shafts, substantially as described.

9. The combination, with a movable car, of a cam-track connected thereto, a curved cylinder adapted to receive an expansible motive force, a piston movable lengthwise of said cylinder, a cam-lever pivoted to a fixed support adapted to traverse said cam-track and propel the car, and a connection from said piston to said cam-lever, substantially as described.

10. The combination, with a movable car, of a cam-track connected thereto, a curved cylinder adapted to receive an expansible motive force, a piston movable longitudinally of said cylinder, a rock-shaft, a connection from said piston to said shaft, and a cam-lever on said shaft adapted to traverse said cam-track and propel the car, substantially as described.

11. The combination, with a movable car, of a ∧-shaped cam-track connected thereto, a curved cylinder approximately a half-circle in length adapted to receive an expansible motive force, a piston movable longitudinally of said cylinder, provided with a rigid stem of equal length of a like curvature to the cylinder passing out through one end of the same and traversing the supplementary arc of the cylinder-circle, a rock-shaft arranged at right angles to the plane of the piston's movement, a crank-arm on said shaft having its outer end rigidly attached to the outer end of said piston-stem, and a cam-lever on said shaft having a cam-head adapted to traverse the said cam-track and propel the car, substantially as described.

12. In a railway system, the combination, with a movable car, of a cam-track connected thereto, a rock-shaft arranged crosswise of the car's path, a cam-lever having at one end bifurcated arms embracing said shaft at right angles to its axis and pivotally secured thereto and at the other a cam-head adapted to traverse said track, and a motor for driving said shaft, substantially as described, for the better traversing of curves.

13. The combination, with two or more independent vibratory levers, of two or more independent motors adapted each to move its respective lever through a half-revolution in a constant direction and a flexible connection coupling together said levers having sufficient slack to allow a single throw of one lever before becoming taut, substantially as described, whereby the motor in use is made to restore the idle lever and the movable part of the idle motor to their normal positions.

14. The combination, with a series of vibratory levers, of a corresponding series of stationary motors adapted to move said levers in succession in a constant direction and couplings connecting all of said levers in pairs with allowance for the throw of one of the pair of levers before the coupling comes into use, substantially as described, whereby the working-lever of the pair restores the idle lever to its normal position.

15. The combination, with a movable car having a cam-track connected thereto, of a series of rock-shafts mounted in fixed supports at definite intervals along the line of the car's travel, a corresponding series of cam-levers connected with said shafts, adapted to traverse said cam-track in succession in a constant direction for propelling the car, and a connection coupling together said shafts in pairs with allowance for the throw of one shaft before coming into use, substantially as and for the purpose set forth.

16. The combination, with two or more independent rock-shafts, of a corresponding series of independent motors adapted each to move its respective rock-shaft through a half-revolution, sheaves on said shafts, and a flexible connection coupling together the sheaves of adjacent shafts having sufficient slack to allow only a single throw of the rock-shaft before becoming taut, substantially as described, whereby the working-motor is made to restore the rock-shaft last used to its normal position.

17. The combination, with a series of two or more independent rock-shafts having crank-arms, of a corresponding series of curved cylinders having pistons movable lengthwise of the cylinder and piston-stems attached to said crank-arms and movable through supplementary arcs of the cylinder-circles, sheaves on said rock-shafts, and flexible connections coupling together said sheaves, each having sufficient slack to allow only a single forward throw of the shaft, substantially as described, whereby the piston under pressure restores the piston and rock-shaft last used to their normal positions, substantially as described.

18. The combination, with a movable car, of a series of stationary pressure-motors acting on the car in succession to propel the same, valves for controlling the supply to said motors, levers for operating said valves, and connections from said levers to the car for operating the valves with an automatically-variable cut-off, substantially as described, whereby the air may be used expansively for a greater or less part of the stroke.

19. The combination, with a movable car having a dependent portion, of a series of stationary pressure-motors acting on the car in succession, valves on said motors for controlling the supply of motive force to the same,

vertically-movable horizontal valve-rails corresponding in number to the said motors and supported one above every motor, each rail having bearing-surfaces on its under side in two different horizontal planes for cutting off at part stroke connections from said valve-rails to said valves, and a projection on the dependent portion of said car adapted to engage with said valve-rail, substantially as described.

20. The combination, with a movable car having a dependent portion, of a series of stationary pressure-motors acting on said car in succession, valves on said motors for controlling the supply of motive force to the same, vertically-movable horizontal valve-rails supported one above each of said motors, each rail having bearing-surfaces on its under side on two different horizontal planes, connections from said rails to said valves, a vertically-adjustable bar on the dependent portion of said car, a pair of lateral projections on said bar, one of which is fixed and the other adjustable horizontally to and from the same, and an operating-connection from said adjustable projection to within reach of the car-operator, substantially as described.

21. The combination, with a movable car, of a slotted power-conduit, swiveled bars extending from different parts of the car to the interior of the conduit, and braces connecting said bars, substantially as described.

22. The combination, with a movable car, of laterally-movable head-blocks attached to the front and rear truck-frames, dependent bars swiveled in said head-blocks, and braces connecting said bars, substantially as described.

23. The combination, with a movable car, of a slotted power-conduit, laterally-movable head-blocks on the car, swiveled bars extending from said blocks through the slot into the interior of the conduit, and braces connecting said bars, substantially as described.

24. The combination, with a movable car, of a slotted power-conduit, laterally-movable head-blocks attached to the front and rear of the car, swiveled bars extending from said head-blocks through the slot into the interior of the conduit, braces connecting the parts of said bars within the conduit, a cam-track mounted on said braces, a series of pivoted levers within the conduit along the line of travel adapted to successively engage with said cam-track, and one or more motors for driving said levers, substantially as described.

WHITCOMB L. JUDSON.

In presence of—
HARRY L. EARLE,
JAS. F. WILLIAMSON.