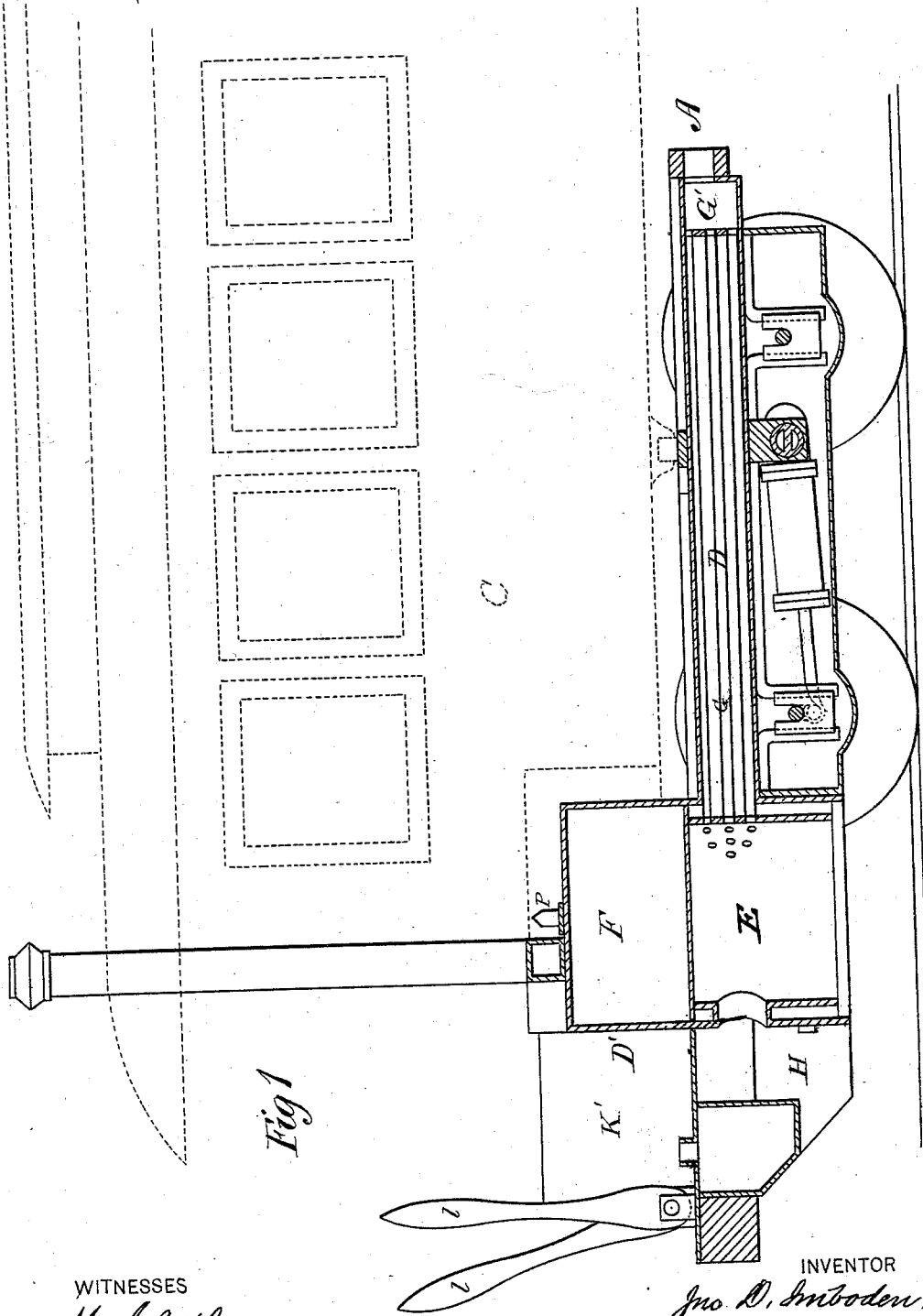


J. D. IMBODEN.
STEAM STREET CARS.

Patented April 24, 1877.

No. 190,046.



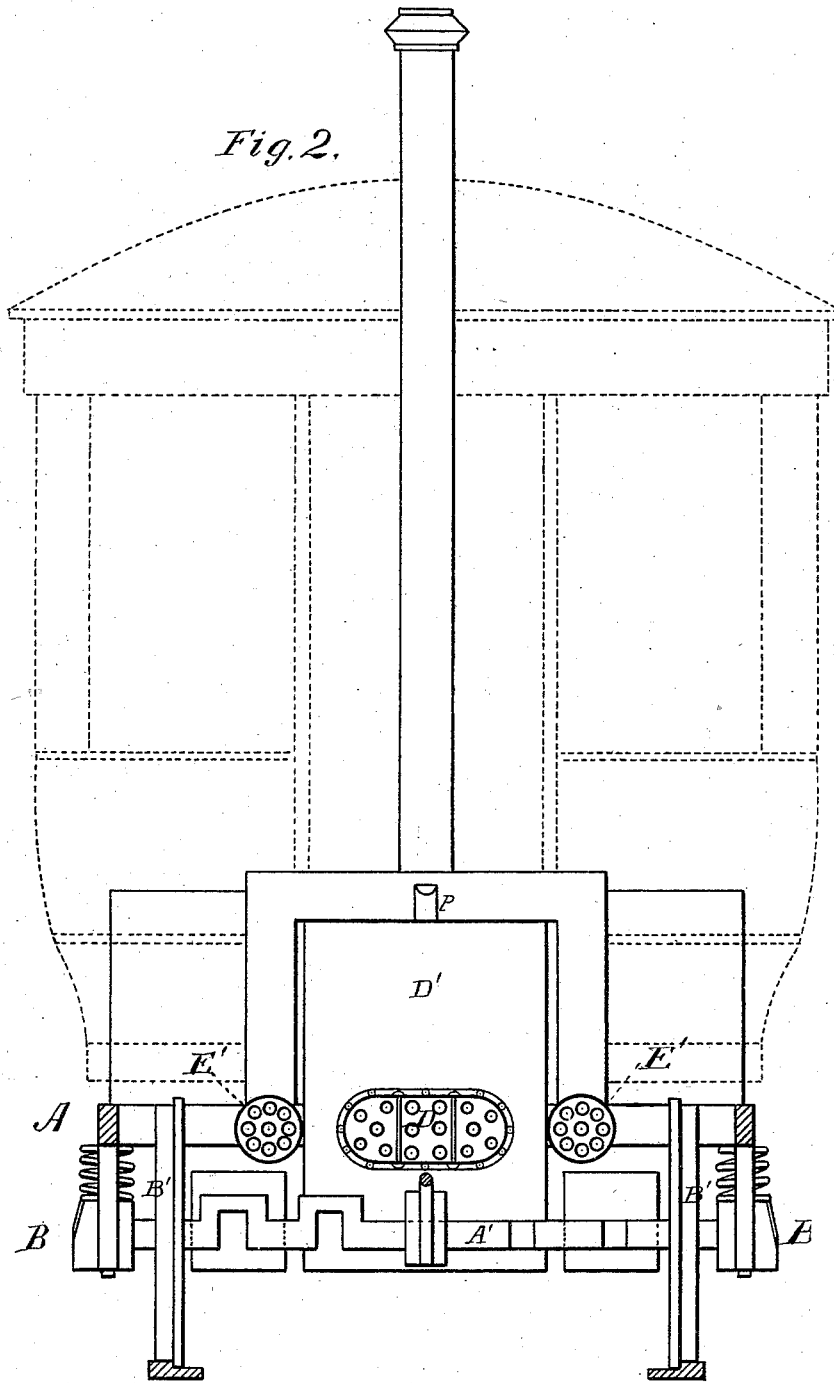
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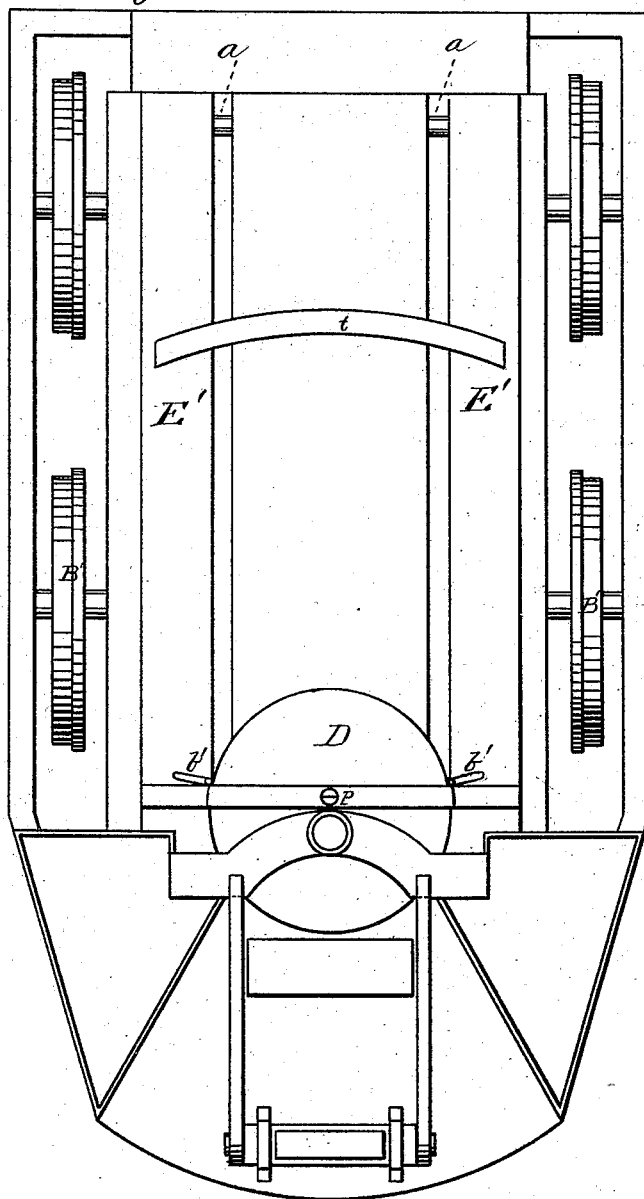
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Fig. 3.



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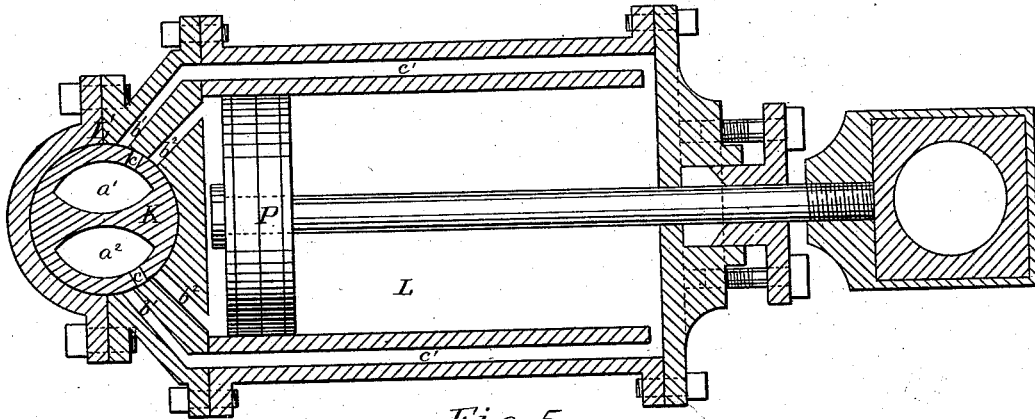


Fig. 5.

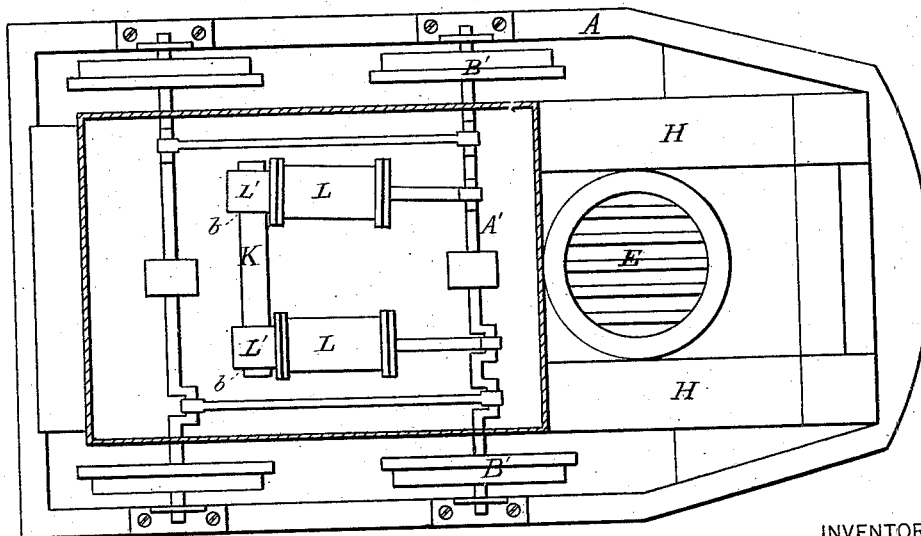
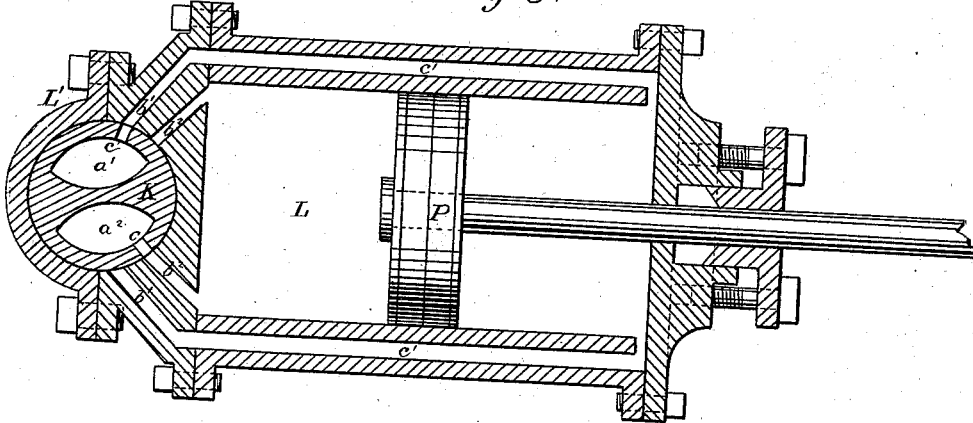


Fig. 4.

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Fig. 6.

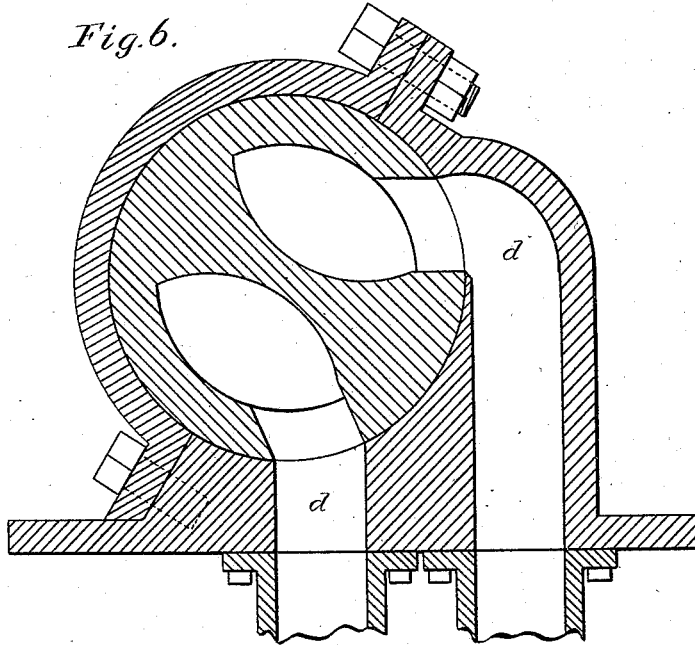
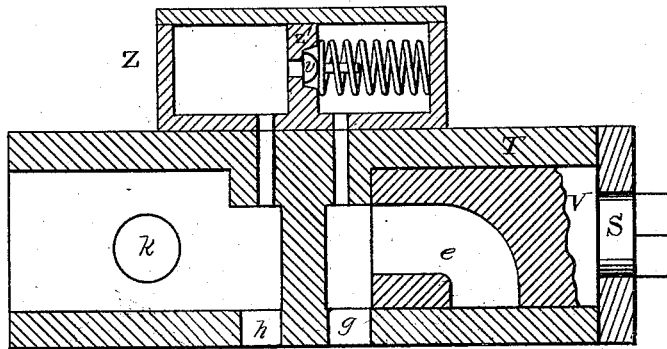


Fig. 7.



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Fig. 8.

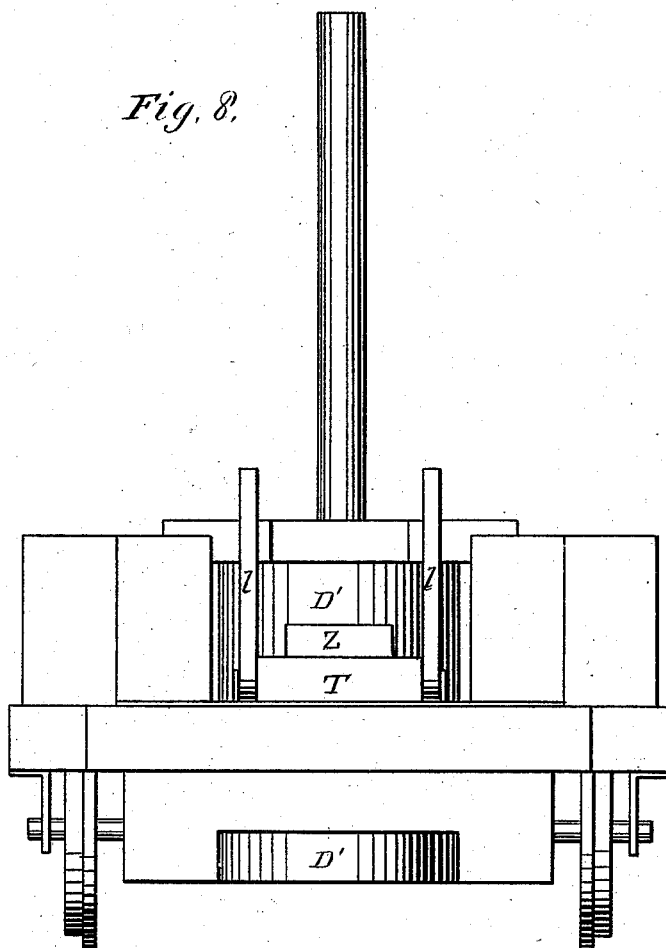
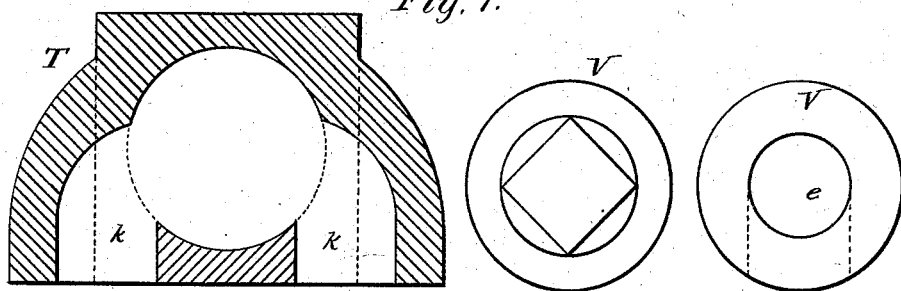


Fig. 9.



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UNITED STATES PATENT OFFICE.

JOHN D. IMBODEN, OF RICHMOND, VIRGINIA.

IMPROVEMENT IN STEAM STREET-CARS.

Specification forming part of Letters Patent No. **190,046**, dated April 24, 1877; application filed December 23, 1876.

To all whom it may concern:

Be it known that I, JOHN D. IMBODEN, of Richmond, in the county of Henrico and State of Virginia, have invented a new and valuable Improvement in Means for Propelling Cars and other Vehicles; and I do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the annexed drawings, making a part of this specification, and to the letters and figures of reference marked thereon.

Figure 1 of the drawings is a representation of a vertical section of this invention. Fig. 2 is a transverse section. Fig. 3 is a top view. Fig. 4 is a bottom view. Fig. 5 represents sections of the cylinders. Fig. 6 represents a transverse section of the trunnion. Fig. 7 is a vertical section of the safety-valve, steam cock and chest. Fig. 8 represents a front view of the motor, and Fig. 9 details of the steam cock and chest.

This invention has relation to steam-engines for the propulsion of street-cars and other vehicles; and it consists in the construction and novel arrangement of a truck or platform frame, above which is the car or receptacle for passengers or freight, and below which is arranged the engine; a pivot-bearing on the truck for engagement with the car, and, in connection therewith, a traverse-bearing for its support; a cab on the end of the truck-frame for the accommodation of the engineer; a horizontal boiler with furnace or heater suspended under or within the truck-frame or under the bottom of the car; a double-ended steam-chest with dual valves for regulating the injection and exhaust, and thereby reversing, slowing, or stopping the engine; a double bored and ported cylinder or trunnion, and, in combination therewith, the piston, cylinders, and pipes communicating with the steam-chest; the vibrating piston-cylinders bearing at one end on the ported trunnion, and connected at the other end, through the medium of the piston bars or rods, with the cranks of the driving-axle; the automatically-adjustable inside bearing and pedestal on the crank-shaft; the coal-bunkers on the front platform, and the suspended water-tanks connected to the truck-frame; the longitudinal blast-pipes

from the forward end of the truck, extending under the same to the fire-box; the horizontal-layer arrangement of the boiler apparatus and engine mechanism; the horizontal-tubed water-heaters parallel to, and in connection with, the main boiler; and the protected safety-valve and its chest, all as hereinafter shown and described.

The object of this invention is to provide, for cars and other vehicles, a motor-truck or under engine to be propelled by steam-power, which will not interfere with their receptive or carrying capacity; and to this end it is designed to utilize the usual waste space between the wheels under the bottoms of such vehicles, by the application of flat or laterally-expanded engines of proper character and suitable framing. Usually, it is preferred to build a horizontal frame or engine, to and under which the engine and its connections are for the most part arranged, and upon which a car or other carrying-receptacle may be readily mounted, without losing any portion of its capacity for the accommodation of passengers or freight, and without interfering with the full operation of the driving mechanism.

In order to fully explain this invention, I will now describe its application to the propulsion of a car of any ordinary pattern for street or other light travel, the car being, in this case, designed to be mounted upon the independent horizontal frame of the engine.

In the accompanying drawings, the letter A designates an engine-frame, usually of iron, of the same width as the bottom of the car-body, and long enough to provide for a front platform and cab on said frame or truck for the accommodation of the engineer, and the arrangement of the parts of the mechanism requiring his direct attention. The truck-frame may extend entirely or only partly the length of the car. It is horizontally level, and consists of transverse and longitudinal beams or bars suitably connected and braced, as shown in the drawings, or otherwise, to bear the strain.

The frame may be cast in one or more pieces, as may be found desirable.

This engine frame or truck has attached to it car-wheels of proper character, and pedestals B, with suitable springs, and carries sus-

pended to it the body of the boiler and furnace or heater, the engine-cylinders, condenser, and water-tank, and the tubing, being in short the main portion of the machine; and the entire mechanism, independent of the simply car-body, is primarily and permanently attached to this frame, the whole constituting a sub-motor or bearing-engine of horizontally extended character. C represents a car-body, which is designed to rest upon, and is supported by, the engine-frame A, suitable springs of rubber or steel being interposed to relieve the passengers from the jarring and jolting incident to rough street-railway tracks, and their numerous crossings and short curves.

In the construction illustrated in the drawings, the main horizontal barrel of the boiler D is arranged longitudinally within the frame, and over the axles, between the wheels. In order to economize vertical space, this horizontal barrel or boiler is preferably made elliptical in transverse section, the shortest diameter being vertical. At the front end of the main barrel is arranged the vertical portion D', the upper part of which forms the steam-dome F, while the lower portion contains the furnace E. This vertical cylinder or chamber D' is designed to extend from a few inches above the ground to a proper height above the level of the frame, to permit the engineer to have a suitably-protected seat upon its top. From the furnace to the other end of the horizontal barrel extend a suitable number of tubular flues, G, through which the products of combustion are discharged into a horizontal fire or smoke box, G', attached to, and at right angles with, the main barrel of the boiler and the flues. From this transverse flame or smoke box back to the front platform, and in the same plane with the main barrel D, are arranged two lateral auxiliary boilers or barrels, E', usually cylindrical in form. These are also supplied with tubular flues, which communicate with the smoke-box G', and into which it discharges its contents of hot air and gases, to be conducted to the dual smoke-stacks or outlet-pipes on the front platform, and thence to the top of the car. The auxiliary barrels of the boiler are connected, by short water-pipes near their rear ends, with the main barrel, as indicated at a, and at their front ends, on top, with the steam-dome, by small equalizing steam-pipes b'. These lateral barrels serve a twofold office: first, to gain an additional length of tubing and corresponding increase of heating-surface, and more perfect absorption of heat by the water; and, in the second place, and of more importance in small boilers, to avoid a check to the evolution of steam, in consequence of a sudden injection of supply-water at a low temperature. To this end the injector or pump, which may be arranged between the engine-cylinders, and operated by cams or eccentric bearings on one of the axles, is connected by a pipe with the heater or auxiliary barrel at the end on the front plat-

form. Cold water pumped into these heaters cannot chill the main barrel or steam-generator, for it cannot reach the latter until it has flowed through the entire length of the lateral heaters E', growing hotter in its progress among the tubes in these cylinders, until by the time it reaches the main boiler its temperature will approximate that of the water in the latter.

The direction of the current of water in the heaters and boiler is directly opposite to that of the hot air and gases from the furnace, which will have a beneficial effect on the material of the boiler and tubes, by preventing sudden contraction and expansion. The smoke or fire box G' is designed to be protected against radiation by a non-conducting jacket, and is designed to be so constructed that it can be readily opened for cleaning or repairing the tubes when necessary. In connection with this form of boiler, the water-tank H is arranged under the front platform, and the coal-bunkers upon the sand, as indicated at K', handy to the engineer, and protected by his cab. In fact, the engineer need not leave his seat for any purpose connected with the running of the engine, except to oil the bearings under the truck, which, being all boxed in from dust and rain by a casing, will hardly need attention more than once a day on street-railways, and perhaps twice on steam roads of higher speed, to which this form of engine is peculiarly adapted, in hauling a single car the separate locomotive being dispensed with.

A' designates the bent or crank axle of the driving-wheels B'.

The machinery of the engine is chiefly arranged below the frame of the truck, and, in the construction illustrated, in a layer below and parallel with the boiler-barrels.

K designates a large steam-trunnion or pivotal bearing, firmly secured by suitable braces or framing in a transverse horizontal position under the boiler, parallel to the crank-axle. This trunnion is constructed with independent parallel steam ways or channels a' a'', running lengthwise, one of these passages being for the supply-steam and the other for the exhaust; or their use may be reversed, as hereinafter described.

L L indicate piston-cylinders without the ordinary valves, which are designed to oscillate on the trunnion K, suitable bearings b being provided thereon for the transversely-cylindrical heads L' of said cylinders, the latter being extended in the direction of the length of the car and toward the main crank-axle. In the bearings b slots or steam-ports c are formed, extending inward to the steam ways or chambers of the trunnion. A pair of such steam-ports is thus provided for each cylinder L, the head L' of which, clasping the trunnion closely, is provided with steam-ports b' b'', of corresponding size, through which, when coincident with the trunnion-ports, steam is designed to pass freely from the trunnion to the cylinder, or in the opposite direction.

In the construction illustrated, steam is designed to be applied on both sides of the piston-head to obtain a double-acting piston, and the ports in the oscillating cylinder-head are doubled, as indicated in the drawings at $b^1 b^2$. Two of these ports admit steam, and the other two allow the exhaust steam to escape. Two are in operation when the piston is being driven out, and the other two when it is being forced back. The ports b^1 connect with steam-channels c' cored out in the walls of the cylinders, to convey the steam to or from the remote ends of the same, suitable communication with the interior of said cylinders being established by means of segmental ports at the heads of the same. One of these channels admits live steam, and the other allows the dead steam to escape to the exhaust channel or chamber in the trunnion. When my engine is constructed on the plan illustrated, two cylinders will suffice, if geared at right angles on the crank-shaft. Of course they must be supplied with the ordinary stuffing-boxes for the piston-rods, which, in this case, are of the usual form employed in steam-engines.

If it is desirable, as it may be in order to overcome heavy grades, to employ four driving-wheels instead of two, the object is attained by connecting the main driving-axle to the axle of a second pair of wheels by connecting rods and cranks, or other convenient gearing. In this case the truck-frame is made of iron, and may not exceed one-half the length of the car-body, though it is of the same width and height as in the case of a single pair of drivers, and is provided with pedestal-boxes and springs of the usual construction.

Between the bearings b of the trunnion spaces are left for the reception of steam-ducts d , Fig. 6, which are firmly clamped around the trunnion by means of screws, or otherwise secured thereto. Through one of these ducts the steam, after passing the throttle-valve, is admitted to one of the steam ways or channels of the trunnion, and through the other duct the exhaust steam is carried off. Each duct has two passages corresponding to the two trunnion-chambers, so that either may be used at will, for induction, on the one hand, or for exhaust on the other. In this manner it is designed to provide means for reversing the engine by simply changing the channel of induction, and making a corresponding change in the exhaust-way, which is effected by the throttle-valves, or, rather, steam-plug S . These are arranged and inserted at opposite ends of a small oblong steam-chest, T , fixed usually on the front platform of the frame, one chamber of which serves for induction, and the other for exhausting. Each chamber is cylindrical, or, preferably, slightly tapering toward its outer end, so that its valve V will be kept steam-tight in its seat by the steam-pressure. In the bottom of the chest, toward the middle of the same, and at the interior ends of the valve-seats, are respectively locat-

ed the steam and exhaust ways g and h , to which the steam and exhaust pipes are connected.

Lateral ducts k are provided on both sides of each valve-seat, and to each set of opposite ducts are connected pipes leading to the trunnion-chambers.

The valves V are provided with elbow-shaped passages e , and are designed, when operated by suitable levers l , to establish or cut off communication between the trunnion-chambers and the ways g and h . A peculiar and important office of the exhaust-chamber and cock is to regulate the speed of the car. By "choking" the exhaust the engine will be caused to work more slowly, and its action may be so retarded by this simple means as to hold back the car in going down grade without the aid of brakes on the wheels. By cutting off the exhaust entirely the engine is caused to stop instantly, and the driving-wheels are brought to a dead-lock; and to start the car again it is only necessary to open the exhaust-cock, when the cylinders, being freed from the resistance of the imprisoned steam on which they had cushioned, renew their motion, so that, practically, the engineer will conduct all the operations of startings, braking, slowing, or stopping the engine by the manipulation of the exhaust-cock alone, the throttle being in the meantime left open.

Z indicates a small cast-iron chest, which forms a closed casing for my safety-valve v . This chest or box is designed to be secured to the top of the valve-chest T , and is provided with apertures communicating with its steam and exhaust chambers. The chest Z is divided by a partition between its own steam and exhaust chambers, as indicated at z' , and in this partition the valve is seated, being pressed home by a spring regulated to exert a certain degree of pressure. Being inclosed securely in the case and hidden, the valve is perfectly guarded from all ignorant or malicious tampering. It cannot be interfered with or rendered incapable of performing its important functions without the aid of shop-tools to take the chest apart. This safeguard is regarded as of primary importance, considering the great number of men, some of whom might be incompetent, that would be required to operate a system of steam street-cars, and the disastrous consequences which would attend an explosion in a crowded street. With this valve and a sound boiler such a disaster is impossible.

Under the front of the frame it is designed to suspend a water-tank, H , for the double purpose of supplying the boiler when necessary, and to condense the exhaust steam, which is conducted to it from the exhaust-cock in a silent manner.

When the form of truck illustrated in the drawings, extending partly the length of the car, is employed, the car-body is designed to be attached to it by means of a pivotal con-

nection, *p*, located over the vertical part of the main boiler, the weight of the car-body being allowed to rest on the truck nearly midway between its wheels, thereby utilizing the load to increase the traction on the rails. In this construction the ordinary elliptic springs are placed under the seats of the passengers, and secured to the car-sills by suitable stirrups. From one of these springs to the other a strong bar of iron extends across under the floor of the car, and is provided with friction-rollers. These in turn rest upon a traverse-plate, *t*, which is secured to the top of the horizontal part of the boiler and heaters. The rear wheels of the car may be arranged and connected in the usual way, the front end of the car being carried by the steam-truck. The four drivers have a comparatively short wheel-base, to turn curves readily, and in doing so the truck is deflected; but the car-body readily adjusts itself to this oscillation on the pintle-hook as a center, being borne up by the friction-rollers attached to the spring-bar. On a curve of twenty-five feet radius the deflection will not exceed six inches at the bearing-point on the truck. As this form of truck and boiler necessitates the closing of the front door of a street-car, I throw a seat across the end of the passage in front, and in this manner increase the ordinary horse-car accommodation.

Sometimes the boiler may be arranged transversely, having within or below it a heating or furnace chamber, the length of boiler and chamber, when transverse, being about equal to the width of the frame *A*, and the same being designed to be suspended under and across said frame, preferably midway between the front and rear sets of wheels, thereby equalizing the load, as far as possible, on the wheel-base. In this transverse construction, therefore, the body of the boiler extends across the frame; and the fire-box, attached to or contained in said boiler, is provided with a door at each end, accessible at the side of the car.

Sometimes, instead of using a fire-box and combustible material, a cylindrical heating-chamber may be formed under the boiler, taking the place of the ordinary fire-box; and in this may be suspended, by suitable journals, a revolving cradle, consisting of a plate of iron, having a semi-cylindrical sheet-iron shell attached on one side, forming a chamber, which is designed to be filled with asbestos or some other incombustible non-conductor. In this construction it is designed to generate heat and keep up steam in the boiler by means of iron billets or ingots of sufficient size or number to nearly fill the open space in the cradle, on the opposite side of the diametrical plate, wherein they are placed after being heated in stationary furnaces. Heated to about 2,500° Fahrenheit, these billets are designed to radiate heat sufficient to evaporate about one gallon of water to every thirty pounds of iron used, under a pressure of one hundred pounds to the inch, provided the in-

ulation is so perfect as to prevent any sensible escape of heat to the atmosphere except through the medium of the boiler. The bottom of the boiler being made cylindrically concave underneath, and the cradle being provided with a suitable ratchet and gearing to bring it under the control of the engineer, he can at will turn off the hot ingot from, or apply it to, the bottom of the boiler. It will add to the economy of this method of heating to provide at the furnaces, where the billets are heated, stationary boilers, to provide the car-tanks with hot water instead of cold.

Sometimes I may use steam only on one side of the piston *P*, driving it out the full length of its stroke; and in this case a piston bar or frame, of oblong form in cross-section, is substituted in place of the ordinary rod, and so arranged that its greatest breadth is in the vertical direction. In order to secure rigidity in piston-rods of this character, which are designed to support a great part of the weight of the cylinders, they may be constructed of parallel rods or bars, one above the other, having vertical webs between. The outer ends of the piston rods or bars are provided with boxes, which clasp the bearings of the cranks of the crank-axle.

In the operation of an engine thus constructed, as the piston of a cylinder is pushed out, the crank connected with its rod or frame is pushed over until the dead-point is reached at the end of the stroke. Then the injection-port is closed, and the crank being carried on by the momentum and the action of the other cylinders, the exhaust-port is opened, and the steam escapes as the piston is pushed home until the crank passes the opposite dead-point, when the exhaust-port is closed and the injection-port opened. The opening and closing of these ports is effected by the vibration of the cylinders *L*, which produces an oscillating motion of the cylinder-heads on the trunnion-bearings.

Sometimes it may be advisable to counter-balance the cylinders on the trunnion.

In the above description I have illustrated this invention in its application to an ordinary street-car or to a light railway-car. Slight modifications will readily occur to those skilled in the art without departing from the principles of the invention. The sub-motor or under engine can readily be applied to the propulsion of heavy cars on large or steam railways, and to vehicles on smooth roads. Therefore I do not confine myself to the precise construction herein set forth.

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

1. An engine-truck frame, carrying the engine and boiler, having at one end the engineer's cab, and having the rest of its surface level and free for the reception of an independent car-body, substantially as specified.

2. The under truck, carrying the boiler and engine, having a pivotal connection for the car in front, and receiving its weight upon a

traverse track or bearing, substantially as specified.

3. In a truck-frame, a horizontal boiler having at each side a horizontal parallel cylinder-heater, at one end a transverse smoke-box, connecting said boiler and heaters, and at the other end the steam-dome and furnace, substantially as specified.

4. The combination, with the flattened elliptical boiler, to economize space under the car, of the parallel lateral cylinder-heaters, connected thereto, substantially as specified.

5. In a truck-frame, the combination, with a horizontal-tubed boiler, of lateral-tubed heaters connected thereto, transverse smoke-box, and vertical furnace and steam-chamber, substantially as specified.

6. In a car-motor, the combination, with the transverse fixed double-chambered steam-cylinder bearing K, of the oscillating cylinders, having head-bands encircling said bearing, and receiving and discharging steam through the ports in said head-bands, substantially as specified.

7. The combination, in a truck-frame, of the horizontal boiler D E' E' and the oscillating engines, arranged thereunder, substantially as specified.

8. In a truck-frame, the combination of the longitudinal horizontal boiler, and, arranged thereunder, the oscillating engines, the ends of which bear on a fixed cylinder provided with double steam-passages, substantially as specified.

9. In a car-motor consisting of a truck, a boiler arranged therein, and an engine arranged under the boiler, the combination of the piston-cylinders and their transverse bearing, the throttle and reversing and stopping valves, and the closed safety-valve, substantially as specified.

In testimony that I claim the above I have hereunto subscribed my name in the presence of two witnesses.

JOHN D. IMBODEN.

Witnesses:

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