(No Model.) 2 Sheets—Sheet 1.

J. G. LIGHTFORD.

MOTOR FOR STREET CARS.

No. 481,715. Patented Aug. 30, 1892.

Fig. 1.

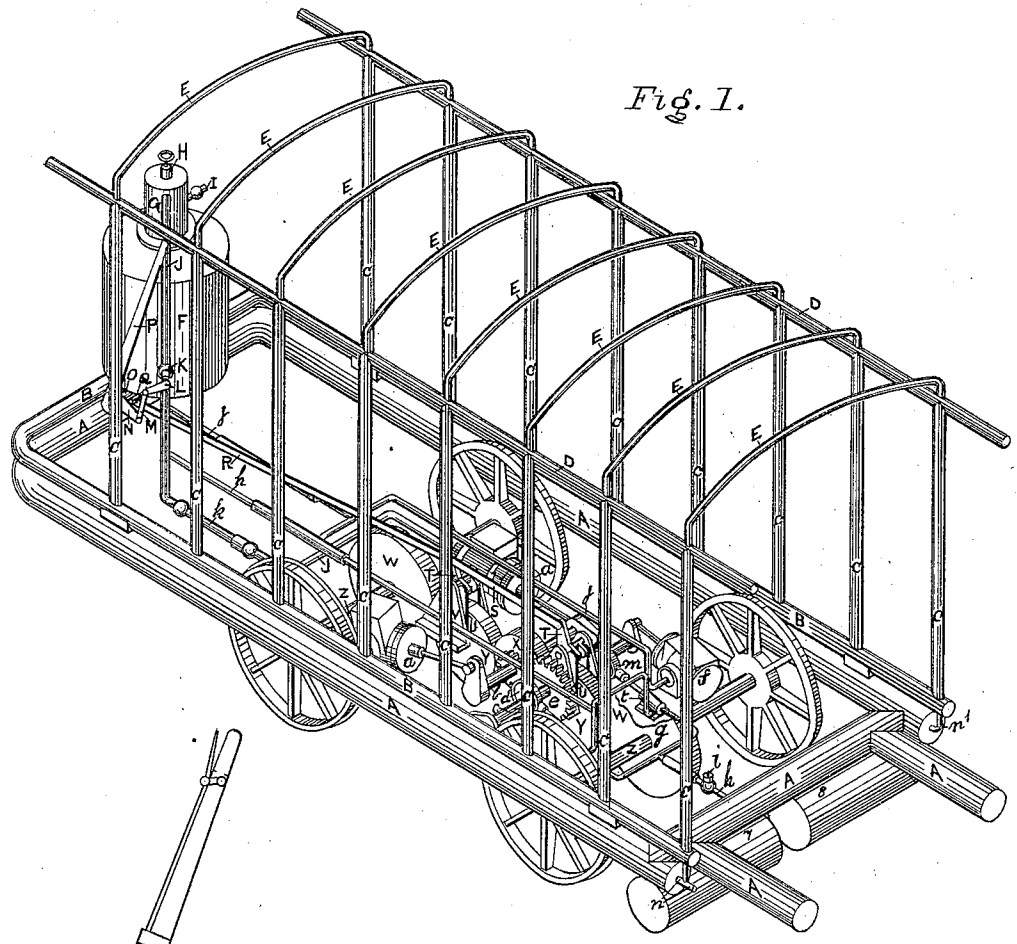
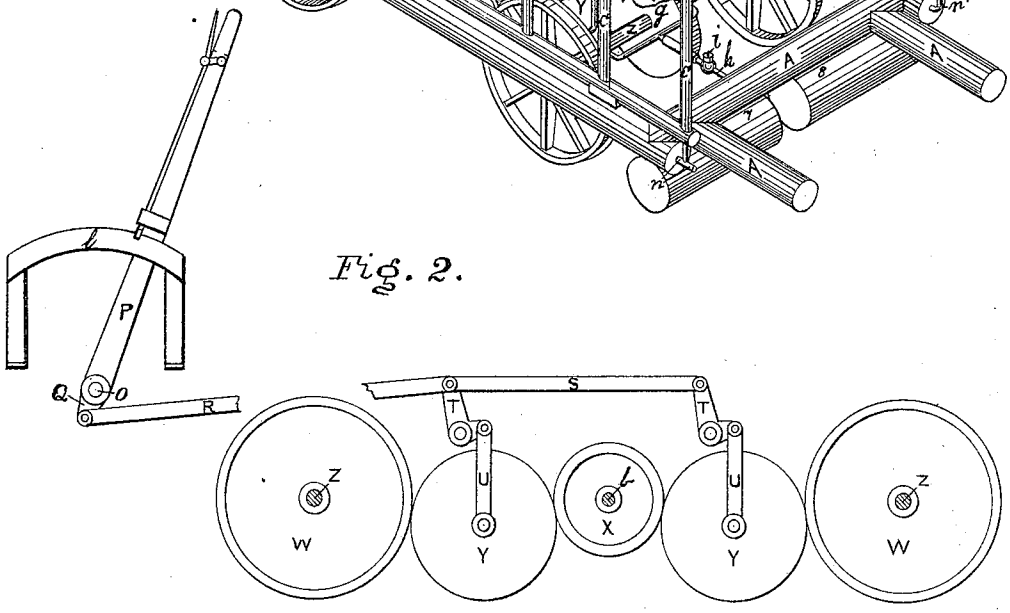


Fig. 2.



Witnesses

H. C. Albrecht

Wm. Lightford.

Inventor

J. G. Lightford.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 2 Sheets—Sheet 2.

J. G. LIGHTFORD.

MOTOR FOR STREET CARS.

No. 481,715. Patented Aug. 30, 1892.

Fig. 5.

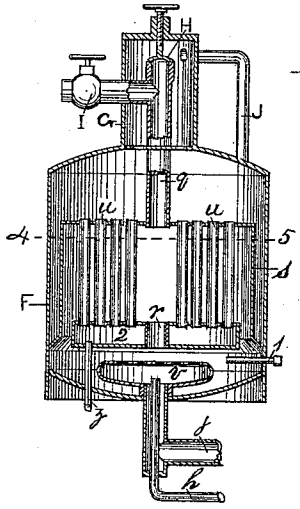


Fig. 6.

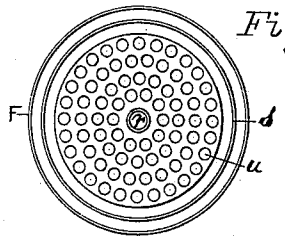


Fig. 3.

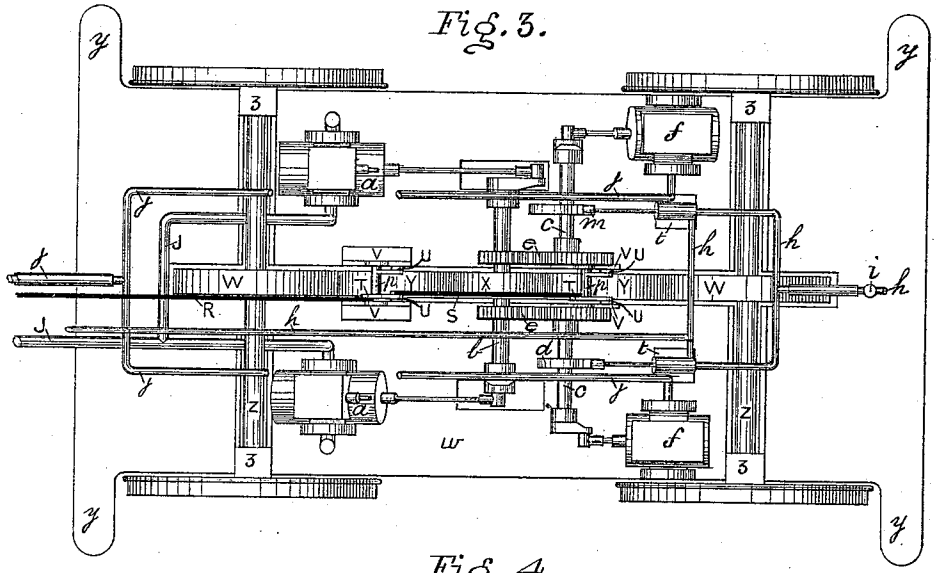
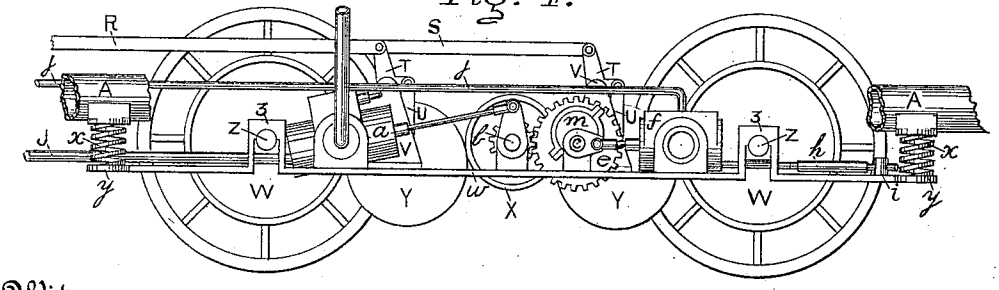


Fig. 4.



Witnesses

G. C. Albrecht

Wm. Lightford.

Inventor

J. G. Lightford.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

JAMES G. LIGHTFORD, OF INDIANAPOLIS, INDIANA.

MOTOR FOR STREET-CARS.

SPECIFICATION forming part of Letters Patent No. 481,715, dated August 30, 1892.

Application filed July 3, 1891. Serial No. 398,404. (No model.)

To all whom it may concern:

Be it known that I, JAMES GORDON LIGHTFORD, a citizen of the United States, residing at Indianapolis, in the county of Marion and State of Indiana, have invented new and useful Improvements in a Combined Steam and Gas Motor for Street-Cars, of which the following is a specification.

My invention relates to that class of motors in which the products of combustion of hydrocarbon gas and the steam generated by the heat produced by such combustion are combined to operate an engine similar to the ordinary steam-engine; and I hereby declare that the following is a full, clear, and exact description thereof, which will enable others skilled in the art to make and use the same.

Knowing the heating-power of the hydrocarbon gas intended to be used in my motor the heating-surface of the boiler is estimated to conduct a definite proportion of that heat to the water to generate steam. The portion of the heat retained in the products of combustion is used to superheat the steam generated in the boiler, thereby increasing its volume, and likewise the volume of the gases, which at their influx to the gas and air-pumps are at the temperature of the surrounding atmosphere. The initial temperature of the compound of gases and steam will be reduced, by its expansion in the working cylinders, to a mean practical working temperature. This temperature is limited by the nature of the material of the cylinders, the piston-packing, and the slide valves. The temperature will be such as to carbonize the ordinary lubricating oils or fats. Therefore metalline is fitted to and used as a self-lubricant in the pistons and slide-valves, thereby avoiding the waste of the heat of expansion by exterior appliances to reduce the temperature. The effective heating-power of the boiler is increased by the augmented temperature of combustion, consequent upon the union of the combustible gases and has been accomplished under high tension, and the extent of heating-surface in the boiler is reduced to correspond with the pressure required in the boiler to propel the car. The shell and tubes of the combustion-chamber can be made of very light material, as the pressure will be equalized on the fire and the water surfaces.

The object of my improvements is to economize fuel, space, and weight of car. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is an isometrical view of the essential parts of the entire machine with the omission of the engine bed-plate. Fig. 2 is a diagram of the transmitting friction-gearing. Fig. 3 is a top view of the working parts of the machinery. Fig. 4 is a side elevation of the same, omitting two of the driving truck-wheels. Fig. 5 is a vertical section of the boiler, and Fig. 6 a horizontal section at the line 4 5.

Similar letters and figures refer to similar parts throughout the several views.

The framework of the car is composed of the sills A A, the distributing-pipes B B, the stanchions C C, &c., the eaves D D, and the roof-rafters E E, &c. These pipes, forming a storage for the gas, are all connected by means of the pipes $n\,n'$ and are charged with gas at a high tension through the pipe n. The pressure of the gas in storage is determined by the distance that the car is required to travel with one charge of gas. The gas to supply the furnace for combustion issues from the storage-pipes by the pipe h, to which is connected a reducing-valve i. The pressure of the gas is thereby reduced to the intended working pressure in the boiler F. The volume of gas to be supplied for combustion is regulated by the gas-pumps $t\,t$, from which it proceeds to the combustion-chamber s by the pipes $h\,h$, &c. The pipes $h\,h$ are fitted at their influx and efflux portions with rubber sections, which will be hereinafter explained. The air required for the combustion of the gas is supplied by the air-pumps $f\,f$, which are of a proper proportionate capacity to supply the exact requisite amount of oxygen for the perfect combustion of the gas. The gas is ignited in the combustion-chamber s at the gas-burner v through the pipe 1 by means of any convenient kindler. The products of combustion impinge upon the under side of the water-bottom 2 of the combustion-chamber s, a portion passing up in the central pipe r and part by the space between the water-bottom 2 and the shell of the combustion-chamber s, thence intermingling with the water-tubes $u\,u$, &c., in the chamber s and passing to the pipe q. The boiler F is supplied

with water sufficient to cover all heating-surfaces in any of the usual ways in general use in steam-boilers. When steam of sufficient tension is generated in the boiler to start the engine in motion, the valve H in the gas-pipe *q* is opened and the products allowed to combine with the steam in the steam-drum G, from whence the combined steam and gas is supplied to the engine by the pipe J. The power to propel the car is transmitted from the engine by means of the friction-wheel X on the engine-shaft *b*, the idler friction-wheels Y Y and the driven friction-wheels W W on the truck-axles Z Z. The idler friction-wheels Y Y are suspended by the links U U U U from the lifter-arms T T on the lifter-shafts *p p*, supported by the lifter-stands V V V V. The lifter-shafts are operated by the bell-crank arms T T, connected by the rods R S with the lever P. The lever P is provided with a spring-catch and works in a segmental guide and catch-plate *b*. The shaft O, attached to the lever P, is provided with an arm Q. This arm is connected with the rod R to transmit the motion of the lever P. On the shaft O is an arm N, connected by the link M with the lever L. The lever L operates the throttle-valve K, placed in the engine supply-pipe J. The engine supply-pipe J is fitted with a ball-and-socket section *k*. The engine is of the twin-cylinder oscillating variety *a a* and differs in no respect from what is in common use, except that the piston-packing and slide-valves are fitted with metalline on the wearing-surfaces in the manner now in general practice. Power to work the gas-pumps *t t* and air-pumps *f f* is transmitted from the engine-shaft *b* by means of the spur gear-wheels *e e* to the pump-shafts *c c*, the gas-pump pistons being operated by the eccentric-wheels *d* and *m*. The air-pumps *f f* are oscillating cylinders with the pistons driven by cranks on the ends of the pump-shafts *c c*. The air is conducted from the air-pumps *f f* to the boiler F by the air-pipes *j j*. These pipes are fitted with a section of rubber-hose pipe between their extension from the engine bed-plate *w* and the boiler F. Projecting from the engine bed-plate *w* are the rider spring-seats *y y y y*, which support the spiral rider-springs X X, upon which the body of the car rides, relieving the truck-axles Z Z and the engine bed-plate *w* from the vibrating motion of the car-body. The object of the ball-and-socket-joint section in the pipe J and the rubber-hose sections in the gas-pipes *h h* and air-pipe *j* is to allow for the vibration of the car-body on which the boiler F rests. The water necessary to supply the boiler is stored in the water-tanks 7 and 8 and is fed to the boiler by means of the pipe *z* entering the boiler at the water bottom 2.

Having described and explained the construction of my street-car motor, I will now proceed to state the mode of operating the same. In the first place the gas required to charge the storage-pipes A, B, C, D, and E will be held in reservoirs under the required tension at convenient stations in the locality where the cars are to do service, and at these stations there will be, also, a means of charging the water-tanks 7 and 8. In charging the storage-pipes with gas there must be a small opening in the most elevated part of the storage-pipes to purge them of air and prevent the compounding of an explosive mixture. When the pipes are charged with gas and the boiler and tanks with water, a supply of air is furnished the combustion-chamber *s* through a branch pipe and valve attached to the air-pipe *j*. (Not shown on the drawings.) The valve H on the top of the pipe *q* is closed and the valve I opened. The gas is then turned on at the reducing-valve *i*, passing through the gas-pump valves to the gas-burner *v*, where it is ignited with a kindler through the ignitor-pipe 1. The products of combustion passes up the pipe *q* and is allowed to escape by the pipe I. When steam of sufficient tension to give motion to the engine is generated in the boiler, the lever P being thrown forward, thereby lowering and relieving the friction-idlers Y Y from contact with the driver and driven friction-wheels X and W W, the engine is then started. The escape-valve I is then closed and the valve H opened, allowing the products of combustion to enter the steam-drum G and combine with the steam and passing to the engine. Motion is transmitted to the air and gas pumps *f f* and *t t* by the gear-wheels *e e* and shafts *c c*, thus supplying the combustion-chamber with the proportionate volumes of gas and air to produce perfect combustion. The tension of the products of combustion in the combustion-chamber *s* will be the same as the combined steam and gas in the drum G. When pressure sufficient to propel the car is generated, the lever P is drawn back, lifting the idler friction-wheels into contact with the friction-wheels X and W W, thereby communicating motion to the truck axles and wheels. In throwing the idlers out of contact in order to stop the car, and consequently relieving the engine from resistance, the efflux from the boiler to the engine is reduced by the throttle-valve K, operated by the arm N on the shaft O, the link M, and the throttle-lever L to insure just a sufficient current of combined gas and air to continue the combustion while the car is temporarily at rest. The velocity of the car is controlled by the usual stop-valve (not shown on the drawings) in the induction-pipe J. Therefore the amount of combustible fuel supplied will correspond with the velocity of the car, and that velocity will be limited only by the laws of frictional resistance inherent in matter.

I disclaim the combination of the products of combustion and steam as a source of potential energy, as I am aware that motors have been in use wherein the combustible gases were generated in the combustion-chamber from the raw material coal; but

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

1. The combination, in a street-car, of the main framework consisting of the sills A A, distributing-pipes B B, stanchions C C, eaves D D, and roof-rafters E E, all being pipes and providing storage for the gas and being connected by pipes *n n'*, all substantially in the manner and for the purpose set forth.

2. In a street-car, the combination of the gas-pumps *t t*, air-pumps *f f*, engine-shaft *b*, spur gear-wheels *e e*, pump-shafts *c c*, having cranked ends that drive the pistons in pumps *f f*, substantially as described.

3. In a street-car motor, the combination of the main framework, all formed of pipes and providing a storage for a gas, the shaft *b*, friction-wheel X, idler friction-wheels Y Y, the driven friction-wheels W W, the truck-axles Z Z, and the lever P, substantially as described.

4. The combination of the main framework consisting of the storage-pipes A, B, C, D, and E, the gas-pumps *t t*, air-pumps *f f*, engine-shaft *b*, spur gear-wheel *e e*, pump-shafts *c c*, friction-wheel X, idler friction-wheels Y Y, driven friction-wheels W W, and truck-axles Z Z, substantially as described.

5. In a street-car motor, the combination of the idler friction-wheels Y Y, the links U U U U, the stands V V V V, shafts *p p*, the arms T T, the rods R S, arm Q, the shaft O, the lever P, and the segmental guide-plate *l*, for the purpose as set forth.

6. In a street-car motor, the combination of the boiler F, the engine-cylinders *a a*, the friction-wheels X, Y Y, and W W, the air-pumps *f f*, gas-pumps *t t*, reducing-valve *i*, and storage-pipes A A, B B, C C, D D, and E E, &c., substantially as described, and for the purpose as set forth.

J. G. LIGHTFORD.

Witnesses:
G. E. ALBRECHT,
WM. LIGHTFORD.