(No Model.)

2 Sheets—Sheet 1.

# J. G. LIGHTFORD.

## COMBINED STEAM AND GAS MOTOR.

No. 515,295. Patented Feb. 20, 1894.

Fig. 1.

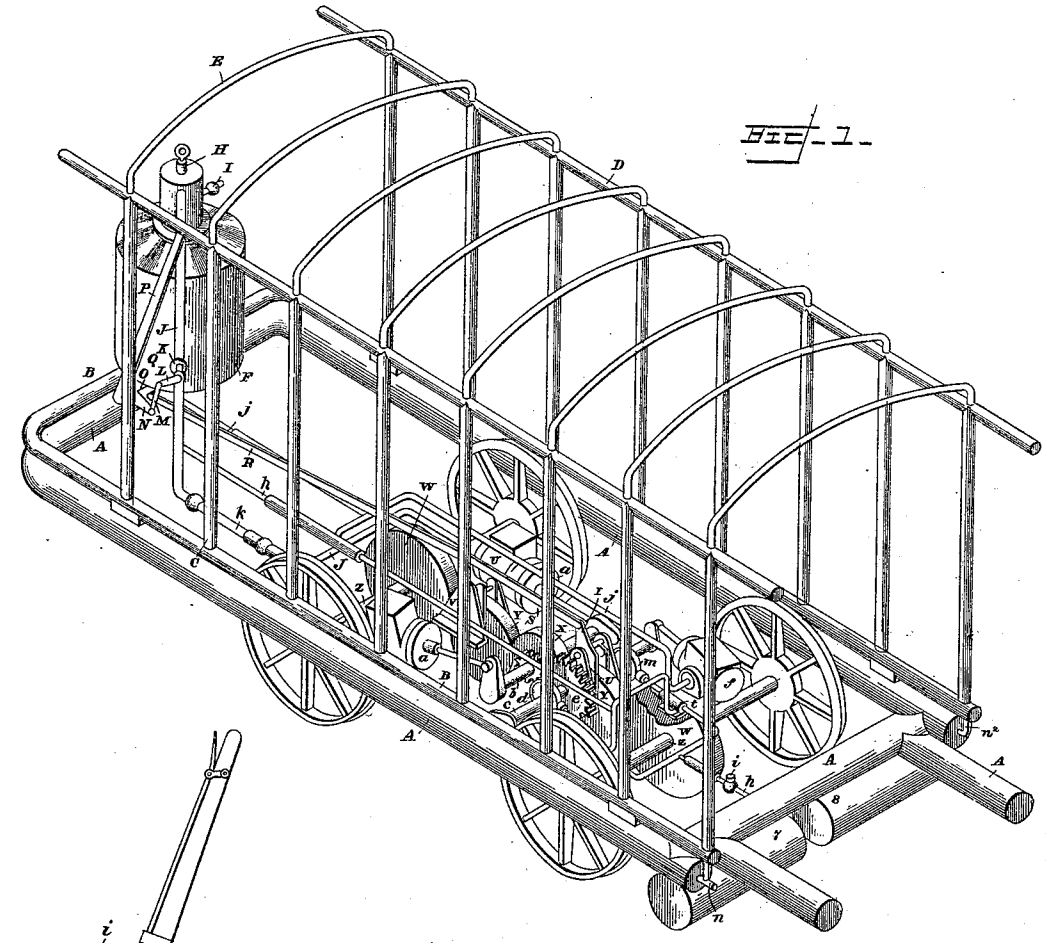
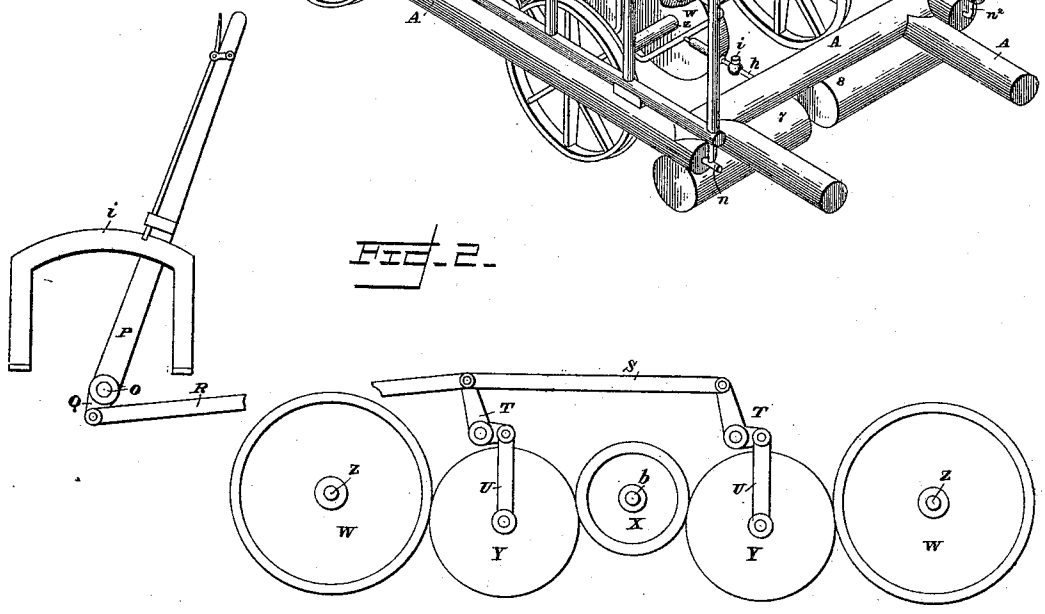


Fig. 2.



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(No Model.) 2 Sheets—Sheet 2.

# J. G. LIGHTFORD.

## COMBINED STEAM AND GAS MOTOR.

No. 515,295. Patented Feb. 20, 1894.

Fig. 5.

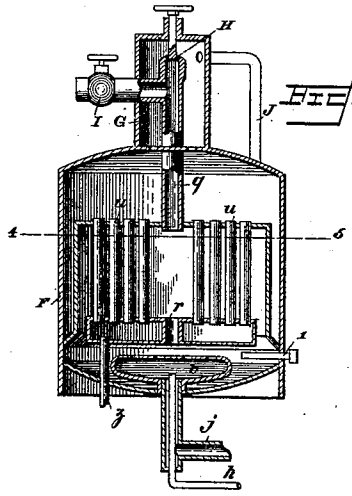


Fig. 6.

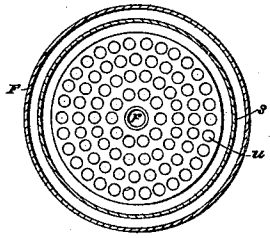


Fig. 3.

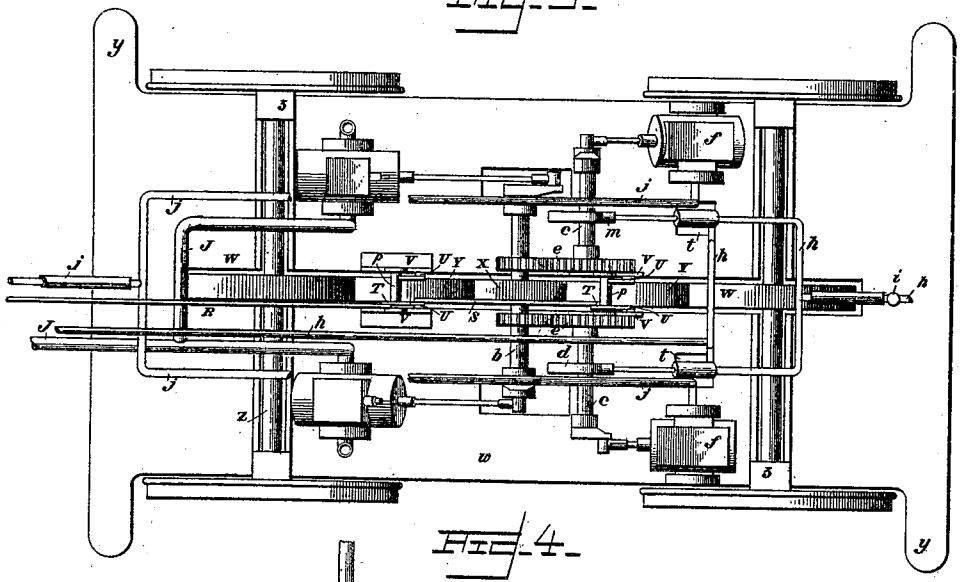
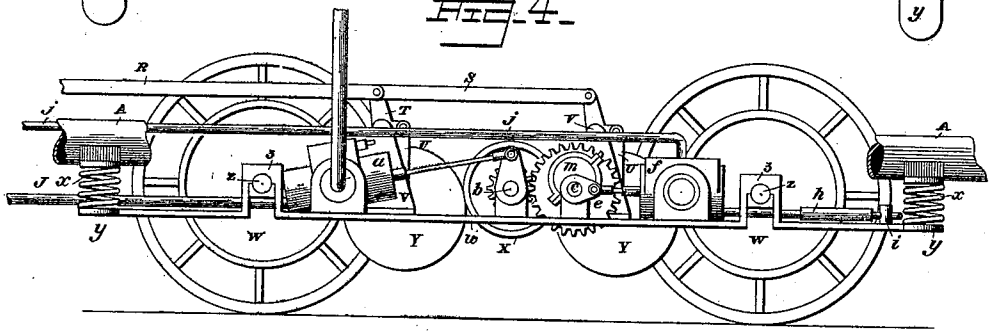


Fig. 4.



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# UNITED STATES PATENT OFFICE.

JAMES G. LIGHTFORD, OF INDIANAPOLIS, INDIANA, ASSIGNOR OF ONE-HALF TO HENRY STACEY, OF SAME PLACE.

## COMBINED STEAM AND GAS MOTOR.

SPECIFICATION forming part of Letters Patent No. 515,295, dated February 20, 1894.

Original application filed July 31, 1891, Serial No. 398,404. Divided and this application filed July 21, 1892. Serial No. 440,735.

(No model.)

*To all whom it may concern:*

Be it known that I, JAMES G. LIGHTFORD, a citizen of the United States, residing at Indianapolis, in the county of Marion and State of Indiana, have invented certain new and useful Improvements in a Combined Gas and Steam Motor; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to that class of motors in which the products of combustion of hydro-carbon gas and the steam generated by the heat produced by such combustion, are combined to operate an engine, similar to the ordinary steam engine.

Knowing the heating power of the hydro carbon 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 super heat the steam generated in the boiler, thereby increasing its volume; 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 cylinder, 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 being 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 invention embraced in the present application constitutes a division of an application formerly filed, on which was granted Patent No. 481,715, for an improvement in motors for street cars, dated August 30, 1892. Said patent covers broadly the construction of the street car, while in the present case, the construction of the motor proper which drives the car, is claimed.

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 perspective 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 comprises, namely, 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, all being 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 chambers 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 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 gas 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. 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 *l*. 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 joint section *k*. The engine is of the twin cylinder *a a* oscillating variety and differs in no respect from what is in common use, except that the piston packings 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 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 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. 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 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 valves 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 igniter pipe 1. The products of combustion pass up the pipe *q* and is allowed to escape by the pipe 1. 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 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 in 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.

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

1. The combination with the storage pipes, having a furnace supply pipe *h* provided with a reducing valve *i*, the boiler F, the water tanks 7 and 8, a combustion chamber S having gas burner *v* and the outlet pipe *q* having valve H, substantially as described.

2. The combination of the boiler F, the air pumps *f f*, the gas pumps *t t*, the combustion chamber S, having gas burner *v*, and water bottom 2, with central pipe *r*, the storage pipes having furnace supply pipes *h*, provided with reducing valves *i*, the water tubes *u u* and gas pipe *q*, with valves H and I, and steam drum G and pipe J, substantially as described.

3. The combination of the water tanks 7 and 8, boiler F, the feed pipe *z* therefor, entering through the water bottom 2, the storage pipes having furnace supply pipe *h*, provided with reducing valve *i*, the combustion chamber S, having gas burner *v*, the air pumps *f f* and gas pumps *t t*, the pipe J and the engine cylinder *a a*, all arranged, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

JAMES G. LIGHTFORD.

Witnesses:
DANIEL M. BRADBURY,
WILLIAM I. RIPLEY.