No. 691,788. Patented Jan. 28, 1902.

R. LUNDELL.

COMBINED AIR AND EXPLOSIVE ENGINE.

(Application filed Mar. 29, 1900.)

(No Model.) 2 Sheets—Sheet 1.

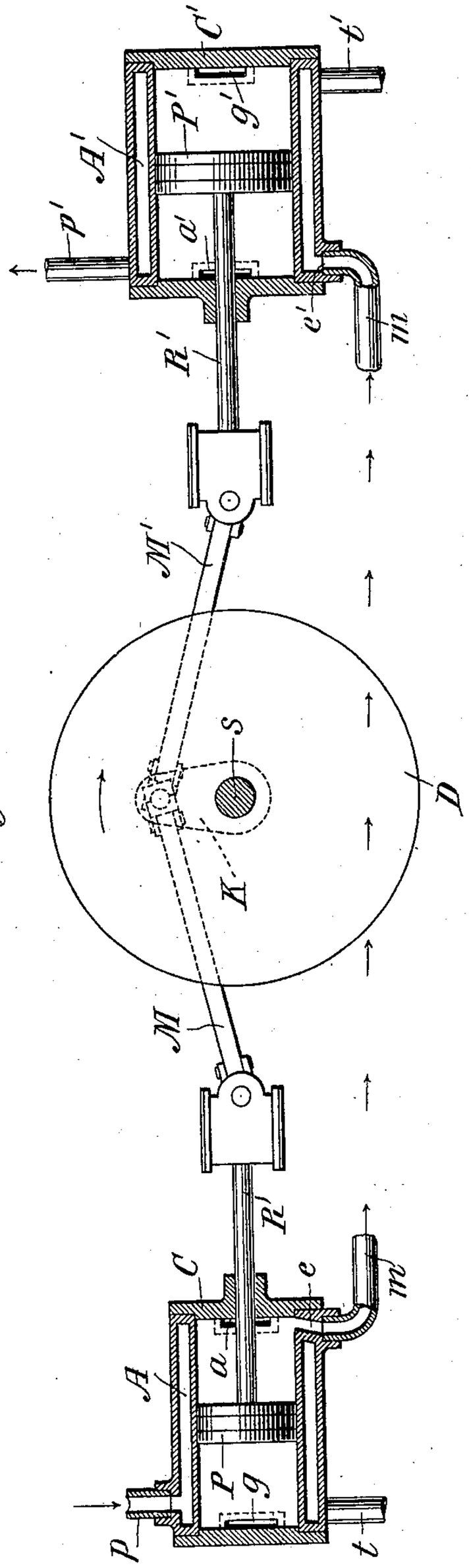

Fig. 1.

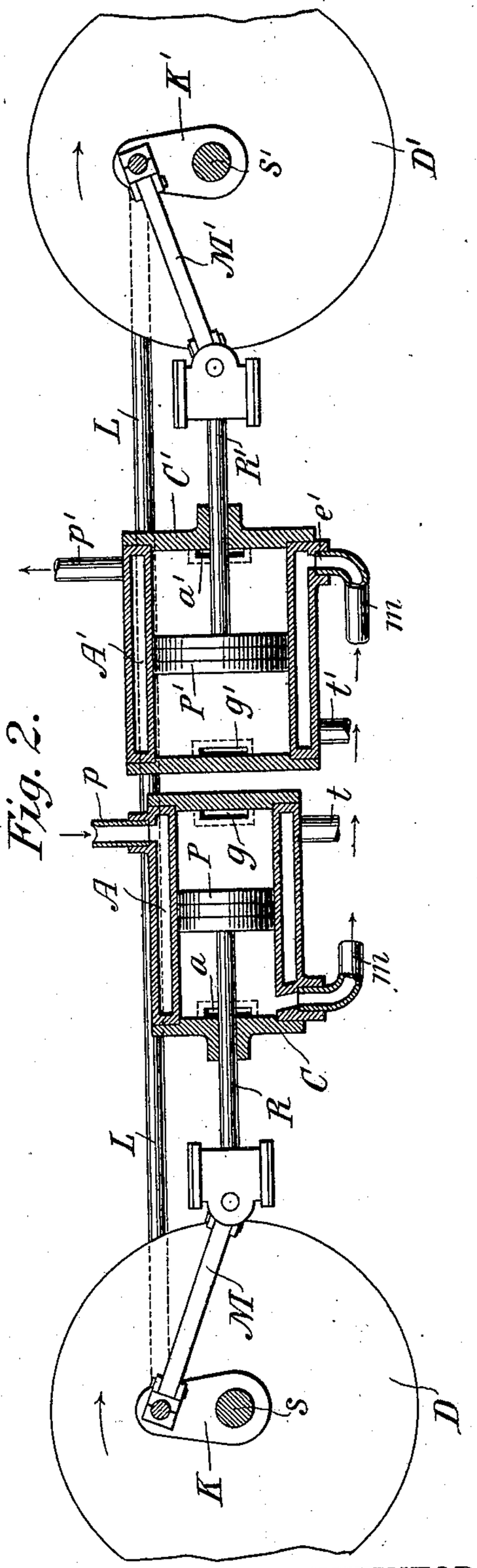

Fig. 2.

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Fig. 3.

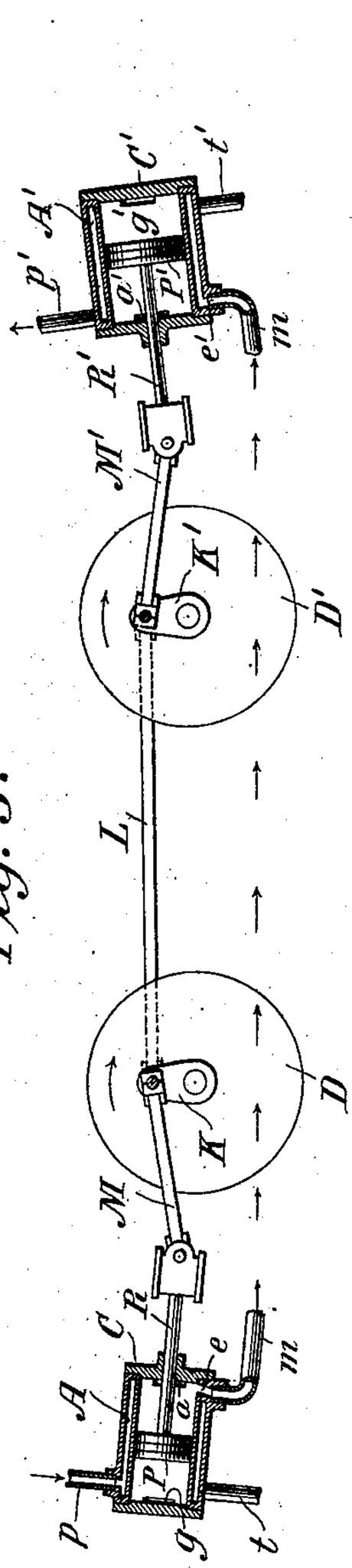
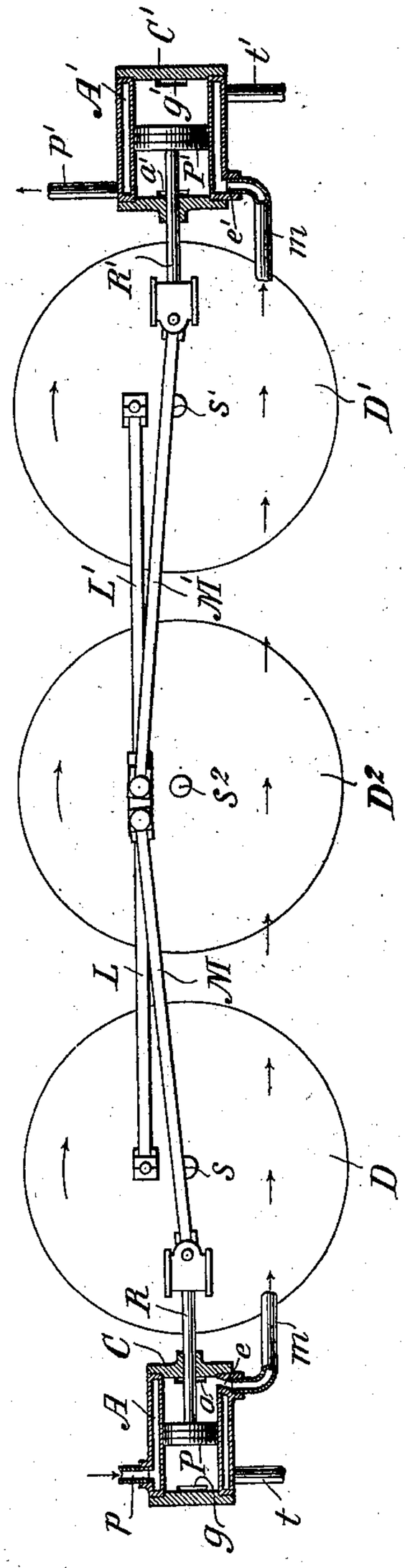


Fig. 4.



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UNITED STATES PATENT OFFICE.

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COMBINED AIR AND EXPLOSIVE ENGINE.

SPECIFICATION forming part of Letters Patent No. 691,788, dated January 28, 1902.

Application filed March 29, 1900. Serial No. 10,634. (No model.)

To all whom it may concern:

Be it known that I, ROBERT LUNDELL, a citizen of the United States, residing at New York, borough of Manhattan, county and State of New York, have made a new and useful Invention in a Combined Air and Explosive Engine, of which the following is a specification.

My invention has for its objects, first, to so combine an ordinary explosive-engine, as a gas-engine, with an engine operated by air or other gases under pressure that it will always be self-starting; second, to so combine two such engines that the heat generated by the explosion of the gas in driving the gas-engine will act expansively upon the air utilized expansively in driving the air-engine, and, third, to so combine two such engines that the heat generated by the gas-engine will act expansively upon the air utilized by the air-engine, and, vice versa, the air utilized by the air-engine will tend to cool the heated parts of the gas-engine.

To these ends my invention consists in the novel combination of engines and operative parts hereinafter described, the essentially novel features of which will be particularly pointed out in the claims at the end of this specification.

For a full and clear understanding of my invention, such as will enable others skilled in the art to construct and use the same, reference is had to the accompanying drawings, in which—

Figure 1 is a part sectional and part side elevational view of a combined air and gas or explosive engine embodying the principles of my invention. Fig. 2 is a similar view illustrating the application of my invention when used in connection with tram or street cars having a long wheel-base. Fig. 3 is a similar view illustrating the application of my invention when used in connection with tram or street cars having a short wheel-base, and Fig. 4 is a similar view illustrating the application of my invention when used in connection with a locomotive having three or more drive-wheels.

My invention contemplates the utilization of two engines combined in one and so arranged and interconnected that the pistons are driven alternately in opposite directions by the combined influence of an explosive gas and a gas or other elastic medium, as air, under pressure, the arrangement being such that during any portion of the stroke of the pistons the explosive agent is acting in one engine and the expansive agent in the other in the same direction, so that the engine is practically self-starting under all conditions of usage. It contemplates, further, the utilization of the heat generated in the explosive part of the engine to act expansively upon the air utilized in that part of the engine which is driven by air under pressure and also the cooling effect of the air used under pressure upon the heated portions of the combined engine. In other words, I propose to utilize effectively the heat which is ordinarily dissipated or wasted in gas or explosive engines and the cold which is ordinarily detrimental in the operation of compressed-air engines in such manner as to increase the efficiency of the combined engines and at the same time avoid the objectionable features ordinarily due to the heating of gas-engines and the cooling of air-engines.

In order that my invention may be fully understood, reference is had to the accompanying drawings in detail and first to Fig. 1, in which C and C′ represent, respectively, high and low pressure cylinders of a combined engine provided one with a piston P and piston-rod R and the other with a piston P′ and piston-rod R′, said piston-rods being connected, respectively, by pitmen M and M′ to the crank K and shaft *s* of the drive wheel or pulley D, as shown. It will be noted that the cylinder C′ and its piston P′ are of larger diameters than are the corresponding parts of the cylinder C and piston P, and this for the reason that the first-named cylinder is what I term a "low-pressure" cylinder. The cylinders C and C′ are both surrounded by air-chambers A and A′, the air-chamber A being connected directly by a pipe *p*, running to the source of compressed air or other gas to be utilized under pressure, while the corresponding air-chamber A′ of the cylinder C′ is connected by a pipe *m*, running to the outlet or exhaust *e* from the high-pressure cylinder C. *t t′* are the inlet-pipes running from

the source of explosive-gas supply, preferably under pressure, to the usual admission-ports $g\,g'$. $a\,a'$ are inlet-ports connecting the air-chambers A and A′ with the interior of the cylinders C and C′, the arrangement of valves, ports, &c., being such as are ordinarily used in connection with gas and air engines and need no description here, it being obvious that their operation for the admission of gas and air to the opposite ends of the cylinders C and C′ would be as is usual in connection with such engines.

The operation of this combined engine is as follows: An explosive gas is admitted through the pipes $t\,t'$ to the ports $g\,g'$ and ultimately to the inner surface of that cylinder C or C′ to which the full or free face of the piston P or P′ is closely approximate at the end of the stroke—say, for instance, in the left-hand end of the cylinder C. At the same time air is admitted from the source of compressed air through the pipe p into the surrounding chamber A of the cylinder C, the previous supply of air admitted thereto under high pressure having been utilized in driving the piston P from right to left, so that the air within the cylinder C is now at relatively low pressure. Consequently this air at low pressure will tend to act through the exhaust e, pipe m, admission-port e', and chamber A′, the admission-valve in the port a' thereby tending to drive the pistons by air-pressure from left to right, so that the drive wheel or pulley D is driven in the direction of the curved arrow. On the completion of the stroke to the right the valves are reversed in the ports of both of the cylinders and the supply of gas which was admitted at the right-hand end of the piston P′ is exploded, thereby tending to drive the piston P′ to the left, and at the same time air is admitted under pressure from the source of high pressure through the chamber A, valve, and port a behind the right-hand end surface of the piston P. It will be apparent that during each rotation of the shaft s of the drive-wheel D there are two explosions of the explosive gas against the full free faces of the pistons P and P′ and also that during each complete stroke there are two air admissions under pressure against the inner faces of the pistons P and P′. As the air is admitted through the pipe p from the source of high pressure into the chamber A it is subjected to the heating influences due to the heat generated in the explosion of the gas entering the cylinder through the port g. In like manner as the air is admitted under low pressure from the port e by the pipe m into the surrounding chamber A′ of the low-pressure cylinder C′ a similar cooling effect is had upon the heated portion of the cylinder and a correspondingly expansive effect upon the air in the chamber A′ before it is admitted through the port a', as already described. It will therefore be apparent that this engine utilizes the heat due to the explosive effect of the explosive gas to expand the air utilized in that portion of the engine driven expansively, while the air in turn by reason of its cooling effect tends to cool the heated portion of the engine.

In Fig. 2 I have illustrated the application of my invention to a tram or street car having a long wheel-base, the cylinders C and C′ being located close together and the arrangement of the cylinders being the reverse of that shown in Fig. 1. In this figure of the drawings the cylinders are located inside of the wheel-base, and the two cranks K and K′ are connected together by a link L.

In Fig. 3 of the drawings I have shown the application of my invention to a tram or street car having a short wheel-base, the cylinders being located outside the wheel-base and on opposite sides of the car-wheels D D′ and the cranks K and K′ connected together by a link L, while in Fig. 4 I have illustrated the application of my invention to a locomotive-engine having three drive-wheels D D′ D^2, the cylinders being located outside of the wheel-base, a common connecting-link L being shown for causing the drive-wheels to be driven together. The structural arrangement of the cylinders and their intermediate connections is substantially alike in all of the figures of the drawings.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. A compound engine having a high-pressure and a low-pressure cylinder and pistons located therein, said cylinders being provided with gas-ports for admitting an explosive gas against the full free faces of the pistons and additional ports for admitting a gas under pressure against the other faces thereof, the cylinders being so interconnected that the gas under pressure as it leaves one of them is admitted at lower pressure as it enters the other, substantially as described.

2. A compound gas and air engine having two cylinders and interconnected pistons therefor, said cylinders being each provided with a surrounding air-chamber for maintaining a free circulation of air around them so as to produce a cooling effect thereon; together with supply pipes and ports for admitting an explosive gas against the full free faces of the pistons and additional ports for admitting air under pressure against the other faces thereof, a connecting-pipe being located between the cylinders for exhausting the air from one cylinder and admitting it to the other, substantially as described.

3. A compound engine having a high and a low pressure cylinder and a piston located in each, said cylinders being each provided with a gas-port for admitting an explosive gas against the full free face of each piston and each provided also with an additional port for admitting a gas under pressure against the opposite face of each piston; in combination with pipes, valves and connections adapted to be operatively connected with a source

of gas-supply, both of said pistons being operatively connected to a common driving-shaft and the arrangement such that gas under pressure, as it leaves one of the cylinders, is admitted at a lower pressure as it enters the other, substantially as described.

4. A compound engine having a high and a low pressure cylinder, the latter being of greater diameter than the former and a piston located in each, said pistons being operatively connected with a common driving-shaft; in combination with an air-chamber surrounding each cylinder, said air-chambers and cylinders being so interconnected that an explosive gas is adapted to act alternately upon the free faces of the pistons, and air under pressure from a direct source of supply upon the other face of the smaller piston, the exhaust-air from the smaller cylinder being adapted to act upon the opposite face of the low-pressure piston, the arrangement being such that the explosive effect of the gases tends to expand the air acting under pressure, and, on the contrary, the cooling effect of the air tends to reduce the temperature set up by the successive explosions, substantially as described.

In testimony whereof I have hereunto subscribed my name this 10th day of March, 1900.

ROBERT LUNDELL.

Witnesses:
C. J. KINTNER,
M. F. KEATING.