(No Model.) 4 Sheets—Sheet 1.

J. S. CONNELLY.

GAS MOTOR.

No. 457,459. Patented Aug. 11, 1891.

Fig. 1.

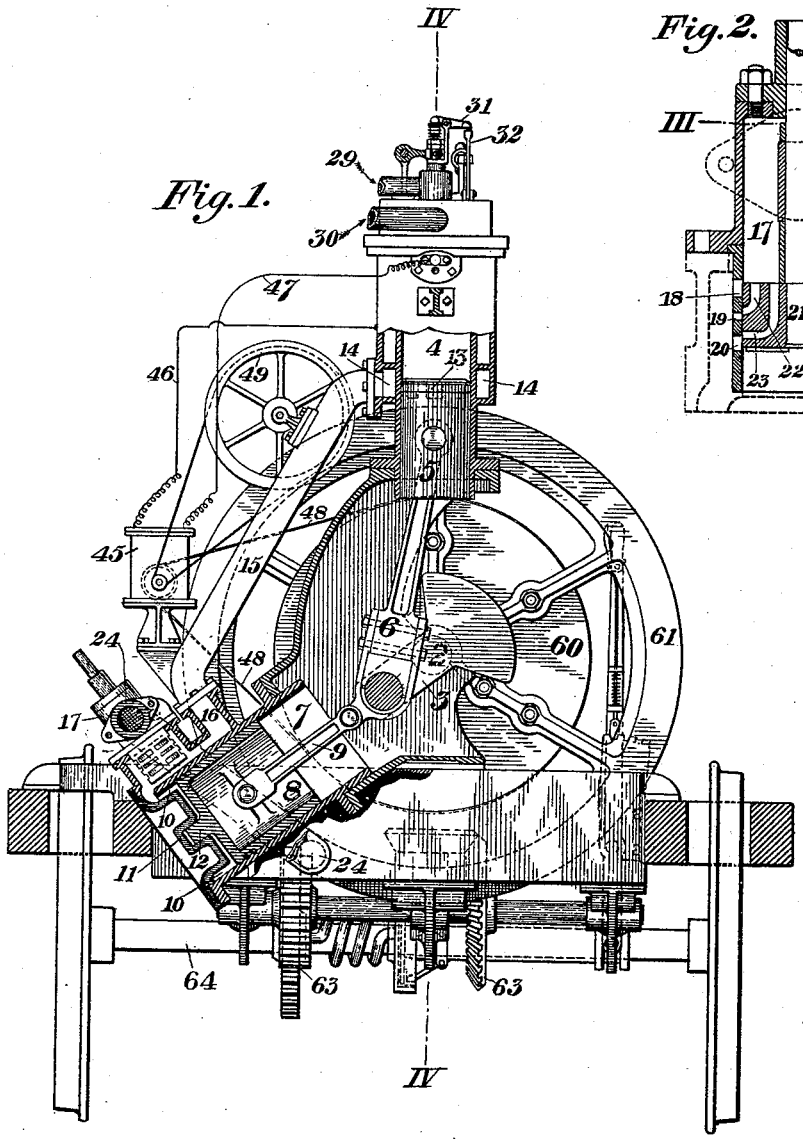


Fig. 2.

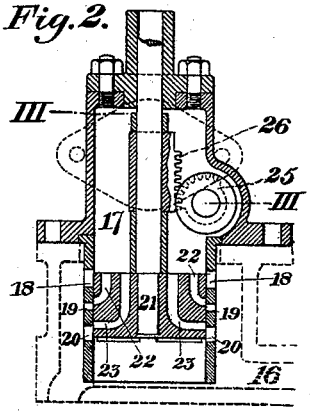
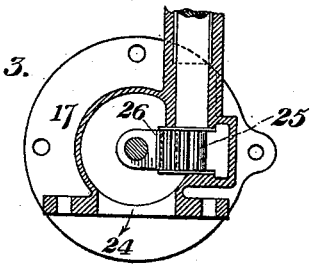


Fig. 3.



WITNESSES

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J. S. CONNELLY.

GAS MOTOR.

No. 457,459. Patented Aug. 11, 1891.

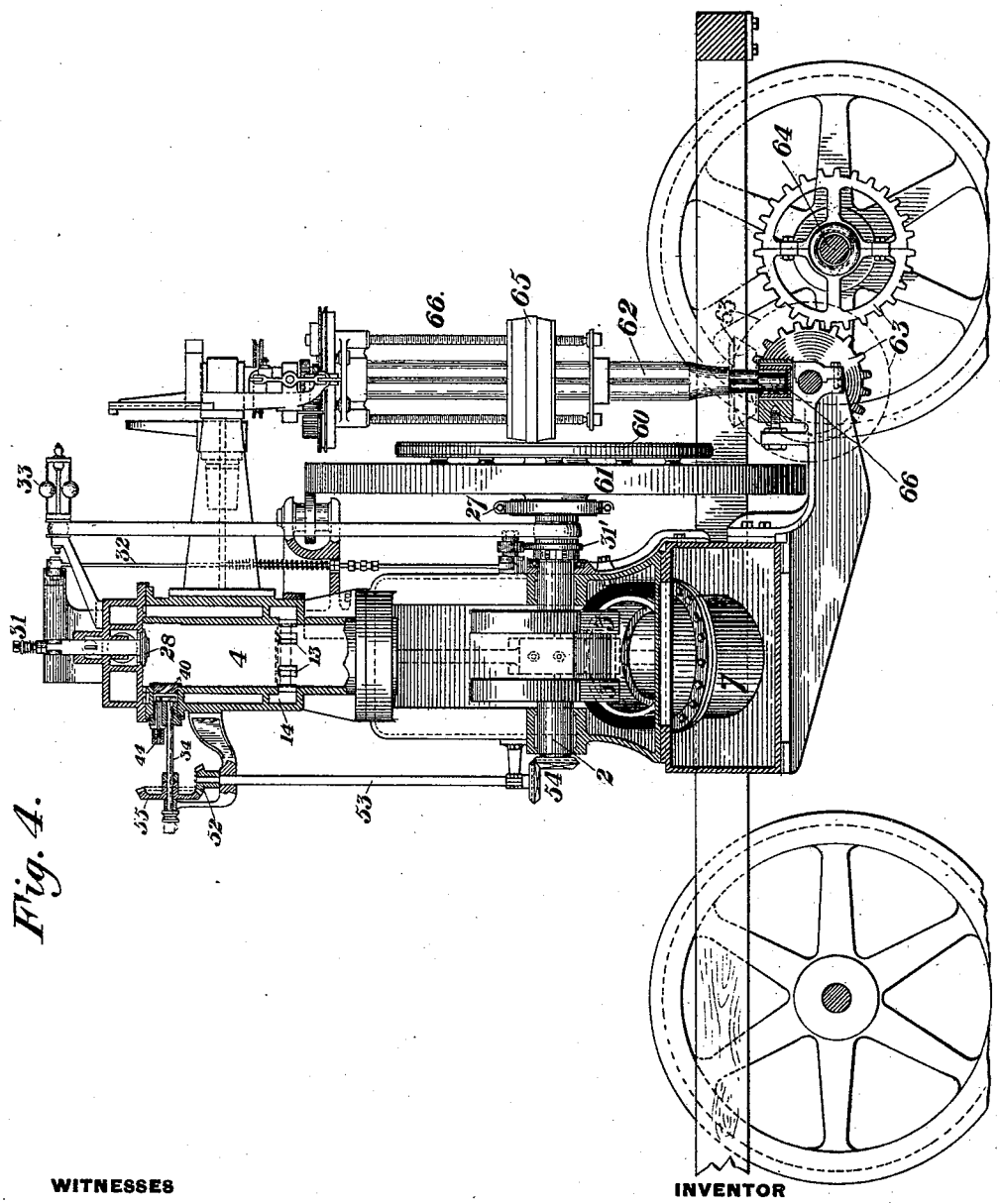

Fig. 4.

WITNESSES

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(No Model.)

4 Sheets—Sheet 3.

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GAS MOTOR.

No. 457,459. Patented Aug. 11, 1891.

Fig. 5.

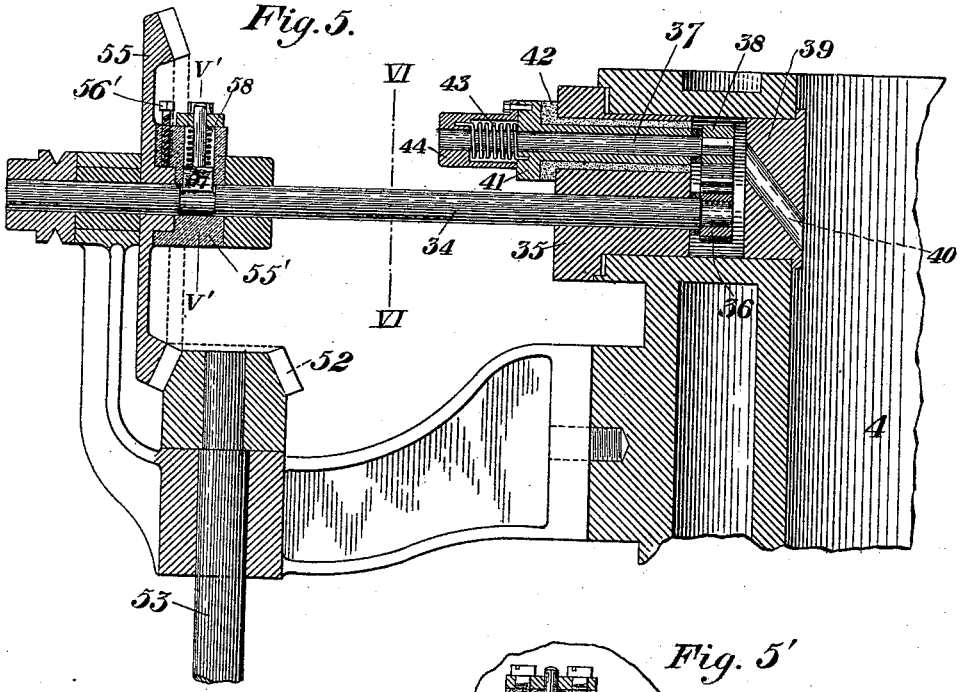


Fig. 5'

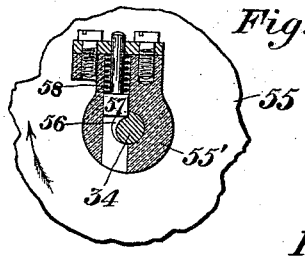


Fig. 6.

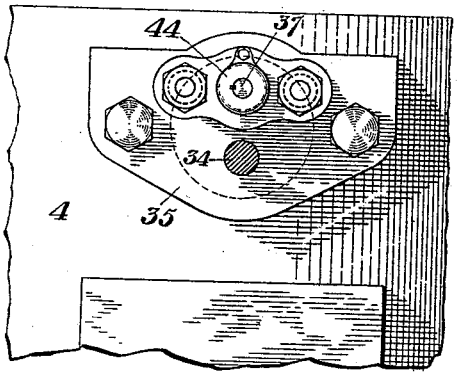
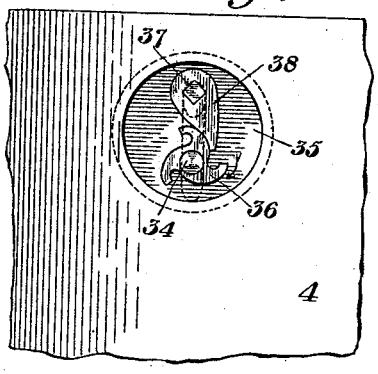


Fig. 7.



WITNESSES

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(No Model.) 4 Sheets—Sheet 4.

J. S. CONNELLY.

GAS MOTOR.

No. 457,459. Patented Aug. 11, 1891.

Fig. 9.

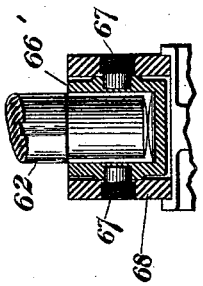
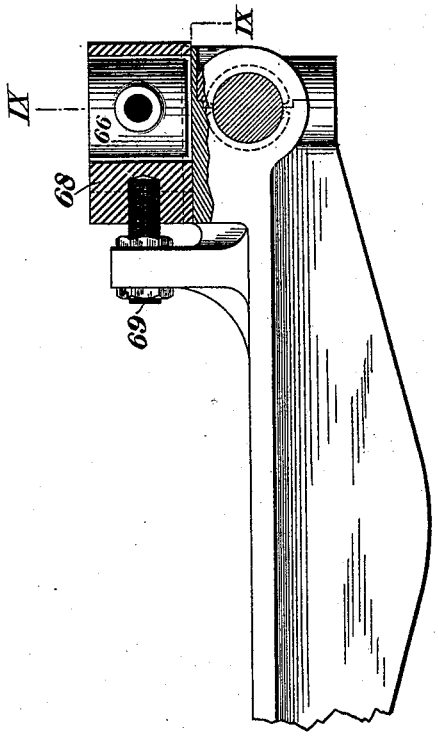


Fig. 8.



WITNESSES

H. L. Gill

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his Attorneys.

UNITED STATES PATENT OFFICE.

JOHN S. CONNELLY, OF PLAINFIELD, NEW JERSEY.

GAS-MOTOR.

SPECIFICATION forming part of Letters Patent No. 457,459, dated August 11, 1891.

Application filed November 10, 1890. Serial No. 370,892. (No model.)

To all whom it may concern:

Be it known that I, JOHN S. CONNELLY, of Plainfield, in the county of Union and State of New Jersey, have invented a new and useful Improvement in Gas-Motors, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a sectional side elevation of my improved gas-engine, the section being on a vertical plane through the primary and secondary cylinders. Fig. 2 is a vertical section on the line II II of Fig. 1. Fig. 3 is a horizontal cross-section on the line III III of Fig. 2. Fig. 4 is a vertical section on the line IV IV of Fig. 1. Fig. 5 is an enlarged vertical section of the igniting mechanism. Fig. 5′ is a vertical cross-section on the line V′ V′ of Fig. 5. Fig. 6 is a sectional elevation on the line VI VI of Fig. 5. Fig. 7 is an elevation of the terminals of the igniting mechanism. Fig. 8 is an enlarged vertical sectional view of the bearing of the transmitting-shaft, and Fig. 9 is a vertical section on the line IX IX of Fig. 8.

Like symbols of reference indicate like parts in each.

The gas-engine which I have illustrated in the drawings is a compound engine—that is to say, it has two cylinders whose pistons are connected with the same shaft, a primary cylinder in which the charge of gas and air is first exploded, and a secondary cylinder into which the exploded charge escapes after it has exerted propulsive force on the piston of the primary cylinder. Such construction is of advantage in gas-engines because it utilizes much better than does a single-cylinder engine the full energy of the charge. In the use of compound engines, however, the action of the secondary cylinder and piston is noisy, so much so as to unfit the engines for use for many purposes. The reason for this I have found to be as follows: It is impossible to make the connection between the piston and piston-rod of the secondary cylinder and between the piston-rod and crank so exact that there shall be no loose motion of the parts, and when the piston is being started on its outstroke by revolution of the main shaft the joints of the parts are separated to the fullest extent. It has been the practice heretofore not to admit the charge into the secondary cylinder until after the piston has thus commenced its outstroke, and the effect of the sudden force exerted on the piston by the entrance of the gases is to force the parts quickly together with a jarring and disagreeable noise.

One object of my invention is to obviate this difficulty, and I accomplish it by so relating the positions of the cylinders with reference to their crank or cranks and the location of the exhaust-port of the primary cylinder that the exhaust from the primary cylinder into the secondary cylinder shall occur just as the secondary piston is at the end of its instroke and before the parts have been separated or loosened by the draft of the crank on the piston. The propelling charge then, on entering the secondary cylinder, finds the joints of the parts all closed together by the pushing of the crank on the piston, and therefore operates without any jar. As a useful auxiliary to this part of my invention, I prefer to employ a cushioning device at the inner end of the secondary cylinder, which, as the piston reaches the end of its stroke, insures the closing together of the joints and holds them together until the charge has acted on the piston with its outward propulsion. The parts of my invention above indicated are of use even when the engine is so used (by enlargement of the opening of the exhaust-valve at the moment of the escape of the gases from the primary cylinder) that no effective power is transmitted to the secondary cylinder, which is used only for the indraft of the next explosive charge. In such case the escape of the gases from the primary cylinder produces a blow on the piston of the secondary cylinder, which, though not sufficient to act appreciably to propel it, is enough to make the disagreeable noise above referred to if my improvements were not employed.

Another feature of my invention relates to the exhaust-valve through which the exploded gases are discharged from the cylinders. Heretofore it has been the practice to employ an exhaust-valve communicating with the primary and secondary cylinders and operated mechanically, so that it shall be closed

at the time when the discharge from the primary cylinder to the secondary cylinder occurs, and that it shall be open during the back-stroke of the secondary piston. The purpose of this is to cause the total remaining energy of the gases to be exerted on the secondary piston and to prevent them from escaping uselessly into the air. This would answer well enough if there were an explosion at every outstroke of the primary piston; but it is the general practice in operating gas-engines to employ a governor so constructed and geared with the valve which admits the gas from the explosive charge that when the engine runs above its normal speed the valve shall be closed temporarily. The primary piston may thus make two or three successive strokes without explosions, and in such case, if no special device be employed to prevent it, the secondary piston must of necessity on its outstroke create a vacuum which would seriously retard the motion of the engine. To prevent this it has been common to employ a snifting-valve located at the rear of the secondary cylinder and adapted to open when a partial vacuum is produced by the cause above mentioned. There are, however, serious objections to the use of a snifting-valve. If it is made to open easily, there is danger that it will open when suction is created in the cylinders by the normal action of the piston at the end of its stroke in drawing in the explosive charge of gas and air, and this of course would interfere with the indraft of the charge. If it is made difficult to open, so as to overcome the danger last indicated, it is at the serious loss of power of the engine, which on idle strokes must part with considerable energy in overcoming the suction which must occur before the valve opens. Besides this, snifting-valves in any case are objectionable, because it is practically impossible to provide efficient and noiseless means for closing them with sufficient rapidity. These matters, which are of great consequence in gas-engines, I provide for by employing an exhaust-valve which is open in the first part of the outstroke of the secondary piston, preferably, however, open but for a small area during the discharge of the gases from the primary cylinder. Of course by this construction a little power is lost by reason of the partial escape of the exploded gases while still under tension; but this is much more than overbalanced by the great saving of power which arises from the prevention of the difficulties incident to snifting-valves, as above mentioned.

Other parts of my invention will be indicated and explained in the course of the following description:

In the drawings, 2 represents the main shaft of the engine, having a crank 3. 4 is the primary cylinder having a piston 5 connected with the crank by a connecting-rod 6, and 7 is the secondary cylinder whose piston 8 is connected with the crank by a rod 9. The secondary cylinder is constructed so that at the end of the instroke of the secondary piston it shall nearly touch the head, and for this purpose there is preferably an annular space 10 at the end of the cylinder with which the passage from the primary cylinder communicates. There is also a cylindrical chamber 11 formed in said cylinder-head, into which a cylindrical projection 12 at the end of the piston is adapted to enter for the purpose of creating an air-cushion, as hereinafter explained. The primary cylinder is provided preferably near its outer end with a peripheral series of exhaust-ports 13, opening into an annular chamber 14, which by a pipe 15 communicates with a chamber 16, situate at the secondary cylinder and opening into the passage 10. The exhaust-valve is situate in the chamber 16, and is preferably constructed as shown in Figs. 1, 2, and 3. The valve-chamber 17 extends into the chamber 16, and is provided with ports 18, 19, and 20. A piston-valve 21 reciprocates in the chamber 17, and is provided with ports 22 and and 23, which extend to the upper end of the valve. The exhaust-pipe 24 leads from the chamber 17 above the limit of stroke of the piston-valve. The valve is reciprocated by suitable mechanism, which may consist of an oscillatory pinion 25 in gear with a toothed rack 26, forming part of the valve-stem, which pinion may be driven by suitable mechanism from an eccentric 27 on the main shaft. In Fig. 2 the valve is shown when just at the point of beginning its downstroke. In such stroke the ports 18 will soon be uncovered and the ports 19 and 20 put into communication with the piston-ports 22 and 23, so as to put the chamber 16 into communication through a restricted opening with the exhaust-pipe, and during the remainder of the downstroke and until nearly the conclusion of the upstroke of the valve such communication is maintained constantly. Practically the exhaust-valve is closed during one-eighth of the time and is open during the remainder, the moment of closing being near the end of the outstroke of the secondary piston, when the necessary suction is to be created to draw the next explosive charge. The reason for employing several series of ports in the valve-chamber 17 is that the closing of the valve may be effected with proper rapidity. It is possible, though with some disadvantage, to employ but one such port or series of ports.

28 is the admission-valve for the gas and air, which are drawn through pipes 29 and 30 to constitute the explosive charge in the primary cylinder. This valve is operated by mechanism 31, moved by an eccentric 31′ and rod 32. It is unnecessary to describe in detail the construction and precise operation of this valve, since it does not form part of my present invention, and it will be well understood by those skilled in the art. Suffice it to say that the valve is operated so that it shall open just before the secondary piston reaches the end of its outstroke and while the

exhaust-valve is closed, so that said piston shall serve to draw in the gaseous charge.

33 is the governor, by which the valve is controlled, as above stated.

By referring to Fig. 1 it will be seen that the secondary cylinder is set at an oblique angle to the line of the primary cylinder, so that when the ports 13 begin to be uncovered by passage of the primary piston the secondary piston has reached the end of its instroke. This end may be attained otherwise—*e. g.*, by connecting the pistons with separate cranks set at proper angle to each other—but it is desirable to set the cylinders at an oblique angle, since this enables me to obtain the result above specified with a single crank, and consequently with less expense and complication of parts than otherwise.

As thus constructed, the operation of the engine is as follows: Suppose the parts to be in the position shown in Fig. 1, the secondary piston being on the turning-point at the end of its instroke, the primary piston being about to uncover the ports 13, and the exhaust-valve being partially open. As the primary piston continues its downstroke, the ports 13 are uncovered and the exploded gases from the primary cylinder, still under considerable tension, rush through the pipe 15 and enter the secondary cylinder, imparting to its piston an outward propulsion. As the space back of the secondary piston is small, but little of the energy of the gas is wasted in idle expansion at that place, and as the piston is just passing the dead-center and has a slow motion the gases act on it at the best possible moment of time. Some of the gases escape through the open exhaust-port, but the amount is inconsiderable as compared with the other advantages above indicated as resulting from the open exhaust. When the secondary piston nears the end of its stroke, at which time the gases have lost their expansive force, the exhaust-valve is closed quickly, and as the primary piston has not then returned far enough to cover the ports 13 the resulting vacuum draws in from the pipes 29 and 30 the gas and air which are suffered to enter by reason of the opening of the valve 28 at that moment. During the remainder of the back-stroke of the primary piston it compresses the charge of gas and air, and at the conclusion of its back-stroke the igniting device (hereinafter to be described) ignites the charge and again propels the piston. On the beginning of the back-stroke of the secondary piston the exhaust-valve is opened, so that as the piston is retracted it expels the spent gases before it. During such back-stroke as the parts are pushed by the crank their joints are held well together, and at the conclusion of the stroke the entrance of the projection 12 into the cylindrical cavity 11 creates an air-cushion, which further closes the joints and holds them closed until the gases enter again from the primary cylinder. These gases, finding the parts pressed firmly together, operate on the piston without the usual jarring noise mentioned above. If the speed of the engine should increase, so that by operation of the governor the primary piston should make a stroke or several strokes without explosion, it is obvious that this will not interfere with the motion of the secondary cylinder by creating back pressure or suction thereon, since the exhaust-valve is open during the outstroke of the piston and will admit air freely to the cylinder, thus serving the function of the snifting-valve.

I shall now proceed to describe the other parts of my invention.

In Figs. 5, 6, and 7 I show in detail the electrical mechanism for igniting the explosive charge in the primary cylinder.

34 is a shaft which extends through a plug 35 set in the side of the primary cylinder, and at its inner end is fitted with a wheel 36. 37 is a rod which also extends through the plug 35, and has at its inner end a pawl 38, which bears against the periphery of the wheel 36. This wheel has teeth formed, as shown, with curved outer edges and abrupt ends, and the pawl has its edge curved so as to be adapted to fit against the peripheries of the teeth. When the wheel is rotated in the direction of the arrow, as hereinafter described, the pawl will bear against the side of a tooth until the end of the tooth comes to the end of the pawl, whereupon the pawl, urged by suitable spring-pressure, will suddenly move inwardly upon the next tooth. The pawl and wheel form the terminals of an electric circuit, and at the moment of separation of the pawl from the tooth an electric spark is produced, which ignites the explosive charge in the cylinder. The advantage of this construction of the pawl and wheel is that all the wear by friction occurs at the periphery of the wheel and not at the ends of the teeth, and such wear will not disturb the adjustment of the parts nor change the moment when the spark occurs. In advance of the pawl and wheel is a plug 39, having an oblong downwardly-inclined slot 40, which affords communication with the interior of the engine-cylinder, and by reason of its inclination prevents the oil from the cylinder from getting access to the pawl and wheel and spoiling their electrical action. The shaft 37 is preferably set in a bushing 41, surrounded by a lining 42 of insulating material. At its outer end it is provided with a spring 43, whose tension is regulable by means of a set-nut 44. The dynamo 45, by which the electric current is generated, is shown in Fig. 1. The dynamo is driven by a belt 48 from one of the moving parts of the motor, and its conductors 46 and 47 are in electrical connection with the pawl and wheel of the igniting apparatus.

49 is a hand-wheel connected with the dynamo and adapted to operate the dynamo for generation of the electric current when the engine is first started.

I shall now describe the means which I em-

ploy for driving the shaft 34. To rotate this shaft I connect it with a gear-wheel 52 on a shaft 53, which is driven by gearing 54 from the engine-shaft by means of a pinion 55, which is set on the igniting-shaft, and is so connected therewith that it shall transmit motion to the latter shaft when the engine is running forward, but not when it is reversed. This is effected by the device shown in Figs. 5 and 5′.

55′ is a wheel set against the hub of the pinion 55 and having a flange which encircles said hub, and is adapted to be fixed thereto by a set-screw 56′. Inside the hub of the wheel 55′ the shaft is provided with a peripheral notch or groove 56, tapering in depth and terminating in a shoulder, the depth of the groove increasing in the direction of motion of the pinion produced by forward motion of the engine.

57 is a spring-actuated pawl or dog set in a hole in the hub of the wheel 55′ and pressed by its spring 58 into contact with the periphery of the shaft. So long as the pinion is fixed to the wheel 55′ and rotates in the direction of the arrow shown in Fig. 5′ the engagement of the pawl with the shoulder at the end of the groove will transmit rotary motion to the igniting-shaft; but if the engine should be reversed the pinion would revolve in the opposite direction to that above described, and as the pawl cannot then catch on said shoulder no rotation will be transmitted to the igniting-shaft. The means used to permit rotation of the igniting-shaft in one direction only is important, because it prevents injury to the ignitor, which would otherwise occur in case, through any cause, the motion of the engine should be reversed.

In the operation of the engine it is necessary that the spark should be made after the admission and compression of the charge and at the beginning of the outstroke of the primary piston when the engine-crank is at its up center. The parts should be adjusted so that the time of this ignition should occur very accurately, and it is for this purpose that I employ the wheel 55′ detachably fixed to the pinion.

To set the ignitor-shaft so that the explosion shall occur at the proper moment, I place the engine-crank on its up center, then loosen the set-screw 56 and turn the wheel 55′ (turning with it the shaft 34 within the pinion 55) until the ignitor-pawl 38 drops on one of the teeth of the wheel 36. I then tighten the set-screw 56′ so as to connect the wheel 55′ and the pinion, and thenceforth the spark will be produced exactly at the same point in the cycle of action of the engine.

It will be understood that it is possible to get the benefit of part of my invention by making the wheel 55′ and the pinion of one integral piece, and I intend to cover such construction in the claims. In this case the advantage of preventing reverse motion of the ignitor-shaft would be secured without securing adjustability of the igniting mechanism.

I shall now describe the means which I employ for transmitting the motion of the engine, for example, to the action of a tram-car or other driven mechanism.

60 is a disk fixed to the face of the engine fly-wheel 61, and 62 is a shaft which is connected by gearing 63 with the car-axle 64. 65 is a second disk set on the shaft 62, and adapted to bear against the face of the disk 60 and to be driven thereby. The disk 65, by means of screw mechanism 66, unnecessary to be described and illustrated in detail, is adapted to be moved toward and from the center of the disk 60 to vary the speed of the transmitted motion, and in order that the driving-gear may operate properly it is desirable to arrange the parts so that the disk 65 may be pressed with greater or less force against the face of the disk 60, accordingly as it is nearer to or more remote from the center. This is described and claimed in a prior patent, No. 426,985, granted to me on April 29, 1890. For this purpose I set the shaft 62 in a pivotally-arranged bearing or step at its lower end, so that the shaft may be moved to and from the face of the disk 60. Said bearing is shown in Figs. 4, 8, and 9. The step 66 is a cup-shaped piece of metal pivotally connected at opposite sides by trunnions or pivots 67 to a block 68, which is supported between flanges on the engine-frame and is adjustable by means of a set-bolt 69. The shaft may thus be moved laterally on the axis of the trunnions by mechanism which need not be described herein, and by means of the set-bolt lateral adjustment of the bearings also may be had. The end of the shaft and the base of the step 66 are preferably made convex to reduce the bearing-surface to the smallest possible area.

In the drawings I show my improved engine applied to the operation of a car used for street-railway purposes, to which end the apparatus is very well adapted. It should be understood, however, that the invention is not limited to such use, since the engine may be employed with advantage as a stationary engine. The parts of the engine may be varied also in form, details, and general arrangement without departing from the scope of the invention as stated in the following claims.

I claim—

1. The combination, with the explosion-chamber, of a rotatory igniting-shaft, gearing connecting the same with the driven parts of the engine, and an intermediate ratchet-and-detent connection, whereby motion of the igniting-shaft in one direction only is possible, substantially as and for the purposes described.

2. The combination, with the explosion-chamber, of a rotatory wheel having a tooth with curved periphery and abruptly termi-

nating end, and a pawl whose side is shaped to fit against the periphery of the wheel, said wheel and pawl forming the terminals of electric circuit, substantially as and for the purposes described.

3. The combination, with the explosion-chamber of a gas-engine cylinder, of electric igniting-terminals, and a plug having an inclined slot separating the terminals from the cylinder, substantially as and for the purposes described.

4. In a gas-engine, the combination of the primary cylinder and the secondary cylinder, the pistons of which are connected with a common crank and the said cylinders being set with their axial lines at an oblique angle to each other, and a passage connecting the cylinders, said parts being so related in position that the discharge shall occur when the piston of the secondary cylinder is at the end of its instroke and before it begins its outstroke, substantially as and for the purposes described.

5. In a gas-engine, the combination of the primary cylinder and the secondary cylinder, a passage connecting them and adapted to discharge the partially-spent gases from the primary cylinder to the secondary cylinder, said parts being so related in position that the discharge shall occur when the piston of the secondary cylinder is at the end of its instroke, and an air-cushion chamber for the secondary cylinder, substantially as and for the purposes described.

6. In a gas-engine, the combination, with the connected primary and secondary cylinders and their pistons, of an exhaust-valve and mechanism for operating the same, said mechanism being so timed that the exhaust-valves shall be open at or about the beginning of the stroke of the secondary cylinder and shall remain open nearly to the end of said stroke, substantially as and for the purposes described.

7. In a gas-engine, the combination, with the connected primary and secondary cylinders and their pistons, of an exhaust-valve and mechanism for operating the same, said mechanism being so timed that the exhaust-valve shall be open at or about the beginning of the stroke of the secondary cylinder and shall remain open nearly to the end of said stroke, that it shall then close to create a suction for drawing in the explosive charge, and that it shall then open and shall remain open during the instroke of the secondary cylinder, substantially as and for the purposes described.

8. In a gas-engine, an exhaust-valve consisting of a valve-chamber 17 and a piston-valve adapted to reciprocate therein, said valve and chamber having ports adapted to be closed at the end portion only of the stroke of the valve, substantially as and for the purposes described.

9. In a gas-engine, an exhaust-valve consisting of a valve-chamber 17 and a piston-valve adapted to reciprocate therein, said valve and chamber having several lateral ports adapted to be covered at the end portion only of the stroke of the valve, substantially as and for the purposes described.

10. In a gas-engine, the combination, with the explosion-chamber, of a rotatory igniting-shaft, a driving-pinion not directly fixed to the shaft, and a detachable connection—such as a set-screw—adapted to fix the driving-pinion to the shaft, substantially as and for the purposes described.

11. In a gas-engine, the combination, with the explosion-chamber, of a rotatory igniting-shaft, a driving-pinion not directly fixed to the shaft, a wheel 55′, set on the shaft and connected therewith by a ratchet-and-detent connection, and a detachable connection—such as a set-screw—adapted to fix the wheel to the driving-pinion, substantially as and for the purposes described.

In testimony whereof I have hereunto set my hand this 29th day of October, A. D. 1890.

JOHN S. CONNELLY.

Witnesses:
E. E. ELDREDGE,
J. W. CONNELLY.