No. 724,239. PATENTED MAR. 31, 1903.

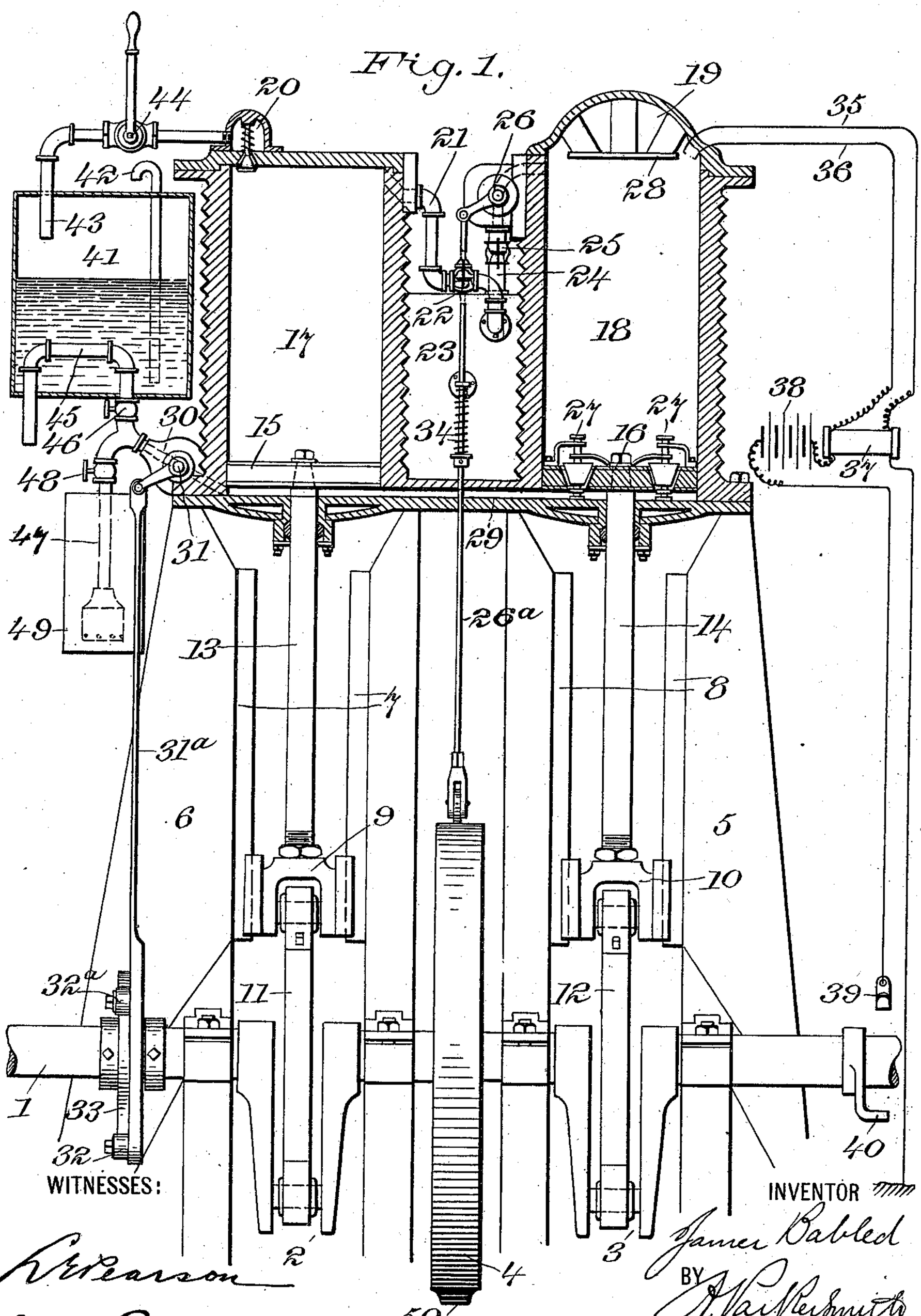
J. BABLED.

COMPOUND GAS ENGINE.

APPLICATION FILED MAR. 7, 1901.

NO MODEL. 4 SHEETS—SHEET 1.

Fig. 1.



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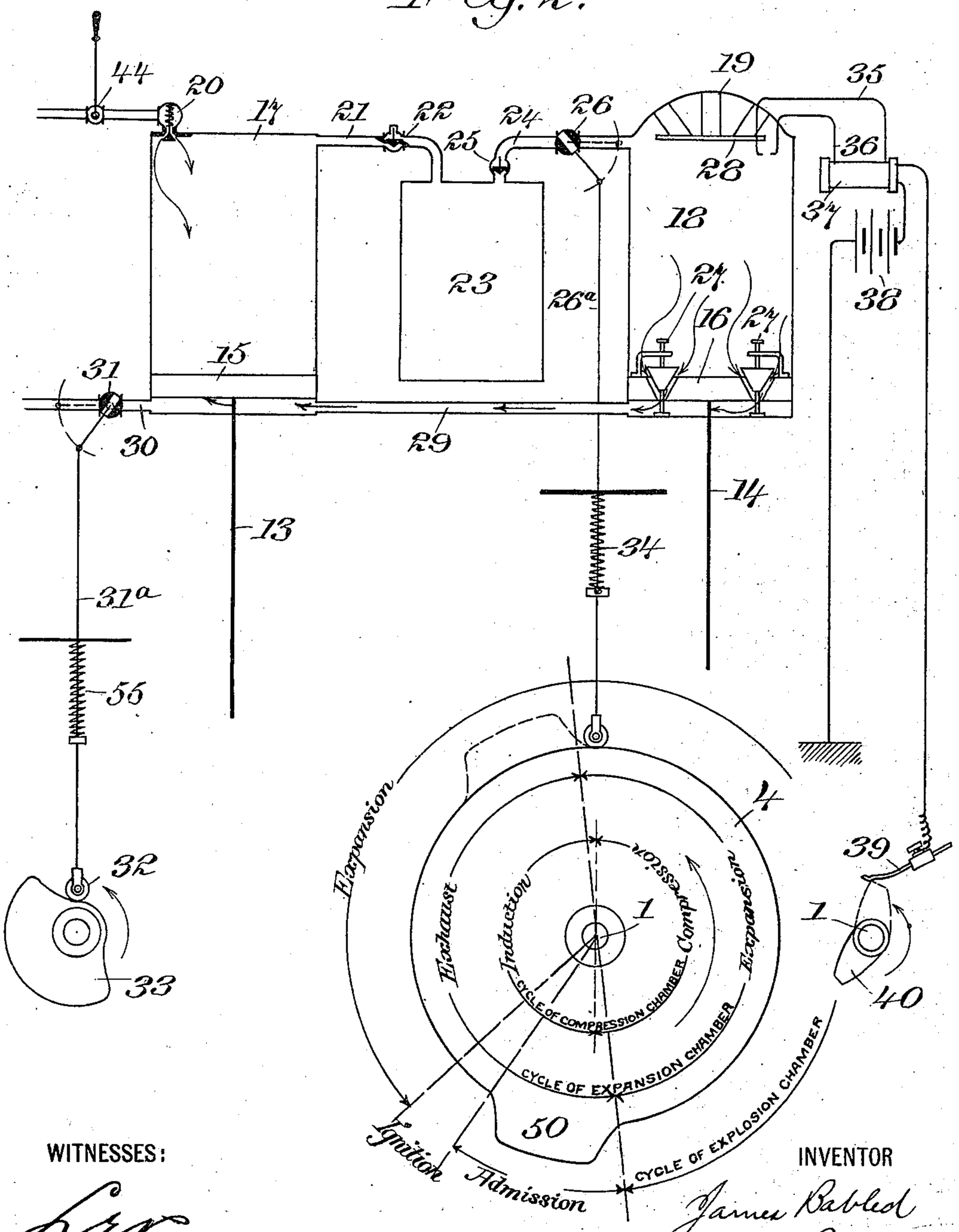
NO MODEL. 4 SHEETS—SHEET 2.

Fig. 2.



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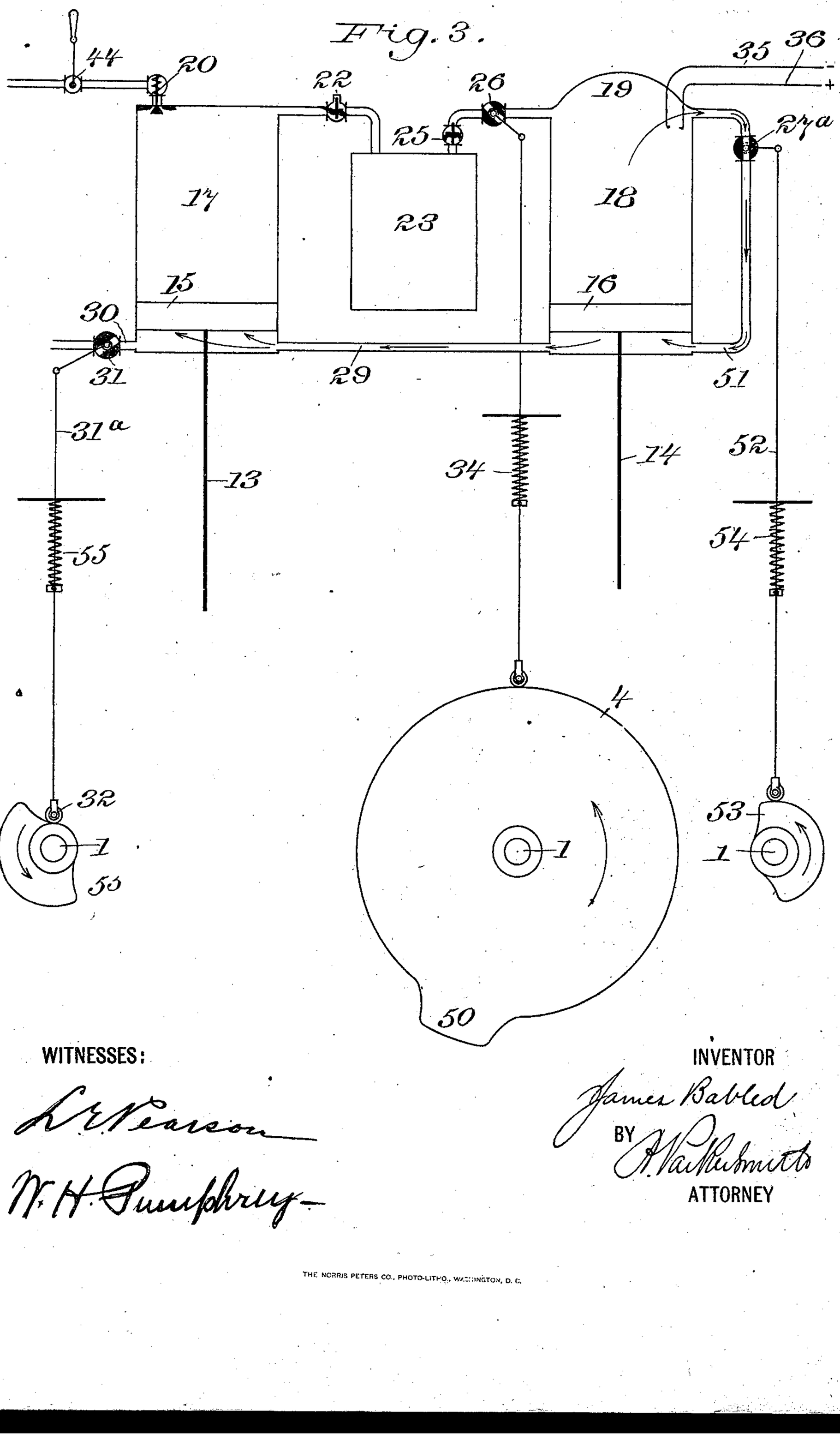
NO MODEL. 4 SHEETS—SHEET 3.

Fig. 3.



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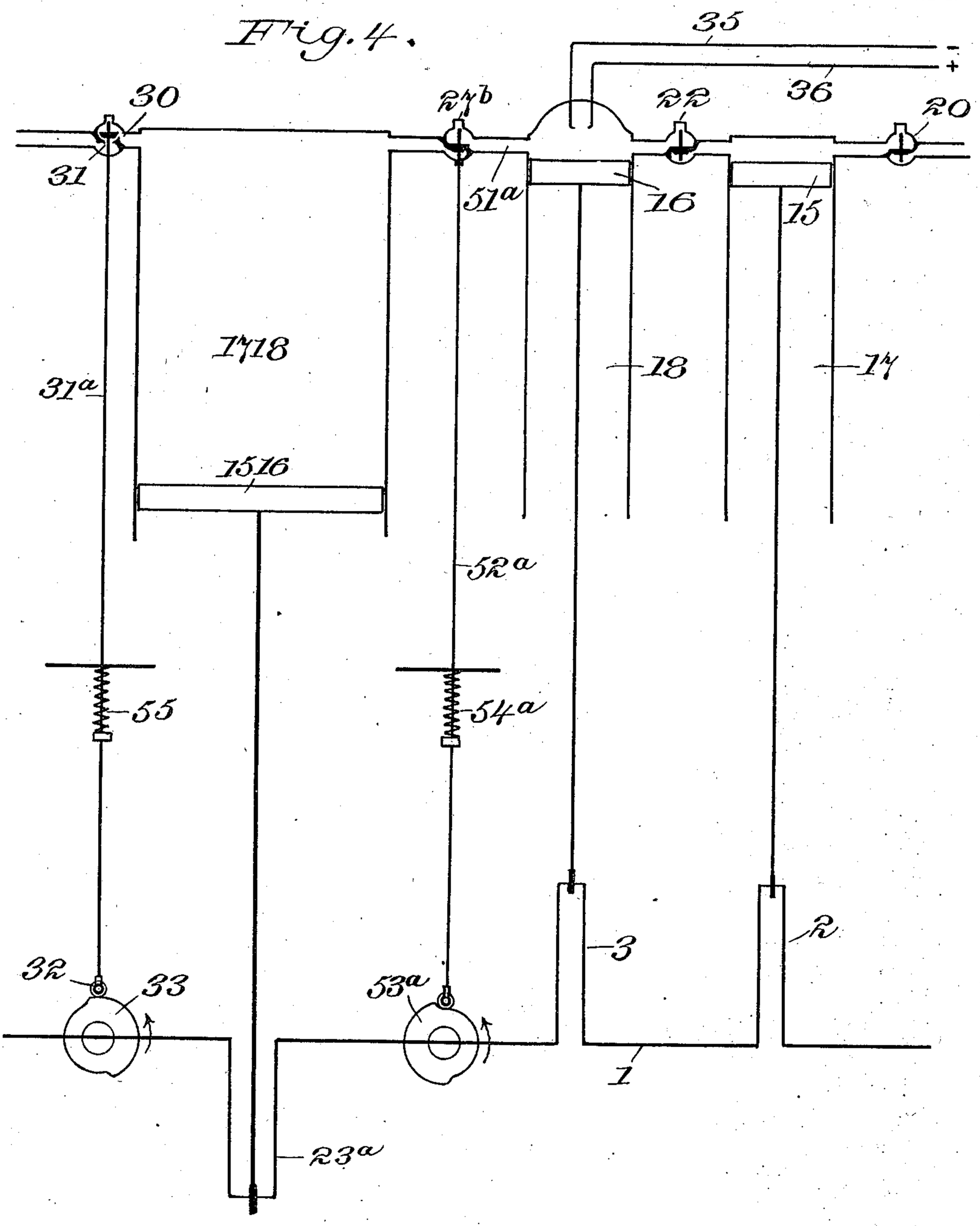
APPLICATION FILED MAR. 7, 1901.

NO MODEL. 4 SHEETS—SHEET 4.

Fig. 4.



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UNITED STATES PATENT OFFICE.

JAMES BABLED, OF DALLAS, TEXAS.

COMPOUND GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 724,239, dated March 31, 1903.

Application filed March 7, 1901. Serial No. 50,155. (No model.)

To all whom it may concern:

Be it known that I, JAMES BABLED, a citizen of the United States of America, and a resident of Dallas, Dallas county, State of Texas, have invented certain new and useful Improvements in Compound Gas-Engines, of which the following is a specification.

My invention relates to gas or other explosive engines in general, and more specifically consists of an improved arrangement for compounding such engines, so as to permit of a more extended expansion of the gases and also dividing the expansive force between the in and out stroke of the engine, whereby a continuous driving force is obtained. This arrangement also permits of the drawing in and compressing of each charge of gas while the preceding charge is expanding, and consequently instead of having the power applied during one stroke out of four only, as is the case with the ordinary gas-engine, or on every other stroke, as is the case with the ordinary double-cylinder engine, I obtain an application of power on every stroke of my improved form of engine.

Certain improvements in details of mechanism designed to operate with my invention and various modifications involving the same general principle are also shown and described.

The preferred form of apparatus embodying my invention, with various diagrams illustrating its operation, are embodied in the accompanying four (4) sheets of drawings, in which—

Figure 1 is a side elevation and partial section of an engine embodying my invention. Fig. 2 is a diagram showing the operation thereof. Fig. 3 is a diagram of a slight modification, and Fig. 4 is a diagram showing a three-cylinder single-acting piston-engine arranged to operate in accordance with the principle of my invention.

Throughout the drawings like reference-figures refer to like parts.

The engine shown in the drawings has crank-shaft 1, with cranks 2 and 3 and fly-wheel 4. This crank-shaft is journaled in the twin frame 5 and 6, which supports the cylinders 17 and 18. On these frames are the guides 7 and 8, on which the cross-heads 9 and 10 slide, the cross-head 9 being connected to the crank 2 by the connecting-rod 11 and the cross-head 10 being connected to crank 3 by the connecting-rod 12. Piston 15 in cylinder 17 is connected to the cross-head 9 by the piston-rod 13, and the piston 16 in the cylinder 18 is connected to the cross-head 10 by the piston-rod 14. The cylinder 18 I call the "explosion-cylinder," because the explosion or combustion of gases takes place in its upper or outer end. Any suitable extension 19 of the said end of said cylinder is provided for an explosion-chamber. The cylinder 17 I call the "compression-cylinder," because the charge of gas and air or vapor and air is drawn into its upper end through the inlet-valve 20 and then compressed by the return stroke of the piston 15 and forced through the pipe 21 and check-valve 22 to the compression-tank 23. Pipe 24 extends from this compression-tank to the upper end of the explosion-cylinder 18, being controlled by the check-valve 25 and plug-valve 26. This plug-valve is a throttle-valve controlling the supply of combustible mixture to the upper end of the explosion-cylinder 18 and is controlled by the valve-rod 26^a, spring 34, and cam 50 on fly-wheel 4.

In the piston 16 I provide one or more valves 27, opening inward toward the explosion end of the cylinder and having slightly-projecting stems adapted to strike the lower end of the cylinder on the downward stroke or the plate 28 on the upward stroke.

A passage-way 29 (indicated in Fig. 1) connects the lower or corresponding ends of the cylinders 17 and 18, and the exhaust passage-way 30 is connected to one or the other of said cylinders at this end. As shown in Fig. 1, it is connected to the lower end of cylinder 17. The exhaust-passage 30 is controlled by any convenient form of valve, such as the plug-valve 31, operated by the valve-rod 31^a, cam-rollers 32 32^a, and cam 33 on the main shaft 1.

The explosive mixture in the explosion-cylinder 18 may be ignited by any one of the well-known means now in use; but I prefer to employ an electric spark produced between the terminals of the wires 35 and 36, inserted in the explosion-chamber 19. Said wires constitute the secondaries of the induction-coil 37, supplied with current from any conven-

ient source of electricity, such as a battery 38, located in the primary circuit, which is opened and closed by the action of the spring contact-piece 39 and the projection 40 on the shaft 1.

While my engine may be supplied with ordinary illuminating or producer gas, I have illustrated an arrangement by which the necessary combustible vapor may be generated by the apparatus itself. This consists of the naphtha or gasolene tank 41, into which air is admitted through the pipe 42 and compelled to pass through the liquid hydrocarbon before it is sucked up through the pipe 43 into the compression-cylinder 17. The air thus becomes ladened with hydrocarbon vapor in the well-known way and forms a combustible mixture.

44 is a hand-valve for closing the supply-pipe.

In order to facilitate the vaporization of the liquid hydrocarbon, I may cause the hot exhaust-gases or a portion thereof to pass through the pipe 45, controlled by the valve 46 and constituting a branch of the exhaust. This pipe 45 is immersed in the liquid hydrocarbon in the tank. 47 is another branch to the exhaust-pipe, controlled by the valve 48 and leading to any convenient form of muffler, as 49.

In the modification shown in Fig. 3 the valves 27 in the piston 16 are dispensed with and their work of equalizing the pressure on the two sides of the piston 16 during the return stroke is done by the valve 27^a, which controls the passage-way 51, extending from one end of the cylinder to the other. This valve 27^a is positively opened and closed by any convenient valve mechanism, such as the valve-rod 52, cam 53 on the main shaft, and spring 54. The other parts of the engine in diagram Fig. 3 are the same as in Fig. 1, but represented diagrammatically.

In the modifications shown in Fig. 4 the principle of my invention is embodied in an engine using only single-acting cylinders. The use of single-acting cylinders is desirable in gas-engines in many cases to keep the parts cool. In this arrangement also the compression-tank 23 is done away with, the compressed gases being forced directly from the compression-cylinder 17 into the explosion-cylinder 18. In this construction instead of having the expanding gases during the return stroke operate on the under sides of the pistons 15 and 16 said gases are led into the larger cylinder 1718 and caused to operate on the piston 1516 therein. This latter piston is connected to a third crank 23^a, set opposite to the cranks 2 and 3. The expanding gases instead of being conducted through the valves 27, Figs. 1 and 2, or through the passage-way 51 and valve 27^a, Fig. 3, are conducted through the passage-way 51^a and valve 27^b from the explosion-cylinder 18 to the expansion-cylinder. The valve 27^b is operated by the valve-rod 52^a and spring 54^a in conjunction with the cam 53^a, as before. I have shown all the valves in this case, however, as puppet-valves instead of plug-valves, as in the other constructions. Said valves are so set as to be driven against their seats by the explosion occurring in cylinder 18.

In the arrangement shown in Figs. 2, 3, and 4 the exhaust is operated by a single-acting cam and the spring 55 in coöperation therewith.

The method of operation of my invention is as follows: Referring to Fig. 1 and diagram Fig. 2, the engine is supposed to be at the end of the explosion and intake stroke—that is to say, the charge of gases expanded in the upper end of cylinder 18 has driven piston 16 down to the lowermost position and has carried the piston 15 along with it, drawing in a combustible charge of vapor and air into the cylinder 17. On the return stroke the charge in the cylinder 17 will be compressed and forced into the compression-tank 23. At the same time the valves 27 having been lifted will be held in their open position by the friction of their guides, and the partially-expanded gases in the cylinder 18 will pass through those valves and expand into the lower end of cylinder 17, producing equilibrium of pressure on two sides of piston 16 and a working pressure on the entire area of the under side of piston 15. Thus the expanding gases furnish the power to compress the charge in cylinder 17, and also when the engine is properly constructed they furnish a surplus of power to be expended in driving the crank-shaft on the return stroke. When the pistons have reached the upper limit of motion, the valves 27 are closed by their stems striking against the plate 28, and the throttle-valve 26 is momentarily opened by the cam 50, permitting the compressed gases in the tank 23 to flow into the combustion or explosion chamber formed by the extension 19 of the cylinder 18. When the crank is far enough past the dead-center to begin to produce an appreciable downward movement of the piston, the throttle-valve 26 is closed, and the projection 40 strikes the contact-piece 39, completing the electric circuits, before described, and producing a powerful spark between the terminals 35 and 36 of the secondary circuit in the combustion or explosion chamber. This explosion of combustible gases forces the piston down, and the operation above described is repeated. During this downstroke the exhaust-valve 31 is open and the expanded gases in the lower ends of the two cylinders 17 and 18 are forced out, the exhaust-valve, of course, closing on the upstroke. As before described, the combustible mixture may be obtained by drawing air through the liquid hydrocarbon in the tank 41, and the volatilization of this liquid hydrocarbon may be accelerated by throwing a greater or less proportion of the hot exhaust-gases through the pipe 45 by opening the valve 46,

or the whole of said gases may be discharged in the muffler 49. The various valve motions should be such as shown in diagram Fig. 2, so that admission to the explosion-cylinder will occur during an angle of crank motion from just before the dead-center to a slight distance beyond. Then the sparking action or ignition occurs during a small angle represented by the period of contact of the projection 40 and the spring contact-plate 39. Expansion then occurs in cylinder 18 during the entire remainder of the crank revolution. The exhaust occurs, of course, from the lower ends of the cylinders during the one hundred and eighty degrees of crank revolution beginning with the admission at the other end of the cylinder.

It may happen in some cases that the valves 27 in piston 16 would give trouble on account of sticking or leaking as a result of expansion and contraction, and for this reason I propose the modified arrangement shown in Fig. 3, in which the connection from the upper to the lower end of the cylinder 18 is afforded through the external relief-pipe or passage-way 51, controlled by a valve 27^a, operated by a cam or other convenient means so as to close the connection during the explosion-stroke and open it during the return stroke.

As before stated, the use of a double-acting piston in gas-engines may sometimes lead to a destructive heating of said piston and the cylinder containing it, and for that reason single-acting cylinders open at one end to the air may be preferred. In the apparatus shown in Fig. 4 such a series of single-acting cylinders is arranged to work upon the principle of my invention. The compression-cylinder performs the office of the upper end of the cylinder 17 in Fig. 1. The explosion-cylinder 18 forms the office of the upper end of the cylinder 18 in Fig. 1. The partially-expanded gases, however, instead of being led around to the other sides of pistons 15 and 16 are led through the passage-way 51^a to the single-acting cylinder 1718, which has a cross-section equal to or more than the sum of cross-sections of the cylinders 17 and 18. In this cylinder the continued expansion of gases does the same work as it does on the under sides of the pistons 15 and 16 in the arrangement shown in Fig. 1; but the pressure being applied to the upper surface of piston 1516 its motion has to be the opposite of the motion of pistons 15 and 16, and so it is connected to a crank 23^a, set at one hundred and eighty degrees from the cranks 2 and 3. In this construction also the compression-tank 23 is done away with, the simple check-valve 22 sufficing to control the connections between cylinders 17 and 18. The valve 27^b is set to close at or just before the point on the upstroke of pistons 15 and 16 at which the increasing pressure of the gases being compressed in cylinder 17 equals the decreasing pressure of the gases flowing from cylinder 18 into expansion-cylinder 1718. The valve 27^b having closed at that time, a further increase of compression in the cylinder 17 will lift the check-valve 22, and there being no clearance in the cylinder 17 the completion of the stroke of piston 15 will force all of the charge through check-valve 22 into explosion-cylinder 18. On the beginning of the downstroke check-valve 22 will close automatically, and ignition immediately following the gases compressed in the explosion-chamber 19 will burn and force the piston 16 through its outstroke. On the instroke of piston 16 the gases expanding into cylinder 1718 exert a driving force against piston 1516 several times larger than their back pressure on piston 16, and the net result is a driving force for the engine on that stroke also, so that this form of the engine is double-acting as well as that shown in Figs. 1, 2, and 3. The operation of the exhaust-valve 31 is as before described, and the operation of the valve 27^b is similar to that of 27^a. (Shown and described in reference to Fig. 3.)

The advantages of my invention comprise, as before stated, the expanding of the gases down to the lowest point, thereby taking all the work possible out of them, the production of a double-acting gas-engine which has a positive driving action during both strokes or through an entire revolution, and in the avoiding of high temperatures by carrying on the expansion of gases through two cylinders, whereby the amount of heat absorbed by any particular cylinder is reduced and the engine parts are not raised to a temperature which becomes destructive. The sending of a regulated quantity of hot exhaust-gases through the hydrocarbon also enables me to produce exactly the right degree of vaporization of said hydrocarbon.

It is evident, of course, that various changes could be made in the details of the apparatus illustrated along the lines suggested in the diagrammatic views and otherwise without departing from the spirit and scope of my invention, so long as the principle of compression in one chamber, explosion in a second chamber, and a continued expansion in a third chamber or connected set of chambers is preserved. Other valve operating and igniting mechanisms might be substituted, of course, and different apparatus or connections for supplying the combustible mixture to the engine, but all these changes are matters of detail and not of principle, and the resulting structures I should still consider within the scope of my invention.

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

1. The combination of the driving-cylinder, the combined driving and compressing cylinder, the crank-shaft, and pistons in said cylinders connected to said crank-shaft, an inlet-valve connected to the compression end of the combined driving and compressing cylinder, a connection from the same end of

said cylinder to the corresponding end of the driving-cylinder, a check-valve in said connection, and an ignition apparatus connected with said driving-cylinder.

2. The combination of the driving-cylinder, the combined driving and compressing cylinder, the crank-shaft, and pistons in said cylinders connected to said crank-shaft, an inlet-valve connected to the compression end of the combined driving and compressing cylinder, a connection from the same end of said cylinder to the corresponding end of the driving-cylinder, a check-valve in said connection, and an ignition apparatus connected with said driving-cylinder, together with a passage-way connecting the other ends of the two cylinders, the exhaust-valve also connected to said ends of the cylinders, a valve-controlled passage-way between the two opposite ends of the driving-cylinder, means for holding the valve which controls said passage-way closed during the explosion-stroke and open on the return stroke, and mechanism which holds the exhaust-valve open on the explosion-stroke and closed on the return stroke.

Signed by me at Dallas, county of Dallas, this 25th day of September, 1899.

JAMES BABLED.

Witnesses:

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A. E. EAGAN.