No. 741,178. PATENTED OCT. 13, 1903.

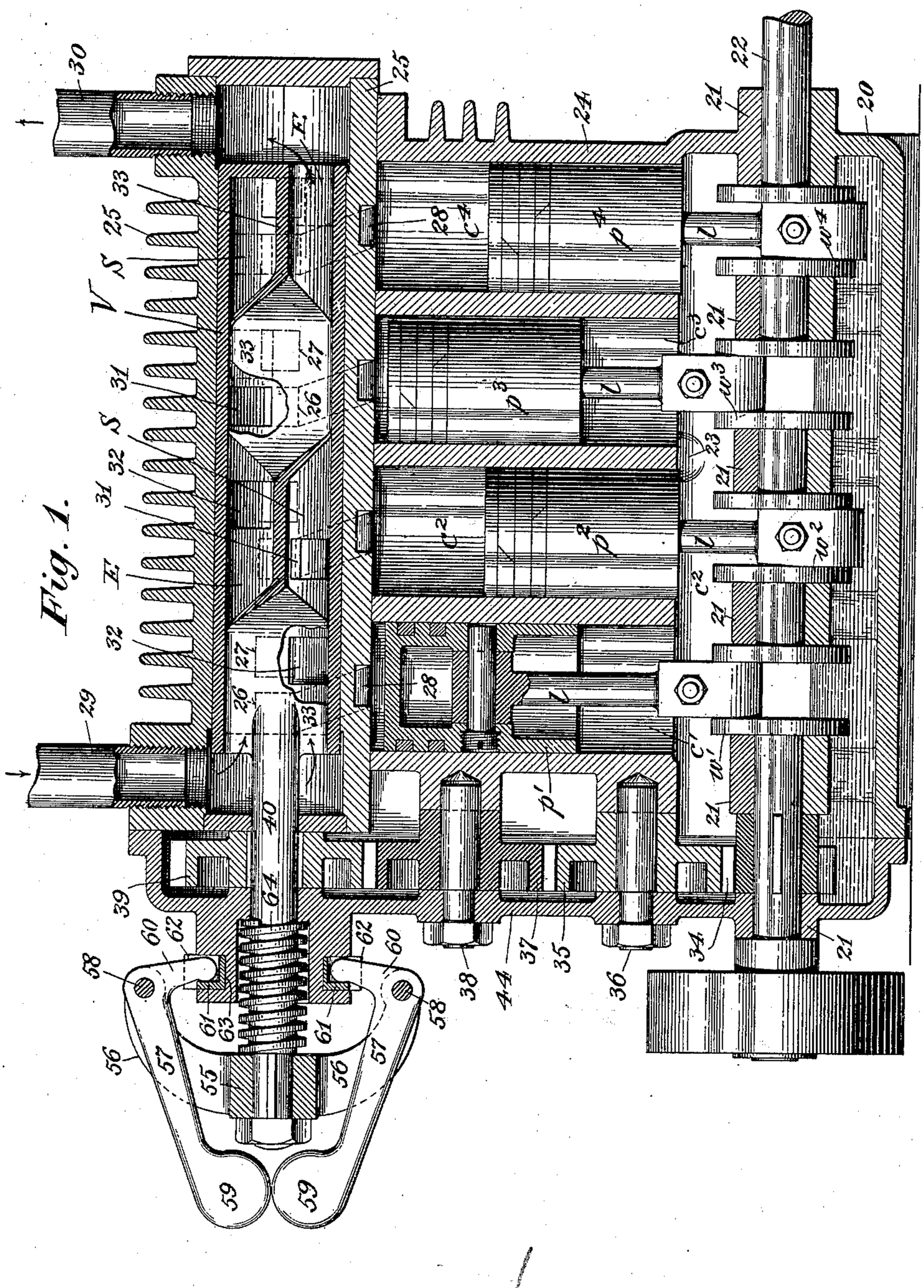
C. W. SPONSEL.

EXPLOSIVE ENGINE.

APPLICATION FILED NOV. 5, 1901.

NO MODEL. 4 SHEETS—SHEET 1.

Fig. 1.



Witnesses
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NO MODEL. 4 SHEETS—SHEET 2.

Fig. 3.

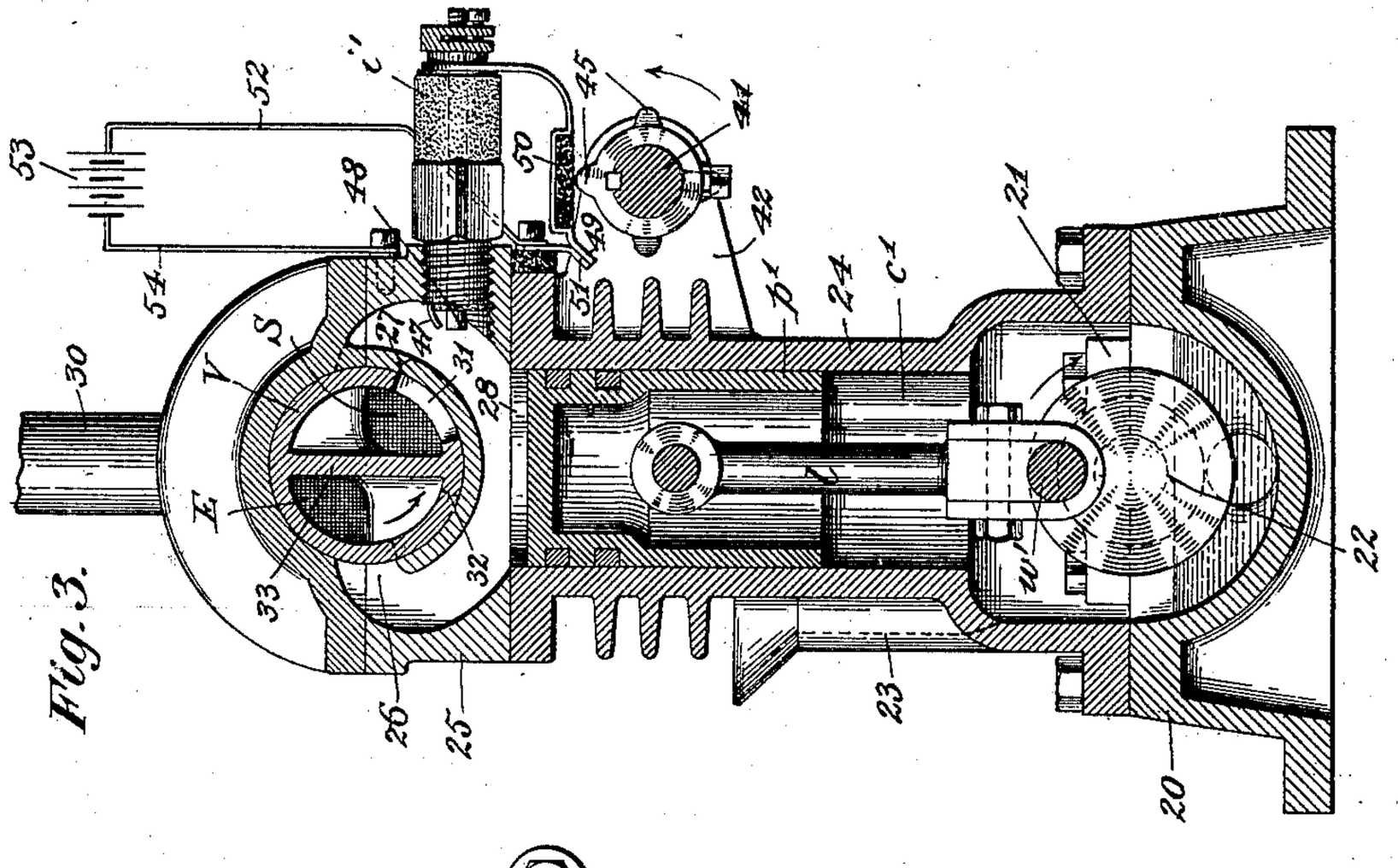
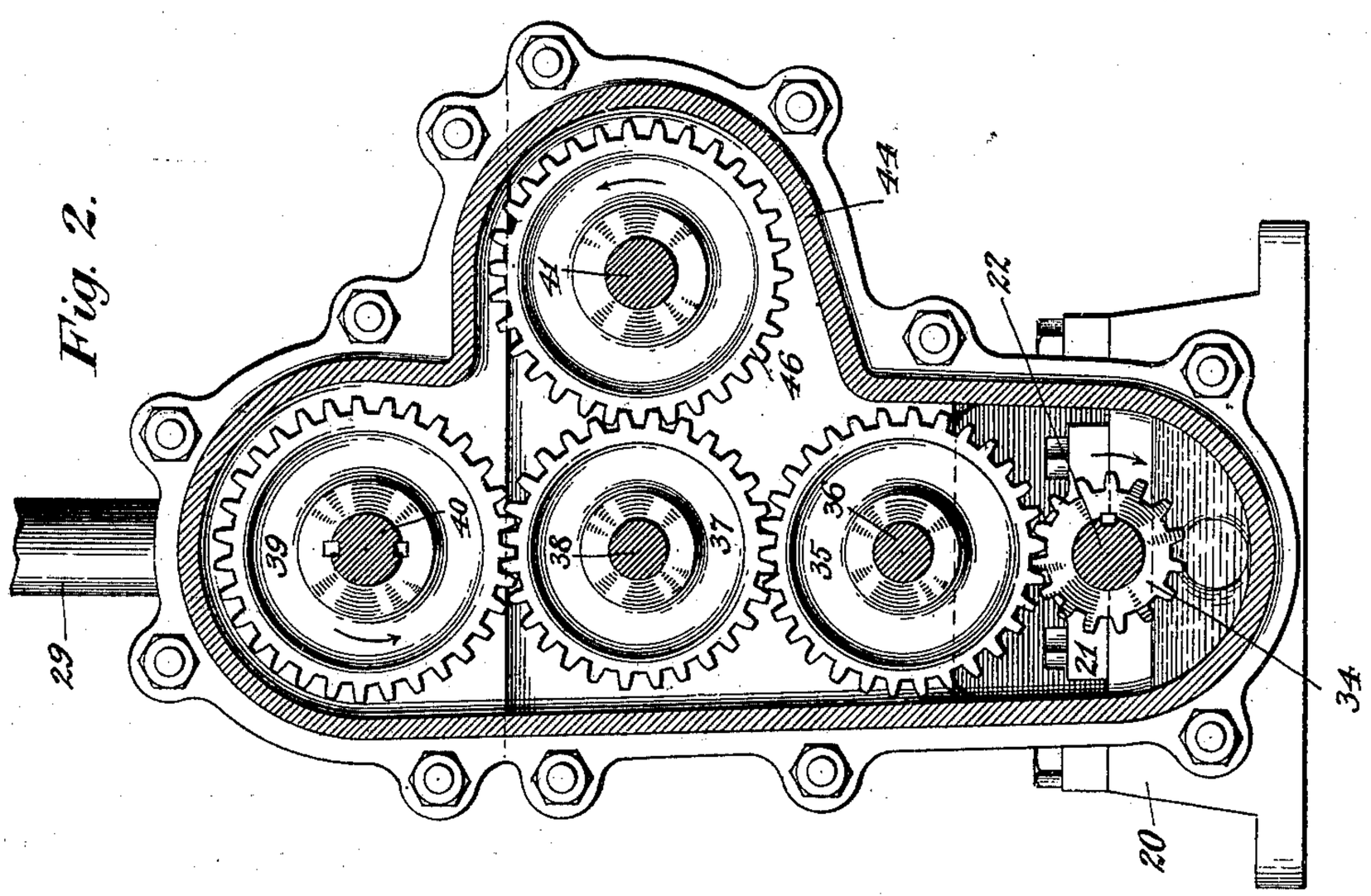


Fig. 2.



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NO MODEL. 4 SHEETS—SHEET 3.

Fig. 4.

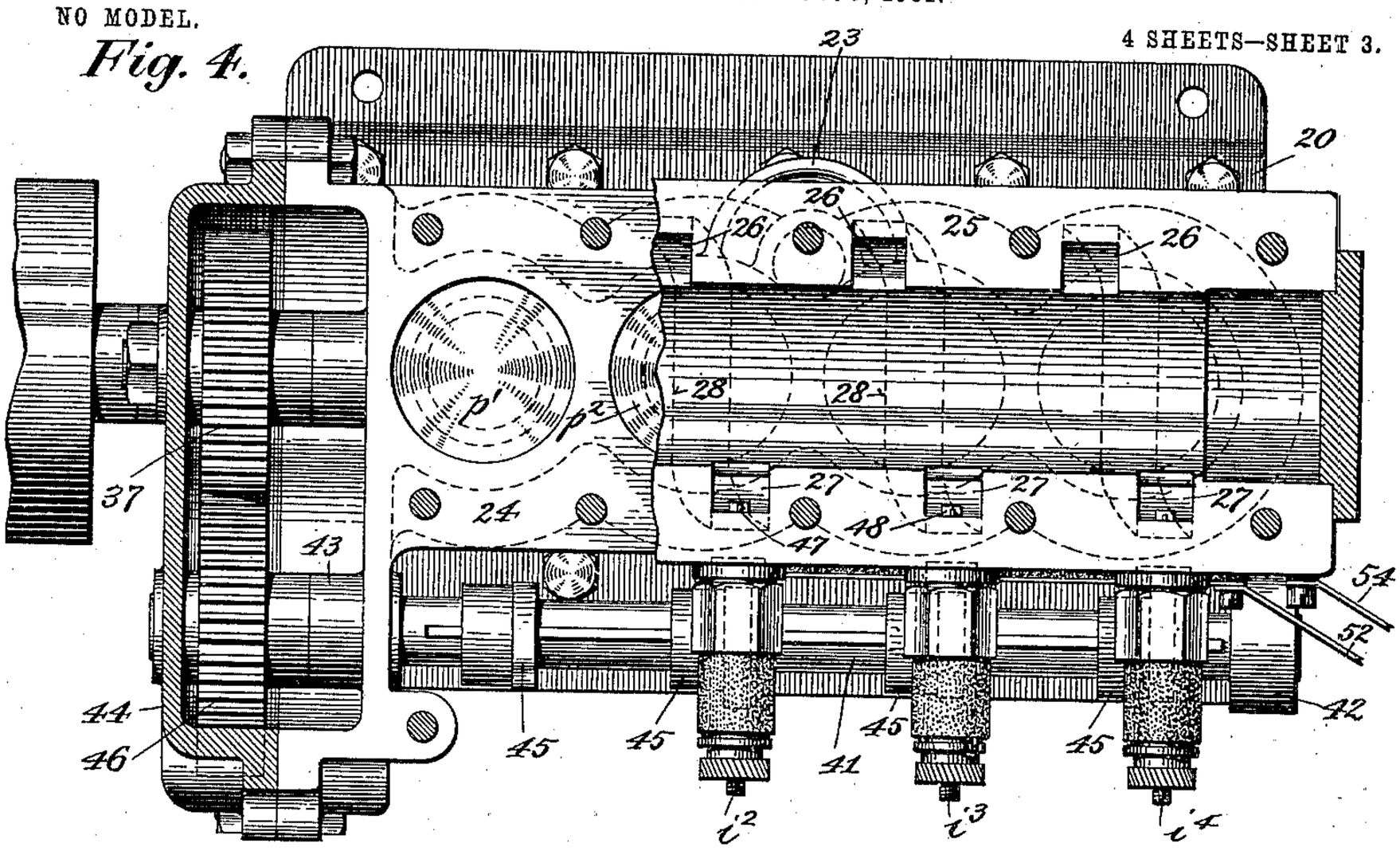


Fig. 5.

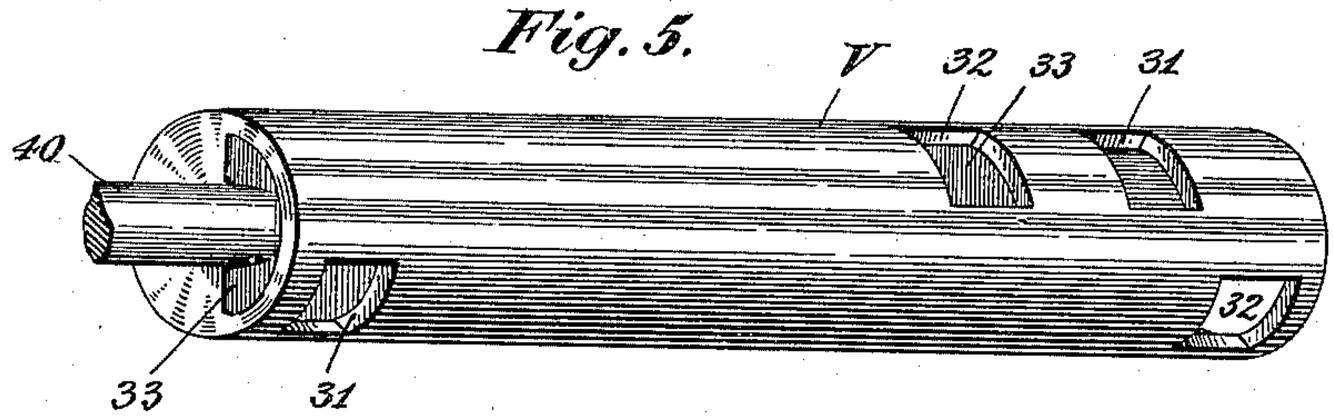
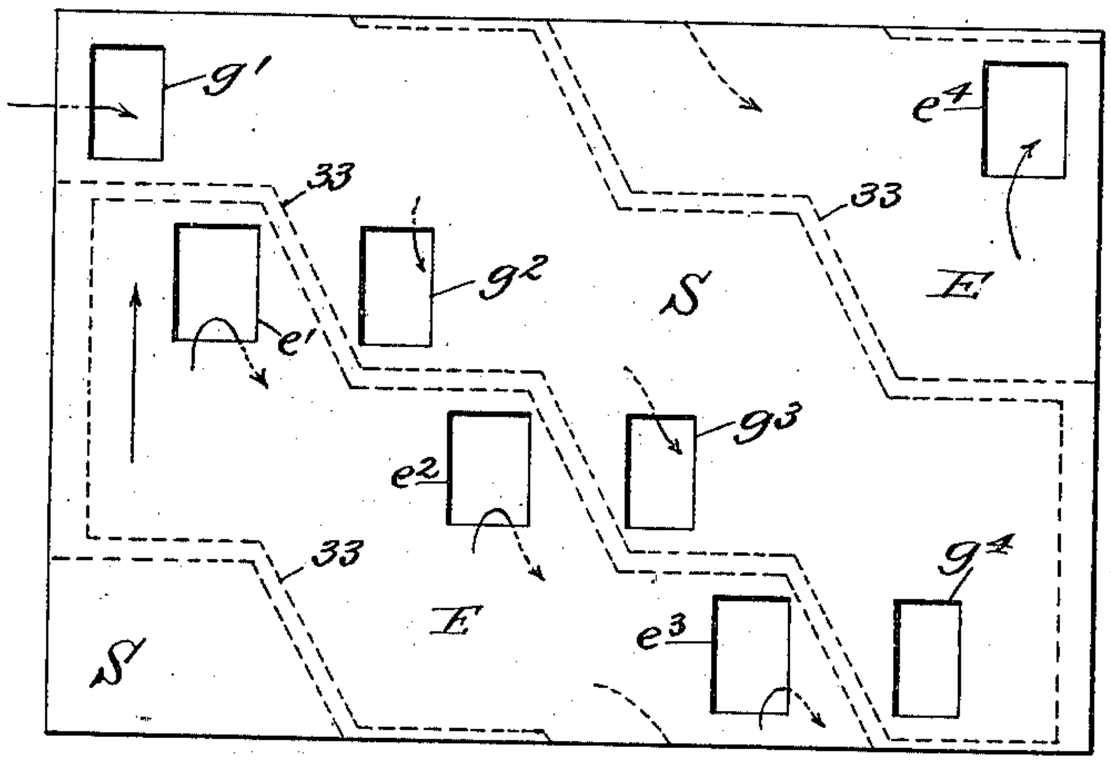


Fig. 6.



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EXPLOSIVE ENGINE.

APPLICATION FILED NOV. 5, 1901.

NO MODEL. 4 SHEETS—SHEET 4.

Fig. 7.

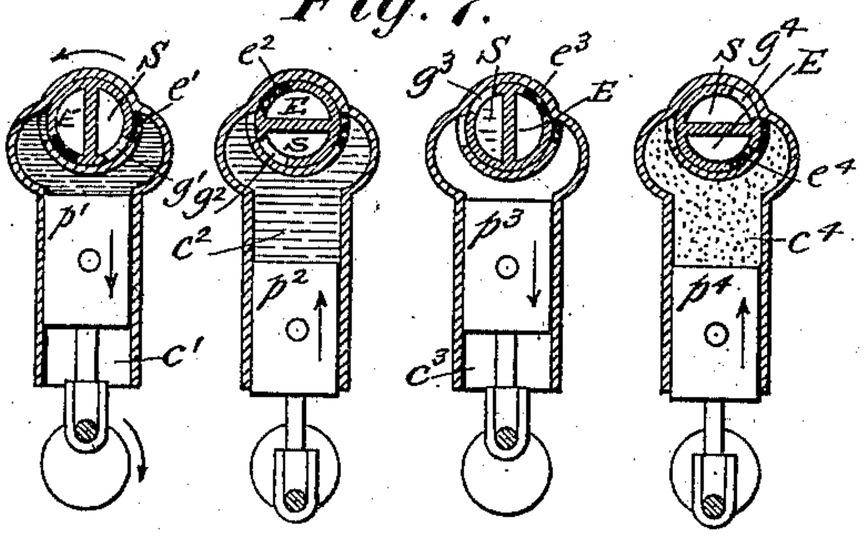


Fig. 8.

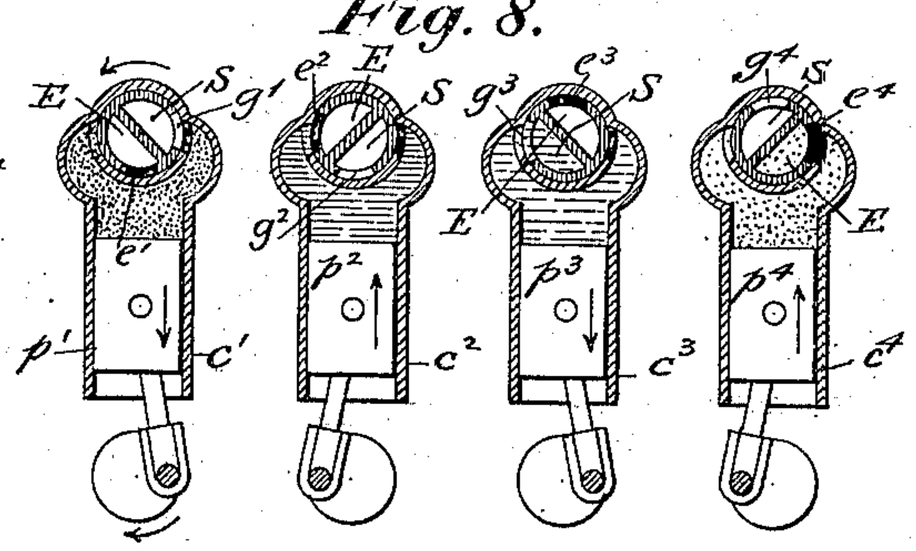


Fig. 9.

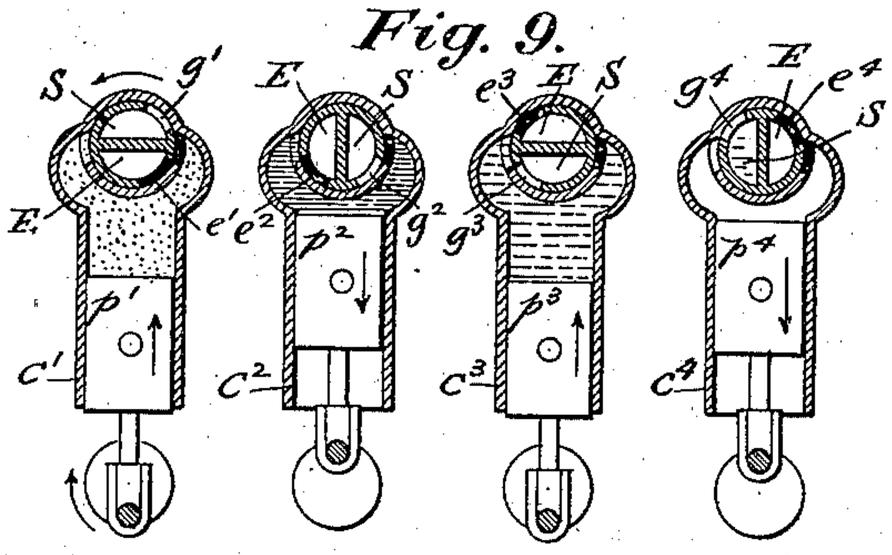


Fig. 10.

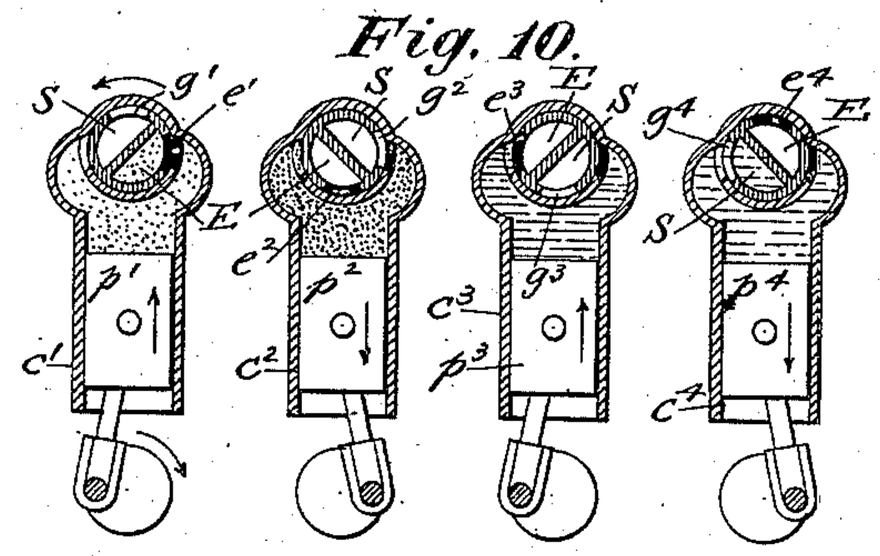


Fig. 11.

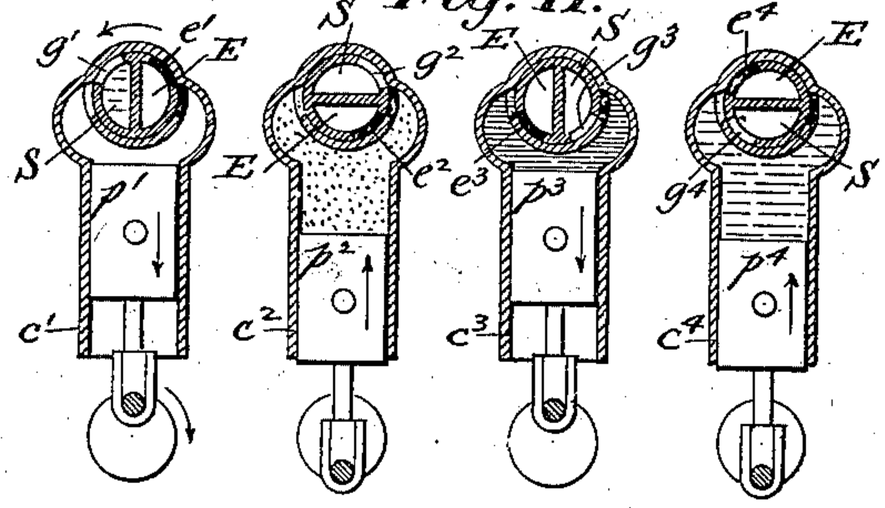


Fig. 12.

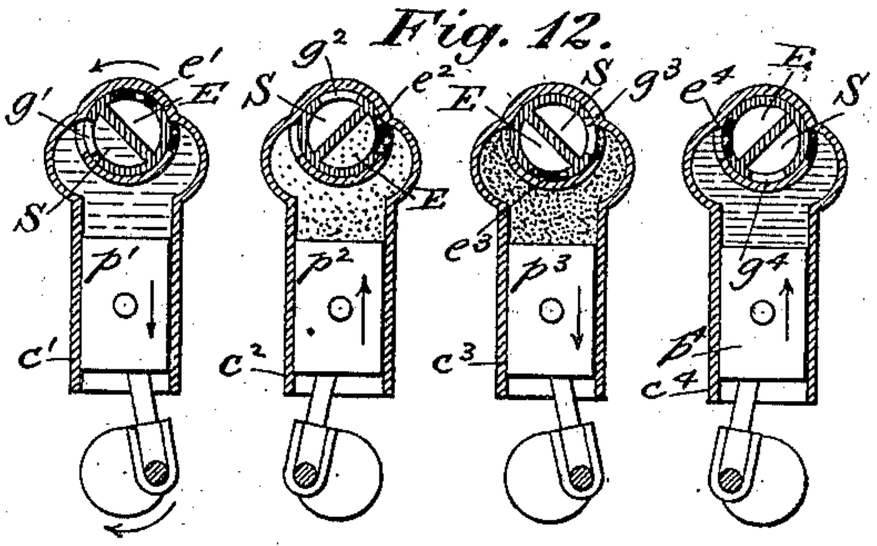


Fig. 13.

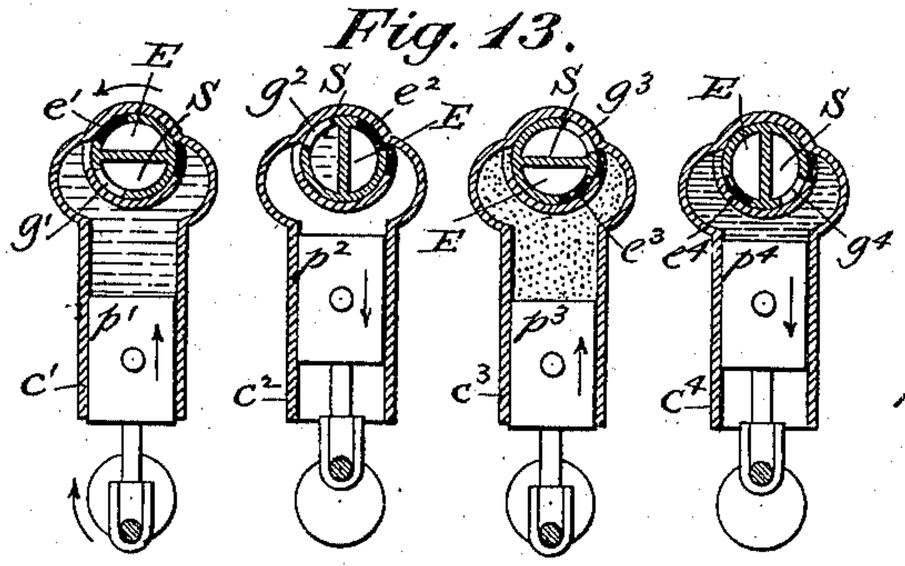
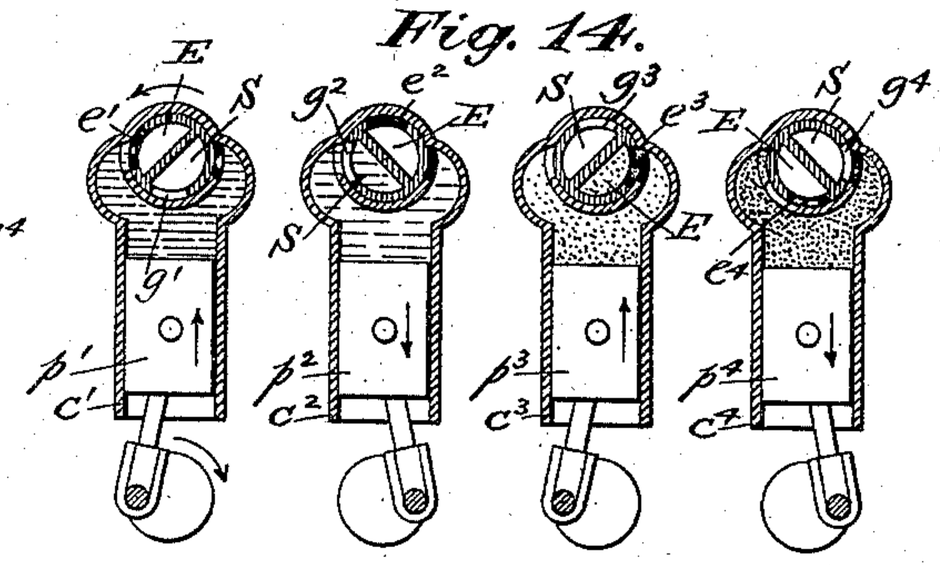


Fig. 14.



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No. 741,178. Patented October 13, 1903.

UNITED STATES PATENT OFFICE.

CHARLES W. SPONSEL, OF HARTFORD, CONNECTICUT.

EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 741,178, dated October 13, 1903.

Application filed November 5, 1901. Serial No. 81,229. (No model.)

To all whom it may concern:

Be it known that I, CHARLES W. SPONSEL, a citizen of the United States, and a resident of Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Explosive-Engines, of which the following is a full, clear, and exact specification.

This invention relates to explosive-engines, and more especially to that class thereof in which the power for driving the piston is derived from explosions within the cylinder of a suitable explosive vapor, such as a mixture of air and naphtha or any other suitable hydrocarbon gas; and my invention has for one of its objects the production of a compact and efficient gas-engine adapted to be run at a high rate of speed, which may be maintained even if the "load" of work which the engine is to perform varies.

A further object of my invention resides in the provision of a series of successively-effective cylinders and pistons, which latter may be connected to a common driving member or shaft, and in the coöperation therewith of a device for admitting gas into said cylinders alternately, so that an impulse will be imparted to the shaft during each revolution of the shaft.

My invention has, furthermore, for its object the provision of a valve which comprises a supply-chamber and also an exhaust-chamber, both being combined in one shell and separated from each other by a partition or wall extending from end to end of the valve and in constant communication with suitable gas supply and exhaust conduits, respectively.

Another object of my invention may be found in the combination, with such valve, of a device whereby said valve may be shifted longitudinally to contract or close the gas-inlet ports, or vice versa, according to the variation of the load and the inherent change of speed, so that the engine is at all times under complete control and regulation.

Further objects of my invention reside in the particular construction and organization of some of the coöperative elements, as will be hereinafter described, and pointed out in the claims.

It is a well-known fact that gas-engines as generally built contain a multiplicity of working parts, some of which are of delicate construction, and consequently easily disarranged or rendered inoperative. The conditions which an engine of this class should meet are especially in connection with automobiles of such a character that compactness, lightness in weight, simplicity in construction and operation, and variableness in efficiency form important factors and points for consideration. It has also been found in practice that the best results in gas-engines are obtained when the driving member or shaft receives at least two impulses during each complete rotation, these impulses being distributed one during each half-turn, or about one hundred and eighty degrees apart, so that no matter when any variation in the load may take place the engine will not need run at any time without a certain amount of pressure to drive it. Hence my invention includes as one of its features a series of successively-effective cylinders and pistons, preferably four in number, so that while the charge contained in one cylinder is fired and serves to turn the driving member for one hundred and eighty degrees another charge is compressed in another cylinder ready to be fired as soon as the first charge has completed its work. At the same time the remaining cylinders will draw in a charge and exhaust, respectively, after a manner common to gas-engines in general, so that during the first half-rotation of the crank-shaft a cylinder may draw in a charge, compress the latter during the next half-rotation or return stroke, receive its working impulse and expand during the third half-rotation, and finally exhaust the fired gas during the fourth half-turn of the shaft.

From the foregoing it will be understood that each individual cylinder will become effective once during two rotations of the driving-shaft, and in order to insure a proper timing of the gas-supply and the opening of the exhaust-conduit my invention comprises a valve which consists, substantially, of a cylindrical shell extending across all the inlet and exhaust ports of the several cylinders and divided into two distinct and separate chambers, one of which will supply gas to the cylinders, while the other will serve to con-

duct the used gas, after its explosion and work in the cylinders, into a suitable exhaust-chamber or the open air.

My invention has been clearly illustrated in the accompanying drawings, in which—

Figure 1 represents a central longitudinal section of a gas-engine incorporating my improvements. Fig. 2 is an end view of the same looking from the left of Fig. 1, the covering-plate of the inclosing casing being removed to disclose one form of operating the valve from the main driving-shaft. Fig. 3 is a central vertical cross-section through the first cylinder on the left of Fig. 1. Fig. 4 represents a top view of the lower portion of the valve-chest and its ports, partly broken away to show the body containing the cylinder. Fig. 5 is a perspective view of the valve in its preferred form. Fig. 6 illustrates the development of the peripheral surface of the valve; and Figs. 7 to 14, inclusive, are diagrams showing the operation of the group of cylinders and the relative positions of the valve during successive ninety-degree movements of the crank-shaft.

It may be stated at this time that any suitable explosive hydrocarbon gas may be used, and no attempt has been made to show any apparatus for vaporizing and mixing the gas with air in the required proportions.

Referring to the drawings, 20 designates a suitable bed having a plurality of bearings 21 for the main driving member or shaft 22 of the gas-engine. This bed is shown dished (see Fig. 3) to serve as a receptacle for oil or other lubricant, which may be maintained at a certain level, so as to be churned or splashed about by the rotation of the crank-shaft, the oil being supplied through a well 23, disposed in the cylinder-body 24, which in the present instance is provided with four working cylinders c' c^2 c^3 c^4. These cylinders contain pistons p' p^2 p^3 p^4, which are preferably of the reciprocatory type and may be connected to wrist-pins w' w^2 w^8 w^4 of the shaft 22 by links 1, respectively.

Disposed above the cylinder-body 24 and firmly secured thereto is a valve-chest 25, preferably made in two parts, as is clearly shown in Figs. 1 and 3, and provided with a series of gas-supply ports, however not being in alinement with each other peripherally, while, on the other hand, they will terminate in a single opening, as indicated by 28 in Fig. 4.

Referring to Fig. 1, it will be seen that at the left end of the valve-chest may be provided a suitable gas-supply conduit, such as 29, from which gas may be supplied to the gas-ports of the valve-chest at the proper time by a valve V, shown herein as a cylindrical shell and comprising a gas-supply chamber and an exhaust-chamber which are separated from each other by a partition or wall extending from end to end thereof and which are in constant communication with the gas-supply conduit 29, above referred to, and near the other end of the valve with an exhaust-conduit 30, respectively. The valve V has, therefore, both of the chambers closed at opposite ends, so as to prevent the gas from passing through the valve and into the exhaust-conduit directly, while, on the other hand, the products of combustion or explosions are thereby conducted directly to the exhaust-conduit and cannot in any way come into contact with the live gas as supplied by the conduit 29.

As above stated, my invention includes as one of its features a series of successively-effective cylinders and pistons, which are so organized that gas will be supplied to the cylinders, subsequently compressed therein, then fired, and finally exhausted in regular order and in a predetermined manner. Hence it will be evident that the gas-supply ports 31, which are peripherally disposed on the valve V, will be in circumferential alinement with the gas-ports 26 of the valve-chest, while at the same time they must be disposed angularly around the axis of the valve in such a manner that gas will be admitted to the succeeding cylinders at the proper time and in regular order. Likewise it will be understood that the exhaust-ports 32 in the valve V also find their outlet in the outer surface of said valve and are disposed in circumferential alinement with the exhaust-ports 27 of the valve-chest 25 and that their angular position around the axis relative to a gas-supply port of the same cylinder is properly timed.

The cycle of operation of a group of cylinders is in the present instance such that while the first cylinder is drawing in a charge of live gas the second cylinder is exhausting, so that for this reason the gas-inlet port of the valve into the first cylinder and the exhaust-port in the valve of the second cylinder are at diametrically opposite sides of the valve (see Fig. 12) and that likewise the valve V will make a rotation of forty-five degrees in order to close the inlet-port for the first cylinder and turn the inlet-port for the second cylinder into position for the latter to draw in a charge of gas.

Now it has been stated above that the valve V comprises a gas-supply chamber and an exhaust-chamber, both chambers being separated from each other by a partition or wall and disposed across all the ports leading into the several cylinders, and for this reason the partition 33 runs straight and in alinement with the axis of the valve directly over the ports of any one cylinder, while the cross-section of the same laterally of the valve changes in position between each pair of adjacent cylinders.

In Fig. 6 is shown the development of the valve V, illustrating the manner in which the ports are disposed and the manner in which the gas-supply chamber is separated from the exhaust-chamber by the partition 33. Here it will be seen that the gas-ports g', g^2, g^3, and g^4 for the several cylinders, re-

spectively, follow each other in regular angular rotation on the surface of the valve and that they all are in direct and constant communication with the gas-supply chamber S, which is completely separated from the exhaust-chamber E by the partition 33, (indicated by dotted lines, representing the line of its junction with the inner surface of the valve-shell and at diametrically opposite points thereof.) It is also here shown that the supply-chamber S is closed at the right-hand end of the valve and takes its supply of gas at the left-hand end thereof, while the exhaust-chamber E is closed at this end and may communicate with a suitable conduit or the open air at the right-hand end.

From the foregoing it will be understood that the partition 33 follows to some extent the contour of a spiral or screw-thread having intermittent straight central portions, and the rotation of a valve in the present instance is such that the movement of the valve will serve in drawing in gas from the supply-conduit, as well as facilitating the discharge of the exhaust-gas therefrom. Inasmuch as it is essential in a valve of this class that it should be perfectly balanced in order to insure its running freely, I deem it preferable to dispose the inlet and outlet ports in the valve-chest at substantially diametrically opposite points, so that when a charge of compressd gas in any one cylinder is fired the resultant pressure will be equalized at nearly opposite points and on substantially equal areas, and this will nullify the tendency of crowding the valve-shell against its bearing-surface in the valve-chest.

The gas-engine incorporating my invention and shown in the drawings is so organized that the crank-shaft will have two rotations for each single rotation of the valve and constitutes what might be called a "four-cycle" machine. This relative movement of crank-shaft and valve is effected in the present instance by a train of gears illustrated in Figs. 1 and 2, in which the shaft 22 is shown having a pinion 34 meshing into an intermediate 35, which is journaled on a stud 38 and which in turn transmits movement through an intermediate 37, pivotally supported on a stud 38, to a gear 39, which is mounted upon the stem 40 of the valve V and the diameter of which is twice that of the pinion 34.

Suitable sparking or igniting mechanism is provided in connection with each of the several cylinders, this mechanism comprising a shaft 41, journaled in bearings 42 on the cylinder-body 24 and also in a bearing 43, provided on a casing 44, which serves for the purpose of closing the open end of the oil-chamber in the bed 20, above mentioned, and also as a protection for the train of gearing just described.

The igniting mechanism is clearly shown in Figs. 3 and 4, in which the shaft 41 is shown having a series of cams 45 and which is operated at the same rate of speed as the valve V—as, for instance, by a gear 46, mounted upon said shaft and also meshing into the intermediate 37, above referred to.

Inasmuch as each of the cylinders is fired at a different period during the two-cycle movement of the crank-shaft, I provide a plurality of sparking plugs or igniters i', i^2, i^3, and i^4, each of which is grounded in the valve-chest with one terminal 47, while the other terminal, 48, thereof is insulated therefrom and is in electric connection with a spring-retracted contact or brush 49, provided with an insulating-block 50, adapted to be engaged by one of the cams 45, above mentioned.

The several igniters are energized at the proper time by their brushes 49 coming into contact with a stationary brush 51, which may be secured to but insulated from the cylinder-body 24, the current between said brush 51 and the grounded terminal 47 being established through a wire 52, a battery and coil or other source of energy 53, and a connecting-wire 54, as is clearly shown in Fig. 3.

Means are provided whereby the amount of gas to be supplied to the cylinders, according to the different requirements or variation in the load, may be regulated, and in the present instance I accomplish this result by shifting the valve V longitudinally of its axis so as to contract or even close all of the gas-supply ports, and in this manner wire-draw the gas to regulate the amount of the gas charge and its subsequent compression.

While it is evident that the valve may be shifted thus by hand, I preferably employ in connection with this engine a device which is automatic in its action and will serve as a governor controlled by the speed of the crank-shaft. This device is clearly shown in Fig. 1, in which the valve-stem 40 is shown provided at its outer end with a yoke 55, the opposite arms 56 of which are bifurcated to receive angle-levers 57, pivoted at 58 to said arms and having weighted ends 59, adapted to be thrown outward by centrifugal force on the rotation of the valve V. The angle-levers 56 have also arms 60, projecting toward the center of the valve and engaging in recesses in a ring 61, preferably made in two parts, said recesses being limited at their sides by flanges 62, between which said arms 60 may play, and which at the same time serve as mediums for rotating the ring 61 in unison with the valve V. The two-part ring 61 is rotatably supported in a groove 63, formed in a hub on the casing 44, and it will act as a thrust-receiving member for shifting the yoke inward or toward the right and against the action of the spring 64, resting with one end against said yoke and having its other end seated in a recess 65 in the hub above referred to. The shifting movement of the valve V from the position shown in Fig. 1 toward the right will cause the gas-inlet ports of the valve to overlap those in the valve-shell, and therefore decrease the opening or area of the passage

through which the gas will be admitted into the cylinder, and the engine may be thus regulated, as desired, this regulation depending upon the rotation speed of the valve, the weight of the governor-weights 59, and the resistance of the spring 64.

The operation of my improved gas-engine is clearly shown in the diagrams, Figs. 7 to 14, inclusive, and is as follows: In order to distinguish clearly between the different conditions of the gas and also to differentiate between the gas-ports and the exhaust-ports in the drawings, the different conditions are represented by different characterizations, viz: Live gas is indicated by lines, these lines being more or less contracted to designate the conditions of the gas in regard to its compression. In a similar manner the used and exploded gas is represented by stippling. Inasmuch as the gas-inlet ports and the exhaust-ports in the valve are not disposed in the same plane laterally thereof and in order to insure a clear understanding by a graphic representation of the gas and the position of its ports, the gas-inlet ports are left white, while the exhaust-ports are shown black in the cross-sections of the valve and valve-chest.

With these explanations in mind it will be seen by referring to Fig. 7 that the first cylinder c' of the group of four cylinders of the engine has a compressed charge of gas ready to be fired and to move the piston downward. This will result in moving the piston p^2 upward, compressing the gas contained in cylinder c^2, while piston p^3 is just ready to draw in a charge and piston p^4 is ready to move upward to exhaust or discharge the exploded gas from cylinder c^4.

In Fig. 8 the crank-shaft is shown as being turned ninety degrees from the position shown in Fig. 7, while in Fig. 9 the pistons have arrived at a position opposite to that shown in Fig. 7, the crank-shaft having made a movement of one hundred and eighty degrees, while the valve has been moved only ninety degrees. This position of the valve shows that in cylinder c' the exhaust-ports are just on the point of communication, while cylinder c^2 has a compressed charge of gas ready to be fired to impart an impulse to the crank-shaft during the second half of its rotation. In cylinder c^3 the gas-supply port of the valve has just closed, rendering it possible to compress the gas charge in said cylinder during the next movement of one hundred and eighty degrees of the crank-shaft, while cylinder c^4 has just finished its exhaust and stands ready to draw in another charge.

In Fig. 11 the group of pistons is in a position corresponding to that shown in Fig. 7 and ready to start on the third cycle movement—viz., cylinder c' ready to draw in a charge, cylinder c^2 ready to exhaust, cylinder c^3 contains a compressed charge and is ready to be fired, while cylinder c^4 has just received a charge and the gas-supply port of the valve has been closed to permit such a charge to be compressed. In Fig. 13 the pistons are shown ready to enter on their fourth cycle of movement—viz., piston c' compressing a charge, cylinder c^2 drawing in a charge, cylinder c^3 ready to exhaust, and cylinder c^4 contains a compressed charge of gas and is ready to be fired.

By comparison of the several diagrams just enumerated it will be seen that an impulse is imparted to the crank-shaft at each half-rotation thereof and that therefore a continuous pressure or forward movement is imparted thereto. The succession in which these impulses are imparted to the crank-shaft are also clearly shown, while the beginning of the operation of any one of the cylinders or pistons during its four-cycle movement can be readily determined by a comparison of the different positions and conditions illustrated in the diagrams, in which Figs. 8, 10, 12, and 14 illustrate the intermediate steps.

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

1. In a gas-engine, the combination, with a series of successively-effective cylinders, and pistons operative therein; of a valve having a supply-chamber and an exhaust-chamber, both chambers being provided with peripheral ports, alternately in communication with said cylinders; means for rotating said valve once for every two full strokes of said pistons; and means for shifting said valve longitudinally and for varying the supply of gas from the supply-chamber into said cylinders.

2. In a gas-engine, the combination, with a series of successively-effective cylinders; the pistons operative therein; of a rotatable valve having inlet and outlet ports; and a valve-chest having inlet-ports and exhaust-ports disposed at diametrically opposite sides of said valve and in communication with said cylinders and coöperative with the valve-ports.

3. In a gas-engine, the combination, with a series of successively-effective cylinders; and pistons operative therein; of a valve-chest, having inlet-ports and exhaust-ports disposed at diametrically opposite sides thereof and in different transverse planes longitudinally of the chest; and a rotatable valve having inlet and exhaust ports for coöperation with the ports of said valve-chest.

4. In a gas-engine, the combination, with a series of successively-effective cylinders; and pistons operative therein; of a valve-chest having one inlet-port and one exhaust-port for each cylinder, said ports being disposed at diametrically opposite sides of the chest, and in different transverse planes longitudinally of the chest; a conduit connecting each set of said ports and in communication with one cylinder; and a cylindrical valve mount-

ed for rotation in said chest, and having inlet and exhaust ports, alternately in communication with the chest-ports respectively.

5. In a gas-engine, the combination, with a series of successively-effective cylinders; and pistons operative therein; of a valve-chest having one inlet-port and one exhaust-port for each cylinder, said ports being disposed at diametrically opposite sides of the chest, and in different transverse planes longitudinally of the chest; a conduit connecting each set of said ports and in communication with one cylinder; and a cylindrical valve mounted for rotation in said chest, and having inlet and exhaust ports, alternately in communication with the chest-ports respectively; and means for shifting said valve longitudinally for varying the area of the inlet-ports and the flow of gas therethrough.

6. In a gas-engine, the combination, with a series of successively-effective cylinders; of a valve-chest having a series of inlet-ports, and exhaust-ports in communication with the cylinders respectively, said ports being disposed at diametrically opposite sides of the chest and in alinement longitudinally, but in different planes transversely of the chest; a valve having an inlet-chamber and an exhaust-chamber, said chambers being separated from each other by a partition, and each having ports for coöperation with the chest-ports, respectively; and means for shifting said valve longitudinally and for varying the flow of gas through the inlet-ports.

7. In a gas-engine, the combination, with a series of successively-effective cylinders; of a valve-chest having a series of inlet-ports, and exhaust-ports in communication with the cylinders respectively, said ports being disposed at diametrically opposite sides of the chest and in alinement longitudinally, but in different planes transversely of the chest; a cylindrical valve-shell comprising an inlet and an exhaust chamber separated from each other by a spiral partition, each chamber having inlet-ports, and also exhaust-ports, each set being disposed equidistantly circumferentially of the valve-shell, and having the exhaust-port for one cylinder in longitudinal alinement with the inlet-port for the next effective cylinder.

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