No. 706,711. Patented Aug. 12, 1902.

G. S. ANDRES.

MULTIPLE CYLINDER EXPLOSIVE ENGINE.

(Application filed Dec. 18, 1899. Renewed May 15, 1902.)

(No Model.) 2 Sheets—Sheet 1.

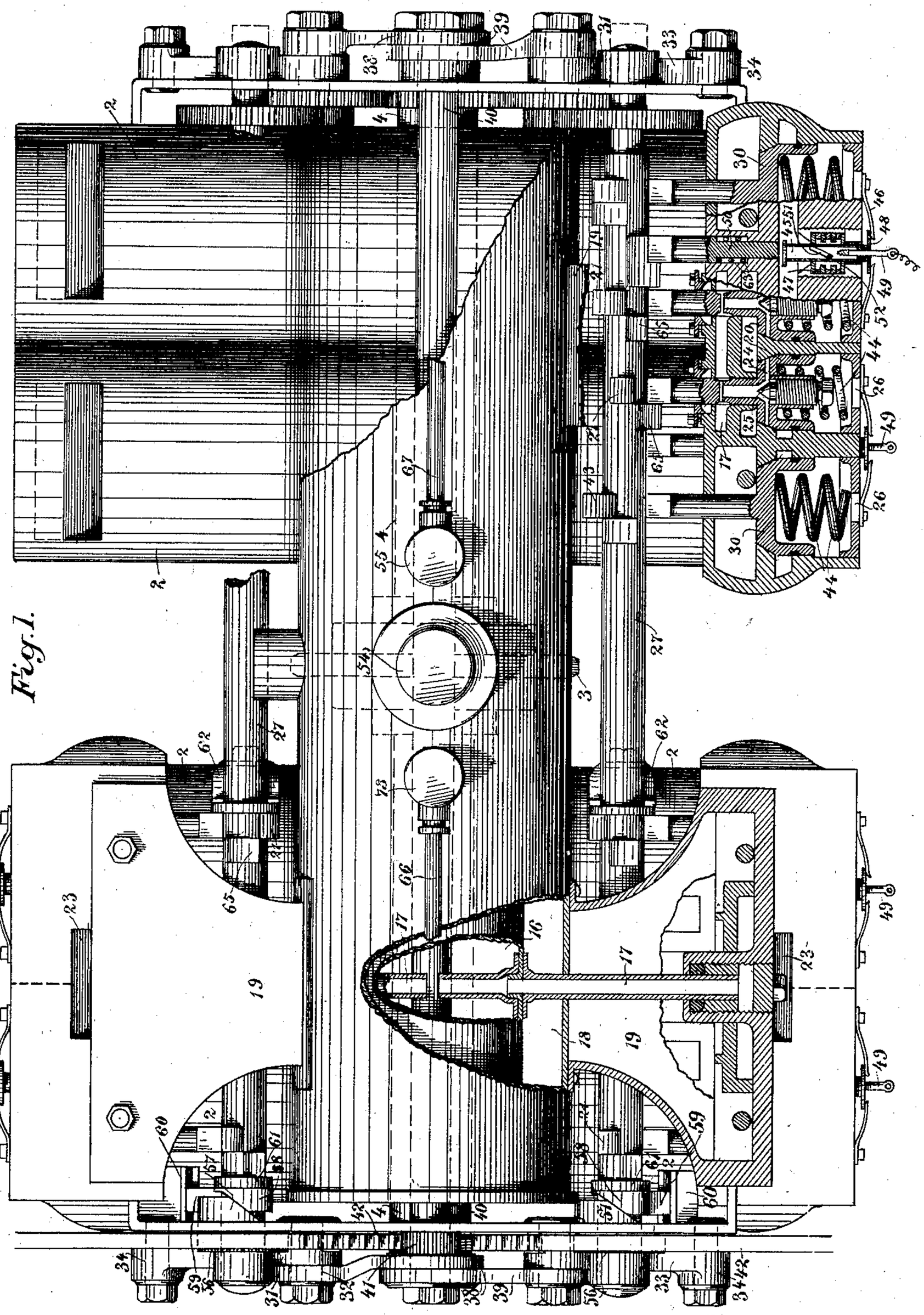

Fig. 1.

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2 Sheets—Sheet 2.

Fig. 2.

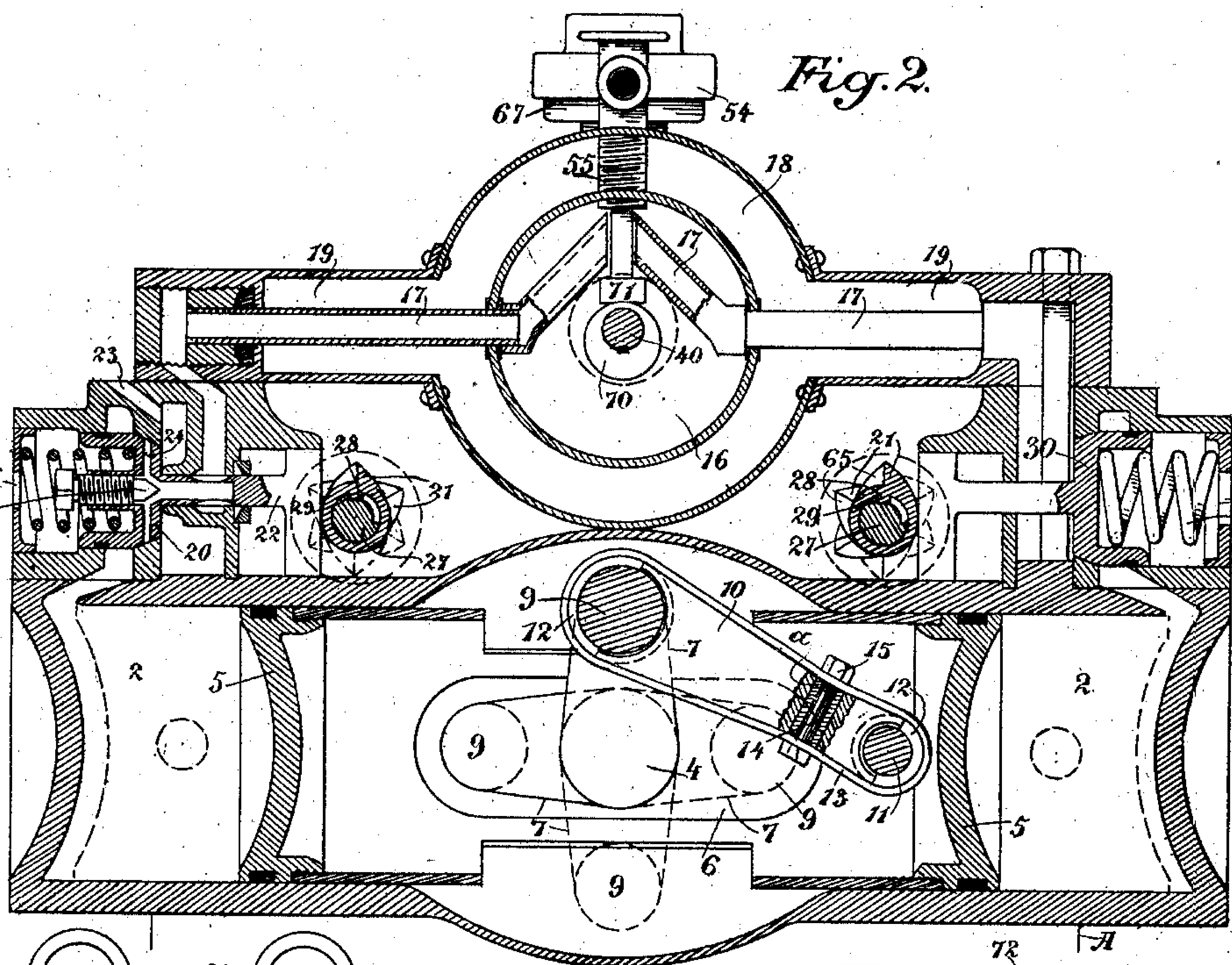


Fig. 5.

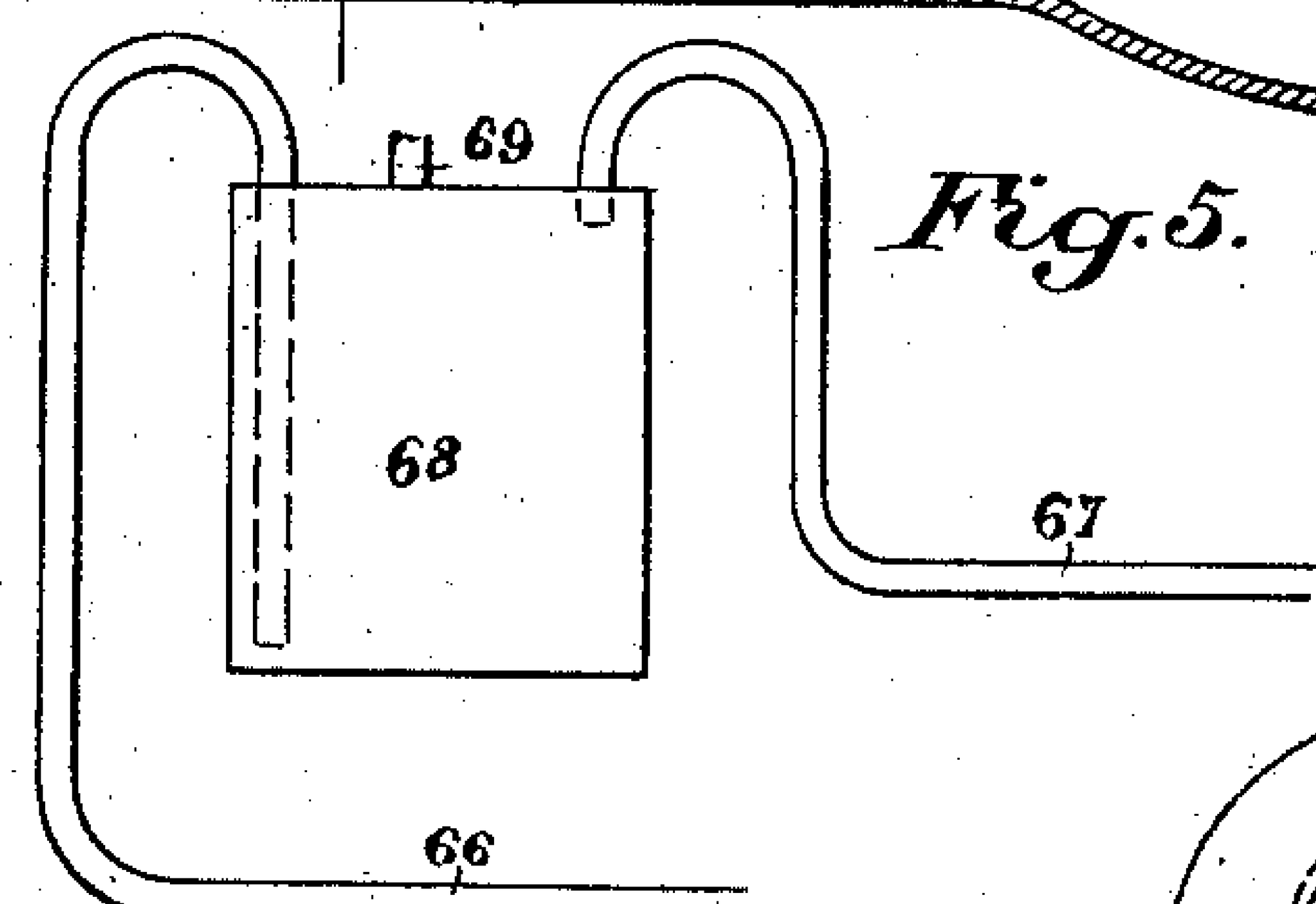


Fig. 4.

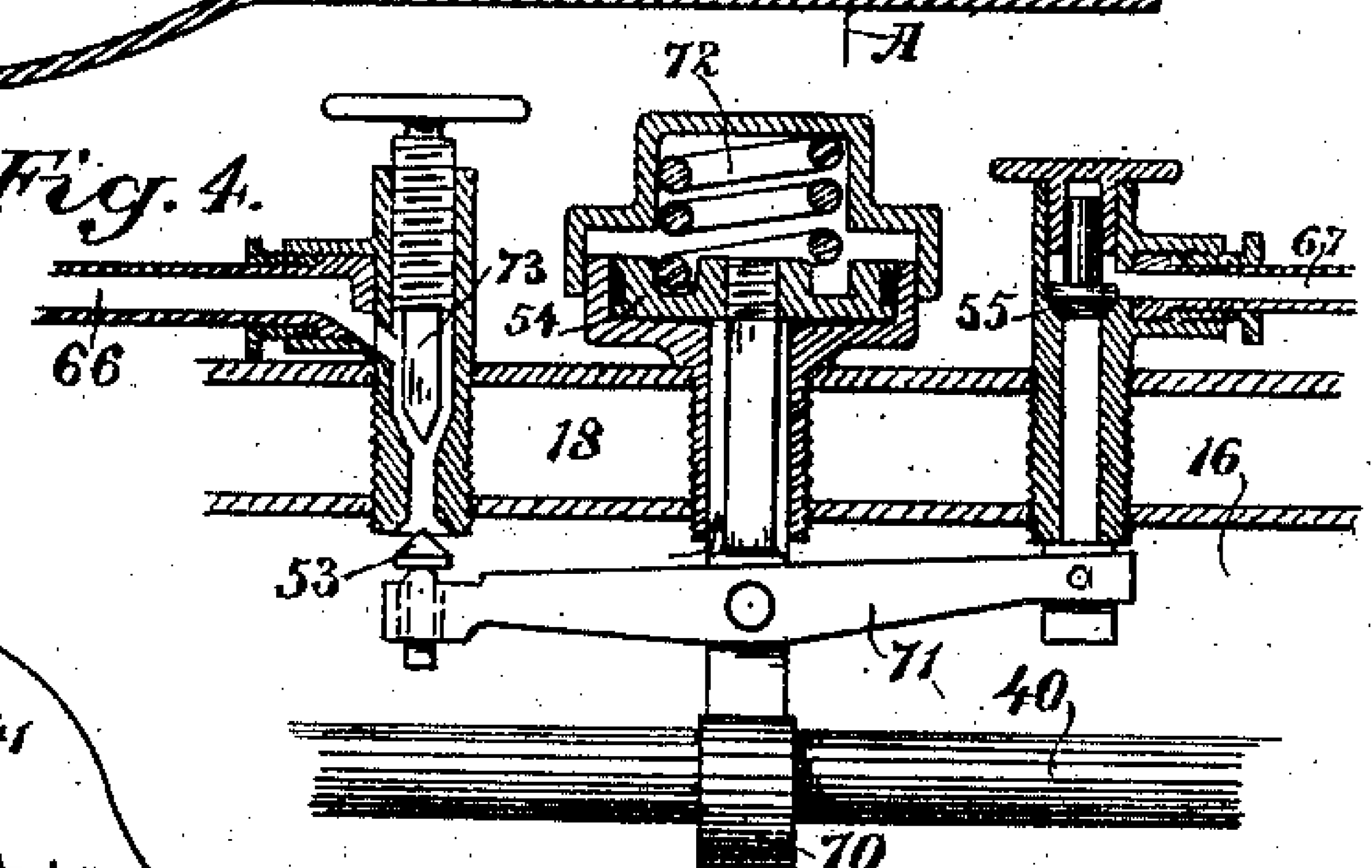


Fig. 3.

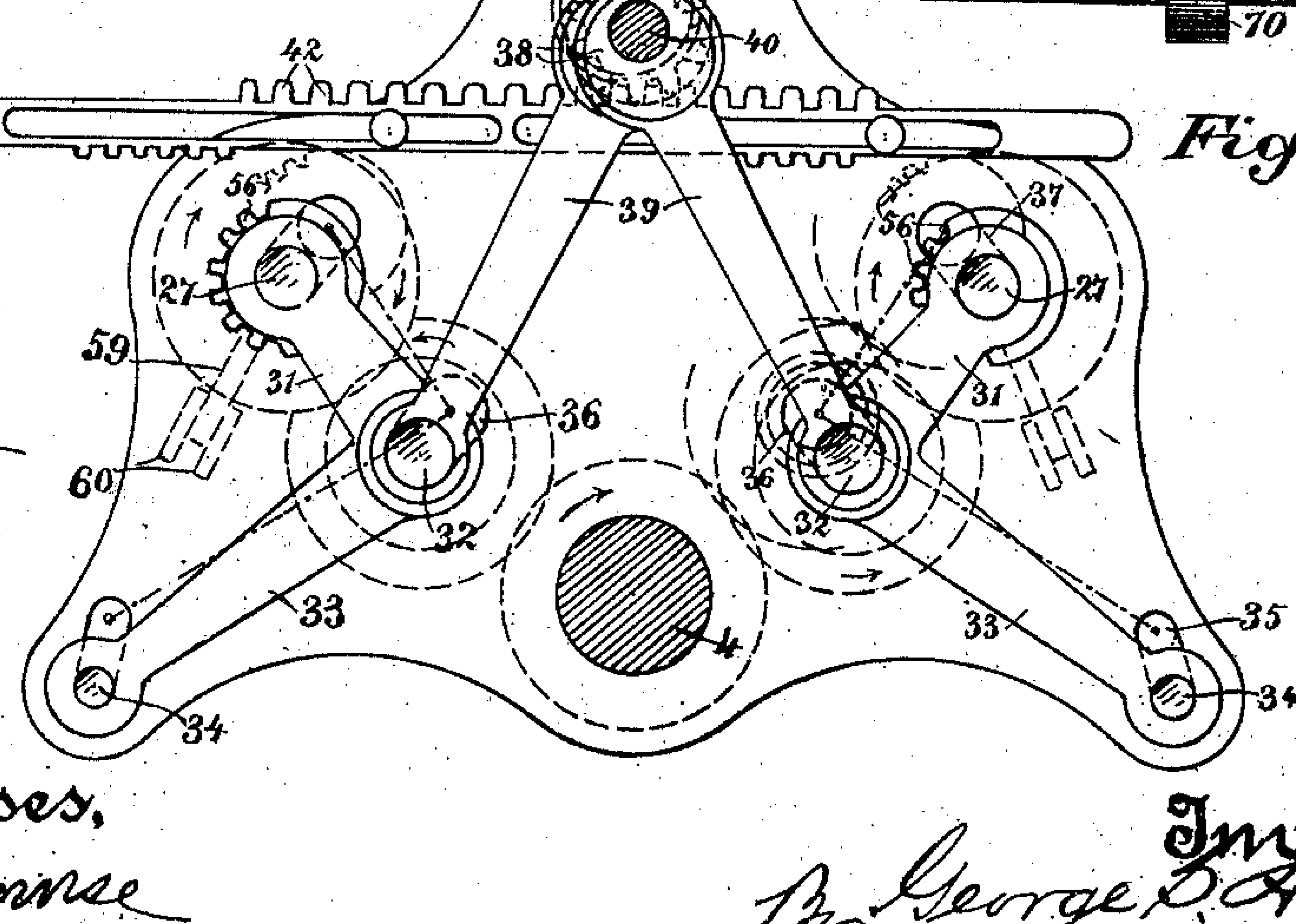
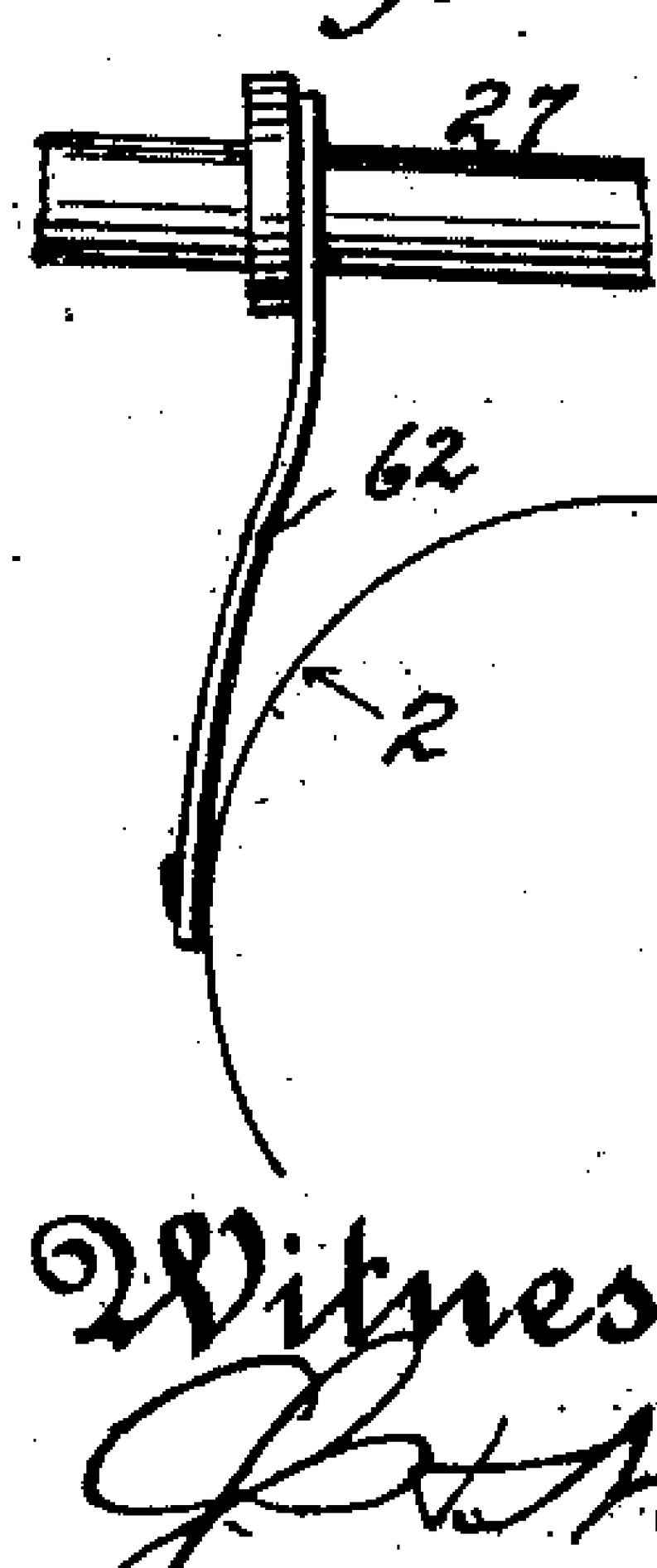


Fig. 6.



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UNITED STATES PATENT OFFICE.

GEORGE S. ANDRES, OF SAN FRANCISCO, CALIFORNIA, ASSIGNOR TO OCTOMOBILE COMPANY, OF SAN FRANCISCO, CALIFORNIA, A CORPORATION OF CALIFORNIA.

MULTIPLE-CYLINDER EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 706,711, dated August 12, 1902.

Application filed December 18, 1899. Renewed May 15, 1902. Serial No. 107,469. (No model.)

To all whom it may concern:

Be it known that I, GEORGE S. ANDRES, a citizen of the United States, residing in the city and county of San Francisco, State of California, have invented an Improvement in Multiple-Cylinder Explosive-Engines; and I hereby declare the following to be a full, clear, and exact description of the same.

My invention relates to improvements in that class of engines which are actuated by successive explosions of gas or vapor in such a manner as to propel the pistons of the engine.

The object of the invention is to provide for an application of the explosive forces which will transmit the power of the engines to a crank-shaft common to all the cylinders in such succession that frequent impulses will be given to the shaft at regular intervals during the period of its rotation, and the vibration due to the four-cycle one, two, three, or four cylinder motors is avoided, thus dispensing with the usual fly-wheel.

My invention consists of the parts and the constructions and combinations of parts which I shall hereinafter describe and claim.

Figure 1 is a plan view and partial section of my apparatus. Fig. 2 is a longitudinal and vertical section of two cylinders and connected parts transverse to the shaft. Fig. 3 is an end view. Fig. 4 is a sectional view of oil, governor, and pressure valves. Fig. 5 is a view of oil-tank and pipe connections. Fig. 6 is a detail view of the spring 62.

In the use of four-cycle explosive-engines four strokes of a reciprocating piston and two complete revolutions of the shaft are made for each explosive impulse, and this causes a vibration which is greatly increased as the diameter of the cylinder and power of the engine are increased, so that the application of this class of engines to propel carriages and the like is accompanied by constant and disagreeable vibrations and the unequal application of power. The use of two or four cylinders as commonly applied but partially overcomes this difficulty by reason of the impulses not being synchronous.

In my invention I so dispose a series of eight cylinders, singly or in pairs, and connect them with a common crank-shaft that the impulses of the explosions are applied through their cranks to the shaft, so that there is one impulse to each quarter-revolution of the shaft.

As shown in my invention, I have a bed-plate A, common to two of the cylinders 2, which are arranged in pairs, each pair standing opposite to each other, and two pairs of four of the cylinders being arranged in a group thus form two groups of cylinders which are separated from each other sufficiently to admit the driving-gear sprocket or pulley 3 being fixed upon the common power and crank shaft 4 at any point intervening between the two groups of cylinders or as shown in plan view. The cylinders are preferably cast with permanently-closed outer ends, and access is had to them by disconnecting their central connections and sliding them rearwardly until they are clear of their pistons.

The pistons 5 of each opposing pair of cylinders are so formed as to move in unison, and the connecting-webs are slotted longitudinally, as shown at 6, so that the shaft 4 passes through all of these webs, and it has cranks 7 fixed upon or formed with it in such relation to each other that the crank with which one pair of pistons are connected may be at right angles with the next pair, directly opposite to the third pair, and at right angles with the fourth pair, which is again opposite the crank of the second pair. A bar or plate 10 extends from the crank-pin 9 to the pin 11, which is connected with each pair of pistons, and this bar has its ends fitted to partially inclose the pins. Segmental brasses 12 fit around the pins and form the journal-boxes therefor. Around the whole structure of the bar or plate 10 and the segmental brasses 12 passes a steel or other suitable endless band or strap 13, and through this band passes a bolt 14 with a nut 15 upon the opposite end. A pipe *a* incloses the bolt, and its ends abut against the inside of the band. The nut 15, being screwed upon the bolt, draws the two sides of the band 13 toward each other and correspondingly tightens it upon the parts 10 and 12, so that they are held in close contact

with their respective pins. The tube or distance-piece *a* acts as a stop to limit the approach of sides of the band 13. Whenever by reason of wear it is necessary to make any adjustment, the nut 15 is loosened and the tube *a* shortened and the nut 15 again tightened, which will draw the band a little tighter and will thus close up the brasses with relation to the pins and compensate for any wear which may have taken place at these points.

The arrangement of the inlet-valves of the cylinders is such that the pistons will have completed the movements necessary to charge one cylinder with compressed explosive vapor at each quarter-revolution of the crank-shaft. Thus there will be a continuous succession of impulses applied through the cranks to this shaft with a resulting great steadiness of operation.

In order to supply the explosive gas or vapor, I have shown a cylindrical generator 16, having pipes 17 leading from it to the ends of the engine-cylinders 2, with suitable means for regulating the supply of gas which enters the cylinders, which will be hereinafter described. Surrounding the generator-chamber 16 is an exterior chamber 18, into which the exhaust-passages 19 from the cylinders discharge, so that there will be a constant accession of the hot exhaust products from the cylinder to surround the inner chamber 16. Any suitable hydrocarbon liquid for the purpose is delivered into the cylinder 16 from a suitable tank or source of supply. If crude petroleum-oil is employed, it is supplied by a pump and by its own pressure when heated in chamber 16 in proportion sufficient for the use of the cylinders. The vapor or gas produced within the chamber 16 will always be under a certain regulated pressure, the supply of liquid being regulated so as to keep up the desired pressure by regulating-valves 53 55 and pressure device 54. The gas passing through the passage 17 is admitted to the engine-cylinder 2 by the opening of a valve 20, which is here shown in the form of a puppet-valve seated in its chamber and opened periodically and at the proper interval by cams 21, which are driven from the engine-shaft, as will be hereinafter described. The stem 22 of the valve 20 has its inner end so formed that the cam 21 will act to force the valve 20 open, so that as the piston 5 recedes from the rear end of the cylinder it will draw air in through the passage 23, and at the same time a charge of gas passing through the passage 17 and into the hollow valve-stem 22 is delivered outwardly against the beveled face of the valve 20 through radial passages 24 and mingle with the air which is being drawn in through 23, so as to form an explosive mixture. The rate of admission of gas is regulated by means of a valve 25, which may be of any suitable description. In the present case it is shown as conical and may be seated so as to entirely close the passage through the valve-stem 22 or may be opened to admit any desired amount of gas, depending upon the pressure and the requirements of the engine. The regulating-valve 25 is adjusted from the outside of the valve-chamber through an opening, (shown at 26.)

The valve 20 is in the form of a piston extending backwardly from its beveled seat-face, and as this piston fits closely within the chamber in which it slides and is fitted with packing-rings there will be no escape of gas or vapor. Through the rear of the valve-chamber cover a hole 26 is bored to give free action of valve-piston and prevent compression of gases in back of valve-chamber.

The operation of the cam 21 of each cylinder is produced by a cam-shaft 27, upon which a cam is mounted so as to turn loosely; but a lug 28 contacts against the shoulder 29 and holds the cam 21 in its proper position as long as it is rotating in a direction to open the admission-valve at the proper intervals, but allows the cam to turn faster than the shaft on closing or at the last part of its revolution. The cam-shaft 27 is driven by gearing from one end of the main shaft, this gearing being so proportioned and connected as to rotate the cam-shafts in proper relation with the movements of the various pistons.

The arrangement of the gears is well shown in Fig. 3.

If it is desired to change the force of explosion or quantity of gas admitted, it is effected by means of bell-crank levers on each end of the engine. In the arms 31 of these levers the ends of the cam-actuating shaft are journaled. The angle of this lever is fulcrumed to one of the gear-pins 32, and the other arm 33 of the lever has a pin 34, which is slidable in a slot 35. The gear-pin 32 is movable in an arched slot 36, the curvature of which is about the radius of the crank-shaft, and the cam-shaft 27 is movable transversely to its length in a slotted channel 37 to vary the amount of gas admitted and the exhaust and also lengthwise to bring a different set of cams in line with each valve-stem to reverse the engines. The pins 32 are connected with eccentrics 38 by eccentric-rods 39. The eccentrics 38 are mounted upon each end of a shaft 40, which carries a pinion 41, and the pinion is engaged by a guided slidable rack 42. This rack is connected with an actuating-lever within convenient reach of the engineer or operator, and when the rack is moved in one direction it rotates the shaft 40 and the cams 38, so that through the eccentric-rods 39 the pins 32 will be moved in their slots 36, thus acting upon the arms 33 and 31 of the bell-crank lever to cause the pin 34 to move along the slot 35, and by this compound movement the cam-shaft 27 is correspondingly moved in its channel 37, thus moving the cam 21 with relation to the valve-stems 22 and causing them to vary the opening and closing of the valves. It will be manifest that such a movement will cause the cam to open the valve less in proportion as the cam has moved away and

more as it is brought nearer. When the engine is to be reversed, it is done by moving the cams entirely out of contact with the valve-stems.

The rack 42 engages with the two pinions 56 on the outer ends of shafts 27, which contain a certain number of teeth, as shown, and there is an incline 57 projecting inwardly and pressing against the collar 58, also loose on shaft 27 and held in position by the tailpiece 59 and side blocks 60, which prevent collars 58 from turning. The loose collars 58 bear in turn upon collars 61, which are a part of cam-shaft 27. As the rack is moved back on reaching the center of its run the teeth 42 engage with the teeth on pinions 56 and cause them to turn, bringing the two beveled surfaces 57 and 58 in contact, causing the collars 61 to be forced back, thereby moving the cam-shaft lengthwise and bringing the reverse set of cams 65 in front of the valve-stems. The cam-shaft 27 is forced back to its former position by spring 62, (see Fig. 6,) when the rack is run forward again. The exhaust-valves 30 are suitably placed with relation to the inlet-valves and ends of the cylinders and are operated similarly to the admission-valves by cams 43, mounted upon cam-shaft 27, which is revolved by suitable gears or connections with the main engine-shaft, and when the engine is reversed the cams which actuate the exhaust-valves are operated similarly to those of the inlet-valves and firing-pins 45.

All the valves are closed against their seats after the cams pass by springs 44, which press upon the backs of the valves, as shown.

The igniting devices consist of slidable insulated pins 45, which are normally pressed inward by springs 46. These pins are slidable through metallic sleeves or guides, which are surrounded by insulating material 47. Upon the outer ends of the pins 45 are fixed the metallic disks 48, against which the springs 46 press, with insulating material under said disks. Through these insulating-disks and in no way connecting them with the metallic connection a pin 49 passes into the pin 45, and one conducting-wire connects with this pin 49 and any suitable electrical spark-generating device. The other electrical conducting-wire is attached to some part of the engine and the above-mentioned electrical device.

50 is a pin slidable in line with the pin 45 and actuated by a cam which presses periodically against its inner end, forcing it out and into contact with 45 at about the instant when the gas has been compressed in the cylinder in readiness for an explosion. At the proper instant the pin 50 recedes by the action of spring 63, the pin 45 following it by the action of the spring 46 until the pin 45 is seated, when the pin 50 separates from it and produces the igniting-spark.

In order to prevent the coating of the contact ends of the pins with carbon and to keep them bright, so that perfect contact is formed, the spark will be produced. The pin 45 has a spiral slot 51, which is slidable upon a pin 52, which projects into the slot, and when the pin 50 contacts with 45 and pushes it outwardly 45 will rotate and the friction between the ends of the two pins will keep them bright.

The cam-shaft 27 turns one revolution to two of the crank, and it is designed that the cam shall open the valve to admit gas to follow the piston one-half of the stroke. When the lug 28 is in contact, so that the revolution of the cam-shaft advances the cam, the latter moves to a point where it fully opens the valve, and as it passes the line of movement of the valve the spring 44, acting against the valve, suddenly turns the cam forward by reason of its being loose upon the shaft, and thus allows the valve to close quickly.

68 is a tank with an inlet-pipe 69. Pressure to start may be furnished by an air-pump or other means, and this forces the liquid through pipe 66 and valve 53 when the latter is opened. This valve is normally closed and is connected with the governor-piston 54 and the check-valve 55. The valve 55 when opened allows pressure from the generator 16 to be transmitted through the pipe 67 to the tank 68, thus furnishing the necessary pressure to supply oil to the generator while the engine is running. When the engine is shut off, by turning the shaft 40 until the cam-shafts 27 have been shifted to a point intermediate between the forward and reverse positions the eccentric 70, which is mounted upon the shaft 40, pushes up the bar 71, which is connected with valve 53 and governor 54. This movement closes valve 53 and pushes the governor-piston 54 up against the tension of the spring 72.

When the engine is to be started, the shaft 40 is turned and the eccentric allows the bar 71 to come down and allow the valve 53 to open unless the pressure in 16 is sufficient to keep it closed by a pressure upon the governor-piston 54 sufficient to overcome the tension of spring 72.

73 is a manually-operated throttle or shut-off valve. This being open and there being sufficient pressure in the tank 68 oil will flow through pipe 66 and valve 53 to the generator 16, where it is converted into gas, which passes to the engine-cylinders, as previously described. If the pressure increases too much in the generator, it will force the governor-piston 54 up and through the fulcrumed arm 71 will close the inlet-valve 53 until the pressure again falls.

The valve 55 is normally seated and closed by pressure through pipe 67 from tank 68; but a greater pressure in the generator will open it and replenish the pressure in 68, so as to maintain it comparatively steady.

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

1. In an explosive-engine, four pairs of oppositely-placed cylinders, pistons fitting each

pair of cylinders having an intermediate uniting web whereby they are movable in unison, a crank-shaft extending between the adjacent ends of said cylinders, having cranks at each ninety degrees of the circumference of the shaft, connecting-rods uniting each pair of pistons with one of the cranks, valves and mechanism including cam-shafts and cams loose thereon and adapted to engage the shafts by which an explosive mixture is admitted and compressed into each cylinder, means for igniting the explosive mixture successively in the cylinders whereby an impulse is given to the crank-shaft at each quarter of its revolution.

2. In an explosive-engine, four pairs of oppositely-placed cylinders lying in the same plane, an intermediate shaft with cranks at angles of ninety degrees with each other, connections between the pistons and said cranks, inlet and exhaust valves whereby an explosive mixture is admitted to each cylinder successively, and the waste products exhausted therefrom, cam-shafts and cams loose thereon and adapted to engage the shafts to open said valves.

3. In an explosive-engine, a plurality of cylinders disposed in pairs in the same horizontal plane, an intermediate crank-shaft, pistons in each cylinder connected and movable in unison, connections between said pistons and the cranks, spring-pressed admission and exhaust valves, cam-shafts and cams loosely mounted thereon and engaging shoulders on the shafts, mechanism by which said shafts are revoluble whereby the inlet and exhaust valves are opened successively, and mechanism for adjusting the position of the cams and regulating the opening of the valves.

4. In an explosive-engine, a plurality of cylinders, standing in a common plane and disposed in pairs opposite to each other, pistons in said cylinder connected to move in unison, connecting-rods between each pair of pistons and the crank common thereto, spring-closed inlet and exhaust valves, cam-shafts having shoulders and cams loose on the shafts and engaging said shoulders by which said valves are alternately opened, a generator and connection between it and each inlet-valve chamber whereby gas is admitted when the valve is opened, and an air-inlet passage through which air is drawn to mix with the gas by the receding piston when the valve is opened.

5. In an explosive-engine, a plurality of cylinders lying in a common plane in pairs, each pair having the pistons connected with each other and with a crank-shaft common to all so as to move in unison, admission and exhaust valves and cam-shafts and cams loose thereon by which the valves are actuated, and mechanism for moving the shafts and cams to or from the valve-stems, by which said valves are regulated, a generator, means for supplying hydrocarbon liquid thereto, an exterior casing surrounding said generator and connected with the exhaust-passages of the engine, and passages leading from the generator to the inlet-valves.

6. In an explosive-engine, a plurality of cylinders disposed in pairs opposite to each other and in a common plane, a crank-shaft extending between the adjacent ends of the cylinders and connections between the cranks and the pistons whereby each pair of pistons moves in unison within their cylinders, inlet and exhaust valves with passages through which gas and air are admitted to form an explosive, and means for operating the valves including cam-shafts having shoulders and cams loose on the shafts and engaging said shoulders.

7. In a gas-engine and in combination, cylinders lying in the same plane, with pistons connected in pairs, a shaft extending between the adjacent ends of the cylinders having cranks set at angles with each other and connections between each pair of pistons and one of the cranks, admission and exhaust valves, shafts having cams loosely mounted thereon and shoulders whereby the cams are caused to turn with the shafts to open the valves, said cams turning freely upon the shaft after passing the point at which the valves are fully opened whereby the valves are allowed to close instantaneously.

8. In a gas-engine and in combination with cylinders, pistons movable therein, a shaft intermediate of the cylinders, and cranks with which the pistons are connected in pairs, inlet and exhaust valves, shafts with cams thereon whereby the valves are opened, said cams being movable upon the shafts to allow the valves to close after being fully opened, supports in which the cam-shafts are journaled and mechanism by which they and the cams are moved to or from the valve-stems to vary the opening of the valves.

9. In a gas-engine and in combination, cylinders, pistons movable therein, a crank-shaft with which the pistons are connected, admission and exhaust valves for the cylinders, shafts having cams mounted thereon by the revolution of which the valves are opened, supports in which the cam-shafts are journaled, fulcrumed lever-arms by which said supports are carried, a shaft with eccentrics fixed thereon and connections between the eccentrics and the lever-arms, whereby the turning of the shaft moves the arms and the cam-shafts to vary the position of the cams with relation to the valve-stems, and a mechanism by which the eccentric-shaft is rotated.

10. In a gas-engine and in combination, cylinders having pistons movable therein, a crank-shaft with which the pistons are connected to move in unison, admission and exhaust valves, cams mounted upon shafts and adapted to open and close the valves, fulcrumed lever-arms carrying the journals of the cam-shafts and guides for the movements of said arms, a shaft carrying eccentric-rods

connecting with the fulcrums of the levers whereby they are movable, a pinion upon the eccentric-shaft, a slidable rack engaging the pinion whereby the shaft is rotated to vary the positions of the lever-arms and the cam-shafts carried thereby.

11. In a gas-engine and in combination, cylinders having pistons movable therein, a crank-shaft with which the pistons are connected to move in unison, inlet and exhaust valves, cam-shafts and cams mounted thereon adapted to engage the valve-stems and open the valves when the crank-shaft is turned in one direction, other cams mounted upon the shafts and adapted to open the valves so as to reverse the movement of the crank-shaft, journal-boxes for the cam-shafts, beveled or inclined cams carried upon the shafts and a mechanism whereby said cams are moved so that the cam-shafts are caused to slide in the line of their axis and change the positions of the valve-actuating cams to reverse the engine.

12. In a gas-engine and in combination cylinders, pistons movable therein, a crank-shaft with which the pistons are connected, inlet and exhaust valves, shafts having two sets of cams mounted thereon, one set adapted to open the valves to rotate the crank-shaft in one direction, and the other to open the valves to rotate the shaft in the opposite direction, journal-boxes in which the cam-shafts are slidable longitudinally whereby the cams are moved to reverse the movements of the valves and engine, mechanism consisting of a slidable rack-bar, pinions upon the cam-shafts with which said rack engages when moved, and inclined cams mounted upon the cam-shafts so that their faces engage when the shafts are rotated and the cam-shafts are moved longitudinally to change the engagement of the valve-actuating cams.

In witness whereof I have hereunto set my hand.

GEORGE S. ANDRES.

Witnesses:
GEO. H. STRONG,
S. H. NOURSE.