J. E. FRIEND.

ROTARY GAS ENGINE.

APPLICATION FILED AUG. 5, 1907.

913,635.

Patented Feb. 23, 1909.

6 SHEETS—SHEET 1.

FIG. 1.

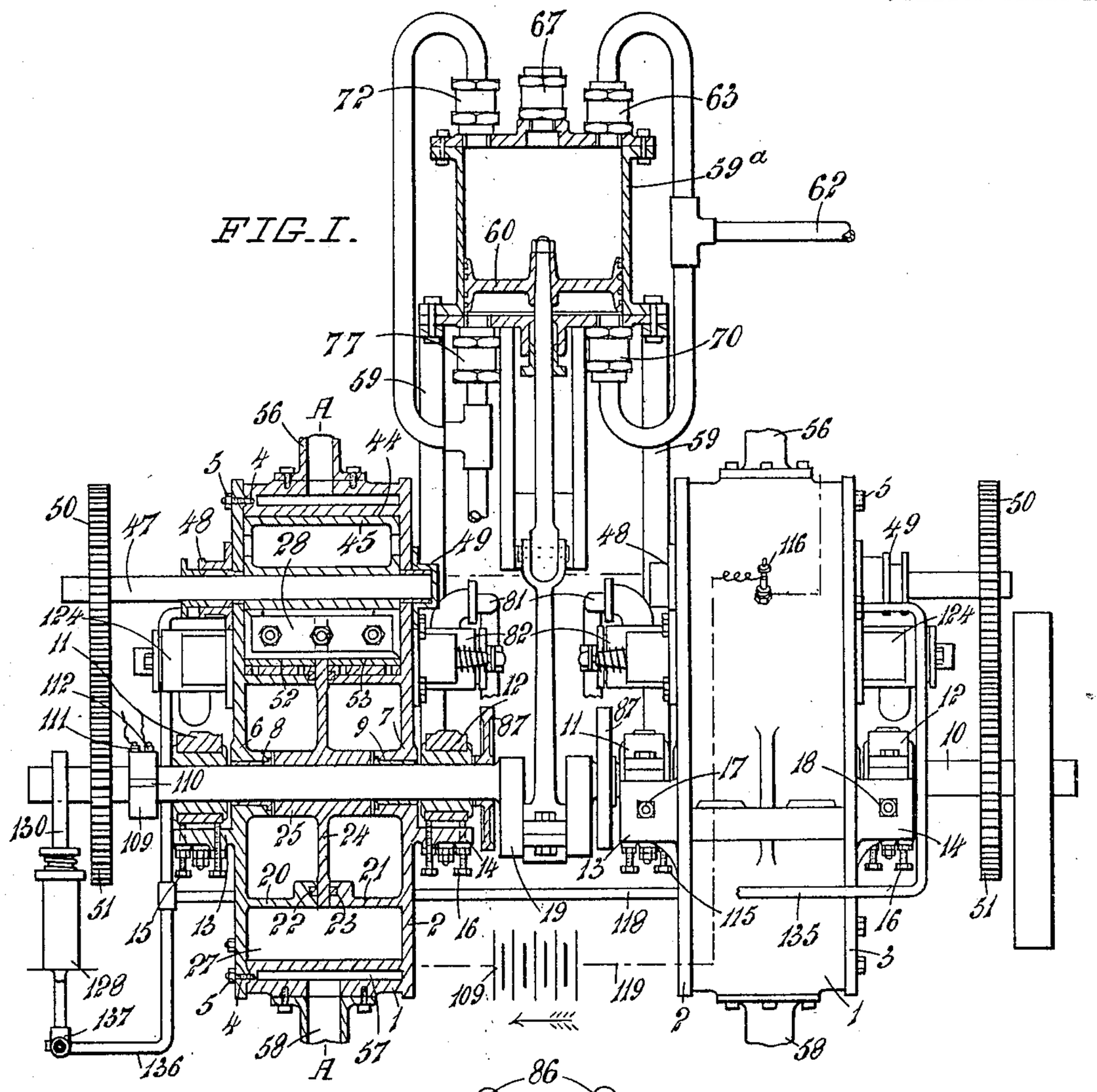


FIG. 3.

Witnesses:

Otis M. Milton

Sydney H. Higgs

Inventor.

George Edward Friend

by Baldwin & Hayward

Attorneys.

J. E. FRIEND.

ROTARY GAS ENGINE.

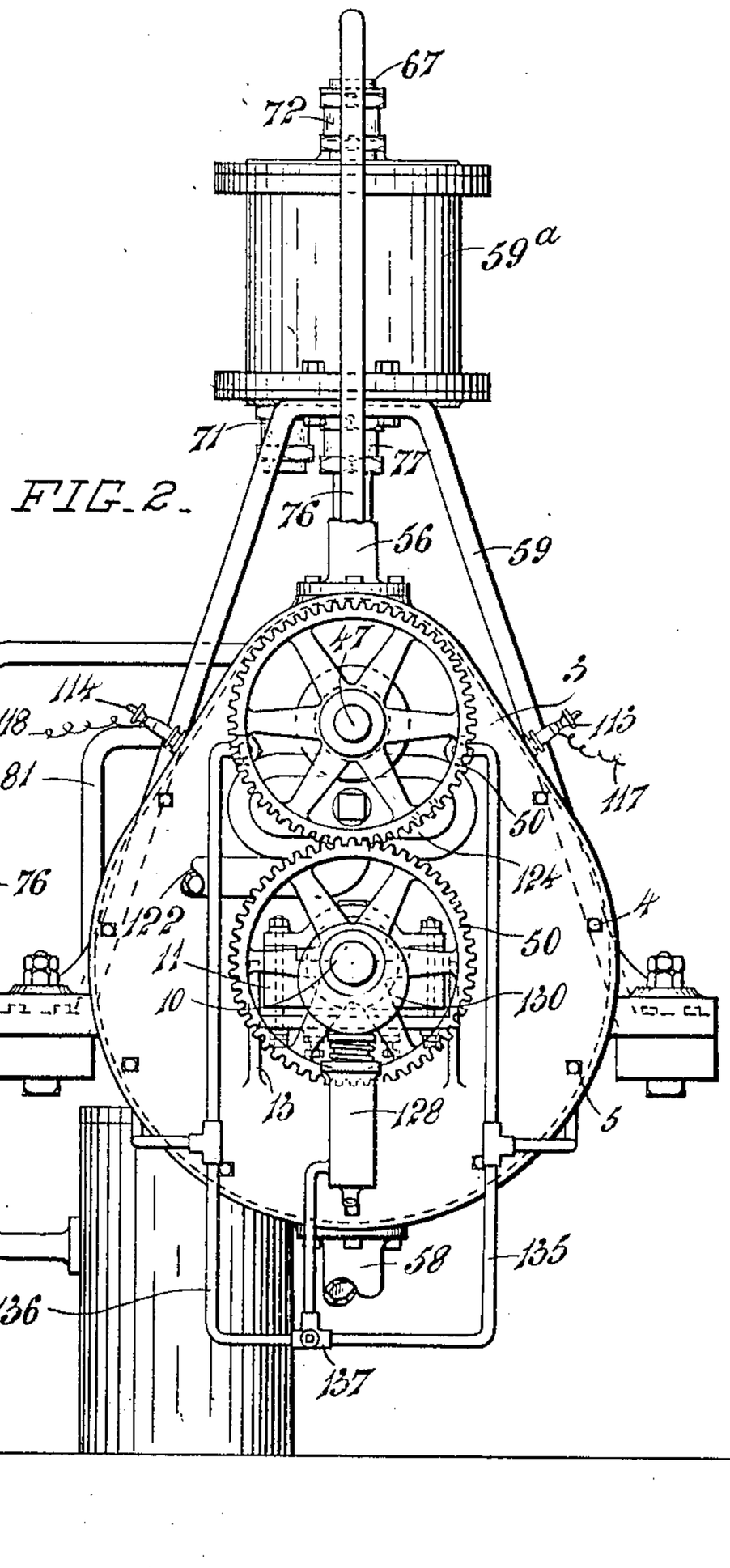
APPLICATION FILED AUG. 5, 1907.

913,635.

Patented Feb. 23, 1909.

6 SHEETS—SHEET 2.

FIG. 2.



Witnesses:

Otto M. Miller

Sydney H. Higgs.

Inventor:

George Edward Friend.

by Baldwin & Hayward.

Attorneys.

J. E. FRIEND.

ROTARY GAS ENGINE.

APPLICATION FILED AUG. 5, 1907.

913,635.

Patented Feb. 23, 1909.

6 SHEETS—SHEET 3.

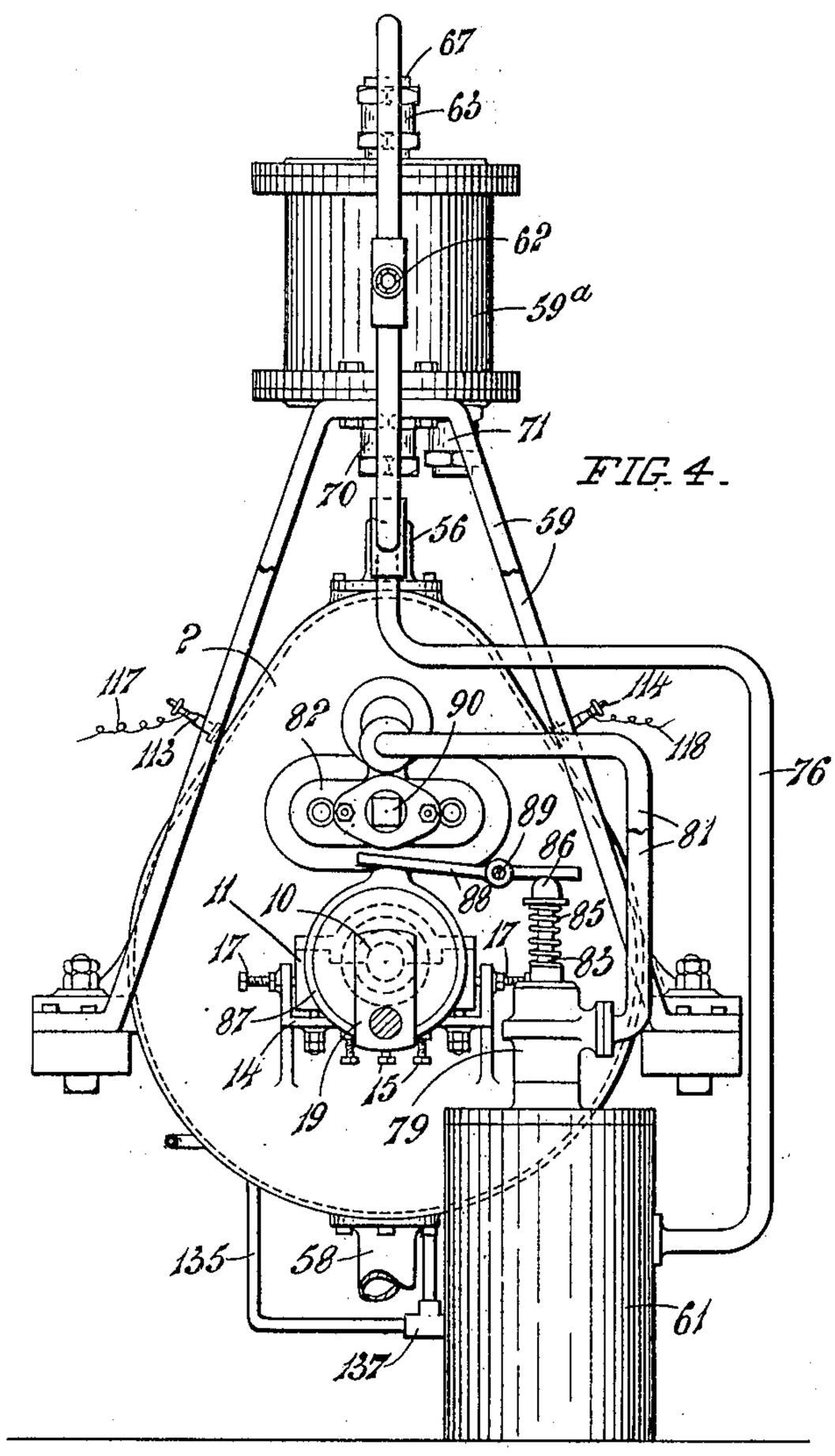


FIG. 4.

Witnesses:

Alb. M. Milton

Sydney A. Higgs

Inventor.

George Edward Friend

by Baldwin & Hayward

Attorneys.

J. E. FRIEND.

ROTARY GAS ENGINE.

APPLICATION FILED AUG. 6, 1907.

913,635.

Patented Feb. 23, 1909.

6 SHEETS—SHEET 4.

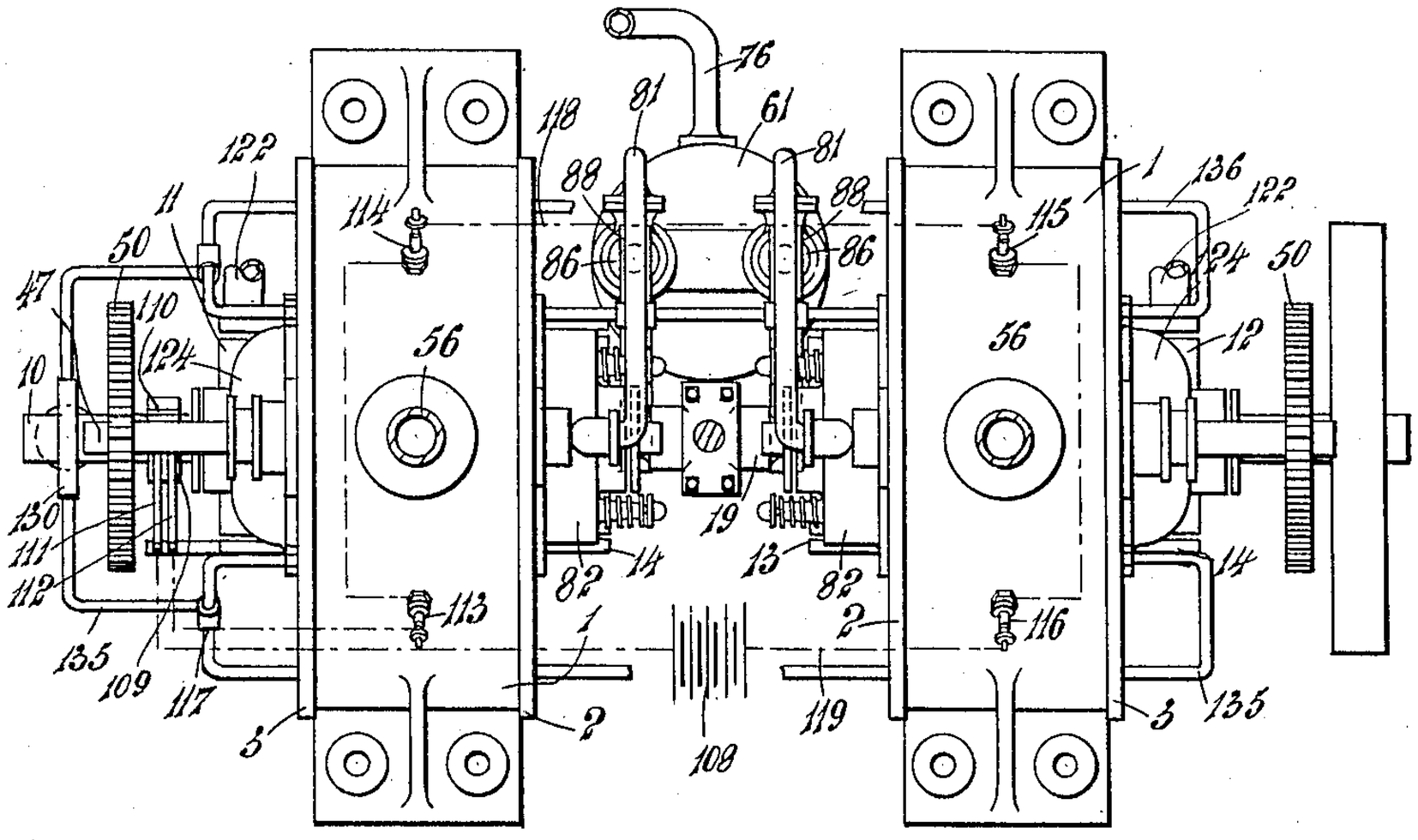


FIG. 5.

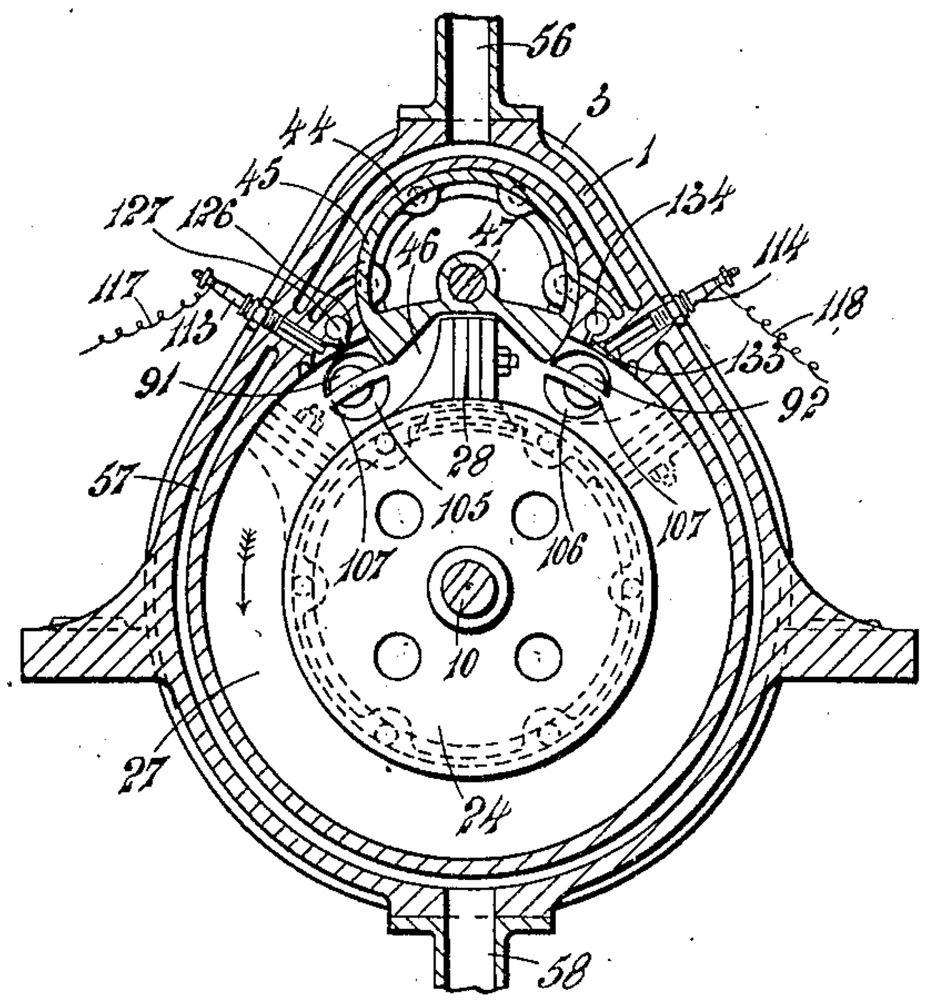


FIG. 6.

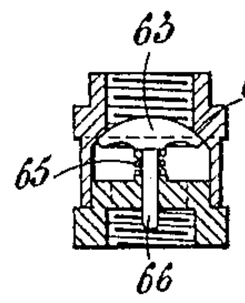


FIG. 7.

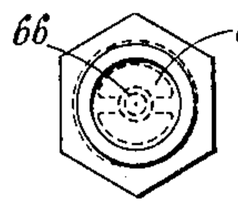


FIG. 8.

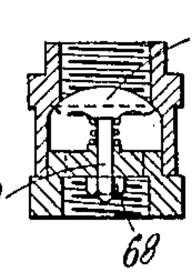


FIG. 9.

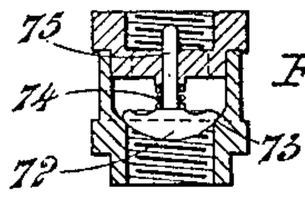


FIG. 10.

Witnesses:

Otto M. Wilton

Sydney H. Higgs

Inventor:

George Edward Friend

by Baldwin & Hayward

Attorneys.

913,635.

J. E. FRIEND.

ROTARY GAS ENGINE.

APPLICATION FILED AUG. 5, 1907.

Patented Feb. 23, 1909.

6 SHEETS—SHEET 5.

FIG. 11.

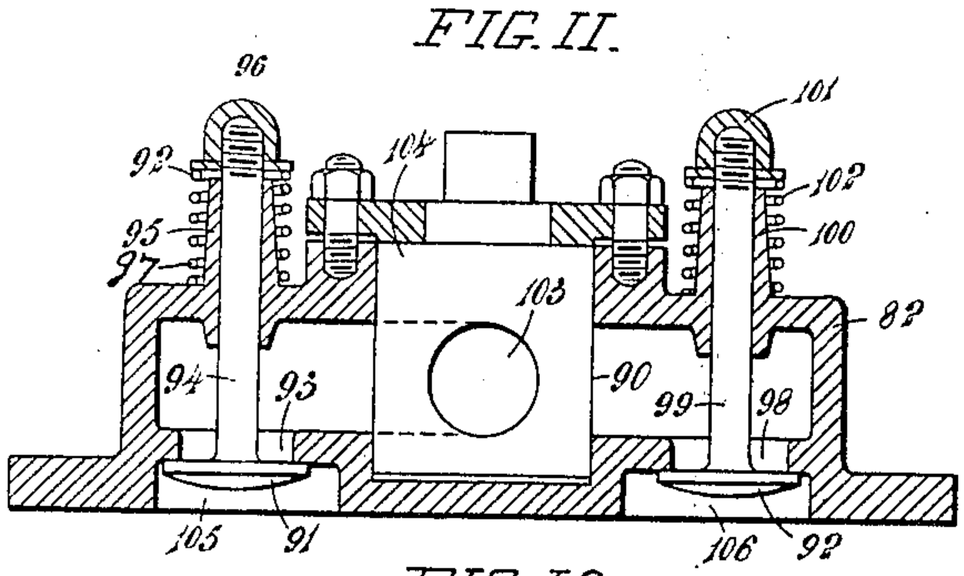


FIG. 12.

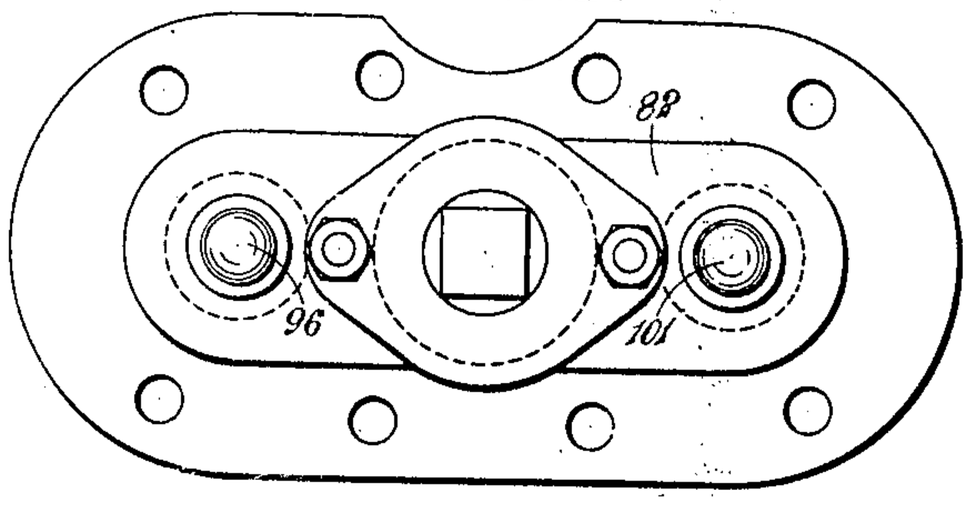


FIG. 13.

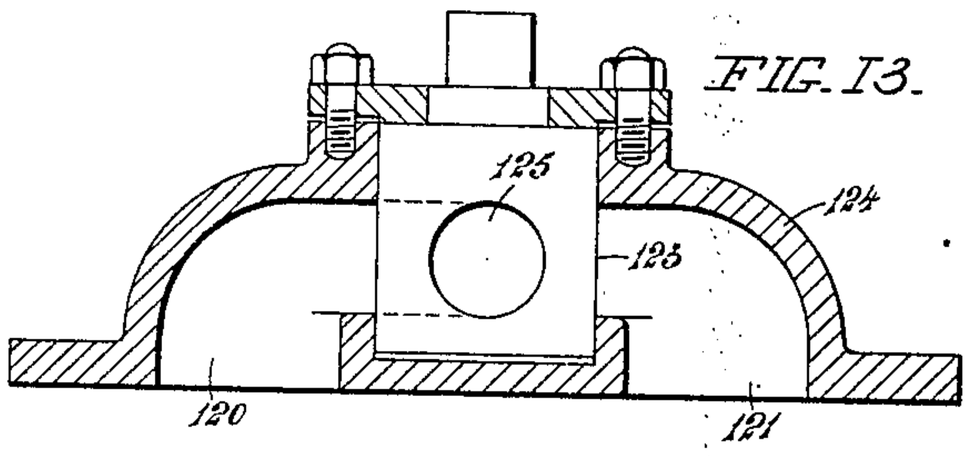
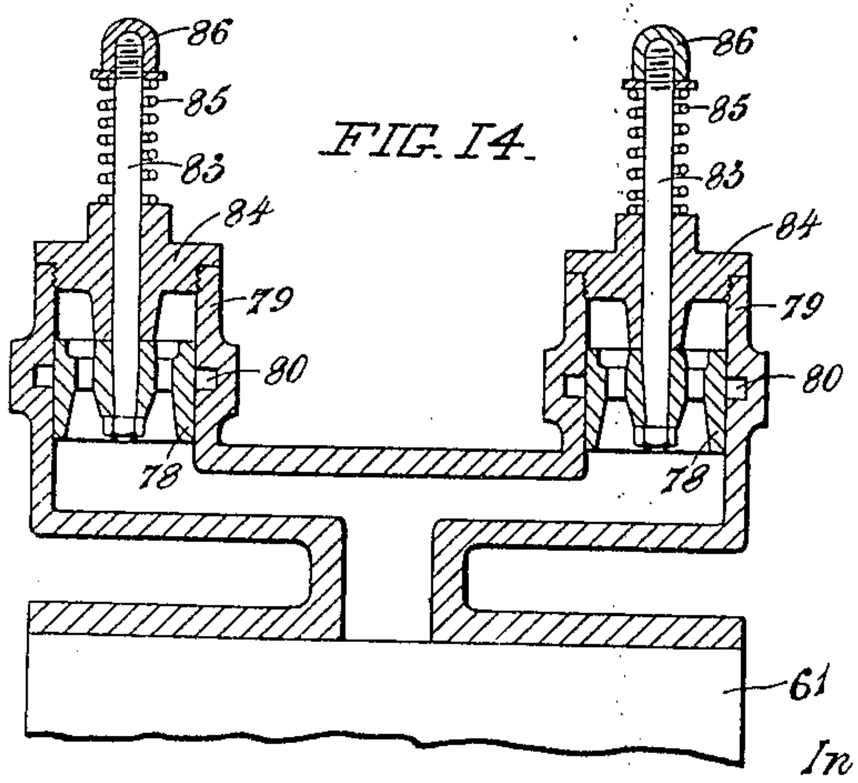


FIG. 14.



Witnesses:
Otho M. Milton
Sydney H. Riggs

Inventor.
George Edward Friend
by Baldwin & Raymond
Attorneys.

J. E. FRIEND.

ROTARY GAS ENGINE.

APPLICATION FILED AUG. 6, 1907.

913,635.

Patented Feb. 23, 1909.

6 SHEETS—SHEET 6.

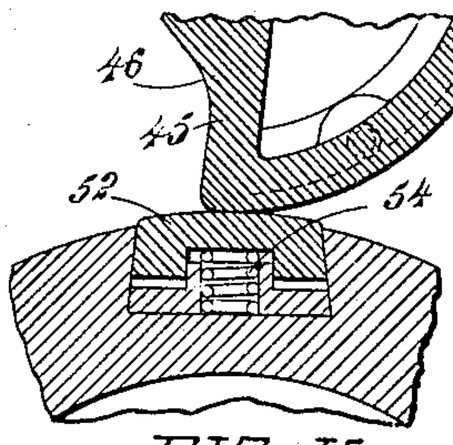


FIG. 15.

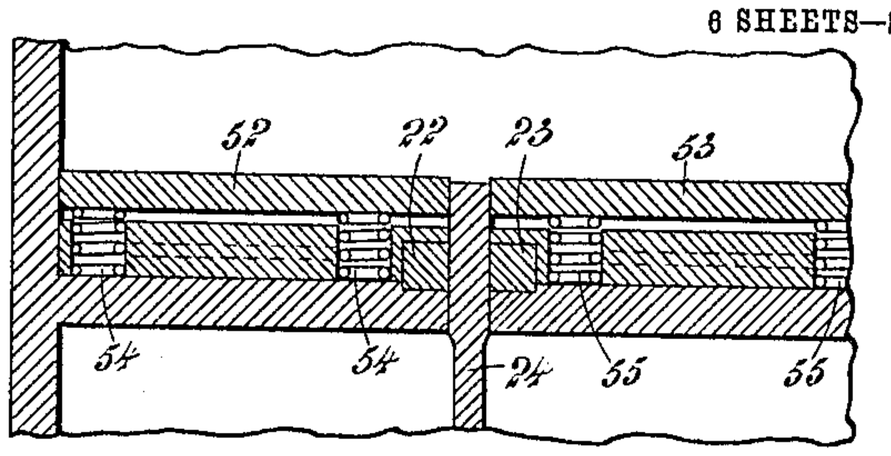


FIG. 16.

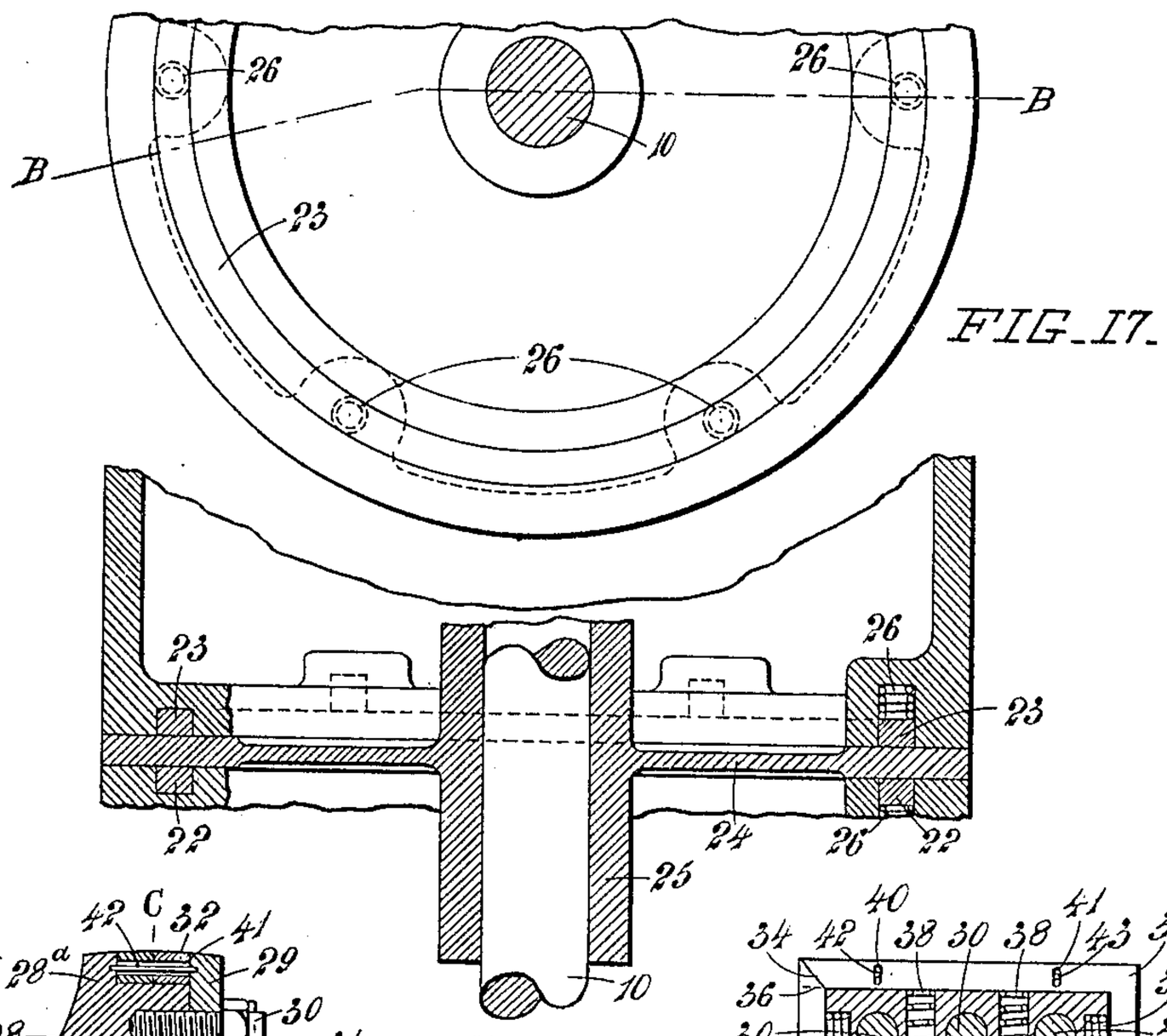


FIG. 17.

FIG. 18.

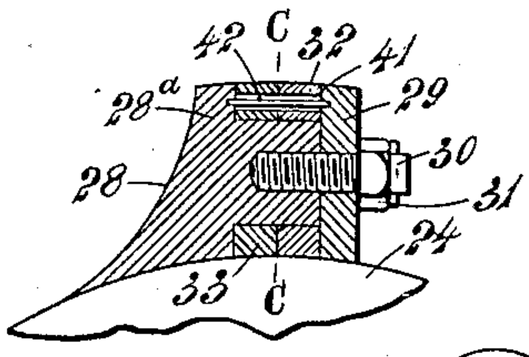


FIG. 19.

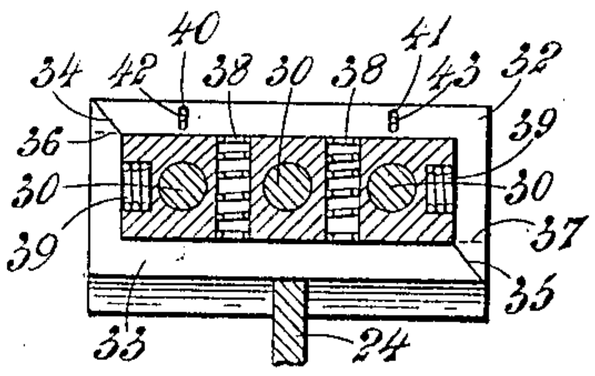


FIG. 20.

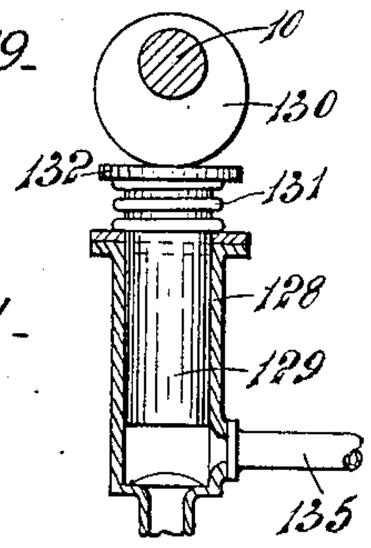


FIG. 21.

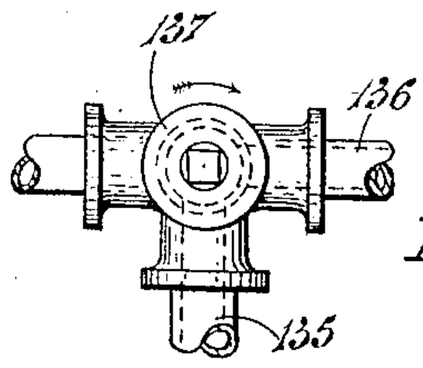


FIG. 22.

Witnesses:

Otho Milton

Sydney A. Biggs

Inventor.

George Edward Friend

by Baldwin & Hayward

Attorneys.

UNITED STATES PATENT OFFICE.

JOHN EDWARD FRIEND, OF WELLINGTON, NEW ZEALAND.

ROTARY GAS-ENGINE.

No. 913,635. Specification of Letters Patent. Patented Feb. 23, 1909.

Application filed August 5, 1907. Serial No. 387,032.

To all whom it may concern:

Be it known that I, JOHN EDWARD FRIEND, a subject of His Majesty the King of Great Britain and Ireland, residing at 71 Lambton Quay, Wellington, in the Colony of New Zealand, have invented a certain new and useful Improved Rotary Gas-Engine, of which the following is a specification.

The invention provides an engine having a revolving piston operated by an exploded mixture of gas and air.

According hereto a piston fixed upon the periphery of a disk revolves within an annular chamber. The explosive charge is admitted to the annular chamber between the piston and a cylindrical abutment provided with a groove or cavity which synchronizes in rotation with the piston and allows it to pass. The charge is then exploded and the force thereof causes the piston to make a rotation when the used gas is exhausted and a new charge taken in. The explosive charge is prepared by compressing gas and air in an independent receiver.

Referring to the drawings:—Figure 1 is a side elevation partly in section, Fig. 2 an end elevation, Fig. 3 a side elevation of a receiver, Fig. 4 an end elevation looking from the direction of the arrow Fig. 1. Fig. 5 a plan, Fig. 6 a central cross section on line A—A Fig. 1. Fig. 7 a sectional elevation of a gas valve Fig. 8 a plan Fig. 9 a sectional elevation of an air valve Fig. 10 a sectional elevation of an air and gas valve, Fig. 11 a sectional plan, Fig. 12 a front elevation of the valve chest, Fig. 13 a sectional plan exhaust chest Fig. 14 a sectional elevation of the receiver valves, Fig. 15 is a sectional elevation, Fig. 16 a longitudinal section of the contact bars, Fig. 17 a part end elevation of a circular wall, Fig. 18 a sectional plan on line B—B, Fig. 17 Fig. 19 a sectional elevation, and Fig. 20 a longitudinal sectional elevation of a piston on line C—C, Fig. 19, Fig. 21 a sectional elevation of a pump, and Fig. 22 is an elevation of a three way cock.

The circular casing 1 has an integral end 2 and has its other end closed by a cover 3 secured to the casing by studs 4 and nuts 5. Bearings 6 and 7 integral with the end 2 and cover 3 respectively are provided with bushes 8 and 9 through which a main shaft 10 passes. Bearings 11 and 12 supported upon brackets 13 and 14 integral with the end 2 and cover 3 respectively are adjustable vertically by means of set screws 15 and 16 and laterally by set screws 17 and 18. The shaft is thus capable of adjustment to be truly axial within the casing 1.

In the drawing I have illustrated a pair of engines mounted side by side as this construction provides a high effective form of the invention. The main shaft 10 has a crank 19 and is used for both engines, as the engines are similar I will describe one of them and use the same figures to indicate the corresponding parts of the other. Corresponding circular walls 20 and 21 respectively integral with the end 2 of the casing and cover 3 project towards each other. A disk 24 having a boss 25 is secured upon the main shaft 10 and fits accurately between the rims of the walls 20 and 21 a gas tight joint being made between these parts by the packing rings 22 and 23 in recesses in the rims of the walls and pressed upon the faces of the disk by springs 26. A piston 28, fitting the annular chamber 27 provided between the peripheries of the circular walls 20 and 21 and the casing 1 has a head 28^a integral with the disk 24, and a cover plate 29 secured to the head by bolts 30 and nuts 31 retains in position the "L" shaped packing bars 32 and 33 which have a rectangular cross section and when arranged in pairs fit the rectangular cross section of the annular chamber. The meeting ends of the bars 32 and 33 may be chamfered as shown by full lines at 34 and 35 in Fig. 20 or the said ends may be formed to meet as shown by dotted lines at 36 and 37 in the same figure. These packing bars are operated by springs 38 whereby they are made to bear against the top and bottom of the annular chamber and by end springs 39 whereby they are made to bear against the end 2 and the cover 3 of the casing. The upper part 32 of each packing bar is provided with slotted holes 40 and 41 which fit loosely over pins 42 and 43 respectively screwed into the piston head 28 see Figs. 19 and 20. This arrangement permits limited movement of the packing bars, which are thus prevented from moving outward to such an extent as to catch the edges of a cylindrical chamber 44, integral with the casing 1. A cylindrical abutment 45 provided with a groove or cavity 46 fits within the chamber 44 and is mounted upon a spindle 47 having bearings 48 and 49 secured to the end 2 and cover 3 respectively. The abutment is continuously rotated by means of a toothed wheel 50 secured upon the shaft 47 and meshing with a corresponding

tooth wheel 51 fixed upon the shaft 10. The revolution of the piston is thus made to synchronize with the rotation of the groove 46 whereby the piston is allowed to pass the abutment. Contact bars 52 and 53 dovetailed into the walls 20 and 21 are operated by springs 54 and 55 which tend to project the bars above the periphery of the circular walls. These bars produce a gas tight joint between the abutment 45 and the circular walls.

The casing and the chamber 44 are cooled by admitting water through a pipe 56 and circulating it through a channel 57 formed around the said casing and chamber and discharging it through pipe 58.

A pump mounted on standards 59 comprising a cylinder 59[a] fitted with a piston 60 reciprocated by the crank 19 compresses an explosive mixture of gas and air within the receiver 61. The gas is drawn into the pump at one end of the cylinder from a gas supply main 62 through the valve 63 (see Figs. 1, 4 and 7) working upon a seat 64 the valve being automatically closed by a spring 65 located upon the stem 66. Air is simultaneously drawn into the pump through an air valve 67, see Fig. 9, similar to the valve 63 but having a nut 68 upon its stem 69 whereby the lift of said valve may be regulated as desired. Gas and air are drawn into the opposite end of the pump through a gas valve 70 corresponding with valve 63 and an air valve 71 corresponding with the air valve 67. The mixture of air and gas is delivered from one end of the pump to the pipe 76 leading to the receiver 61 through a valve 72, (see Figs. 1, 2 and 10) working upon a seat 73 and returned by a spring 74 upon its stem 75. From the opposite end of the pump the mixture is delivered to the pipe 76 through a valve 77 corresponding in all respects to the valve 72. A charge of the explosive mixture between the abutment 45 and the piston 28 when the piston is in either of the positions indicated in dotted lines Fig. 6, the receiver having a valve 78 shown in detail in Fig. 14. This valve is hollow and cylindrical and slides within a casing 79 opening and closing ports 80 therein through which the explosive mixture passes by means of pipe 81, to the valve chest 82. The valve 78 has a stem 83 projecting through a cover 84 a spring 85 upon said stem tending to maintain the valve in its closed position, and a nut 86 screwing upon the stem regulates the compression of the spring.

A cam 87 upon the main shaft 10 vibrates at each revolution a lever 88 pivoted at 89 and bearing at its opposite end upon the nut 86 whereby the valve 78 is opened for passage of gas to the valve chest 82 through the cock 90. The valve chest is fitted upon the end of the casing and contains two non-return valves 91 and 92. The valve 91 closes an opening 93 communicating with a port 105 leading to the annular chamber, the valve having a stem 94 working through the neck 95 a nut 96 upon the stem compresses a spring 97 located upon the neck and tending to close the valve. The valve 92 is of precisely similar construction closes the opening 98 communicating with port 106 leading to the annular chamber upon the opposite side of the abutment to port 105, the valve has a stem 99 passing through the neck 100, and the nut 101 thereon compressing spring 102.

The cock 90 has a portway 103 passing half way through the plug 104 and then branching at right angles the plug may therefore be turned to direct the explosive mixture to either the valve 91 or 92 according to required direction of revolution of the piston. As shown in Fig. 6 in dotted lines the piston is arranged to revolve in the direction of the arrow the full lines showing the piston passing the abutment. When the piston is desired to revolve in the opposite direction the cock 90 is turned and the explosive charge admitted through the valve 92 to the space between the abutment and the piston, the piston being then upon the opposite side of the abutment to that shown in dotted lines in Fig. 6. The ports 105 and 106 are crossed by bars 107 which prevent the piston packing bars from catching in the ports.

The ignition of the explosive charge is effected by an electric spark from a battery 108. Upon the main shaft 10 is a contact breaker consisting of a drum 109 of non-conducting material across the periphery of which extends a strip of copper 110. The wiper 111 rests upon the drum and is in electrical connection with a terminal of the battery 108, a second wiper 112 rests upon the drum and is in electrical connection through wire 117 with sparking plugs 113 and 114 one upon each side of the abutment 45, and through wire 118 with sparking plugs 115 and 116 upon the second engine and similarly arranged in regard to the abutment thereof. The wire 119 continues the circuit to the battery so that at each revolution of the shaft sparks are generated at the plugs within the annular chambers. Exhaust ports 120 and 121 upon opposite sides of the abutment and opposite to the openings 93 and 98 are one or other of them according to the direction in which the piston is revolving opened to an exhaust pipe 122 through the cock 123 in the exhaust chest 124 (see Figs. 1, 2, 5 and 13) which has a portway 125 which permits this to be done.

After the explosive charge has been ignited between the abutment and the piston a small quantity of water in fine spray is injected through a narrow slot 126 extending across the annular chamber, communicating with a passage 127 in the casing through which water is forced at each revolution of

the main shaft by a pump 128 said pump having a plunger 129 and being connected with the passage 127 by a pipe 135, the plunger being operated by contact with a cam 130 upon the main shaft, and returned by a spiral spring 131 threaded upon the plunger and bearing against the collar 132. A similar slot 133 is provided upon the opposite side of the abutment, communicating with a passage 134 which is connected by a pipe 136 with the three way cock 137 upon the pipe 135 whereby water may be cut off from one of the passages and admitted to the other according to the direction in which the engine is running.

What I do claim and desire to secure by Letters Patent of the United States is:—

1. In a rotary gas engine a casing, a shaft co-axial with the casing, a cam upon the shaft a receiver, a valve upon the receiver operable by the cam, a valve chest having an opening in the casing, a pipe connecting the receiver and valve chest and a non-return valve covering the said opening into the casing substantially as specified.

2. In a rotary gas engine a casing, a shaft co-axial with the casing, a cam upon the shaft, a receiver, a valve upon the receiver operable by the cam, a valve chest having openings into the casing, non-return valves covering the said openings, a pipe connecting the receiver and valve chest and a cock in the valve chest having a right angled portway forming communication between the pipe and one or other of the valves substantially as specified.

3. In a rotary gas engine a casing, a shaft co-axial with the casing, a cam upon the shaft, a receiver, a valve upon the receiver operable by the cam, a valve chest having openings into the casing, non-return valves covering the said openings a pipe connecting the receiver and valve chest and a cock in the valve chest having a right angled portway forming communication between the pipe and one or other of the valves, an exhaust chest upon the casing opposite the valve chest and having exhaust openings into the casing, a cock in the exhaust chest having a right angled portway communicating with the atmosphere and one or other of the said exhaust openings substantially as specified.

4. In a rotary gas engine, a casing, a shaft co-axial with the casing, a crank upon the shaft, a pump operable by the shaft, valves for admitting gas to the pump, other valves for admitting air to the pump, other valves for emission of the contents of the pump, a receiver, pipes connecting the pump and receiver, a spring operated valve on the receiver a cam upon the shaft and adapted to operate the said valve, a valve chest having openings into the casing non-return valves covering the said openings a pipe connecting the receiver and valve chest and a cock in the valve chest having a right angled portway forming communication between the pipe and one or other of the non-return valves, substantially as set forth.

5. In a rotary gas engine a casing, a shaft co-axial with the casing, a piston revoluble in an annular chamber within the casing, an abutment having a cavity and rotatable across the annular chamber, means for admitting an explosive mixture of gas and air to the chamber between the piston and the abutment, means for igniting the mixture a cam upon the shaft a pump having a spring operated plunger operable by the cam and a pipe leading from the pump to a slot across the annular chamber parallel to the abutment substantially as specified.

6. A rotary engine comprising a casing, circular walls projecting towards each other within the casing, a main shaft co-axial with the circular walls, a disk upon the main shaft, a piston upon the disk and revoluble in the annular chamber formed by the circular walls and the casing, an abutment having a cavity and rotatable across the annular chamber a spindle upon which the abutment is secured toothed wheels one each upon the main shaft and spindle respectively and gearing together a cam upon the shaft a receiver a valve upon the receiver operable by the cam, a valve chest having openings into the casing non-return valves covering the said openings, a pipe connecting the receiver and valve chest, a cock in the valve chest having a right angled portway forming communication between the pipe and one or other of the valves, an exhaust chest upon the casing opposite the valve chest and having exhaust openings into the casing, a cock in the exhaust chest having a right angled portway communicating with the atmosphere and one or other of the said exhaust openings, substantially as specified.

In testimony whereof I have signed my name to this specification in the presence of two witnesses.

JOHN EDWARD FRIEND.

Witnesses:

HENRIE HAMPTON RAYWARD

ERNEST SMITH BALDWIN.