No. 789,921. PATENTED MAY 16, 1905.

E. R. LANGFORD.

ROTARY GAS ENGINE.

APPLICATION FILED AUG. 3, 1903.

4 SHEETS—SHEET 1.

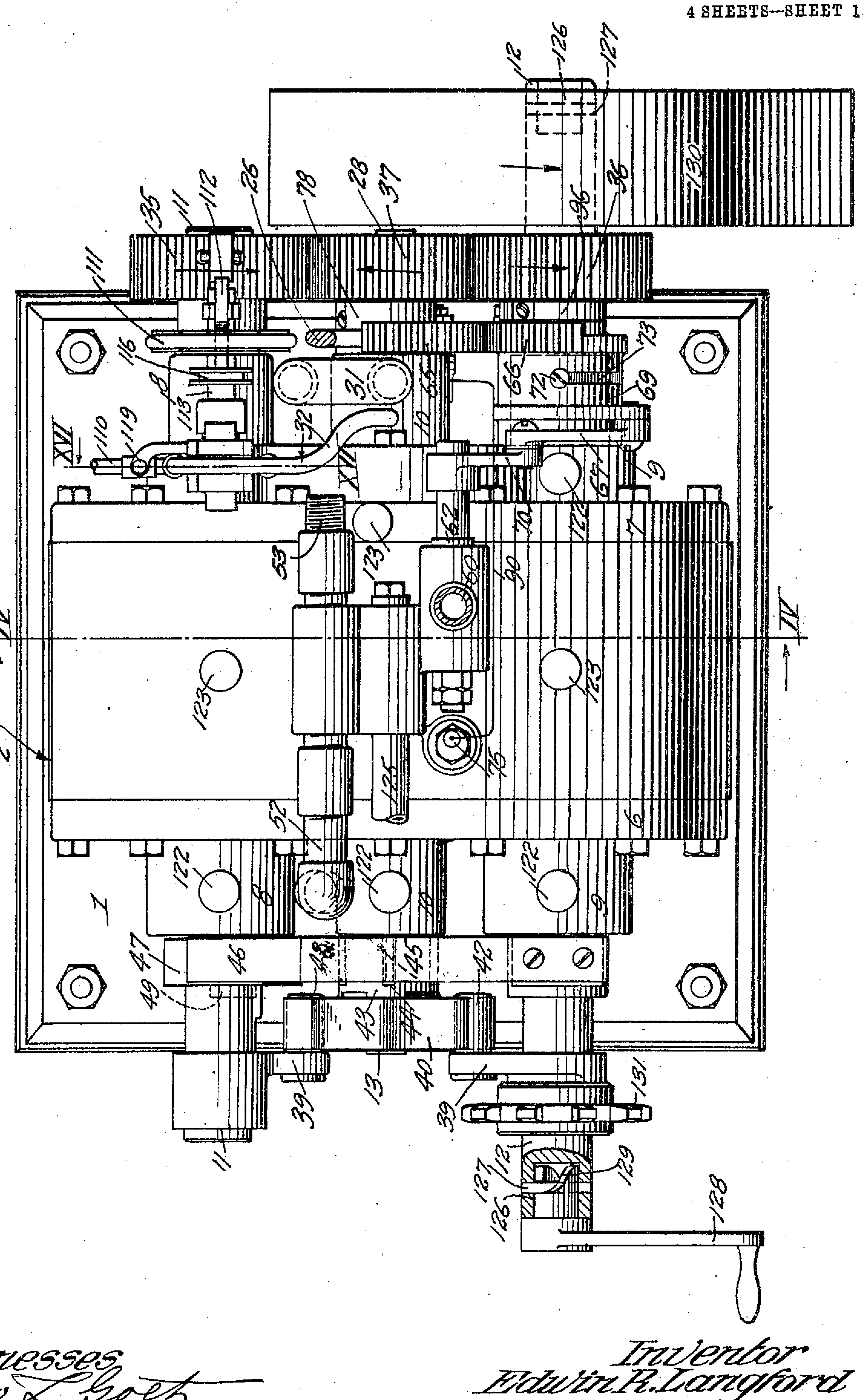

Fig. I

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Fig. II

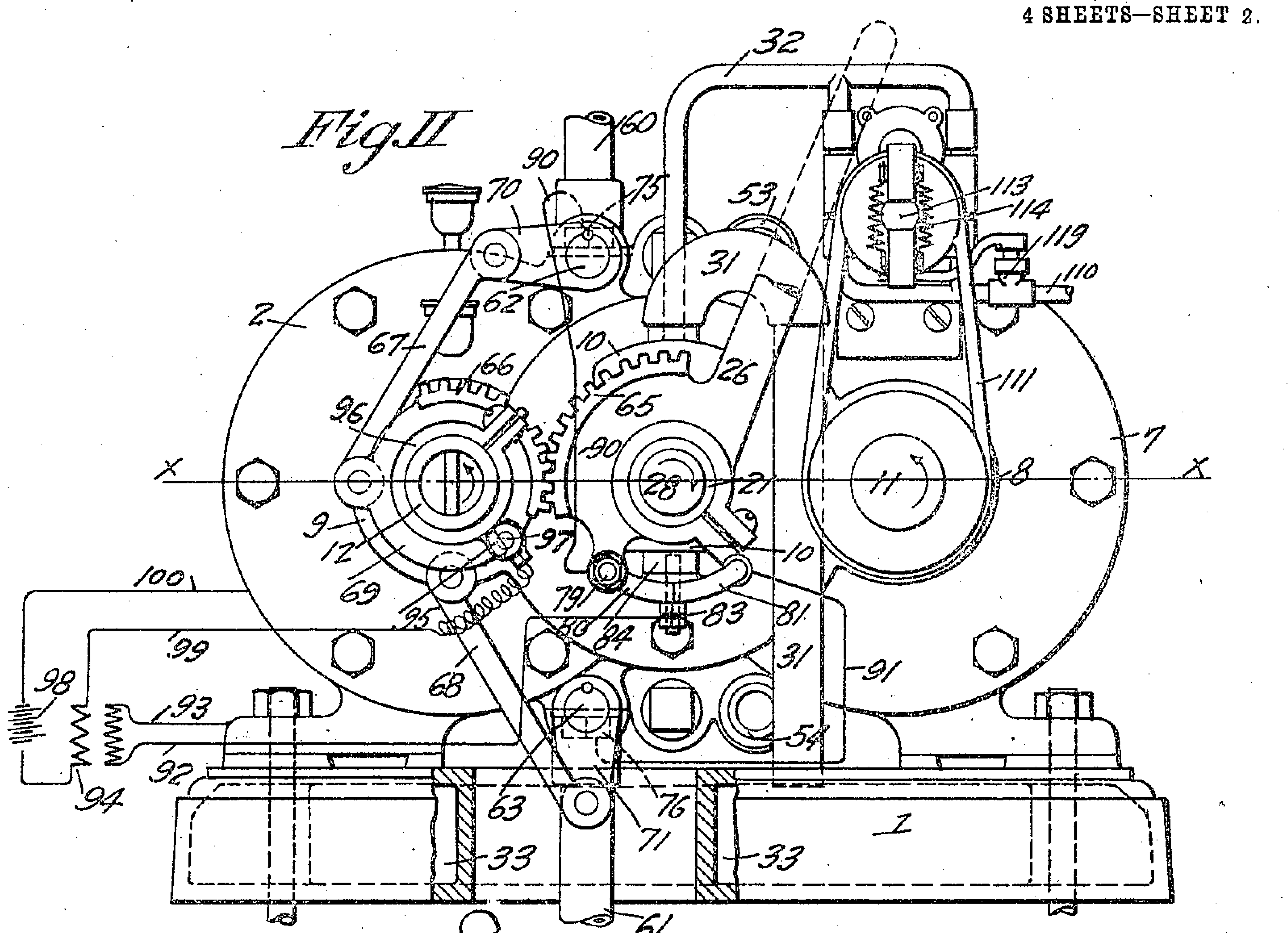
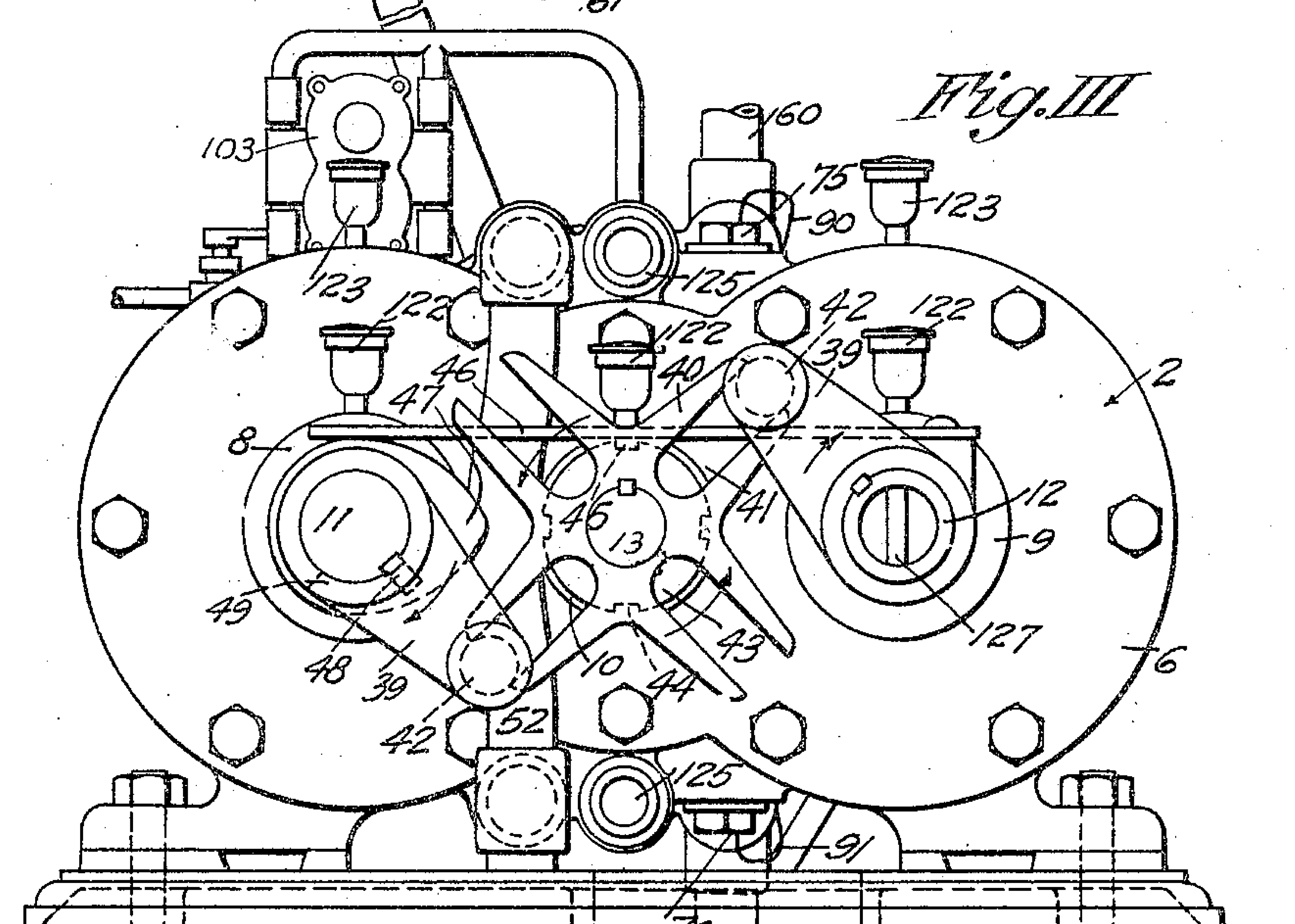


Fig. III



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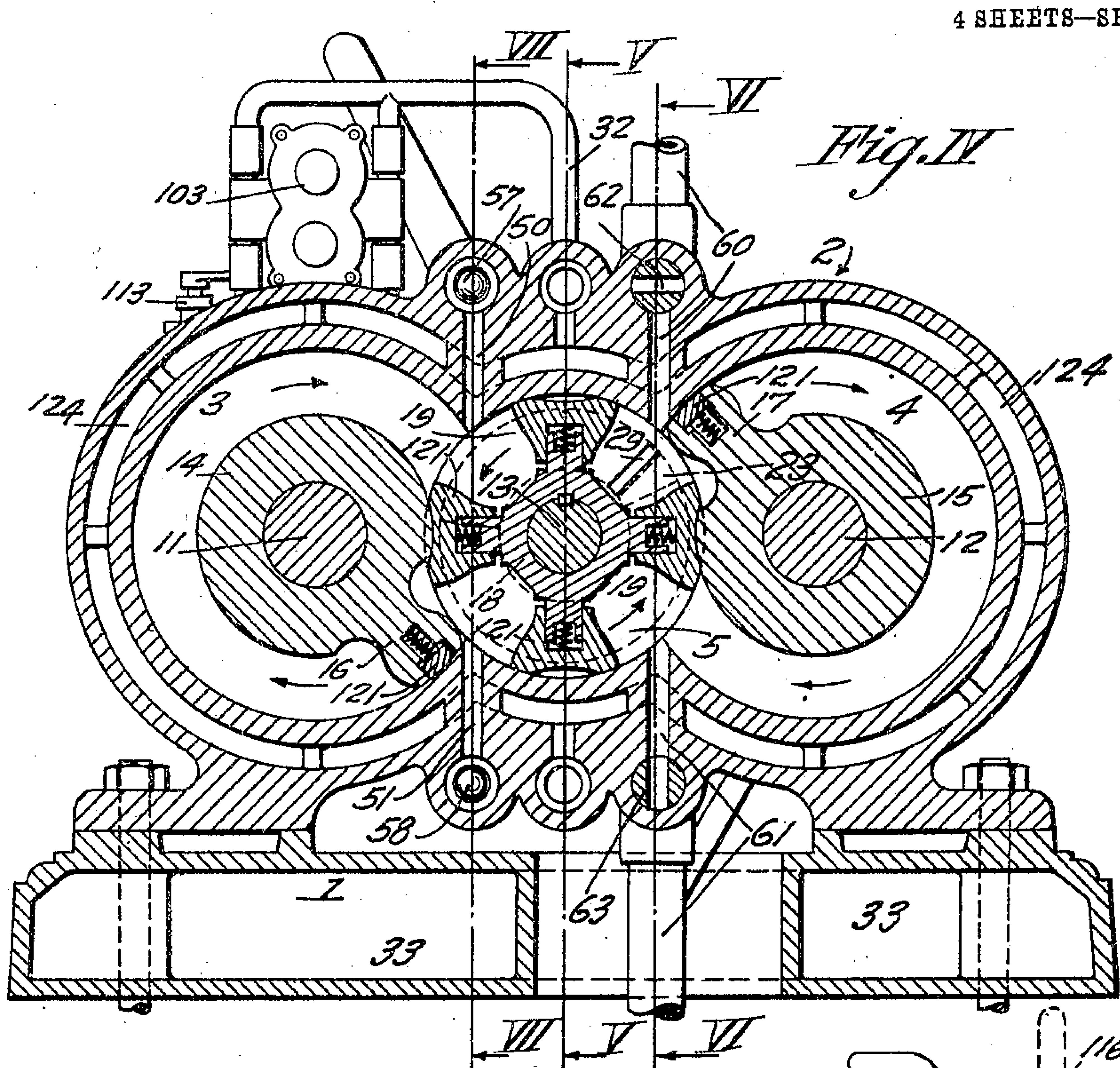

Fig. IV

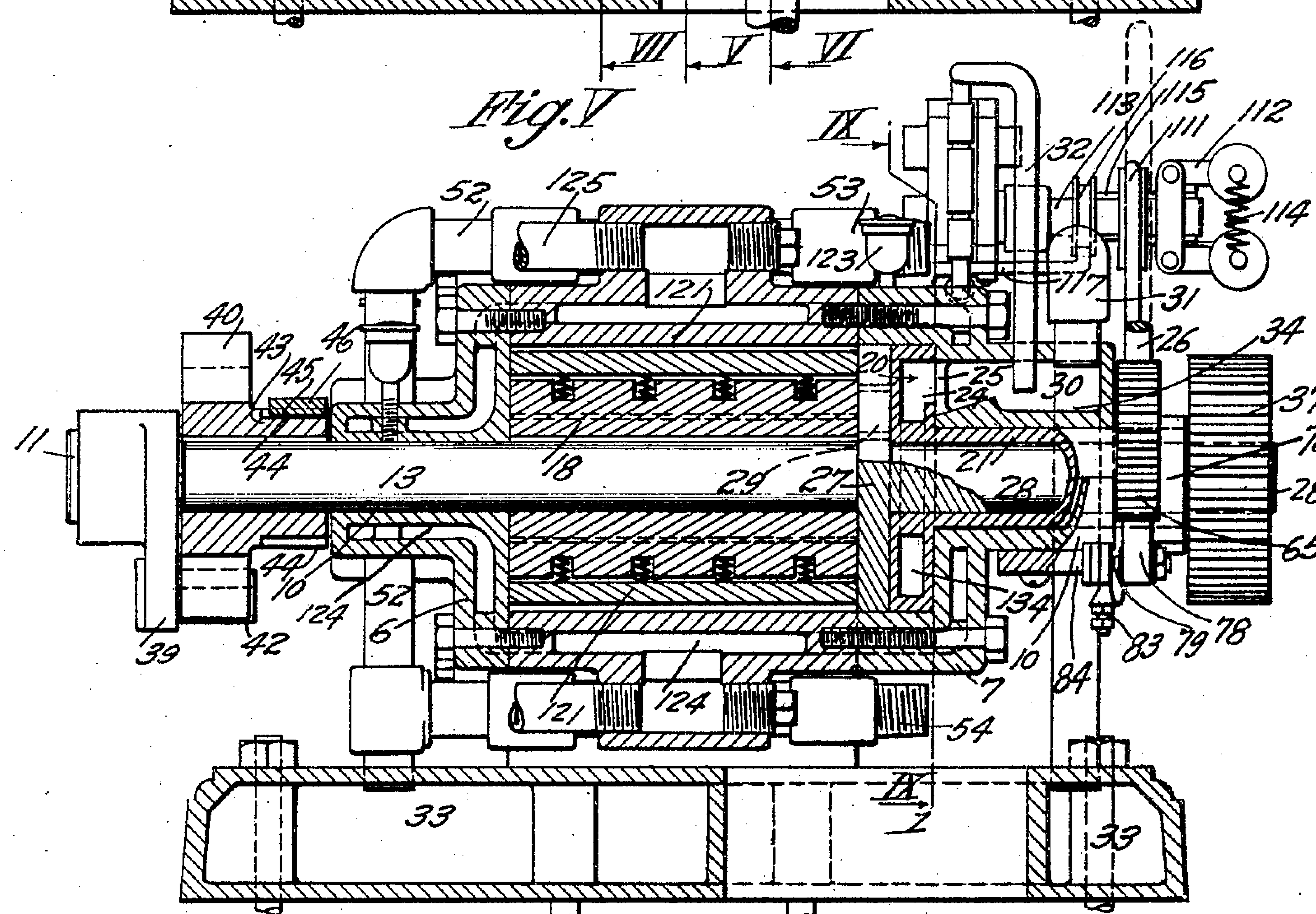

Fig. V

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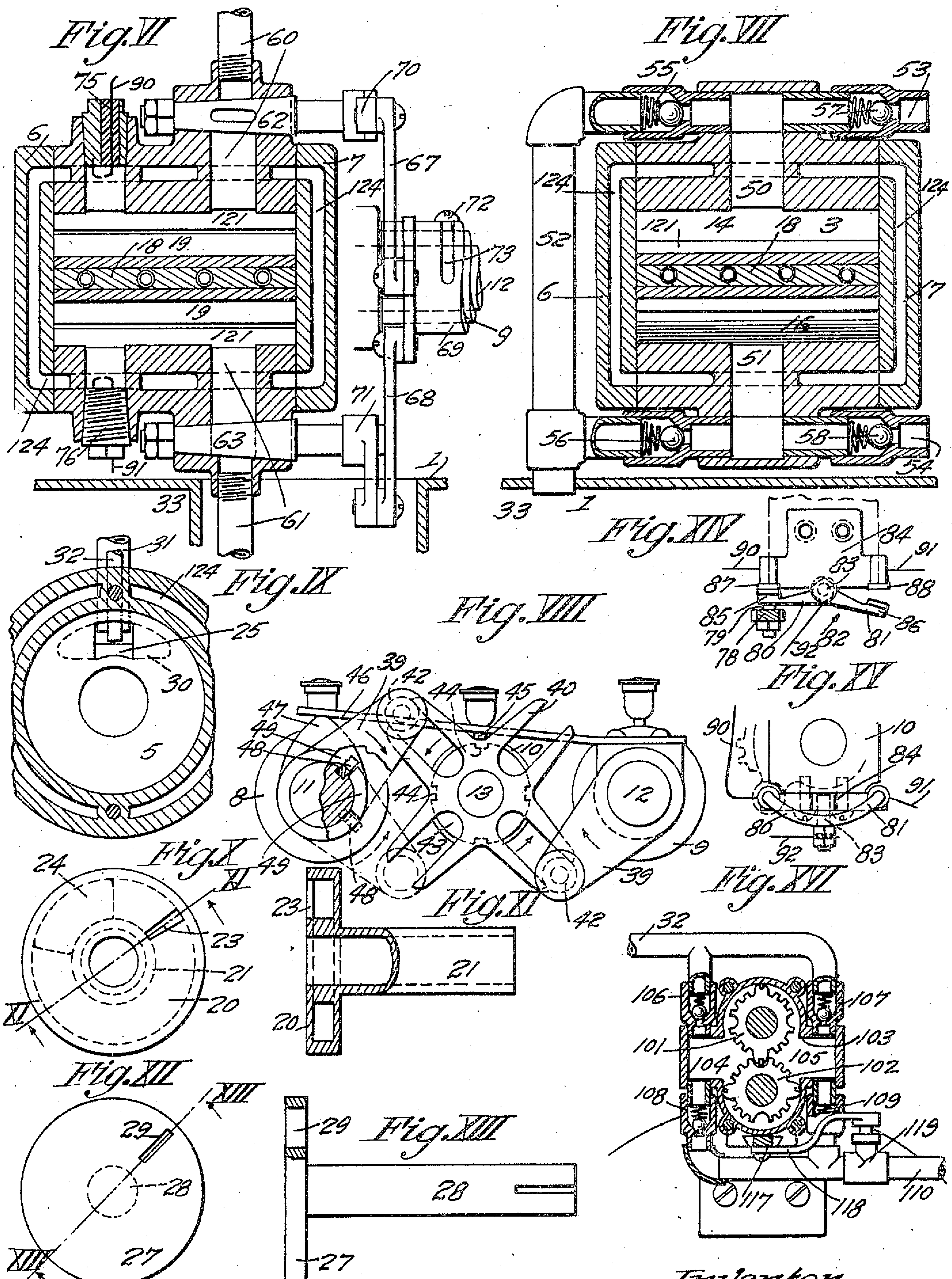
4 SHEETS—SHEET 4.



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UNITED STATES PATENT OFFICE.

EDWIN R. LANGFORD, OF LOS ANGELES, CALIFORNIA, ASSIGNOR OF ONE-HALF TO JAMES L. HERRICK, OF FAIRBANK, ARIZONA TERRITORY.

ROTARY GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 789,921, dated May 16, 1905.

Application filed August 3, 1903. Serial No. 168,013.

To all whom it may concern:

Be it known that I, EDWIN R. LANGFORD, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented new and useful Improvements in Rotary Gas-Engines, of which the following is a specification.

This invention relates to rotary internal-combustion engines; and its primary object is to provide an engine of this character wherein the entire cycle of operations shall be performed upon and by rotatively-acting parts in such manner as to admit of extremely high speed, together with a high degree of power and freedom from noise and wear.

A further object of the invention is to provide an engine of this character wherein each of the operations of compression and explosion or expansion is performed in such manner as to utilize approximately the entire stroke or revolution of the corresponding piston, thereby reducing to a minimum the intervals between operative strokes, both in compression and expansion, and correspondingly increasing the capacity of the engine and the uniformity and smoothness of its movement.

An additional object of the invention is to provide for effecting the above result in such manner that the operation of compression is substantially simultaneous with that of explosion or expansion, so that the power developed by the explosion can in part be utilized directly for the act of compression without necessitating storage of the power or energy in a fly-wheel or balance-wheel, thereby adding to the smoothness or evenness of the movement and reducing the weight of the machine to a minimum.

Another object is to provide a rotary internal-combustion engine which shall be reversible, thus enabling it to be used in many applications for which a non-reversible rotary engine would be inapplicable.

Other objects and features of the invention will appear in and from the following description.

The accompanying drawings illustrate the invention.

Figure I is a plan of the engine. Fig. II is an end elevation taken from the right of Fig. I, omitting the connecting-gears and power-transmitting pulley. Fig. III is an end elevation looking from the other end. Fig. IV is a transverse section on the line IV IV in Fig. I. Fig. V is a longitudinal section on line V V in Fig. IV. Fig. VI is a longitudinal section on line VI VI in Fig. IV. Fig. VII is a longitudinal section on line VII VII in Fig. IV. Fig. VIII is an end elevation showing an operating-cam and locking means for the rotary abutment. Fig. IX is a section on the line IX IX in Fig. IV. Fig. X is an end view, and Fig. XI is a partly sectional side elevation, of a rocking valve to be operated by a reversing-lever to control admission. Fig. XII is an end view, and Fig. XIII a partly sectional side elevation, of a rotating valve to be operated by the engine to control admission. Fig. XIV is a top view, and Fig. XV a front view, of a circuit-changer for the sparking circuit. Fig. XVI is a vertical section of the oil-pump on the line XVI XVI in Fig. I.

1 designates a suitable base upon which is mounted a casing 2, containing and supporting the various operative parts of the machine.

The casing 2 is formed with parallel cylinders or chambers 3 4, constituting, respectively, the compression and expansion or explosion cylinders and an intervening abutment chamber or cylinder 5 parallel to and intersecting the chambers or cylinders 3 and 4. The heads 6 and 7 close the casing and are provided with bearings 8, 9, and 10 for the shafts 11, 12, and 13, mounted to rotate axially in the compression, expansion, and abutment cylinders, respectively.

Piston members 14 and 15, fast on the respective shafts 11 and 12, carry the pistons 16 and 17, working in the cylinders 3 and 4, and the rotary abutment member 18, fast on shaft 13, rotates and fits within the abutment-chamber 5 and is provided with cavities or involute depressions 19, adapted to mesh or coöperate with the pistons 16 17 and to permit passage thereof in the rotation of the parts, while preventing flow of the gases between such parts.

The abutment-cylinder 5 is extended or prolonged at one end to receive suitable valve or port devices controlling the admission of explosive mixture. Such devices may comprise a rocking valve or port member 20, controlled by a reversing-lever 26 and a rotary valve 27, operated continuously by the engine. Rocking valve 20 has a tubular shaft 21, mounted to rotate in bearing 10 of the casing, valve 20 being formed as a disk on said tubular shaft and provided with ports 23 24, opening, respectively, toward the abutment-chamber and toward a fixed port 25 in the casing. The outer end of tubular shaft 21 is connected to and controlled by the reversing-lever 26, and the port 24 in the valve member is of sufficient length, as shown in Fig. X, to maintain connection with the fixed port 25 in both positions of the reversing-lever. The rotary valve member 27 is interposed between the abutment and the rocking valve member 20 aforesaid and consists of a disk fast on the shaft 28, rotating within the tubular shaft 21 aforesaid, said disk being provided with a port or passage 29, controlling communication between the port 23 aforesaid in the rocking valve 20 and the abutment-chamber. The fixed port 25 communicates with a chamber 30 in the casing 2, and suitable air and fuel supply pipes 31 32 also communicate with said chamber to furnish explosive mixture. Pipe 31 leads from an air-tank 33, which may be arranged or formed in the base 1 of the engine. Chamber 30 constitutes a mixing-chamber and may have a well or pocket 34 to temporarily retain the oil as it flows from pipe 32. Valve-disk 20 is also desirably hollow to form an additional mixing-chamber 134.

The rotary piston members 14 15 are connected so as to rotate in the same direction by two gears 35 36 on the shafts 11 and 12 of said members meshing with an intermediate gear 37 on the valve-shaft 28, the valve 27 being thereby driven oppositely to the piston members.

Rotary abutment 18 is provided with operating means whereby it is intermittently rotated to permit passage of the pistons and alternating with such rotating movements is held stationary while the pistons complete their rotations, it being understood that the pistons are in engagement with the abutment during only a part of each revolution. Thus in the construction shown such engagement is during a quarter-revolution, and the abutment is provided with four cavities 19, ninety degrees apart, and is rotated one-quarter of a revolution at each operation. Such action is effected by a cam device operated by the machine and comprising a Geneva-stop cam member 40, fast on shaft 13 of abutment 18 and provided with four radial slots 41, located ninety degrees apart and engaged by rolls or studs 42 at the ends of arms 39 on the one or both of the shafts 11 12, this engagement taking place during only one-quarter of each revolution of said shafts. To hold the shaft 13 stationary during the other three-quarters of the revolution, a lock-disk 43 is provided on said shaft having four equidistant notches 44, engaged by a tooth or detent 45 on a flat spring 46, which is fastened at one end to a fixed support and at the other end is engaged by a cam 47, mounted on shaft 11. The engagement between shaft 11 and said cam 47 is loose, so as to allow a certain slip or lost motion when the shaft reverses its movement, said shaft having a key or lug 48, engaging with a lug or tooth 49 on said cam, of such circumferential length as to allow the shaft when reversed to move three-quarters of a revolution before moving the cam.

The compression-cylinder 3 is provided with ports 50 51, located adjacent to or at the point of intersection with the abutment-cylinder, said ports communicating on the one hand with an air-pipe 52, leading to reservoir or air-tank 33, and on the other hand with respective intakes or inlets 53 54, leading from the outer air, check-valves 55 56 being interposed in the connection between said ports and the pipe 52, so as to allow flow to said pipe, but to shut off backflow, and check-valves 57 58 being interposed in the intake connections to permit inflow, but to close on outward flow. Movement of the compression-piston in the direction of the arrow in Fig. IV will cause compression of air toward the upper port 50 and suction of air from the lower port 51. Check-valve 57 will therefore be closed by pressure and check-valve 55 will open, allowing compressed air to flow to reservoir 33. At the same time check-valve 56 will be closed and check-valve 58 will open, allowing air to pass in at the lower port 51. On reverse movement of the compression-piston the check-valves will operate reversely, so as to allow air to be drawn in at the upper port 50 and so compressed through the lower port to the reservoir 33.

The explosion chamber or cylinder 4 is provided with exhaust outlets or passages 60 61 at the intersection thereof with the abutment-chamber, and valves 62 63 are provided in said passages and connected to the reversing-controller means in such manner as to open one or the other of such exhaust-passages, according to the direction in which the engine is to turn. The reversing-controller is here shown as a lever 26, fast on the shaft 21 above referred to, said shaft carrying a segment-gear 65, engaging with a segment-gear 66, mounted to turn loosely around the bearing of shaft 12. Bars or links 67 68 are pivoted to the hub 69 of segment-gear 60 and to arms 70 71 on the respective valves 62 63, so that as the reversing-lever is thrown one way or the other it will through gears 65 66, links 67 68, and arms 70 71 cause one of the valves 62 63 to be closed and the other to be opened. A fixed stud 72, projecting into slot 73 in hub

69, acts as a stop for the reversing-lever by engaging the ends of said slot.

Spark-plugs 75 76 are arranged, respectively, in the top and bottom of the explosion-cylinder 4, at the intersection thereof with the abutment-cylinder, and all connected to an electric discharge-circuit through a circuit-changer that connects one or the other of the spark-plugs, according to the direction of movement of the engine. This circuit-changer is here shown as operated by the reversing-lever 26, the hub 78 of said lever carrying an insulated button 79, adapted to engage with the respective arms 80 81 of a switch-lever 82, pivoted at 83 to a fixed insulating-support 84, and having contacts or terminals 85 86 at its opposite ends contacting with fixed terminals 87 88, connected, respectively, by wires 90 91 (see Fig. II) to spark-plugs 75 76. One side, 92, of the secondary or sparking circuit is connected to pivot 83 of the switch-lever, and the other side, 93, of said circuit is connected to the frame or body of the machine. When lever 26 is thrown to the right, (see Fig. II,) the contacts 85 87 are closed and the secondary circuit is completed from spark-coil 94 through wire 92 to switch 82, contacts 85 87, and wire 90 to the terminal of spark-plug 75, which is within sparking distance of the metal of the cylinder, from which connection is made by wire 93 to the other side of the spark-coil.

The interrupter or circuit-breaker for the primary circuit may consist of an arm or lug 95, carried by a ring 96, adjustably clamped on shaft 12, and a contact 97, carried by but insulated from the rocking hub 69 aforesaid, so that each rotation of piston-shaft 12 will cause an interruption of the circuit, and the movement of the reversing-lever will shift the time of interruption through one-quarter of a revolution. In practice the contact 95 will be adjusted in angular position such that the circuit will be closed and broken to cause a discharge at the moment when the piston 14 is leaving the abutment 18, the space between the piston and abutment constituting an explosion-chamber. The primary circuit leads from battery 98 and the primary of spark-coil 94 by wire 99 to the insulated contact 97, and from the contact 95 the circuit is continued through the machine and a wire 100 to the other side of the battery.

The form of pump here shown has rotating pistons 101 102, (see Fig. XVI,) working in a casing 103, provided on opposite sides with ports 104 105, communicating, on the one hand, through check-valves 106 107, with pipe 32 and communicating, on the other hand, through check-valves 108 109, with an oil-supply pipe or suction-pipe 110. These check-valves all open upwardly or toward the pipe 32, so as to operate similarly to those above described for the air-compression cylinder, causing the oil or fuel to be forced from pipe 110 to pipe 32 in either direction of rotation of the pump-pistons, and the fuel-supply is therefore not affected by reversal of the engine. These pump-pistons are operated by belt, chain, or gearing connection 111 with the engine—say with shaft 11.

A governor mechanism is shown comprising centrifugal arms 112, pivoted on an operating-shaft 113 of the pump and held inwardly by springs 114 and engaging slides 115, which are connected to a ring 116, slidable on shaft 113. A slide 117 engages with said ring 116 and with one arm of a lever 118, pivoted to a fixed support and connected to a valve 119 in the oil-suction pipe 110 to control the supply of oil in accordance with the requirements of the engine.

Suitable spring-packing 121 may be provided for the piston members 14 15 and for the rotary abutment 18. Inasmuch as the rotary abutment only moves intermittently and is stationary the greater part of the time while the piston members 14 and 15 are turning in contact therewith, it is possible to make these packing-surfaces conform to an extended arc of contact with the said piston members, so as to prevent leakage, the packing members 121 on the rotary abutment being concaved at their outer or bearing faces to fit the convexity of the piston members 14 and 15. Lubricating means (indicated at 122) are provided for the various bearings and oil-cups 123 for supplying oil to the abutment-chamber and to the compression-cylinder. Water-jacketing 124 is shown for the several cylinders, supply and outlet connections therefor being indicated at 125.

To facilitate starting of the engine, one of the shafts thereof, as 12, has a socket 126 in each end, provided with a cross-pin 127, adapted to be engaged by the usual starting-handle, (indicated at 128 in Fig. I,) which has ratchet-teeth to engage said pin 127 to start the engine. When the shaft starts to rotate by the action of the engine, the pin 127 engages the inclined faces 129 of said teeth to throw the latter out of engagement and free the handle. By providing sockets at each end of the shaft I enable the same starting-lever to be used in starting the engine in either direction.

Suitable means are provided for transmitting the power developed by the engine—for example, a pulley 130 on shaft 12 or a sprocket 131 on said shaft.

The operation of the engine is as follows: Proper fuel-supply connections having been made and the reversing-lever thrown to the position corresponding to the desired direction of rotation, the engine is started by turning the shaft 12 by handle 128 until the mixture of the air compressed in cylinder 3 and the oil forced in by the pump is ignited by the sparking means, whereupon the engine will continue to run by its own power. Assuming the engine to rotate in the direction of the arrows, in each rotation air will be drawn into the cylinder 3 through the lower port, and in the next succeeding rotation this air will be compressed by the piston 16 and will be forced through the upper port and the pipe into the air-tank 33. Similarly oil will be forced by the oil-pump, as above described, into the chamber 30, where it meets the air coming from air-tank 33 and pipe 32, and a mixture is thus formed in chamber 30 and in the chamber 134 in valve-shell 20, communicating with said chamber. The position of the port 23 in said chamber is such that the port 29 in rotating valve 27 registers therewith just before the piston 17 is about to leave the cavity 19 in abutment 18, with which it has been in engagement, and thus a charge of explosive mixture is admitted to said cavity and to the space between the abutment and the piston. As the valve 27 continues to rotate it closes the port 23 at the moment when the piston 17 starts at forty-five degrees to a line ($x x$ in Fig. II) connecting the axes of the rotary piston members, and at the same moment the electric discharge is provided through the spark-plug 75 to ignite the mixture. The piston 17 then moves under the pressure of the exploded mixture and at the same time sweeps out in front of it, the mixture remaining between its front face and the lower exhaust-outlet 61. When the piston 17 has thus traveled three-quarters of a revolution, it comes into engagement with the next succeeding cavity 19 of abutment 18. At the same time devices 47 44 45 unlock the cam member 40, and the latter is operated to turn the abutment in correspondence with the movement of the piston through ninety degrees, the abutment being then again locked with the succeeding cavity 19 in position to receive the charge of mixture as the port 23 reaches the position to communicate with said cavity and with port 29.

To reverse the engine, the lever 26 is thrown over to the other side, thereby shifting port 29 so that mixture will be admitted between the piston 17 and the rotary abutment when the piston approaches the abutment from the lower side of the explosion-cylinder and when said piston and abutment are in approximation on the lower side of the line $x x$. This movement of lever 26 also shifts the secondary circuit connection to the lower spark-plug 76. Assuming that the engine is already in motion, as above described, when the lever is thrown over it will continue to rotate in the same direction until it approaches the abutment, and at this moment a charge of mixture will be admitted and then ignited, as above described, and a backward impulse will thus be given to the piston, reversing the movement of the engine. At this moment of reversal the cam 47 has unlocked the cam 40, as shown in Fig. VIII, and in the reverse movement shaft 11 will turn freely within cam 47 for three-quarters of a revolution and will then strike the cam and carry the same along with it, again locking the abutment at proper intervals.

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

1. In a rotary internal-combustion engine, two piston-cylinders, constituting respectively compression and explosion cylinders, an intervening abutment-cylinder, rotary piston members carrying pistons working in the piston-cylinders, a rotary abutment member working in the abutment-cylinder and having a plurality of cavities to permit passage of the pistons, and means for intermittently rotating the abutment member during the passage of the pistons.

2. In a rotary internal-combustion engine, compression and expansion cylinders, rotary piston members working therein, an intervening abutment-cylinder, a rotary abutment therein coöperating with the piston members in both cylinders, means for intermittently rotating said abutment, said abutment having cavities permitting passage of the pistons during the partial rotation of the abutment, and with packing portions engaging with the rotary piston members through an extended arc of contact, while the abutment is stationary.

3. In a rotary internal-combustion engine, compression and expansion cylinders, rotary pistons working therein, an abutment-cylinder between the aforesaid cylinders, air-supply means connected to receive air compressed by the compression-cylinder and opening into the abutment-cylinder, an abutment provided with cavities permitting the passage of the pistons in said cylinders, and adapted to expose the air-supply opening in the abutment-cylinder and means for intermittently rotating said abutment.

4. In a rotary internal-combustion engine, a casing provided with cylinders, piston members working therein, an intervening cylinder and an abutment member working therein, an arm connected to each piston member, and a part connected to the abutment member and having slots engaged by said arms on opposite sides of the abutment-axis to intermittently rotate the abutment member.

5. In a rotary internal-combustion engine, a casing provided with cylinders, a piston member and an abutment member working therein, an arm connected to the piston member, a part connected to the abutment member and having slots engaged by said arm to intermittently rotate the abutment member, locking means for said abutment, and a cam operated by the engine to release said locking means.

6. A reversible rotary internal-combustion engine, comprising a cylinder, a piston member working therein, air-supply means, a rotary valve connected to and operated by the

engine, a second valve engaging directly with and movable on said first-named valve and coöperating with said first-named valve and with said air-supply means to control admission of air to the cylinder, and means for varying the position of said second valve.

7. A reversible rotary internal-combustion engine, comprising a cylinder, a piston working therein, air-supply means, a rotary valve connected to and operated by the engine, a second valve engaging directly with and movable on said first-named valve and coöperating with said rotary valve and with said air-supply means to control admission of air to the cylinder, and a reversing device connected to vary the position of said second valve to admit air at different parts of the revolution.

8. In a rotary internal-combustion engine, two cylinders, a piston member working in one cylinder, an abutment member working in the other cylinder, and provided with cavities adapted to receive and permit passage of the piston, and a rotary valve in the abutment-cylinder engaging directly with and movable on the abutment member and adapted to open into an abutment cavity and connected to be operated by the engine.

9. In a reversible rotary internal-combustion engine, an explosion-cylinder, a piston member working therein, an abutment-cylinder opening into the explosion-cylinder and a rotary abutment working therein and having cavities adapted to receive and permit passage of the piston, a rotary valve in said abutment-cylinder having a port adapted to open into said cavities, air-supply means and a valve in said abutment-cylinder, provided with a port coöperating with said air-supply means and with the port in the rotary valve, and movable to vary the time of admission through said valves.

10. An internal-combustion engine comprising compression and explosion cylinders, rotary piston and abutment members working therein and provided with parts adapted for the compression of air and for the expansion of exploded mixture, by rotatively-acting parts, means for supplying the air compressed in the compression part to the expansion part of the engine, fuel-supply means and igniting means, reversing means adapted and arranged to shift the point of admission of fuel and air to the expansion part of the engine, to cause operation in reverse directions, a reservoir, air connections to said reservoir from each side of the compression-cylinder, provided with outwardly-opening check-valves, and air-inlet means to each side of said cylinder provided with inwardly-opening check-valves.

11. An internal-combustion engine comprising compression and explosion cylinders, rotary piston and abutment members working therein and provided with parts adapted for the compression of air and for the expansion of exploded mixture, by rotatively-acting parts, means for supplying the air compressed in the compression part to the expansion part of the engine, fuel-supply means and igniting means, reversing means adapted and arranged to shift the point of admission of fuel and air to the expansion part of the engine, to cause operation in reverse directions, a reservoir, air connections to said reservoir from each side of the combustion-cylinder, and valve means in said connections reversing the connection to the reservoir from one side to the other of the compression-cylinder on reversal of the engine.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, at Los Angeles, in the county of Los Angeles and State of California, this 24th day of July, 1903.

EDWIN R. LANGFORD.

Witnesses:
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F. M. TOWNSEND.