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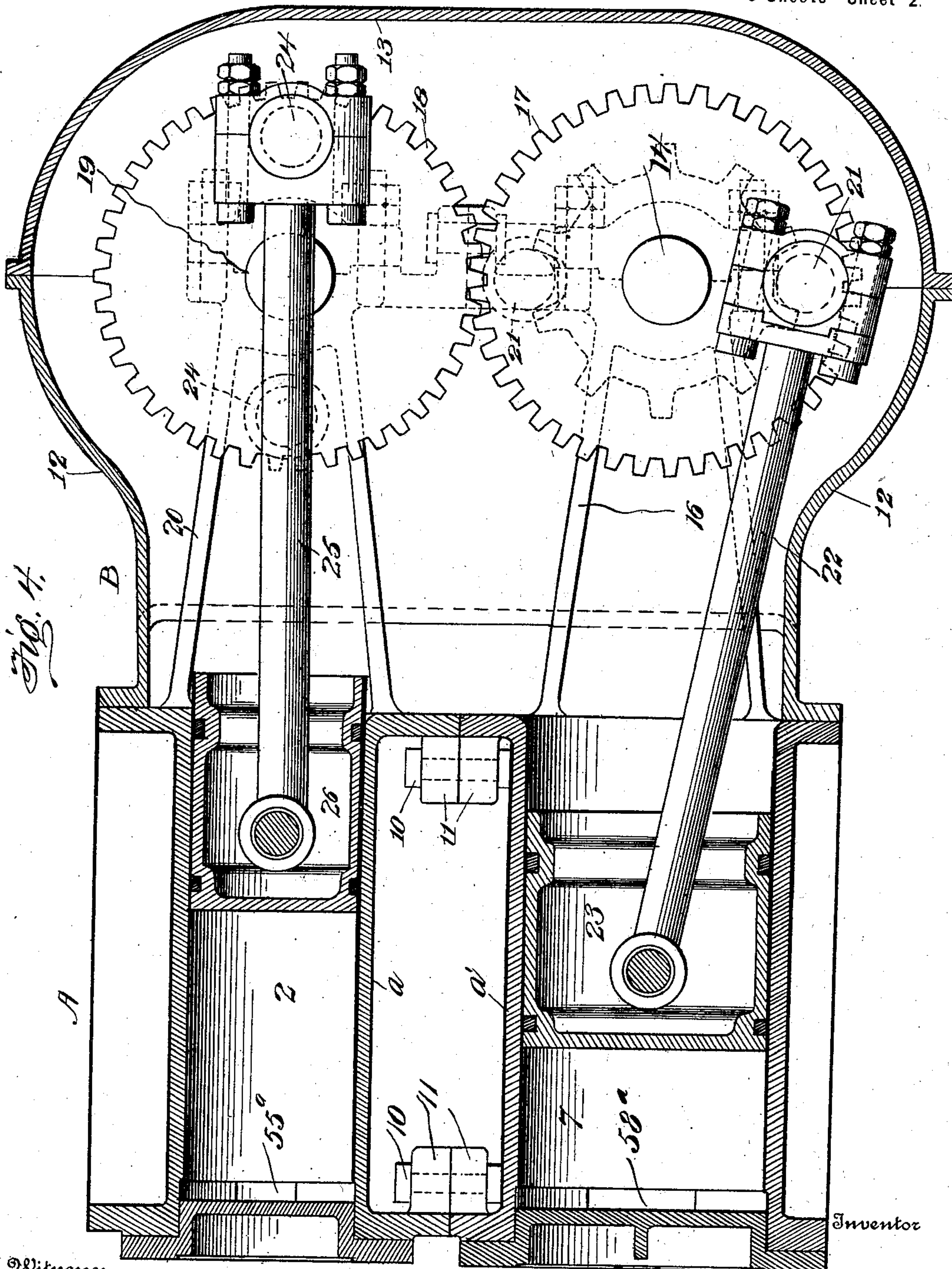
Patented Sept. 9, 1902.

I. S. DAVIS.  
STEAM MOTOR.

(Application filed Nov. 2, 1901.)

(No Model.)

5 Sheets—Sheet 2.



Witnesses  
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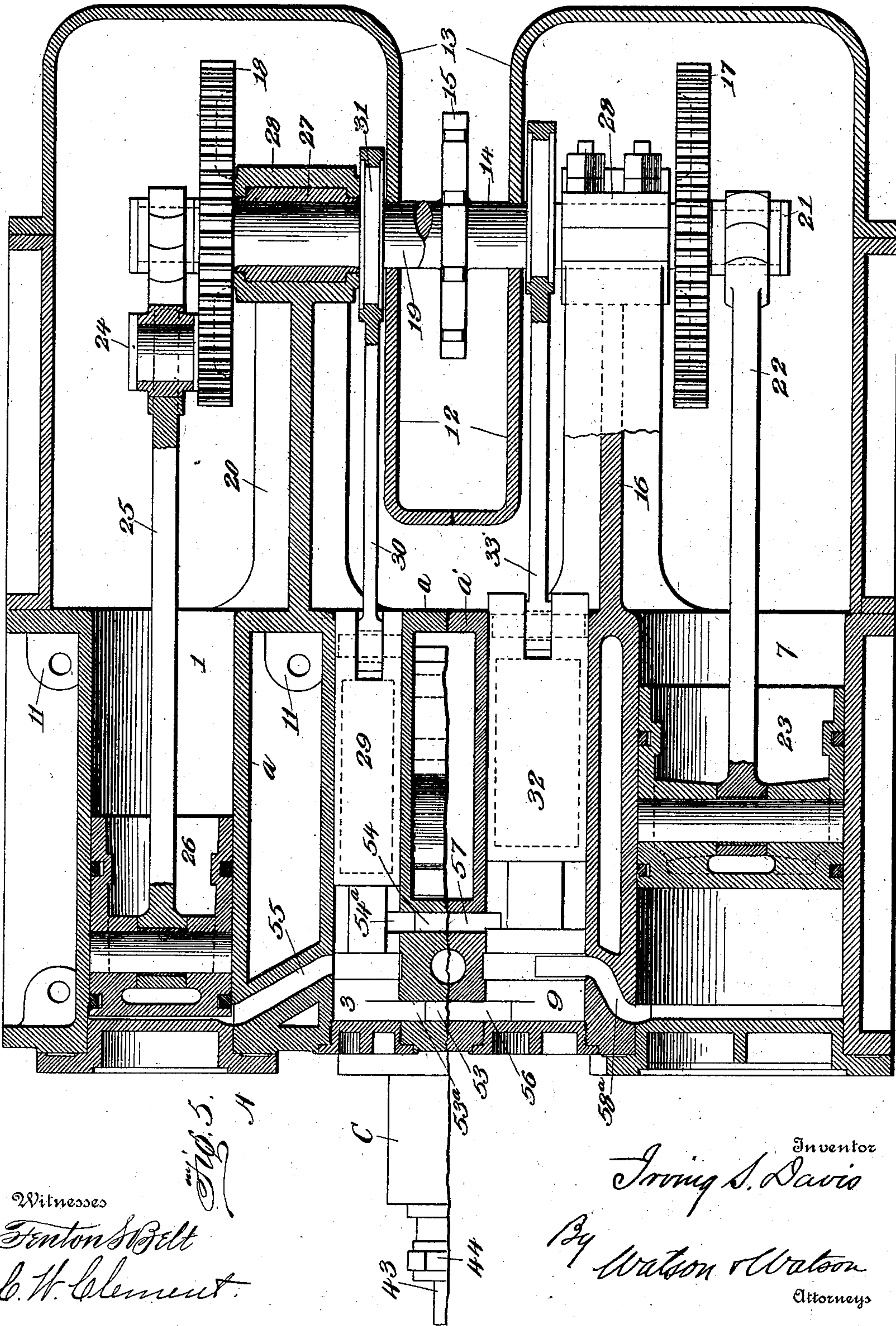
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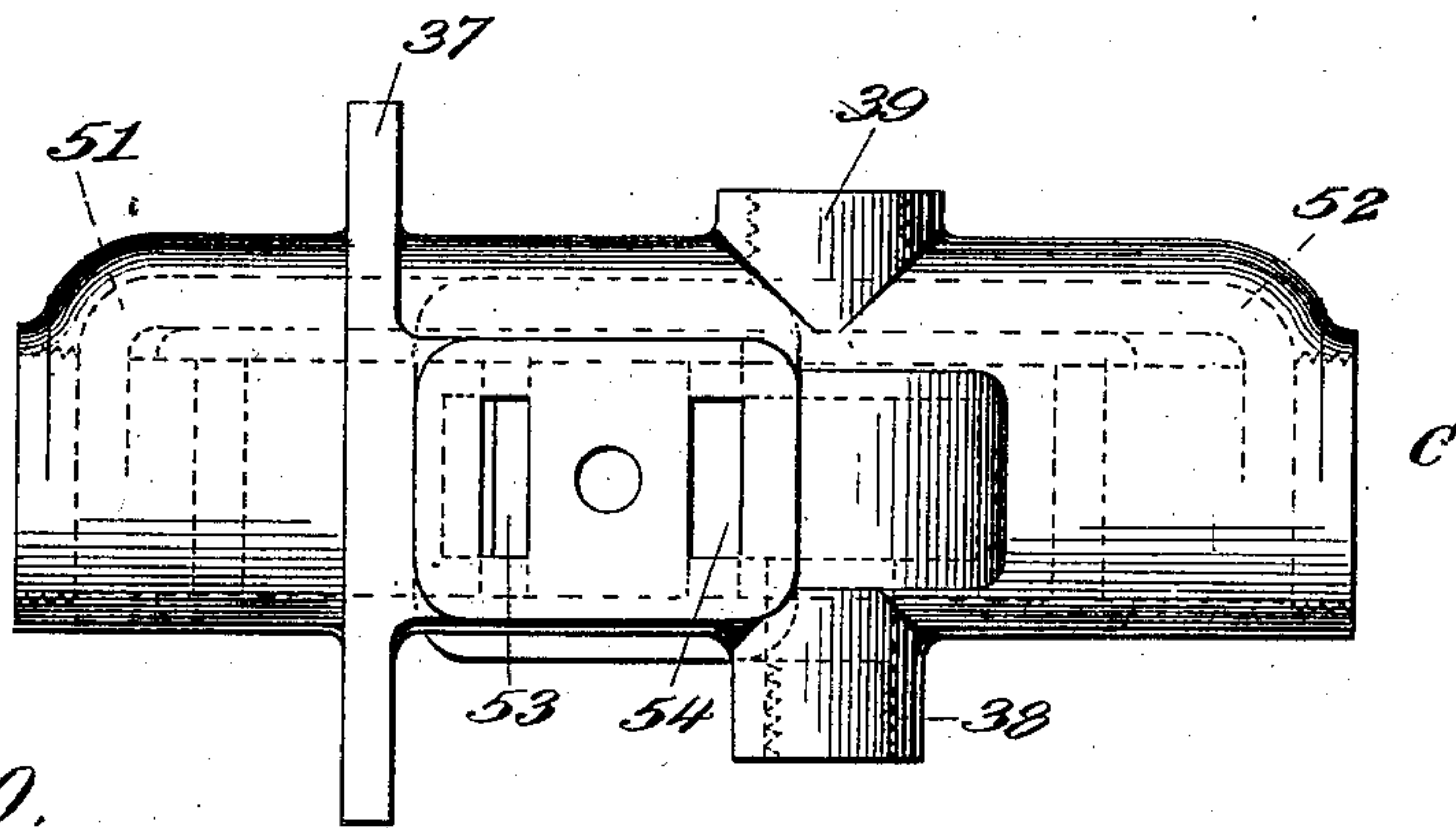
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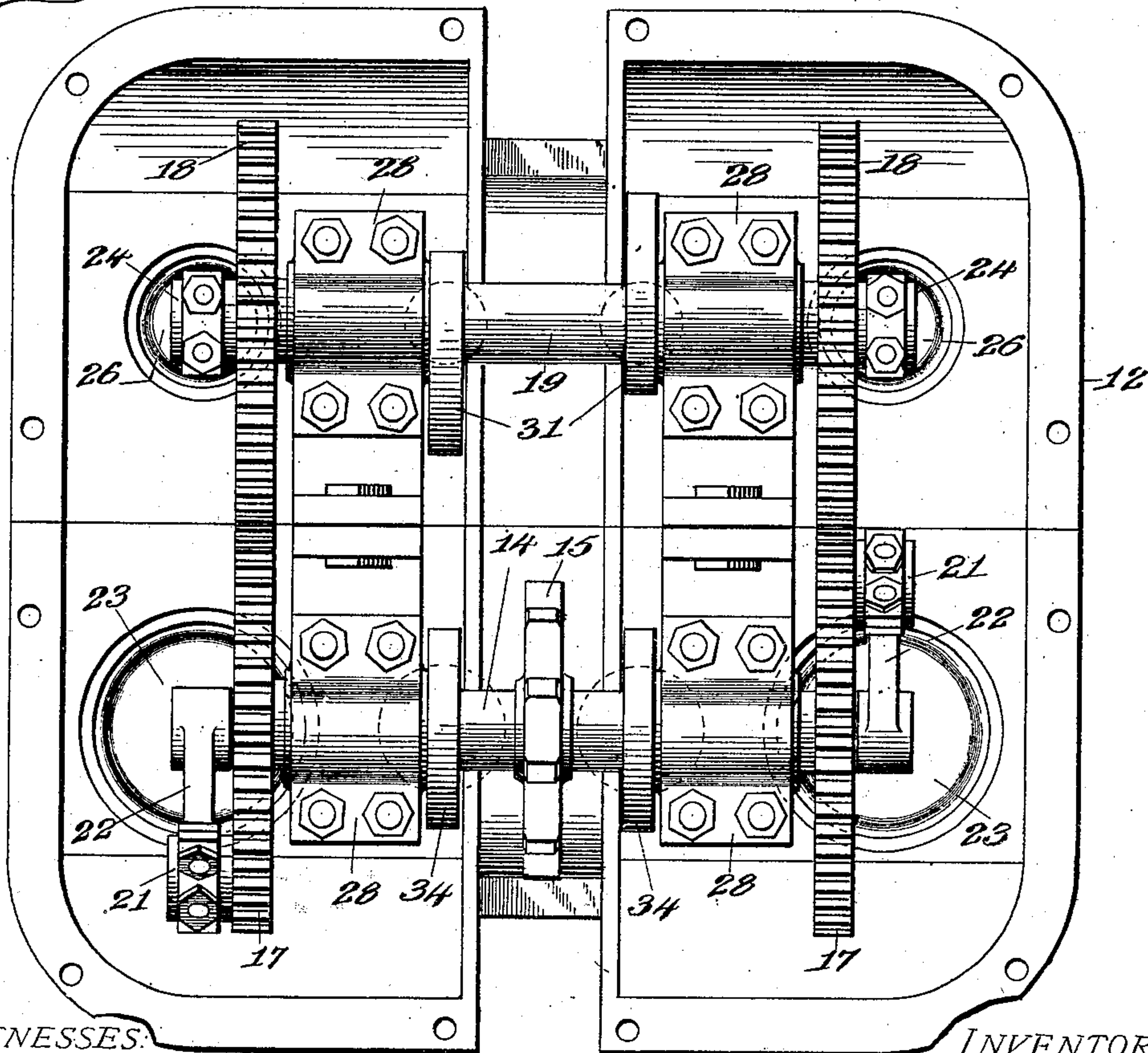
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*Fig. 6*



*Fig. 10.*



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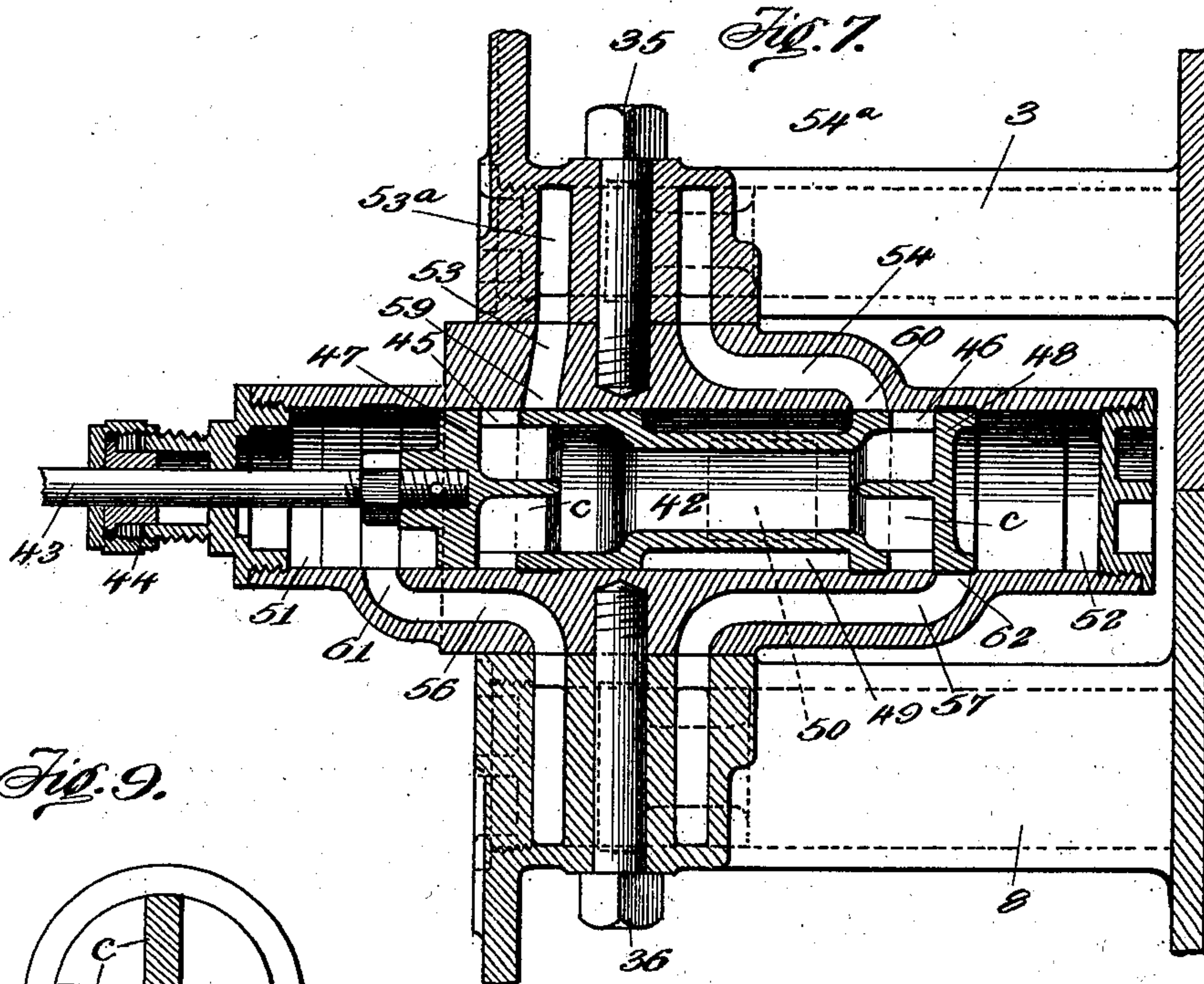
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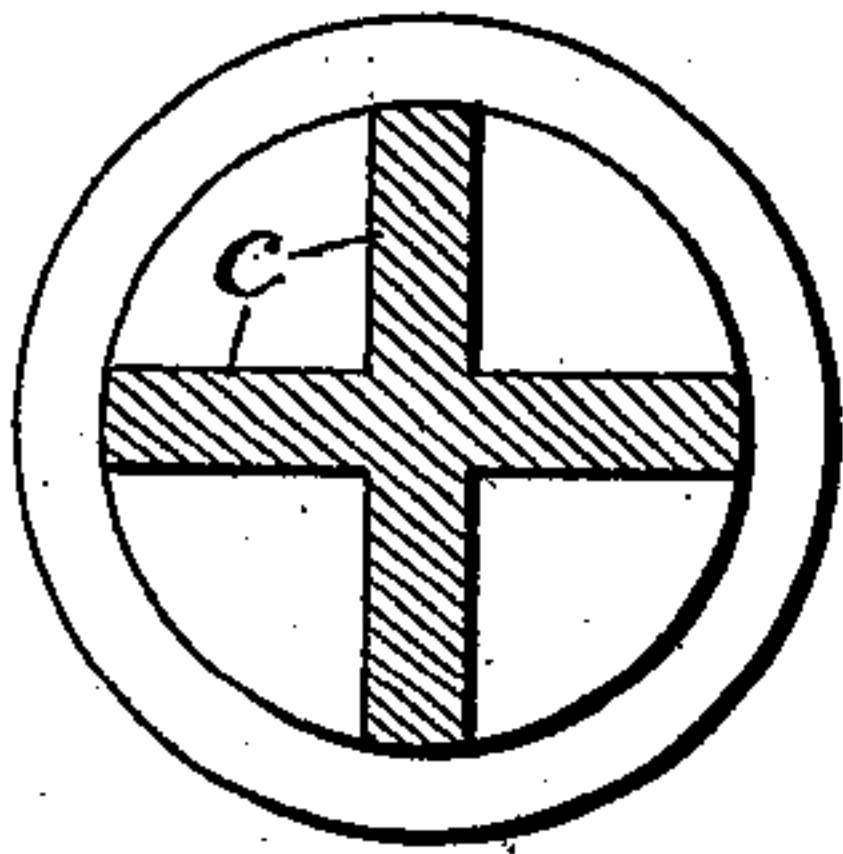
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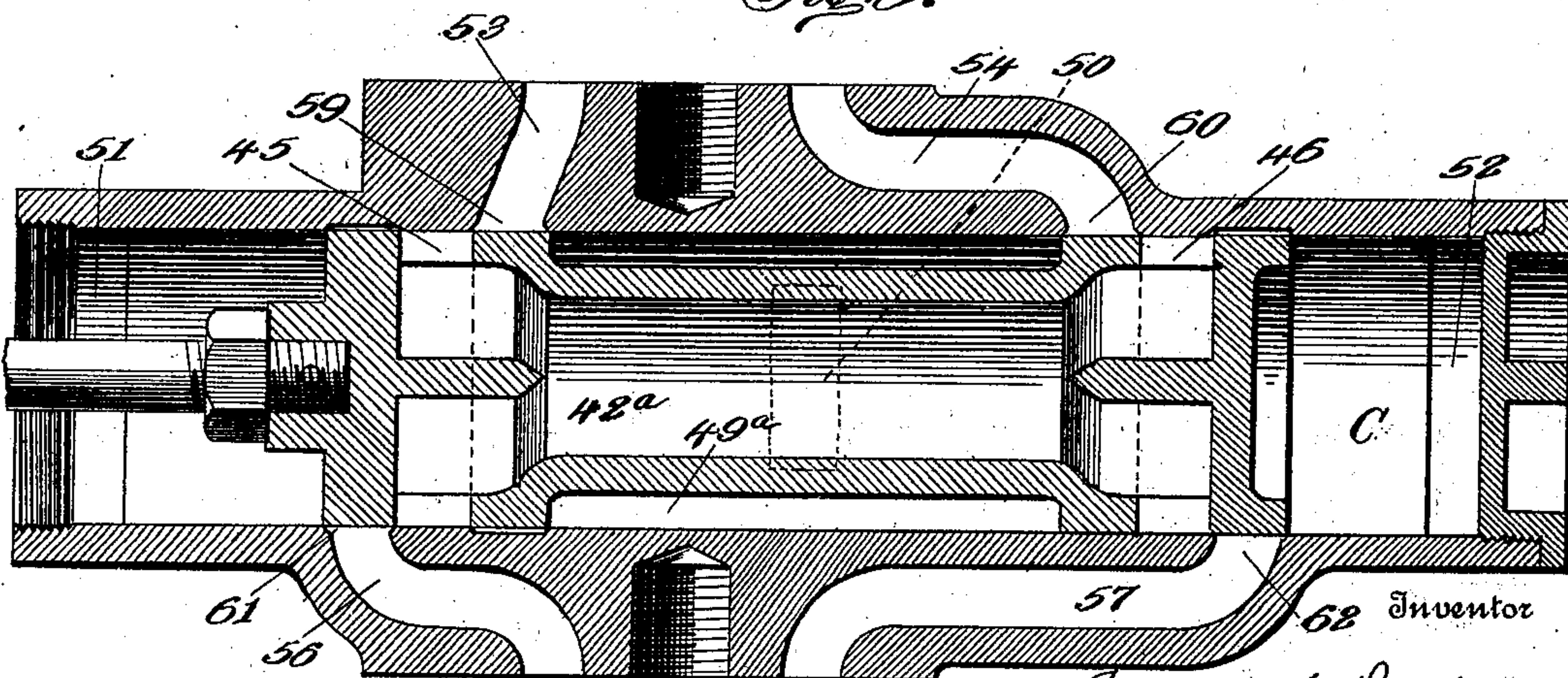
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*Fig. 9.*



*Fig. 8.*



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# UNITED STATES PATENT OFFICE.

IRVING S. DAVIS, OF SCRANTON, PENNSYLVANIA.

## STEAM-MOTOR.

SPECIFICATION forming part of Letters Patent No. 708,758, dated September 9, 1902.

Application filed November 2, 1901. Serial No. 80,919. (No model.)

*To all whom it may concern:*

Be it known that I, IRVING S. DAVIS, a citizen of the United States, residing at Scranton, in the county of Lackawanna, State of Pennsylvania, have invented certain new and useful Improvements in Steam-Motors, of which the following is a specification.

This invention comprises certain improvements in steam-motors particularly adapted for use on automobiles; and it relates to the arrangement of the parts whereby a balanced motor is produced and to the arrangement of valves and ports whereby the motor may be driven in either direction and operated either as a simple or compound motor.

In the accompanying drawings, which illustrate the invention, Figures 1 and 2 are plan and side views, respectively, of the motor. Fig. 3 is a view, on a larger scale, of one end of the motor, showing the arrangement of cylinders and valves. Fig. 4 is a section through the motor on the line 4 4 of Fig. 3. Fig. 5 is a section on the line 5 5 of Fig. 3. Fig. 6 is a plan view of the controlling-valve casing. Fig. 7 is a vertical longitudinal section through the same and through the controlling-valve and a portion of the cylinder-frame, the arrangement of ports being such as to operate the motor either compound or simple in moving forward and simple in moving backward. Fig. 8 is a vertical longitudinal section through a reversing-valve and its casing, by which the motor may be operated simple or compound in either direction. Fig. 9 is a cross-section through the controlling-valve, taken through one of its ports; and Fig. 10 is a front end view of the motor with the caps of the casing removed.

Referring to the drawings, A indicates the cylinder-frame, which comprises the upper portion *a*, having therein at its opposite sides the high-pressure cylinders 1 and 2, between which are arranged the piston-valve cylinders 3 and 4, adapted to control the admission of steam to and exhaust from said cylinders, respectively, and to the upper portion *a* is bolted the lower portion *a'*, having the low-pressure cylinders 6 and 7 and the slide-valve cylinders 8 and 9 arranged to control the admission of steam to and exhaust from said cylinders, respectively. As shown,

the cylinders are symmetrically arranged, the high-pressure cylinders being directly over the low-pressure cylinders. The two parts of the cylinder-casing are secured together by means of bolts 10, passing through lugs or projections 11 at the meeting faces of the two parts. Bolted to the forward end of the cylinder-frame is a gear-casing B, which incloses the working parts of the motor, this casing consisting of the bifurcated part 12, having the caps 13. Each arm of the casing incloses the working parts of one high-pressure and one low-pressure cylinder, and upon the driving-shaft 14 a driving sprocket-wheel or gear 15 is arranged between the two arms of the casing. The driving-shaft, as shown in the drawings, is journaled within the casing centrally, opposite the low-pressure cylinders, in brackets 16, which are formed integral with the cylinder-frame, and upon the opposite ends of the driving-shaft are arranged gears 17, which mesh with gears 18, of a similar diameter, mounted upon a shaft 19 in the casing opposite the high-pressure cylinders, said shaft being journaled in brackets 20, similar to the brackets 16. The gears 17 are provided with crank-pins 21, which are connected by connecting-rods 22 to the pistons 23 in the low-pressure cylinders, the pins 21 being arranged one hundred and eighty degrees apart. The pins 24 upon the gears 18, also arranged one hundred and eighty degrees apart and at an angle of ninety degrees to the pins on the gears 17, are connected by connecting-rods 25 to the pistons 26 in the high-pressure cylinders. It will be seen that with this arrangement when the high-pressure pistons are at the end of the stroke the low-pressure pistons will be at half-stroke. The engine is single-acting, and one piston at least will be active at all times. As the gears 17 and 18 intermesh the cranks driven by the high and low pressure pistons will always remain at right angles to one another or at such angle as they may be set, and the power applied to both gears is transmitted to the driving-shaft 14 and the sprocket-wheel or other gear which is used to drive the vehicle or other machinery to which it may be geared. The intermeshing gears of course move in opposite directions, and the connecting-rods of the



high and low pressure pistons will therefore move in opposite directions. The shafts 14 and 19 are journaled in bearings 27, which are secured to the brackets 16 and 20 by suitable caps 28. Piston-valves 29, controlling the admission of steam to and exhaust from the high-pressure cylinders, are connected by rods 30 to eccentrics 31 upon the shaft 19, and piston-valves 32, controlling the admission of steam to and exhaust from the low-pressure cylinders, are connected by rods 33 to eccentrics 34 upon the shaft 14. Removably secured in the central portion of the cylinder-frame is a controlling-valve casing C, said casing being inserted from the rear end of the frame and positioned and secured thereto by means of bolts 35 and 36. This valve-casing is further secured, by means of bolts passing through a flange 37, upon the outer end of the casing, which fits against the cylinder-frame. The valve-casing is provided at one side with a steam-inlet opening 38 and an exhaust-outlet opening 39 at the opposite side in which are fitted the steam and exhaust pipes 40 and 41, respectively. Within the valve-casing is arranged a longitudinally-movable hollow controlling-valve 42, (see Fig. 7,) to which is attached a valve-rod 43, extending through a stuffing-box 44 at the outer end of the casing. This valve controls the admission of steam to all of the slide-valve cylinders 3, 4, 8, and 9. As shown, the controlling-valve has annular ports or openings 45 and 46 in its wall near its opposite closed ends or heads 47 and 48, which heads are connected to the central portion of the valve by spiders c, and a portion of the valve between said ports is reduced in diameter in order to provide an elongated annular steam-space 49 opposite the steam-inlet port 50. (Indicated in dotted lines in Fig. 7.) Exhaust passage-ways 51 and 52 lead from the opposite ends of the valve-casing to the exhaust-outlet 39, as shown in dotted lines in Fig. 6. A passage-way 53 leads upwardly from the interior of the casing C, and thence branches laterally in opposite directions, entering the rear ends of both high-pressure valve-cylinders through ports 53<sup>a</sup>. A passage-way 54 also leads upwardly from the fore part of the casing and enters both high-pressure valve-cylinders through ports 54<sup>a</sup> in front of the passage-ways 55 and 55<sup>a</sup>, which lead from said valve-cylinders to the rear of the working pistons 26 in the high-pressure cylinders 1 and 2. The course of the passage-way 53 is indicated in dotted lines in Fig. 3 and that of the passage-way 54 is parallel therewith. Figs. 4, 5, and 7 show the passage-ways in full lines. Similar passage-ways 56 and 57 lead from the lower side of the casing C downwardly and thence laterally into the slide-valve cylinders 8 and 9 on either side of the passage-ways 58 and 58<sup>a</sup>, which extend from said valve-cylinders into the main low-pressure cylinders 6 and 7.

The ports 59 and 60 at the upper side of the controlling-valve casing are intermediate of the ports 61 and 62 at the lower side, as shown in Fig. 7.

Referring to Fig. 7, it will be seen that in the position which the controlling-valve occupies no steam can enter the engine-cylinders from the steam-port 50. When the controlling-valve is moved to the right, however, until the ports 45 and 46 register with the ports 59 and 62, respectively, steam may pass from the steam-port 50 through port 60 into the passage-way 54 and from thence to both high-pressure valve-casings. The eccentrics are so arranged as to admit steam to the high-pressure steam-cylinders alternately. After the steam has entered one of the cylinders—for instance, the cylinder 1—it will after the piston 26 has finished its stroke exhaust through the passage-ways 55 and 53, ports 59 and 45, into and through the controlling-valve, and thence by way of the ports 46 and 62 and the passage-way 57 into the low-pressure valve-cylinder 9, from whence it will be admitted through passage-way 58<sup>a</sup> to the low-pressure cylinder 7, which is diagonally opposite the high-pressure cylinder 1. After the steam has expanded in said low-pressure cylinder 7 and driven the piston 23 outward the forward movement of the low-pressure valve 32 will permit the steam to escape at the rear of said valve into the passage-way 56, and thence through the valve-casing C and exhaust passage-way 51 to the exhaust-pipe 41. When the piston in the high-pressure cylinder 1 has completed its outward stroke and has passed the dead-center, steam will be admitted by the valve in the valve-cylinder 4 behind the piston in the high-pressure cylinder 2, from whence it will exhaust through the passage-ways previously mentioned, valve-cylinder 8, and passage-way 58 into the low-pressure cylinder 6 upon the opposite side of the casing, and from thence will pass outwardly through the passage-way 56, valve-casing C, and exhaust passage-way 51 to the exhaust-pipe.

In the position of the controlling-valve where the ports 45 and 46 register with the ports 59 and 62, respectively, therefore, the engines will run in one direction—forward—as compound engines. If the controlling-valve be moved farther inward—that is, to the right in Fig. 7—until the left-hand end 47 of the valve passes the port 59 and the ports 60 and 62 are both in communication with the steam-space 49, the engines will run as simple engines in the same direction, steam at full boiler-pressure being admitted to the high and low pressure cylinders through the ports 60 and 62 and exhausting through the ports 59 and 61 into the left-hand end of the casing, thence passing into the exhaust passage-way 51. The engine may therefore when considerable power is required to start or operate the vehicle be started and continue as a simple engine, with full pressure in the high and low



pressure cylinders, or it may with a slight movement of the valve be operated as a compound engine.

In order to reverse the motor, the controlling-valve is moved outwardly to the extreme left in Fig. 7, when the port 59 will be in communication with the steam-space 49, the valve-port 46 will register with the steam-inlet 50 and port 45 with port 61, and the ports 60 and 62 will both communicate through the right-hand end of the valve-casing with the exhaust passage-way 52. Live steam will then be admitted through said port 59 to the high-pressure cylinders and through ports 46, 45, and 61 to the low-pressure cylinders, and the exhaust will pass through ports 60 and 62 to the passage-way 52. The engine will therefore run backward as a simple engine.

While in the construction just described the controlling-valves and ports are arranged to operate the engines compound or simple in one direction and as simple engines in the opposite direction, a slight change in the arrangement of the ports will provide for operating the engines compound in both directions or simple in both directions. In Fig. 8 I have shown such an arrangement. In this figure the steam-inlet port 50 is located about midway between the ports 59 and 60 of the valve 42<sup>a</sup>, and the steam-space 49<sup>a</sup> is longer than in Fig. 7 and extends to substantially equal distances from the ports 45 and 46 in the valve. When the valve is moved to the right from the position shown, so that the ports 45 and 46 register with the ports 59 and 62, respectively, the port 60 will be in communication with the steam-space 49<sup>a</sup> and the port 61 will be in communication with the exhaust passage-way 51. Steam may therefore pass from the steam-space 49<sup>a</sup> through the port 60 to the high-pressure cylinders, thence through the valve 42<sup>a</sup> by way of the ports 59 and 62 to the low-pressure cylinders, and thence by way of the ports 61 and 51 to the exhaust-pipe. The motor will therefore be driven in one direction as a compound machine. When the valve C is moved to the left until the ports 46 and 45 register with the ports 60 and 61, respectively, the steam-space 49<sup>a</sup> will be in communication with the port 59, and the port 62 will communicate with the exhaust passage-way 52, and the course of the steam through the engines will then be reversed, the steam passing from the port 59 through the high and low pressure cylinders, and thence to the exhaust by way of the port 62 and passage-way 52. The motor will then run compound in the opposite direction. If the valve be moved far enough to the left or to the right, so that the ends of the cylinder C clear the port 60 or the port 59, the engine will then act as a simple engine. If the piston be moved to the left, for instance, until the ports 60 and 62 communicate directly with the exhaust-port 52 while the ports 59 and 61 communicate with the steam-space 49<sup>a</sup>, it will be evident that steam will pass

through the ports 59 and 61 to the high and low pressure cylinders, respectively, and from thence will exhaust through the ports 60 and 62 into the exhaust passage-way 52. Therefore the engine will run as a simple engine, the low-pressure pistons receiving the full boiler-pressure. Similarly, when the valve C is moved to the right far enough to connect the ports 60 and 62 with the steam-space 49<sup>a</sup> and the ports 59 and 61 with the exhaust-port 51 the engine will run in the opposite direction as a simple engine.

The motor when applied to a vehicle may be supported in any desirable way, and the power may be transmitted from the driving-shaft to the vehicle-wheels by any suitable gearing. The arrangement of the engine is such that the moving parts will always be in balance and the power applied to the driving-shaft will be continuous.

An important feature of the invention is the arrangement of the controlling-valve, steam-ports, and passage-ways, whereby the engine may be operated as a simple or compound engine and may be moved in either direction by a single controlling-valve.

Having thus fully described the invention, what I claim, and desire to secure by Letters Patent, is—

1. A steam-motor comprising a pair of crank-shafts suitably geared to revolve in unison, a pair of steam-cylinders opposite each crank-shaft, pistons within said cylinders, connecting-rods connecting each crank-shaft with the pistons in the opposing pair of cylinders, a valve for each steam-cylinder adapted to control the inlet and outlet of steam thereto, and an adjustable controlling-valve and ports leading therefrom to the several cylinders, said controlling-valve and ports being arranged to cause the motor to operate either simple or compound according to the position of the controlling-valve.

2. A steam-motor comprising two pairs of cylinders, a crank-shaft opposite each pair of cylinders, said shafts being suitably geared to revolve in unison, pistons within the cylinders, connecting-rods connecting each crank-shaft with the pistons in the opposing cylinders, a valve for each cylinder adapted to control the inlet and outlet of steam thereto, an adjustable controlling-valve and ports leading from the several cylinder-valves to the controlling-valve, said controlling-valve and ports being arranged to cause the motor to move in either direction and to operate either simple or compound, according to the position of the controlling-valve.

3. A steam-motor comprising a cylinder-frame having two pairs of cylinders, a crank-shaft opposite each pair of cylinders, said shafts being suitably geared to revolve in unison, pistons within the cylinders, connecting-rods connecting each crank-shaft with the pistons in the opposing cylinders, a valve for each cylinder adapted to control the inlet and outlet of steam thereto, a controlling-



valve casing removably secured within the cylinder-frame, a controlling-valve adjustable within said casing and ports in the cylinder-frame leading from the several cylinders to ports in the controlling-valve casing, said valve and ports being arranged to cause the motor to move in either direction and to operate either simple or compound according to the position of the controlling-valve.

4. A steam-motor comprising high-pressure and low-pressure cylinders, a valve for each cylinder arranged to control the inlet and outlet of steam thereto, a controlling-valve and passage-ways leading therefrom to the cylinder-valves, said controlling-valve and passage-ways being so arranged as to cause the motor to operate simple or compound, according to the position of the controlling-valve.

5. A steam-motor comprising high-pressure and low-pressure cylinders, a valve for each cylinder arranged to control the inlet and outlet of steam thereto, a controlling-valve and passage-ways leading therefrom to the cylinder-valves, said controlling-valve and passage-ways being so arranged as to cause the motor to run in either direction and to operate simple or compound, according to the position of the controlling-valve.

6. In a steam-motor, the combination with two pairs of cylinders, pistons within the cylinders, a crank-shaft opposite each pair of cylinders and connecting-rods connecting each pair of pistons to the opposing crank-shaft, of a controlling-valve arranged between the two pairs of cylinders, ports leading from said valve to the several cylinders, said valve being arranged to control the direction of the steam through the cylinders whereby the motor may be operated either simple or compound and in either direction.

7. In a steam-motor, two high-pressure cylinders, two low-pressure cylinders, a separate valve-cylinder and a slide-valve therein for each steam-cylinder, a controlling-valve cylinder having a central steam-inlet and exhaust passage-ways leading from its opposite ends, two passage-ways leading from said controlling-valve cylinder to the slide-valves of the high-pressure cylinders, two passage-ways leading from said controlling-valve cyl-

inder to the slide-valves of the low-pressure cylinders, and a controlling-valve within the controlling-valve cylinder arranged to direct the steam through said passage-ways to operate the engine simple or compound and in either direction.

8. In a steam-motor, the combination with a pair of high-pressure cylinders, a pair of low-pressure cylinders, and separate valves arranged to control the admission of steam to said cylinders, of a controlling-valve cylinder having exhaust-ports at either end, a central steam-inlet, two ports on either side of the steam-inlet leading to the high-pressure-cylinder valves and two ports leading to the low-pressure-cylinder valves and a hollow cylindrical controlling-valve within said controlling-valve cylinder, said controlling-valve having heads at either end, ports extending through its walls adjacent to the heads, and an intermediate portion opposite the steam-inlet of less diameter than the heads.

9. A steam-motor comprising two shafts geared to turn in unison, each shaft having two diametrically opposite cranks and the cranks of the two shafts being relatively ninety degrees apart, a pair of steam-cylinders opposite each crank-shaft, pistons within said cylinders, connecting-rods connecting said pistons with the cranks on the opposing shaft, a slide-valve for each cylinder and a pair of eccentrics on each shaft arranged to operate the valves of the opposing cylinders.

10. A steam-motor comprising two shafts geared to turn in unison, each shaft having two diametrically opposite cranks, a pair of steam-cylinders opposite each crank-shaft, pistons within said cylinders, connecting-rods connecting said pistons with the cranks on the opposing shaft, a slide-valve for each cylinder and a pair of eccentrics on each shaft arranged to operate the valves of the opposing cylinders.

In testimony whereof I affix my signature in presence of two witnesses.

IRVING S. DAVIS.

Witnesses:

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