No. 671,557.

Patented Apr. 9, 1901.

L. E. KROTZ.
ROTARY ENGINE.
(Application filed Nov. 28, 1900.)

(No Model.)

5 Sheets—Sheet 1.

Fig. 1.

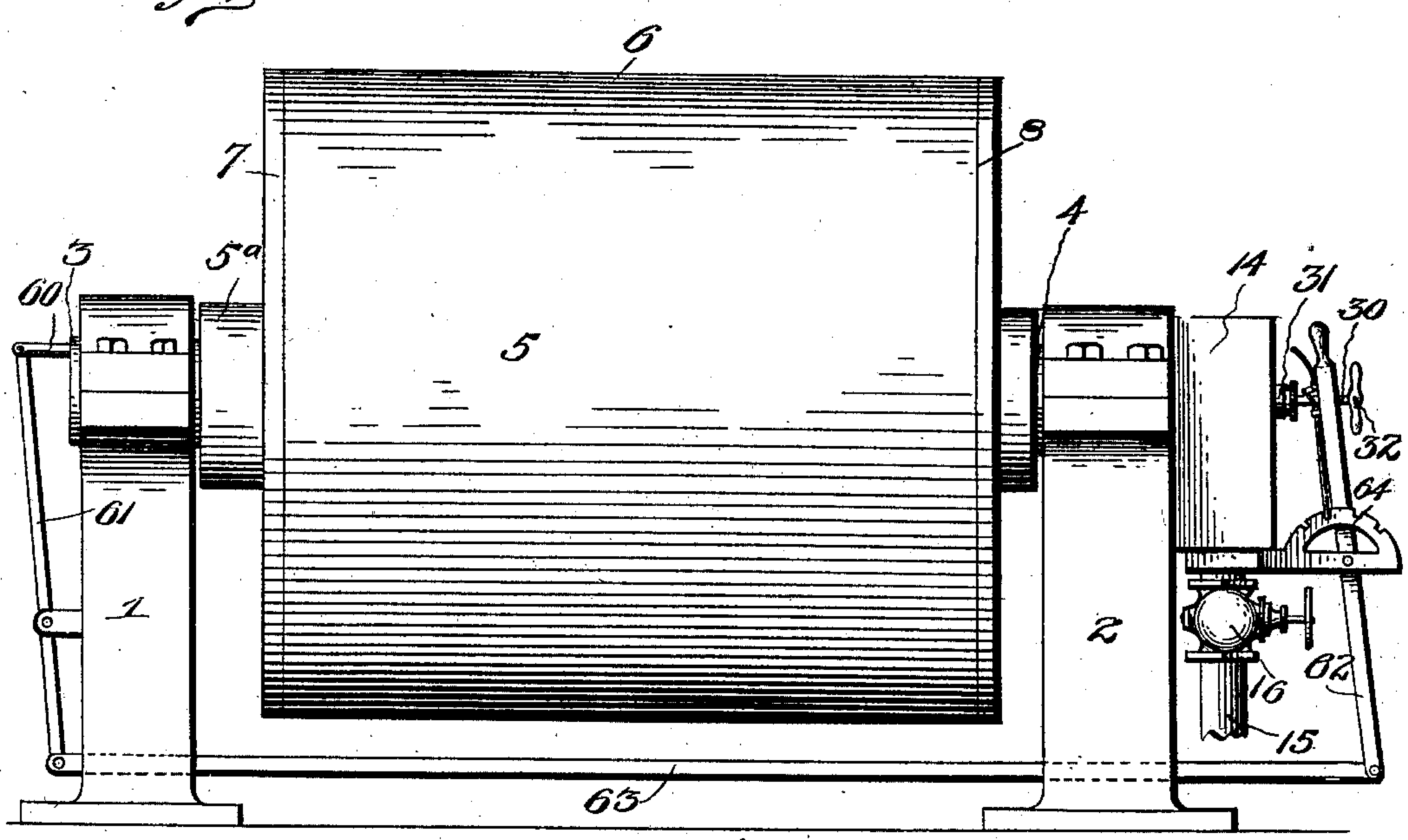
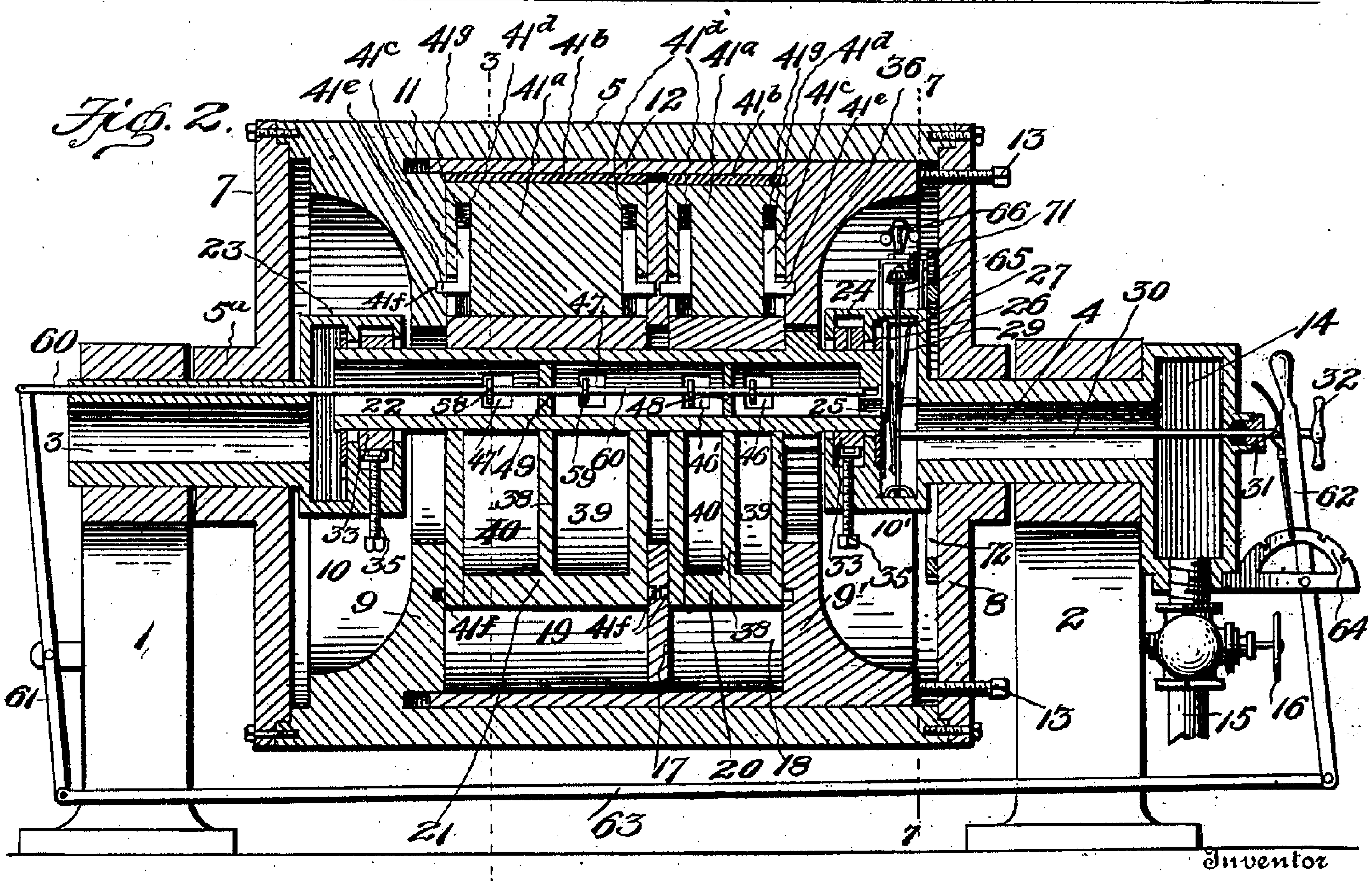


Fig. 2.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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(No Model.) 5 Sheets—Sheet 2.

Fig. 3.

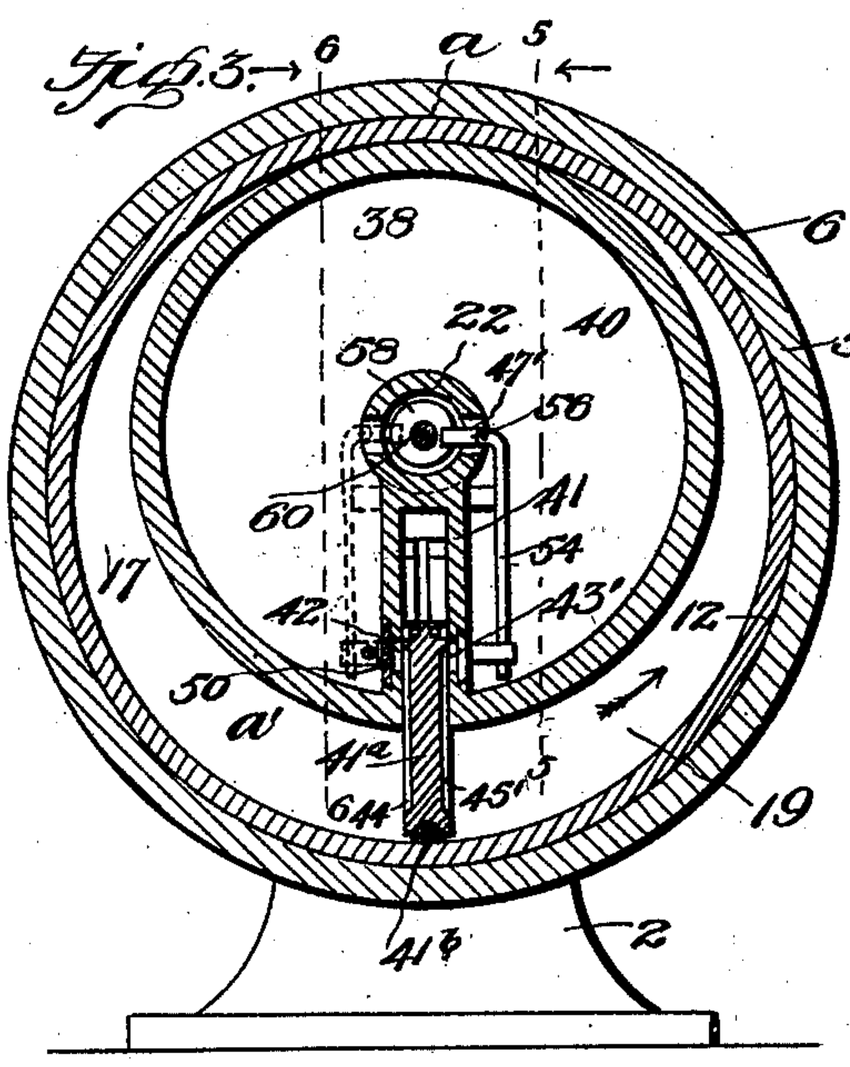


Fig. 4.

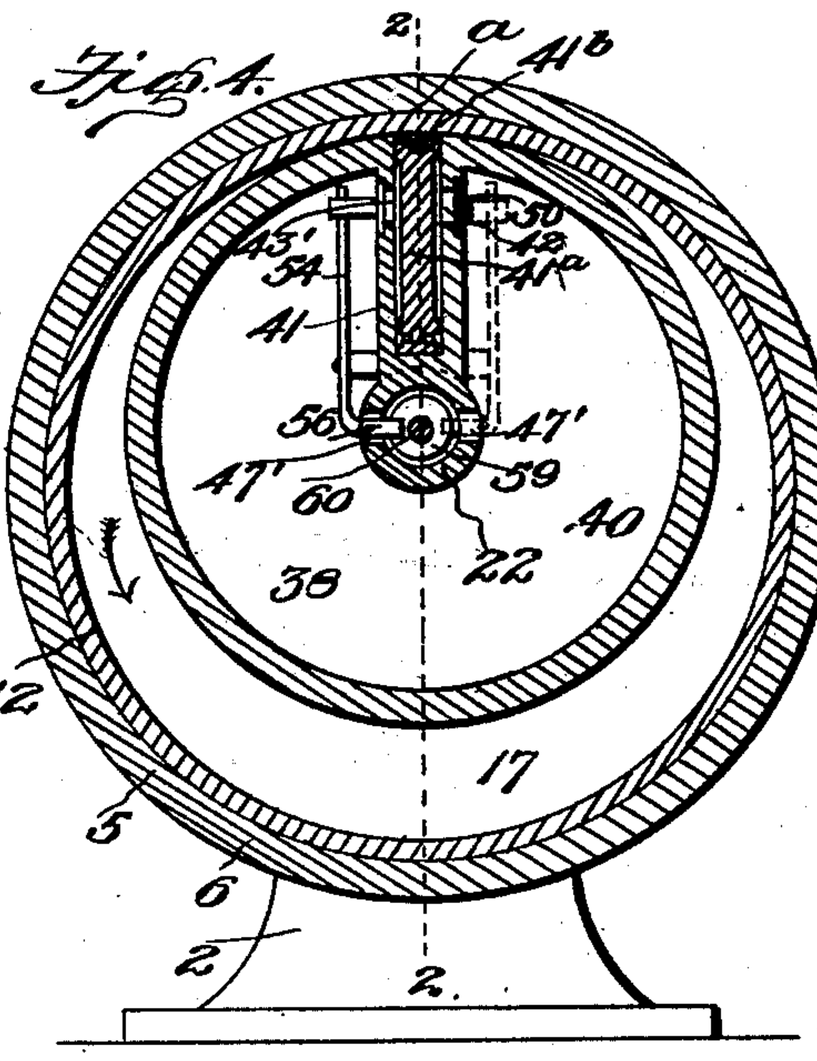
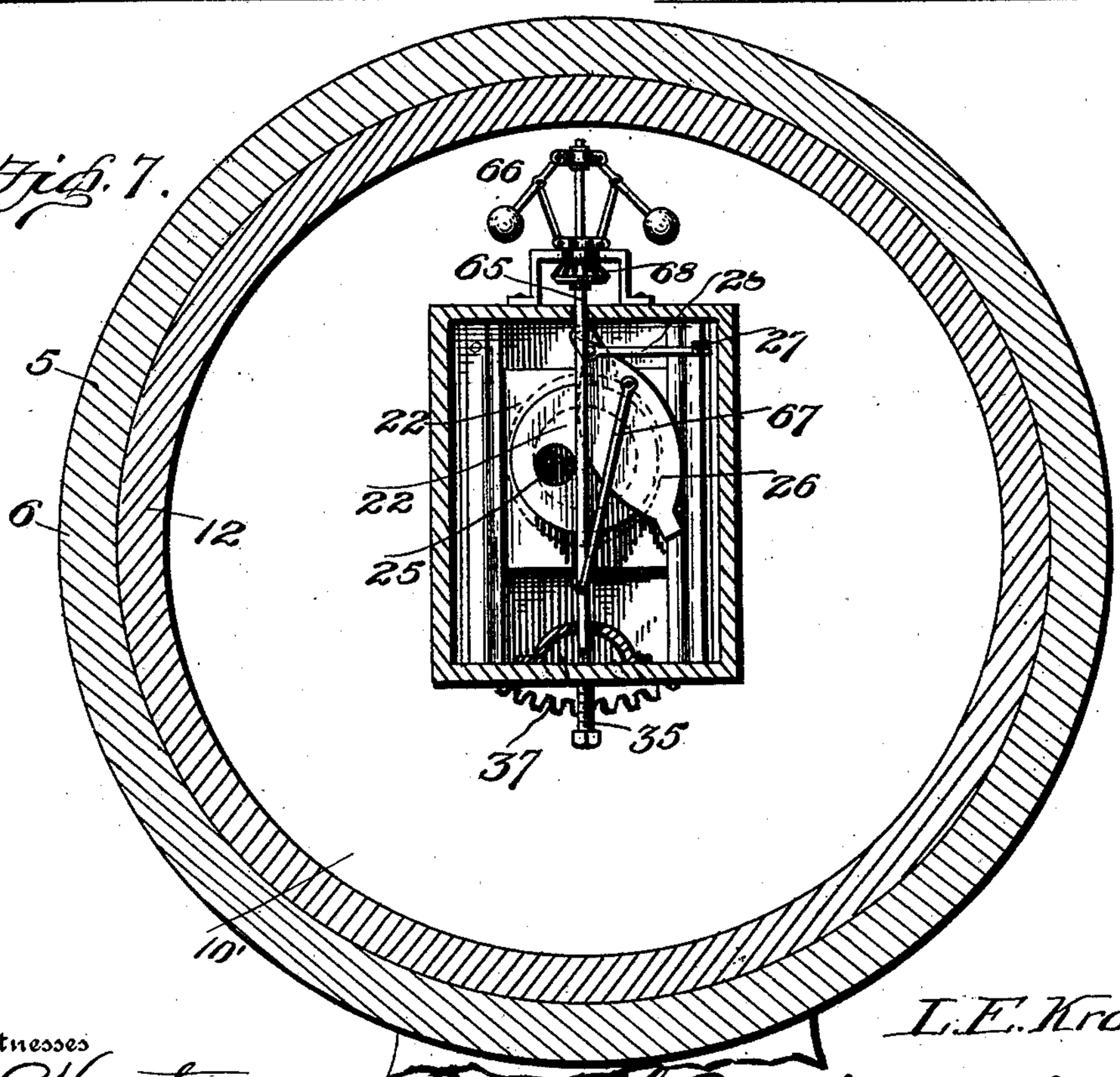


Fig. 7.



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(No Model.)

5 Sheets—Sheet 3.

Fig. 5.

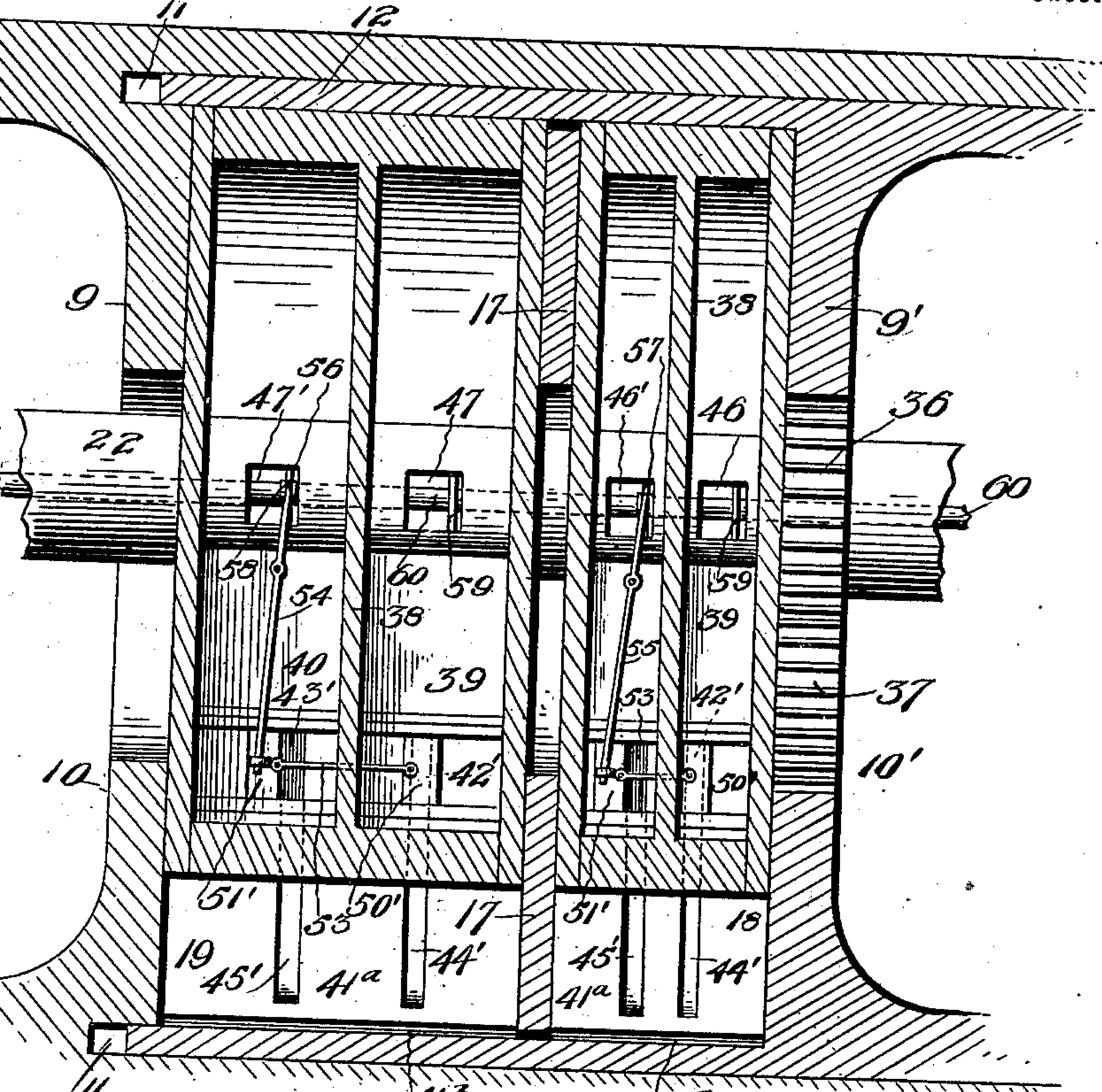
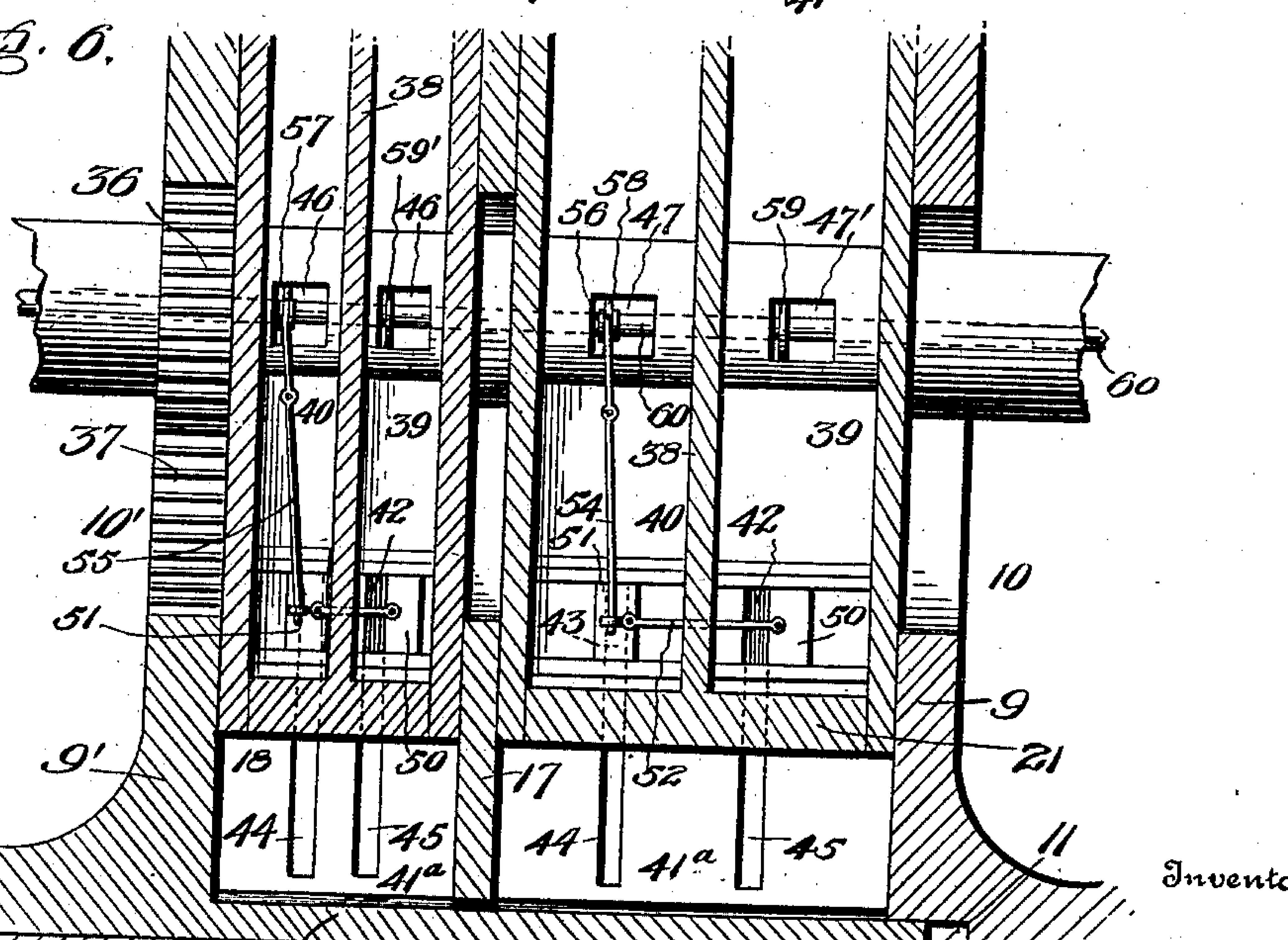


Fig. 6.



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5 Sheets—Sheet 4.

Fig. 8.

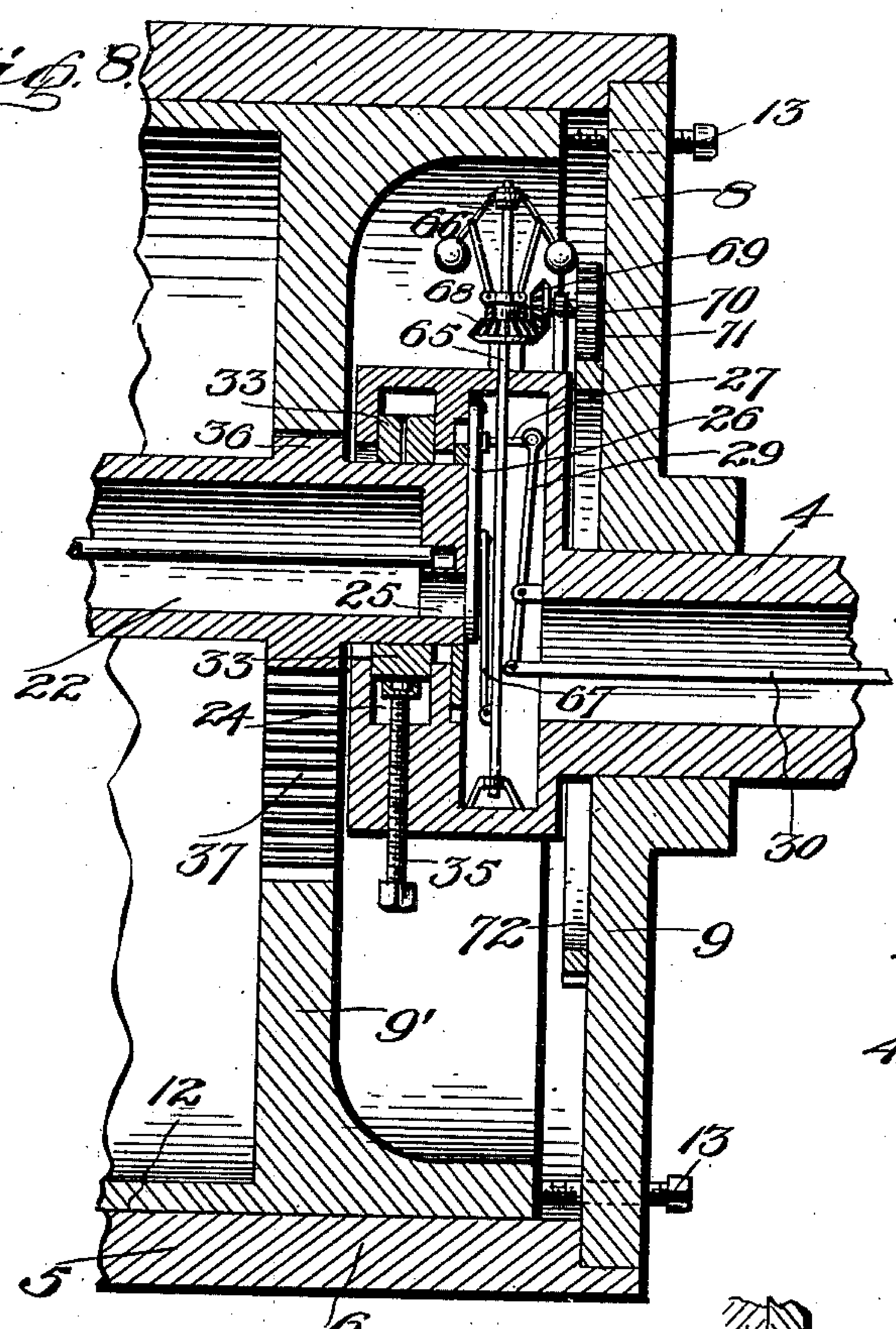


Fig. 9.

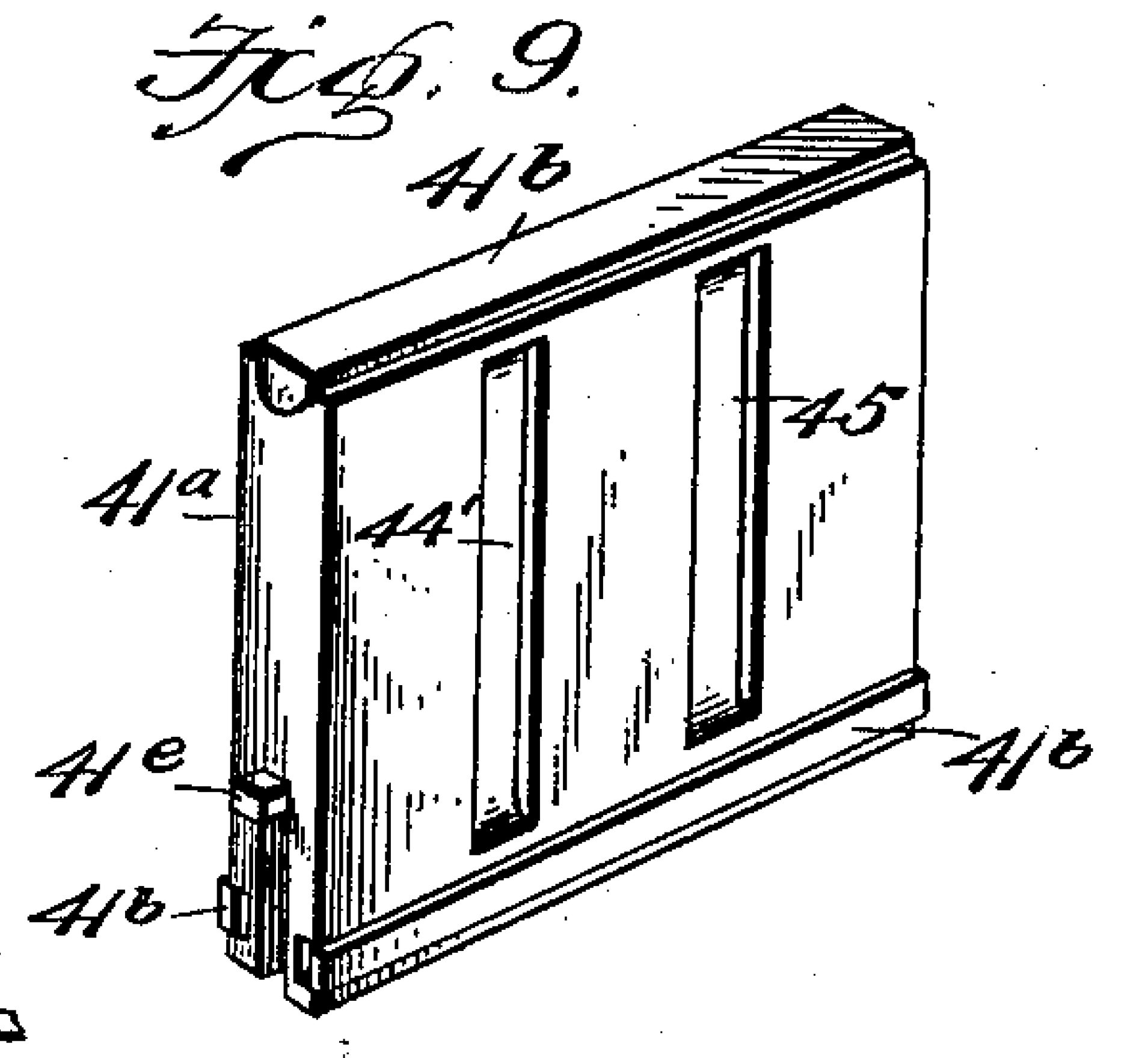


Fig. 10.

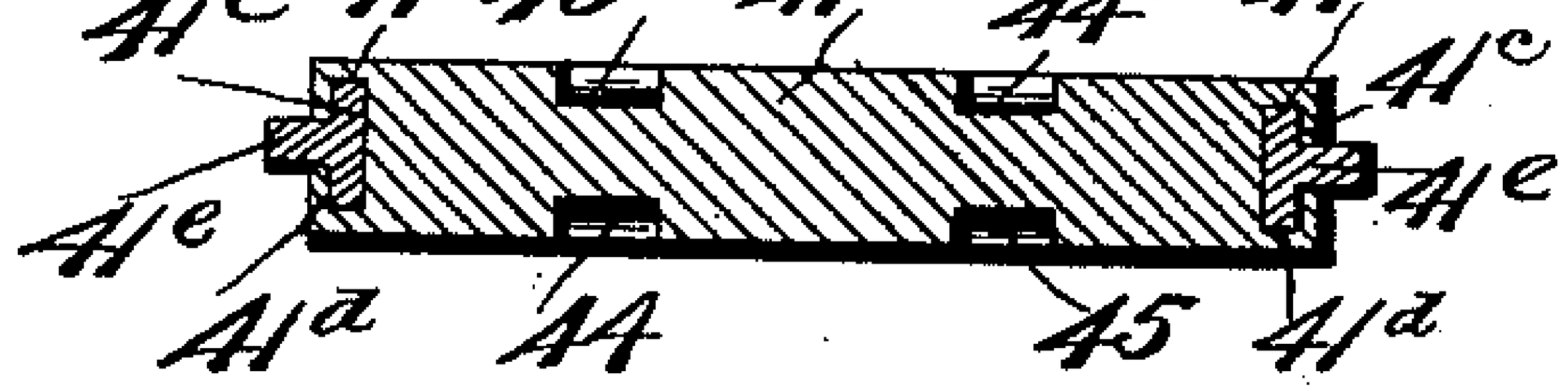


Fig. 11.

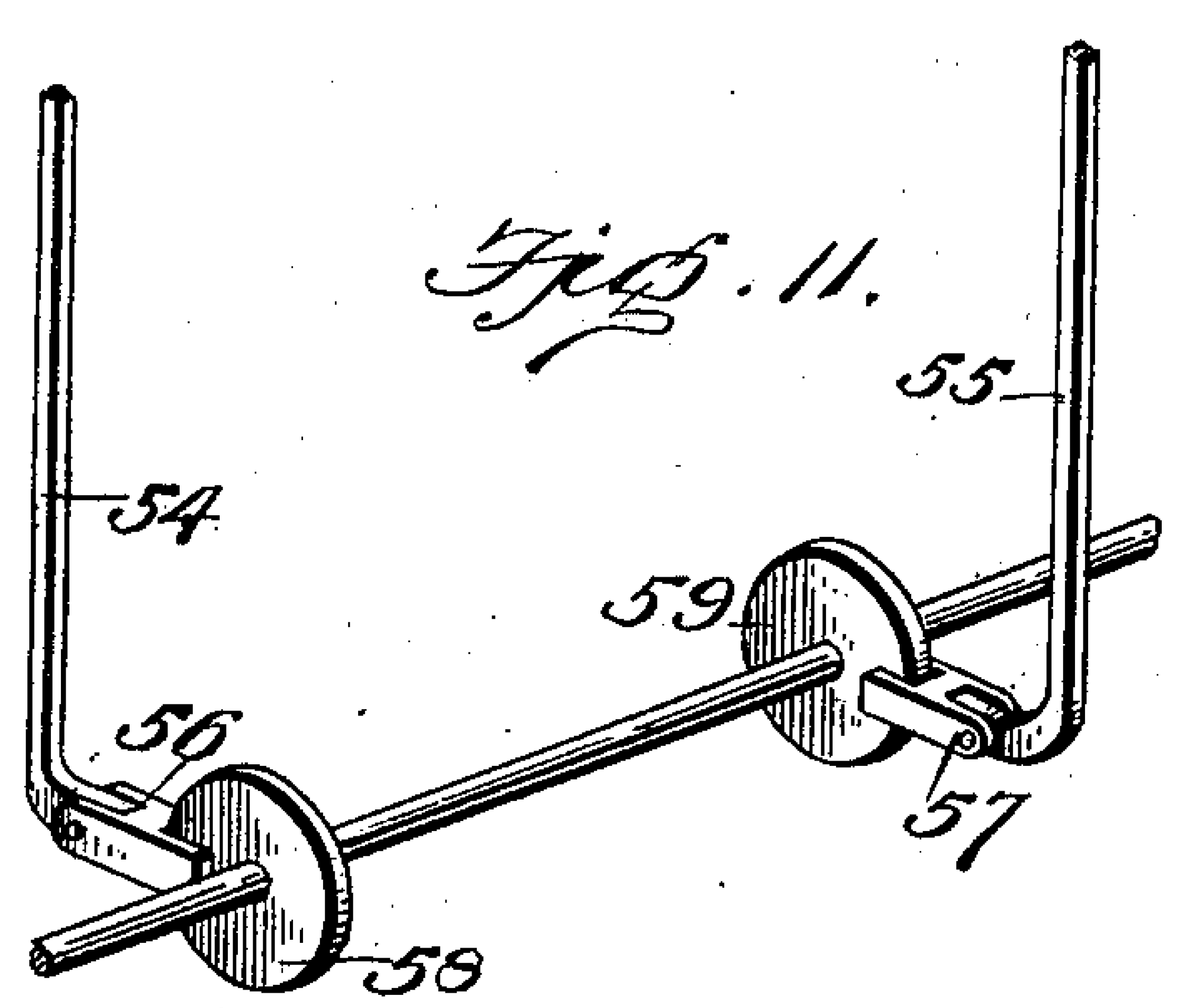


Fig. 12.

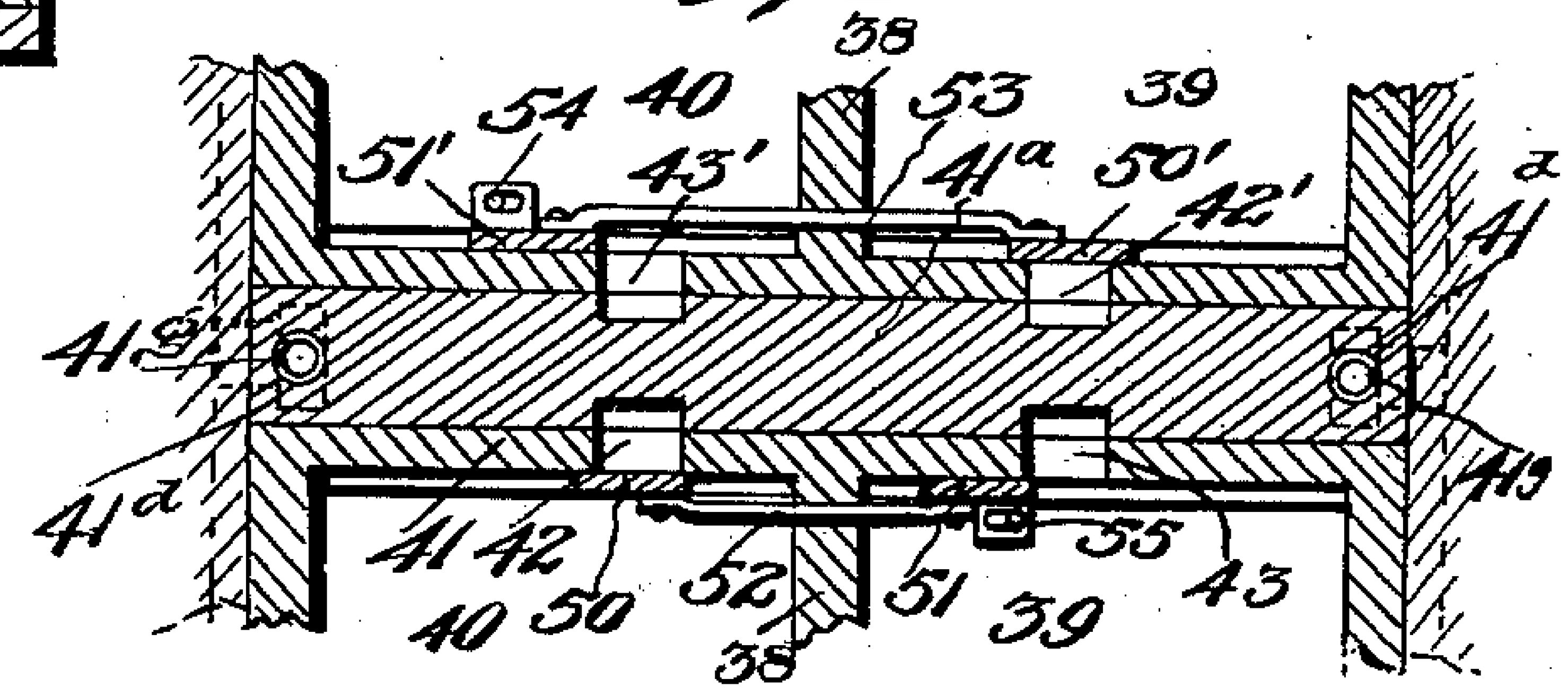
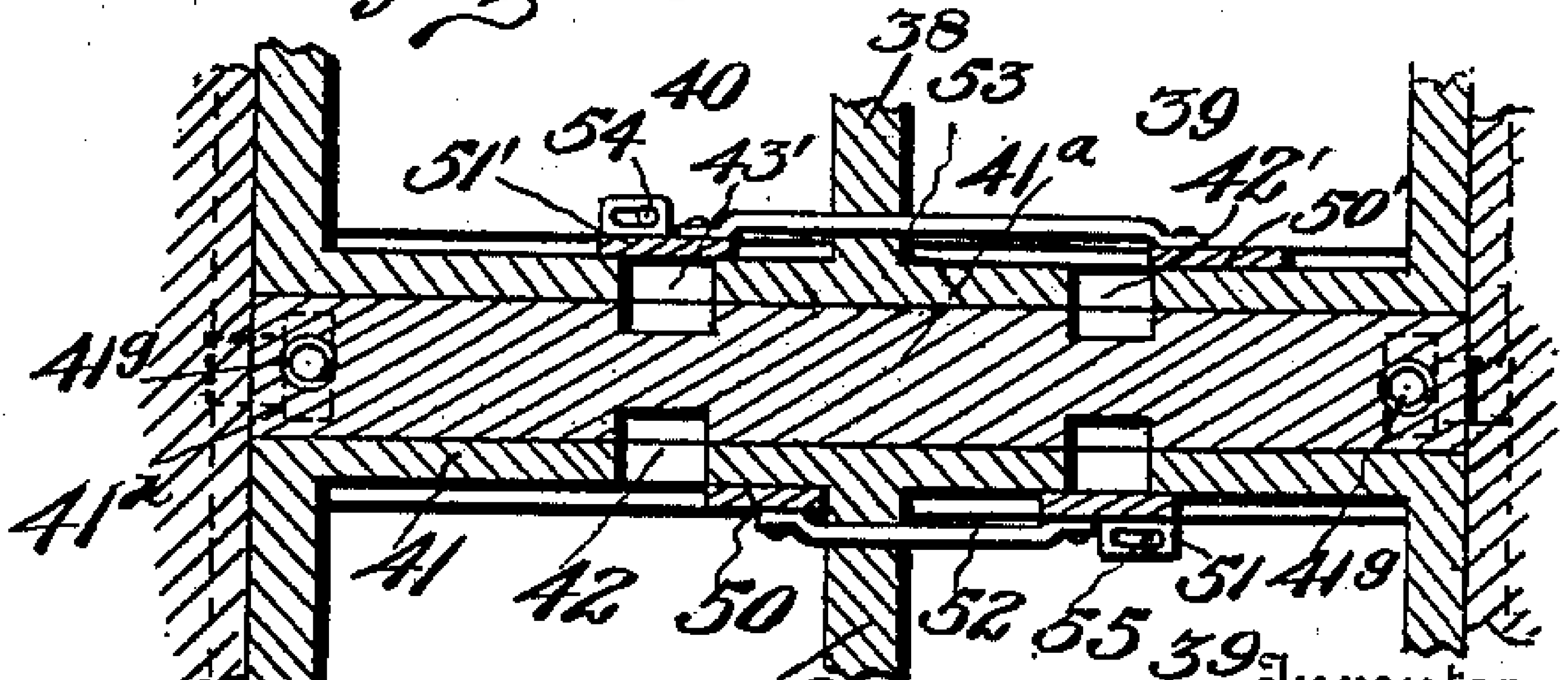


Fig. 13.



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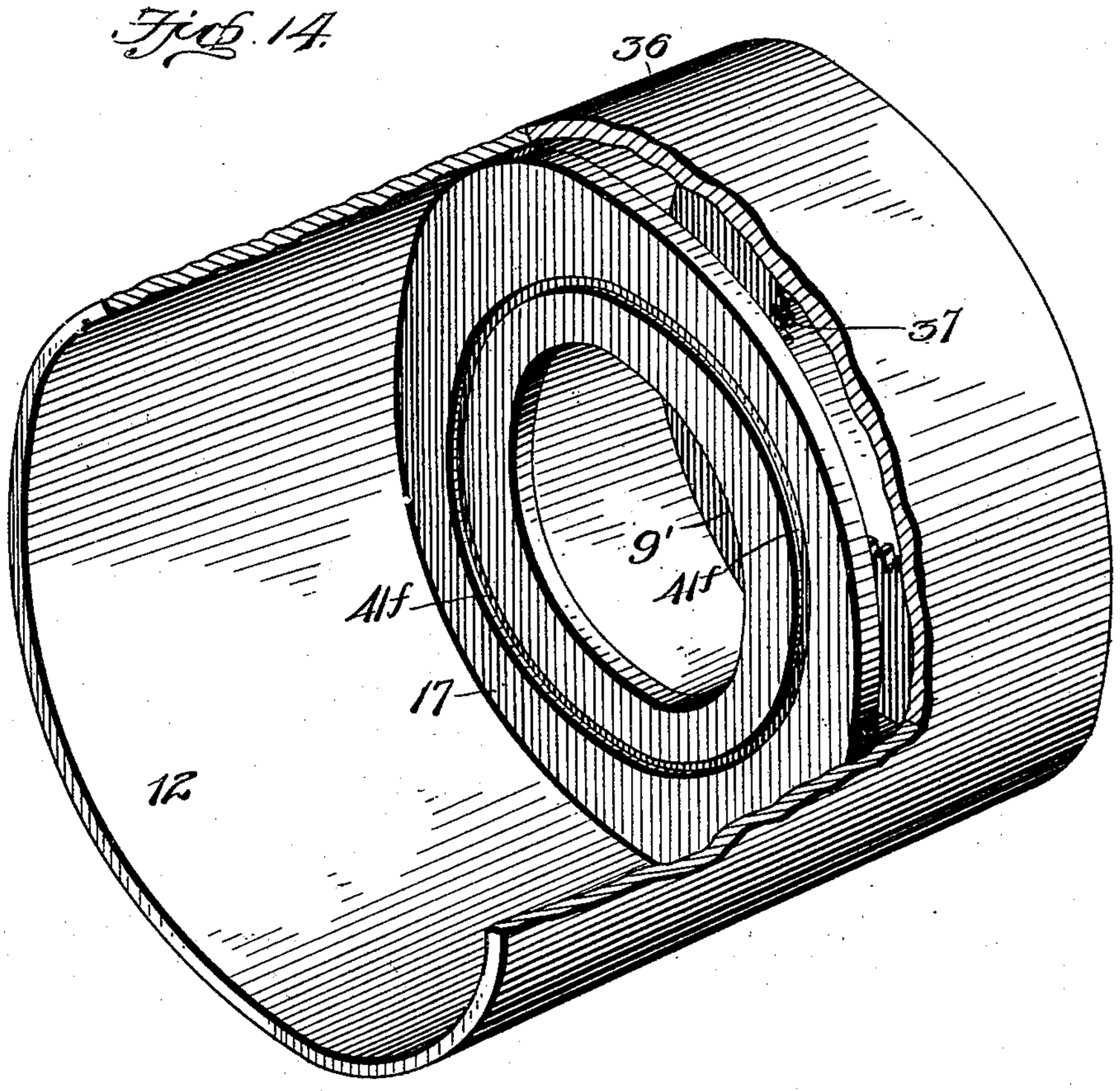
(Application filed Nov. 28, 1900.)

(No Model.) 5 Sheets—Sheet 5.

Fig. 14.



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UNITED STATES PATENT OFFICE.

LINFORD ELLSWORTH KROTZ, OF VICTOR, COLORADO.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 671,557, dated April 9, 1901.

Application filed November 28, 1900. Serial No. 38,047. (No model.)

To all whom it may concern:

Be it known that I, LINFORD ELLSWORTH KROTZ, a citizen of the United States, residing at Victor, in the county of Teller and State of Colorado, have invented certain new and useful Improvements in Rotary Steam-Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in rotary steam-engines, and has for its object the production of an engine of this character which will use steam expansively in an effective manner, which embodies improved features of construction capable of employment in a single or duplex high-pressure or compound engine, and which is reversible and designed to give both high power and speed.

The invention consists in certain novel features of construction, combination, and arrangement of parts, as will be hereinafter more fully described, and particularly pointed out in the appended claims.

In the accompanying drawings, Figure 1 is a side elevation of a rotary engine embodying my invention. Fig. 2 is a vertical longitudinal section of the same on line 2 2 of Fig. 4. Fig. 3 is a vertical transverse section of the same on line 3 3 of Fig. 2, showing the piston at the intermediate point in the revolution of the inner eccentric cylinder. Fig. 4 is a similar view showing the piston at the starting-point at which both the supply and exhaust of steam are cut off. Fig. 5 is an enlarged detail longitudinal sectional view through the piston-chambers and inner eccentric cylinders on line 5 5 of Fig. 3 looking toward the exhaust side. Fig. 6 is a similar view looking toward the inlet side. Fig. 7 is a vertical transverse section on line 7 7 of Fig. 2. Fig. 8 is an enlarged detail longitudinal section through the governor-chamber, showing the governor mechanism. Fig. 9 is a perspective view of a piston-wing. Fig. 10 is a longitudinal section thereof. Fig. 11 is a detail view of parts of the reversing mechanism. Figs. 12 and 13 are sections through the piston-wing casing, showing the positions of the reversing-valves in the rotation of the piston in both directions. Fig. 14 is a detail perspective view of the inner adjustable head and flange, the latter being partly broken away to show the adjustable partition therein.

Referring now more particularly to the drawings, the numerals 1 and 2 represent standards or pillow-blocks, in which are mounted stationary tubular journals 3 and 4, on which the outer engine-cylinder 5 revolves. This cylinder comprises in its construction an annular body 6, closed at each end by heads 7 and 8, which are removably applied thereto, and provided upon its interior, adjacent to the head 7, with a fixed annular end wall or head 9, concaved upon its outer face to form an intervening space or chamber 10 between it and said head 7 and formed upon its inner face with an annular groove 11. Into this groove extends the outer edge of a cylindrical flange 12, projecting from the inner face of a longitudinally-adjustable annular end wall or head 9′, located adjacent to the head 8. The outer face of this wall or head 9′ is concaved to form between it and the head 8 a space or chamber 10′, corresponding to the chamber 10. The head 9′ and its flange 12 fit steam-tight within the cylinder and are adjustable toward the head 9 by means of screws or other suitable adjusting devices 13, working in the head 8. Connected to or formed upon the tubular journal 4 and in open communication therewith is a steam-chest 14, to which is connected a steam-supply pipe 15, having a controlling-valve 16. The journal 4 being in communication with the steam-chest serves as a conductor whereby live steam is conveyed to the engine, while the journal 3 serves as an exhaust.

An adjustable annular partition 17 fits steam-tight upon the interior of the cylindrical flange 12 and separates the interior of the outer cylinder 5 into high and low pressure steam or piston chambers 18 and 19, in which are disposed the high and low pressure inner cylinders 20 and 21, mounted upon a hollow shaft 22, extending through said steam-chambers and through the apertures in the heads or walls 9 and 9′ and journaled at its ends in boxings 23 and 24, formed or provided upon the inner ends of the tubular journals 3 and 4 and located in the said chambers 10

10′. This shaft is provided at its inner end, within the boxing 24, with a restricted feed-port 25 in communication with the journal 4 and through which steam is conducted to the steam-chambers 18 19 in the manner hereinafter described. An automatic cut-off valve 26, pivoted at its upper end, is adapted to swing across and open and close the port and may be adjusted to regulate the supply of steam by means of a bell-crank lever 27, having one of its arms connected by a link 28 to the valve and its other arm jointed to the upper end of an intermediately-pivoted vertical operating-lever 29. A sliding rod 30 is connected at its inner end to said lever and extends to the exterior through the tubular journal 4 and a stuffing-box 31 in the steam-chest 14 and is provided at its outer end with an operating key or handle 32. By operating this handle by pulling it outwardly or shoving it inwardly the valve 26 may be thrown to either side of the center of the shaft 22 to coöperate with the valve mechanism, according to the direction of motion of the piston-cylinders. Fig. 7 shows the position in which the valve stands when the engine is rotating to the left. From this it will be seen that valve 26 will close port 25 at about a three-quarter revolution. The pistons being in the same position as this port, no steam is admitted through this port for the balance of the travel of the pistons in the steam-chambers on that revolution. Upon reversing the engine to rotate to the right, with the valve in the same position, the port 25 will be closed on the first quarter-revolution and open on the last three-quarters; hence the necessity for shifting the valve over from one to the other side of the port when the engine is reversed.

The hollow shaft 22 is mounted eccentrically to the axis of the outer cylinder 5 and is adjustably supported in bearings 33 in the boxings 23 and 24, each of which bearings is provided with an adjusting-screw 35, and said shaft is formed at one end with gear-teeth 36, which mesh with teeth 37 upon the inner circumference of the head or wall 9′, whereby said cylinder is caused to rotate with the shaft. The inner or piston cylinders 20 and 21 are mounted adjustably and concentrically on the shaft, and consequently eccentric to the axis of the outer cylinder 5, so that a portion of the perimeter of each piston-cylinder normally lies in contact with the inner circumference of the outer cylinder. In the present instance the parts are so arranged as to bring each piston-cylinder into contact with the interior surface of the outer cylinder at the point *a* along a line at the top of each and in a vertical plane through their axes.

The interior of each inner or piston cylinder is divided by a partition 38, extending transversely of the shaft 22 into supply and exhaust chambers 39 and 40, and is provided at one point with a radial piston-casing 41, extending through the partition and across said chambers and from the hollow shaft 22 through the perimeter of the cylinder. In this casing is slidably mounted a piston-wing 41^a, formed with recesses in which are disposed packing-strips 41^b, forming a steam-tight connection between the piston-wing and inner surface of the outer cylinder 5 and said wing and the walls of the casing 41. Each piston-wing is held within its casing by keys 41^c, slidably fitted in sockets 41^d therein and formed at their outer ends with laterally-extending toes or bit portions 41^e, which are adapted to play in openings in the ends of the wing and to fit within and traverse grooves 41^f, formed in the head 9 and partition 17 or the head 9′ and said partition, as the case may be. Springs 41^g are disposed within the sockets and act to press the piston-wings outwardly to hold the outer edge thereof at all times in contact with the inner surface of the cylinder 5. The side walls of the piston-casing are provided in the supply and exhaust chambers 39 and 40 of each inner or piston cylinder 20 and 21 with duplicate supply and exhaust ports 42 42′ 43 43′, which are located at the outer end of the casing and coöperate with feed grooves or recesses 44 44′ 45 45′, arranged in the opposite sides of the piston-wing, the grooves 44 44′ coacting with one set of supply and exhaust ports 42 42′ and the grooves 45 45′ with the other set of supply and exhaust ports 43 43′. Steam is supplied to the chambers 18 and 19 through supply-ports 46 47 and exhausts therefrom through companion exhaust-ports 46′ 47′ in the hollow shaft 22. These ports are arranged in pairs at diametrically opposite sides of the shaft, and the ports of each set are separated by partitions or diaphragms 48 and 49, the supply-port 46 being separated from the exhaust-port 46′ by the partition or diaphragm 48 and the supply-ports 47 from the exhaust-ports 47′ by the partition or diaphragm 49.

The piston-cylinders in the compound engine herein shown are formed or keyed upon the shaft 22 and rotate at the same speed and in the same direction and are necessarily of different relative areas to secure approximately equal pressure. I have shown this form of engine as best adapted to illustrate the construction and principle of operation of my invention; but it will of course be understood that the same may be embodied in a single or duplex high-pressure engine by changes in the construction falling within the spirit and scope of the invention. In the single form of engine the piston-cylinder 20 and coöperating parts would alone be employed; but the construction of the cylinder would be substantially the same. In the duplex high-pressure engine piston-cylinders of approximately the same area would be employed and arranged at diametrically opposite points, so as to secure the direct pressure of steam throughout each entire revolution, and the construction of the hollow shaft and outer cyl-

inder would be approximately the same as in the present case. I do not therefore desire to limit the invention to the specific construction and arrangement of parts herein shown for purposes of illustration only, as the foregoing and other changes may be made without departing from the spirit of the invention.

The engine is provided with reversing mechanism and with governor mechanism. The reversing mechanism is arranged in duplicate in each cylinder, and each set comprises in its construction two pairs of slide-valves 50 51 50′ 51′. The valves 50 51 control the ports 42 43 in one side of the valve-casing 41, but on opposite sides of the partition 17, the valve 50 being disposed in the supply-chamber 18 and the valve 51 in the exhaust-chamber 19. These valves are connected by a stem or rod 52, extending through said partition 38, to move in unison and to alternately open and close the ports 42 43, the valves being so arranged that when the valve 50 uncovers the port 42 the valve 51 covers the port 43, as shown in Fig. 6, and vice versa. The valves 50′ 51′, on the other hand, control the ports 42′ 43′ in the opposite side of the valve-casing 41 and on opposite sides of said partition 38 and are connected by a stem or rod 53, extending through the partition, so as to alternately close the ports 42′ 43′, the movement of the valves in one direction closing the port 42′ and opening the port 43′, as shown in Fig. 5, and in the reverse direction opening said port 42′ and closing said port 43′. The ports 42 42′ coact with each other to form supply and exhaust ports when the engine is running in one direction, while the ports 43 43′ similarly coact when the engine is running in the reverse direction. These ports are diagonally disposed on opposite sides of the partition 17, as shown in Fig. 12. Thus it will be understood that the valves 50 50′ and 51 51′ are companion valves and simultaneously open or close the ports governed thereby. The two pairs or sets of valves of each cylinder are operated through the medium of pivoted levers 54 and 55, which are mounted to swing in a direction longitudinally of the hollow shaft 22 and are connected at their outer ends to one of the valves of each set and provided at their inner ends with pivoted or knuckle-jointed shifting lugs 56 and 57, which project through the ports 46 46′ or 47 47′, as the case may be, in the hollow shaft 22 and are bifurcated to straddle disks 58 and 59 upon a rod 60, extending longitudinally through said shaft. As will be readily understood, the lugs 56 and 57 project through the ports 46 46′ and ports 47 47′ at diametrically opposite sides of the shaft and are simultaneously operated by the movement of the rod. The lugs 56 and 57 loosely engage the disks 58 and 59, so as to turn freely about the same when the engine is running. The rod 60 slides longitudinally in boxes in the shaft 22 and hollow journal 3 and extends to the exterior through the latter. The outer end of the rod is pivotally connected to the upper end of a lever 61, fulcrumed to the standard 1, which is connected to an operating-lever 62 through the medium of a connecting-rod 63, extending through the standards 1 and 2 below the engine-cylinders. This operating-lever is pivoted to a segment-rack 64 upon the steam-chest 14 and is provided with a pawl to engage the teeth of the rack to hold the parts fixed in adjusted position. The operation of this mechanism will be clear from the foregoing description.

The governor mechanism is clearly shown in Figs. 7 and 8 and is mounted in a chambered extension of the boxing 24 and comprises a vertically-sliding rod 65, connected at its upper end to a ball-governor 66 and at its lower end to a link 67, which is jointed thereto and to the valve 26. A bevel-gear 68 is carried by the governor and meshes with a pinion 69 on one end of a counter-shaft 70, which is provided at its opposite end with a spur-gear 71, meshing with a gear-ring or annulus 72 on the inner side of the head 8 of the outer cylinder. The rod 65 slides up and down as the balls of the governor move in and out and operate the valve 26 in an obvious manner to control the passage of steam to the port 25.

The operation of the engine is as follows: The reversing mechanism is operated to set the reversing-valves to control the passage of steam according to the direction in which it is desired to have the engine rotate. When it is desired to have the engine rotate in the direction of the arrow shown in Figs. 3 and 4, or to the left, the reversing mechanism is operated to cause the valves 50 50′ 51 51′ to close the ports 43 43′ and open the ports 42 42′, as shown in Fig. 12. When, however, it is desired to have the engine rotate in the reverse direction, or to the right, the valves are reversed from the position stated to close the ports 42 42′ and open the ports 43 43′, as shown in Fig. 13. Now assuming that the valves are set in the former position to rotate the engine to the left and the piston-wing is in the position shown in Fig. 3, steam is admitted to the supply-chamber 39 of the high-pressure piston-cylinder 20 through the ports 46 and fills said chamber. It then flows outwardly through the port 42′ in the piston-casing 41 and feed-groove 44′ in the piston into the high-pressure chamber 18 of the outer cylinder 5 and fills the space a' behind the piston and between the same and contacting portion a of the two cylinders 5 and 20, and thereby exerts pressure on the piston, forcing the same upwardly and around to the left and rotating the cylinder 20 and also the cylinder 5 through the meshing gear-teeth thereof in the same direction. As the piston-cylinder continues to revolve and the distance between it and the wall of the cylinder 5 decreases the piston-wing is gradually forced inward against

the tension of its springs, cutting off the flow of steam, and the cylinder revolves by momentum past the contacting point *a*. On moving past this point the piston is again gradually forced out, and the steam confined in the chamber 18 passes through the port 42 and feed-passage 44 into the chamber 40 on the exhaust side of the inner drum or cylinder and thence exhausts through the port 46′ into the hollow shaft 22. From this point the steam then passes into the low-pressure chamber 19 and takes the same course through the ports and feed-passages thereof as in the case of the high-pressure cylinder and finally exhausts through the port 47′ to the hollow shaft and from thence through the tubular journal 3 to the atmosphere. Thus both the impact and expansive force of the steam is utilized. During the exhaust through the port 42 and feed-passage 44 the steam is admitted behind the piston through the port 42′ and feed-passage 44′, whereby a continuous supply and exhaust of steam occurs. In driving the engine in the reverse direction, or to the right, it will be clear from the foregoing description that steam enters through the ports 43 and feed-passages 45 and exhausts through the ports and passages 43′ and 45′.

While the engine is primarily intended for use with steam as the impelling agent, compressed air, gas, or other expansive fluids may be efficiently employed. Power may be derived from the engine for driving machinery of any desired kind by means of a belt passed around the cylinder 5 or sleeve 5ª or through the medium of suitable gearing.

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

1. A rotary engine comprising an outer rotary cylinder, an inner rotary cylinder provided with supply and exhaust chambers and ports communicating with said chambers, a hollow shaft carrying said inner cylinder and having supply and exhaust ports communicating therewith, and a piston carried by said inner cylinder and controlling the passage of steam through the ports therein, substantially as set forth.

2. A rotary engine comprising inner and outer rotating cylinders, a piston carried by the inner cylinder, a hollow shaft carrying the inner cylinder, and reversing mechanism having operating means extending through said shaft, substantially as set forth.

3. In a rotary engine, the combination of an inclosing cylinder provided at one end with a stationary internal head, a movable internal head having a cylindrical extension engaging the fixed head and forming therewith a piston-chamber, means for adjusting said movable head and extension, and a piston rotatably mounted in said piston-chamber, substantially as set forth.

4. In a rotary engine, the combination of an inclosing cylinder, removable heads closing the ends of the cylinder, a stationary internal head near one end of the cylinder, a movable internal head near the opposite end of the cylinder and provided with a cylindrical flange or extension slidably engaging said stationary head and forming therewith a piston-chamber, adjusting devices upon the adjacent removable head of the cylinder for adjusting said movable internal head and extension, and a piston rotatably mounted in said piston-chamber, substantially as set forth.

5. In a rotary engine, the combination of a rotary outer inclosing cylinder, a rotary eccentric internal cylinder having supply and exhaust chambers, a hollow shaft having supply and exhaust ports communicating with said chambers, and supporting said internal cylinder, and a piston controlling the passage of steam through said ports and chambers of the inner cylinder, substantially as set forth.

6. In a rotary engine, the combination of a rotary outer inclosing cylinder, a rotary eccentric internal cylinder having a partition forming supply and exhaust chambers and a piston-wing casing provided with communicating ports, a hollow feed-shaft supporting said internal cylinder and having supply and exhaust ports communicating therewith, and a piston-wing mounted in said casing and having feed-grooves coöperating with the ports, substantially as set forth.

7. In a rotary engine, the combination of a rotary outer inclosing cylinder, a rotary eccentric internal cylinder having a partition forming supply and exhaust chambers and a piston-wing casing provided with communicating ports, reversing-valves governing said ports, a hollow feed-shaft supporting said internal cylinder and having supply and exhaust ports communicating therewith, and a piston-wing mounted in said casing and having feed-grooves coöperating with the ports, and mechanism for operating said reversing-valves, substantially as set forth.

8. In a rotary engine, the combination of a rotating outer inclosing cylinder having high and low pressure chambers, high and low pressure eccentric rotating internal cylinders mounted in said chambers and provided with supply and exhaust chambers and ports communicating therebetween, piston-wings carried by the inner cylinders and governing the feed of steam through said ports, and a hollow feed-shaft carrying the inner cylinders and having independent sets of supply and exhaust ports communicating with the chambers thereof, substantially as set forth.

9. In a rotary engine, the combination of an outer inclosing rotating cylinder, an inner eccentric rotating cylinder having supply and exhaust chambers and a piston-casing provided with ports communicating therewith, reversing-valves controlling said ports, a piston having feed-grooves, a hollow shaft having ports, pivoted levers for operating the

valves, a rod extending through the shaft, and carrying disks, pivoted lugs on the levers loosely straddling the disks, and operating means connected to the rod, substantially as set forth.

10. In a rotary engine, an outer rotating cylinder, an inner rotating cylinder, a hollow feed-shaft, and a piston carried by the inner cylinder and controlling the supply and exhaust of steam to and from said outer cylinder, substantially as set forth.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

LINFORD ELLSWORTH KROTZ.

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