J. E. FRIEND.

ROTARY STEAM ENGINE.

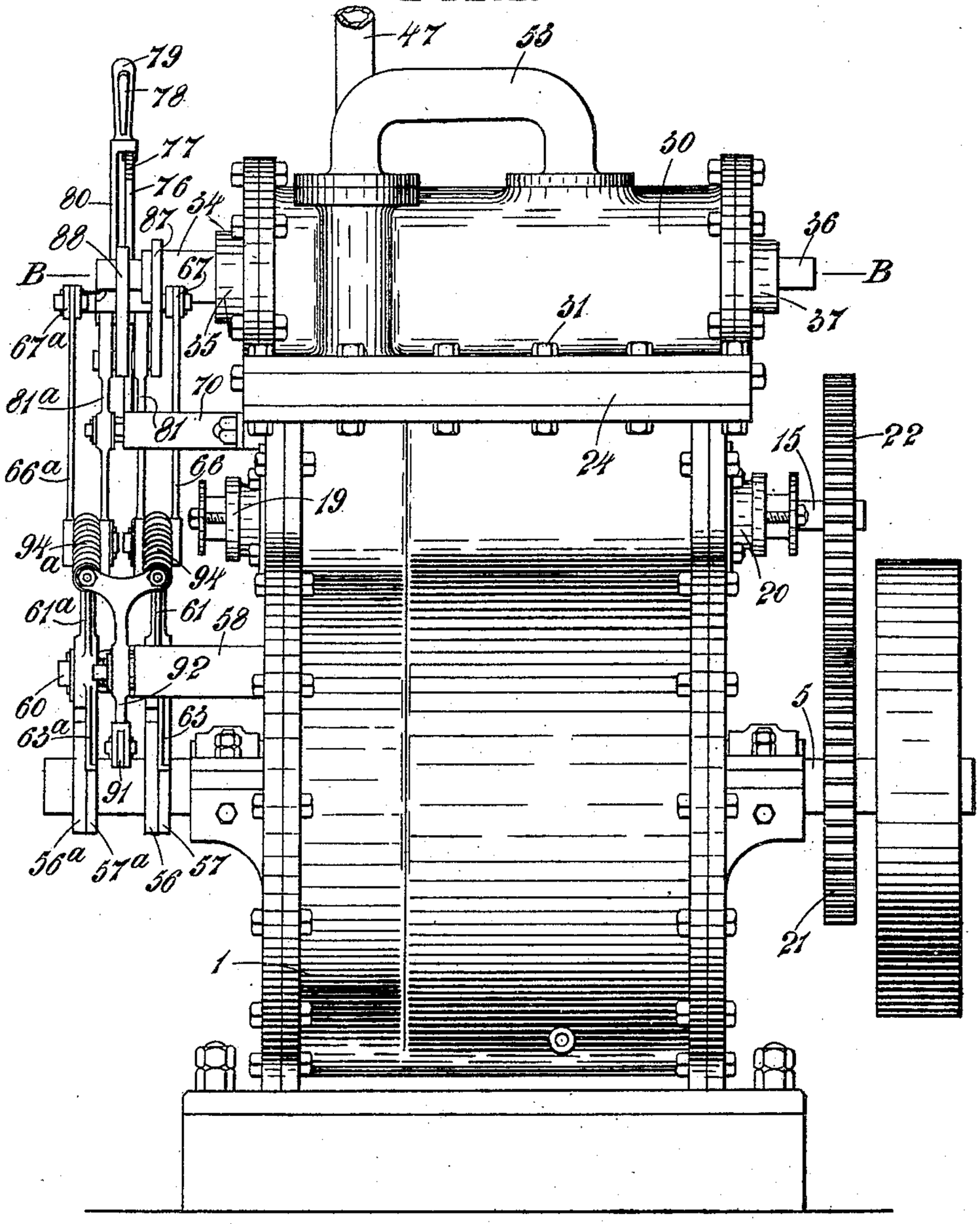
APPLICATION FILED MAY 14, 1907.

935,101.

Patented Sept. 28, 1909.

8 SHEETS—SHEET 1.

FIG. I.



Witnesses.
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Otho M. Miller

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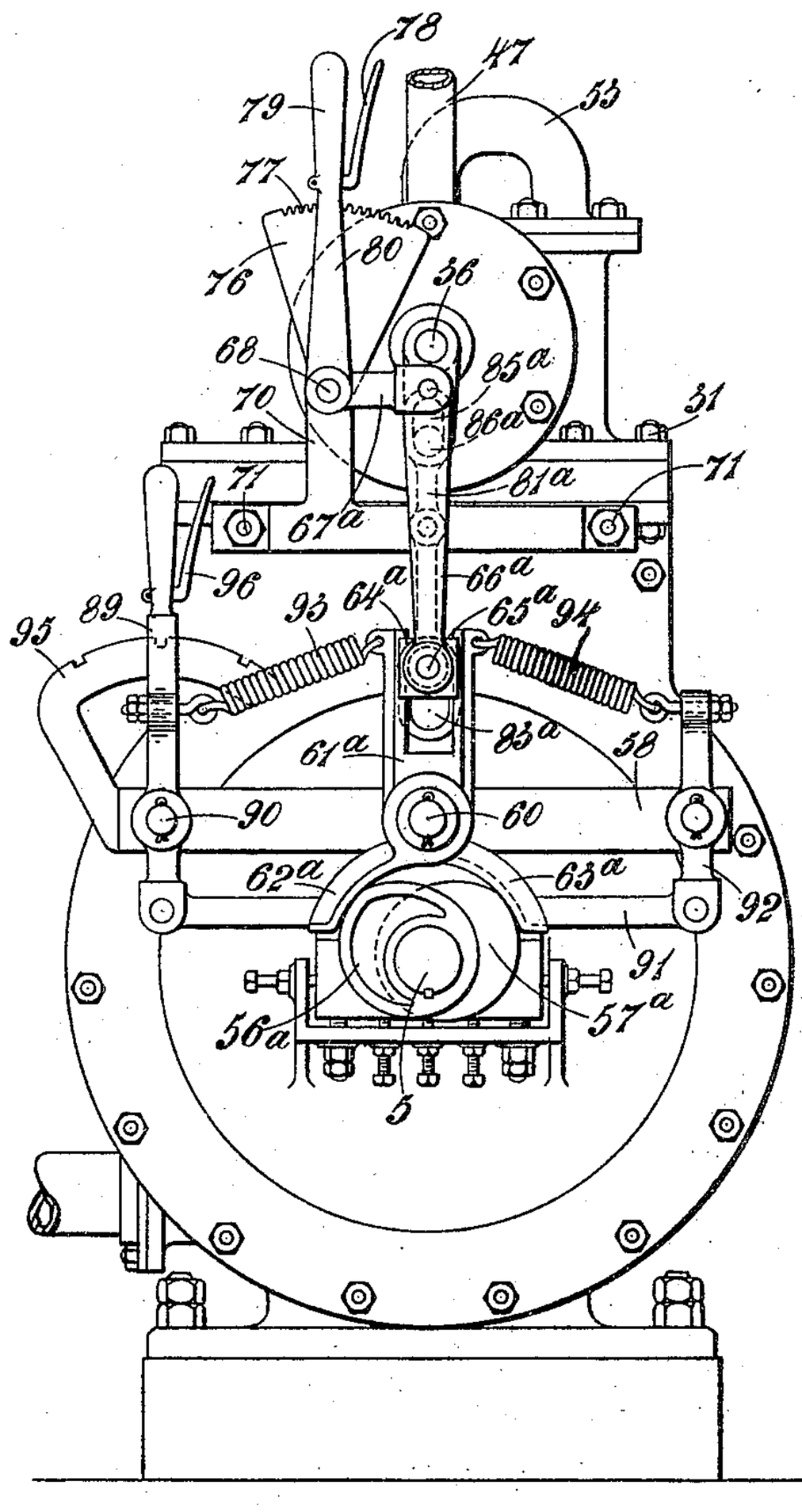
8 SHEETS—SHEET 2.

FIG. 2.



Witnesses.
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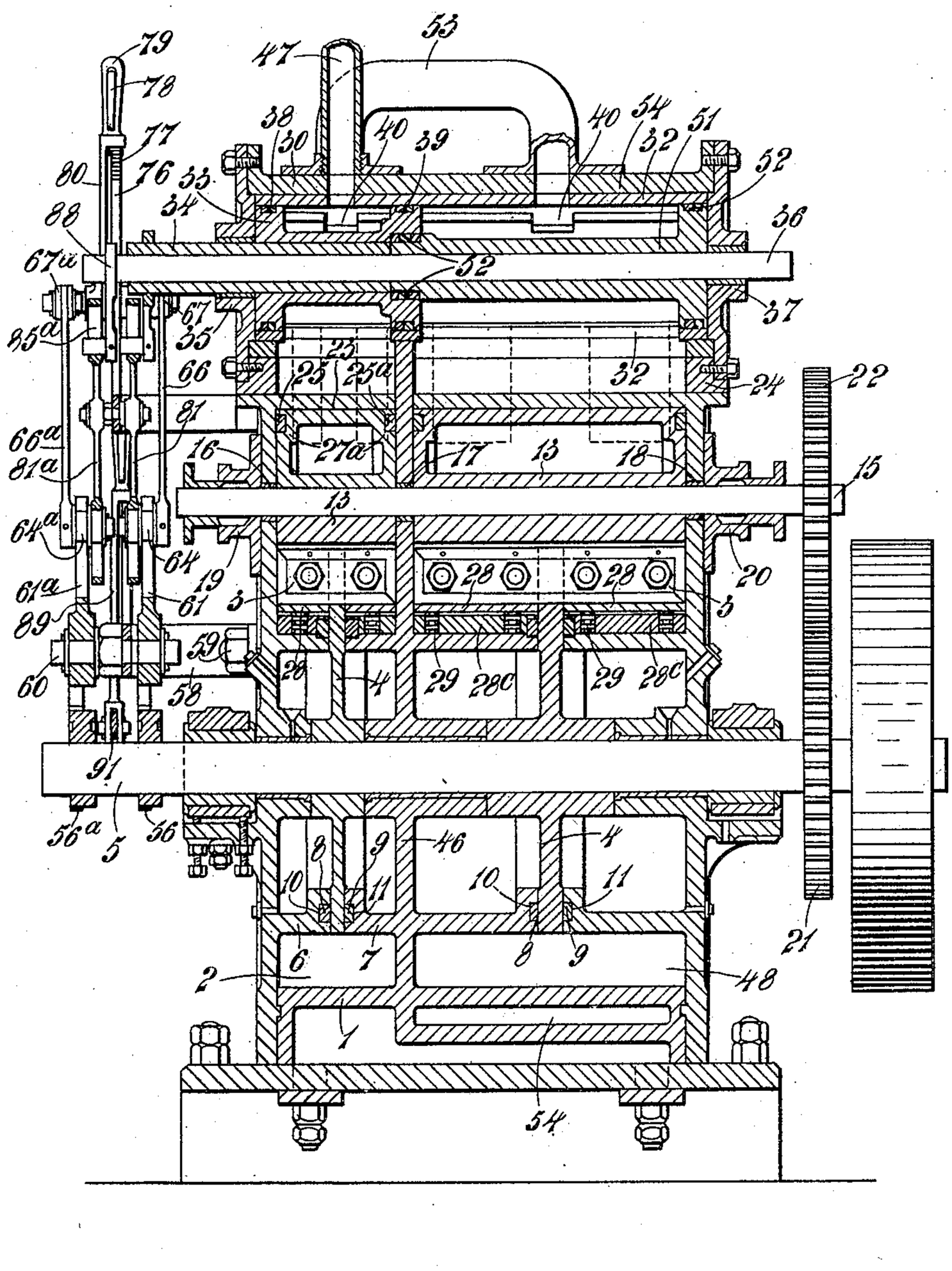
8 SHEETS—SHEET 3.

FIG. 3.



Witnesses.

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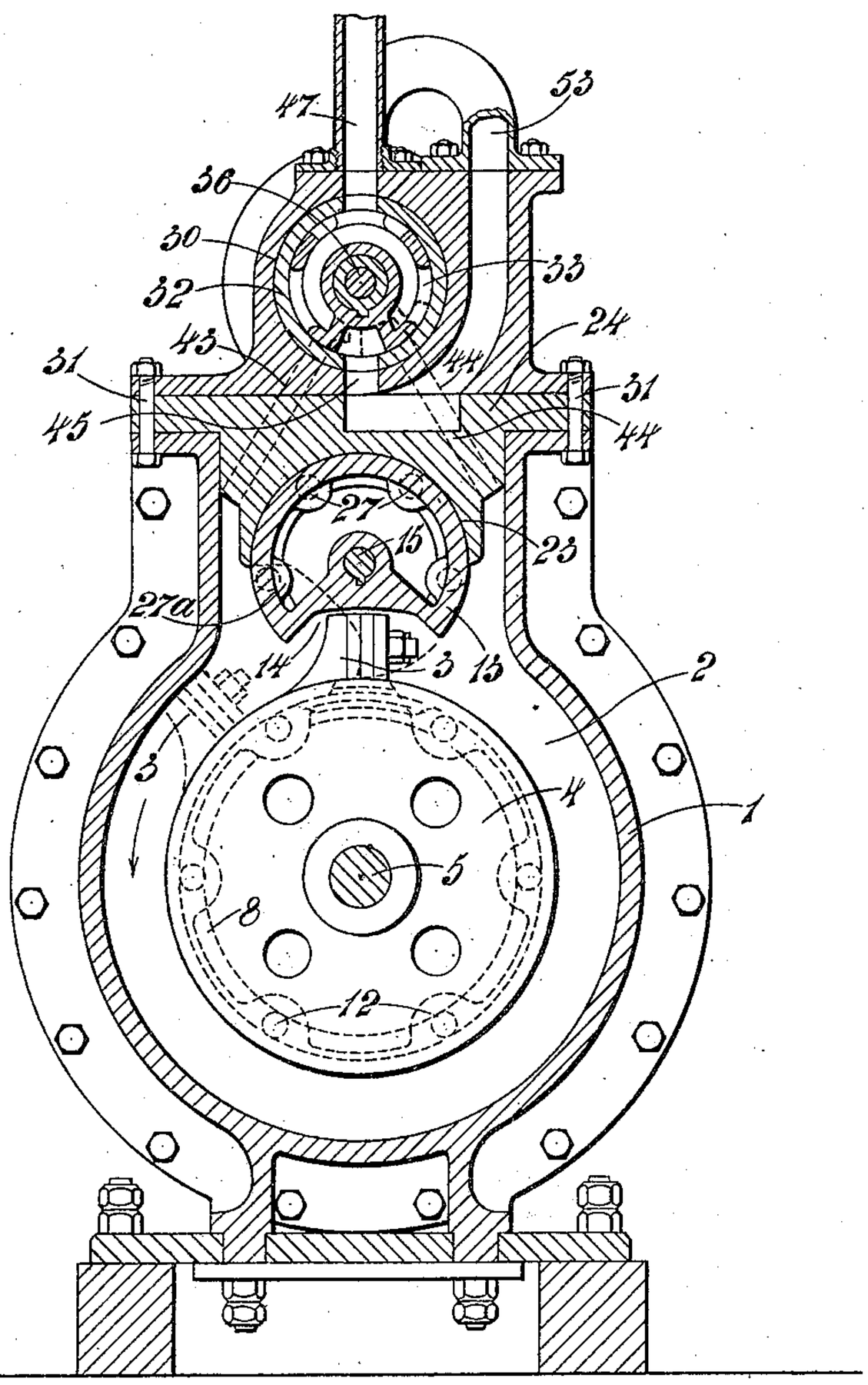
8 SHEETS—SHEET 4.

FIG. 4.



Witnesses.

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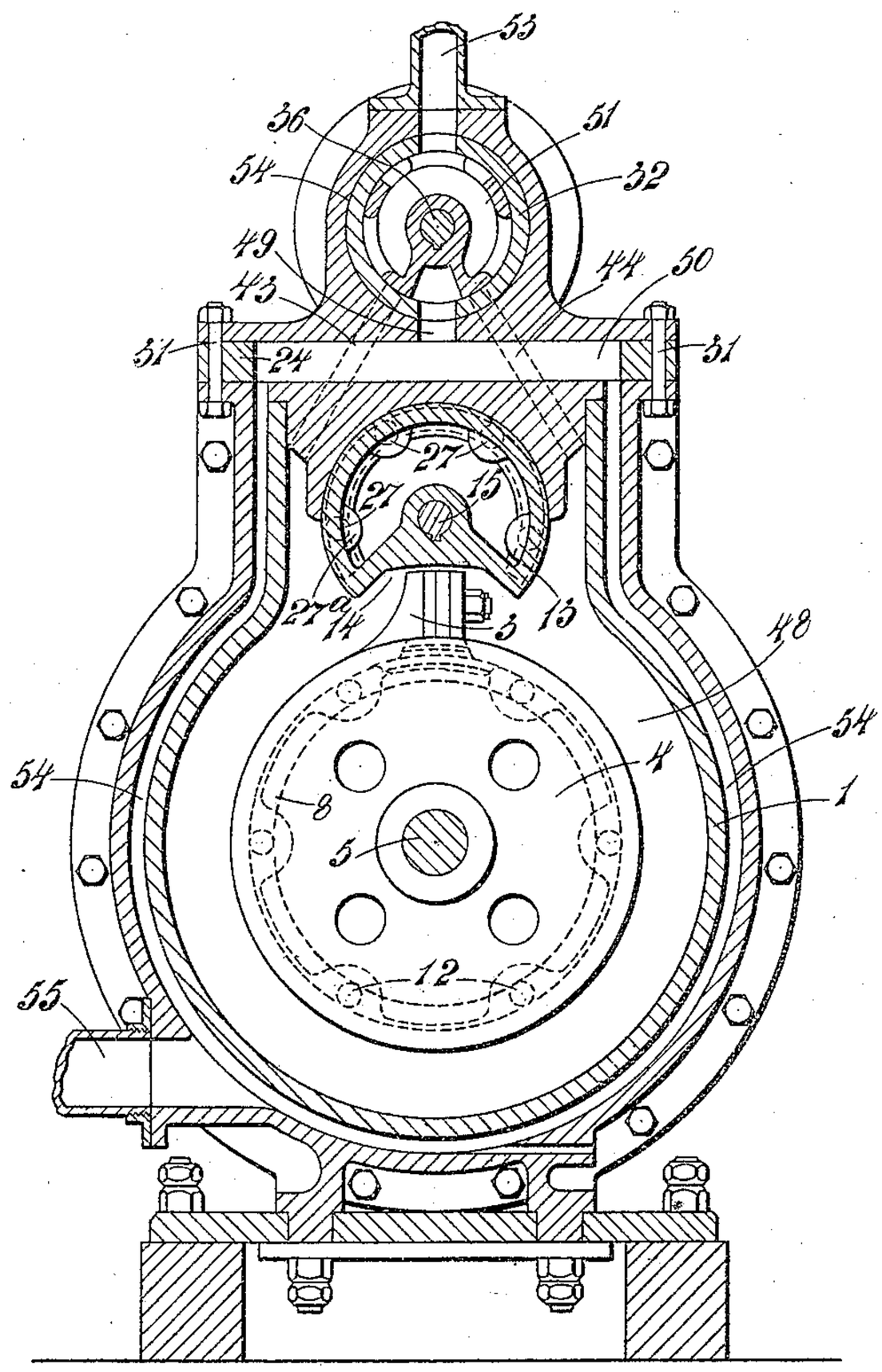
8 SHEETS—SHEET 5.

FIG. 5.



Witnesses.
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8 SHEETS—SHEET 6.

FIG. 7.

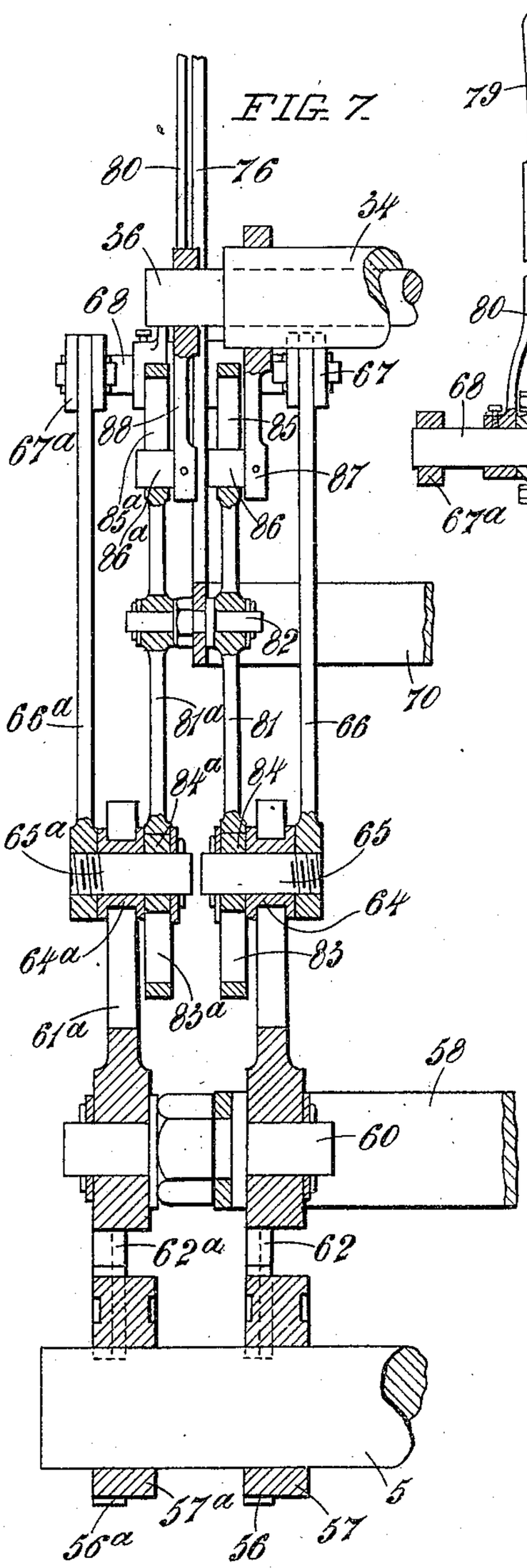

FIG. 8.

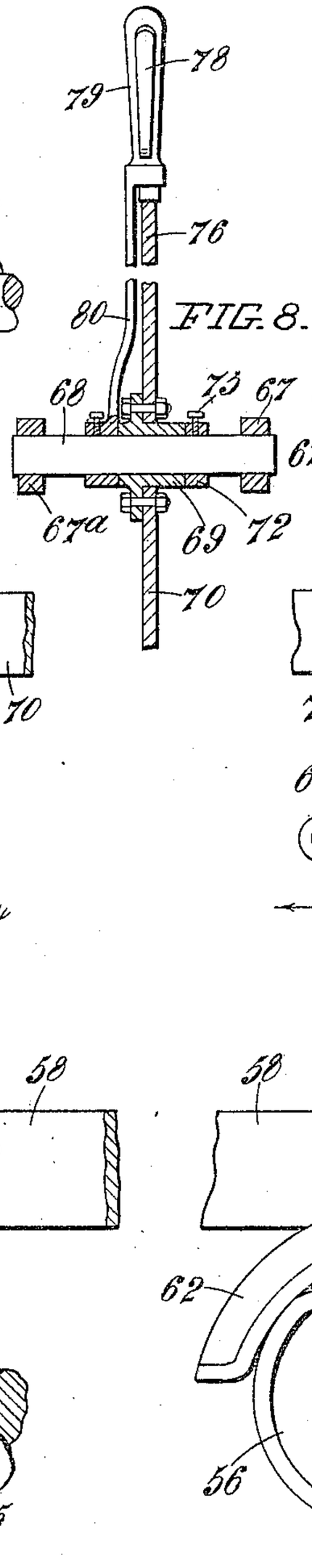

FIG. 6.

A

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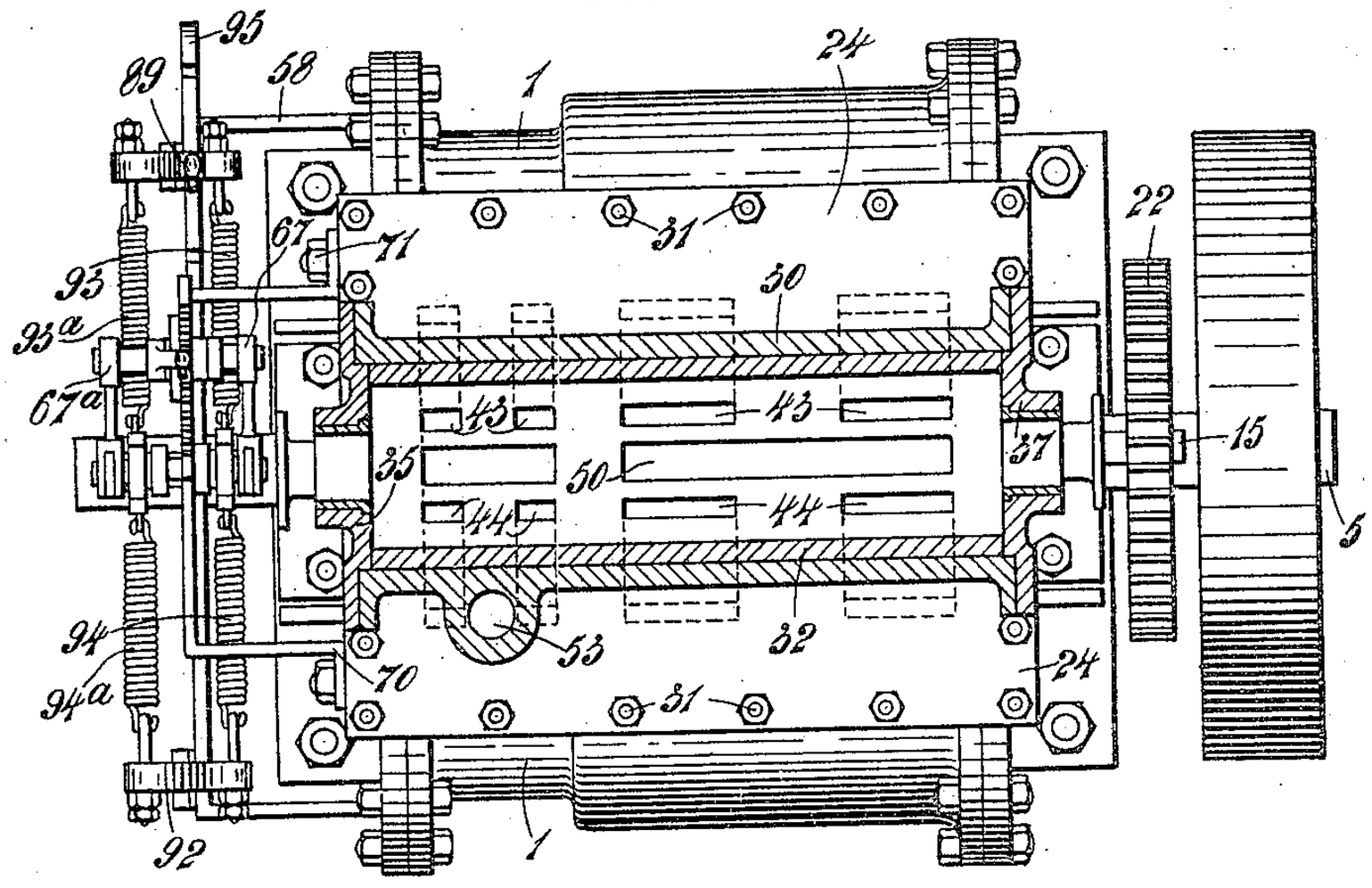
8 SHEETS—SHEET 7.

FIG. 9.



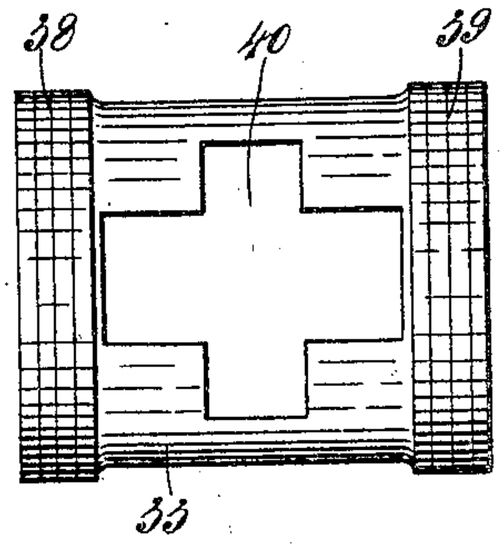


FIG. 10

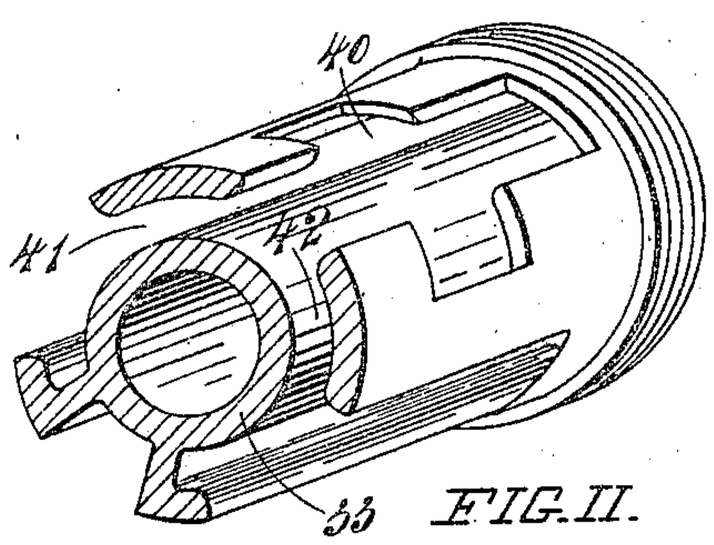


FIG. 11.

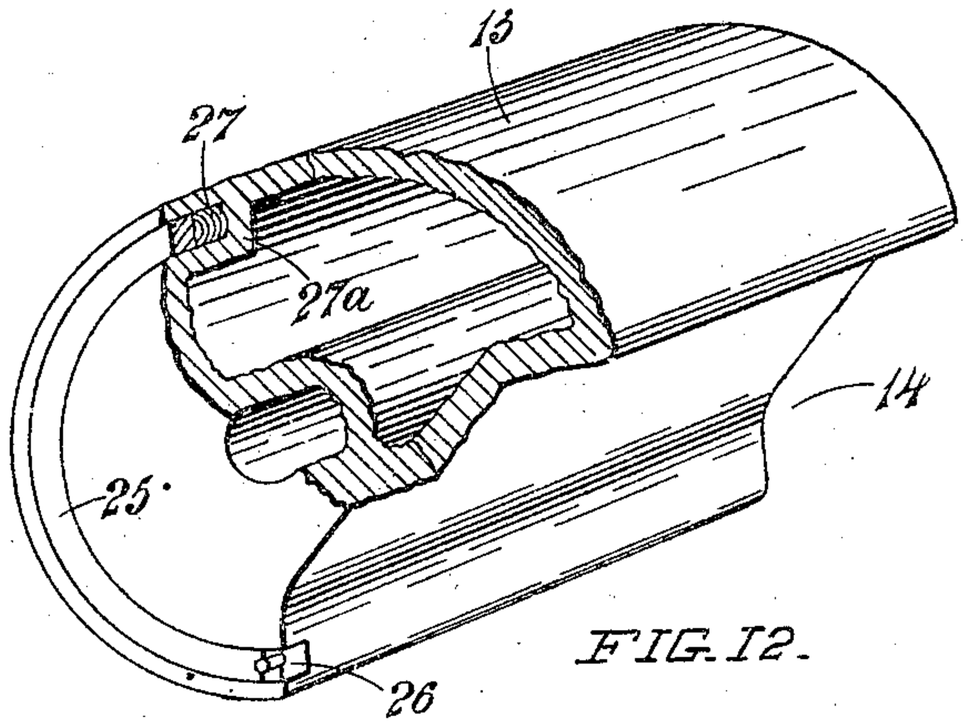


FIG. 12.

Witnesses.
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ROTARY STEAM ENGINE.

APPLICATION FILED MAY 14, 1907.

935,101. Patented Sept. 28, 1909.

8 SHEETS—SHEET 8.

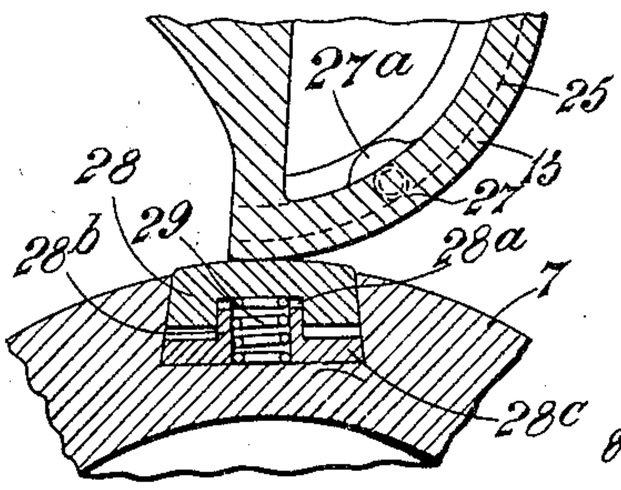

FIG. 13.

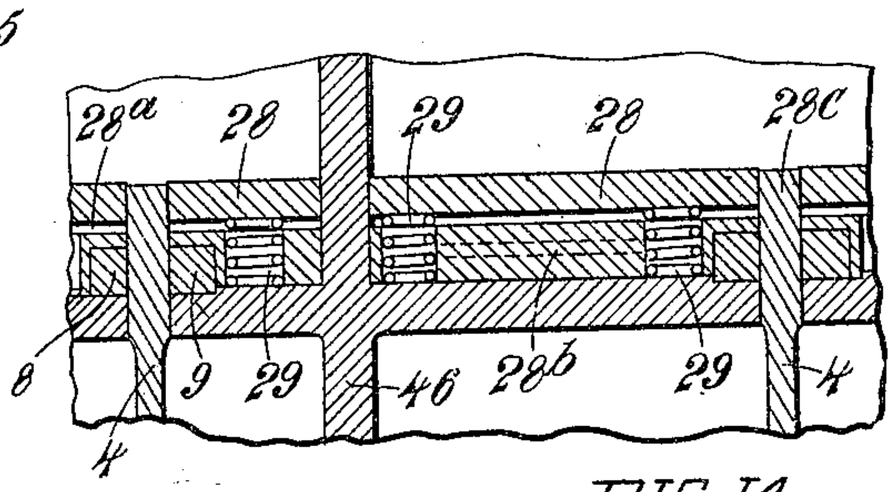

FIG. 14.

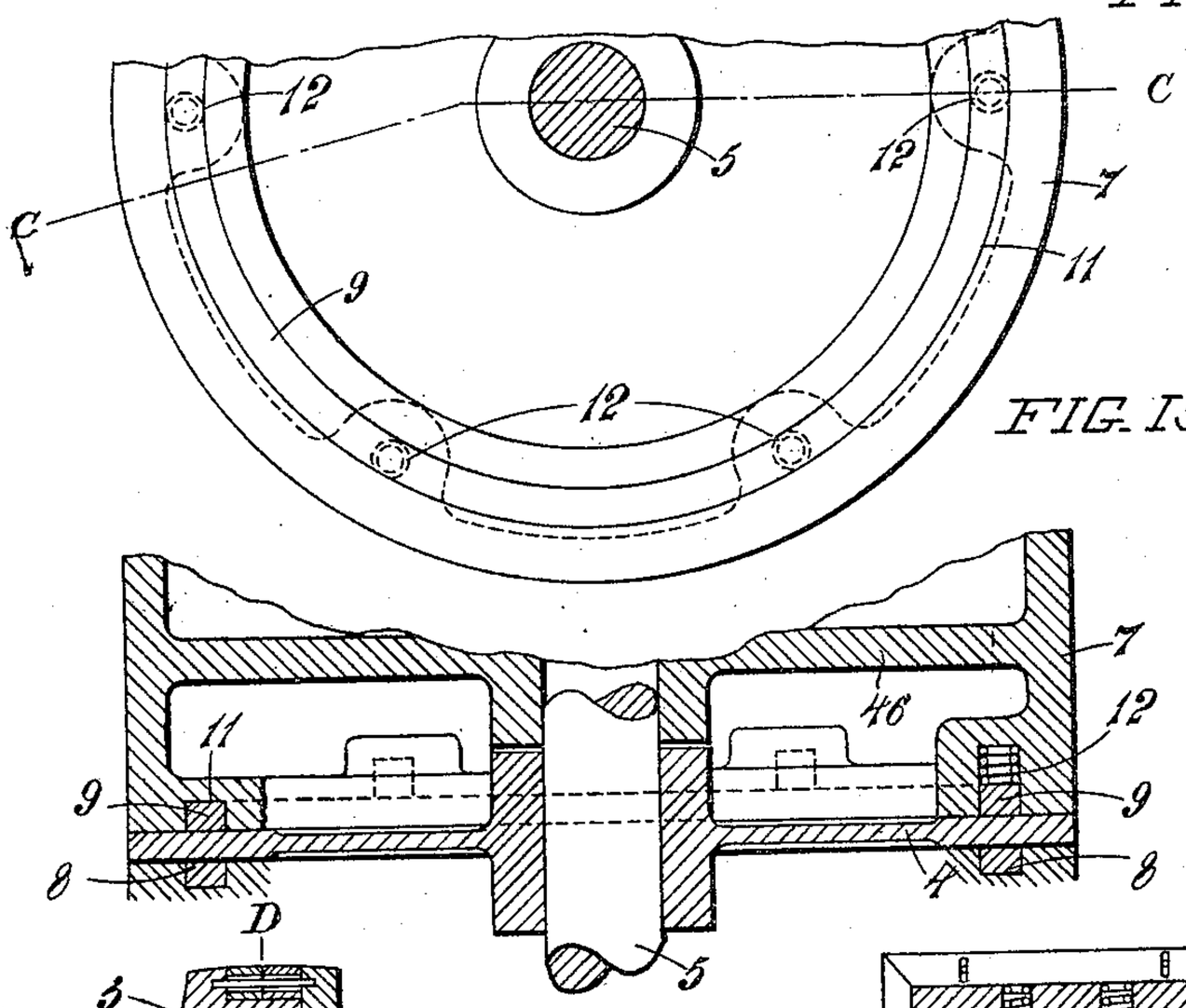

FIG. 15.

FIG. 16.

FIG. 17.

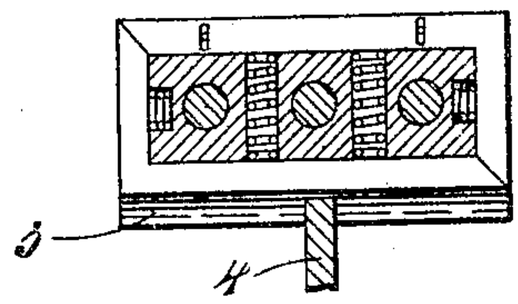

FIG. 18.

Witnesses.
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UNITED STATES PATENT OFFICE.

JOHN EDWARD FRIEND, OF WELLINGTON, NEW ZEALAND.

ROTARY STEAM-ENGINE.

935,101. Specification of Letters Patent. Patented Sept. 28, 1909.

Application filed May 14, 1907. Serial No. 373,577.

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 Provincial District of Wellington, in the Colony of New Zealand, have invented certain new and useful Improvements in Rotary Steam-Engines, of which the following is a specification.

The invention relates to the class of rotary steam engines in which a piston carried upon the circumference of a disk revolves in an annular chamber.

Improvements are herein provided upon the invention described in the specification accompanying my application for Letters Patent Serial No. 353,812 and dated the 24th day of May 1907. Said improvements comprise an improved abutment to replace the rocking valve of my said former invention and new valve operating mechanism. The abutment is made cylindrical and is continuously rotated in a corresponding recess in the engine casing. A groove or cavity formed in the abutment is made to synchronize with the rotation of the piston which is thus allowed to pass the abutment, the annular chamber being closed by the abutment immediately after the passing of the piston. The pressure of the steam is taken and escape thereof to the exhaust side of the piston is prevented by the abutment.

A cylindrical rocking valve for controlling admission and exhaust steam to and from the engine is oscillated by cams on the main shaft through the medium of a system of levers and arms, one or other of a pair of horns being thrown into engagement with one of the cams according to the direction in which the engine is to rotate.

In the drawings accompanying this specification I have illustrated a compound engine but my invention is applicable to engines of both high pressure and multiple expansion type.

Figure 1 is a side, and Fig. 2 an end elevation. Fig. 3 a longitudinal section elevation. Fig. 4 is a cross sectional elevation through the high pressure side of the engine. Fig. 5 a similar sectional elevation through the low pressure side. Fig. 6 an end elevation of the valve gear. Fig. 7 a sectional elevation on line A—A, Fig. 6. Fig. 8 an elevation of a reversing shaft and its mountings. Fig. 9 a sectional plan on line B—B, Fig. 1 with the steam valve removed. Fig. 10 is a plan, and Fig. 11 a sectional perspective elevation of the steam valve. Fig. 12 a sectional perspective elevation of the abutment. Fig. 13 is a sectional elevation, and Fig. 14 a longitudinal section of contact bars. Fig. 15 a part end elevation of a circular wall, Fig. 16 a sectional plan on line C—C, Fig. 15. Fig. 17 a sectional elevation of a piston, and Fig. 18 a longitudinal sectional elevation on line D—D, Fig. 17.

I will first describe the high pressure side of the compound engine particularly referring to Figs. 1, 2, 3 and 4. The circular casing 1 with its annular chamber 2, the piston 3 upon the circumferential periphery of the disk 4 mounted upon the shaft 5, and the circular walls 6 and 7 are similar to the corresponding parts described in my previously mentioned specification.

The packing rings 8 and 9 (see Figs. 3, 14, 15 and 16) are introduced into annular recesses 10 and 11 formed in the circular walls 6 and 7 and behind the rings. Compression springs 12 are employed to keep the rings tight against the faces of the disk 4. Escape of steam between the circular walls and the disk is thus prevented.

A cylindrical abutment 13 (see Figs. 3, 4 and 12) provided with a groove or cavity 14 extending throughout its length, is fixed to a spindle 15 mounted in bushes 16, 17 and 18, and passing through stuffing boxes 19 and 20 (see Fig. 3). A toothed wheel 21 secured upon the main shaft 5 gears with a tooth wheel 22 of corresponding size secured upon the spindle 15 which with the abutment 13 fixed upon it thus makes one revolution for each revolution of the shaft 5. Instead of toothed wheels other equivalent gearing may be used, such as sprocket wheels and chain. The abutment fits revolubly within a circular recess 23 formed in the casing of the engine (see Figs. 3 and 4) and is made steam tight at its ends by rings 25 and 25[a] located in annular grooves 26 formed in the respective ends of the abutment and held in operative position against the ends of the casing 2 by springs 27 of which there are preferably four for each ring, the springs being carried in pockets 27[a] in the abutment. The cylindrical part of the said abutment is made steam tight with the circular walls 6 and 7 by bearing during its revolution against contact bars 28 (see Fig. 13) operated upon by springs 29. The blocks are dovetailed in the circu-

lar walls as shown to prevent them rising unduly above the periphery of the walls when not in contact with the abutment. The bars have grooves 28[a] receiving the ribs 28[b] of plates 28[c] dovetailed into the circular walls. While in contact with the abutment, the bars are forced slightly downward against the pressure of the springs 29 and escape of steam past the bars is prevented by the ribs 28[b]. Holes are formed in the ribs to receive the springs 29.

A steam valve chest 30 is secured upon the cover 24 by bolts 31 which fix the cover to the casing 1 and the said valve chest has a cylindrical liner 32 within which is contained a cylindrical steam valve 33 secured to a sleeve 34, mounted one end in a bearing 35 and through which passes a spindle 36 mounted in a bearing 37 (see Figs. 1, 3, 4 and 9). The valve 33 is operated by gear to be hereinafter described and at its ends is made steam tight with the liner 32 by rings 38 and 39. The valve, see Figs. 10 and 11, has a steam inlet 40 at the top and ports 41 and 42 through which steam supplied from pipe 47 (Figs. 1 and 3) passes to the ports 43 and 44 leading from the steam valve chest 30 through the cover 34 to the annular chamber 2.

In Fig. 4 the engine is assumed to be running in the direction of the arrow and the piston is in position where the ports 43 and 44 are closed by the valve. As the piston moves the abutment revolves by the toothed wheels described and when the relative positions of the piston abutment and valve shown in dotted lines in Fig. 4 are reached the valve 33 which has been simultaneously operated by means to be described opens the port 43 for admission of steam between the piston and the abutment and simultaneously opens the port 44 to communication with an exhaust port 45 through which steam passes to the low pressure engine through a pipe 53. The valve gear hereinafter described is arranged so that the port 44 will remain open until the piston approaches the end of a complete revolution while the steam is cut off after a part revolution of the piston and is worked expansively thereafter. When the engine is reversed steam is admitted through the port 44 and passes out by the port 43.

The low pressure side of the engine (see especially Figs. 3 and 5) is similar to and separated from the high pressure side (shown in Fig. 4) by a partition 46. It has, however, a greater width and consequently a larger piston area, see Fig. 3. The steam valve 51 also has a greater width and has packing rings 52 in its ends whereby a steam tight joint is made with the high pressure steam valve 33 and with the liner 32. This valve 51 is secured to the spindle 36. The exhaust steam from the high pressure annular chamber 1 is conducted by the pipe 53 to the valve chest 54 and after being admitted to the low pressure annular chamber 48 (Figs. 3 and 5) and exhausted through the valve 51 and port 49 passes into a chamber 50 whence it passes through the space 54 to steam jacket the annular chamber and finally is led to a condenser by the exhaust pipe 55.

The valve gear is shown more particularly in Figs. 6, 7 and 8 and in case of the high pressure engine consists of cams 56 and 57 fixed to the main shaft 5 at diverse angles. A bracket 58 secured to the casing by bolts 59 has a stud 60 upon which is pivoted a rocking lever 61.

Horns 62 and 63 integral with the rocking lever are adapted to be operated by the cams 56 and 57 respectively. The upper end of the rocking lever is bifurcated and fitted with a sliding block 64 through which a pin 65 passes, and is fixed to a suspension link 66 pivoted to an arm 67 fixed upon a shaft 68 mounted in a bearing 69 upon a bracket 70 which is fixed to the steam chest by bolts 71 (see Fig. 2). The bracket 70 terminates in a quadrant 76 provided with teeth 77 adapted to be engaged by a pawl 78 pivoted to the handle 79 of a lever 80 secured to the shaft 68. To vary the oscillation of the valve and thereby to regulate the admission of steam to the annular chamber the pin 65 with the block 64 thereon is raised or lowered by operating the lever 80. The shaft 68 is retained in position in bearings 69 by the boss of lever 80 and by a collar 72 having a set screw 73.

An intermediate lever 81 pivoted upon a stud 82 secured to the bracket 70 has a slotted eye 83 wherein is fitted a sliding block 84 mounted upon the pin 65. The upper end of this lever 81 is provided with another slotted eye 85 which receives a pin 86 projecting from an arm 87 secured to the sleeve 34 of the steam valve 33.

A reversing lever 89, (see Figs. 2, 3 and 9) fulcrumed upon a stud 90 fixed to the bracket 58 is connected by a bar 91 to a lever 92 and the said levers 89 and 92 are connected to the rocking lever 61 by springs 93 and 94 respectively whereby the said rocking lever is inclined in either direction as required to bring either of the horns 62 or 63 into operative position with its cam 56 or 57, the resilience of the springs permitting the rocking lever to be rocked by the cams. The reversing lever is provided with a quadrant 95 and pawl 96. The valve gear for the low pressure side of the engine is constructed similarly to the gear for the high pressure side just described, and the principal parts are numbered as follows:—The cams 56[a] and 57[a], rocking lever 61[a], horns 62[a] and 63[a], block 64[a], pin 65[a], suspension link 66[a], arms 67[a], lever 81[a], slotted eye 83[a], sliding block 84[a], slotted eye 85[a] and pin 86[a] which pro-

jects from the arm 88 secured to the spindle 36.

The engine is reversed by throwing the reversing lever 89 to one end or other of its quadrant 95. The spring 93 or 94 as the case may be pulls over the lever 61 and retains one or other of the horns 62 or 63 in operative position against the cam 56 or 57, the spring yielding to allow the lever 61 to rock under the operation of the cam.

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

1. In a rotary engine as described herein in combination a cylindrical abutment provided with a cavity, a casing in which the abutment rotates, circular walls within the engine, with means for making a steam joint between the periphery of the abutment and said circular walls said means comprising contact blocks dovetailed in said circular walls and compression springs for projecting the same, substantially as specified.

2. In a rotary engine such as described an abutment, a circular wall, a ribbed plate fitting a dovetailed recess therein and a contact bar having a groove to receive the rib of said plate, and springs located in holes in the said plate, substantially as specified.

3. A compound rotary steam engine comprising a casing, a partition dividing the casing in a plane at right angles to its axis, circular walls projecting toward each other within the casing on each side of the partition, a main shaft axial with said circular walls, a disk secured to the shaft upon one side of the partition, a piston upon the disk, a second disk similarly secured upon the other side of the partition, a piston of larger area thereon, the said pistons rotating in annular chambers bounded by the circular walls and the casing, rotatably mounted abutments one for each annular chamber, means for rotating the abutments, steam valves controlling admission and exhaust of steam, gear for actuating the steam valve and a pipe conducting steam exhausted from one annular chamber for use in the other annular chamber, substantially as set forth.

4. The combination in a rotary engine of a main shaft, cams thereon set at diverse angles rocking levers adapted to be rocked by the cams, blocks slidable in bifurcations of the rocking levers pins through the block, suspension links to which the pins are fixed, arms to which the suspension links are pivoted, a rocking spindle to which the arms are secured, a lever secured to the spindle, a valve spindle, a sleeve fitting the valve spindle, steam valves secured to the spindle and sleeve respectively, arms fixed to the spindle and sleeve respectively, pins projecting from the arms, pivoted intermediate levers having eyes for engaging the said pins and the pins of the suspension links respectively, a reversing lever, with means for retaining the same in a plurality of positions, a pivoted lever, a rod connecting the reversing lever to said pivoted lever, and springs connecting the said levers to the rocking levers, substantially as set forth.

5. In a rotary engine means for oscillating a cylindrical steam valve comprising in combination a main shaft, a cam thereon, a rocking lever adapted to be rocked by the cam, a block slidable in a bifurcation of the rocking lever, a pin through the block, a suspension link carrying said pin, an arm upon which the suspension link is pivoted, a spindle upon which the steam valve is secured, an arm fixed upon said spindle, a pin projecting from the arm, a pivoted intermediate lever having eyes for receiving said pin and the pin of the suspension link respectively, substantially as specified.

6. In an engine of the type described, reversing gear comprising a reversing lever and quadrant a pivoted lever, a rod connecting the reversible lever to the pivoted lever, a pivoted rocking lever, means for rocking said lever and springs connecting the said levers to the rocking lever, a block slidable in a bifurcation of the rocking lever, a pin through the block, a suspension link carrying said pin, a steam valve, a spindle upon which the steam valve is secured, an arm fixed upon said spindle, a pin projecting from the arm and engaged by the slotted eye of the intermediate lever, substantially as set forth.

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

JOHN EDWARD FRIEND.

Witnesses:

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ERNEST SMITH BALDWIN.