No. 831,754. PATENTED SEPT. 25, 1906.

F. S. SULLIVAN.

ROTARY ENGINE.

APPLICATION FILED OCT. 28, 1905.

2 SHEETS—SHEET 1.

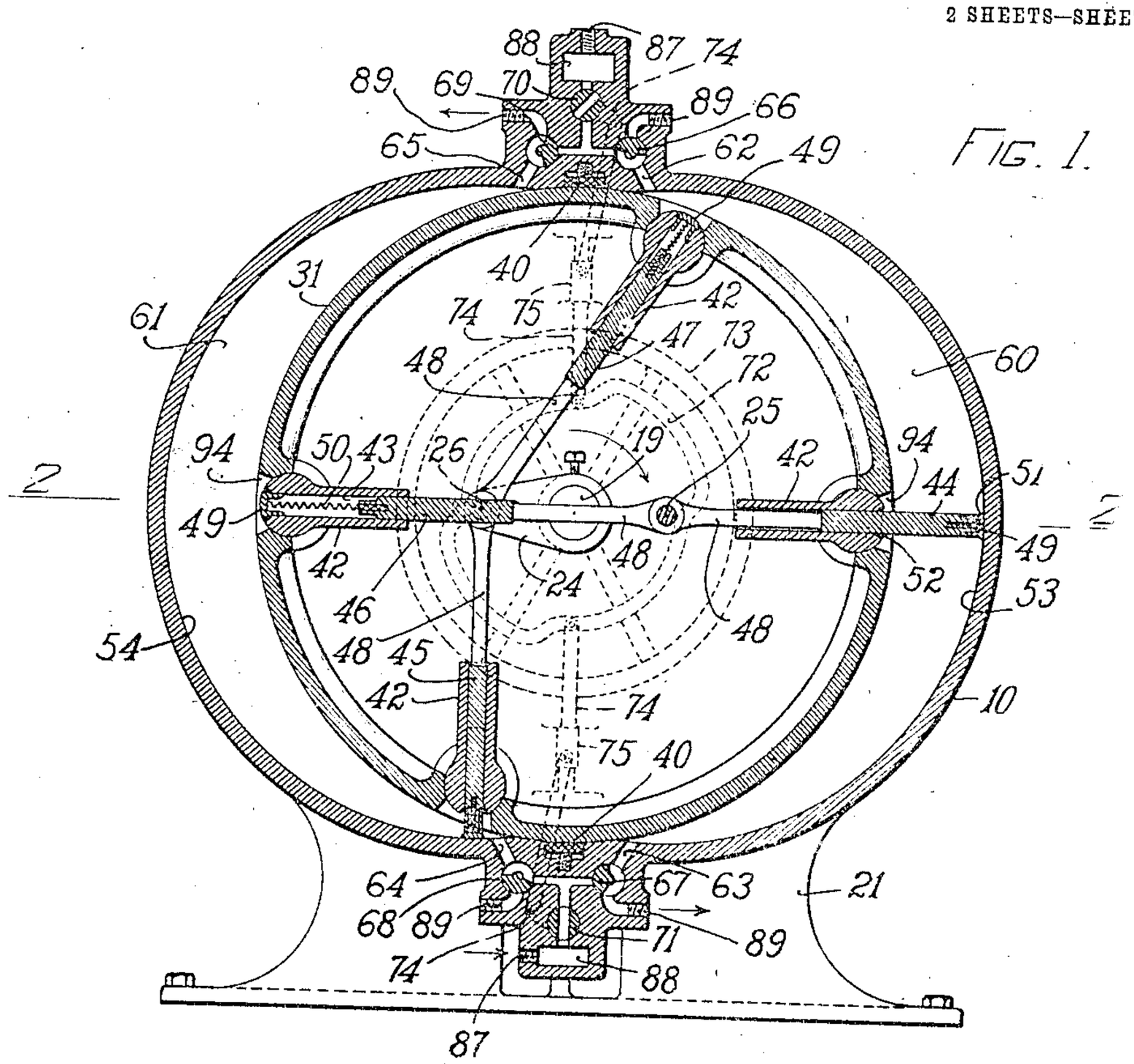

FIG. 1.

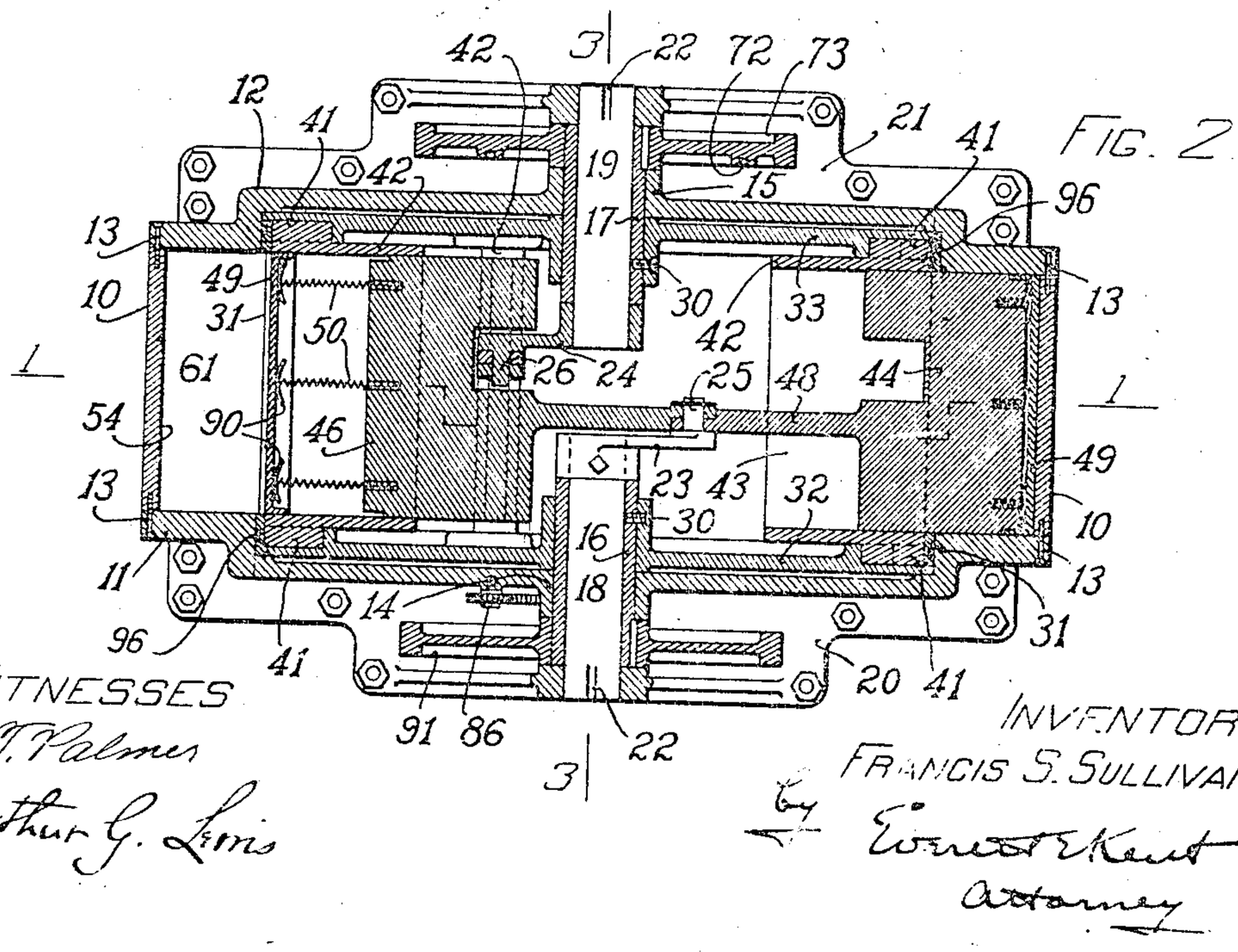

FIG. 2.

WITNESSES

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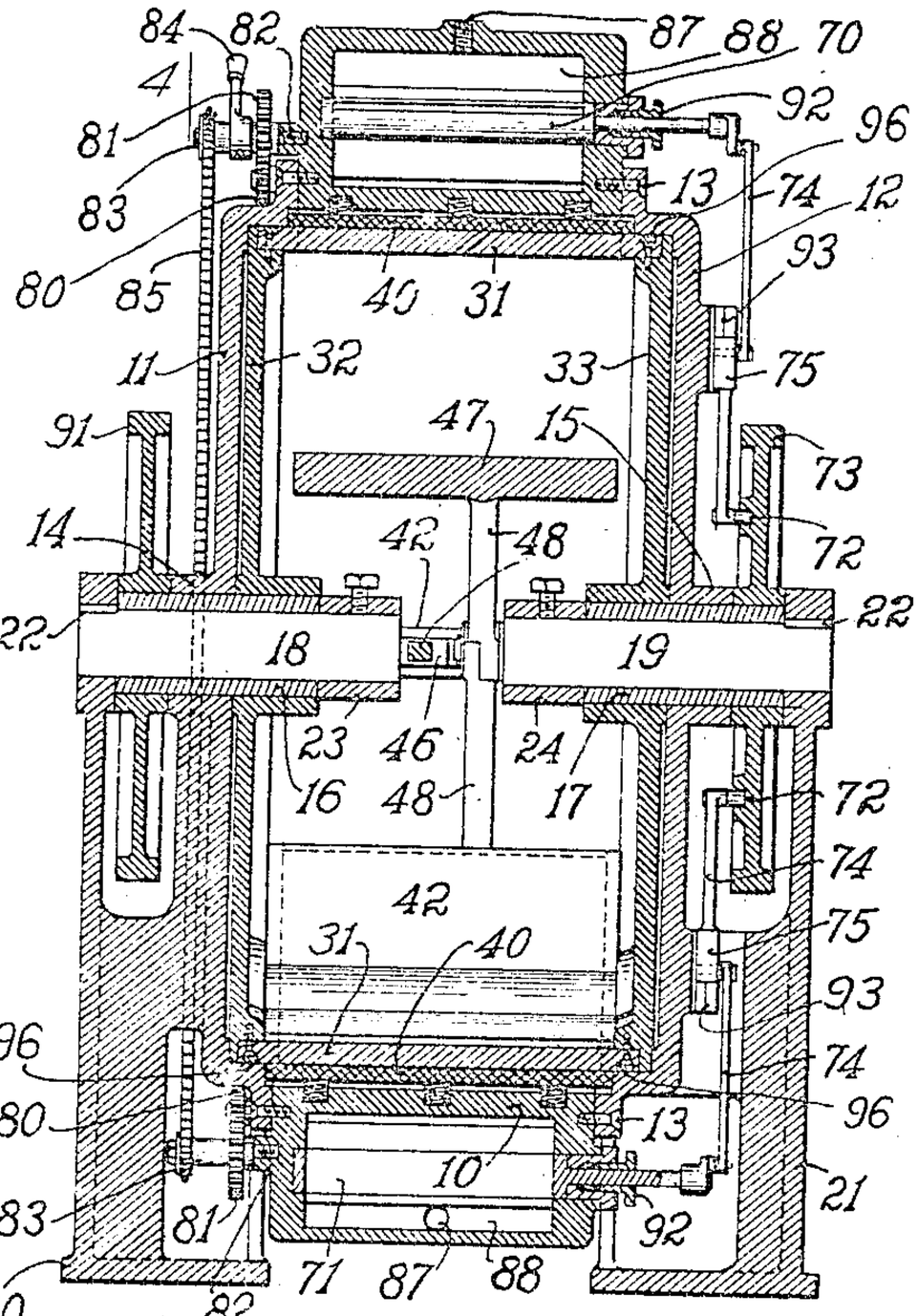

FIG. 3.

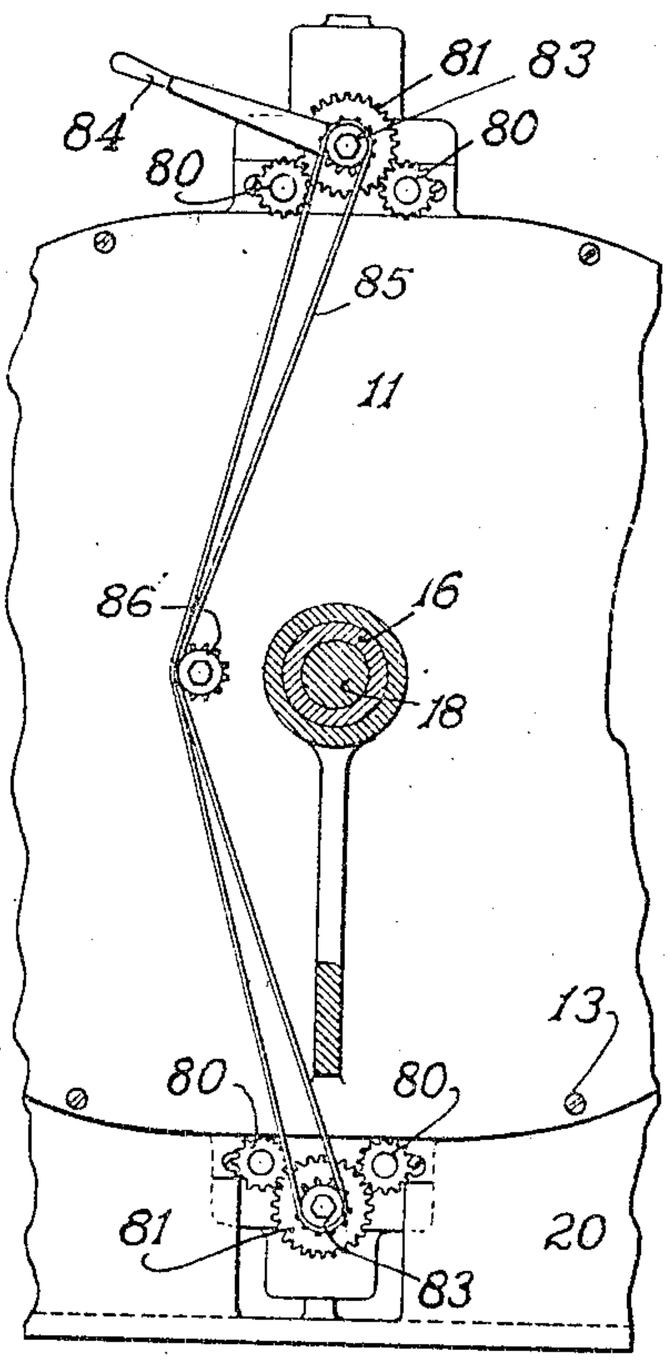

FIG. 4.

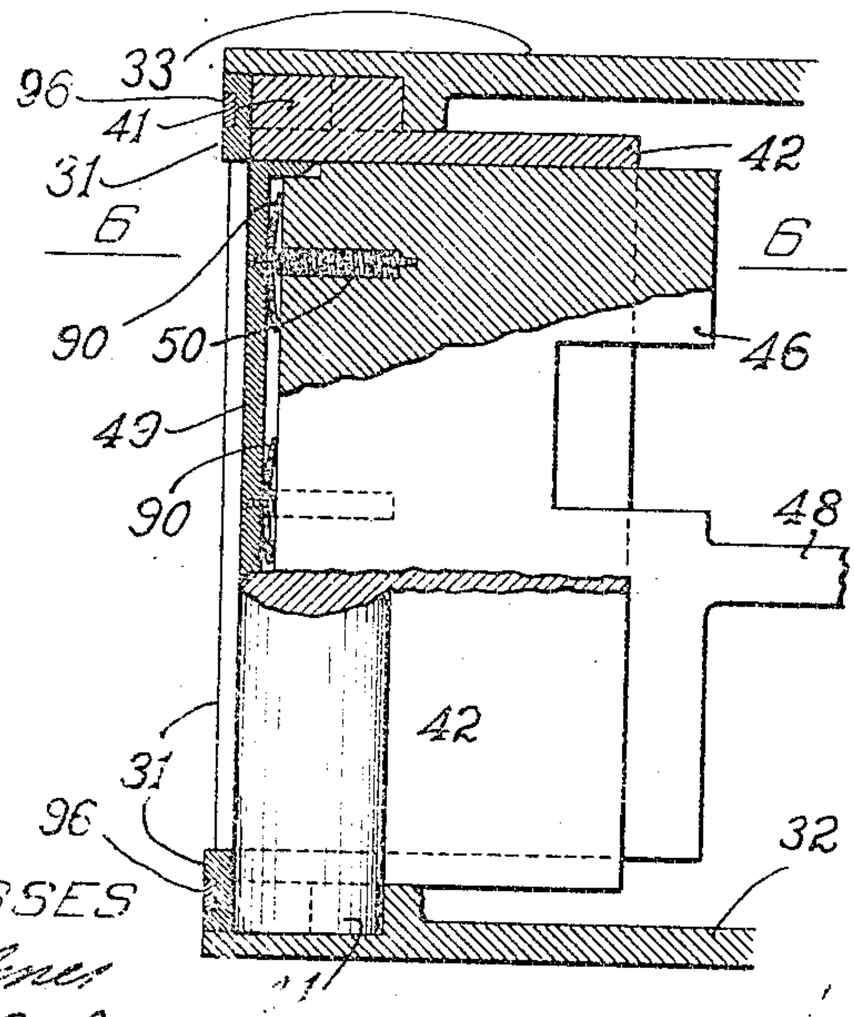

FIG. 5.

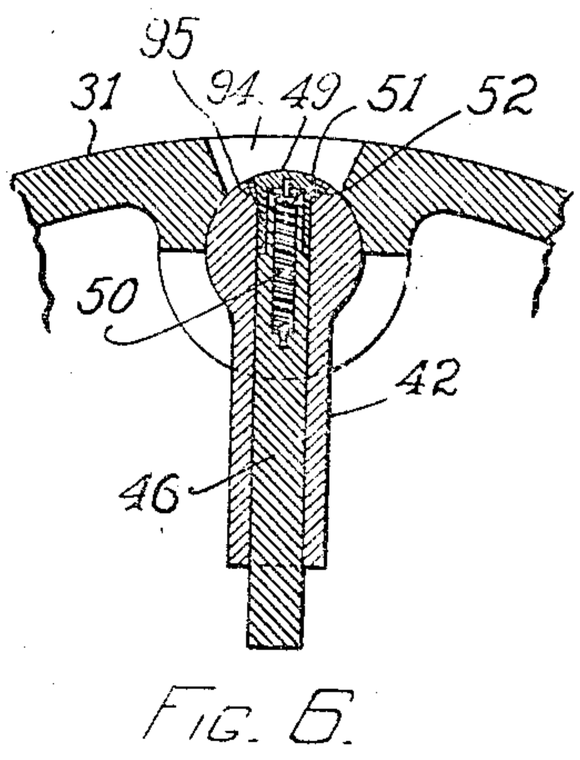

FIG. 6.

WITNESSES

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UNITED STATES PATENT OFFICE.

FRANCIS S. SULLIVAN, OF TRAVERSE CITY, MICHIGAN.

ROTARY ENGINE.

No. 831,754. Specification of Letters Patent. Patented Sept. 25, 1906.

Application filed October 28, 1905. Serial No. 284,867.

To all whom it may concern:

Be it known that I, FRANCIS S. SULLIVAN, a citizen of the United States, residing at Traverse City, in the county of Grand Traverse and State of Michigan, have invented new and useful Improvements in Rotary Engines, of which the following is a specification.

This invention relates to rotary engines of the receding-piston type, and has for its underlying principles two symmetrically-arranged expansion-chambers and three distinct centers of rotations—viz., one for the drum and one for each set of pistons.

The particular advantage of my invention is the symmetrical and economical use of full boiler-pressure steam and the expansion thereof, giving to my engine not only greater efficiency, but also a more uniform distribution of load than is possible in any other form of rotary engine known to me. This equalization of load causes more quiet and steady action and as a consequence prolonged life of the parts.

Other features are simplicity of construction, interchangeability of parts, reversibility, lightness, and compactness, and other features incidental to the construction hereinafter described.

Although I have shown in the drawings a valve mechanism suitable for steam control, I do not limit myself to this form of construction, as my invention can be used with other fluids or with gas or other internal-combustion source of energy as a motive power without departing from the principle thereof.

Referring to the drawings, Figure 1 is a vertical longitudinal section of my engine corresponding to the offset line 1 1 shown in Fig. 2. Fig. 2 is a plan section corresponding to line 2 2 of Fig. 1. Fig. 3 is a vertical transverse section corresponding to line 3 3 of Fig. 2. Fig. 4 is a partial side elevation, with some of the parts sectional, on a line corresponding with 4 4 of Fig. 3. Fig. 5 is an enlarged sectional view of a portion of the drum, showing one of the pistons within its sheath. Fig. 6 is a sectional detail taken on line 6 6 of Fig. 5.

The outside shell 10 is supported within the two side plates 11 and 12 and secured thereto by bolts 13. Side plates 11 and 12 are each formed to provide bearings 14 and 15 for the hollow sleeves or hubs 16 and 17, said sleeves being rotatably mounted on stationary shafts 18 and 19 and are further provided with standards 20 and 21, each of which is formed to support and hold the outer ends of shafts 18 and 19 rigidly against rotation, as at 22 22. To the inner ends of shafts 18 and 19 are secured stiff arms 23 and 24, provided at their free ends with pivot-pins 25 and 26. The inside drum is secured at 30 30 to sleeves 16 17 and as here shown is composed of shell 31 and side walls 32 33, so united as to prevent the passage of steam to its interior. The common axis of shafts 18 and 19 and the centers of pivot-pins 25 26 are here shown as lying in the same horizontal plane, and the former is spaced midway between the two latter. Their combined positions determine the shape of outer shell 10, which may be described as three intersecting cylinders of equal diameters struck from these three axes as centers. The outer diameter of shell 31 is the same as the common inner diameter of outer shell 10, and as the drum is mounted on the sleeves 16 and 17 and rotates therewith shell 31 forms a snug fit within the central section of outer shell 10. As it is desirable that this fit should be steam-tight, I provide spring-pressed plates 40, recessed in the walls of outer shell 10 and adapted to bear against shell 31.

Within the drum and journaled at 41 41, Fig. 5, are rotatably mounted the piston-sheaths 42 42, each provided with lengthwise slots 43 43 for receiving the several pistons 44, 45, 46, and 47. Pistons 44 and 46 are rotatably mounted on pivot-pin 25, and pistons 45 and 47 are similarly mounted on pivot-pin 26 by means of connecting-rods 48 48, and all are provided along their outer edges with removable caps 49 49, yieldingly held in place by springs 50 50. The outer edges of these caps 49 are beveled at 51 to fit beveled recesses 52 in sheaths 42 for preventing these caps 49 from receding with their respective pistons within sheaths 42, as illustrated in Figs. 1 and 2.

From the foregoing it will be noticed that as the drum revolves pistons 44 and 46, with their parts, sweep around in contact with surface 53, and likewise pistons 45 and 47 contact with surface 54 of the shell 10, and all are in turn withdrawn within the drum when performing the balance of their circuits. In

Fig. 1 the pistons 44 and 45 are shown in active and pistons 46 and 47 are shown in inactive positions.

The two expansion-chambers 60 and 61 are each provided near their upper and lower extremities with ports 62 63 and 64 65, respectively. The functions of these ports are interchangeable and are controlled by their adjacent valves 66, 67, 68, and 69; but as set in the drawings 62 and 64 are admission and 63 and 65 are exhaust-ports. 70 and 71 are steam-control valves for regulating the cut-off in chambers 60 and 61 and are automatically operated by cam-groove 72, mounted on fly-wheel 73, through the agency of linkage 74 and cross-head 75, in such a manner that cut-off in chamber 60 is timed to coincide with admission in chamber 61, and vice versa. This particular timing of the valve operation can of course be varied as may be desired to suit the differing needs; but for conciseness this description adheres closely to the form shown in the drawings, and this particular form is shown because it is the one deemed best.

The reversing mechanism for changing the direction of rotation is best shown in Fig. 4 and consists of the pinions 80 80, rigidly mounted on the projecting ends of valves 66, 67, 68, and 69, each pair being connected by an idler-gear 81, rotatably mounted on stud 82, said idler being rigidly connected to sprocket-wheel 83. On the hub of one of the idler-gears 81 is rigidly mounted the hand-lever 84, and sprocket-chain 85 communicates the motion of lever 84 to the opposite idler 81. 86 is an idle sprocket-wheel, which serves to guide chain 85 around the intervening parts. By inspecting Figs. 1 and 4 it will be seen that an upward motion of lever 84 will reverse the positions of valves 66 and 69, as well as 67 and 68.

87 87 are steam-inlets, which admit steam to steam-chests 88 88, and 89 89 are exhaust-outlets.

I consider it advisable to provide elastic means for maintaining a close fit between surfaces 53 and 54 and the ends of the various pistons 44 45 46 47. For this purpose I interpose a series of flat springs 90 between caps 49 and the edges of their respective pistons, such springs being stronger than the coiled springs 50 before mentioned. (See Figs. 5 and 6.) In action these springs 90 limit the action of springs 50 when the piston is away from the cylinder-wall and prevent the caps 49 from seating on the edge of the piston; but when in contact with the cylinder-wall the pressure is sufficient to overcome the stiffness of springs 90 and cause them to yield and permit closer seating of caps 49 against the piston edge, at the same time insuring a closer joint with the cylinder-walls.

Referring to the drawings in general, 91 is a pulley-wheel, and it and fly-wheel 73 are keyed to their respective sleeves 16 and 17.

92 92 are stuffing-boxes for maintaining steam-tight joints around the spindles of valves 70 and 71.

93 93 are cross-head guides secured to side plate 12 for receiving cross-heads 75.

94 94 are openings in shell 31 of the drum for permitting the necessary play of the pistons.

95 95 are facings of steam-resisting material, such as copper, in which springs may be set to receive and absorb the shock of stopping the caps 49 when each piston is drawn inward.

96 96 are metal rings surrounding the ends of the drum to make a steam-tight joint with the outer shell. These rings may be expansible, as is customary with packing-rings.

Minor features—as drip-cocks, packing, governor, &c.—have been omitted in the drawings, as such are not essential to a proper understanding of my invention.

The operation of my engine is as follows: The exhaust-valves are always open. Referring to Fig. 1, it will be noticed that piston 44 is midway in its passage through chamber 60, and piston 45 is ready for admission of steam to chamber 61. Valve 70 is closed, and valve 71 is open. By this it will be understood that piston 44 is at cut-off and 45 at admission, the direction of rotation being indicated by the arrow. Valves 70 and 71 maintain their positions for about one-fourth of a revolution and then change, causing cut-off for piston 45 and admission for piston 46. Thus boiler-pressure steam is admitted to each chamber 60 and 61 twice in every revolution of the drum, changing at each quarter (approximately) from one chamber to the other, so that live steam is continually acting upon the drum upon one side or the other, and, nevertheless, each charge of live steam is expanded before being exhausted. By suitably arranging the valve mechanism the cut-off can be made to occur earlier or later in stroke, as desired, in the ordinary way. It will be observed that each rotating part is symmetrically balanced and that although each piston-blade 44 45, &c., successively projects from and is withdrawn to the interior of the inner drum, while rotating at a high speed, nevertheless this motion does not result in throwing either drum or pistons out of balance, because each pair of pistons is supported independently of the drum and rotates about its own stationary and independent center. It will be observed also that by reason of the arrangement of each set of piston-blades concentrically with one portion of the outer shell the adjustment of said blades with respect thereto can be accurately arranged and when arranged will remain sub-

stantially constant with a minimum of wear. In these respects the invention differs from those types of engines in which a blade is forced out by a cam from a central rotating body to an outer shell surrounding it. The motion about the fixed pivot is smoother, steadier, and has less friction than motion controlled by a cam, and the pressure of the piston edge against the outer shell may be regulated delicately by the springs of the piston-cap. Also the momentum of the blade when the blade is thrown by a cam against the outer shell is eliminated as an element in the wear and tear of the engine here described, all such being borne independently of both outer and inner shells by the fixed pivot which supports the pistons and around which they revolve. The pistons can be arranged at any desired angle to each other. As here shown, piston 45 does not come into action until piston 44 has completed a considerable portion of its stroke; but, if desired, the piston 44 might be set farther back toward piston 47 on the circumference of the drum 31 and piston 46 set correspondingly back toward piston 45, the positions of pistons 45 and 47 remaining unchanged, with the result that steam would be then admitted to piston 45 almost as soon as to piston 44, and the two would then be receiving live-steam pressure at the same time on opposite sides of the drum, thus giving greater balance to the rotary force. Other angular arrangement of the pistons may be made or other variations of details without departing from the principle of the invention.

I claim—

1. A rotary engine, comprising a rotary drum; a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep the said wall, there being admission and exhaust ports for each chamber.

2. A rotary engine, comprising a rotary drum; a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep the said wall, there being admission and exhaust ports for each chamber, arranged at converse ends near the intersection of said walls with the drum; and a packing set in the outer shell bearing against the drum between the adjacent valves of opposite chambers.

3. A rotary engine, comprising a rotary drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep said wall; there being admission and exhaust ports for each chamber; and sheaths for the pistons projecting within the drum.

4. A rotary engine, comprising a rotary drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep said wall; there being admission and exhaust ports for each chamber; and sheaths for the pistons projecting within the drum, and journaled at the surface thereof.

5. A rotary engine, comprising a rotary drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep said wall; there being admission and exhaust ports for each chamber; and caps carried by the pistons and arranged to close the openings left when the pistons are drawn within the drum.

6. A rotary engine, comprising a rotary drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep the said wall; there being admission and exhaust ports for each chamber, said pistons having separable outer portions elastically connected to the piston-shank and adapted to remain at the drum-surface when the shank is drawn inward.

7. A rotary engine, comprising a rotary drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep said wall, there being admission and exhaust ports for each chamber; valve mechanism; and means to operate the valve mechanism by rotation of the drum.

8. A rotary engine, comprising a rotary

drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; a set of piston-blades for each said chamber pivoted within the drum at the axis of the outer cylindrical wall of such chamber and arranged to project through the drum and sweep said wall, there being admission and exhaust ports for each chamber, there being a port at each end of each chamber, and a three-way valve therein; a passage from each port-valve to the exhaust; an admission-valve to control the fluid-supply; and gearing joining said port-valves, thereby to adjust the valves for rotation of the engine in opposite directions.

9. A rotary engine, comprising a rotary drum, a stationary outer shell having cylindrical walls intersecting the drum and forming therewith expansion-chambers on opposite sides thereof; there being admission and exhaust ports for each chamber; hubs on the drum; stationary axles projecting from each side through the hubs to interior of the drum, there being a clearance between the inner ends of said axles; a pivot supported by each axle within the drum, and offset to the axis of one of the outer cylindrical walls; a set of piston-blades pivoted on each pivot and arranged to project through the drum and sweep said outer wall, the shanks of said pistons completing their revolutions by passing through the clearance between said two axles.

10. In a rotary engine, a rotary drum; two fixed pivots within the drum, each being eccentric to the drum and concentric with one portion of the exterior shell of the engine; said shell, forming expansion-chambers on two sides of the drum, one for each pivot; there being admission and exhaust ports for each chamber; pistons pivoted on said pivots and passing through the drum into said chambers; hubs for journaling the drum, and a driving-wheel on one hub outside the shell.

11. In a rotary engine, a rotary drum, two fixed pivots within the drum, each being eccentric to the drum and concentric with one portion of the exterior shell of the engine; said shell, forming expansion-chambers on two sides of the drum, one for each pivot; there being admission and exhaust ports for each chamber; pistons pivoted on said pivots and passing through the drum into said chambers; hubs for journaling the drum; and fixed supports for said pivots entering the drum through said hubs.

12. In a rotary engine, a rotary drum; two fixed pivots within the drum, each being eccentric thereto and concentric with one portion of the exterior shell of the engine; said shell forming expansion-chambers on two sides of the drum, one for each pivot; there being admission and exhaust ports for each chamber; a pair of pistons pivoted on one of said pivots and arranged to pass through diametrically opposite points of the drum into their chamber; a like pair of pistons for the other pivot and chamber, piercing the drum at points approximately quartering with the first pistons; and valve mechanism for the admission-ports.

13. The combination, in a rotary engine, of a rotary drum; a piston pivoted at a fixed point therein, eccentric thereto; an outer shell concentric with the piston and intersecting the drum forming therewith an expansion-chamber outside the drum; there being a slot through the drum for the passage of the piston into the chamber; a sheath set in the slot and inclosing the piston, said sheath being journaled on the drum.

14. The combination, in a rotary engine, of a rotary drum; a piston pivoted at a fixed point therein, eccentric thereto; an outer shell forming therewith an expansion-chamber outside the drum; there being a slot through the drum for the passage of the piston into the chamber; and a cap arranged to close the slot when the piston is within the drum.

15. The combination, in a rotary engine, of a rotary drum, two pistons pivoted at a fixed point therein eccentric thereto; an outer shell concentric with the pistons and forming an expansion-chamber covering approximately half the circumference of the drum; there being slots through the drum set approximately half a circumference apart for passage of the pistons into the chamber; and there being ports at each end of the chamber.

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

FRANCIS S. SULLIVAN.

Witnesses:
H. C. DAVIS,
CARL O. ERICKSON.