No. 667,713. Patented Feb. 12, 1901.

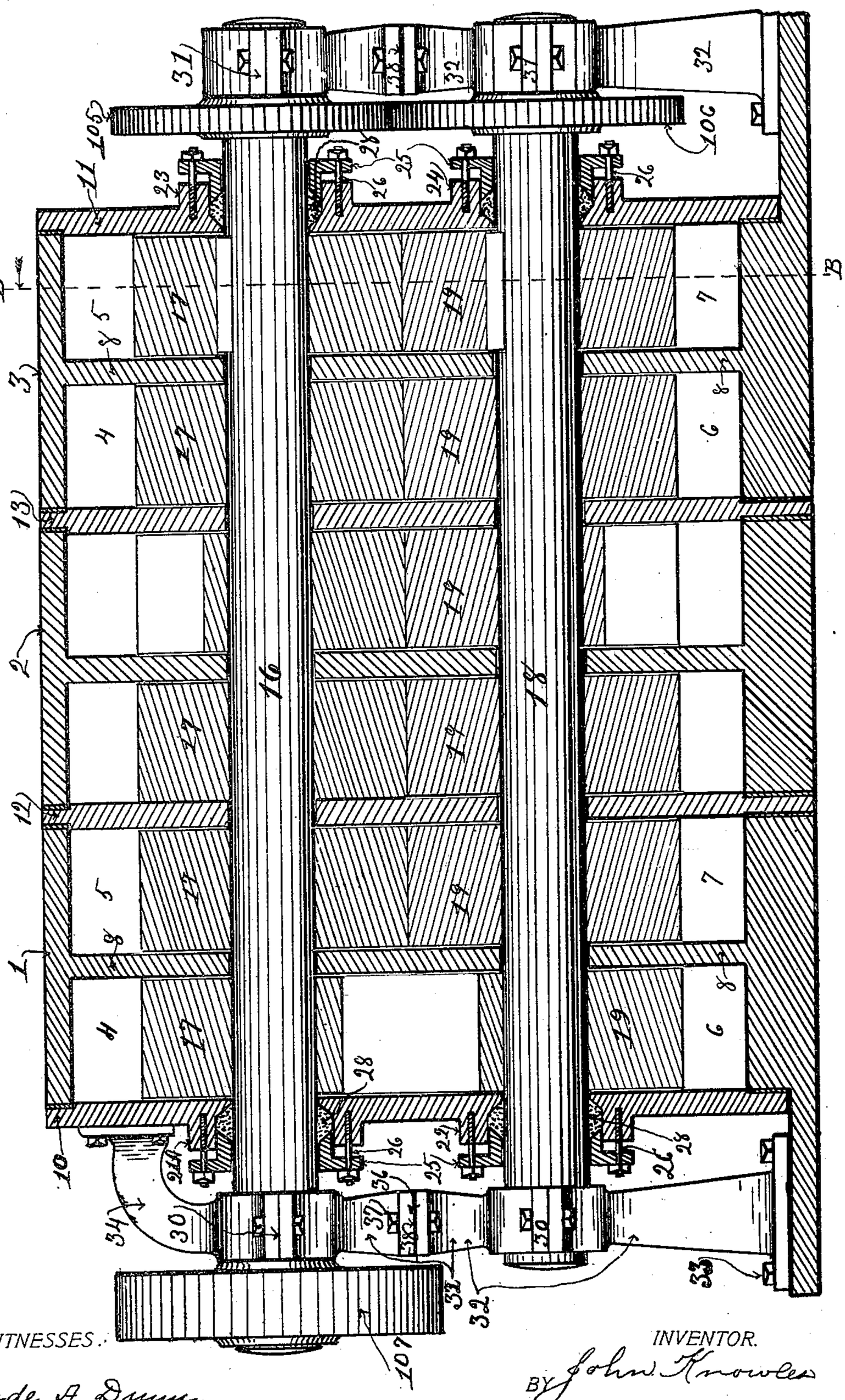
J. KNOWLES.

ROTARY ENGINE.

(Application filed Oct. 12, 1900.)

(No Model.) 4 Sheets—Sheet 1.

FIG 1



WITNESSES:

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FIG 2

FIG 5

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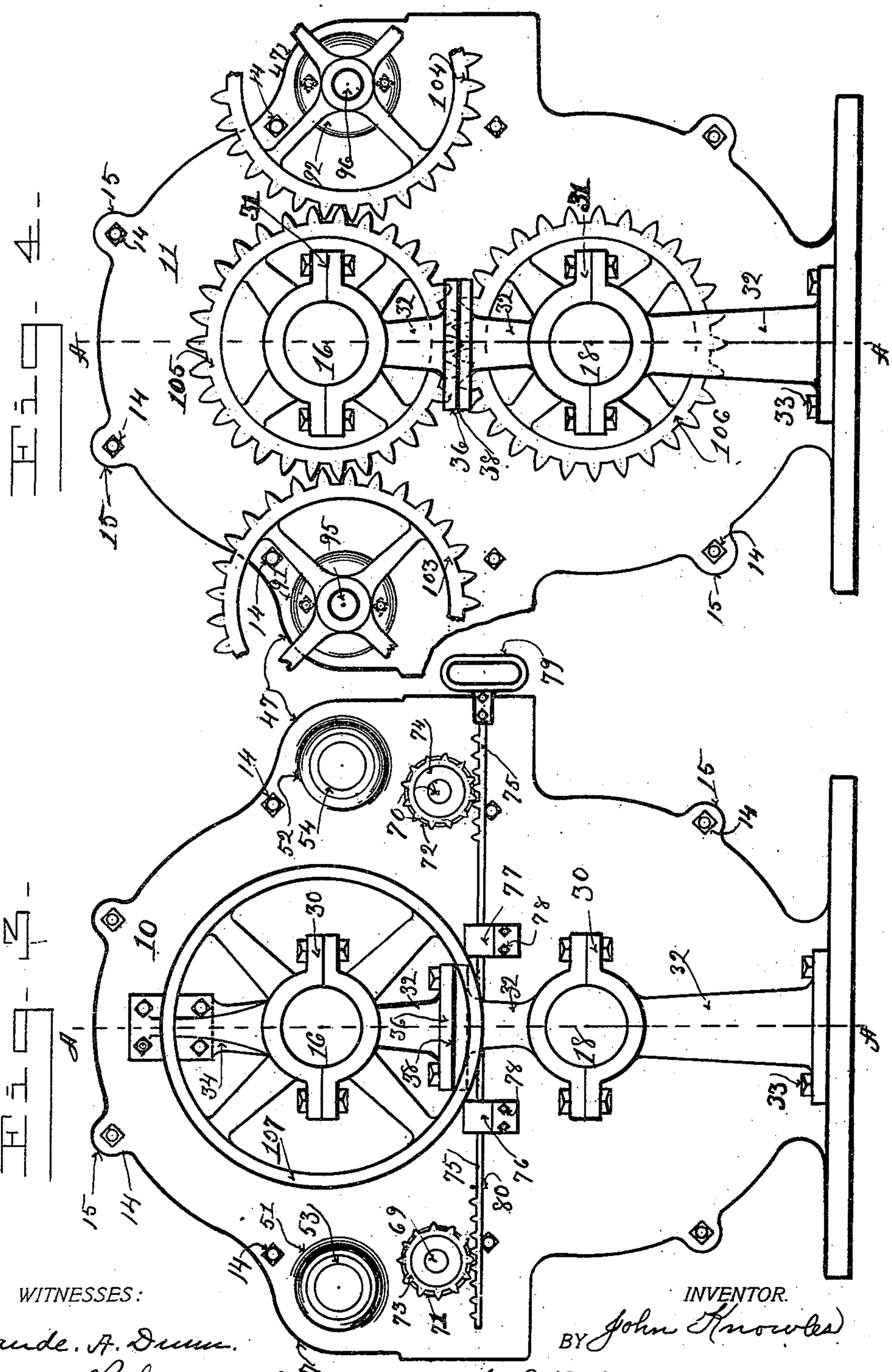
4 Sheets—Sheet 3.



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(No Model.) 4 Sheets—Sheet 4.

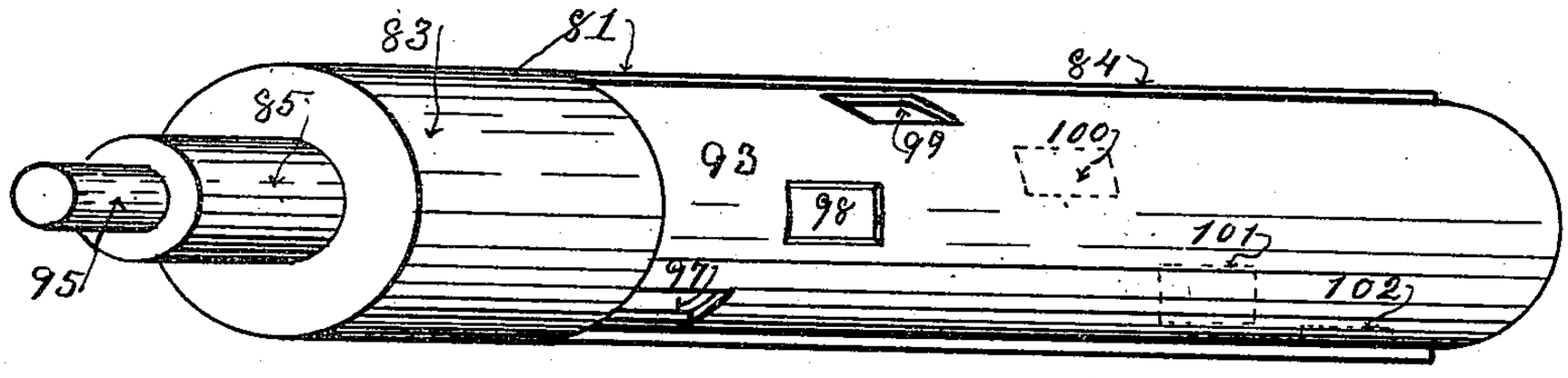

FIG. 6.

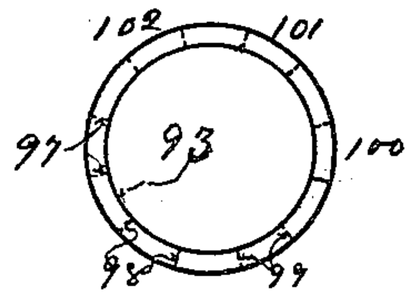

FIG. 7.

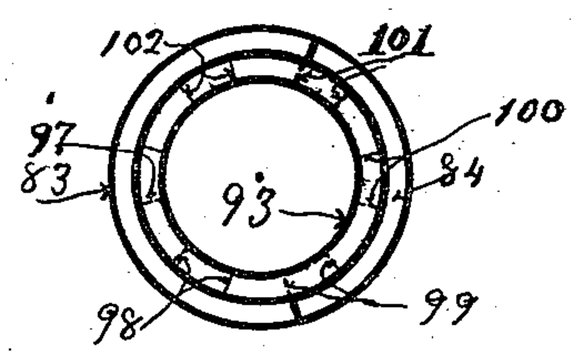

FIG. 8.

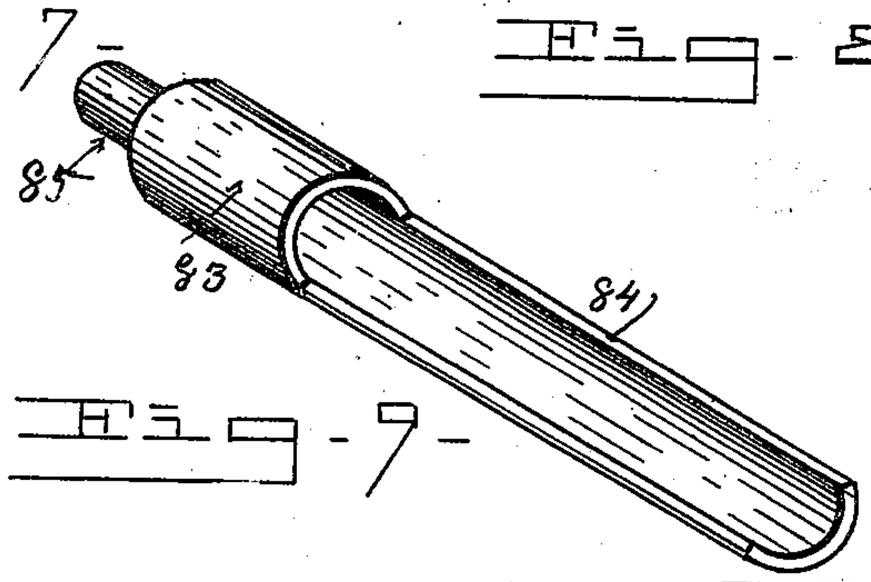

FIG. 9.

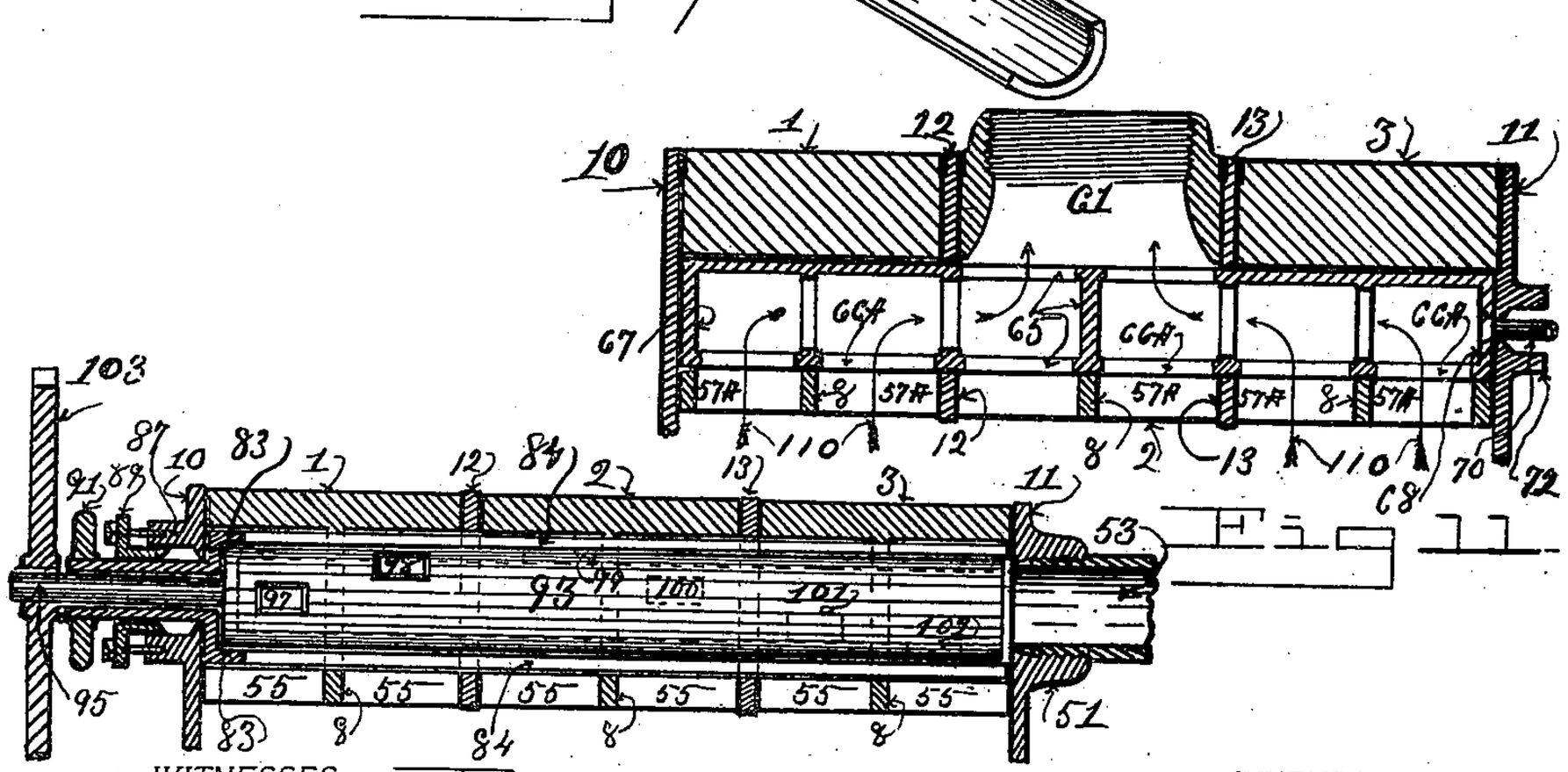

FIG. 10.

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JOHN KNOWLES, OF VICTOR, COLORADO.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 667,713, dated February 12, 1901.

Application filed October 12, 1900. Serial No. 32,884. (No model.)

To all whom it may concern:

Be it known that I, JOHN KNOWLES, a citizen of the United States of America, residing at Victor, in the county of Teller and State of Colorado, have invented certain new and useful Improvements in Rotary 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, reference being had to the accompanying drawings, and to the figures of reference marked thereon, which form a part of this specification.

My invention relates to improvements in rotary engines; and the objects of my invention are, first, to provide a rotary engine having a plurality of cylinders arranged side by side and the cylinders arranged in sections and each section having two cylinders bisecting each other and containing pistons coöperatingly arranged and having a driving-shaft arranged axially through all the cylinders and pistons of each parallel series of cylinders and pistons and coöperatively connected to rotate in unison together; second, to provide an adjustable cut-off-valve mechanism that will permit the steam or actuating fluid to be cut off at different points in its operative passage through the cylinders, and, third, to provide a simple and compact automatic engine that can be manufactured cheaply and that occupies but a small space and will develop a large amount of power. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a longitudinal vertical section of my improved rotary engine on line A of Figs. 2, 3, and 4. Fig. 2 is a vertical cross-section of one of the sections of Fig. 1 on line B. Fig. 3 is an end elevation of the fly-wheel or rear end of the engine. Fig. 4 is an end elevation of the valve-gear or front end of the engine. Fig. 5 is a section through the valves on line A C of Fig. 2. Fig. 6 is a perspective view of the steam-inlet valve and its adjustable cut-off valve. Fig. 7 is an end view of the tubular steam-valve, showing its parts equally distributed around its surface. Fig. 8 is an end view of the steam-inlet end of the steam-inlet valve and its adjustable cut-off valve. Fig. 9 is a perspective view of the steam-inlet's cut-off valve. Fig. 10 is a sectional view of a fragment of the engine, showing the steam-inlet valve in longitudinal elevation and its cut-off valve partially in elevation and partially in section and the adjacent sections of the engine in section. Fig. 11 is a sectional view of the exhaust-valve and the adjacent portion of the cylinders.

Similar numerals of reference refer to similar parts throughout the several views.

Referring to the drawings, the engine is made up of a plurality of sections. In Figs. 1, 10, and 11 I illustrate three sections 1, 2, and 3, comprised in one engine. Each section contains four cylinders 4, 5, 6, and 7, arranged in pairs, each pair 4 and 5 and 6 and 7 being placed on opposite sides of a central partition 8, which forms an integral part of the casing or shell of the cylinders. The cylinders are preferably arranged to stand in vertical alinement, although they could be arranged in horizontal alinement or in any other position desired.

10 and 11 designate the outer cylinder-heads of the engine, and 12 and 13 the parting or dividing cylinder-heads. The several sections and their cylinder-heads are bolted together by bolts 14, that pass loosely through projecting ears 15, which are formed on the sections and cylinder-heads.

All the cylinders and all the pistons are of the same sizes and arrangement.

A driving-shaft 16 passes through the upper series of pistons 17, and a driving-shaft 18 also passes through the lower series of pistons 19. The pistons are keyed or otherwise secured to the shafts. The pistons comprise a disk portion 20 of considerably-smaller diameter than the cylinder, from which a piston-arm 21 projects in a curved radius to the inner periphery of the cylinders. These shafts extend through the central partition and through all the cylinder-heads. The outer cylinder-heads are provided with stuffing-boxes 21^{A}, 22, 23, and 24. These stuffing-boxes consist of hollow tubes, into which glands 25 fit slidably. The glands are adjustably secured to the hubs by the studs 26. Suitable packing 28 is placed in the stuffing-boxes to prevent leakage of steam. The shafts 16 and 18 are journaled in boxes 30 and 31, respectively, which have an arm member 32, that extends to the base, to which they

are secured by bolts 33. A bracket portion 34 extends from one arm to the adjacent cylinder-head 10 and is bolted to it. The lower and upper boxes are illustrated connected together by an arm 32, which is divided into two parts that are clamped together at 36 by bolts 37. Several thin pieces 38 of any suitable material, such as paper, may be placed between the clamped parts of the arm, which will permit a little vertical adjustment of the shafts toward one another to compensate for wear of the engaging surfaces of the pistons. Upon the shafts 16 and 18, on each side of the partition of each section, I secure piston-disks 17 and 19, respectively. These piston-disks comprise a disk portion 20, which is considerably smaller in diameter than the diameter of the cylinders, and an arched arm portion 21, that projects from the disk portion and extends to the inner periphery of the cylinders. The pistons on opposite sides of the partitions and from one end of the engine to the other are arranged with their arms standing at one-sixth of the circumference of the cylinder apart, as shown in Fig. 2.

The diameters of the disk portions of the pistons are equal, and their peripheries meet and bear and roll upon each other through about one-half of their diameters. The disks are cut away under each arm portion, and a recess 42 is formed in each of a curvature and of just sufficient size to allow the arm of each piston-disk to rotate around its own axis in the recess of the coöperating piston when the arm of each piston passes into the plane or orbit of the coöperating piston, each arm folding into the recess of the other and rolling around its curve 42, which is formed to register with the outside periphery of the arms. There are thus four cylinders and two pairs of pistons in each section, and two coöoperating pistons are required in each pair of the intersecting cylinders to make an operative rotary engine. The steam-inlet valves and their adjustable cut-off valves and the steam-ports leading into the cylinder and the exhaust-valves are arranged in lateral projecting portions 47, formed on the sides of the cylinder-casing at equal distances from the vertical plane of the shafts 16 and 18 and parallel with them.

I employ two sets of steam and exhaust valves in order that I may reverse the direction of movement of the pistons at will. The steam-inlet ports consist of round holes 48 and 49, bored into the projections 47 of each of the cylinder-casings axially with the shafts. At their steam-entrance ends 51 and 52 pipes 53 and 54 are threaded to them, which lead to a source of steam-supply. The ports 48 and 49 are of two diameters, one end being a full circle and the balance of their length containing an inwardly-projecting portion 54^A, the inner surface of which is concentric to the larger bore, but forms the seat for the periphery of the inner valve at this point along its length. The ports 48 and 49 are intersected by ports 55 and 56, which extend from the lower sides of the ports 48 and 49 and form the central portion of each side of the partition of each section into the adjacent cylinder portion of each section, each port entering its respective cylinder close to the horizontal central portion of the engine between the two pistons. At the point where they enter their respective cylinders they also form the exhaust-ports of that pair of cylinders as they intersect the exhaust-ports 57 and 58 and form at their entrance into the cylinder either an exhaust or an inlet port, depending on which way the engine is running. These combined exhaust and steam ports 57^A and 58^B intersect exhaust-ports 59 and 60, which are bored through the projecting portions 47 of each of the sections of the cylinder under the steam-inlet port and parallel with it. These exhaust-ports intersect outlet-ports 61 and 62, that are formed in the opposite sides of the central cylinder-section of the engine through the hub portions 63 and 64.

At the point of intersection of the steam-inlet port and the exhaust-ports exhaust-valves 65 and 66 are placed. These valves rest in the circular ports 59 and 60, bored out in the projections of the cylinders. The valves are alike and extend across all the cylinders, as shown in Fig. 11. They consist of round hollow members 65 and 66, with about one-half of their shell cut away at points in their length to form ports 66^A, that will register opposite the combined exhaust and inlet ports. Their ends are closed by disk portions 67 and 68, from which valve-stems 69 and 70 extend. These stems pass through stuffing-boxes 71 and 72, formed in the adjacent cylinder-head and extend beyond it. Upon the ends of the stems gears 73 and 74 are secured. These gears mesh into a toothed bar 75, which extends from one gear to the other. (See Fig. 3.) The bar is slidably supported in boxes 76 and 77, which are secured to the adjacent cylinder-head by bolt 78. The gear-teeth of the bar are arranged to mesh with those of the gears and are placed to turn both gears in the same direction and in unison, and as the gears are of the same diameter the valves are rotated the same amount of their circumference. These exhaust-valves are, however, set opposite to one another, so that one is always closed and the other is always open to the exhaust-ports and steam-inlet ports, as shown in Fig. 2, in which the exhaust-valve 65 and exhaust-port 61 are open and the steam-inlet port 55, which leads to the exhaust-valve 65, is closed. At the opposite side of the cylinder the exhaust-valve 66 is turned to close the exhaust-port 60, which opens the steam-inlet port 56, that leads to it from the valve 94, and thus opens the steam-inlet port through the ports of the valve 94 and the ports of the cut-off valve and the port of this exhaust-valve 66 into the cylinders. On one end of the toothed bar a

handle 79 is placed, by which an operator may slide it through its boxes and reverse the positions of the valves. A stop-pin 80 is placed in the bar to define the movement of the bar and of the valves, which should be about two-fifths of their revolution, this amount of movement being sufficient to reverse the ports.

The steam-inlet cut-off valves 81 and 82 are tubular valves and are seated to rotate a portion of a revolution in the steam-inlet ports 48 and 49, respectively. These valves comprise a very short section of a tube 83 at one end that fits in the full circle portion of the ports 48 and 49 and a little less than a semicircular portion 84 the rest of their length, which extends across all of the cylinders on opposite sides of the inwardly-projecting portion 54^{A}. (See Figs. 6, 8, 9, and 10). One end of each valve is open, but from the opposite ends hollow stem portions 85 and 86 project through the adjacent cylinder-heads, which are provided with stuffing-boxes 87 and 88 and glands 89 and 90, that surround the stem portions of the cut-off valves which extend beyond them and contain on their ends hand-wheels 91 and 92, by which they may be turned partially in their seats. Both of these valves are made and arranged alike. The steam-valves 93 and 94 are revolubly mounted inside of the cut-off valves and also fit against the inwardly-projecting portion 54^{A} of the shell. They comprise hollow tubes extending the entire length of the inside of the cut-off valves and are open at the end adjacent to the steam-inlet pipes. Their opposite ends contain a disk portion from which stems 95 and 96 extend through the hollow stem of the cut-off valves and beyond them. Through the shell of the inlet-valves I form ports, arranging them equidistant apart around the circumference of the valves, and also arranging them in spiral order also equidistant apart from one end to the other, as shown in Figs. 6 and 7. There are six of these ports, numbered 97, 98, 99, 100, 101, and 102, and each port is placed centrally in the central portion of that portion of each section of the cylinder-sections it comes opposite, so that as the inlet-valve revolves it opens and closes these ports to the two groups of steam-inlet ports 55 and 56, that convey steam to the exhaust-valves and steam-passages 57^{A} and 58^{B}, and to their respective cylinders in alternate order from one end of the engine to the other.

The stems 95 and 96 of the steam-valves are each provided with a gear-wheel 103 and 104 of equal diameter, which are secured to them. These gears mesh with a gear 105, that is secured to the adjacent shaft 16 of the upper pistons. A gear-wheel 106 is also secured to the shaft 18 of the lower pistons and meshes with the gear-wheel 105. These three gears are of equal diameters, but the valve-gears may be much lighter. The gears on the shaft hold the pistons in operative rotative relation and prevent any movement or creeping of one over the other. Should any movement take place, the pistons would collide with each other and lock themselves against rotative movement. These gears also assist in driving each shaft from the piston movement of the other. Upon the opposite end of the upper shaft a belt fly-wheel 107 is secured.

All the pistons should be packed on all sides to prevent steam passing them to the exhaust-ports, and while the form of the pistons is such that the circular packing-rings in common use for packing circular pistons cannot be used with them, yet there are many piston-packings in use that can be adapted to them. Consequently my invention contemplates the use of any suitable packing for the opposing surfaces of the pistons and the cylinders. I illustrate, however, in Patent No. 652,317, issued to me June 26, 1900, in Figs. 5, 6, 9, and 10, a simple packing which can be used to pack the pistons.

The operation is as follows: The cut-off valves 81 and 82 are so arranged relative to the group of steam-inlet passages 55 and 56 that they can be turned in the ports 48 and 49 by the hand-wheels 91 and 92 to wholly close them against the passage of steam from the inside of the inner steam-valve through its ports into these passages, or it can be turned to open a passage between these ports equal to the whole area of each of these passages or of any part of the common points of cut-off of steam in steam-engines, such as one-fourth, one-third, or one-half of the stroke of steam-engines. For example, I illustrate in Fig. 2 the cut-off valve set to cut off at about one-sixth of the piston's revolution and of the cut-off valve's circumference—that is, the distance between the points 107 and 108 of the cut-off valve and the casing is one-sixth of the circumference of the cut-off valve and is substantially equal in area to the ports in the inner valve. Consequently as the inner valve rotates its port as it registers with it travels about one-sixth of its circumference and discharges steam only during one-sixth of its circumference; but as the admission of steam takes place between the first registering edge of the port of the inner steam-valve as it rotates with the port of the seat of the cut-off valve, steam is being admitted during a period of travel of the inner valve equal to the sum of both valves. Consequently the pair of pistons that are actuated by this particular port of the inner valve receive steam during only one-third of their revolution. Consequently if the cut-off valve is allowed to remain in its present position each pair of pistons will be cut off at one-third of their revolution and each pair must be driven through the balance of their revolution by the expansive force of the steam; but as the six ports of the inner steam-valve are arranged in a spiral order equidistant apart around the circumference of the valve with their centers at one-third of its circumference apart the engine as a whole is receiving steam

throughout each of its complete revolutions. The ports in the inner steam-valve (see Fig. 6) can be each made wider than shown in that figure, and, if desired, they can be made enough wider to make the side edges of each port to come nearly to or even with—that is, axially—or to overlap when viewed in axial alinement the side edges of each other. If the cut-off valves are turned by their hand-wheels upward, so that the steam-port-passage spaces 55 and 56 between the points 108 and 109 shall be equal to one-fourth or one-third or one-half of the circumference of the cut-off valve, the piston's steam will be determined by the several ports of the steam-valve as they pass this passage during one-fourth or one-third or one-half of its revolution and the pistons will receive steam during twice the relative distance of the sums of the two ports for each of the respective distances mentioned. As both of the steam-valves are illustrated connected rotatively with the driving-shafts, both will rotate with them, the shafts and valves each making a complete revolution at the same speed and in the same time; but as only one valve can be used at a time I have selected the steam-valve 82 for the steam-inlet port and closed the steam port or passage 55 from the valve 81 on the opposite side of the engine by opening the exhaust-valve 65, thus opening the exhaust-port 57^A and also closing the exhaust-port 58^B below the inlet-valve 82 by closing the exhaust-valve 66. Where the engine is to run in but one direction, steam would be connected to but one of the steam-inlet valves; but where it is to be run in both directions, as for automobiles or boats, steam will have to be connected to both of the inlet-valves. Consequently the steam flows into the valve 82 from the supply-pipe 54 and flows from it through its ports 97, 98, 99, 100, 101, and 102 in successive order as the valve revolves and through the passages in the steam-port 56, through the passages in the exhaust-valve 66, and combined exhaust and steam port 58^B into the intersecting cylinders between the pistons of each pair of disks, forcing them to rotate in opposite directions. I will thus have six pairs of pistons receiving steam in successive order and at six different points and at equal periods of times apart in each revolution. When the pistons reach the opposite side of the cylinders from the inlet-valve 82, the steam passes into the combined steam and exhaust ports 57^A and through the ports of the exhaust-valve 65 into its hollow center and along it through the port-holes 66^A into the exhaust-port 61 and out to the atmosphere, the steam following the direction of the arrow 110 in Fig. 11.

While I have illustrated my valve mechanism in the casing of the cylinders at their ends, I do not wish to be limited to this location for them, as I can place them at most any point in the casings of the cylinders.

While I have preferably illustrated an engine containing six pairs of cylinders, it is obvious that I can employ either more or less. The combining of a group of cylinders in one engine enables me to use steam expansively and economically and to produce a small engine of large power.

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

1. In a rotary engine the combination of the intersecting cylinders and cylinder-casing sections bolted together, with the disks and piston-arms in said cylinders, the driving-shafts extending through said disk and cylinders, the adjustable journal-boxes supporting said driving-shafts and piston-disks, and the gears of equal diameter and pitch on the ends of said shafts, with a steam-inlet-valve mechanism comprising suitable ports and an inner steam-inlet and outer cut-off valves arranged in said cylinders and consisting of a tubular member arranged axially with said shafts adjacent to said cylinder and extending across all of the cylinders and having in the shell of said steam-inlet valve a plurality of ports corresponding in number to the number of pairs of cylinders and arranged at equidistances apart and in spiral order axially of the valve, and each port positioned opposite and connected by suitable steam-port passages with each pair of cylinders, and having the cut-off valve contain an open port in its shell extending axially throughout its length to the outer ends of the steam-ports in said steam-inlet valve, and arranged to open or close the steam ports or passage leading from the steam-inlet valve to said cylinder, a hollow stem on said cut-off valve extending beyond the cylinders, a stem on said steam-inlet valve extending through said stem of said cut-off valve, a suitable stuffing-box around said stems, a hand-wheel on the end of the stem of said cut-off valve, and a gear on the end of said steam-inlet-valve stem of the same pitch-diameter of and meshing into the gears on the ends of said shafts, and an exhaust-valve and ports arranged operatively to control the exhaust from said cylinders, substantially as described.

2. In a rotary engine the combination with the plurality of cylinders of the driving-shafts and the piston-disks operatively arranged in said cylinder to rotate said driving-shafts; gears mounted on said driving-shafts arranged and adapted to keep said disks rotatively in fixed relative unison, with a tubular steam-inlet valve arranged axially along the length of said cylinders having a plurality of ports in their shells arranged equidistant apart in their circumference and also arranged spirally of their circumference to register opposite said cylinder-ports leading from said valve to each of said cylinders, a tubular-shaped cut-off valve surrounding said steam-inlet valve containing an axial port registering in the rotative path of the ports of said steam-inlet valve and arranged

to adjustably close said ports from said steam-valve to said cylinder and the gears on the ends of said steam-inlet valves meshing into the gears of said driving-shafts, and adapted to rotate said valves synchronously with said shafts and piston-disks, substantially as described.

3. In a rotary engine, the combination of the cylinders, the cylinder-heads, the piston-disks and driving-shafts, the supporting-boxes and the gears on said driving-shafts, with the steam-inlet and cut-off valves, the gears on said steam-inlet valves meshing into the gears of said driving-shafts, the hand-wheels on said cut-off valves and the stuffing-boxes surrounding said cut-off valves, and with the steam inlet and exhaust ports, the tubular exhaust-valves in said cylinders having stems extending beyond said cylinders, pinions mounted on said stems, a toothed rack-bar slidably mounted on the outside of one end of said cylinders, and arranged in mesh with said pinions and a handle on said rack-bar, substantially as described.

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

JOHN KNOWLES.

Witnesses:
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ADA M. AKIN.