No. 883,894.

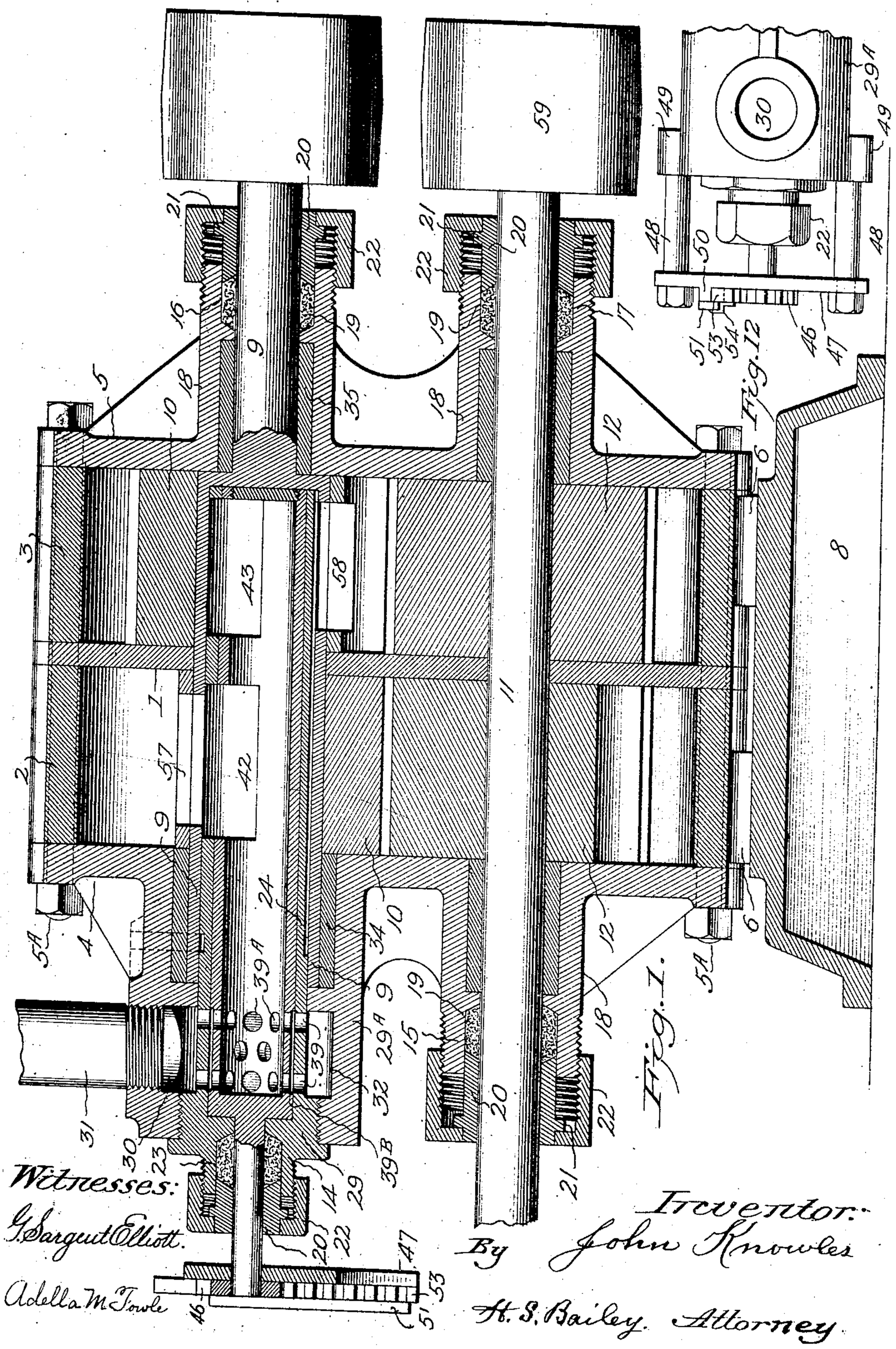
PATENTED APR. 7, 1908.

J. KNOWLES.

ROTARY ENGINE.

APPLICATION FILED AUG. 23, 1907.

3 SHEETS—SHEET 1.



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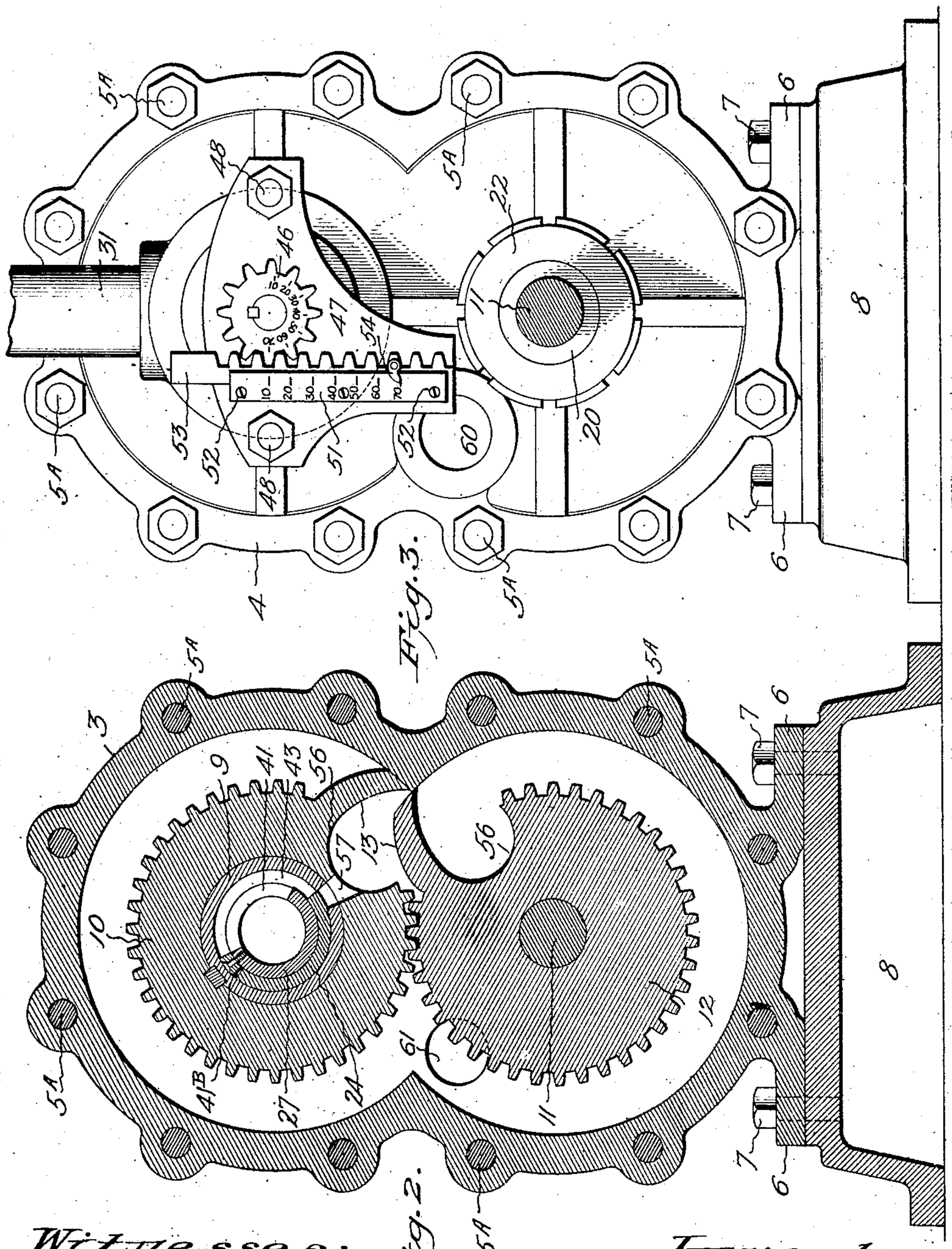

Fig. 3.

Fig. 2.

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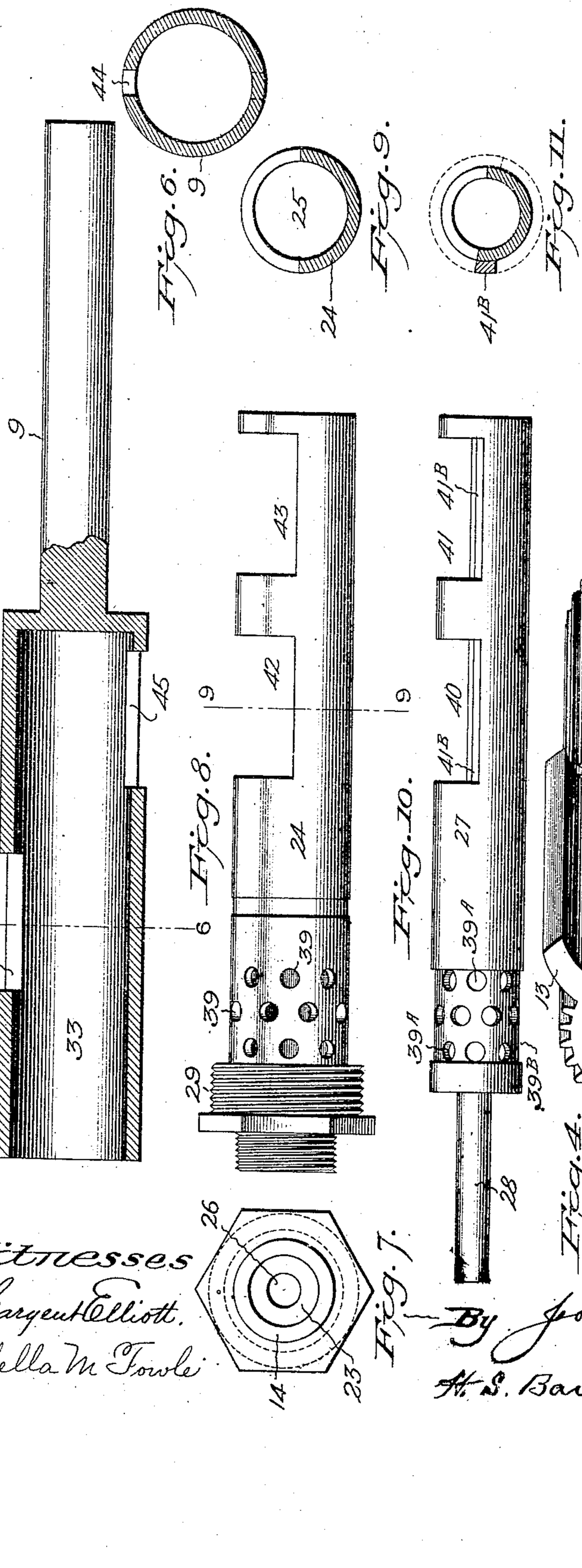

Witnesses

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UNITED STATES PATENT OFFICE.

JOHN KNOWLES, OF DENVER, COLORADO.

ROTARY ENGINE.

No. 883,894. Specification of Letters Patent. Patented April 7, 1908.

Application filed August 23, 1907. Serial No. 389,857.

To all whom it may concern:

Be it known that I, JOHN KNOWLES, a citizen of the United States of America, residing in the city and county of Denver and State of Colorado, have invented a new and useful Rotary Engine, of which the following is a specification.

My invention relates to improvements in rotary engines, and the objects of my invention are: first, to provide a rotary engine comprising a pair of engines arranged side by side, each engine being provided with two intersecting piston cylinders containing rotary pistons coöperatingly arranged and having a driving shaft arranged axially through both the lower and upper horizontally alined cylinders and pistons of both engines, said pistons and shafts being cooperatively connected to rotate in unison; second, to provide an adjustable rotary cut-off valve mechanism that will permit the steam or actuating fluid to be cut off at different predetermined points or parts of the revolution of the driving pistons in their respective cylinders; and third, to provide a simple and compact automatic rotary 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 vertical, longitudinal sectional view of my improved rotary engine. Fig. 2, is a transverse, vertical sectional view through the rear cylinders, showing the pistons in the positions they occupy relatively to each other, immediately preceding the admittance of steam to the cylinders. Fig. 3, is a front elevation of the engine. Fig. 4, is a perspective view of the steam inlet shaft, showing the two oppositely positioned pistons thereon. Fig. 5, is a sectional view of the steam inlet shaft, the pistons being removed. Fig. 6, is a transverse, sectional view thereof on the line 6—6 of Fig. 5. Fig. 7, is a front end view of the steam inlet sleeve upon which the steam inlet shaft revolves. Fig. 8, is a side view of the steam inlet sleeve. Fig. 9, is a transverse sectional view of the same on the line 9—9 of Fig. 8. Fig. 10, is a side view of the cut-off valve which is rotatably journaled in the steam inlet sleeve. Fig. 11, is a transverse sectional view thereof. And Fig. 12, is a fragmental plan view illustrating the manner of securing the cut-off valve indicating mechanism to the front cylinder head.

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

Referring to the drawings, the engine consists of a central partition disk portion 1, on the opposite sides of which a pair of intersecting cylindrical rings 2 and 3 are secured. To the ends of these cylindrical rings cylinder heads 4 and 5 are secured by bolts 5^A, which extend through the cylinder heads and the cylindrical rings and the partition and bolt them all together. The centers of the cylinders of both pairs of intersecting cylinders are preferably arranged to stand in a vertical plane, although if desired they can be arranged to stand in a horizontal plane, and the partition and cylinders are provided with feet 6, which are secured by cap screws 7, to a foundation bed plate 8, which is adapted to be secured to a suitable foundation or to a floor. As the cylindrical ring portions each contain two intersecting cylinders, there are four cylinders and four pistons to the two engines and two cylinder heads. A driving shaft 9 passes through the upper cylinders and pistons 10 and cylinder heads and the central partition of both engines, and a driving shaft 11 also passes through the lower cylinders and pistons 12, and the cylinder heads and the central partition of both engines. The pistons are keyed or otherwise secured to their respective shafts 9 and 11. The pistons comprise a disk portion of considerably smaller diameter than the cylinder, from which a piston arm 13 projects in a curved radius to the inner periphery of the cylinders. The outer cylinder heads are provided with stuffing boxes 14 and 15, and 16 and 17. The stuffing boxes 15, 16, and 17 are formed in integral projecting hubs 18, which are provided with axial packing apertures 19 that surround the driving shafts, into which glands 20 fit slidably. These glands are provided with collar portions 21, adjacent to their outer ends, and are adjustably secured to the hubs by caps 22, which fit over the ends of the glands against the collars 21, and are threaded to the ends of the hubs.

The stuffing box 14 comprises a gland 20, and a cap 22; the gland, however, fits slidably into a packing aperture 23, formed in the axial center of a sleeve 24, which is provided with an axial bore of two diameters 25

and 26, that are formed to receive a tubular valve 27, and its stem portion 28. The sleeve 24 is provided with a head portion 29, which is threaded into an axial bore in a hub 29A, of the front cylinder head 4. The head portion of the sleeve 24 is provided with a projecting reduced portion on its outer end, in which the packing aperture 23 is formed, the exterior surface of which is threaded to receive the cap 22. This hub is provided with a side steam, or other actuating fluid, inlet aperture 30, in which a pipe 31 is threaded, and this inlet aperture connects with a chamber 32 formed in the axial center of the hub 29A, which surrounds the sleeve 24. The sleeve 24 extends through this cylinder head hub and into an axial bore 33, formed in the adjacent end of the driving shaft 9. This driving shaft 9, is made in two diameters, the larger of which extends from the rear end of the upper cylinder through the partition and into the left hand cylinder to within a short distance of the steam inlet aperture, its forward end being journaled in the forward cylinder head in a bushing 34, of any suitable anti-friction metal. The portion of the shaft 9 of smaller diameter, is rotatably journaled in and extends through the rear cylinder head and through an anti-friction bushing 35, which is inserted in an axial bore formed in the hub 18 of the cylinder. The bore 33 of the shaft 9 extends into it to within a short distance of the point where the smaller diameter of the shaft begins, and the hollow portion of the shaft fits revolubly on the sleeve 24, which extends into it to its inner or closed end. The adjustable cut-off valve comprises the tubular portion 27 and the stem portion 28.

The tubular portion fits within the axial bore 25 of the sleeve and extends from the forward end of this bore, which extends slightly forward of the fluid inlet aperture 30 of the hub of this cylinder head, to the opposite or rear end of the sleeve; consequently both the sleeve 24 and the tubular portion of the valve extend through the upper forward piston and its cylinder and nearly through the upper rear piston and its cylinder within the hollow shaft 9. The sleeve and the valve are each provided with a plurality of circumferential rows of fluid inlet apertures 39 and 39A respectively, which extend through their shells and are positioned to register with the fluid inlet aperture in the axial center of the hub of the forward cylinder head. The tubular portion of the valve is also provided with a circumferential recess or depression 39B, along its length where these apertures are positioned, which prevents the apertures 39 and 39A from becoming wholly or partially closed when the valve 27 is shifted to change the percentage of cut-off. The tubular valve and the sleeve are provided respectively with ports 40 and 41 and 42 and 43, which are formed in their shells centrally with respect to the two pistons and cylinders. These ports are preferably formed and arranged in the following manner:

The ports 40 and 41 are cut through and across the shell of the tubular valve in width preferably about sixty-two degrees of its circumference, and at points coincident with the centers of the upper cylinders and pistons of both engines, and these ports are of a great enough area to fully supply the heaviest duty they are capable of performing, the length of the ports being preferably about two-thirds of the width of the cylinders and piston. To the outside surface of the tubular portion of the valve and along one side edge of its ports 40 and 41, I removably secure by screws or other suitable means steam cut-off and stop lips 41B, which act to limit the rotative movement of the valve within the fixed sleeve, and also to close up the ports 42 and 43 of the sleeve as the valve is rotated. These stop lips project through the ports 42 and 43 of the sleeve, and contact with the wall of the shafts axial port, and they strike the opposite side edges of these ports when the valve is rotated from one side to the other of their width. The sleeve is also provided with the two ports 42 and 43, formed across it through its shell of a width of approximately one-half of the diameter of the sleeve, and these ports are positioned to register directly over and are of the same length as the ports of the tube valve. The piston shaft 9, which rotates on the sleeve, is also provided with two steam inlet ports 44 and 45, which register over and with the ports 42 and 43 of the stationary sleeve, and also with the ports of the adjustable valve, and these shaft ports are of ample area in width to admit sufficient steam to the upper pistons and cylinders of both engines, but they are preferably positioned on opposite sides of the shaft 9; consequently they admit steam to the pistons and cylinders in alternate order as the shaft rotates and one engine on one side of the partition receives its steam at or about the time the other engine is exhausting its steam, as will be explained more fully hereinafter.

The stem 28 of the adjustable tubular valve extends from the tubular portion through an aperture in the sleeve 24; in which it is free to rotate and through the packing chamber 23 of the head 29, and upon its outer end an indicating mechanism is mounted. This adjustable cut-off indicating mechanism is arranged as follows: An index gear wheel 46 is mounted on and secured to the outer end of the valve stem. An index plate 47 is secured to the front of the cylinder head by bolts 48, that extend through index plate and through lugs or ears 49, formed on opposite sides of the hub 29A,

and support the index plate beyond the cap of the stuffing box of the valve stem. The index plate is provided with a vertically arranged projecting lug strip 50, to which a strip 51 is secured by screws 52. This strip is arranged to extend beyond the lug toward the valve stem gear far enough to form a guideway between it and the surface of the index plate. A toothed bar 53, is slidably fitted in this guideway space between the strip and index plate and its teeth mesh with the teeth of the valve stem gear 46. The upper end of this toothed bar is adapted to be attached to a governor which may be connected by a belt to a pulley placed on the end of the driving shaft 11. I do not, however, illustrate the governor and belt and pulley, as they and their use and application to steam engines are well known, but the toothed bar is adapted to be moved automatically up and down and to rotatively move the gear and valve stem and cut-off valve as the governor is operated above the increased or decreased speed of the engines above or below its nominal speed, as is well understood. The valve is set to cut-off the inflowing steam at various degrees of the operative rotative stroke of the upper pistons, by means of a graduated index of degrees indicative of different degrees of the operative movement of the pistons and of the valve ports relative to the ports of the fixed sleeve 24. These indexes consist of two scales of degrees of the operative rotary stroke of the upper pistons. One scale is placed on the cap of the guideway of the toothed bar, with the degrees arranged in a vertical row from 70 degrees down to 10 degrees, graduation marks being preferably placed at five degrees apart from 70 to 10. The other scale is placed in a circular row of radiating graduation marks on the face of the gear 46 of the valve stem, which are arranged with the 70 degree graduation opposite to the 10 degree graduation of the toothed bar scale. Upon the toothed bar an indicating pointer 54 is secured, which is arranged to overlap the cap and extend to close to the graduation. The valve and toothed bar normally stand at 70 degrees cut-off as shown, in which position the valve ports are wide open, and in order to set the valve at any desired amount of cut-off less than 70, the toothed bar is raised until the indicator pointer comes opposite to the degree of cut-off desired. If a steam cut-off of one-half of the operative stroke of the pistons is desired, which is three-quarters of their full rotary or circumferential stroke or revolution, the bar should be raised until the pointer registers with the 50 degree graduation mark. The valve ports 40 and 41 of the tubular valve will then stand half open relative to the ports 42 and 43 of the fixed sleeve 24, and the attachment between the bar and the governor should be adjusted to normally hold the bar at this point at the speed it is desired the governor should allow the engines to run at. The governor then is free to move the bar to increase or diminish this amount of cut-off automatically as the speed of the engines increases or diminishes under varying loads.

Upon the shafts 9 and 11 on each side of the partition I secure the pistons 10 and 12 respectively. These pistons comprise disk portions which are considerably smaller in diameter than the diameter of the cylinders, and the arched arm portions 13, that project from the disk portion and extend to the inner periphery of the cylinders. The pistons on opposite sides of the partitions are arranged with their arms standing at one-sixth of the circumference of the cylinder apart. The diameters of the disk portions of the pistons are equal and their peripheries are provided with intermeshing gear teeth that fit actuatingly together and bear and roll upon each other through about seven-eighths of their diameters. The disks are cut away under each arm portion, and a recess 56 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 the curved wall of the recess, which is formed to register with the curve of the outside periphery of the arms. There are thus four cylinders and two pairs of pistons in each engine, and two coöperating pistons are required in each pair of the intersecting cylinders to make an operative rotary engine. The pistons are preferably keyed to their respective shafts and the two upper pistons 10 are provided with ports 57 and 58, which register respectvely with the ports 44 and 45 of the shaft 9. These piston ports 57 antd 58 extend through the center of the width or thickness of the pistons from the inner wall of their axial bore to the inner wall 56 of their piston arm curved recesses. Consequently steam is admitted to these upper cylinders through the shaft 9, and the pistons 10, to the upper cylinders of these two engines in positions to strike against the inner curved surface of the piston arms of the pistons.

The shaft 11 is preferably the driving shaft of the two engines; it is extended through and beyond both engine cylinders, and a belt driving pulley 59 is mounted on and secured to it.

The operation of my improved compound rotary engine is as follows: The steam flows through the inlet pipe 31 from a source of supply into the steam chamber in the hub of the forward cylinder head around the sleeve

24, and through the steam inlet apertures 39 and 39[A] of the sleeve and valve into the interior of the tubular portion of the adjustable rotary valve, from which it discharges through the ports 40 and 41 into and through the ports 42 and 43, thence through the ports 44 and 45 of the shaft 9, as the shaft rotates, and from the ports of the shaft 9, through the piston ports 57 and 58 into the cylinder, and pushing against the piston arms 13 of the pistons 10 and 12 moves them to rotate in their cylinders, the intermeshing teeth on the pistons causing them to move in unison. The driving shaft 11 and its pulley are thus rotated, and power is transmitted by belt from said pulley, The area of the inlet ports of the valve and sleeve is such relative to the oppositely positioned ports of the shaft 9, that the upper pistons and their shaft 9 have no dead center when the valve is set to cut-off at 70 percent. one or the other of the two groups of ports of the sleeve and valve being open to the ports of the shaft 9 and its pistons at all times. The valve is adjusted to cut-off the steam at from 10 to 70 percent. of the operative rotative stroke of each of the pistons 10 and 12, by turning its index pointer to the degree of cut-off required that is marked on the index plate. Thus, if 30 percent. cut-off of the rotative stroke of the piston is desired, the pointer is turned to the index numeral 30, of the index dial, which will rotate the valve in the sleeve to stand open relative to the ports of the sleeve 30 percent. of the rotary movement of the pistons, which is one revolution of the pistons. The steam in the front cylinders exhausts through a port 60, while a similar port 61 serves to exhaust from the rear cylinders.

Some of the features of my present invention were patented to me in the United States Patents No. 733,052 of July 7, 1903, and 748,192 of Dec. 29, 1903, 667,713 of Feb. 12, 1901, and 652,317 of June 26, 1900. My present invention, however, is much simpler, less expensive to construct, more compact, requires less installing space, and is better adapted for the requirements expected of engines at the present time than the engines of my former patents were; and it contemplates broadly an operative and adjustable cut-off rotary valve mounted in the axial center of the steam driven pistons and their axial shaft.

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

1. A cut-off valved rotary engine, comprising operative cylinders and rotary pistons, a shaft extending through said cylinders and pistons, a tubular valve provided with ports leading to said cylinders, a sleeve surrounding said tubular valve and extending into said shaft, ports in said sleeve registering with the ports of said tubular valve, ports in the opposite sides of said shaft registering in alternate order with the ports of said sleeve, means for securing said pistons to said shaft, ports in said pistons connecting with the ports of said shaft, and means for adjustably setting said tubular valve relative to the ports of said sleeve to cut-off the steam at any predetermined point of the said piston's operative stroke of revolution.

2. A cut-off valved rotary engine, comprising an operative cylinder and rotary piston, a shaft provided with an axial aperture at one end rotatably mounted in said cylinder and extending through and secured to said piston, a steam inlet port in said cylinder, a fixed sleeve extending into said cylinder into the axial aperture in said piston shaft, and provided with steam ports adapted to admit steam from said cylinder's inlet port into the interior of said sleeve, a port through the shell of the sleeve, a port through the shell of said shaft's apertured portion arranged to register with said sleeve port as said shaft rotates, a port in said piston communicating with said shaft port and with the cylinder of said piston, a tubular valve rotatably mounted in said sleeve provided with ports communicating with said sleeve's steam inlet ports, a port in said tubular valve registering with the port in said sleeve, a stem on said tubular valve, means for rotating said tubular valve to vary the steam inlet area of its port relative to said sleeve's port, and means for defining the rotary movement of said rotary valve in said sleeve.

3. A cut-off valved rotary engine, consisting of the intersecting cylinders, the shafts rotatably journaled therein, and the intermeshing toothed disk pistons mounted on said shafts in said intersecting cylinders, one of said shafts being provided with an axial aperture in one end, with a sleeve fixed in said cylinder and extending into said piston's axial aperture, and provided with steam inlet ports, a steam port in said cylinder registering with said sleeve's steam ports, a port in said sleeve into said piston's axial aperture, a port through said rotating shaft and pistons arranged to register with the port in said sleeve as said piston and shaft rotate, and communicating with the interior of said piston's cylinder, a rotary movement tubular valve in said sleeve provided with steam inlet aperture registering with the inlet ports of said sleeve, a port in said tubular valve registering with said sleeve's shaft port, and means including an index plate for rotatably moving said tubular valve to set its port at any desired degree of cut-off relative to said piston's operative rotative stroke.

4. In a cut-off valved rotary engine, the combination of the intersecting cylinders

and pistons and the piston shafts, one of which is provided with an axial port, and with side ports extending from its axial port through its shell, a steam inlet into said cylinder, a sleeve fixed in said cylinders and provided with a steam inlet port connecting with said cylinder's steam inlet port and extending into the axial aperture of said piston's shaft, an inner tubular valve in said sleeve provided with ports connecting with said sleeve's steam inlet ports, and provided with cylinder ports in its periphery arranged in a straight line, and registering with said sleeve's piston's shaft ports, a stem on said tubular valve extending from said sleeve, means for packing said stem, a stop on said tubular valve for limiting the movement of its ports relative to said sleeve's piston's shaft ports, an index on said cylinder, an index connected with said tubular valve stem, and means including an adjustable pointer for setting said tubular valve at any predetermined point of cut-off relative to said sleeve's piston shaft's ports.

5. In a cut-off valved rotary engine, the combination with a pair of coöperating rotary engines, each engine comprising two intersecting piston cylinders, a separating partition between each engine, a shaft through each set of horizontally alined cylinders of the two engines, one of said shafts being provided with an axial steam inlet port and with oppositely arranged peripheral ports, disk-shaped intermeshing toothed pistons, each provided with a piston arm mounted on said shafts in the intersecting cylinders of each engine, a port in each piston registering at one end with its piston's cylinder and at its opposite end with the ports of said shaft, a fixed sleeve, in one of said engine cylinders extending into said piston's axial port, a steam inlet port in said sleeve, a steam inlet port through one of said engine cylinders into said sleeve, a pair of steam ports in the periphery of said sleeve in alinement with each other, arranged in alinement with the peripheral ports of said piston's shaft, a rotary tubular valve provided with a steam inlet port registering with said sleeve's steam port and provided with ports in alinement registering with said sleeve's ports, means for limiting the rotary movement of said tubular valve, and means including a stem on said tubular valve for automatically adjusting the position of said tubular valve's ports relative to said sleeve ports to obtain different predetermined degrees of steam cut-off relative to the rotary stroke of revolution of said pistons.

6. In a cut-off valved rotary engine, the combination of the cylinders, the pistons, and the driving shafts, of one of said shafts being provided with an axial port and with oppositely arranged ports in its periphery registering with its axial port, and a port in each piston registering with its piston's cylinder and with one of said shaft's peripheral ports, with the fixed sleeve and its ports extending into said shaft's axial port and registering with said shaft's peripheral ports, the tubular valve and its ports in said sleeve, and an operative automatic index valve adjusting mechanism adapted to move said tubular valve to give various predetermined degrees of steam cut-off to the said tubular valve and sleeve relative to a rotary stroke of revolution of said pistons.

7. In a cut-off valved rotary engine, the combination of a plurality of rotary engines, each comprising a pair of intersecting piston cylinders, the intermeshing toothed pistons in each pair of intersecting cylinders and the piston shafts, one of said shafts being provided with an axial port and with oppositely arranged peripheral ports connecting with its axial port, and the pistons on said ported shaft being provided with ports connecting with their respective cylinders and with the ports of their supporting shaft, a steam inlet into one cylinder of said engines, a sleeve fixed in said steam inlet cylinder and extending into the axial port of said shaft, and provided with steam ports connecting with said cylinder's steam inlet port, ports in said sleeve registering with the ports of said shaft, a rotary movement tubular valve mounted in said sleeve provided with ports registering with the ports of said sleeve, a stuffing box on the end of said sleeve, a stem on said tubular valve extending through said stuffing box, a gear on the end of said stem, an index plate on the engine cylinder adjacent to said stem, a guideway on said index plate, a toothed bar slidably mounted in said guideway in mesh with said stem's gear, an index representing a graduation predetermined part of the piston's rotary stroke of revolution on said index plate and on said gear arranged to register with each other as said toothed bar and stem gear are moved, and means including any suitable operative governor and a power transmitting pulley on the shaft of said pistons that is driven by said steam inlet pistons for automatically moving said toothed bar and stem gear for maintaining any predetermined degree of said index whereby variable degrees of steam inlet cut-off area of the ports of said tubular valve relative to the ports of said sleeve and to said piston's rotary stroke may be given to said valve and be automatically and operatively maintained by said governor.

8. In a cut-off valved rotary engine, the combination of the cylinders, the pistons, and the piston's supporting shafts, one of which is provided with an axial port and with oppositely arranged peripheral ports connected with said axial port, of a steam inlet in one of said cylinders, a sleeve fixed in said steam inlet cylinder provided with a plu-

rality of circumferential rows of steam inlet ports and extending into said shaft's axial ports, ports in the periphery of said sleeve registering with said shaft's peripheral ports, a tubular cut-off valve in said sleeve provided with steam ports registering with said sleeve's ports, and means including an index device connected to said cut-off valve for adjusting said cut-off valve at any desired operative degree of said piston's operative rotary stroke.

9. In an automatically adjustable and operating cut-off valved rotary engine, the combination of a plurality of rotary engines, each comprising a pair of intersecting cylinders and toothed intermeshing pistons, and their supporting shafts, means for securing said pistons to said shafts, one horizontally alined set of pistons being provided with a steam inlet port, an axial port in one end of said ported piston's supporting shaft and oppositely arranged peripheral ports in said shaft registering with its axial port and with said piston's ports, a steam inlet port in one of said engine's cylinders, a sleeve in said engine extending into said shaft's axial port, steam inlet ports in said sleeve registering with the ports of said shaft, and of the cylinder of said engine, a rotary movement tubular cut-off valve in said sleeve, steam ports in said cut-off valve registering with the ports of said sleeve, means for setting said cut-off valve at any desired degree of cut-off relative to said sleeve's ports, an index connected to said tubular valve adapted to determine the degree of cut-off movement given to said cut-off valve, and means connected to said cut-off valve and its index and to said piston's driving shaft for automatically controlling said engines.

10. A cut-off valved rotary engine, comprising a plurality of cylinders, each provided with a steam driving piston and a piston driven by each of said steam driven pistons, a steam admitting shaft extending through said engines and secured to the axial centers of said steam driven pistons, steam inlet ports in said shaft, a steam inlet port in said steam driven pistons registering with said ports of said shaft and with their respective cylinders, a power distributing shaft journaled in said engines and secured to the axial centers of said driven pistons, and means including an adjustable and automatically controlled cut-off valve mounted in said steam admitting shaft for providing a variable steam cut-off valve mechanism for said steam driven pistons.

11. In a rotary engine, the combination with a casing, comprising duplicate pairs of intersecting cylinders separated by a partition; of intermeshing pistons in each pair of cylinders of less diameter than the cylinders, having arms which extend to the circular walls of the cylinders, a hollow shaft upon which the axially alined pistons of the separate pairs are secured, having oppositely arranged ports registering with radial ports in said pistons; a stationary sleeve extending into said shaft, connected with a steam inlet, and having ports registering with the shaft ports; a rotatable tubular cut-off valve in said sleeve, having ports registering with the sleeve ports, and means for limiting the rotary movement of the valve relatively to the sleeve ports, a stem on said valve, a pinion on said stem, a toothed arm operated by said pinion for indicating the degree of cut-off of said valve, a shaft upon which the remaining pair of axially alined pistons is secured, and a pulley on one end of said shaft.

12. In a cut-off valved rotary engine, the combination of a rotary engine, comprising the cylinders, the pistons with a rotative piston shaft provided with an axial bore and with radial ports through its shell into its axial port, a fixed sleeve in said engine extending into the axial bore of said piston's shaft, and provided with ports registering with said shaft's radial ports, a cut-off valve in said sleeve having ports registering with the ports of said sleeve and piston shaft, a projecting port lug on one edge of each of said cut-off valve's ports fitting into and projecting through the ports of said sleeve and bearing against the inner peripheral wall surface of the axial port of said piston shaft, and means for adjustably moving and setting said cut-off valve and its cut-off lug in the ports of said fixed sleeve to secure any desired degree of steam inlet cut-off relative to the ports of said rotating piston shaft, and the rotary stroke of said pistons in said cylinders.

13. A cut-off valve for rotary engines, comprising an operative cylinder provided with a rotary piston, a rotary shaft secured to said piston, an axial bore in said shaft, a radial port in said shaft extending through its shell into its axial bore, a fixed sleeve in said shaft's axial bore, provided with a radial port through its shell registering with the radial port of said shaft, and a cut-off tubular valve member rotatably mounted in said sleeve and provided with an axial inlet port and with radial ports extending through its shell and registering with the radial ports of said fixed sleeve and said rotating shaft, a port closing lug detachably secured to one edge of the radial port of said cut-off steam inlet valve member, fitting and extending through the radial port of said fixed sleeve, with its peripheral surface in operative relation to the inner surface of said shaft's axial bore, means for admitting steam through said engine to said tubular cut-off valve member, and means for adjusting said cut-off valve member, to vary the area of its steam inlet port relative to the area of the radial ports of said sleeve and shaft to any

desired degree of the operative rotary stroke of said piston.

14. A cut-off valve for rotary engines, comprising the cylinders and the pistons, a portion of said pistons being provided with steam inlet ports, a shaft on each operative pair of pistons, one of which shafts is provided with an axial bore, and radial ports through its shell onto its axial bore, the fixed sleeve in said shaft's axial bore provided with a radial port through its shell registering with the ports of said shaft, a tubular cut-off valve member rotatably mounted in said sleeve and provided with radial ports registering with the ports of said fixed sleeve and ported piston shaft, and a cut-off lug detachably secured to said cut-off valve member along one edge of each of its radial ports, said lug being arranged to fit into the ends of said sleeve's ports and extend through them to the inner wall surface of the axial bore of said ported piston shaft, means including a steam inlet port in one of said cylinders, connecting with said sleeve and cut-off valve member for admitting steam to said cut-off valve member, and means including graduated indexed plate connected to said cut-off valve member for adjustably setting said cut-off valve member and its cut-off lug at any desired predetermined degree of steam cut-off relative to said piston shaft's ports and the operative rotary stroke or revolution of said rotary pistons.

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

JOHN KNOWLES.

Witnesses:
G. SARGENT ELLIOTT,
ADELLA M. FOWLE.