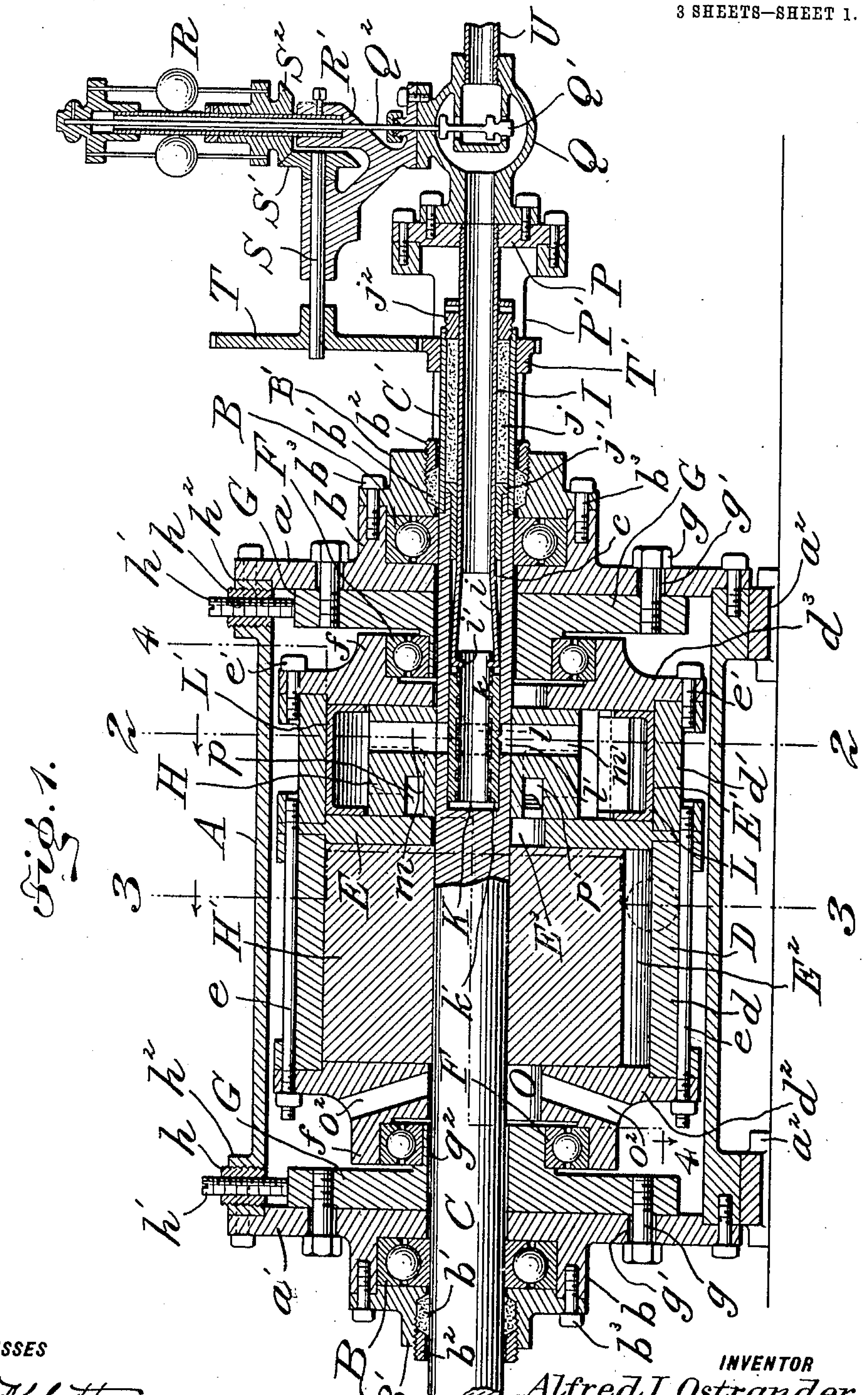
No. 892,443. PATENTED JULY 7, 1908.

A. I. OSTRANDER.

ROTARY ENGINE.

APPLICATION FILED JULY 17, 1907.

3 SHEETS—SHEET 1.



WITNESSES

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V. E. Nichols

INVENTOR

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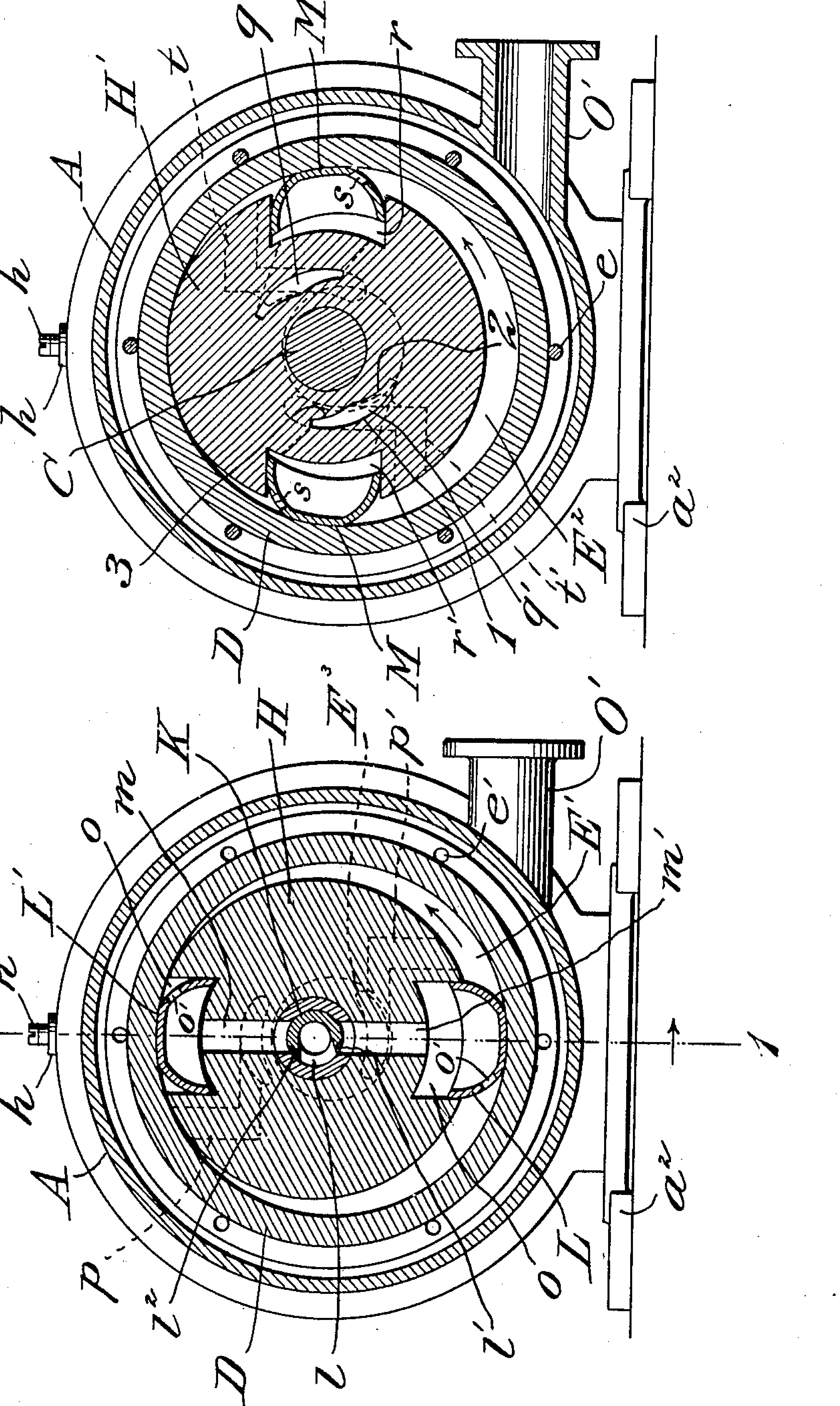

Fig. 3.

Fig. 2.

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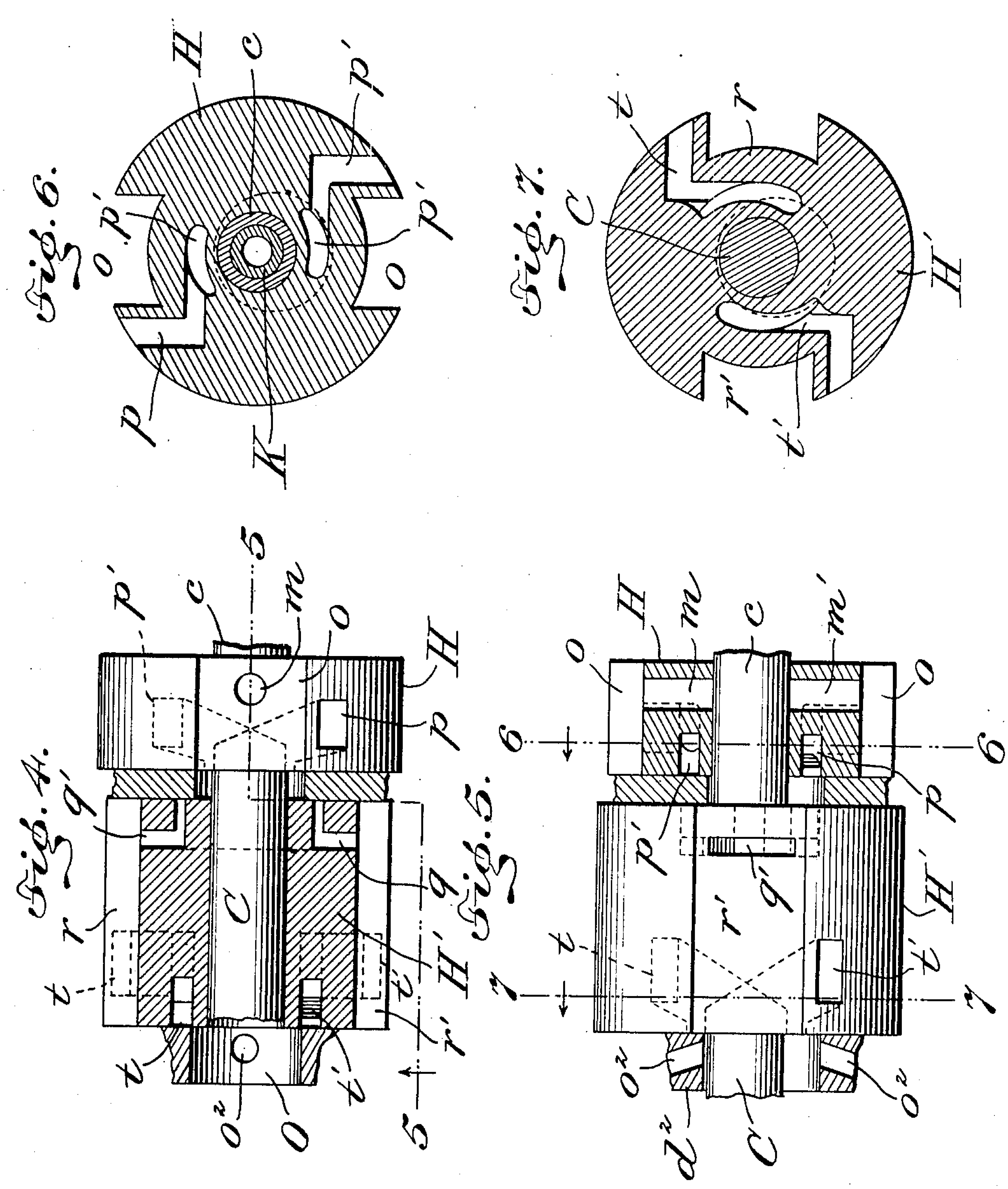

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UNITED STATES PATENT OFFICE.

ALFRED I. OSTRANDER, OF YONKERS, NEW YORK.

ROTARY ENGINE.

No. 892,443. Specification of Letters Patent. Patented July 7, 1908.

Application filed July 17, 1907. Serial No. 384,145.

To all whom it may concern:

Be it known that I, ALFRED I. OSTRANDER, a citizen of the United States, residing in the city of Yonkers, county of Westchester, and State of New York, have invented a certain new and useful Multiple-Expansion Rotary Engine, of which the following is a specification.

This invention is a rotary engine of that type wherein steam, or other motive fluid, is used expansively for the purpose of securing maximum efficiency by an economical consumption of the motive fluid which is adapted to be supplied at a relatively low pressure.

In some respects, the invention of the present application is similar to the invention forming the basis of a prior patent, No. 813,819, granted to me on February 27, 1906, for a multiple expansion rotary engine, and so far as some features of said present invention are concerned, they may be considered an improvement upon the engine of the aforesaid patent.

One improvement in the engine consists of a novel construction of the motive fluid ports in the members or abutments of the rotatable piston and a partition or division wall (one or more), for the purpose of controlling the admission and cutting off at the proper time of the motive fluid during the operations of exhausting such fluid from a high pressure cylinder to a lower pressure cylinder.

Another part of the invention is a new form of cut-off located, preferably, in a hollow part of the piston shaft and in the plane of rotation of the inlet ports to the high pressure cylinder. Said cut-off is anchored within the rotary piston and its shaft, and such anchoring of the cut-off is secured, preferably, by a flexible or loose connection between the cut-off and a supply pipe by which the motive fluid is fed, primarily, to the high pressure engine cylinder.

In the new engine, the piston shaft is, preferably, bored out for a part of its length for the purpose of providing a passage whereby the motive fluid is admitted to the high pressure cylinder; and the aforesaid cut-off is so constructed, and it is flexibly connected to the supply pipe, with a view to compensating for inaccuracies in the bore of the piston shaft and to secure, practically, a fluid tight fit or engagement therewith.

Another part of the invention consists of means for adjusting the cylinder with respect to the rotary pistons, whereby the cylinder may be brought into proper contact with the rotary pistons at the point of tangency.

In the accompanying drawings, I have illustrated one practical embodiment of the invention, but the construction shown therein is to be understood as illustrative only, and not as defining the limits of the invention.

Figure 1 is a vertical longitudinal section through my new rotary engine on the line 1—1 of Fig. 2. Figs. 2 and 3 are vertical cross sections on the lines 2—2 and 3—3 respectively of Fig. 1. Fig. 4 is a detail view of the multiple piston member or abutment in plan, and the low pressure piston member or abutment in horizontal section on the line 4—4 of Fig. 1. Fig. 5 is a side elevation of the multiple piston, partly in horizontal section, the line of the section being indicated by the dotted line 5—5 of Fig. 4. Figs. 6 and 7 are cross sections on the lines 6—6 and 7—7, respectively, of Fig. 5.

A designates an external stationary casing, preferably cylindrical in shape, and provided with heads, a, a', and supports, a^2, a^2, adapted to be secured in any approved way to a suitable foundation. The heads of said casing are provided with external annular flanges, b, adapted to receive the ball bearings, B, for the engine shaft, C. Said ball bearings are held in place by stuffing boxes, B′, having the packings, b', which are compressed by adjustment of the glands, b^2, said stuffing boxes being fastened in place by bolts, b^3, thus preventing leakage of the motive fluid around the shaft, C. Within the stationary casing, A, is a rotatable piston cylinder, D, the latter being supported by ball bearings for rotation freely within said casing. The cylinder, D, consists of suitable sections, d, d', and heads, d^2, d^3. The sections, d, d', of said cylinder clamp a division wall or partition, E, between their adjacent ends, and for this purpose the cylinder is provided with bolts, e, adapted to fasten the head, d^2, to the section, d, and also to clamp the two sections, d, d', upon the edge portion of the division wall, E. The other head, d^3, is fastened to the cylinder section, d', by bolts, e'. The heads, d^2, d^3, of the rotatable cylinder are provided at their ends with hubs, f, within which hubs are arranged the ball bearings, F, adapted to support said cylinder loosely within the casing, A.

The engine is equipped with means for adjusting the cylinder, D, bodily with respect to the rotary pistons for the purpose of adjusting the cylinder to a proper contact with the rotary pistons at the point of tangency. One means for securing such adjustment of the cylinder is shown in Fig. 1, wherein slidable members, G, are connected to the heads, *a*, of the stationary casing, A, by means of bolts, *g*, the latter passing through slots, *g'*, in the heads, *a*, *a'*. The adjustable members, G, are provided with hubs, g^2, adapted to support the ball bearings, F, said hubs, g^2, and the bearings, F, being in eccentric relation to a shaft, C, whereby the shaft and the cylinder are eccentric one to the other. The cylinder, D, is concentric with the casing, A, and it is supported by the ball bearings, F, for rotation freely within said casing. The members, G, are adapted to be adjusted by a differential screw device herein shown as consisting of sleeves, *h*, and screws, *h'*. The sleeves, *h*, are provided with external and internal threads, and each sleeve is screwed into a female threaded boss, h^2, which is provided on the casing, A. The screws, *h'*, are threaded into the sleeves and they are connected with the members, G, whereby the sleeves and the screws may be adjusted to secure an accurate adjustment of the cylinder in contact with the rotary pistons at the point of tangency, after which the bolts, *g*, should be tightened for the purpose of rigidly holding the members, G, and the cylinder, D, in their adjusted positions.

From the preceding description it will be noted that the shaft, C, and the cylinder, D, are mounted by independent bearings on the stationary casing; and, furthermore, the bearings, B, for the shaft, C, are exteriorly of said casing, whereas the bearings, F, for the cylinder are within said casing, all as clearly shown in Fig. 1.

The division wall, E, is secured at a suitable point within the cylinder, D, so as to produce two piston chambers therein, one of said piston chambers, E', receiving the high pressure piston member or abutment, H, while the other piston chamber, E^2, receives the low pressure piston member or abutment, H'. The members, E', E^2, are of different area for the accommodation of the small and large piston members, H, H', respectively, and both of these piston members are made fast with the engine shaft, C, in any suitable way, said piston members being concentric with the shaft and occupying an eccentric relation to the cylinder, D, whereby said piston members are adapted for engagement with the internal surface of the cylinder at one point therein, termed the point of tangency, as shown in Figs. 2 and 3 of the drawings.

The engine shaft, C, is hollow for a part of its length, said shaft being preferably bored so as to produce an internal passage, *c*, within which is arranged the devices for supplying and regulating the admission of the motive fluid to the high pressure piston member, H, and from the chamber, E', in which said member, H, operates, the motive fluid is exhausted into the chamber, E^2, for the purpose of utilizing said motive fluid in the propulsion of the piston member, H'. The hollow part, *c*, of the shaft extends to and through the ball bearing, B, at the right of the engine in Fig. 1, and to the end portion of this hollow part is secured a sleeve, C', which constitutes an extension of the engine shaft, said extension protruding beyond the stuffing box, B'.

Within the extension, C', of the engine shaft is arranged a supply pipe, I, the inner extremity of which is split to produce the flexible fingers, *i*, each of which is provided with a hook, *i'*. The feed pipe, I, occupies a stationary position within the extension, C', and the end portion of the hollow piston shaft, *c*, and the space between said extension, C', and the feed pipe is filled by a packing, *j*, which prevents the leakage of the motive fluid around the feed pipe, said packing being confined in place by a sleeve, *j'*, and a collar, j^2, the former being secured in the end portion of the hollow shaft, *c*, and the latter being fastened in the end portion of the extension, C'.

Within the hollow part of the shaft, C, is a cut-off, K, which is anchored in a stationary position by the members, *i*, of the feed pipe, I. This cut-off is shown as consisting of a tube, *k*, preferably of steel, and an incasing material, *k'*, for said tube, said incasing material being composed of a suitable anti-friction metal, such as "Babbitt" metal, which is cast around the tube, *k*, see Fig. 1. The external diameter of the tubular cut-off, K, corresponds to the internal diameter of the hollow part, *c*, of the engine shaft, and the tube, *k*, of this cut-off is extended beyond the Babbitt metal incasing material, *k'*, whereby the prongs, *i'*, of the feed pipe may be engaged with said tubular cut-off for the purpose of holding and anchoring it in a stationary position. The tubular cut-off is provided with a port, *l*, which is in the plane of rotation of the ports, *m*, *m'*, which are provided in the high pressure piston member, H, said ports, *m*, *m'*, being provided radially in said piston member, H, see Figs. 1 and 2. The port, *l*, is of suitable area to coincide with the ports, *m*, *m'*, of said piston member. It is preferred to provide the tubular cut-off, K, with notches, *l'* and l^2, which open into the port, *l*, as shown in Fig. 2, whereby the motive fluid may be admitted to one or the other of the ports, *m*, *m'*, in starting the engine should the port, *l*, of the cut-off be out of registration with either of the radial ports, *m*, *m'*.

The piston member, H, is provided in its periphery with pockets, *o*, and in these pockets are the piston shoes, L, L′, each shoe being hollow and constructed substantially as disclosed in my prior patent to which reference has been made. As therein shown and described, each piston shoe is provided with three arcuate faces, one of which engages with the internal surface of the cylinder, D, and the other two faces engage with the opposite side walls of the pocket, *o*. Each piston shoe is provided, furthermore, with a port, *o*′, adapted to permit the motive fluid to pass from the proper inlet port, *m*, or *m*′, into the cylinder back of the piston shoe, after the latter passes the point of tangency, as will hereinafter appear.

The division wall, E, is provided with a port, E^3, which is substantially crescent shaped as shown by dotted lines in Fig. 2 of the drawings, the inner edge of said port being formed by the piston shaft and the outer edge by the periphery of a circular opening in the division wall E, concentric with cylinder, through which opening the shaft passes eccentrically.

The high pressure member, H, of the piston is provided, in addition to the inlet ports, *m*, *m*′, with the irregularly shaped exhaust ports, *p*, *p*′, each exhaust port being of the angular form shown in dotted lines in Fig. 4 and full lines in Fig. 6. The exhaust ports, *p*, *p*′, open through the periphery of the piston member, H, in advance of the piston shoes, L, L′, but the other end of each exhaust port opens through that face of the piston member which is next to the division wall, E. Said end of the exhaust port, *p*, or *p*′, is of the approximately crescent shape shown in full lines, and in the position shown in Fig. 6, of the drawings. By reason of this shape and position of the ports *p*, and *p*′, they are adapted to register alternately with the port, E^3, of the division wall, E, in a way to properly control the passage of the motive fluid to said port, E^3.

The low pressure piston member, H′, which operates in the chamber, E^2, of the piston cylinder is provided with inlet ports, *q*, *q*′, having the angular form shown in Figs. 3 and 4, each inlet port being approximately crescent shaped as shown in full lines in Fig. 3 at the intake end thereof, said end of each exhaust port being formed by three arcs or circles indicated at 1, 2, and 3. The arc 1 is concentric with the axis of the shaft, C, the arc 2 is struck from a center at one side of said axis of the shaft, and the arc 3 is struck from a center at the opposite side of said axis of the shaft, said arcs 2 and 3 intersecting each other at the middle of the port. The ends of each port are narrower than the middle portion of the port, and by reason of the peculiar relation of the arcs 2 and 3, the port, *q*, or *q*′, of the low pressure piston member H′, is adapted to properly register with the port, E^3, in the division wall. The outlet ends of the ports *q*, *q*′, open into pockets, *r*, *r*′, which are formed in the periphery of said piston member, H′, and these pockets accommodate the piston shoes, M M′. Each piston shoe is similar to one of the shoes, L, L′, and to the corresponding shoe employed in the engine of my prior patent, that is to say, each shoe, M, or M′, has three arcuate faces and it is provided with a port, S. The low pressure piston member, H′, is provided, furthermore, with exhaust ports, *t*, *t*′, having the irregular shape shown in Fig. 7 of the drawings. The intake end of each exhaust port, *t* or *t*′, opens through the periphery of the piston member, H′, at one side of a piston shoe, M or M′, whereas the other or discharge end of each port, *t* or *t*′, is of the approximately crescent shape and in position shown in Fig. 7. The discharging end of said ports, *t*, *t*′, are adapted to register alternately with an exhaust port, O, see Fig. 1, which port is formed in the head, d^2, of the piston cylinder, and from this exhaust port, O, extends a plurality of exhaust passages, o^2, whereby the motive fluid is exhausted into the stationary casing, A, from whence the motive fluid is finally exhausted through the discharge elbow, O′, of said casing, A.

The feed pipe, I, is fastened at its upper end to a cap, P, that is bolted to or formed as a part of a bracket P′, the latter being made fast with the stuffing box, B′, of the casing, A, whereby the feed pipe is held in a stationary position within the rotary engine shaft and the tubular extension, C′, thereof. To this cap is bolted the casing, Q, of a valve, Q′, the movement of which is controlled by a centrifugal governor, R. The frame, R′, of said governor is made fast with the valve casing, Q, and in this frame is journaled the governor shaft, S, one end of said shaft having a bevel gear, S′, adapted to impart motion to the governor head through the medium of the bevel gear, S^2. The other end of the governor shaft is provided with a spur gear, T, which meshes with a gear pinion, T′, that is made fast with the extension, C′, of the engine shaft, whereby the governor mechanism is geared to the engine shaft and said governor is thus actuated directly by said engine shaft. It will be understood that the stem, Q^2, of the valve is connected with the head of the governor, and undue speed of the engine shaft operates the governor for the purpose of throttling the inlet of steam to the feed pipe, I, this steam being conveyed from a boiler or other source of supply by a pipe, U, which is fastened to the valve casing, Q.

The operation is as follows:—A motive fluid, such as steam, is supplied by the pipes, U, and I, and through the governor valve, to the hollow part, *c*, of the engine shaft. Assuming that the piston shoe, L′, has passed the point of tangency, so that the forward end of said piston shoe, L′, is about 45 degrees to the left of or in advance of said point of tangency, the port, m, of the high pressure piston member, H, registers with the port, l, of the tubular cut-off, K, and the motive fluid is supplied to the piston chamber back of the shoe, L′, and fills the space in said chamber between the piston member, H, the cylinder wall, the shoe, L′, and the point of tangency, whereby the pressure of the fluid drives the piston toward the left in Figs. 2 and 3. After the piston and the shoe have moved through an arc of about 135 degrees from the point of inlet of the fluid, so that the shoe is on a diameter passing through the point of tangency, communication of the port, m, with the port, l, of the cut-off is interrupted or broken, and the fluid acts expansively until the forward ends of the shoes, L, L′, are in a horizontal plane, or at 90 degrees with a line through the point of tangency. At this time, the crescent shaped discharge end of the exhaust port, p', registers with the port E^3, in the division wall, E, and the crescent shaped intake end of the inlet port, q, in the low pressure piston member, H′, is also in register with the same port, E^3, whereby the fluid passes from the high pressure piston chamber, E′, to the low pressure piston chamber, E^2, for the purpose of utilizing the fluid exhausted from the chamber, E′, in the chamber, E^2, so as to act on the piston shoe, M′, and assist in driving the piston. The cycle of operations described in connection with the shoes, L′, M′, and port, p', q, during a revolution is duplicated in connection with the shoes, L, M, and ports, p, q', but at 180 degrees behind the first mentioned cycle of operation, thereby obviating a dead point and securing an even turning effect, it being noted that the fluid acts both by pressure and expansion in the respective chambers of the cylinder. The fluid is exhausted from the low pressure chamber, E^2, by the alternate registration of the exhaust ports, t, t', with the chamber, O, from whence the fluid is discharged through the passages, o^2, into the casing, A, and thence through the outlet, O^2.

The peculiar shape of the ports, p, p', and q, q', in the members, H, H′, of the piston, and of the shape and eccentric relation to the aforesaid ports of the port, E^3, in the division wall, E, between the chambers of the cylinder, is an advantage for the reason that the fluid is controlled in such a way as to properly cut off and supply the fluid from one chamber to the other. The intake ends of the ports, q, q', in the piston member, H′, are so related to the eccentric port, E^3, that the rear end of the front port is out of register with the eccentric port, E^3, when the forward end of the rear port is beginning to register with said eccentric port, E^3. The exhaust ports, p, p', may both be in register with the port, E^3, at the same time, the ports, t, t', may also be both in register with the port, O, at the same time. This condition is shown in Fig. 3 for ports, t, t'. As already described, when the forward ends of either pair of shoes reach a plane at 90 degrees with the point of tangency, the exhaust port for the forward shoe registers with its outlet port. As shown in Fig. 3, the forward ends of the shoes have passed said plane and the exhaust port, t', for the shoe M′, has registered with the port, O, but the port, t, is still in register with the port, O, in order to exhaust the motive fluid between the shoe, M′, and the point of tangency.

In starting the engine, should the ports, m, m', be out of register with the port, l, in the cut-off, K′, the fluid is admitted by the forwardly and backwardly extending ports, l', l^2, in said cut-off to one or the other of the inlet ports, m, m'.

The governor is driven directly by the extension C′, of the engine shaft, and in the event of excessive speed, said governor shifts the valve, Q′, to throttle the inlet of the fluid to the engine.

Although I have shown and described the invention as embodied in a compound engine wherein two pistons and two chambers are used so as to utilize the steam twice, both by pressure and expansion, it will be understood that the principle of the invention may be extended by adding to the number of pistons, chambers and other co-related parts for using the steam expansively an increased number of times, or the engine may be constructed with but one cylinder and piston member.

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

1. In an engine, a plurality of cylinders, a division wall between said cylinders and provided with a substantially crescent shaped port or opening, an eccentric piston member or abutment having exhaust ports adapted to register successively with the port of the division wall, and another eccentric piston member having intake ports adapted to register with said port of the division wall.

2. In an engine, a plurality of piston chambers, a division wall between said chambers, said division wall having a crescent shaped port, and a plurality of eccentric piston members each having approximately crescent shaped ports adapted to register with the port of said division wall.

3. In an engine, a cylinder, a division wall therein, having a substantially crescent shaped port, and a piston provided with substantially crescent shaped ports one end of said ports in the piston being composed of a plurality of intersecting arcs struck from different centers, two of said arcs forming one

wall of the port and the remaining arc the other wall thereof.

4. In an engine, a cylinder, a division wall therein, having a substantially crescent shaped port, and piston members, one having exhaust ports and the other provided with inlet ports, the ends of said ports next to the aforesaid division-wall port being substantially crescent shaped and the ports in the low pressure piston member being so related to one another that one piston port is moving out of register with the division-wall port when the other piston port is moving into register with said division-wall port, and the exhaust ports of the high pressure piston member are so related and constructed that each port will come in register with the division-wall port, when the forward ends of the high pressure piston shoes are in a plane substantially at 90 degrees with a plane through the point of tangency, and will continue in register with said division-wall port during about three quarters of a revolution.

5. In an engine, a cylinder, a division-wall therein, having an eccentric substantially crescent-shaped port, a piston member having radial inlet ports and irregular exhaust ports, the latter having crescent-shaped delivery ends adapted to register with the aforesaid eccentric division wall port, shoes movable with the piston member, another piston member provided with inlet ports, which ports at their intake ends are substantially crescent-shaped and are adapted to register with the aforesaid eccentric division wall port, exhaust ports in the last mentioned piston member, an exhaust chamber and ports in the cylinder, and piston shoes seated in the second named piston member over the inlet ports thereof.

6. In an engine, a stationary casing, a piston shaft journaled therein, a rotatable cylinder within said casing, bearings engaging the ends of said cylinder for supporting it at the axis of rotation within the casing, and adjusting means coöperating with said bearings for bodily adjusting said cylinder with respect to the piston member, whereby the cylinder is brought into a proper degree of contact with the piston member at the point of tangency.

7. In an engine, a stationary casing, a piston shaft journaled therein, a rotatable cylinder within the casing, slides on which said cylinder is supported, and means for adjusting said slides, whereby the cylinder may be adjusted relatively to the piston member.

8. In an engine, a stationary casing, a piston shaft journaled therein, a rotatable cylinder within the casing, slides on which said cylinder is supported, and double screws for adjusting said slides.

9. In an engine, a stationary casing, a piston shaft eccentric with the casing, slides mounted on the casing, a cylinder rotatably mounted on the slides and arranged eccentric to the shaft, said cylinder having openings for the passage of the shaft, and double screws whereby the eccentric cylinder may be adjusted to proper contact with the piston member.

10. In an engine, a casing having ball bearings, a shaft eccentric to the casing and supported by said bearings, slides mounted on the casing and provided with ball bearings, means for adjusting the slides, means for fastening the slides in fixed relation to the casings and a rotatable cylinder mounted by the second named bearings on the aforesaid slides so as to turn freely thereon and to be adjusted therewith.

11. In an engine, a cylinder, a solid piston shaft hollow for a part of its length, a piston having inlet ports, a non-revoluble cut-off situated in the hollow part of said shaft and having a port adapted to register with the inlet ports of said piston, a steam inlet pipe entering said hollow part of the shaft, and rigid anchoring means on the inlet pipe engaging loosely with said cut-off.

12. In an engine, a cylinder, a hollow piston shaft, a piston having inlet ports, a non-revoluble cut-off situated in said shaft and having a port adapted to register with the inlet ports of said piston, a supply pipe the inner end of which enters the piston shaft, and rigid members extending from the supply pipe and loosely connected with said cut-off for holding the same in position within the hollow shaft.

13. In an engine, a cylinder, a hollow piston shaft, a piston having inlet ports, a non-revoluble cut-off situated in said shaft and having a port adapted to register with the inlet ports of said piston, said cut-off being provided, also, with auxiliary ports which communicate normally with the aforesaid port, of the said cut-off, and means for retaining the cut-off in position.

14. In an engine, a hollow piston-shaft, and a composite cut-off in said shaft, said cut-off comprising a hollow core and a jacket composed of anti-friction metal incasing said core, the core and the jacket being provided with ports for the inlet and egress of a motive fluid.

15. In an engine, a hollow rotatable piston shaft, a composite tubular cut-off in said shaft, said cut-off comprising a metallic tube and an incasing material of anti-friction metal for said tube, and anchoring means for said cut-off.

16. In an engine, a hollow rotatable piston shaft, a tubular cut-off therein, an inlet pipe, and rigid anchoring means fast with said pipe and having a loose connection with said cut-off.

17. In an engine, a hollow rotatable piston

shaft, a tubular cut-off therein, a supply pipe, and members fast with the pipe and loosely attached to the cut-off.

18. In an engine, a hollow rotatable piston shaft, a tubular cut-off therein, a supply pipe, and fingers extending from said pipe and connected loosely to said cut-off for retaining the latter in position.

19. In an engine, a hollow rotatable piston shaft, a tubular cut-off therein, a non-revoluble supply pipe connected to said cut-off, means for holding said pipe from rotation within said piston shaft, and a packing between the pipe and the piston shaft.

20. In an engine, a rotatable hollow piston shaft, a bracket, a supply pipe extending into the shaft and held by the bracket against rotation with the shaft, a tubular cut-off seated in the shaft and attached to the supply pipe, a valve supported by the bracket in coöperative relation to the supply pipe, and a governor geared to the piston shaft and coöperating with the valve.

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

ALFRED I. OSTRANDER.

Witnesses:

H. I. BERNHARD,

MARGARET C. POWELL.