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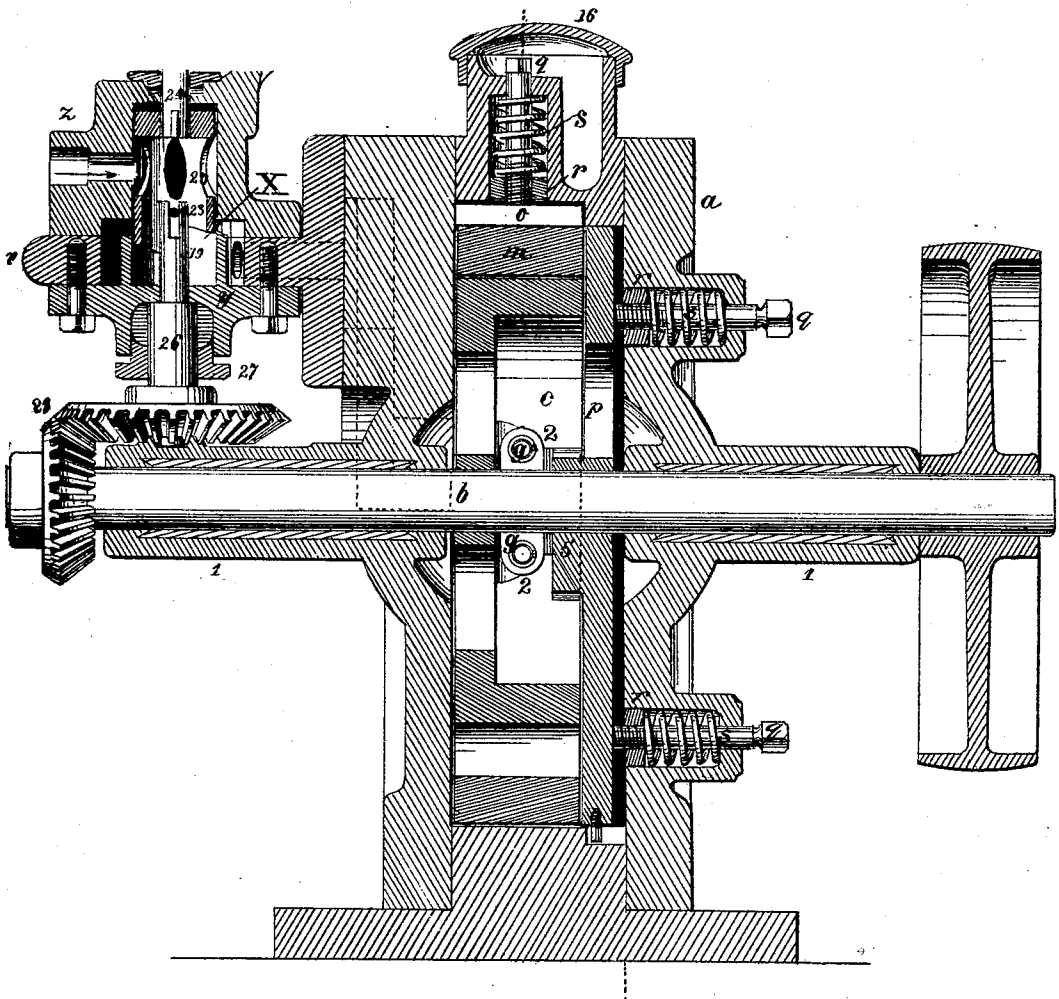
Rotary Engines.

No. 145,505. Patented Dec. 16, 1873.

FIG. 1.



WITNESSES:

Jas. L. Ewin

Walter Allen

INVENTOR:

Charles C. Klein

By Knight Bros Attorneys.

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FIG. 7.

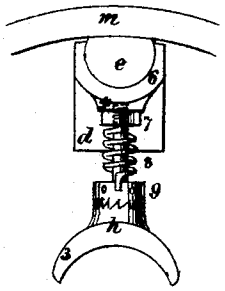

FIG. 9.

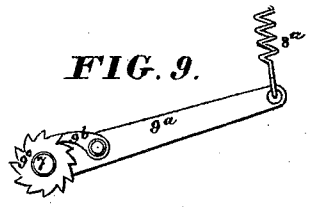

FIG. 8.

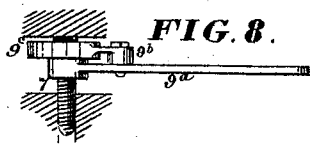

FIG. 2.

WITNESSES:

Jas. L. Ewin

Walter Allen

INVENTOR:

Charles C. Klein

By Knight Bros Attorneys.

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C. C. KLEIN.

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FIG. 6.

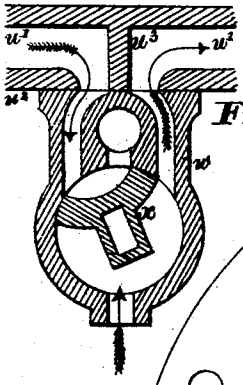

FIG. 4.

FIG. 5.

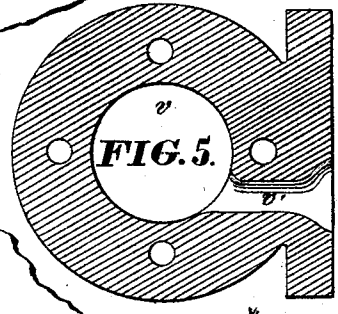

FIG. 3.

WITNESSES:

Jas. L. Ewin

Walter Allen

INVENTOR:

Charles C. Klein

By Knight Bros. Attorneys.

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C. C. KLEIN.

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FIG. 10.

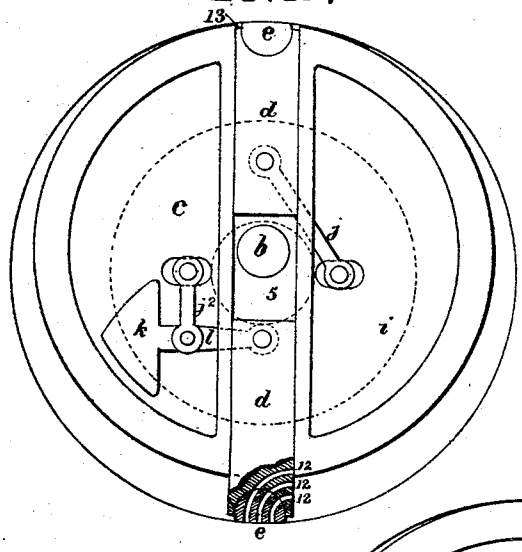


FIG. 11.

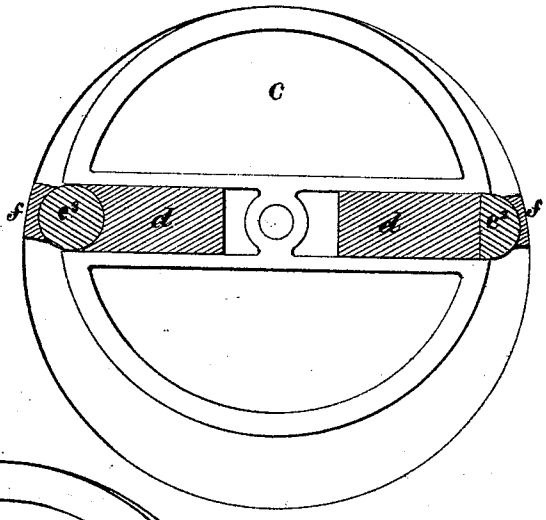


FIG. 12.

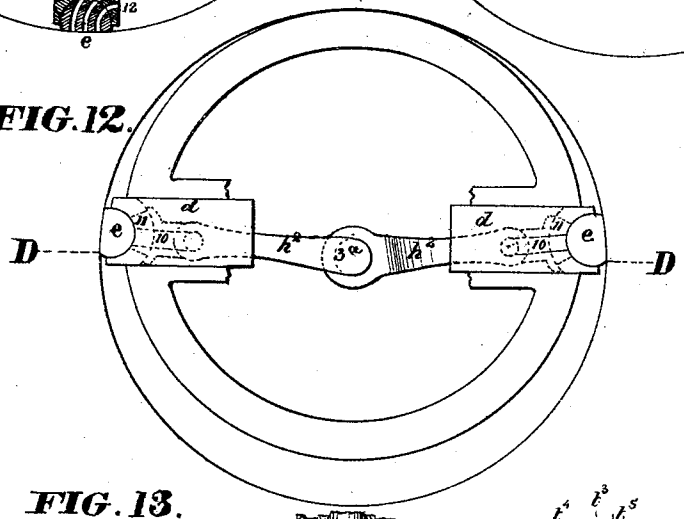
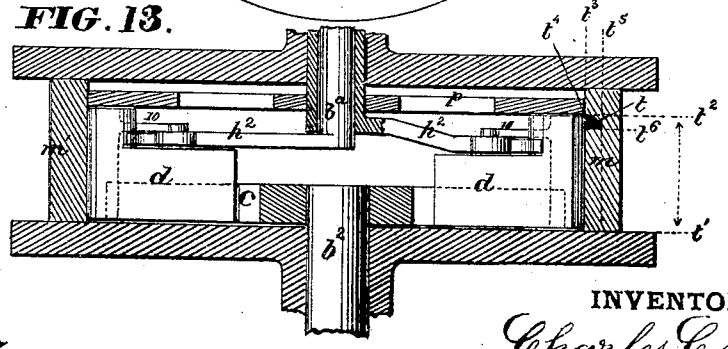


FIG. 13.



WITNESSES:

Jas. L. Ewin

Walter Allen

INVENTOR:

Charles C. Klein

By Knight Bros Attorneys.

UNITED STATES PATENT OFFICE.

CHARLES C. KLEIN, OF PHILADELPHIA, PENNSYLVANIA.

IMPROVEMENT IN ROTARY ENGINES.

Specification forming part of Letters Patent No. **145,505**, dated December 16, 1873; application filed October 30, 1873.

To all whom it may concern:

Be it known that I, CHARLES C. KLEIN, of the city and county of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Rotary Engines, of which the following is a specification:

The invention herein described relates to improvements in that class of motors and pumps known as "Beale's rotary engines," in which a rotary wheel is placed eccentrically within a cylinder of larger diameter, so that an abutment is formed where the periphery of the wheel touches, pistons being provided in the wheel, which enter the same when they approach the abutment, and slide outward when they have passed, maintaining constant contact with the inner surface of the cylinder.

The improvements consist, first, in cylindrical or parti-cylindrical pistons, (two or more,) in combination with slides having shoulders concentric therewith, and links interposed between these shoulders, and a bearing concentric with the cylinder, for supporting the same; secondly, in springs interposed in a peculiar manner between the piston-slides to project the same; thirdly, in means by which the piston-links are rendered self-adjusting, to take up wear, and at the same time are adapted to afford a positive support; fourthly, in an arrangement of steam-passages for balancing the pistons and piston-slides; fifthly, in an inner cylinder, attached to and revolving with the piston-wheel, so that the motion of those parts of the engine as are lubricated solely or chiefly by steam is reduced to a minimum, the chief movement being thrown upon parts which can be perfectly lubricated; sixthly, in certain means by which the revolving cylinder is rendered self-lubricating; seventhly, in supporting-springs, in combination with adjusting-screws, traversing nuts, and bearing-plates, for taking up wear and preventing lost motion and leakage; eighthly, in the combination of a revolving cylinder and pistons and an eccentric wheel of the same width between parallel disks, so as to equalize the wear; ninthly, in cylinder-ports constructed so as to be opened gradually and to give a free exhaust at first; tenthly, in a reversible steam-chest and a pair of exhaust-nozzles, with a plug for the one out of use, and a peculiar arrangement of steam-nozzle and cylinder-passages, to operate in combination with the aforesaid devices, or with a substitute valve-case, so that the parts of all engines of a given size shall be alike, whether the engine is intended to run right-handed or left-handed, or to be reversible at will by means of a reversing-valve.

Figure 1 is a vertical longitudinal section of a rotary steam-engine, illustrating this invention. Fig. 2 is a front view of the same, with front plate removed and other portions in section, on the line A, to expose internal parts. Fig. 3 is a horizontal section, on the lines B, of the main cylinder or case and its inclosed parts. Fig. 4 is a rear view, partly in vertical section on the line C, Fig. 3. Fig. 5 is a horizontal section of the reversible steam-chest. Fig. 6 is a horizontal section, representing a reversing-valve, with its case or chest applied to the back plate of the engine, as a substitute for the steam-chest shown in Fig. 5. Fig. 7 is a fragmentary front elevation on a larger scale, showing one of the piston-links and a portion of the revolving cylinder represented in Figs. 1, 2, and 3. Fig. 8 is a side view, and Fig. 9 a plan of a modification of the adjusting device shown in Fig. 7. Fig. 10 illustrates a front view of the interior of the cylinder, the wheel being provided with different means for balancing the pistons. Fig. 11 illustrates a front view of the interior of the cylinder, the wheel being provided with pistons of modified construction. Fig. 12 is a like illustration of a modification of the piston-links. Fig. 13 represents a horizontal section on the line D, Fig. 12.

Like letters of reference indicate corresponding parts in the several figures.

The outer cylinder or case *a* and the eccentric driving-shaft *b* and piston-wheel *c* of this engine are substantially similar in form and arrangement to others of that class of engines and pumps known as "Beale's rotary engines," and hereinbefore referred to. Extended bearings 1 are provided for the driving-shaft, and, preferably, lined with anti-friction metal, as illustrated in Figs. 1 and 3. The piston-wheel *c*, being constructed with suitable guideways, is furnished with radial piston-slides *d*, at the

outer ends of which pistons *c*, of peculiar construction, are applied. These may be described as small cylinders, with axes parallel to those of the piston-wheel and cylinder, and equal in length to the width of the wheel. The outer side of each piston may be flattened to an arc of the radius of the cylinder, so as to form a wide bearing-surface; or, as the equivalent of this construction, each piston may be provided with a cap, *f*, fitting the periphery of the piston on one side, and the cylinder on the other, as illustrated in Fig. 11.

The cylindrical form of piston has been adopted, in combination with the "flat-arc" bearings, in order that the latter may, at all times, accommodate themselves to, and rest fairly against, the inner surface of the cylinder. With cap-plates applied as above suggested, this object may be accomplished, if each piston is semi-cylindrical, as illustrated at c^2 in Fig. 11.

The employment of a perfectly-cylindrical piston is illustrated at c^3, Fig. 11.

The pistons may be either solid or hollow, as illustrated in Fig. 2, and of any suitable material.

The pistons and piston-slides may all be made hollow, and perforated for distributing the lubricant from the interior of the cylinder; but the holes for this purpose should not be placed so as to form passages for the steam when the pistons pass the ports.

The outer ends of the piston-slides are, preferably, equal in width to the rim of the piston-wheel, and rectangular in cross-section where they work through this rim. Their stems may be of different shapes, and guided in any approved manner, as illustrated in Fig. 2 and Figs. 10 to 13, inclusive. These piston-slides are, preferably, projected by helical or other suitable springs *g*, applied to arms 2 projecting from the inner ends of the piston-slides, so as to exert their force on the pistons centrally.

The piston-slides may be considered as having a twofold longitudinal motion, one in relation to the piston-wheel, and one in relation to each other. The first motion is equal in amount to the difference between the external diameter of the piston-wheel and the inside diameter of the cylinder, and the second motion is equal in extent to the difference between the internal diameter of the cylinder and a chord drawn horizontally across the cylinder in the plane of the vertically-eccentric driving-shaft. Were it not for this second motion the piston-slides might be connected rigidly to each other. In view of the same, the springs *g*, or their equivalents, are necessarily employed. If these springs abutted at one end against a fixed support on the piston-wheel, the springs would alternately expand and be compressed to the full amount of the difference between the diameters of the piston-wheel and cylinder; but, as they are applied between the arms of the piston-slides and connected with nothing else, it follows that they move with the piston-slides as far as their first motion is concerned, and are compressed only to the comparatively small extent of the second motion of the piston-slides, and are subjected only to a small strain; and, as their position relatively to the pistons never changes, the springs exert no deleterious influence by friction or otherwise.

In the larger class of engines and pumps it becomes necessary to keep the pistons in contact with the cylinder-surface by means more positive than springs. For this purpose piston-links *h* are employed, having arc-shaped bearings 3 4 at their respective ends to engage with a circular central support, 5, concentric with the cylinder and with shoulders 6 on the piston-slide *d*, concentric with the pistons *e;* or piston-links h^2, Figs. 12 and 13, may be employed, having concentric pivots 3^a at the axis of the cylinder, and attached to the pistons *e*, or to the piston-slides *d*, concentrically with the piston or both, as illustrated. This constitutes a very simple and frictionless device, and is superior for small engines and pumps, where it may be employed without springs. It will be observed that the links in this form serve to draw in the piston-slides as well as to project them; but the driving-shaft b^2 is necessarily terminated within the case in engines fitted with this device last described, and may not extend through, as illustrated in Fig. 13.

In the several illustrations the piston-links are represented as applied to but one end of each piston. In the general form illustrated in Fig. 2, they may readily be applied at both ends of each piston. The principles which govern the construction of the piston-links in their various forms are as follows, namely: First, the inner pivot or arc of each link must be concentric with the cylinder; second, if the link is attached directly to the piston, such attachment may be made permanently or rigidly and at any point within or without the periphery of the piston, or the attachment may be made in such a manner that the piston can slide upon the link in a radial line drawn from the center of the cylinder; third, if the slide *d* is interposed between the link and piston—that is, if the link acts upon the piston through the slide *d*—then the surface on the slide *d* against which the link presses must be concentric with the piston.

To provide for taking up wear as it occurs, one end or bearing, 4, of each piston-link is preferably made adjustable in the direction of the length of the link, and one or more traversing screw-nuts or screws, 7, are provided for making the adjustments, and springs, 8, for preserving the same, or for taking up wear between the adjustments. These springs are preferably applied to the adjusting screw or nut 7, so as to act on the same to tighten it, and so as to preserve an unyielding support, as illustrated in Figs. 2 and 3, but more clearly in Fig. 7. One end of the spring 8 is attached to the adjusting screw or nut 7, and its other end is attached to the moving member of a ratchet winding device, 9, composed in this instance of a pair of crown-ratchets. The

spring operates by its resiliency to turn the screw or nut whenever wear permits the adjustment, but at all times the screw or nut furnishes an unyielding support.

This method of taking up wear is applicable to reciprocating engines and to other machinery.

A modification of the device, as illustrated in Figs. 2, 3, and 12, is shown in Figs. 8 and 9. The spring 8^a is applied to the end of a lever, 9^a, carrying a pawl, 9^b. A screw is employed in this instance, a ratchet, 9^c, constituting its head. With this the pawl 9^b meshes. The screw may be single or right-and-left. This device is set by forcing the lever 9^a backward, the pawl 9^b slipping over the backs of the ratchet-teeth, and the spring 8^a acts, through the lever 9^a, pawl 9^b, and ratchet 9^c, to turn the adjusting-screw in the proper direction to expand the piston-link.

In Fig. 2 a form of piston-link *h* is illustrated, in which a pair of screws, 7, are applied to a slide, 4^a, to which the spring 4, constituting also the outer bearing of the link, is applied. The relative position might obviously be reversed, if preferred, the slide in this case constituting the bearing. It is also proposed to apply the adjusting device to the inner bearings 3. Convenient orifices in the heads of the case *a* give access to these adjusting devices. The outer ends of the piston-links *h* may be provided with stems 10, attached to the piston through orifices 11 in the ends of the piston-slides, as illustrated in Fig. 2, and in Figs. 12 and 13; or the pistons and links may be cast together or otherwise inseparably united. As supported by links alone, any preferred number of pistons may be employed in each engine or pump, and, as supported wholly or in part by interposed springs, as above described, the employment of an additional pair of pistons, with their appurtenances, is proposed. Means for balancing the weight of the pistons and piston-slides, so as to facilitate their retraction, are essential to the most perfect working of the engine. A preferred provision for this purpose and two substitute devices are illustrated in Fig. 10. The preferred balancing provision operates to balance the weight of the pistons and piston-slides in their different angular positions, and consists of a series of holes, 12, in the piston-slide and piston, extending from the steam side or sides thereof to the bearing-surface of the piston. The mouths of these holes are arranged at different distances from the end of the piston-slide, so as to be exposed successively. Each hole, as it receives the steam, increases the balancing effect, until, when the lower vertical position of the piston has been attained, the steam acts upon a sufficient area to balance the whole weight of the piston. The first substitute balancing device above referred to consists of a ring, *i*, Fig. 10, (shown in dotted lines,) mounted within the piston-wheel, so as to revolve concentrically with the cylinder, as on the hub 5, Fig. 2, and connected to the piston-slides through slots in the wheel by links *j*. The pistons and piston-slides may thus be made to balance each other, acting on each other through the links *j* and ring *i*. The second modification consists in the application of counter-weights *k*, Fig. 10, to each of the piston-slides through the medium of levers *l*, these levers having shifting-fulcrums formed by links j^2, attaching them to the ring *i*. In lieu of either of the balancing provisions above described, in order to avoid complication and weight as much as possible, the outer ends of the piston-slides *d*, with the pistons *e*, may be made sufficiently wider than the bearing-surfaces of the pistons that the steam pressure on the exposed balancing-surface 13, Fig. 10, shall counterbalance the weight of the piston and piston-slide. In order, primarily, to reduce the friction and wear of those parts of the engine which have direct steam contact, and consequently imperfect lubrication, and to throw the chief movement upon parts which can be perfectly lubricated, a ring or cylinder, *m*, is introduced within the case *a*, and attached to one of the pistons *e* by screw 14, Fig. 2, or otherwise so as to revolve therewith.

To investigate the principle on which this construction is based, the revolving cylinder *m* may be considered as having two motions—one in relation to the case *a*, in which it revolves, and one in relation to the piston-wheel *c*. The latter and the inner cylinder *m* complete a revolution in the same time; but at the abutment-point *n*, Fig. 2, the revolving cylinder *m* slides on the surface of the piston-wheel *c* to an extent in each revolution equal to the difference between the circumferences of the piston-wheel and cylinder. The loose piston *e*, or each loose piston, slides upon the surface of the cylinder *m* to a like extent. These motions are reciprocating, and the sum of the relative movements of the steam-covered surfaces is very small, compared to that between a rotary piston-wheel with two or more pistons and the surface of a stationary cylinder, as will be apparent. For small engines the revolving cylinder *m* and one of the pistons *e* may be cast together of babbitt-metal, or other anti-friction metal which will stand steam heat. Adequate means are, however, provided for lubricating the outer surfaces of the revolving cylinder *m*—namely, grooves 15, Fig. 2, extending across the periphery of the cylinder and inward on its edges, but not into the interior of the cylinder, in combination with oil or tallow cups 16 17 on the top and sides of the case *a*, communicating with its interior by channels 18. It will be observed that the grooves in the revolving cylinder will be kept full by the reservoirs, and will carry and conduct the lubricant around and inward, so as to perfectly distribute the same. The journals 1, in which the driving-shaft *b* rotates, may be rendered self-oiling by any approved method. It is proposed to lubricate the interior of the engine by means of a compound of tallow, soap, sulphur, and

graphite, in such proportions as to melt at 212° Fahrenheit, or less; or a metallic alloy of bismuth, lead, and tin, to melt at this heat, (as per Newton's fusible metals,) may be employed.

In order to take up the wear between the periphery of the revolving cylinder *m* and the case *a*, and between the ends of the revolving cylinder *m*, piston-wheel *c*, piston-slides *d*, and pistons *e*, and the case *a*, adjustable packing-plates *o p* are provided within the latter, as illustrated in Fig. 1. In the illustration but one end plate, *p*, is employed, but it is obvious that this may be duplicated. In order to adjust these plates so as to preclude jamming, and to regulate their pressure against the revolving cylinder *m* and other parts, and to extend the adjustments, packing-screws *q* are employed, which are furnished with nuts *r* and abutment-springs *s*, contained in suitable recesses in the top and end or ends of the case. These recesses and the nuts *r* fitting the same are non-circular to prevent the latter from turning. By turning the screws *q*, the nuts *r* are adjusted, and, as these abut against the springs *s*, the latter determine and equalize the pressure, and perpetuate or prolong the effect of the adjustments, as stated. The device illustrated in Figs. 7 to 9 may be employed to adjust the packing-plates in lieu of the device just described. Packing o^2 may also be applied to the sides of the piston-slides *d*, as illustrated in Fig. 2, where a pair of packing-plates with springs compressed behind the same are shown in dotted lines. The springs are designed to operate only in the event of wear, the packing-plates resting solidly on the bottoms of their recesses. An effect of the revolving cylinder *m*, additional to that above set forth, is to distribute the wear in a superior manner, so as to preclude a certain deleterious result of wear in other engines. If the length of the revolving cylinder *m*, piston-wheel *c*, and piston *e*, and the width of the piston-slides *d*, should be reduced by wear, the packing plate or plates *p* can be set up by means of the screws *q*, to form a steam-tight joint. If, now, the cylinder *m* were stationary, the pistons would by wear enlarge its diameter, and, although the springs *g*, or adjustable piston-links *h*, would still keep them tight against the cylinder-surface, and the end packing plate or plates *p* would compensate for wear in the other direction, there still would be formed by wear a space, *t*, Fig. 13, which in a pump would not occasion much trouble, but in an engine would cause a great wase of steam. To see how this space *t* is formed, let t^1 t^2, Fig. 13, represent the original width of piston; t^3, the original inner surface of the cylinder; t^4, the back of the case, and *p* the packing-plate. Before wear occurs, the packing-plate *p* forms a steam-tight joint with the pistons at the corner t^4. If we now suppose the cylinder *m* enlarged by wear to the line t^5, and the width of the piston reduced by wear to the line t^6, it will be seen that the space *t* is formed by such wear; and this is precluded by the employment of a revolving cylinder, the ends of which wear equally with those of the piston-wheel and pistons, as aforesaid. In pumps where a little leakage is not of consequence, a pair of end plates, *p*, may be attached to the ends of the cylinder *m*, and revolve therewith. In order to graduate the admission of steam, and at the same time provide for a perfectly free exhaust from the first, the cylinder-ports *u*, Fig. 2, are made to approximate to the shape of the upper extremities of the steam-space, their upper ends nearest to the abutment-point *n* being very narrow, and their width increasing downward to their lower extremities. It will be seen that the narrow ends of the ports are the first uncovered to admit steam, while in exhausting a greater proportionate area of port is opened at first than if the ports were of the usual shape. When the pair of pistons *e* stand in their horizontal position, the steam-space between them has the greatest cubical capacity, and if the pistons are allowed to travel some distance beyond this horizontal position before the steam is allowed to escape from between them, it follows that this steam is compressed in proportion to the decreased capacity, and the piston-wheel is thus cushioned. To produce this effect, the cylinder-ports *u* should be so arranged that the piston which is about to act shall shut off the steam from the preceding piston before the exhaust is opened by the latter, as illustrated in Fig. 2. To adapt the improved engine to be most readily built or converted so as to run right-handed or left-handed, as required, the case *a* and a valve-chest, *v*, Figs. 1 and 5, for application thereto, are constructed so that the latter may be reversed; or a substitute chest, *w*, Fig. 6, containing a reversing-valve, *x*, may be applied instead thereof. To this end the cylinder-ports *u* are extended, by passages u^1, Figs. 3 and 4, to a central nozzle, u^2, through which the passages open on their respective sides of a vertical partition, u^3. The valve-chest *v* is constructed with a single steam-passage, *v'*, on one side of a central line through the same, and this communicates with one or the other of the passages u^1, according to what side of the chest is uppermost. With this preferred form of steam-chest, the exhaust-steam is not made to traverse the steam-passages u^1, but escapes freely through exhaust-nozzles u^4, one of which is formed opposite each cylinder-port *u*, that on the steam side being kept closed by a plug, u^5, which is removed and applied to the other orifice when the valve-chest is reversed. These exhaust-nozzles facilitate supporting and venting the cores for forming the cylinder-ports and passages, and other provisions for these purposes are not required. The reversing arrangement, as a whole, obviates any necessity for changing or multiplying patterns and simplifies the manufacture, while it does not in the least impair the working or appearance of the engine, as will be observed. When the chest *w*, Fig. 6, is applied, so as to employ the re-

versing-valve x, both of the exhaust-nozzles w^1 are necessarily closed by plugs w^5, and the exhaust steam passes through the cavity of the valve x, which may be of any approved form. The lower and upper sides of the steam-chest v receive, respectively, a bottom plate, y, and a recessed cap, z, Fig. 1. Within the case thus formed is located a combined throttle and cut-off valve, X, Figs. 1, 7, and 8, and an extension of the cap z, or an attachment thereto, constitutes the frame of a centrifugal governor, Z, Figs. 1 and 2.

The following is claimed as new:

1. The pistons e, constructed of cylindrical or parti-cylindrical form, and having flat-arc bearing-surfaces f formed thereon, in combination with piston-slides d, having shoulders concentric therewith, and piston-links h arranged between these shoulders and a pivotal support, 5, concentric with the cylinder, substantially as herein specified.

2. The combination of the opposite radial piston-slides d, having the arms 2 and the interposed expanding-springs g, as described.

3. In combination with the cylindrical or parti-cylindrical pistons, shouldered piston-slides, and central pivotal support, the piston-links h, attached to the pistons by stems 10, as herein set forth.

4. In combination with the cylindrical or parti-cylindrical pistons, shouldered piston-slides, and central pivotal support, the piston-links h, adjustable in length to take up wear, as described.

5. The combination, with the piston-links, of the automatic positive adjustment device, consisting of an adjusting screw or nut, 7, a spring, 8, attached thereto, to turn it forward, and a ratchet device, 9, for winding the spring, substantially as herein specified.

6. The steam-passages 12 in the pistons and piston-slides, for balancing the pistons and piston-slides, in the manner herein set forth.

7. The inner cylinder m, attached to one of the pistons and revolving therewith within the outer cylinder or case, substantially as herein described, for the purposes set forth.

8. The combination, with the inner revolving cylinder m, of the grooves 15, oil or tallow cups 16 17, and passages 18, arranged and operating substantially as specified.

9. The combination of the screws q, the springs s, and the non-circular traversing nuts r, working in corresponding recesses in the case, for adjusting and supporting the packing-plates o p, in the manner set forth.

10. The combination of the eccentric piston-wheel c, piston-slides d, pistons e, and a revolving cylinder, m, of one and the same length or width, and revolving between two parallel plain surfaces, as herein described.

11. In a rotary engine, the rearwardly-expanding cylinder-ports u, arranged and operating as herein set forth, for the purpose specified.

12. The reversible steam-chest v and the exhaust-nozzle plug or plugs w^5, in combination with the steam-nozzle w^2 and exhaust-nozzles w^4, formed and arranged substantially as shown and described, for the purposes set forth.

CHAS. C. KLEIN.

Witnesses:
CHAS. E. PANCOAST,
FRANK D. RAMSAY.