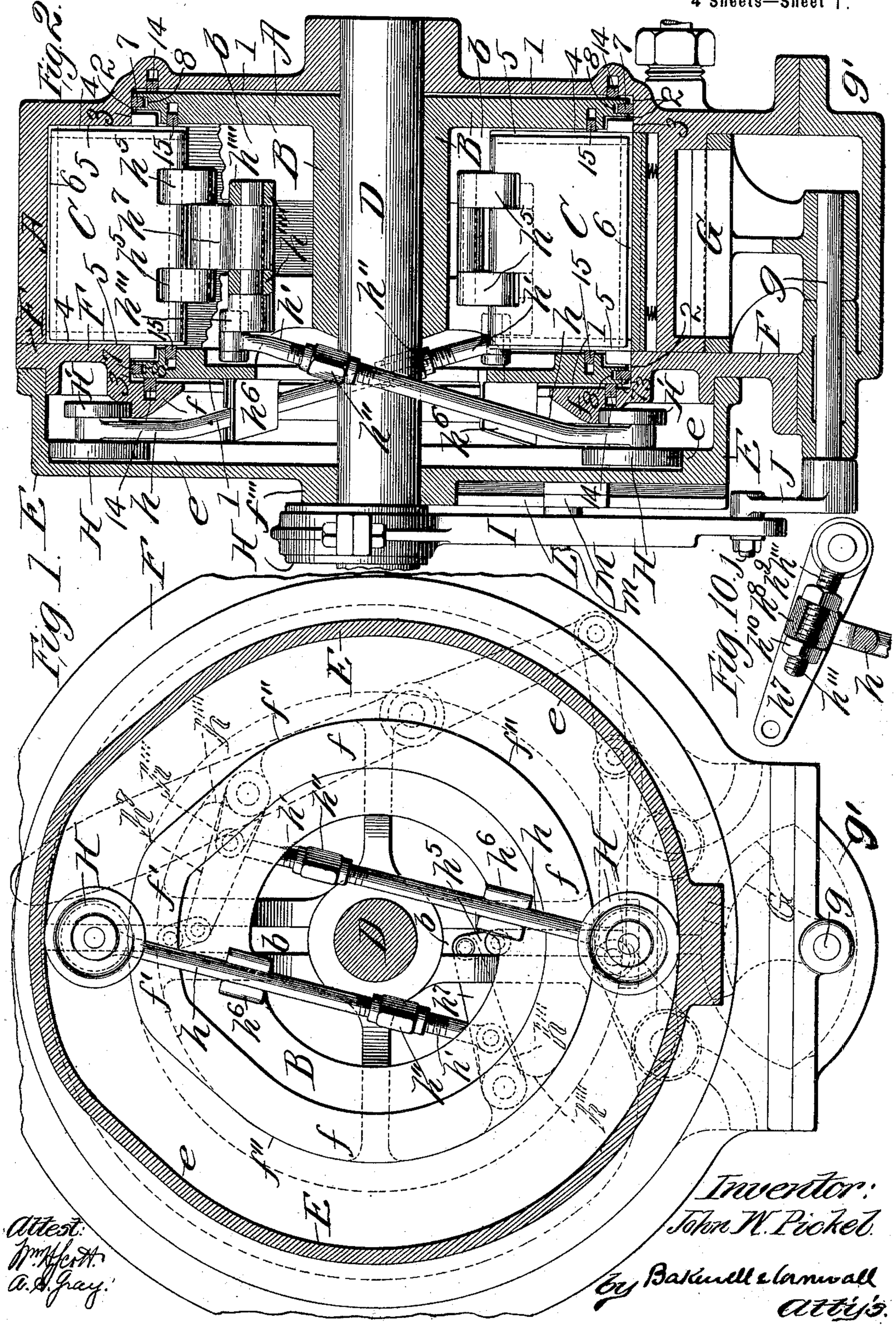
No. 654,412. Patented July 24, 1900.

J. W. PICKEL.

ROTARY ENGINE.

(Application filed July 24, 1899.)

(No Model.) 4 Sheets—Sheet 1.



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(No Model.) 4 Sheets—Sheet 2.

Fig. 4.

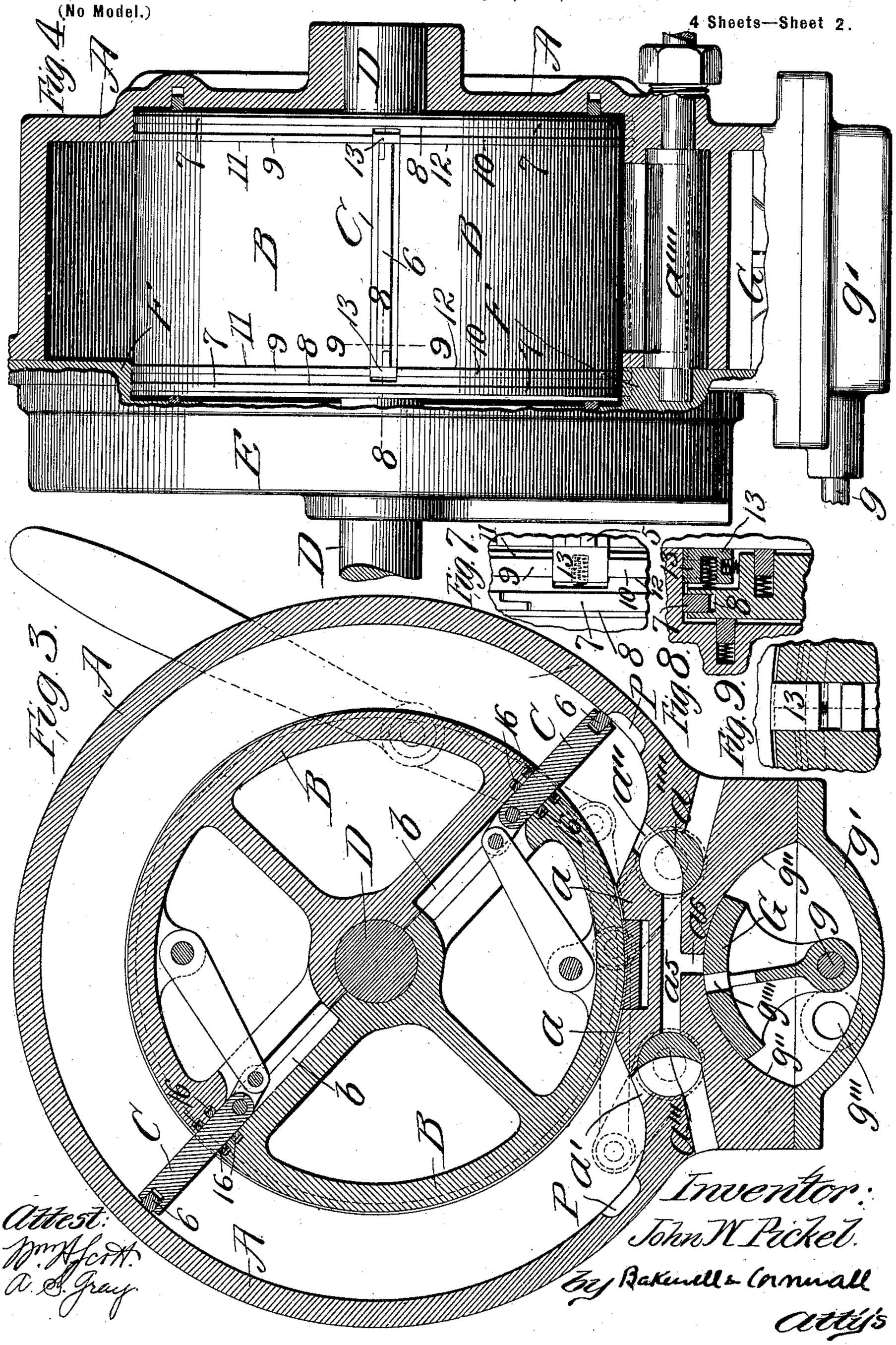

Fig. 7.

Fig. 8.

Fig. 9.

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Fig. 5.

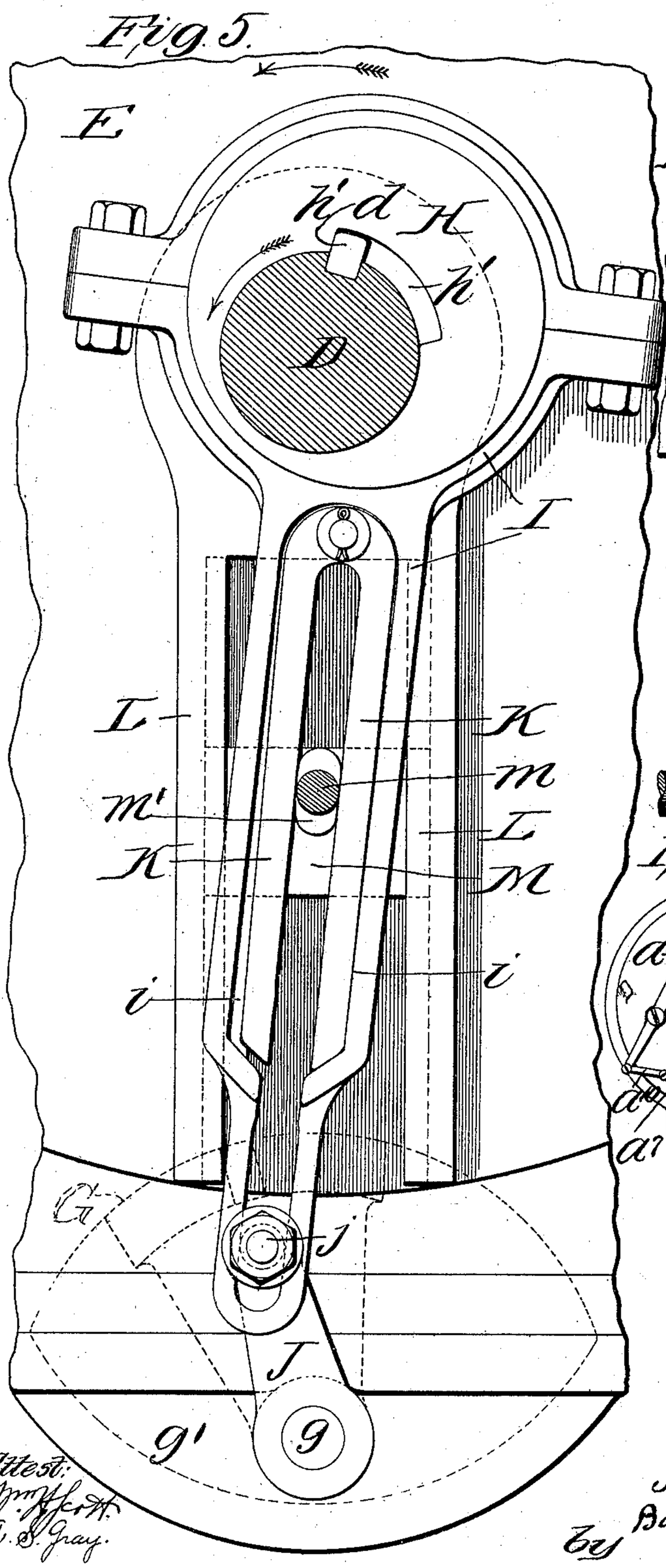

Fig. 6.

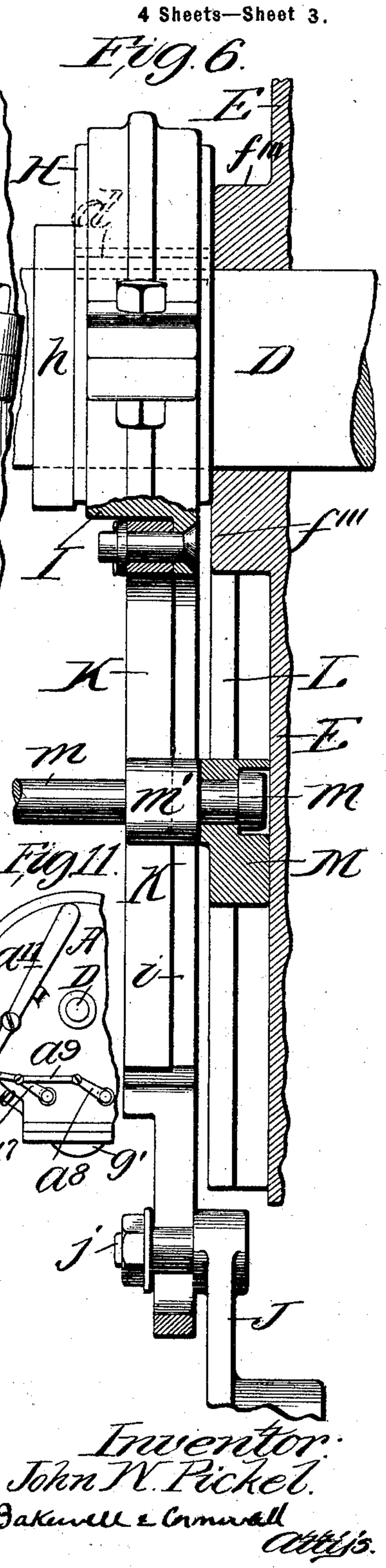

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Fig. 12.

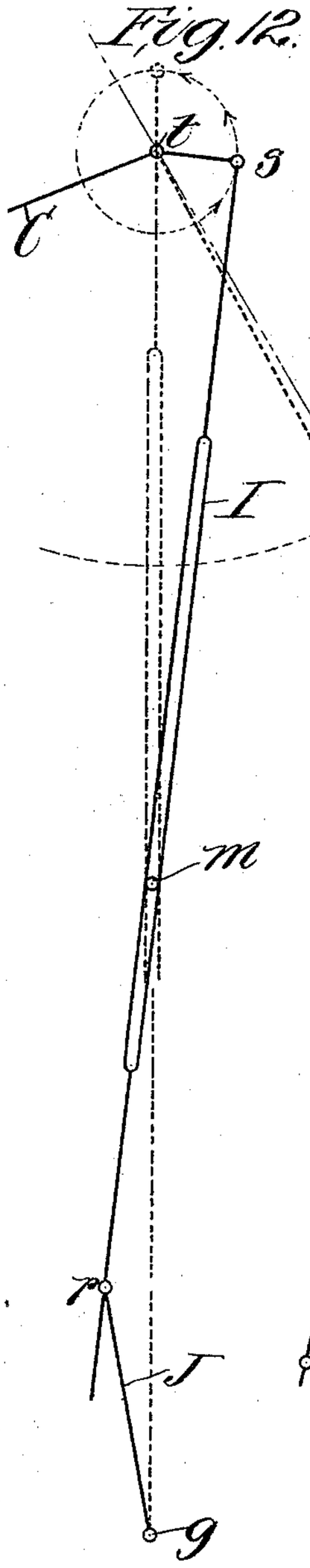


Fig. 13.

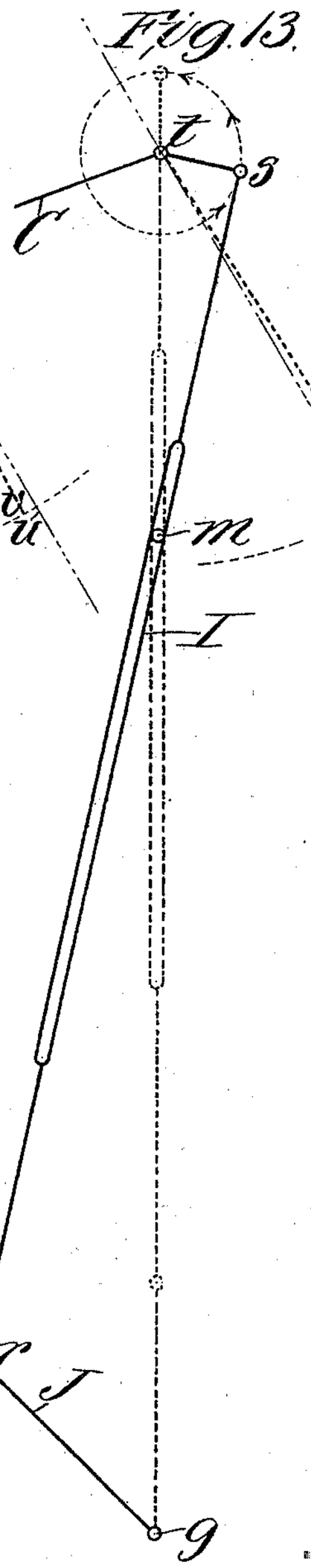


Fig. 14.

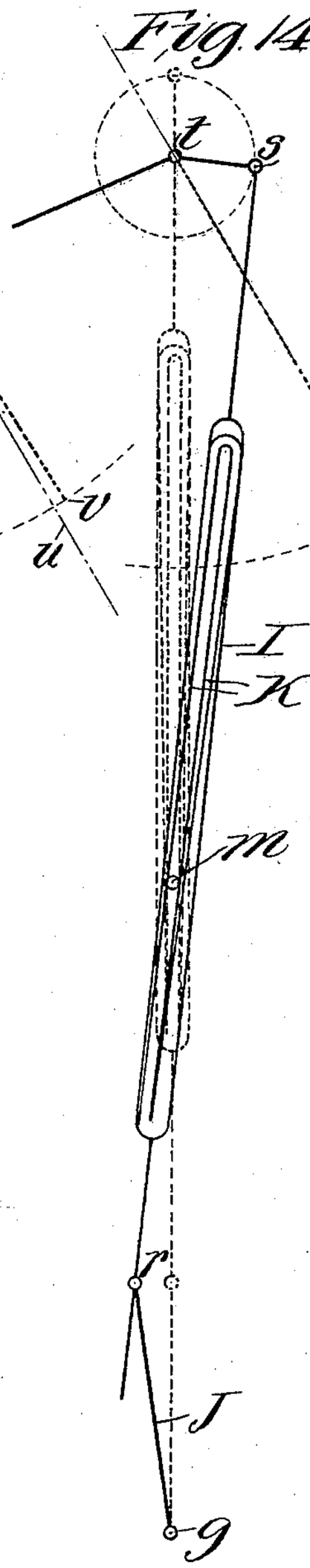
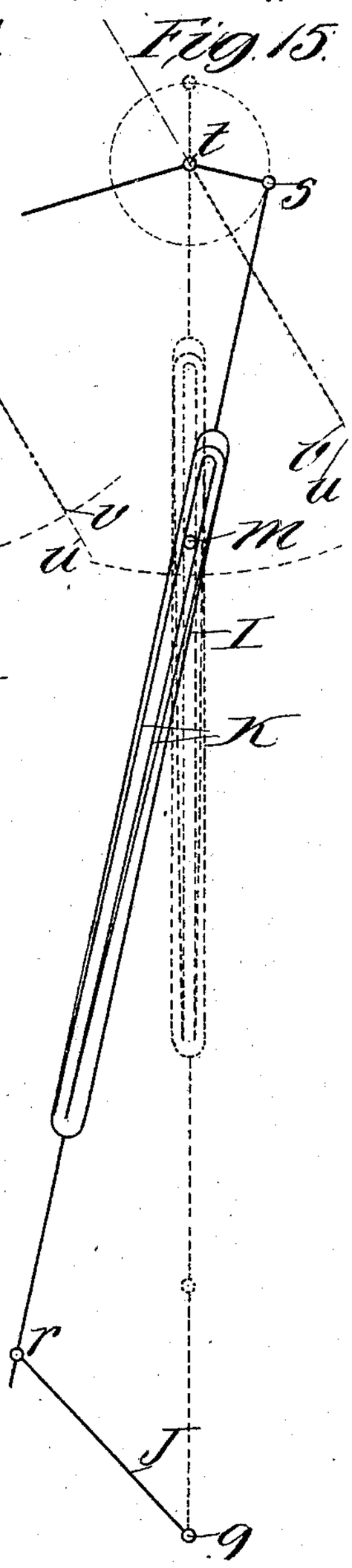


Fig. 15.



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UNITED STATES PATENT OFFICE.

JOHN W. PICKEL, OF CRYSTAL CITY, MISSOURI.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 654,412, dated July 24, 1900.

Application filed July 24, 1899. Serial No. 724,941. (No model.)

To all whom it may concern:

Be it known that I, JOHN W. PICKEL, a citizen of the United States, residing at Crystal City, Jefferson county, State of Missouri, have invented a certain new and useful Improvement in Rotary Engines, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a vertical transverse sectional view of my improved rotary engine, taken on the line 1 1 of Fig. 2. Fig. 2 is a vertical longitudinal sectional view of the same, taken on the line 2 2 of Fig. 1. Fig. 3 is a vertical transverse sectional view of the same, taken on the line 3 3 of Fig. 2. Fig. 4 is in part a side elevational view and in part a longitudinal sectional view of the same. Fig. 5 is an enlarged front elevational view of the cut-off mechanism employed in carrying out my invention. Fig. 6 is a side elevational view of the same, partly in section. Fig. 7 is an enlarged detail plan view of one portion of the piston and piston-head, illustrating the manner in which the "packing" is arranged. Fig. 8 is an enlarged vertical sectional view of the same, taken on the line 8 8 of Fig. 4. Fig. 9 is an enlarged sectional view of the same, taken on the line 9 9 of Fig. 4, the piston being omitted. Fig. 10 is an enlarged detail view of a portion of the mechanism employed in sliding the piston-head, wherein I have shown a slight modification which consists in providing a certain adjustment for the parts. Fig. 11 is a detail view showing the manner of operating the valves simultaneously; and Figs. 12 to 15 are diagrammatic views of the cut-off mechanism, showing the manner of compensating for the difference in the throw of the cam upon the movement of the fulcrum of the eccentric-rod.

This invention relates to a new and useful improvement in rotary engines, and has for its object to provide a construction which will be simple, durable, and efficient, and one which will create the least possible friction between its moving parts, and at the same time insure against leakage of and be economical with the motive fluid.

The essential features of this invention reside, first, in the novel construction capable of being packed in a simple and effective manner; second, in the novel means employed for controlling the movement of the piston-heads; third, in the novel construction which renders the machine flexible; fourth, in the novel automatic variable cut-off; fifth, in the novel construction of the reversing valves; sixth, in the novel construction employed whereby the same ports and valves are utilized when the engine is running in either of two directions, and, finally, the invention consists in the novel construction, arrangement, and combination of the several parts, all as will hereinafter be described and afterward pointed out in the claims.

In the drawings, A represents the cylinder or casing, B the piston, C the piston-heads, and D the main shaft, of my improved rotary engine. The shaft D is journaled in the cylinder or casing and in a cap-piece E, which cap-piece is bolted or otherwise secured to a cylinder-head F, which in turn is bolted or otherwise secured to the cylinder A. The piston B is fixed to said main shaft, and the piston-heads C, of which there are preferably two, are designed to move radially in suitable grooves *b*, formed in said piston, said piston-heads being also located at diametrically-opposite points on said piston.

The internal diameter of the cylinder is somewhat greater than the diameter of the piston, and as said piston and cylinder are concentric, with the exception of the abutment portion *a*, a space is left therebetween, which space is traversed by the piston-heads, said space being designed to receive pressure fluid, as is well understood.

The engine illustrated in the drawings is a reversible one and is constructed with two ports a' and a'', arranged one on each side of the abutment *a*, said ports being controlled by suitable rotary valves a''' and a'''', respectively, said valves a''' and a'''' being so connected that they move simultaneously by suitable manually-operated cranks, links, and operating-lever, (illustrated in dotted lines in Figs. 1 and 3 and in full lines in Fig. 11,) whereby when one valve is admitting pressure fluid to the engine the other valve will be exhausting the same. This feature

will, however, be hereinafter more fully explained.

a^5 represents a port designed to register with both of the valves a''' and a'''', or, more correctly speaking, registers with the passage of one valve when in one running position; being out of registration with the other valve when in the same position, and vice versa when the engine is reversed.

G represents a cut-off valve which is practically in the form of a quadrant and is caused to rock in one direction or the other through the instrumentality of a rock-shaft g, to which it is secured, said rock-shaft g being suitably journaled in a cap-piece g', which in turn is secured to the casing A. The valve G, as before stated, is in the form of a quadrant and is so proportioned that its working face is an arc struck from the center of the rock-shaft g, and obviously its seat, which I have marked g'', is an arc struck from the same center. This space formed between the arc g'' and the cap-piece g' is practically a motive-fluid chest in that the motive fluid is introduced therein through a supply-port g''', and thus said chest is kept constantly full of motive fluid.

x x represent exhaust-ports which coöperate with the valves a''' and a'''', said ports being formed in the casing A and communicating with the atmosphere. The valve G is provided with a port g'''', formed through its arc portion, said port being located centrally between the ends of said arc, and when said valve is rocked to and fro this port is caused to register and pass a port a^6, which is in communication with the port a^5. Thus it will be seen that when the valve G passes the port a^5 a certain amount of motive fluid is admitted behind one of the piston-heads and rotates the piston and its shaft, as is well understood.

The rotary valves a''' and a'''' are designed to control the admission and exhaust of motive fluid to and from the engine and are only employed in an engine built to run in either of two directions, such as is illustrated in the accompanying drawings. These valves are identical in construction and consist of a cylindrical body formed with a cut-out portion which when the valve is in position in its seat constitutes a port or passage, and these valves are so arranged in their seats that the port of one valve is in full registration with one of the abutment-ports and the port which conducts motive fluid to the engine, while the other of said valves is in registration with the other abutment-port and the exhaust-passage. These valves are so connected that they move simultaneously through the instrumentality of cranks a^7 a^8, connecting-rod a^9, link a^{10}, and a lever a^{11}, which latter is pivotally mounted in a convenient place, but preferably on the casing of the engine. It will also be observed from a glance at Figs. 3 and 11 that the ports of the valves and the admission and exhaust ports coöperating therewith are so arranged and proportioned that when the operating-lever a^{11} is thrown the admission-port of one valve is positively closed before the exhaust-port of the same valve starts to open, and in the other valve the exhaust-port will be positively closed before the admission-port starts to open. This is a highly-desirable feature, as it enables the operator to reverse the engine without permitting any motive fluid to escape from the motive-fluid chest through the exhaust-openings of the casing. Another feature in the construction of these valves a''' and a'''' and their coöperating ports is that when the operating-lever a^{11} is moved to a certain position and simultaneously the two valves a''' and a'''' are rocked to a certain position communication is established between both exhaust-ports and the interior of the cylinder of the engine through the instrumentality of the valve-ports and the ports a' and a''. This position of the parts will permit air to be drawn into the cylinder behind one of the piston-heads and driven from the cylinder in advance of one of the piston-heads, thus permitting the main shaft of the engine and its carried parts to rotate by momentum after the motive fluid is cut off.

I will now describe the manner in which I cause the piston-heads to move inwardly toward the main shaft when they pass the abutment a and how I prevent the great amount of friction which would otherwise be produced if the piston-head were simply forced inwardly by the inclined approaches to the abutment.

The cylinder-head F is provided upon its outer face with a flange f, which is for a greater part of its length concentric with the main shaft and of a certain radius. This flange has also another short concentric portion, which I shall designate by f', of a greater radius than the first-mentioned portion, and these two concentric portions are connected by practically tangential portions, (see Fig. 1,) thus forming what I shall term a "roller-track" f''. The cap-piece E, which, as before mentioned, is secured to the cylinder-head F, is provided upon its inner face with a roller-track e, corresponding in contour with the roller-track f'', but preferably of somewhat-larger dimensions. It will be observed from a glance at the drawings (Fig. 2 in particular) that the abutment a is located in the lower portion of the cylinder, while the portion f' of the roller-track f'', as well as the corresponding portion of the roller-track e, is located at the upper portion of the engine. The reason for this is that a more direct connection can thus be made between the roller which traverses these tracks and the piston-heads which said rollers operate.

H and H′ represent rollers designed to traverse the tracks e and f'', respectively, these rollers being journaled in a rod h, which rod h is adjustably connected to a rod h' through the medium of a turnbuckle h'', said rod h' being in turn pivoted to a lever h''', which lever

is in turn suitably pivoted to a lug or lugs h'''', formed on the piston. h^7 represents another lever, also pivoted to said lugs h'''', and the free end of this lever h^7 is through the instrumentality of a link or links h^5 pivoted or connected to the inner end of the piston-head. It will be understood that while I have described but one set of roller connections this mechanism is duplicated on the other side of the machine, the same being clearly illustrated in Fig. 1 of the drawings. The rods h are preferably guided and supported by lugs h^6, which extend outwardly from the edge of the piston, and thereby cause said rods and their carried parts to rotate therewith. Inasmuch as the piston-heads are diametrically opposite each other, it necessarily follows that the duplicate rollers H and H′ are also diametrically opposite each other and that when one piston-head is passing over the abutment a its controlling-rollers H and H′ are on the upper portion of the roller-tracks e and f'' or on the portion f' of track f'' and on the corresponding portion of the track e, while the other piston-head not passing the abutment has been moved outwardly from the piston and occupies a position in the motive-fluid space in the cylinder, and its controlling-rollers H and H′ are now upon the lower portions of their tracks or the concentric portion having the shorter diameter, and this position of the parts will remain undisturbed until these rollers are forced upwardly upon the portion f', at which time their controlled piston-head will just be ready to pass the abutment a.

In order to effectually pack this rotary engine and at the same time permit of wear of the parts, I have made the piston proper somewhat smaller than the recess in which it is designed to be placed in the cylinder—as, for instance, I leave a clearance 1 between each end of the piston and the heads of the cylinder. Likewise a clearance 2 is left between the periphery of the piston and the bored recess 3 in the cylinder-heads. I also leave a clearance between the piston-heads and the cylinder-heads, as at 4, said clearance being filled by suitable packing-strips 5, one each side of said piston-heads. 6 represents another packing-strip, which is fitted into the upper edge of the piston-head. The piston proper is provided with two continuous packing-rings 7, which fit in circumferential grooves 8, arranged close to its outer edges and some little distance inwardly from the rings 7, as two half-rings 9 and 10, which half-rings fit in circumferential grooves 11 and 12. These two half-rings abut or rest against a spring-actuated packing-block 13, (see Figs. 7, 8, and 9,) which packing-block is of a breadth equal to the thickness of the piston-heads and in perfect alinement therewith, and by virtue of its tendency to move toward the piston-head and the tendency of the packing-strips 5 to move toward it a perfectly-tight joint is insured.

In order to prevent motive fluid from passing from the interior of the cylinder down between the piston and the casing, I have arranged packing-strips 14, and to prevent said fluid from passing through the slot in which the piston-head reciprocates I have arranged packings 15.

16 indicates packing-strips arranged on each side of the piston-heads, said strips being located in and near the upper end of the slot in which said piston-heads slide. This construction provides for what I have termed the "flexibility" of the engine, which flexibility consists in permitting the piston of the engine to revolve and at the same time be effectually packed regardless of whether it is perfectly true, or, to be more explicit, if the engine-shaft is not perfectly at right angles to the cylinder when the same is mounted or should the bearing become worn down after long use the engine will continue to run smoothly, for the reason that the spaces left all around the piston will permit said piston to cant or occupy a position not exactly parallel to the cylinder, and as the packing-rings and strips are all spring-actuated they will be either depressed or allowed to expand, as the case may be, and tightly press against said piston and prevent leakage of motive fluid between said piston and the cylinder.

I will now describe the construction and operation of the automatic variable cut-off valve and call particular attention to Figs. 2, 5, and 6 of the drawings.

H represents an eccentric loosely mounted upon the main shaft of the engine and outside of the casing, the same being held against longitudinal movement on the shaft by virtue of a boss f''' of the cap E on one side and a fixed collar h on the other side. This eccentric is provided with the usual opening for the passage of the shaft, and in addition thereto is a recess h', formed outwardly from said opening, but opening thereinto, and in this recess is allowed to pass a key d, securely held in a suitable groove in said main shaft, and as this key d only takes up a small portion of the recess it will be observed that when the shaft D is rotating in one direction—say in the direction indicated by the arrow in Fig. 5—the shaft will immediately impart motion to the eccentric; but when said shaft is rotated in the opposite direction a certain lost motion will occur, or, in other words, the shaft will rotate some distance before the key contacts with the body of said eccentric at the other end of the recess. The reason for this lost motion is that when the eccentric is properly set relative to the piston-heads pressure fluid which is controlled by said eccentric will be admitted behind one of said piston-heads at just the proper time when the engine is running in one direction; but when it is desired to reverse the engine it is absolutely necessary that the piston-heads travel the distance from one side of the abutment to the other before motive fluid

is admitted—as, for instance, we will assume the engine to be at rest and in the position shown in Fig. 3, where it will be noticed that the right-hand valve a'''' is open to motive fluid and the left-hand valve a''' closed to motive fluid, and the piston-head nearest the valve is in proper position for receiving said motive fluid to start the engine in one direction; but if it is desired to start the engine in the opposite direction and the valves a''' and a'''' were reversed the other piston would receive motive fluid; but the eccentric would not be taken up on account of the lost motion until the lower piston had passed the abutment. Hence it is absolutely necessary that the piston-head be allowed to move from its position shown in the drawings to such a position where it will bear the same relation to the valve a''' in such reversal as it formerly did to said valve a''''. This eccentric H is provided with an eccentric strap and rod I, whose loose end is slotted and coöperates with a pin or stud j, arranged in the free end of a lever J, which is rigidly secured to the rock-shaft g, which operates the variable cut-off valve G.

The eccentric-rod I has formed in it a slot i, and located within said slot is a U-shaped bar K, whose upper end is pivoted to said eccentric-strap and is designed to swing thereon. This U-shaped bar, which consists practically of two parallel members connected at their upper ends, practically fills the upper end of the slot i, while the outer faces of these parallel members are slightly tapered to such a degree that the combined width of their lower ends are somewhat narrower than this slot i or are permitted to move some little distance in said slot.

L represents two parallel guide-bars formed on or secured to the cap E, and sliding in said guide-bars is a block M.

m represents a pivoted stud or shaft having formed thereon an elongated or working portion m', said elongated or working portion being designed to pass between the parallel members of the U-shaped bar, said sliding block M being caused to move upwardly and downwardly by virtue of an ordinary mechanical governor, (not shown,) which will be driven from the engine, it being understood, however, that when the engine is at rest this block will be at its lowest point and when the engine is started and the speed increases the block will be moved upwardly proportionately to the speed attained, as will be readily understood.

As before mentioned, I employ a turnbuckle h'', which coöperates with rods h and h', the object of which is to minutely lengthen or shorten the distance between the rollers H and H' and the free end of the lever h''', in order to properly adjust the movement of the piston-head; but obviously this adjustment does not change the leverage, but only allows said piston-heads to move outward a given distance. While this construction may be all that is desired in an accurately-constructed engine, I wish to provide for any inaccuracies which may occur in the construction of the roller-tracks—that is, I wish to be able to not have to rely entirely on the exact differential radius of said tracks, and in order to accomplish this end I provide a construction as is illustrated in Fig. 10, wherein it will be seen that the lever h''' is cylindrical and provided with a male screw-thread, upon which screw-thread is placed an unthreaded collar h^8, which collar is adjusted to and held in any desired position by thread-nuts h^9 and h^{10}, which nuts coöperate with the threaded portion of the lever h''', said nuts being arranged one on each side of the collar h^8, as shown. This collar h^8 is designed to receive and have pivoted thereto one end of the rod h, which rod may, if desired, be bifurcated and straddle said collar, as is obvious.

The operation of the engine just described is as follows: When motive fluid is admitted behind the piston-heads and the piston starts to revolve, the piston-heads will be moved inwardly and outwardly at the proper time through the instrumentality of the rollers and tracks, and as the speed of the engine increases the mechanical governor forces the block M upwardly, thereby increasing the length of the distance between said block and the free end of the lever J and at the same time shortening the distance between the block M and the main shaft of the engine, or, in other words, as the speed of the engine increases the cut-off valve G is caused to move through a greater number of degrees, and hence the peripheral speed of said valve is increased, which increased movement of said valve permits of less admission of the motive fluid.

In Figs. 12 to 15 I have shown diagrammatic views illustrating the manner in which the lost motion of the inverted-U-shaped bar K is utilized to correct the point of greatest throw of the eccentric to accommodate the different positions of the movable fulcrum on which its rod I rocks, whereby the motive fluid is always admitted when the pistons are in the proper position to receive it, whether said admissions be in large or small quantities, depending upon the speed of the engine and the position of the fulcrum.

Referring now to Fig. 12 it will be seen that the eccentric will be at what I term one of its "extreme" positions, wherein the tangential line $r\ s$ equivalent to the rod I, fulcrumed at m, is at right angles to a radial line drawn from s to t, the latter being the axis of rotation of the main shaft and the radius referred to being the throw of the eccentric H. In this position the eccentric-rod will be at the limit of its stroke, and as the fulcrum is near the free end thereof the valve-operating rock-arm J will be at its extreme position. The piston-head C will be in the position shown by the full line. Assuming the engine to be rotating in the direction of the arrow, the pis-

ton C should when the centers *s*, *t*, *m*, and *r* are in alinement be in the proper position to receive steam from the port, which proper position is indicated by the dot-and-dash line *t u;* but by reason of the variability of the fulcrum *m*, said fulcrum in this position of the parts being below what I will term the "medial center" will cause the valve to admit steam when the piston reaches a position behind its proper position, and said piston will receive steam when on the line *t v*. Likewise when the fulcrum *m* is raised above the medial position the piston instead of taking steam at the proper place or on line *t u* will take steam in advance of said line or in a position indicated by the dotted line *t w*.

It is obvious from the above that were the fulcrum *m* to occupy a medial position the piston would receive steam at the proper place; but by reason of the adjustment of said fulcrum on either side of said medial position the piston will receive steam in advance of or behind its proper point. This is accounted for by reason of the circumferential displacement of the point at which the attached end of the eccentric-rod is when at its extreme position, and in order to correct the tendency of the piston to creep either backward or forward lost motion is introduced through the medium of the pivoted yoke K, whereby when the fulcrum *m* is adjusted above or below its medial point said lost motion will permit the piston to lose in proportion to what it would otherwise gain were not this lost motion provided. This is accomplished irrespective of the fact that the tangential line *r s* is always at right angles to the radial line *s t* when the rod I is at the extreme of its stroke.

I will state that Figs. 12 and 13 have been introduced simply for the purpose of illustrating the gain or loss of the piston when in the absence of the yoke K, and Figs. 14 and 15 show how the gain or loss of the piston is compensated for by allowing the valve to rest at the end of each throw for a greater or less period of time, depending upon the position of the fulcrum *m* in the yoke K—that is, when the fulcrum is near the pivoted end of said yoke only a small amount of lost motion is permitted, while when the fulcrum is near the lower end of said yoke a greater amount of lost motion is allowed. This lost motion may be said to permit the piston to gain on the valve in proportion to the circumferential difference of the point *s* on the circle of its travel from normal to abnormal.

P indicates a transverse groove or by-pass arranged across the cylinder in juxtaposition to the abutment, whose function is to relieve the piston-head of pressure when the same is about to be retracted. This prevents the piston-head from binding and enables its easy and ready operation with a minimum amount of friction.

It will be observed from a glance at the drawings and the above description that by connecting the rod formed of the portions *h h'* and the turnbuckle *h''* to the lever *h*⁷ at about one-third of its length from its fulcrum I only need make the difference between the radius of the portion *f* and the radius of the portion *f'* one-third that of the throw of the piston-head. This is advantageous, for the reason that the rollers H and H' will not have to traverse a surface of so great a variation as would be the case if the difference between the radius of the cam-track were equal to the throw of the piston-heads.

In order to thoroughly lubricate the moving parts of the engine, I may, if I so desire, introduce into the casing E, and partially fill the same with, lubricating-oil, which when the machine is running will be forced around and between the moving parts, as will be readily understood.

I am aware that minor changes in the arrangement, construction, and combination of the several parts of my device can be made and substituted for those herein shown and described without in the least departing from the nature and principle of my invention.

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

1. The combination with a cylinder and its shouldered head, of a piston which extends beyond said shoulder in the head, peripheral packing in the piston coöperating with said shoulder in the cylinder-head, and packing in the cylinder-head which bears laterally against the piston; substantially as described.

2. The combination with a cylinder and cylinder-head, the latter being provided with a recess 3, of a piston arranged therein and carrying packing 7, on its periphery, said cylinder-head being provided with packing 14 to coöperate with the piston, a sliding piston-head mounted in the piston, and packing 13 and 15 coöperating with said piston-head; substantially as described.

3. In a rotary engine, the combination with a cylinder and its shouldered head, of a piston which extends beyond said shoulder, said piston being of smaller diameter than the diameter of shoulder beyond which said piston extends, said piston also being of shorter length than the internal length of the cylinder and its shouldered heads, and packing rings or strips which are interposed between said cylinder and piston to coöperate with the latter and maintain the balance thereof; substantially as described.

4. In a rotary engine, the combination with a cylinder and piston, of piston-heads slidingly mounted in said piston, tracks arranged on one side only of the cylinder-rollers coöperating with said tracks, and means interposed between said rollers and said piston-heads for operating the latter; substantially as described.

5. The combination with a cylinder and a piston, of piston-heads movably carried by

said piston, cam-tracks arranged on one side only of the cylinder, rollers coöperating with said cam-tracks, connections between said rollers and said piston-heads, and means for adjusting and regulating the movement received by the piston-heads from the rollers; substantially as described.

6. The combination with a cylinder and piston, of cam-tracks arranged on the cylinder, a lever mounted in the piston so as to rotate therewith, a rod mounted on said lever, a roller carried on the end of said rod for cooperating with said cam-tracks, means for adjusting the length of said rod, and a slidable piston-head which is operated by said lever; substantially as described.

7. The combination with a cylinder and its rotatable piston, of cam-tracks arranged on the cylinder, a rock-shaft mounted in the piston, a rod mounted in guides on the piston and connected to said rock-shaft, a roller mounted in the end of the rod for coöperating with said cam-tracks, a rock-arm extending from said rock-shaft, a slidable piston-head, and a link connection with said rock-arm and said piston-head; substantially as described.

8. The combination with a cylinder and its head of a piston, a cap-piece arranged on said heads the cylinder, cam-tracks arranged on said cap-piece and on said cylinder, rollers coöperating with said tracks, slidable piston-heads mounted in the piston, and connections between said rollers and said piston-heads for moving the latter; substantially as described.

9. In a rotary engine, the combination with a cylinder, cylinder-head, cap-piece, shaft, piston, and piston-heads, a cam-track formed on said cap-piece, a corresponding track formed on said cylinder-head, rollers which are arranged to coöperate with said tracks, rods upon which said rollers are mounted, means for adjusting the length of said rods, and levers or cranks to which the inner ends of said rods are connected, lugs which are formed on the piston to which said levers are pivotally connected, and means for independently operating the piston-heads from said levers; substantially as described.

10. The combination with a cylinder formed with an abutment, of a piston and a piston-head, and means extending partly outside the cylinder for positively withdrawing said piston-head to escape contact with said abutment; substantially as described.

11. In a rotary engine, the combination with a cylinder, its piston and piston-heads, said cylinder being provided with ports for admitting and exhausting motive fluid, of an automatic variable cut-off, an eccentric loosely mounted on the main shaft of the engine, means for permitting said eccentric to have lost motion relative to the shaft when the direction of rotation of the latter is reversed, an eccentric-rod for operating the cut-off valve, and a movable fulcrum for said rod; substantially as described.

12. In a rotary engine, the combination with a cylinder, its piston and piston-heads, said cylinder being provided with ports for admitting and exhausting motive fluid, of an automatic variable cut-off, an eccentric loosely mounted on the main shaft of the engine, means for permitting said eccentric to have lost motion relative to the shaft when the direction of rotation of the latter is reversed, an eccentric-rod for operating the cut-off valve, a movable fulcrum for said rod, and means for moving said fulcrum; substantially as described.

13. The combination with a cylinder, its piston and piston-head, of a cut-off valve, an eccentric driven by the main shaft of the engine, an eccentric-rod for vibrating said cut-off valve, and a movable fulcrum for said eccentric-rod; substantially as described.

14. The combination with a cylinder, its piston and piston-head, of a cut-off valve, an eccentric driven by the main shaft of the engine, an eccentric-rod for vibrating said cut-off valve, a movable fulcrum for said eccentric-rod, means for permitting lost motion between the fulcrum and the eccentric-rod, when said fulcrum is in certain of its positions; substantially as described.

15. The combination with a cylinder, its piston and piston-head, of a cut-off valve, an eccentric driven by the main shaft of the engine, an eccentric-rod for vibrating said cut-off valve, said rod being provided with a slot, a yoke pivotally arranged in said slot, and a movable fulcrum for said rod which coöperates with said yoke; substantially as described.

16. The combination with a cylinder, its piston and piston-head, of a cut-off valve, an eccentric driven by the main shaft of the engine, an eccentric-rod for vibrating said cut-off valve, guideways arranged in juxtaposition to said rod, a block slidingly mounted in said ways, a yoke pivotally mounted on said eccentric-rod and a stud carried by said block and coöperating with said yoke to form a fulcrum therefor; substantially as described.

17. The combination with a cylinder, its piston and piston-head, of a cut-off valve, an eccentric driven by the main shaft of the engine, an eccentric-rod for vibrating said cut-off valve, a movable fulcrum for said eccentric-rod, and means for correcting the throw of the eccentric when the fulcrum is adjusted; substantially as described.

In testimony whereof I hereunto affix my signature, in the presence of two witnesses, this 18th day of July, 1899.

JOHN W. PICKEL.

Witnesses:
WM. H. SCOTT,
A. S. GRAY.