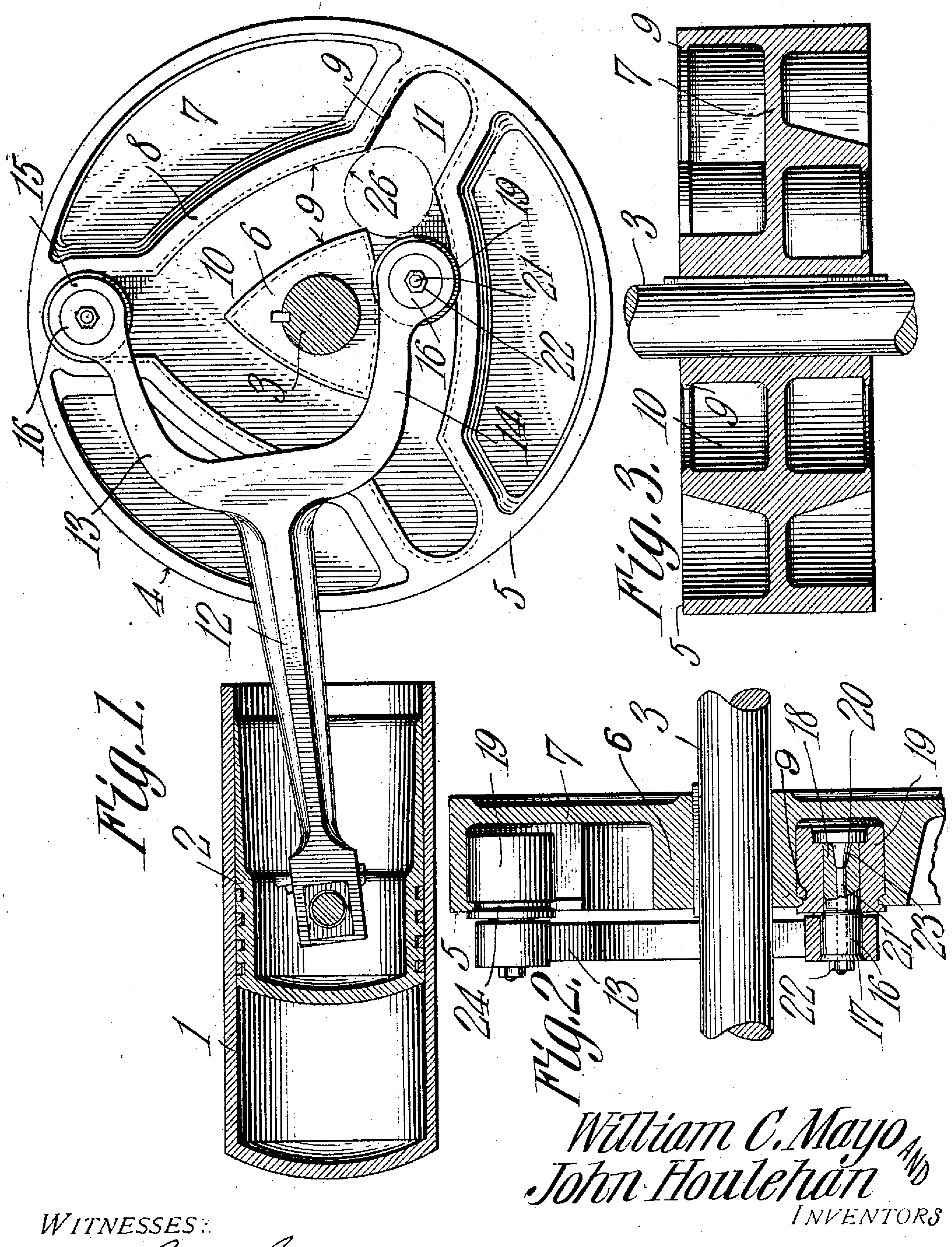
No. 879,289. PATENTED FEB. 18, 1908.

W. C. MAYO & J. HOULEHAN.

MEANS FOR CONVERTING RECIPROCATORY MOTION INTO ROTARY MOTION.

APPLICATION FILED JUNE 26, 1907.

3 SHEETS—SHEET 1.



WITNESSES:

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William C. Mayo AND
John Houlehan
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By C. A. Snow & Co.
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3 SHEETS—SHEET 2.

Fig. 4.

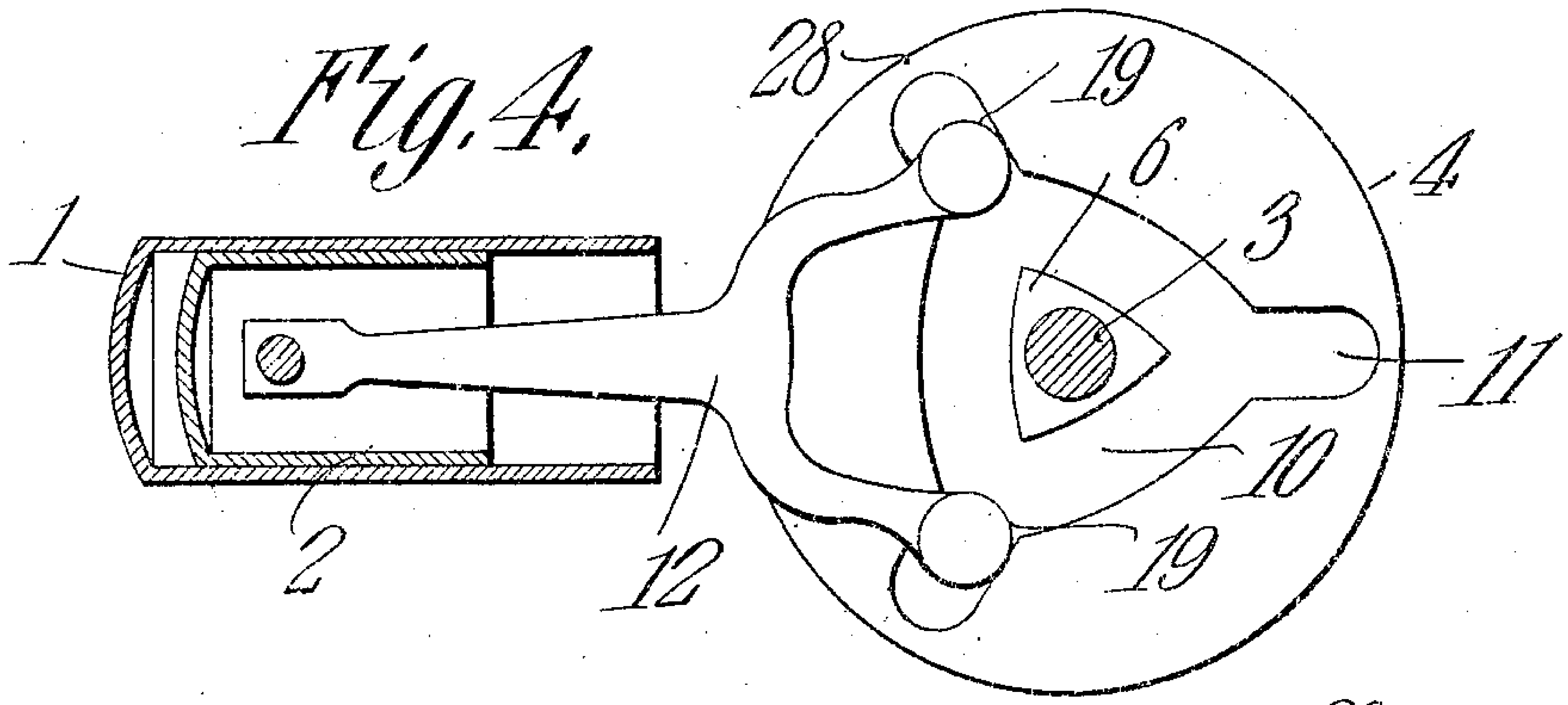


Fig. 5.

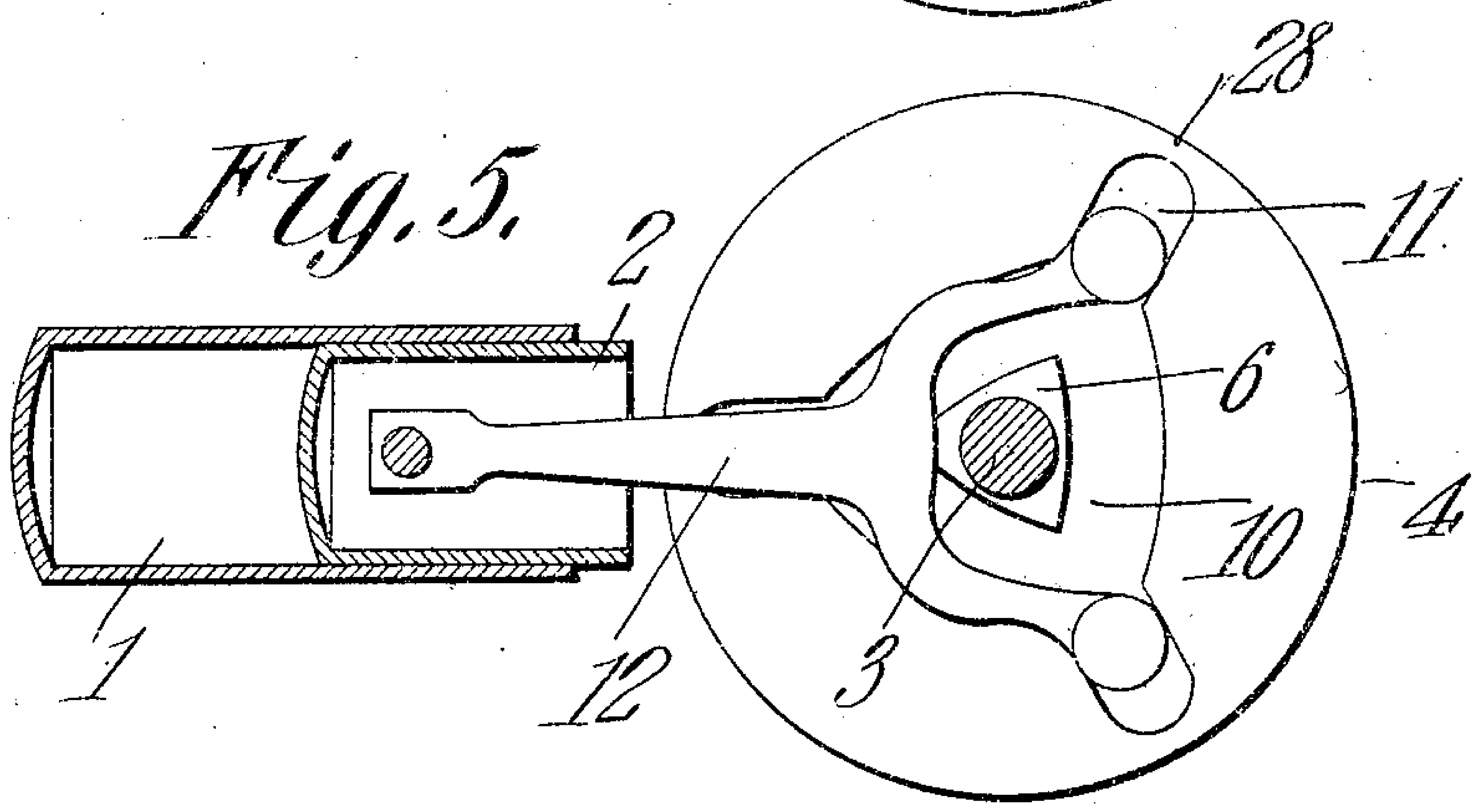
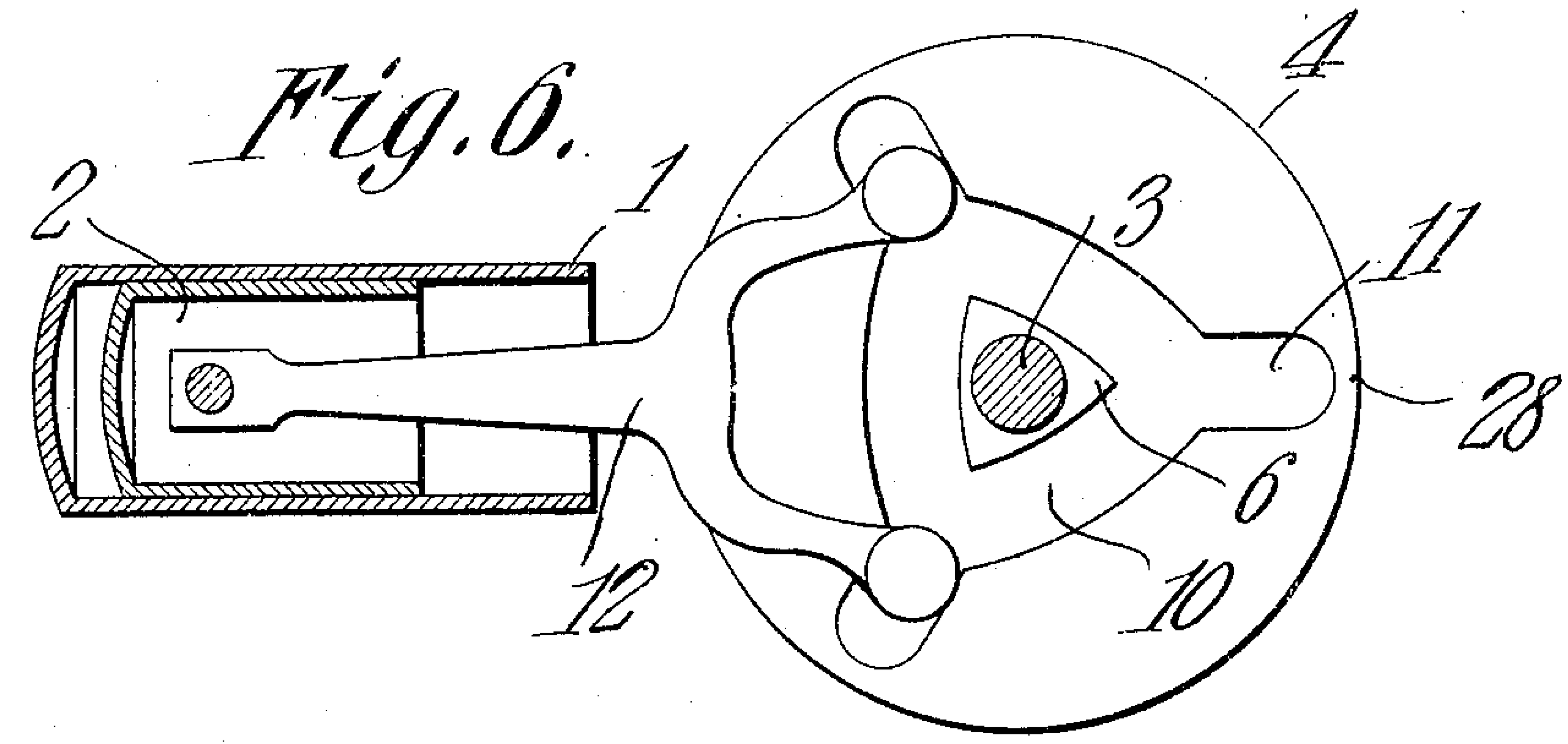


Fig. 6.



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OR CONVERTING RECIPROCATORY MOTION INTO ROTARY MOTION.

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3 SHEETS—SHEET 3

Fig. 7.

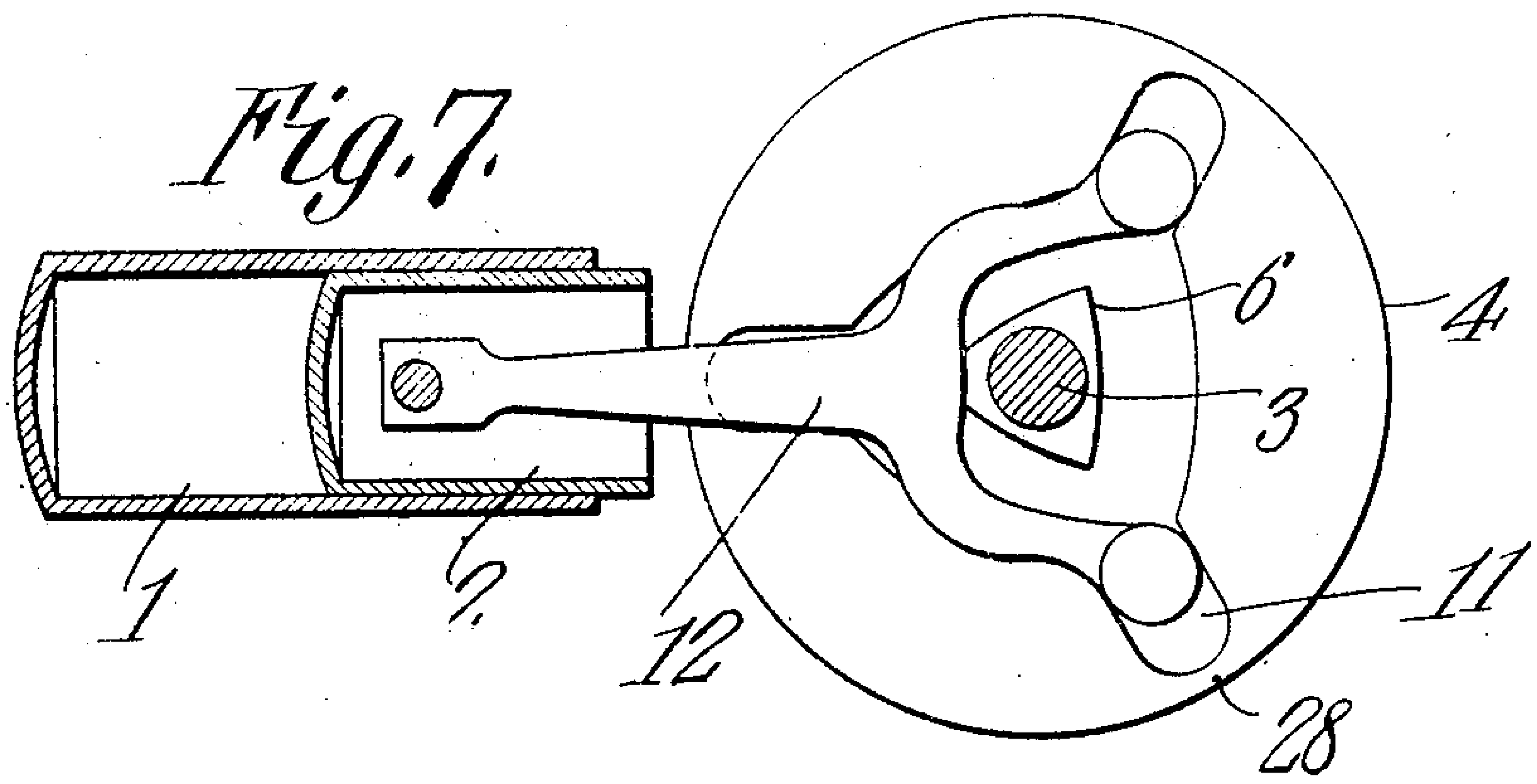


Fig. 8.

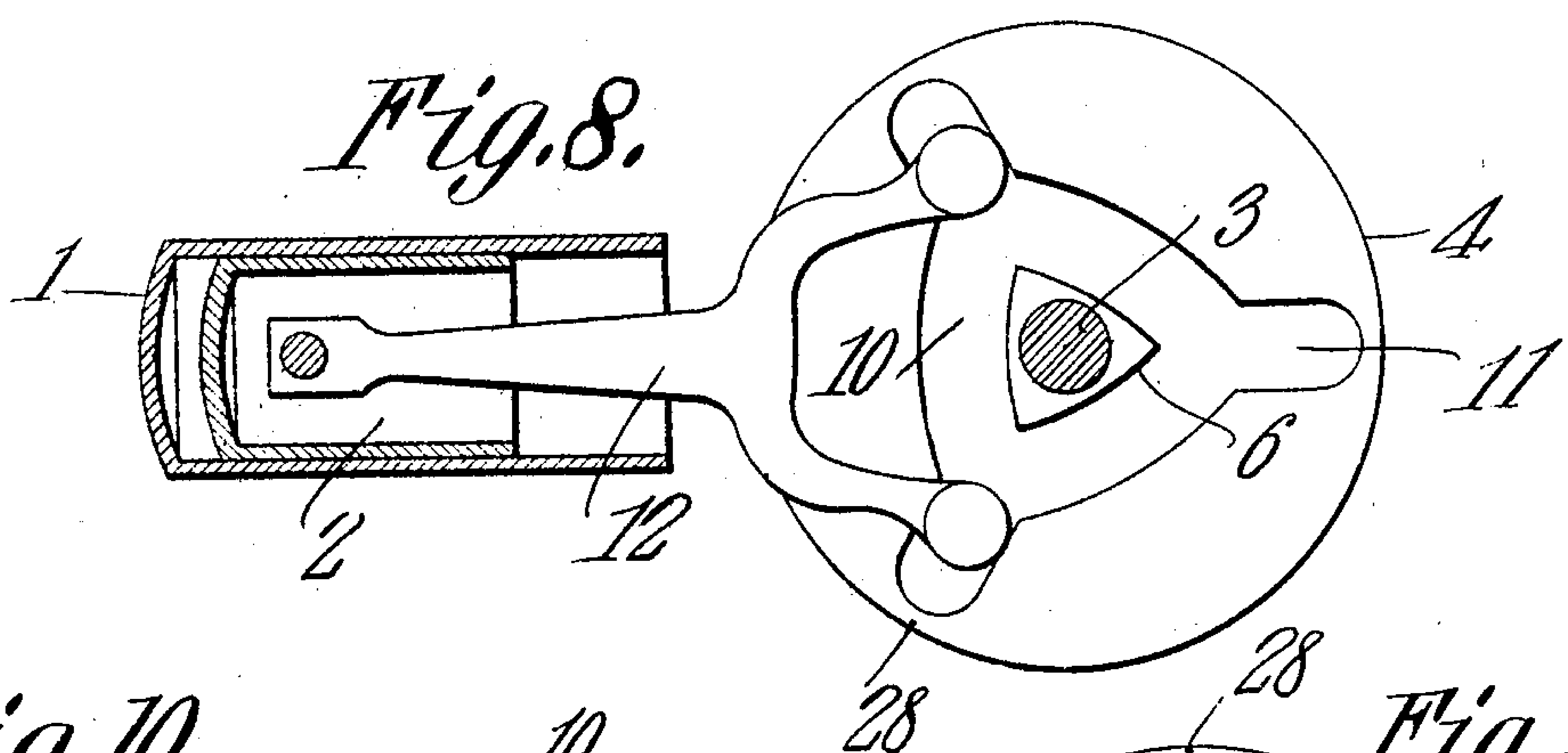


Fig. 10.

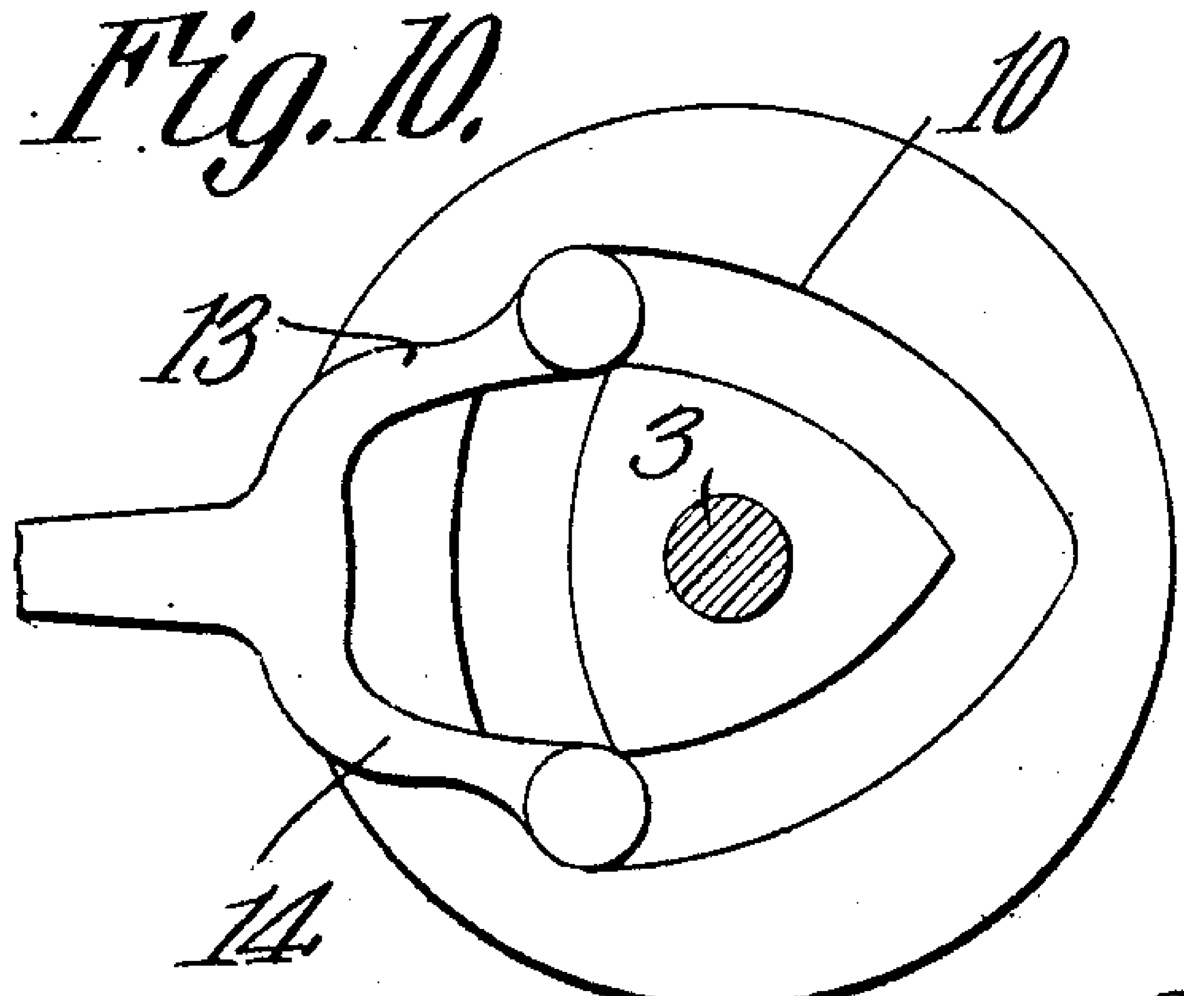
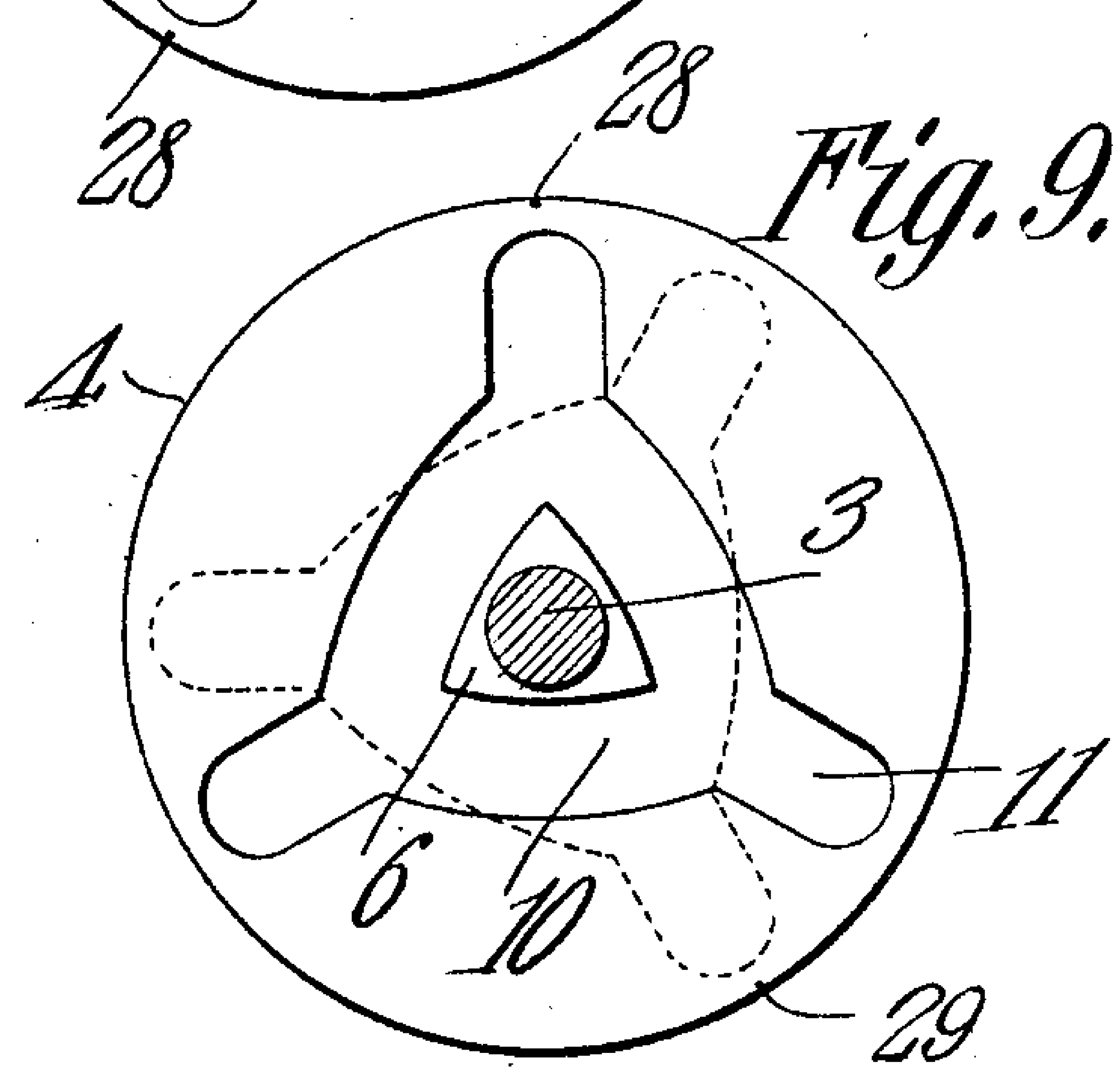


Fig. 9.



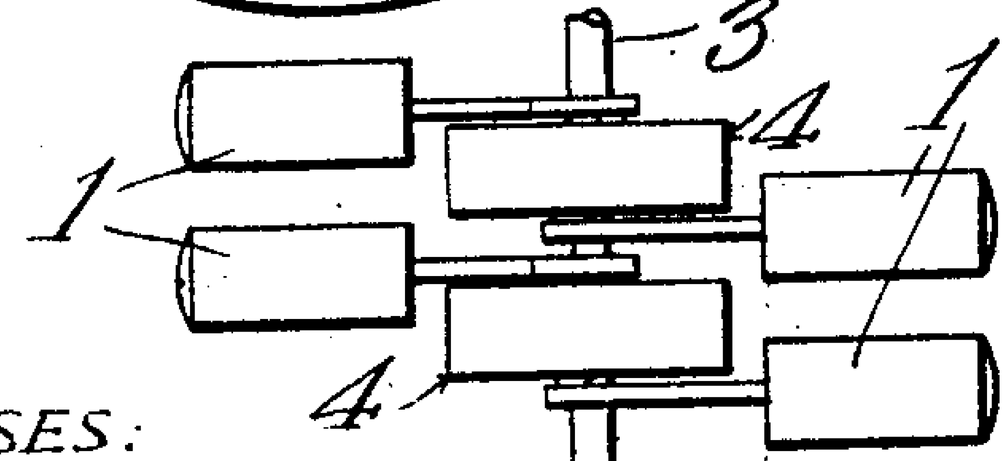


Fig. 11.

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UNITED STATES PATENT OFFICE.

WILLIAM C. MAYO AND JOHN HOULEHAN, OF EL PASO, TEXAS, ASSIGNORS OF ONE-THIRD TO GEORGE E. BRIGGS, OF BARSTOW, TEXAS.

MEANS FOR CONVERTING RECIPROCATORY MOTION INTO ROTARY MOTION.

No. 879,289. Specification of Letters Patent. Patented Feb. 18, 1908.

Application filed June 26, 1907. Serial No. 380,985.

To all whom it may concern:

Be it known that we, WILLIAM C. MAYO and JOHN HOULEHAN, citizens of the United States, residing at El Paso, in the county of El Paso, State of Texas, have invented a new and useful Means for Converting Reciprocatory Motion into Rotary Motion, of which the following is a specification.

This invention has reference to improvements in means for converting reciprocatory motion into rotary motion, or the reverse, and is therefore in its broadest aspect adapted for use in any machine where it is suitable. However, the invention is more particularly adapted for use with explosive engines of any suitable type, whereby the reciprocatory motion of the piston of the engine is converted into rotary motion to drive a rotating shaft.

It is the custom to drive the shafts of explosive engines by means of a crank and pitman connection from the reciprocating piston, so that with each complete reciprocation of the piston, that is, one movement forward and one movement backward, the shaft makes one complete rotation. However, in explosive engine practice, it is found that a high piston speed is productive of economy, both because of high efficiency and the lightness of the parts for a given power, but high shaft speed is often undesirable or prohibitive.

Moreover, the present invention is designed for use in and as an integral part of a complete traction system which we have devised for urban, suburban and interstate railroad traffic wherein each car is a complete unit in itself and is self-contained as to its power generator, which latter, for reasons which need not be here set forth, is preferably in the form of a multi-cylinder explosive engine of the four-cycle type. Such a power generator may develop up to one hundred or more horsepower, and the drive shaft, besides being quite heavy in itself, will carry and propel certain structures rendering high speed prohibitive. Therefore, in order to drive the shaft at a comparatively moderate speed within the limits of the structures carried and driven by said shaft, and at the same time to take advantage of the economy of the high piston speed of explosive engines, and to reduce the weight of the engine very largely in proportion to its power output, we have devised the means forming the subject-matter of the present invention, so that the high piston speed may result in a much slower shaft speed. Moreover, for the purposes of our general system, it is desirable that the shaft should be straight and unbroken by cranks or such devices, thus, among other things, reducing the liability of breakage of the shaft.

The invention comprises means whereby each stroke of the piston, whether forward or return, will move the shaft say, one-sixth of a revolution, so that six single reciprocations of the piston are necessary to cause one single rotation of the shaft. With the four-cycle type of engine the shaft therefore receives three power impulses during two rotations, while with the two-cycle type of engine the shaft receives two power impulses during each rotation. Now, in our system we propose to use a multi-cylinder engine wherein at least four cylinders are active. Therefore, the shaft, being acted upon by all four cylinders in proper sequence, will receive a power impulse for every sixth of a revolution. Furthermore, the structure is such that the power stroke of the pitman acts upon the shaft during the most efficient portion of the rotation, and, therefore, the shaft, when a number of cylinders are used, is constantly acted upon at the most efficient part of the rotative movement, and the power losses due to the approach of the pitman toward the dead-center plane are almost entirely eliminated. It will be understood, however, that while in the foregoing statements and in the detailed description to follow hereinafter the invention is described with reference to a structure whereby six single strokes of the engine piston result in one revolution of the shaft, other relations may be established between the piston speed and the shaft speed. and it is therefore evident that the invention is not confined to the particular speed relation which, for convenience of description, is taken as an example.

The invention in its more limited aspects comprises means whereby the full length of travel of the piston in either direction will result in a rotative movement of the shaft through an arc of about sixty degrees, but each rotative movement will be always in the same direction, so that the shaft has imparted to it a progressive rotation. This movement of the shaft is imparted by a structure or pitman acting upon what may be termed a crank disk, first on one side of said shaft as the piston moves in one direction and then upon the other side of said shaft as the piston moves in the return direction, the active movement of the pitman upon the crank disk being through arcs in the same relation to the shaft, although on opposite sides thereof, but without interference with the shaft, which extends straight through the crank disk and to each side of the same beyond the pitman connection.

The invention furthermore consists in a form of crank disk whereby two pistons having cylinders in opposed tandem arrangement may act upon the same crank shaft in proper power sequence under suitable phase displacement.

By the use of two double crank disks and two pairs of engine cylinders and pistons, each pair in the tandem arrangement referred to, it will be seen that if the engines are of the four-cycle type the shaft will be under power impulses applied so close to the point of maximum efficiency as to closely approach the constancy of application of power to the shaft of a multi-polar electric motor or a steam turbine. If the explosive engines are of the two-cycle type the same constancy of application of power will result when the pistons of but two cylinders are connected on opposite sides of the same crank disk and are suitably displaced in phase.

The invention will be best understood by reference to a practical embodiment thereof, and, therefore, reference is made to the accompanying drawings, in which,—

Figure 1 shows a longitudinal section of a single cylinder explosive engine in partially diagrammatic form, together with its pitman and a crank disk constructed in accordance with the present invention; Fig. 2 is a section through the crank disk in the longitudinal plane of the shaft, the latter and certain other parts being shown in elevation; Fig. 3 is a similar section of a double crank disk; Figs. 4 to 8, inclusive, are partially diagrammatic representations of progressive phases of operation during one rotation of the engine shaft; Fig. 9 is a partially diagrammatic representation of a crank disk constructed after the manner of the one shown in Fig. 3; Fig. 10 is a view of a modified form of crank disk; and Fig. 11 is a diagram showing a multi-cylinder engine.

Referring to the drawings, there are shown the cylinder 1 and piston 2 of an explosive engine but no attempt has been made to show any particular type of engine, since the cylinder and piston may be taken as indicative of any style of engine, whether of the four-cycle or two-cycle type, and whether designed to use gas, gasolene, oil, alcohol, crude oil, distillate, or, in fact, any of the substances employed in engines of the explosive or internal combustion type.

The shaft 3 is a straight shaft unbroken by cranks, and keyed to this shaft is a disk 4 composed of an outer ring 5, an inner hub 6, connecting web 7, and interposed flanges 8, which flanges at their upper edges facing the hub, as well as the corresponding upper edges of the hub, are formed with tongues 9. The disk 4 performs in a manner, as will hereinafter appear, the functions of a crank disk, and, therefore, may be termed a crank disk. The walls of the hub and the corresponding walls of the flanges 8 are parallel, and the spaces between these walls constitute grooves 10. The grooves 10 are each arc-shaped and joined at their ends to form one continuous triarcal groove, while at the points of union the groove is continued radially to form three equi-distant radial pockets or extensions 11 into which the tongues 9 of the flanges 8 are continued.

The piston 2 is provided with a pitman 12, the free end of which is formed into a fork of two branches 13—14, each terminating in an eye 15 receiving one end of a stud 16, the outer end of which may be peened over or upset, as shown at 17. The other end of the stud 16 is formed into a journal extension 18 upon which is mounted a roller 19 having its inner end countersunk to receive the head 20 upon one end of a rod 21 extending centrally through the stud 16 and receiving exterior to the opposite end of the stud a nut 22. The rod 21 where it is joined to the head 20 may be of conical shape, as shown at 23, and be seated in a corresponding conical enlargement in the stud 16.

The end of the roller adjacent to the eye 15 is formed with a circumferential groove 24, shaped to receive the tongues 9 on the hub 6 and flanges 8. The tongues 9 are preferably made slightly tapered, somewhat in the shape of the U. S. standard thread, but may be otherwise shaped if so desired.

In order to assemble the structure the rollers 19 are inserted in the groove 10 at the angle of junction, since at this point the free diameter of the groove is slightly larger than anywhere else in the length of the groove, and the size of a cylinder structure which may be inserted at this point is indicated in Fig. 1 by the dotted line at 26, which dotted line represents the greatest diameter of one of the rollers 19. After these rollers have been inserted with the rods 21 in place the pitman head may be applied so that the journal bearings 18 will enter the rollers and the rods 21 will pass through the studs or stems 16, after which the nuts 22 may be screwed on to the rods 21 and the rollers be thereby connected to the pitman.

It will be seen that the rollers may pass along the grooves 10 and into the pockets 11 without danger of leaving said grooves because of the tongues 9. While the rollers will from time to time pass the spaces indicated by the dotted line 26 at each junction of the arc-shaped grooves, they cannot leave the grooves at this time because when one roller passes the point indicated by the circle 26 the other roller is still locked by the tongues 9. There is therefore no danger of displacement of the parts after having been once assembled. Furthermore, the two arms 13—14 are of sufficient length to permit the piston to move through the entire length of its travel without the base of the fork reaching the shaft 3.

The operation of the structure thus far described will become apparent from a consideration of the several phases of the operation shown in diagrammatic manner in Figs. 4 to 8, both inclusive. Let it be assumed that the particular engine under consideration is of the single cylinder, four-cycle type, and let it be further assumed that in Fig. 4 an explosion has just taken place behind the piston and that the disk 4, as viewed in said figure, is rotating clockwise. The momentum of the disk will carry it by the dead-center in which the pitman is shown in said figure and immediately the lower roller 19 will ride up the inclined wall on the further side of the pocket 11, forcing the upper roller 19 up into the extremity of the corresponding pocket 11. The rotative movement of the disk 4 will continue through an arc of sixty degrees, the lower roller 19 riding along that portion of the triarcal groove 10 then below the center of the shaft. The pitman is now acting upon the disk 4 near its periphery and at approximately the most advantageous point for the application of power. When one-sixth of a revolution of the disk 4 has been completed the lower roller 19 has been brought coincident with the approaching pocket 11 moving clockwise along the lower half of the disk. By this time the forward power stroke of the piston has been completed and the pitman again rests at the dead-center. Now the momentum of the disk carries it past the dead-center, when the relatively inclined walls of the pockets 11 coincident with the rollers 19 will cause the lower roller to drop into the corresponding pocket and the upper roller to move out of the pocket in which it was seated during the power stroke. The continued rotation of the disk now forces the piston toward the rear of the cylinder on its return stroke, while the upper roller 19 passes along the corresponding arc-shaped portion of the groove 10. In a four-cycle engine this return stroke constitutes the scavenger stroke and frees the cylinder from the burned gases. Taking the point 28 of Fig. 4 as the starting point, it will be noticed that on the power stroke it has advanced one-sixth of a revolution, or sixty degrees, as indicated by Fig. 5, while at the completion of the scavenger stroke this point has advanced to one hundred and twenty degrees. Now, when the piston again moves forward under the momentum of the disk 4 practically no work is performed but the fresh charge is drawn into the cylinder, the pitman passing through the same path as described with relation to Figs. 4 and 5, while the point 28 has advanced sixty degrees more, or one hundred and eighty degrees from the starting point, as shown in Fig. 7. On the return stroke of the piston, still under the momentum of the disk 4, whereby the charge is compressed, the point 28 is advanced still another sixty degrees, or two hundred and forty degrees from the starting point, as indicated in Fig. 8. The conditions are now the same as first described with relation to Fig. 4, and another power stroke advances the point 28 to a position three hundred degrees from that considered with reference to Fig. 4, while the succeeding scavenger stroke completes the first revolution of the shaft. Now, by tracing out the cycle of operations through another revolution of the shaft, it will be found that three power strokes are necessary to cause two rotations of the engine shaft 3. It will also be observed that the power stroke always acts upon the disk 4 through the upper roller 19 from the position shown in Fig. 4 to the position shown in Fig. 5 but at a greater radial distance from the shaft, *i. e.*, in the outer end of the corresponding pocket 11. It will be further observed that the power stroke acts upon the disk 4 through an arc extending but thirty degrees to either side of the plane cutting the axis of the disk perpendicular to the plane of the dead-center of the pitman, and that because of the short length of the arc thus described the average leverage exerted upon the shaft 3 during the power stroke very closely approaches the maximum leverage.

Now, considering the structure shown in Fig. 3, it will be observed that on each side of the web 7 are like grooves 10 but these grooves are displaced with reference to each other by thirty degrees, as indicated in Fig. 9, where the groove on the visible face of the disk is indicated in full lines while the groove on the other side of the disk is indicated in dotted lines and displaced by thirty degrees from the visible groove. Let it be assumed that both grooves on the two faces of the disk are engaged by a corresponding pitman connected to oppositely disposed pistons 2 contained in cylinders 1; that is, that the engine is of the tandem type with opposed cylinders, and let it be further supposed that the two engine cylinders operate on the two-cycle system. Under these assumptions, Fig. 4 may be again referred to and the point 28 considered. The first forward stroke of the piston in Fig. 4, considered as the power stroke, carries the point 28 through sixty degrees to the position shown in Fig. 5, while the return stroke, which for the piston under consideration constitutes the compression stroke of a two-cycle engine, carries the point 28 to the one hundred and twenty degree position shown in Fig. 6, while the next power stroke carries the point 28 to the one hundred and eighty degree position shown in Fig. 7, and the next compression stroke carries the point 28 to the two hundred and forty degree position shown in Fig. 8. The third power stroke will carry the point 28 to the three hundred degree position and the return or compression stroke will bring it back to the original position shown in Fig. 4. There are thus three power strokes for each rotation of the shaft 3. Now, consider the engine engaging the groove on the opposite side of the disk 4. In Fig. 9 the point 28 may be assumed to be in the position it occupies when the power stroke of the first considered engine has been half completed. Under these conditions the point 29 corresponding to the groove on the invisible side of the disk as viewed in Fig. 9 is at the beginning of a power stroke but because of the other piston working on the other side of the shaft 3 the power stroke is applied to the lower side of the disk 4. Now, while the first engine is completing its power stroke the second engine is beginning its power stroke, and thus these two power strokes will overlap.

Referring once more to the consideration of an engine of the four-cycle type, let it be assumed that there are two such disks as shown in Fig. 3 mounted upon the shaft 3, and that there are two pairs of tandem cylinders, each pair operating upon one disk upon opposite sides thereof and suitably displaced in phase for operation, it being understood, of course, that the phase relation of the grooves on opposite sides of each disk may be other than thirty degrees, and that the two disks may also be in dephased relation. Assume that engine number one begins its power stroke in the position shown in Fig. 4, and that engine number two begins its power stroke at the completion of the power stroke of engine number one. Also, that engine number three begins its power stroke at the completion of the power stroke of engine number two, and that engine number four begins its power stroke at the completion of the power stroke of engine number three. When this series of operations has been completed engine number one is in position to again begin its power stroke, and so the cycle of operations continues indefinitely. With such a four-cylinder engine the power is applied alternately above and below the shaft as viewed in the figures, but always through the same relative arc and in immediate succession. The shaft is therefore subjected to the continued application of power without intermission, so that it may run with the same general freedom from variation of power impulses and shock and jar strains that is found in the turbine type of steam engine, where the power is continuously applied peripherally, or in the multipolar type of electric motor, where the power impulses are applied in rapid succession but the same peripheral distance from the shaft, and always through short arcs.

It is not absolutely essential for the operation of the device that the two arms 13—14 be of equal length, and if these arms are of unequal length the shape and extent of the grooves may be correspondingly modified. Nor is it essential that the grooves be shaped as heretofore described, since the pockets 11 may be omitted and a simple triarcal groove, such as shown in Fig. 10, may be employed.

With a drive connection such as has been described, it will be seen that the piston of each engine of the four-cycle type makes six movements, three in each direction, for one complete rotation of the shaft, as against two movements, one in each direction, for a simple crank connection between the piston and the shaft. By this means, for a given speed of the shaft, the engine piston will have a speed of reciprocation three times as great as the ordinary crank type of engine. Therefore, for a given power output at the shaft the cylinder may be made approximately one-third the size of one having the slower piston speed. Furthermore, it has been demonstrated that explosive engines having high piston speed are advantageous over those having slow piston speed, both because of the economical fuel consumption and because of the corresponding lightness of construction, but in the larger power units a high shaft speed is prohibited. But by our invention we provide means whereby the piston speed may be three times that of the shaft. Therefore, we are enabled to provide a high power engine having a sufficiently low shaft speed, with all the advantages of economy of operation and lightness of structure found in engines having high piston speed.

Our improvement is particularly applicable to our complete gasolene motor traction system, where economy of weight is of equal importance with economy of operation, and where, because of the large power and slow shaft speed necessary an engine even of the multi-cylinder type, where the pistons are directly connected to the shaft by pitmen and cranks, would be of such large bulk and weight as to be practically prohibited under the conditions of service.

We claim:—,

1. A means for converting reciprocatory motion into rotary motion, or the reverse, comprising a shaft, a rotative member fast thereon and having a triarcal groove formed therein and entirely surrounding the shaft, a reciprocating member, and connections

therefrom to the groove, engaging the latter on both sides of the shaft.

2. A means for converting reciprocatory motion into rotary motion, or the reverse, comprising a shaft, a rotative member fast thereon and having a triarcal groove entirely surrounding the shaft and formed at its meeting points with radial extensions, a reciprocating member, and connections therefrom to the groove, engaging the latter on both sides of the shaft.

3. A means for converting reciprocatory motion into rotary motion, or the reverse, comprising a shaft, a rotative member fast thereon and having a triarcal groove entirely surrounding the shaft and formed with facing tongues at its upper edge, rollers in the groove and provided with peripheral grooves engaged by the tongues, a reciprocating member, and connections therefrom to the rollers in the groove.

4. A means for converting reciprocatory motion into rotary motion, or the reverse, comprising a shaft, a rotative member fast thereon and provided with a triarcal groove surrounding the shaft, a reciprocating member, and a forked connection having arms of sufficient length to straddle the shaft at the extreme limit of movement of the reciprocating member toward the shaft, such arms having connections engaging the groove on opposite sides of the shaft.

5. A means for converting reciprocatory motion into rotary motion, or the reverse, comprising a shaft, and a rotative member fast thereon and provided with a triarcal groove surrounding the shaft and having radial extensions at its meeting angles.

6. An explosive engine comprising a straight or unbroken drive shaft, a crank disk thereon, a cylinder, a piston therein, and a pitman connected to the crank disk on both sides of the shaft and reciprocating through an arc of less than one hundred and eighty degrees.

7. An explosive engine comprising a rotatable shaft, a plurality of cylinders and pistons, connections between the pistons and the shaft, each reciprocating through an arc of less than one hundred and eighty degrees, and means for imparting rotative movement to the shaft by the successive partial rotations of the connections between the pistons and the shaft.

8. An explosive engine comprising a rotatable shaft, a crank disk thereon having a triarcal groove surrounding said shaft, a cylinder and piston, and a pitman between the piston and crank disk, said pitman engaging the triarcal groove simultaneously on opposite sides of the shaft.

9. An explosive engine comprising a rotatable shaft, a crank disk thereon provided with a triarcal groove surrounding said shaft and having radial extensions at the angles, a cylinder and piston, and a pitman between the piston and crank disk, said pitman engaging the triarcal groove simultaneously on opposite sides of the shaft.

10. An explosive engine comprising a cylinder, a piston therein, a rotatable shaft, a crank disk having a triarcal groove, and a pitman provided with a forked end having arms of equal length straddling said shaft and engaging the triarcal groove on opposite sides of said shaft.

11. An explosive engine comprising a plurality of cylinders and pistons, a rotatable shaft, a pitman for each piston having a forked end extending to each side of the shaft, and guideways about the shaft engaged by the forked ends of the pitmen simultaneously on both sides of the shaft, each of said guideways being dephased in position with relation to the next adjacent guideway.

12. An explosive engine comprising a suitable shaft, a crank disk having guide grooves on opposite sides thereof dephased with relation one to the other, a pitman for each groove engaging the same simultaneously on opposite sides of the shaft, a piston connected to each pitman, and a corresponding cylinder receiving the piston.

In testimony that we claim the foregoing as our own, we have hereto affixed our signatures in the presence of two witnesses.

WILLIAM C. MAYO.
JOHN HOULEHAN.

Witnesses:
MABEL O. FAHNESTOCK,
WILLIAM H. GENN.