June 10, 1924. 1,497,481

F. A. BULLINGTON

INTERNAL COMBUSTION ENGINE

Original Filed Aug. 19, 1920 5 Sheets-Sheet 1

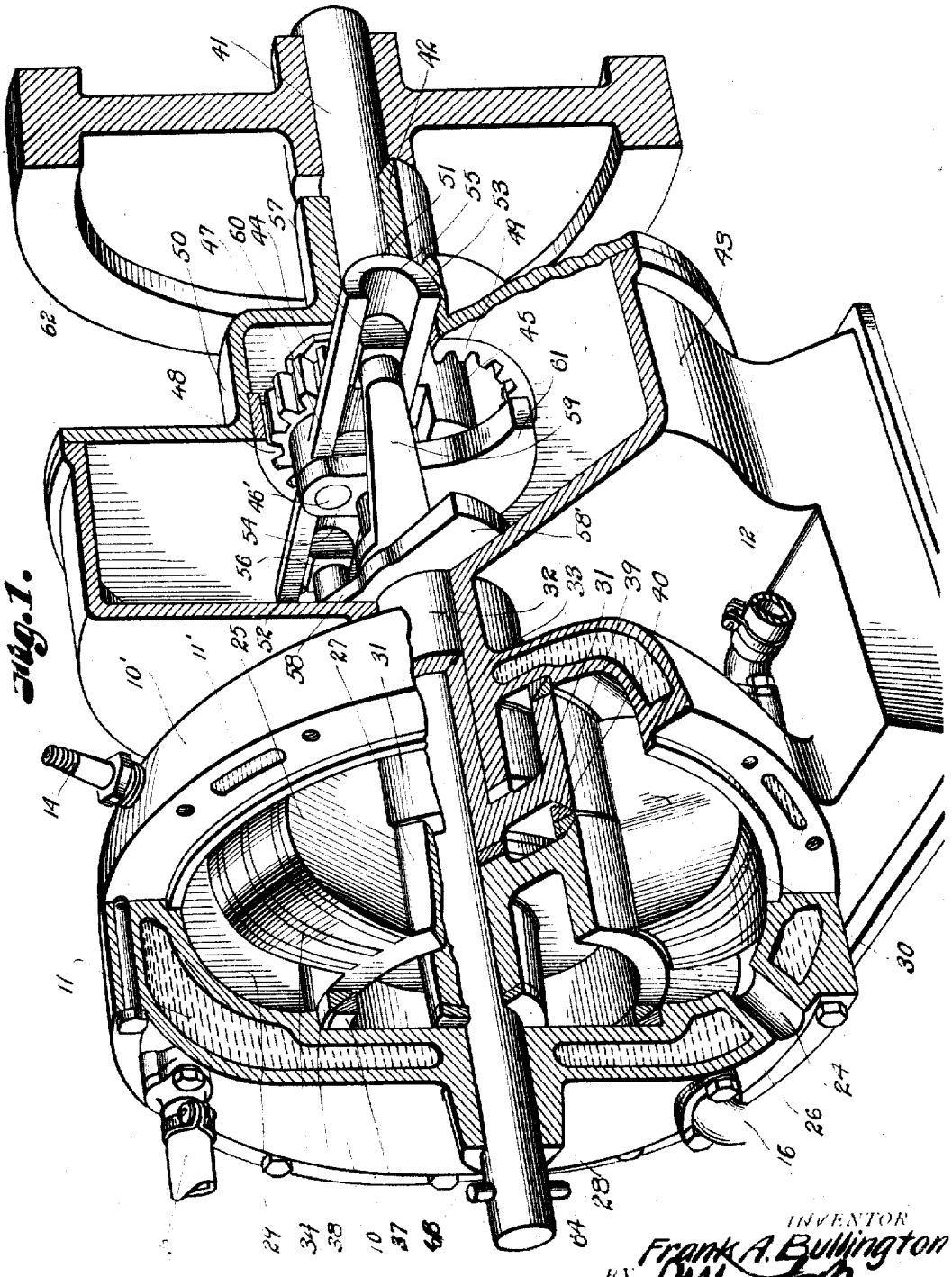


Fig. 1.

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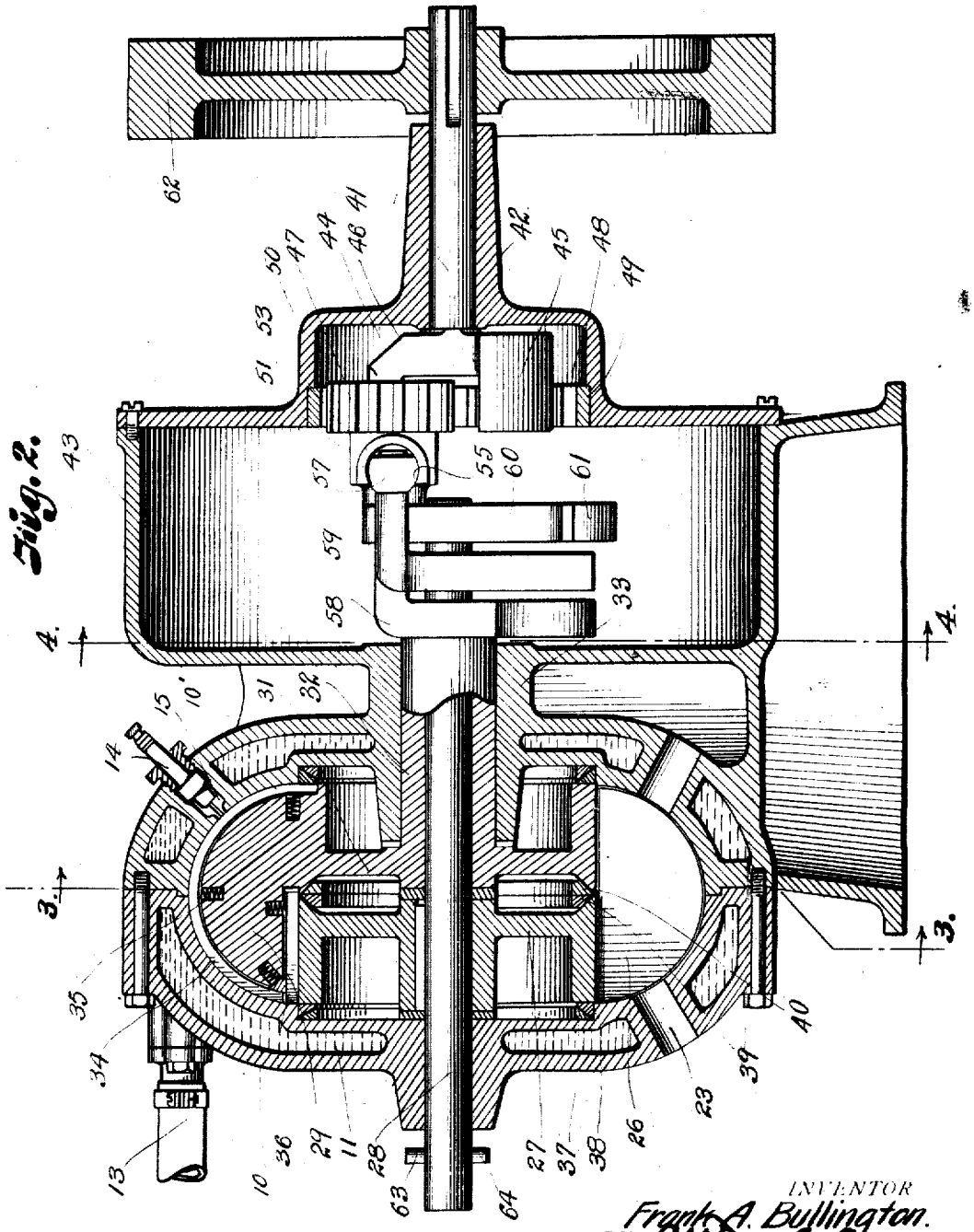
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INTERNAL COMBUSTION ENGINE

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Fig. 2.



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INTERNAL COMBUSTION ENGINE

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Fig. 4.

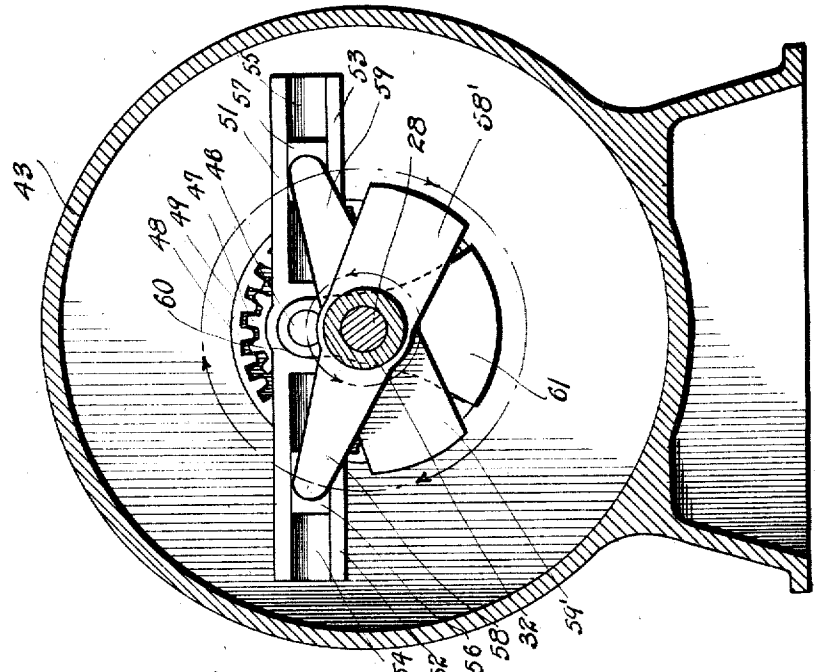
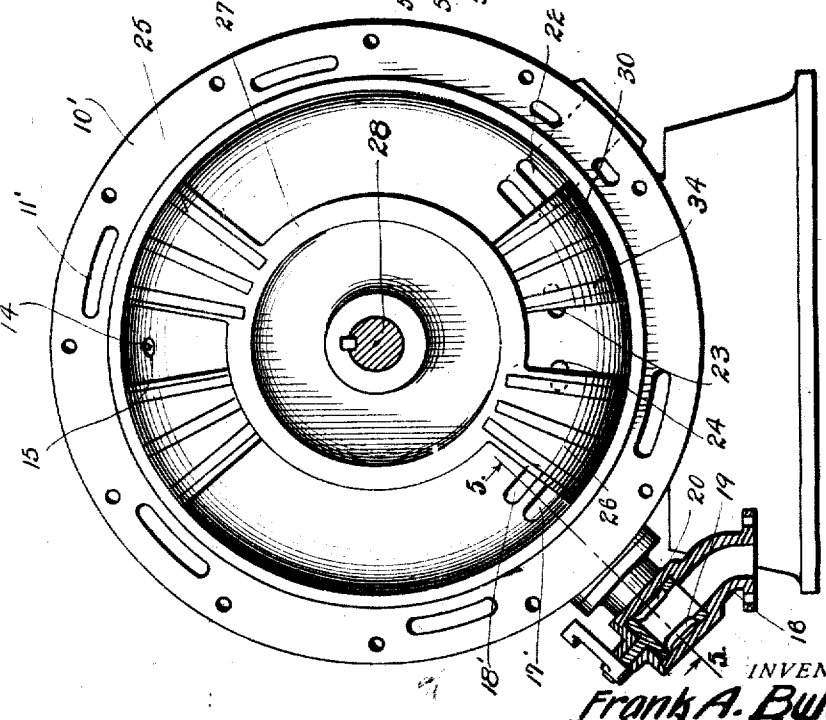


Fig. 3.



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INTERNAL COMBUSTION ENGINE

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Fig. 6.

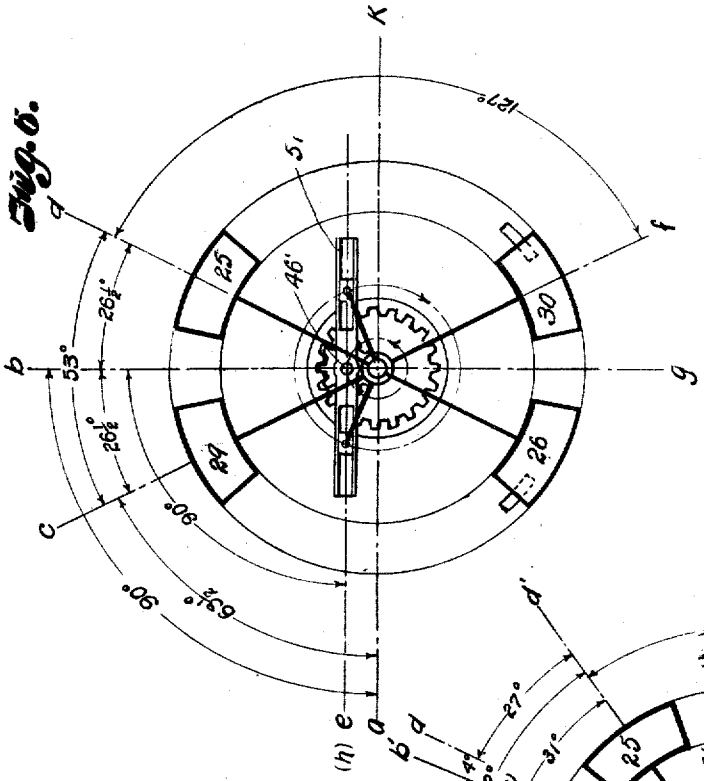


Fig. 7.

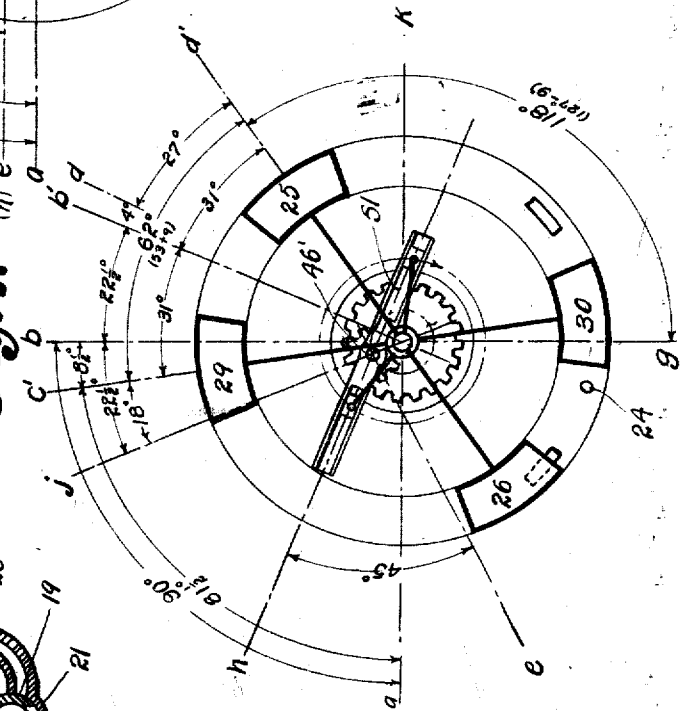
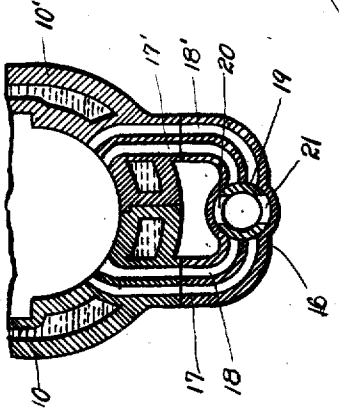


Fig. 5.



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INTERNAL COMBUSTION ENGINE

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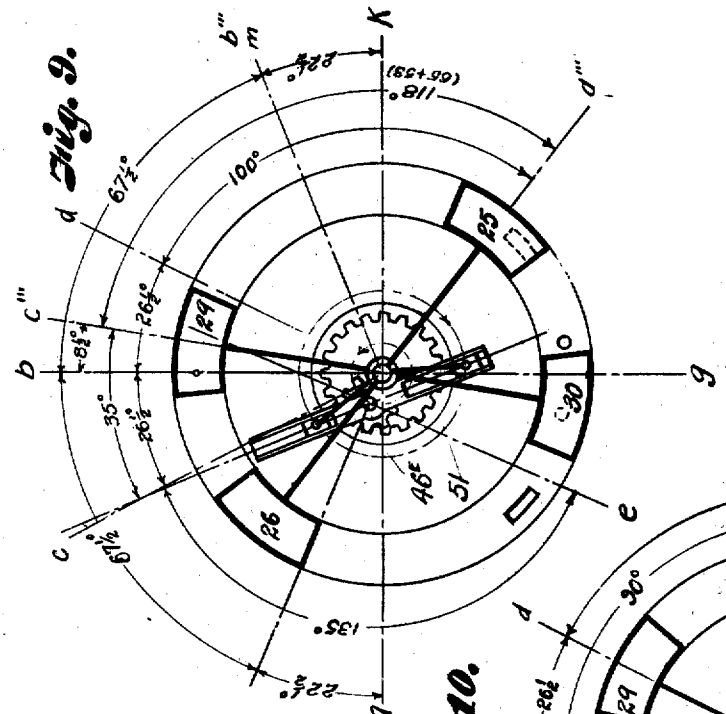


Fig. 9.

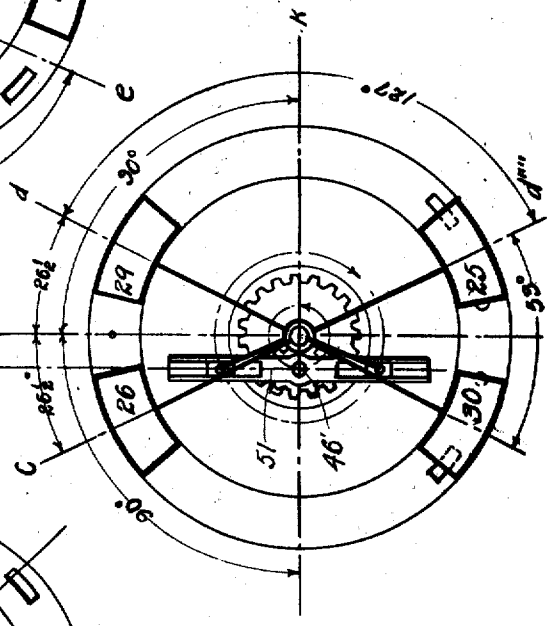


Fig. 10.

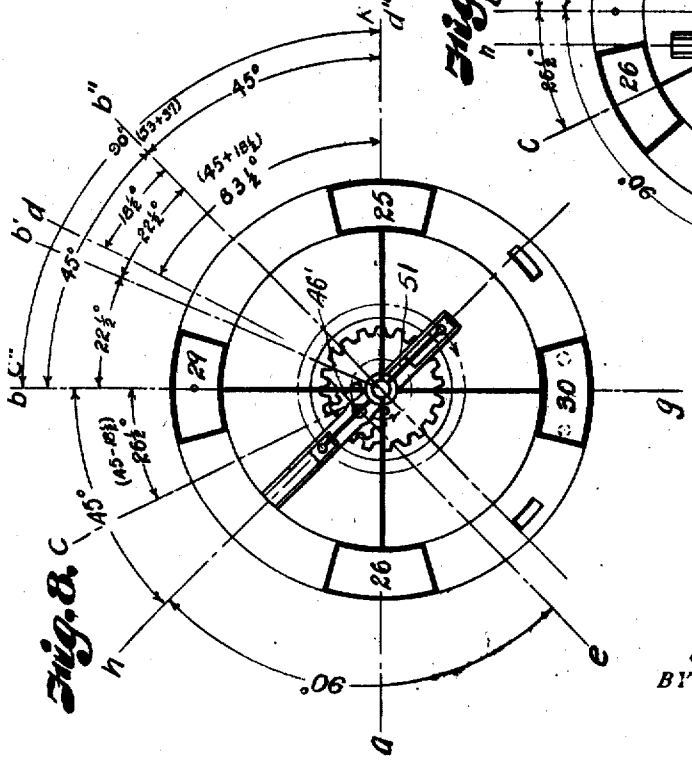


Fig. 8.

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Patented June 10, 1924. 1,497,481

UNITED STATES PATENT OFFICE.

FRANK A. BULLINGTON, OF KANSAS CITY, MISSOURI, ASSIGNOR TO BULLINGTON MOTORS, OF KANSAS CITY, MISSOURI, A COMMON LAW TRUST CONSISTING OF SOLOMON STODDARD, ERNEST E. HOWARD, AND FRANK A. BULLINGTON.

INTERNAL-COMBUSTION ENGINE.

Continuation of application Serial No. 404,592, filed August 19, 1920. This application filed June 10, 1922. Serial No. 567,286.

To all whom it may concern:

Be it known that I, FRANK A. BULLINGTON, a citizen of the United States, residing at Kansas City, in the county of Jackson and State of Missouri, have invented certain new and useful Improvements in Internal-Combustion Engines; and I do declare the following to be a full, clear, and exact description of the invention, 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, and to the figures of reference marked thereon, which form a part of this specification.

This invention as herein illustrated and described relates to prime movers for generating power and particularly to a motor in which an expansible motive fluid is employed to impart motion to pistons which rotate about a common axis.

This application is a continuation of an application filed by me on or about August 19, 1920, Serial No. 404,592.

The particular type of motor involved includes co-operating pistons progressively rotatable about the axis of the power shaft, one piston having relatively accelerated movement with respect to the other and the latter having relatively retarded movement. The pistons, however, rotate within the stator so that first one and then the other becomes the accelerated piston.

In actual practice I prefer to arrange the pistons in pairs, the pistons of each pair being rigidly connected and they are diametrically oppositely located on their respective shafts so that a movement of a piston in one pair will induce a corresponding movement of the other piston in that pair. I also provide means whereby first one set of pistons and then the other set becomes the accelerated pistons, and vice versa in alternate relation throughout the repeated cycles of the motor. Therefore, it will be seen that the various sets of pistons become action elements and reaction elements in alternate relation to generate power within the motor and communicate it to a transmission shaft. That is, if a piston of one pair is the action element for one explosion it is a primary action element and the other piston of the same pair is a secondary action element to cause simultaneous compression action and intake action for succeeding charges, and then one of the pistons of the other pair is a primary reaction element and its mate in the same pair is a secondary reaction element to assist in a simultaneous scavenging or exhausting action of a previously exploded charge and an intake action for a succeeding charge. After one piston has left the spark plug as a primary action element, the next time it leaves the spark plug it will be a primary reaction element.

Devices of the same generic principle as described above have been provided heretofore but in order to maintain an operative co-acting relation between the pistons of the various sets, it is necessary to provide a movement controlling mechanism between the motor shaft and the transmission shaft and in so far as I am aware, such movement controlling mechanism heretofore has been associated with a pivotal point or shaft eccentric to the piston shaft, with the result that the power had to be taken from the motor by some inefficient means.

It is of prime importance to the successful operation of a four cycle rotary combustion motor that each piston accelerate and retard at the same rate so that there will be a uniform application of the power generated within the motor to the driven shaft or power shaft of the motor for in the event that there are variations in the accelerating and retarding movements, obviously there will be a variable in the angular speed of the driven shaft which might be termed a "jumpy" action. Therefore, it is an important feature of my invention that the linkage between the pistons and the power shaft be so constructed and so co-ordinate that under all conditions there will be a uniform alternating accelerating and retarding rotative movement of the pistons.

Prior to my invention pistons have been connected and controlled by linkage but in all devices of which I have knowledge the linkage was so constructed that variables would occur in the accelerating and retarding movements of the pistons. Some attempts have been made to overcome this recognized disadvantage but such structures have included cams or gears for controlling

the movements of the pistons. Where gears are used, obviously, the mechanism was mechanically impracticable because the teeth could not withstand the shocks or blows communicated to them at the moment of explosion or ignition of the fuel charge. Likewise where cams were employed, they were associated with rollers which passed over them and these also caused hammer blows or local shocks to the rollers and to definite parts of the cam at each explosion so that in actual practice they could not stand up.

My invention contemplates means for connecting the pistons to the driven shaft of the motor by suitable linkage or mechanism which will control the movement of the pistons about a common axis so that they will have relative movement to compress fuel charges to combustible pressures and whereby the pistons will have alternate uniform accelerating and retarding rotative movements to insure uniform application of the expansive forces of the ignited charges applied to complementary pistons to thereby, through the linkage, rotate the driven shaft with uniform application of power as well as to insure balanced rotative movement of the pistons.

This I accomplish by so constructing the linkage for connecting the pistons to the driven shaft that all of the parts will have constant movement during the operating periods of the motor so that there will be no stationary parts to receive the impacts of the exploded charges. The constantly rotating connecting linkage between the pistons and the driven shaft will absorb the impact of the exploded charges during their movement and during the time that there will be relative movement between the operating parts of the linkage so that a hammer blow or direct impacting contact will not result as would be the case where a stationary cam, for example, was the guiding element about which pins or shafts of the link members moved or where a fixed gear received all of the force of the exploded charges from a pinion tooth.

With uniform applications of power from the successive explosions, uniform angular rotation of the driven shaft may be provided and insured by a fly wheel thereon.

In the construction illustrated in this application, I utilize gears but these gears do not receive the full impact from the exploded charges; they receive a resultant force of the exploded charges. Such impact is absorbed in the linkage, the gears being utilized merely as delivering the resultant working force or torque to the driven shaft and are important parts in controlling the rotative movement of the pistons and the resultant working force to the driven shaft. It is to be noted, however, that the objections heretofore referred to with respect to the inclusion of gears in a connecting linkage between the pistons and the driven shaft is not present in my invention on account of the fact that the shocks are absorbed at a point in the linkage between the pistons and the gears which have been heretofore referred to.

Attention is called to the fact that the entire linkage planetates about the axis of the pistons and about the axis of the driven shaft and that this planetary movement continues throughout the entire operating cycles of the motor.

In the drawings,

Fig. 1 is a perspective view of the invention partly in section to show the interior of the engine casing and the interior of the crank case and co-operating mechanism.

Fig. 2 is a vertical, longitudinal, sectional view, one of the pistons being shown in section, to illustrate the arrangement of the packing.

Fig. 3 is a view of the motor with the outer half of the casing removed on the line 3—3 of Fig. 2, looking in the direction of the arrow.

Fig. 4 is a cross sectional view on the line 4—4 of Fig. 2.

Fig. 5 is a sectional view on the line 5—5 of Fig. 3.

Fig. 6 is a diagrammatic view showing the positions of the pistons and the piston controlling linkage when the crank is at upper dead center.

Fig. 7 is a diagram showing the position of the pistons when the crank is advanced 22½ degrees from the position shown in Fig. 6.

Fig. 8 is a diagrammatic view showing the position of the pistons and the piston controlling linkage when the crank has advanced 45 degrees from the position shown in Fig. 6.

Fig. 9 is a diagrammatic view showing the position of the pistons and the linkage when the crank has advanced 67½ degrees from the position shown in Fig. 6.

Fig. 10 is a diagrammatic view showing the positions of the pistons when the crank has traveled one-fourth of a revolution to a side dead center position or one complete power stroke, it being understood that the engine shown provides four crank dead center positions and four explosions to a complete revolution of the motor shaft and that the engine is designed to operate on the principle of a four-cycle hydrocarbon engine.

The stator is shown as consisting of a casing comprising the halves 10 and 10′, the outer one 10 of which is removable to permit access to the stator. The interior of the stator is elliptical in cross section but formed to provide a circumferential cham-

ber for the pistons. The casing is provided with a water jacket 11, having an inlet 12 and an outlet 13 whereby a cooling fluid may be circulated about the stator to dissipate heat generated by the explosions within the motor casing. The two halves may communicate through the aligning ports 11' so that the water may circulate through the water jacket.

The stator is provided at an appropriate point with a spark plug 14, having a chamber 15 about the spark plug point communicating with the interior of the stator whereby the charge admitted to the stator may be exploded when under compression. As shown the spark plug is at the top of the stator while the inlet is near the bottom thereof, the arrangement of inlet being best shown in Figs. 3 and 5.

The inlet may consist of a chest or valve casing 16 having a plurality of ports 17, 18, 17' and 18', the latter progressing from the control valve 19 into the stator chamber. The valve 19 is provided with oppositely located ports 20 and 21 whereby when the valve is turned, the effective port and passage area between the carburetor and the interior of the stator casing can be regulatd; that is, maintained at a sufficient effective area to insure the most efficient vacuum condition between the engine and the carburetor. In other words, the arrangement of intake is such as to insure the proper manifold or port area for the speed and temperature of the motor.

The motor is provided with an exhaust port 22 near the lower side of the casing and with an auxiliary exhaust port 23 and a preliminary intake port 24 between the main intake and the main exhaust, as clearly indicated in Fig. 3.

Within the stator is a plurality of pistons arranged in pairs, the pistons of one pair being designated 25 and 26 on the hub or web 27 carried by the piston shaft 28. The pistons of the other pair are designated 29 and 30 carried by the hub or web 31, mounted on the hollow piston shaft or sleeve 32 sleeved upon the shaft 28 and extending through the bearing 33, illustrated as an integral part of the stator casing. Therefore, the pistons 25 and 26 have synchronous movement, one with the other but independent movement with respect to the pistons 29 and 30. The pistons 29 and 30 have synchronous movement one with the other but independent movement with respect to the pistons 25 and 26.

All of the pistons are provided with arcuate piston rings or strips 34, which are normally pressed outwardly by coiled springs 35 in recesses in the pistons, it being apparent by reference to Figs. 1 and 2 that the pistons on the hub 27 are substantially semi-circular and extend over the hub 31, and that the pistons 29 and 30 on the hub 31 overlie the hub 27, as clearly shown in Fig. 1. The lower edges of the pistons which overlie the complementary hubs are provided with spring-pressed packing strips 36, as will be clearly seen by reference to Fig. 2, and the outer faces of the hub are provided with complementary sealing rings 37 and 38 which co-operate to provide close clearances to prevent leakage of the explosive charge.

The inner faces of the complementary hubs 27 and 31 are provided with split ring packings 39 and 40, each bearing and rubbing against the other but carried freely and independently by or within its particular piston hub, this being an advantage over a solid or one-piece packing ring since the split packing ring more effectually seals or packs the joint between the two piston hubs even in the event of slight irregularities or warping between the two complementary piston hubs 27 and 31.

As heretofore explained, it is desired to provide certain relative movements between the two pairs of pistons during the cycle of operation so that first one pair of pistons of a set becomes the accelerated or action pistons while the other pair is reaction pistons and then on the next explosion, the pair of pistons which has previously been the accelerated or action pistons becomes the retarded or reaction pistons and the pistons which in the first instance were the retarded or reaction pistons then become the accelerated or action pistons, the relative functions of the two pairs of pistons alternating at each explosion.

The mechanism for accomplishing the proper functioning of the various pistons includes a coupling for connecting the piston shafts to the transmission element which may be the crank shaft or gear shaft, according to the manner of transmitting the power. The transmission crank shaft 41 is shown as in line with and concentric with the piston shaft 28 and is mounted in a bearing 42, which may be suitably supported by a casing 43, carried by the stator or motor casing. On the inner end of the crank shaft 41 is a hand 44 provided with a counterbalance weight 45 and having a crank 46 having a crank pin 46', on which is rotatably mounted a pinion gear 47, meshing with the internal teeth 48 of a stationary, internally toothed ring gear 49, concentric with the shafts 28 and 41 but eccentric to the axis of the pinion. The internally toothed ring gear 49 is rigidly supported by the casing 43 within the offset portion 50, shown as fixed to the bearing 42 and casing so that the pinion gear will roll over the teeth 48, rotate about its axis or crank 46, and revolve bodily about the axis of the crank shaft 41. Fixed to the pinion

gear 47 and rotatable therewith about the axis of the crank pin 46′ is a bar 51, the oppositely disposed arms 52 and 53 of which constitute slotted cranks, the slots 54 and 55 receiving sliding heads or bearing blocks 56 and 57, to which crank arms 58 and 59 on the piston hollow shaft 32 and piston shaft 28 respectively are pivotally connected.

The crank arms 58 and 59 are provided with counterbalance weights 58′ and 59′ at their free ends, as shown, to assist in carrying over dead centers and to facilitate smooth running of the rotating parts of the motor.

In order to provide an interconnecting, supporting structure or coupling between the crank 46 and the piston shaft 28, I have provided a link, or floating bearing member 60, mounted on and carried by the crank 46, and having a bearing engagement with the shaft 28, at its crank end, the link being provided with a counterbalance weight 61. The counterbalance weight 61, together with the counterbalance weight 46 on the head 44 of shaft 41, provides the necessary counterbalance for the crank pin 46, the pinion gear 47, and the bar 51.

The power shaft 41 is shown as being provided with a fly wheel pulley 62 from which power may be transmitted to whatever driven elements are to respond to the action of the motor. I prefer to extend the piston shaft 28 through the outer half of the casing and provide lugs 63 and 64 thereon so that a crank may be sleeved over the end of the shaft 28 in the usual way for cranking the engine.

When the parts are assembled as shown and the motor is turned over, the pistons rotating in a clockwise direction, so that the initial charge is drawn in and trapped between the pistons 26 and 30, for example, when they occupy the positions of 29 and 26, it is apparent that the piston 26 will move faster on the intake stroke than the piston 30 so as to draw in the charge, the accelerated movement ceasing by the time the piston 30 has closed off the intake port. Then, by reason of the linkage, the piston 30 will become the accelerated piston to compress the charge until the pistons are substantially in the positions of the pistons 25 and 29 in Figs. 3 and 6.

In this position of pistons the crank 46 and connecting mechanism is in a neutral or dead center position and a slight movement forward will carry over dead center, at which time ignition of the compressed charge of fuel between the pistons will be caused by the spark plug and an electric timer (not shown). The resulting explosion and expansion of the charge will accelerate the piston 26, the piston 30 being slightly retarded during this time but also moving forward until the accelerated piston 26 reaches the limit of its expansion stroke, in which position it uncovers or opens the exhaust port 22, whereupon a second explosion occurs in the succeeding chamber. The retarded piston 30 will then be accelerated to close the gap or chamber between the two pistons between which the explosion charge had just previously been ignited and thereby cause the scavenging of the burnt gas from the chamber.

When the pistons are in the position shown in Fig. 6, all parts are practically on dead center so the bearings or blocks 56 and 57 are equal distances on the bar 51 from the pivot or crank pin 46, but when the pistons move slightly forward in a clockwise direction (Fig. 6), the bar 51 will be rotated about the crank pin 46 in a clockwise direction, and the distance between the crank pin and the block 57 will be greater than the distance between the crank pin and the block 56. Therefore, the greater pull will be on the arm 53 to cause the rotation of the pistons to be in the direction of the arrow, causing the forward piston relative to an explosion to at all times be the accelerated or action piston and the rear piston the retarded or reaction piston, and the crank pin 46 and the bar 51 to revolve bodily about the axis of the crank shaft 41 in a contra-clockwise direction and thereby cause the rotation of the crank shaft 41 in the same direction. Since first 25 and 26 are the forward pistons and then 29 and 30 become the forward pistons, it follows that alternately the two sets of pistons become action and reaction pistons during the cycle of operations.

When the piston 26 has reached the limit of its explosion stroke, there will have been a charge of fuel compressed between 25 and 30 and as the momentum carries the link connection, cranks, etc., over dead center, carrying 30 and 25 past dead center, there will be another explosion between 30 and 25 so that 30 becomes the accelerated piston and the space between 26 and 30 will exhaust. When the piston 30 passes and closes the exhaust port 22, its accelerated and scavenging action will not have been completed and for the completion of this action, the remainder of the exploded or burned gas will be passed out through the auxiliary exhaust port 23. As soon as the piston 30 closes off 23, 26 will be uncovering the port 24 so as to draw in a preliminary charge of fresh air before uncovering the inlet port from the fuel supply. After the piston 26 passes the inlet port, the effective volume of the space between 26 and 30 will be increased to take the full charge of fuel and then begin to compress the charge because the piston 29 will be accelerating under the influence of its exploded charge, the peak

of the compression being reached at dead center or adjacent to the spark plug so that the charge will be exploded at the highest point in its compression. Thus it will be seen that a four-cycle operation of the engine takes place after each explosion.

It will also be apparent that the effective port area for the inlet may be controlled by the valve 19 so that the port area can be of appropriate size to insure the most efficient vacuum condition between the engine and the carburetor.

It will be further apparent that after each explosion, the end of the crank for the accelerated piston, that is, the advanced piston, will be a greater distance from the axis of rotation of the bar rigid on the pinion than will the outer end of the crank for the complementary reaction piston. Therefore, the greater pull will be exerted on that portion of the bar co-operating with the advanced piston responding to the explosion, causing the bar to revolve about the axis of the piston shafts in the direction of rotation of the piston shaft by reason of the fact that the pinion rolls with the bar on the teeth of the internal gear. The direction of rotation of the transmission element will be reversed with respect to the motor piston shafts, the movement being such that the engine will continue to rotate in the direction in which it is started.

In order to bring about proper performance of the working parts of the engine in that each piston will accelerate and retard at the same rate to provide a uniform application of the power generated within the motor to the driven shaft or power shaft, it is recommended that the engine be constructed in accordance with the diagrammatic illustrations shown in Figs. 6 to 10, both inclusive.

In Fig. 6 the pistons are shown in their proper relations at the beginning and ending of each stroke action. That is, the two pistons 29 and 25 are in the position with the charge compressed between them. The pistons 26 and 30 have exhausted. The position of the bar 51 (rotatable with the pinion gear 47 and about the axis of the crank pin 46′ on which the pinion gear is mounted) is perpendicular to the crank radius, which is the dead center of the mechanism and occurs four times during one revolution of the motor. The least angular distance between co-operating pistons at any time is 53 degrees and the greatest possible distance between any two pistons is 127 degrees. The angular stroke action, therefore, of complementary pistons is the sum of 127 degrees and 53 degrees, or 180 degrees, and their difference, or 74 degrees.

In Fig. 6 the distance between the radial centers of the pistons is 53 degrees, as indicated by the angle *c*—*d*. Rotation of the crank 47 in a contra-clockwise direction is accomplished by a rotation of the pistons about the motor axis in a clockwise direction and in Fig. 7 the crank 46 has rotated 22½ degrees from the position shown in Fig. 6. The bar 51 has rotated 45 degrees about the axis of the crank pin, the piston 25 has advanced 27 degrees, and the piston 29 has advanced 18 degrees from their respective positions, the positions of the pistons 29 and 25 being indicated at angle *c′* and *d′*. The distance between them has been increased 9 degrees and an imaginary point midway between them, as indicated by *b′*, has advanced 22½ degrees from the point *b* (Fig. 6). The piston 25 has received an accelerated rotation of 4½ degrees and the piston 29 has been retarded 4½ degrees during the 22½ degrees of rotation of the motor.

In Fig. 8 the parts are shown in position with the crank pin 46′ advanced 45 degrees from its position in Fig. 6, and the bar 51 has been rotated 90 degrees about the crank pin. The piston 25 has advanced 63½ degrees and the piston 29 has advanced 26½ degrees from their initial positions, as shown in Fig. 6. The imaginary point midway between the two pistons, as represented by *b* in Fig. 6, has advanced to the position indicated by *b″* in Fig. 8 and the angular movement of the piston 25 in advance of the position indicated in Fig. 7 is indicated by the angle *d*—*d″*. Therefore, the piston 25 has received an accelerated rotation of 18½ degrees and the piston 29 has been retarded in its movement of 18½ degrees.

In Fig. 9 the crank pin 46′ is shown as advanced 67½ degrees from the point it assumed in Fig. 6. The bar 51 has been rotated 135 degrees about the crank pin, the radial center of the piston 25 is indicated at *d‴* and has advanced 100 degrees, while the center of the piston 29, as represented by the line *c‴*, has been advanced 35 degrees from the position shown in Fig. 6. The angular distance between the pistons 29 and 25 has increased 65 degrees and the original midway point between the pistons, as indicated by *b* in Fig. 6, has advanced 67½ degrees. Thus the piston 25 has received an accelerated rotation of 32½ degrees and the piston 29 has received a retarded rotation of 32½ degrees. Therefore, the mean angle of rotation of both pistons is 67½ degrees, the same as that of the crank pin 46′.

In Fig. 10 the parts are shown with a stroke action completed. The crank pin 46′ has advanced 90 degrees, the bar 51 has been rotated 180 degrees about the crank pin and is again perpendicular to the crank radius, the piston 25 has advanced 127 degrees, and the piston 29 has advanced 50 degrees to the position previously occupied by the piston 25 in Fig. 6. The movements of the pistons, bar and crank pin just enumerated in con-

nection with the diagrams have been those which take place between any two pistons from the time of the explosion through the four cycle action of the motor. Of course, in the diagrams each piston 29 and 25 is connected to complementary pistons 30 and 26 respectively so any movement which is imparted to either piston 29 or 25 will impart a corresponding movement to a complementary piston but at a different cycle position during the rotation of the motor. For example, when the piston 25 is moved out under the expansion of the exploded charge away from 29, its complementary piston 26 is moving into charge-compressing position toward 29, and 30 is moving past the exhaust port and the space between 25 and 30 is being exhausted of gas which has previously done useful work.

In order to simplify the description it has been deemed better to simply describe the action of two pistons during the four cycle action of the motor since the movements of any other set of pistons can be readily ascertained in connection therewith.

Attention is called to the fact that the diagrams and the explanations thereof are simply illustrative of an engine in which the stroke of the piston is 68 degrees, it being apparent that the relative movements of the various co-ordinating parts will proportionately vary with engines having piston strokes of different lengths.

From the foregoing it will be seen that I have provided a motor possessing the inherent, theoretical advantages of a rotary engine without the inclusion of the mechanical disadvantages. The motor is so arranged that advantage may be taken of the movement value of a four cycle system of reciprocatory engine without the inherent mechanical disadvantages thereof, such as the use of clack valves and the like. It will also be seen that the arrangement of the parts is so designed that a high degree of efficiency is insured with the given consumption of motive fluid.

What I claim and desire to secure by Letters Patent is:

1. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a driven crank shaft spaced from but concentric with the piston shafts, the crank on the crank shaft rotating about an axis common to the concentric piston shafts and the crank shaft, and means connecting the crank and piston shafts in co-operative relation.

2. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a driven crank shaft spaced from but concentric with the piston shafts, the crank on the crank shaft rotating about an axis common to the concentric piston shafts and the crank shaft, and means connecting the crank and piston shafts in co-operative relation, said means including a rotatable bar carried by the crank, and cranks on the piston shafts having slidable engagement with said bar.

3. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a driven crank shaft spaced from but concentric with the piston shafts, the crank on the crank shaft rotating about an axis common to the concentric piston shafts and the crank shaft, and means connecting the crank and piston shafts in co-operative relation, said means comprising a slotted bar rotatable with the crank but movable in a direction opposite to the rotation of the crank, and cranks on the piston shafts having slidable engagement with said bar.

4. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a driven crank shaft spaced from but concentric with the piston shafts, the crank on the crank shaft rotating about an axis common to the concentric piston shafts and the crank shaft, and means connecting the crank and piston shafts in co-operative relation, said means including a rotatable bar carried by the crank, cranks on the piston shafts having slidable engagement with said bar, and a link between one of the piston shafts and a crank on the crank shaft.

5. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, means connecting the crank and the piston shafts in co-operative relation, said means including a rotatable bar carried by the crank, cranks on the piston shafts having slidable engagement with said bar, and a counterbalancing link between one of the piston shafts and a crank on the power transmission element.

6. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, a pinion gear rotatable on said crank, an internal gear about the pinion with which the teeth of the pinion mesh to provide a rolling contact, a bar rigid with the pinion, and cranks on the piston shafts in sliding engagement with said bar.

7. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, a pinion

gear rotatable on said crank, an internal gear about the pinion with which the teeth of the pinion mesh to provide a rolling contact, a bar rigid with the pinion, cranks on the piston shafts in sliding engagement with said bar, and a floating bearing connecting one of the piston shafts and the crank.

8. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, a pinion gear rotatable on said crank, an internal gear about the pinion with which the teeth of the pinion mesh to provide a rolling contact, a bar rigid with the pinion, cranks on the piston shafts in sliding engagement with said bar, and a floating bearing connecting one of the piston shafts and the crank, said bearing comprising a counterbalancing link.

9. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, cranks carried by the shafts, bearing blocks loosely engaged by the ends of the cranks, a power transmission element, a crank carried thereby, and a rotatable bar mounted on the crank and revolving in a direction opposite to the rotation of the power transmission element, said bar having slots engaged by the blocks on the cranks of the piston shafts.

10. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, cranks carried by the shafts, bearing blocks loosely engaged by the ends of the cranks, a power transmission element, a crank carried thereby, a rotatable bar mounted on the crank and revolving in a direction opposite to the rotation of the power transmission element, said bar having slots engaged by the blocks on the cranks of the piston shafts, and a link connection between one of the piston shafts and the crank.

11. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, means connecting the crank and the piston shafts in cooperative relation, said means including a rotatable bar carried by the crank, cranks on the piston shafts having operative engagement with said bar, and an inter-connecting means between one of the piston shafts and a crank on the power transmission element.

12. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, a pinion gear rotatable on said crank, an internal gear about the pinion with which the teeth of the pinion mesh to provide a rolling contact, a bar rigid with the pinion, and means on the piston shafts in operative engagement with said bar.

13. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, a pinion gear rotatable on said crank, an internal gear about the pinion with which the teeth of the pinion mesh to provide a rolling contact, a bar rigid with the pinion, cranks on the piston shafts in operative engagement with said bar, and a floating bearing connecting one of the piston shafts and the crank.

14. In a rotary motor, a casing, pistons therein, concentric shafts for the pistons, one of which is sleeved upon the other, a power transmission element spaced from but concentric with the piston shafts, a crank on the power transmission element, means connecting the crank and the piston shafts in cooperative relation, said means including a rotatable bar carried by the crank, cranks on the piston shafts having operative engagement with said bar, and inter-connecting means between one of the piston shafts and a crank on the power transmission element.

15. In a rotary four cycle combustion motor, a cylindrical casing, pairs of pistons therein, rotating about a common axis having relative movement to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft, and linkage connecting the pistons to the driven shaft, one of the members of the linkage having planetary movement about the axis of the driven shaft, the linkage being effective to cause uniform alternate accelerating and retarding rotative movements of complementary pistons of complementary pairs to insure balanced rotative movement of the pistons.

16. In a rotary four cycle combustion motor, a cylindrical casing, pairs of pistons therein, rotating about a common axis having relative movement to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft, and linkage connecting the pistons to the driven shaft, one of the members of the linkage having planetary movement about the axis of the driven shaft, the linkage being effective to cause uniform alternate accelerating and retarding rotative movement of complementary pistons of complementary pairs to insure uniform application of the expansive forces of the ignited charges applied to complementary pistons to there-

by rotate the driven shaft at uniform angular speed.

17. In a rotary four cycle combustion motor, a cylindrical casing, pairs of pistons therein, rotating about a common axis having relative movement to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft, and linkage connecting the pistons to the driven shaft, one of the members of the linkage having planetary movement about the axis of the driven shaft, the linkage being effective to cause uniform alternate accelerating and retarding rotative movements of complementary pistons of complementary pairs to insure balanced rotative movement of the pistons and uniform application of the expansive force of the ignited charges applied to complementary pistons to thereby rotate the driven shaft at uniform angular speed.

18. In a four cycle rotary combustion motor, a cylindrical casing, pairs of pistons therein rotative about a common axis, the pistons of one pair having relative movement with respect to the pistons of their complementary pair to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft, and planetary linkage between the respective pairs of pistons and the driven shaft operating to cause uniform acceleration and retardation of the complementary pistons of complementary pairs, each piston retarding at the same rate of speed as it was previously accelerated to insure uniform application of the expansive force of the ignited charge applied to the complementary pistons to thereby rotate the driven shaft at uniform angular speed.

19. In a four cycle rotary combustion motor, a cylindrical casing, pairs of pistons therein rotative about a common axis, the pistons of one pair having relative movement with respect to the pistons of their complementary pair to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft, planetary linkage between the respective pairs of pistons and the driven shaft and operating to cause uniform acceleration and retardation of the complementary pistons of complementary pairs, each piston retarding at the same rate of speed as it was previously accelerated to insure uniform application of the expansive force of the ignited charge applied to the complementary pistons to thereby rotate the driven shaft at a uniform angular speed, and a gearing associated with the linkage for rotating the part of the linkage connected to the shaft about an orbit concentric with the axis about which the pistons rotate.

20. In a four cycle rotary combustion motor, a cylindrical casing, pairs of pistons therein rotating about a common axis, the pistons of complementary pairs having relative movement to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft concentric with the axis about which the pistons rotate and having a crank, a gear eccentrically mounted with respect to the shaft and supported on the crank, a second gear with which the first gear meshes, and planetary linkage having connection with the crank and with the pistons to cause uniform alternative acceleration and retardation of the complementary pistons of complementary pairs to insure uniform application of the expansive force of the ignited charge applied to the complementary pistons, each piston accelerating and retarding at the same rate, the linkage between the pistons and the crank being effective to absorb the explosive shocks so that the gears will be free of such shocks to serve as directional gears for the crank on the driven shaft and through the linkage cause rotation of the pistons.

21. In a four cycle rotary combustion motor, a cylindrical casing, pairs of pistons therein rotating about a common axis, the pistons of complementary pairs having relative movement to compress fuel charges to combustible pressures, means for igniting the compressed charges, a driven shaft concentric with the axis about which the pistons rotate and having a crank, a gear eccentrically mounted with respect to the shaft and supported on the crank, a second gear with which the first gear meshes, and planetary linkage having sliding connection with the crank and with the pistons to cause uniform alternative acceleration and retardation of the complementary pistons of complementary pairs to insure uniform application of the expansive force of the ignited charge applied to the complementary pistons, each piston accelerating and retarding at the same rate, the linkage between the pistons and the crank being effective to absorb the explosive shocks so that the gears will be free of such shocks to serve as directional gears for the crank on the driven shaft and through the linkage cause rotation of the piston.

In testimony whereof I affix my signature.

FRANK A. BULLINGTON.