F. W. CHADBOURNE.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED SEPT. 14, 1916.

1,326,129.

Patented Dec. 23, 1919.

3 SHEETS—SHEET 1.

Fig. 1.

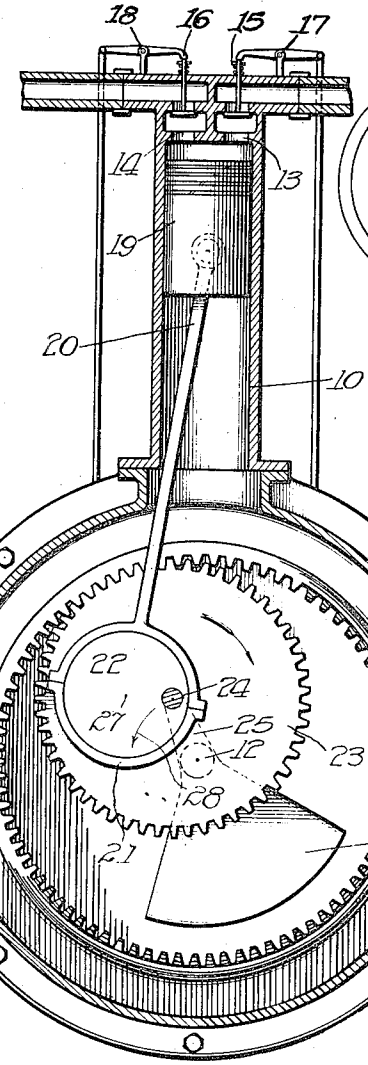


Fig. 3.

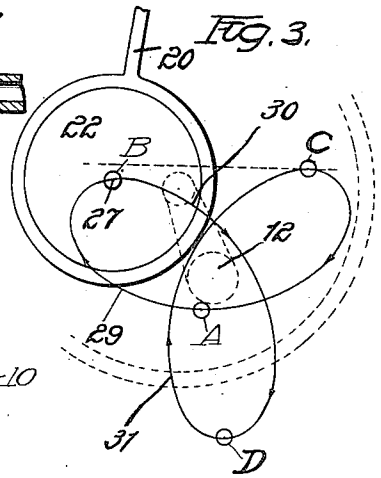
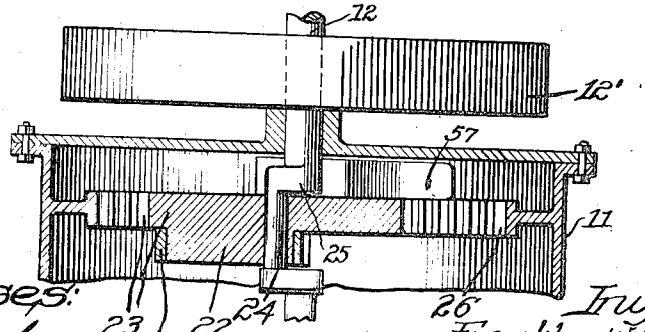


Fig. 2.



Witnesses:
Arthur W. Carlson
Robert C. Baeke

Inventor:
Franklin W. Chadbourne
Williams, Bradbury & Hay.

F. W. CHADBOURNE.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED SEPT. 14, 1916.

1,326,129.

Patented Dec. 23, 1919.

3 SHEETS—SHEET 2.

Fig. 4.

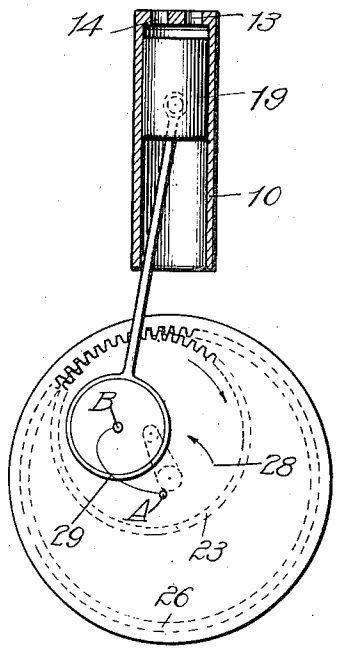


Fig. 5.

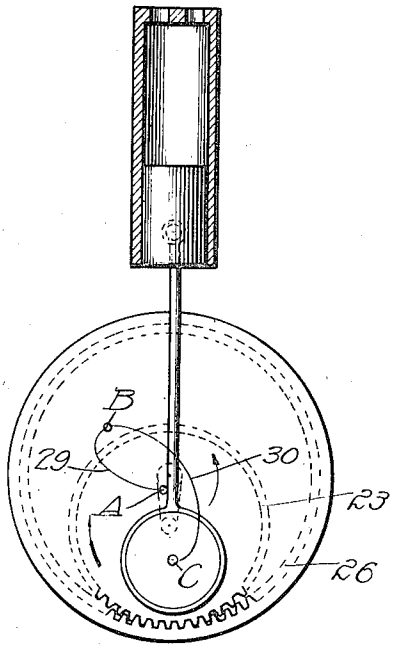


Fig. 6.

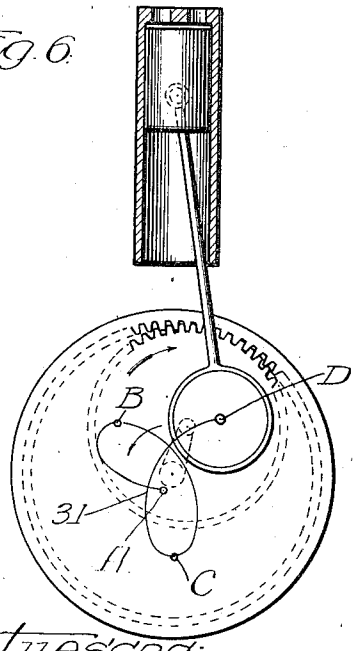
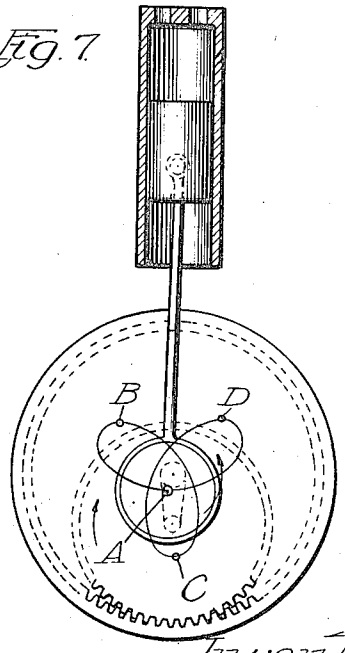


Fig. 7.



Witnesses:
Arthur W. Carlson
Robert F. Brack

Inventor
Franklin W. Chadbourne
Williams, Bradbury & Fitzgerald

F. W. CHADBOURNE.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED SEPT. 14, 1916.

1,326,129.

Patented Dec. 23, 1919.
3 SHEETS—SHEET 3.

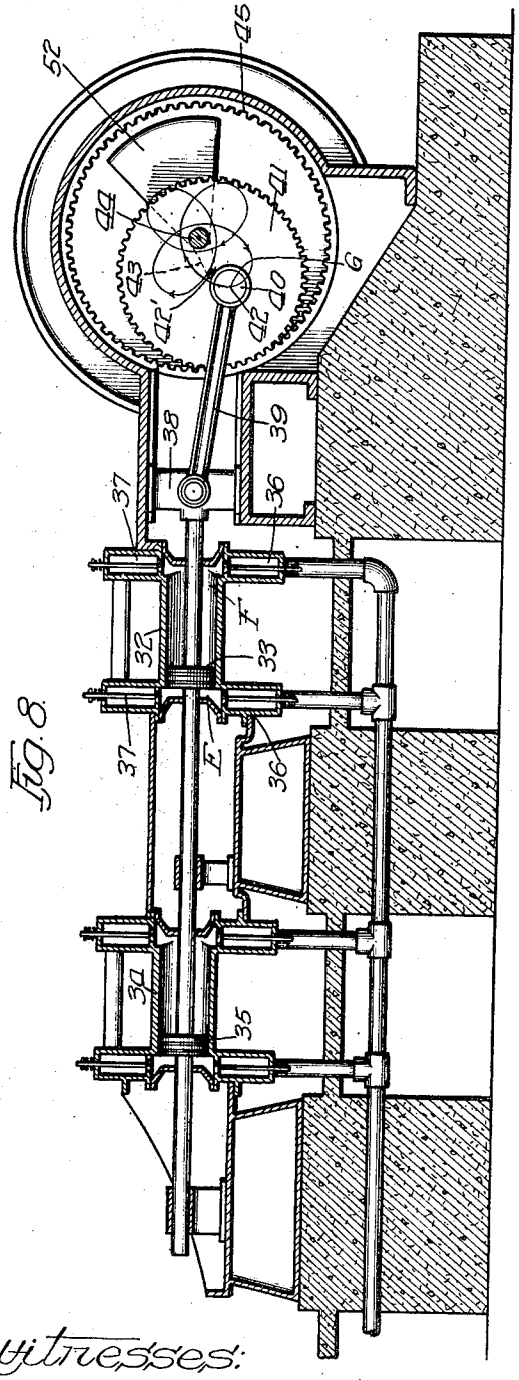


Fig. 8.

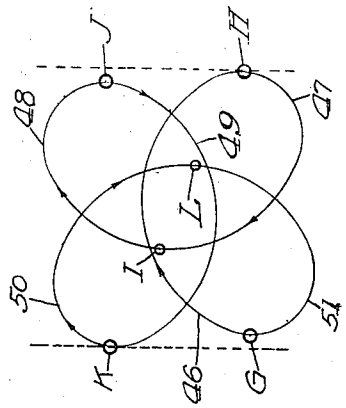


Fig. 9.

Witnesses:
Arthur W. Carlson
Robert F. Baacke

Inventor.
Franklin W. Chadbourne
Williams, Bradbury & Sears
Attys.

UNITED STATES PATENT OFFICE.

FRANKLIN W. CHADBOURNE, OF FOND DU LAC, WISCONSIN.

INTERNAL-COMBUSTION ENGINE.

1,326,129. Specification of Letters Patent. Patented Dec. 23, 1919.

Application filed September 14, 1916. Serial No. 120,014.

To all whom it may concern:

Be it known that I, FRANKLIN W. CHADBOURNE, a citizen of the United States, residing at Fond du Lac, in the county of Fond du Lac and State of Wisconsin, have invented a certain new and useful Improvement in Internal-Combustion Engines, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to internal combustion engines and has for its object the provision of improved mechanism for imparting to the working piston of an internal combustion engine variable strokes to produce a highly efficient engine.

The device of my invention relates particularly to a four-cycle engine wherein four strokes of the piston are required to complete one cycle of operation. In such an engine one stroke of the piston is utilized to take in a certain quantity of combustible gases, a second stroke to compress such gases, a third stroke commonly known as the power stroke, produced by the ignition of the compressed gases, and a fourth stroke which serves to exhaust the burned gases. It is the object of the present invention to impart to the engine piston a variable stroke movement so that the piston on its power stroke is permitted to travel a greater distance than the distance it travels during the intake stroke, thus utilizing the full power of the expanding gases. In the usual internal combustion engine wherein a constant stroke piston is employed the gases at the end of the power stroke contain a pressure considerably above that of atmosphere, which, of course, is not utilized since the piston is not permitted to obtain the full benefit of the pressure contained by the gases.

A further object of the invention is to provide means whereby the piston is on its scavenging stroke moved entirely to the head of the working cylinder, thereby completely scavenging the cylinder of the burned or inert gases and thus preventing a fresh charge from becoming contaminated with the burned gases of the previous explosion. Although the piston is arranged to move entirely up to the head of the cylinder during the scavenging stroke it is arranged to move upon the compression stroke only to a point in the cylinder some distance away from the head thereof, thus providing a space in which the gases are compressed and ignited prior to the power stroke of the piston.

Various means and mechanisms have been employed in the past to obtain this result, but the mechanism provided for such purpose has been complicated and mechanically imperfect, thus providing a reduction of efficiency which would offset the efficiency intended by the variable piston reciprocation. By my invention I provide associated with the usual crank shaft of the engine hypotrochoidal gearing, which gearing is connected with the connecting rod of the engine piston. The hypotrochoidal gearing consists of the usual fixed internal gear and a second rotatable gear arranged to mesh with the internal gear. The second gear is rotatably mounted on the crank arm of the crank shaft and is connected with the connecting rod of the engine piston at a point eccentric to the gear.

Although the device of my invention may be applicable to other mechanical devices in which a variable stroke reciprocating member is employed, I have illustrated in the accompanying drawings my invention applied to internal combustion engines. In the drawings I have illustrated two forms of engines provided with the device of my invention, although it will be understood after reading the following description that it may be employed in connection with other forms of gas engines. These and other objects of my invention will be more clearly pointed out in connection with the accompanying drawings, wherein

Figure 1 is a vertical cross sectional view of a common internal combustion engine provided with the device of my invention for imparting to the engine piston a variable reciprocating movement;

Fig. 2 is a horizontal cross sectional view taken along the line 2—2 of Fig. 1 and looking in the direction indicated by the arrows;

Fig. 3 is a detail view of the lower end of the connecting rod and the path taken by it during a complete cycle of engine operation;

Fig. 4 is a diagrammatical view similar to

Fig. 1, showing the position of the hypotrochoidal gearing at the end of the piston compression stroke;

Fig. 5 shows the gearing at the end of the power stroke;

Fig. 6 illustrates the position of the gearing at the end of the exhaust stroke, and

Fig. 7 the position of the gearing and piston at the end of the intake stroke;

Fig. 8 is a vertical cross sectional view of a double acting engine in which power is applied to both sides of a single piston; and

Fig. 9 is a view illustrating the path taken by the outer end of the piston connecting rod, shown in Fig. 8, during a complete cycle of engine operation.

Similar characters of reference refer to similar parts throughout the several views.

Referring first to Fig. 1, 10 illustrates the working cylinder of the internal combustion engine and 11 the crank case in which is journaled the crank shaft 12. The engine cylinder 10 is provided with the intake port 13 and the exhaust port 14, the intake port being controlled by the intake valve 15 and the exhaust port by the exhaust valve 16. Suitable mechanism is employed as illustrated at 17 and 18 operated through the engine crank shaft for opening and closing the exhaust and intake valves at the desired points of the engine cycle, all of which mechanism is common and need not therefore have any further description.

Reciprocably mounted within the working cylinder 10 is a piston 19 to which is attached the usual connecting rod 20. The lower end of the connecting rod 20 is secured by means of the straps 21 to a boss 22 attached to or forming a part of a spur gear 23. As most clearly illustrated in Fig. 1, the boss 22 is mounted eccentric to the gear 23, or in other words, the center of the boss is positioned on one of the radii of the gear 23. The center of the gear 23 is rotatably mounted on the crank pin 24 of the crank arm 25, and is arranged to mesh with a fixed internal gear 26 rigidly held by the crank casing 11. The ratio between the internal gear and the spur gear when the device of my invention is employed in connection with an engine, as illustrated in Fig. 1, is 3 to 2, in which case twice the distance from the center of the crank shaft 12 to the center of the crank pin 24 is equal to one-half the diameter of the spur gear 23 and one third the diameter of the internal gear 26. The position of the gears and piston when the engine is in a position or condition to ignite the compressed gases is illustrated in Fig. 1. As the gases are ignited and expanded the piston 19 is, of course, moved downwardly with the result that the crank 12 is given a counter clockwise rotation (Fig. 1). As the crank is thus moved in a counter clockwise direction in this figure the gear 23, due to its connection with the internal gear 26, is caused to rotate in a clockwise direction as indicated by the arrow. As a result of both of these movements, that is, the rotation of the gear 23 upon the internal gear 26 and the rotation of the crank shaft and thus the gear 23 around the axis of the crank shaft, the end of the connecting rod is forced to take the path of a hypotrochoidal curve which is illustrated in Fig. 3, the arrows on the curve illustrating the direction of movement of the lower end of the connecting rod or of the central point of the boss 22.

The variable strokes of the piston 19 are produced by the hypotrochoidal gears in the following manner. Starting with the beginning of the compression stroke or at the end of the intake stroke of the piston, the central point 27 of the boss 22 assumes the position A illustrated in Figs. 3 to 7 inclusive, the hypotrochoidal gearing in such instance assuming the relative positions illustrated in Fig. 7, and the piston assuming the position illustrated in this last mentioned figure. As the crank shaft is rotated in the direction indicated by the arrow 28, the gear 23 is rotated around the internal gear 26 to the position illustrated in Fig. 4, thus causing the point 27 of the boss 22 to move in the path indicated at 29 in Fig. 4 to the point B. Attention is called to the fact that when the point 27 reaches the position illustrated in Fig. 4 the piston is moved to a point somewhat below the head of the cylinder 10, thus providing a space in which the gases are compressed and permitted to ignite. As the lower end of the connecting rod therefore moves along the path 29 to the position illustrated in Fig. 4, the piston is moved upwardly to compress the combustible gas, thus providing the compression stroke of the engine. As power is applied to the piston, due to the ignition of the compressed gases, the crank shaft is given rotation in the direction indicated and the spur gear 23 forced to roll around the internal gear 26 to the position illustrated in Fig. 5. The central point 27 of the boss 22 will in such movement of the gear 23 traverse the path illustrated at 30 to the point C, thus enabling the piston to take a stroke which is longer than the piston stroke which compressed the gases. As the crank shaft continues to rotate, the gear 23 is moved to the position illustrated in Fig. 6, with the result that the central point 27 of the boss traverses the path 31 to the point illustrated at D. This last mentioned movement along the path 31 of the lower end of the connecting rod serves to move the piston to the position illustrated in Fig. 6, thus completely exhausting the burned or used gases. Attention is directed to the fact that the point D which is reached by the point 27

of the boss 22 at the end of the exhaust stroke is located in a plane higher than the plane of the point B reached at the end of the compression stroke of the piston, thus enabling all or practically all of the burned gases to be scavenged from the cylinder. As the crank shaft continues to rotate the gear 23 is moved to the position illustrated in Fig. 7, thus returning the point 27 of the boss to the position A and moving the piston downwardly to the position illustrated in Fig. 7 to perform the intake stroke. It will thus be seen that the power stroke of the piston is considerably longer than the intake stroke thereof, with the result that all the power of expanding gases is utilized in rotating the crank shaft. The hypotrochoidal gearing is so constructed and arranged that the curve produced by it is slightly tipped, as illustrated in Fig. 3, so that the point D lies in a plane beyond the point B, with the result that the piston reaches the head of the cylinder upon its exhaust stroke, and reaches to a point short of the head of the cylinder on its compression stroke.

Although I have described the mechanism of my invention associated with but one cylinder of an engine it is apparent that as many cylinders as desired may be employed, the crank shaft in such case extending under all the cylinders and coöperating with mechanism identical with that illustrated in Fig. 1. The crank shaft 12 has secured to it the usual fly wheel 12^1 preferably located outside of the crank casing.

In Fig. 8, 32 illustrates an engine cylinder in which is reciprocably mounted a piston 33. If desired, a second cylinder 34 may be provided and a coöperating piston 35 for the cylinder 34, the pistons 33 and 35 being connected in tandem. The engine illustrated in this figure is a double acting engine, in which power is applied to both sides of each piston 33 and 35. Each cylinder 32 and 34 contains two pairs of valves 36 and 37, one valve of each pair serving as the intake valve and the other valve of each pair serving as the exhaust valve. The pistons are connected to the cross head 38 in turn attached to the connecting rod 39. The outer end of the connecting rod 39 is mounted around a boss 40 attached to or formed integral with the spur gear 41. The central point 42 of the boss 40 is located eccentric to the gear 41 as shown in Fig. 8. The center of the gear 41 is rotatably mounted on a crank pin 42′ carried by the crank arm 43 of the crank 44. The gear 41 is arranged to mesh with the internal gear 45 rigidly fixed to the engine casing. Due to the double acting feature of the engine illustrated in this figure it is necessary to have the outer end of the connecting rod, or in other words, the center point 42 of the boss 40 describe a curve somewhat different than the curve or path followed by the point 27 of the boss 22 of the device illustrated in Fig. 1. To obtain therefore the necessary curve of the outer end of the connecting rod or path through which the outer end of the connecting rod moves, the gear ratio between the internal gear 45 and the external gear 41 is made 4 to 3, with the result that the central point 42 of the boss 40 takes the path of the hypotrochoidal curve illustrated in Figs. 8 and 9.

In describing the operation of the device illustrated in Figs. 8 and 9, let us consider the cylinder 32 as being divided into the two working chambers or cylinders E and F, one on each side of the piston 33. When the piston 33 is in the position illustrated in Fig. 8 and the boss 40 in the position shown, the piston 33 is at the end of the compression stroke with regard to the cylinder E, and at the end of an air intake stroke with regard to the cylinder F, as will subsequently be described. As the compressed gases are ignited in the cylinder E, power is applied to the piston 33 and the crank 44 given a counter clockwise rotation (Fig. 8). As the crank is thus moved in the direction referred to the central point 42 of the boss 40 is moved from the position G along the path 46 to the point H, thus permitting the piston 33 to reach entirely up to the head of the cylinder F and scavenge the last mentioned cylinder. The movement of the boss 40 along the path 46, of course, serves as the power stroke when the cylinder E is considered. As the crank shaft continues to rotate in the direction indicated and referred to the point 42 is moved along the path 47 to the point I, thus providing an intake stroke for the cylinder F. As the point 42 is moved from the position H to the position I along the path 47 the exhaust valve cooperating or communicating with the cylinder E is opened by suitable well known cam mechanism, thus permitting the cylinder E to be partly scavenged of the burned or used gases previously ignited. A continued rotation of the crank 44 moves the point 42 of the boss from the point I along the path 48 to the point J. This last mentioned movement along the path 48 serves to move the piston 3 to compress the gases taken into the cylinder E and causes air to be taken through the exhaust valve of the cylinder E, the exhaust valve of the cylinder E being held open during the stroke 48. As has been described, the piston 33, when the point 42 of the boss 40 reaches the position H, is moved up to the head of the cylinder F, thus completely scavenging the cylinder, but when the point 42 traverses the path 48 to the position J the piston is moved to a point a certain predetermined distance from the head of the cylinder F, thus providing a space for

the compressed gases. As the crank shaft continues to rotate the point 42 of the boss travels along the path 49 to the position K. This stroke serves as the complete scavenging stroke of the cylinder E and the power stroke of the cylinder F, the piston 33 upon this stroke reaching the head of the cylinder E to completely scavenge the burned gases which were only partly scavenged during the stroke illustrated by the path 47. Continued rotation of the gear 43 moves the point 42 of the boss along the path 50 to the point L, which stroke serves as the intake stroke for the cylinder E and a partial scavenging stroke for the cylinder F. Further rotation of the crank moves the point 42 along the path 51 to the point G, thus providing a compression stroke for the cylinder E and a partial air intake stroke for the cylinder F, the exhaust valve of the cylinder F during this last mentioned stroke being held open to permit the intake of air, if such is necessary.

It will be seen from the foregoing description that the power stroke of the piston 33 when considered in connection with either one of the cylinders E or F is considerably longer than the intake stroke of the piston in connection with that particular cylinder, and that the piston is arranged to move clear to the cylinder heads of both of the cylinders during the exhaust strokes of such cylinders and that the piston is arranged to move only part way to the head of both of the cylinders when compression of the gases is to take place in the cylinders. To provide the non-alinement of the points J and H and of the points K and G of the curve the hypotrochoidal mechanism is so arranged that the curve produced by the point 42 positioned on a radius of the gear 41 is slightly tipped, as illustrated in Figs. 8 and 9 to bring the curve formed by the paths 49 and 50 beyond the curve formed by the paths 46 and 51, and to bring the curve formed by the paths 47 and 46 beyond the curve formed by the paths 48 and 49.

To counterbalance the weight of the gear 41 on the crank shaft 44 I provide a counterweight 52 having substantially the weight of the gear 41 and fixed to the crank shaft at a point diametrically opposite the crank pin 42'. In the device illustrated in Fig. 1 I provide a similar counterweight 57 secured to the crank shaft 12 and positioned diametrically opposite the crank pin 24, the weight of the counterweight 57 being the same as the weight of the gear 23.

In the device illustrated in Fig. 1 the crank shaft makes two complete revolutions for each complete cycle of engine operation, whereas in the device illustrated in Figs. 8 and 9 the crank shaft is given three complete revolutions for each complete cycle of engine operation, the pistons in the device illustrated in Fig. 8 performing six strokes, two for each revolution of the crank shaft, for each cycle.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an internal combustion engine the combination with a crank, a cylinder, a piston reciprocably mounted within the cylinder and a piston connecting rod, of a stationary internal gear, a second gear rotatably mounted on the crank arm and meshing with the internal gear, and means for connecting the piston connecting rod with the said second gear at a point eccentric to the gear, the ratio of said internal gear to said second gear being less than two to one.

2. The combination of a reciprocable member, a fixed internal gear, a second gear meshing with the internal gear and having a diameter greater than the radius of said internal gear and means for connecting the reciprocable member with the second gear at a point eccentric to the second gear for producing a variable stroke movement to the reciprocating member.

3. In an internal combustion engine the combination with a crank, a cylinder, a piston reciprocably mounted within the cylinder and a piston connecting rod, of a fixed internal gear having a diameter greater than the radius of said internal gear, a second gear rotatably mounted on the crank arm and meshing with the internal gear, and means for connecting the piston connecting rod with the said second gear at a point eccentric to the gear, the said gears being so assembled relatively to each other that when said piston is at the outer end of its exhaust stroke said eccentric point is nearer said cylinder than when said piston is at the outer end of its compression stroke.

4. In an internal combustion engine the combination with a crank shaft, a cylinder, a piston reciprocably mounted within the cylinder and a piston connecting rod, of an internal gear, a second gear having a diameter greater than the radius of said inner gear rotatably mounted on the crank arm and meshing with the internal gear, means for connecting the piston connecting rod with the said second gear at a point eccentric to the gear and a counterweight carried by the crank shaft at a point diametrically opposite the crank arm and second gear.

5. In an internal combustion engine the combination with a crank shaft, a cylinder, a piston reciprocably mounted within the cylinder and a piston connecting rod, of means for causing said piston to alternately move through strokes of different length comprising a fixed internal gear, a second gear rotatably mounted on the crank arm and meshing with the internal gear, and means for connecting the piston connecting

rod with the said second gear at a point between the center of said gear and its periphery.

6. An internal combustion engine comprising a cylinder, a piston reciprocable therein, a stationary inner gear, and means connecting said inner gear and said piston and lying wholly within the circumference of said inner gear, for giving said piston strokes of variable length.

7. An internal combustion engine comprising a cylinder, a piston reciprocable therein, a stationary inner gear, and means connecting said inner gear and said piston for giving said piston strokes of variable length.

In witness whereof, I hereunto subscribe my name this 8th day of September, A. D. 1916.

FRANKLIN W. CHADBOURNE.

Witnesses:
MARY A. COOK,
ROBERT F. BRACKE.