Dec. 4, 1923. 1,476,309

C. J. TÓTH

INTERNAL COMBUSTION ENGINE

Filed May 3, 1922 3 Sheets-Sheet 1

Fig. 1.

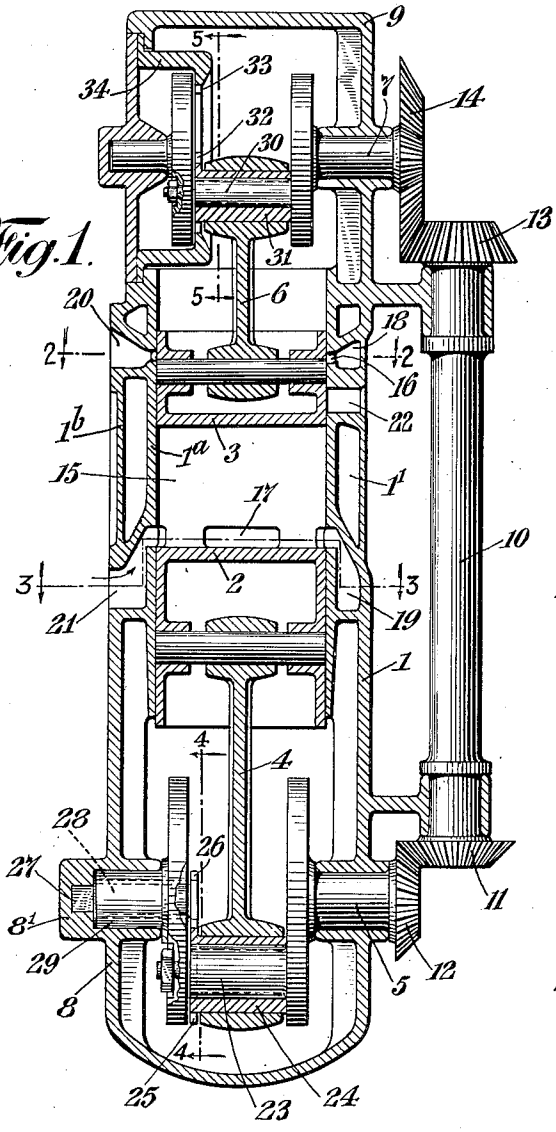


Fig. 5.

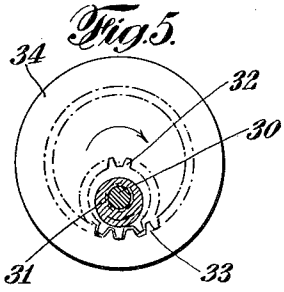


Fig. 2.

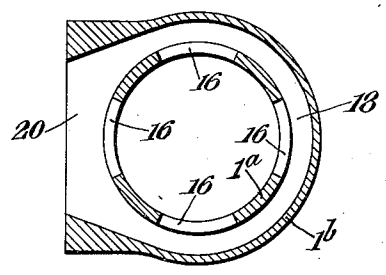


Fig. 3.

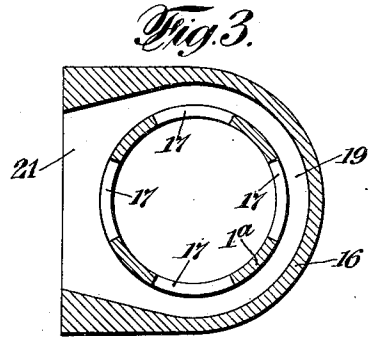
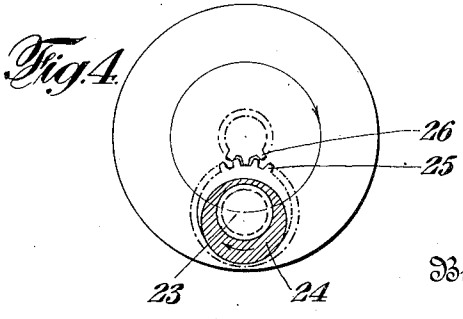


Fig. 4.



Inventor
Charles J. Tóth
By his Attorneys
Ward Crosby and Smith

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Fig. 6.

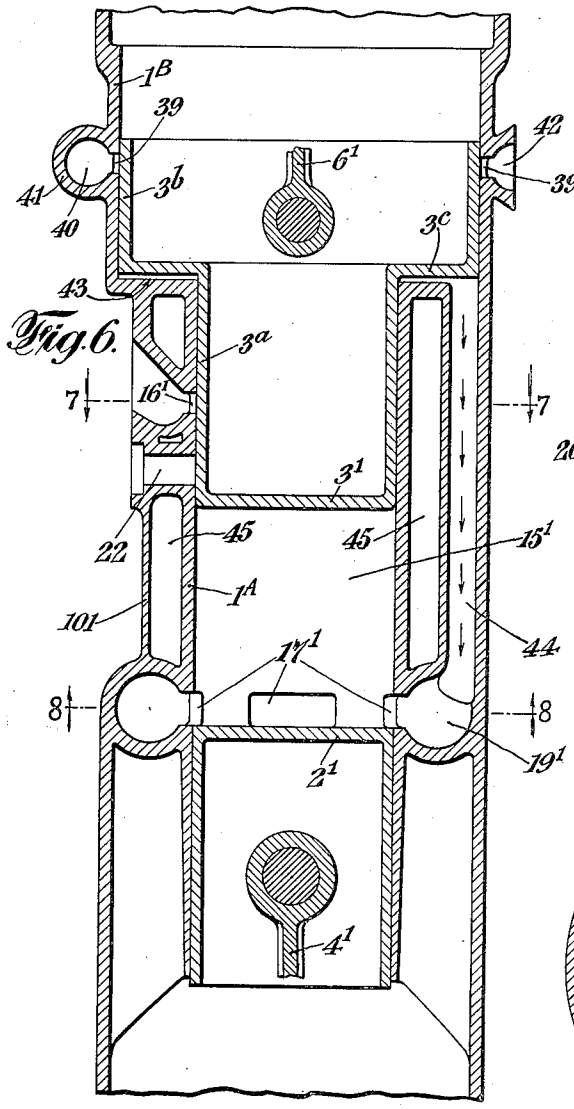


Fig. 7.

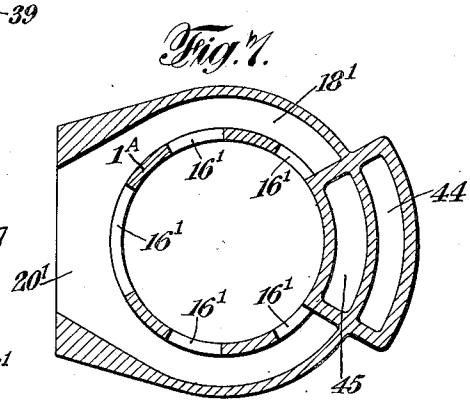
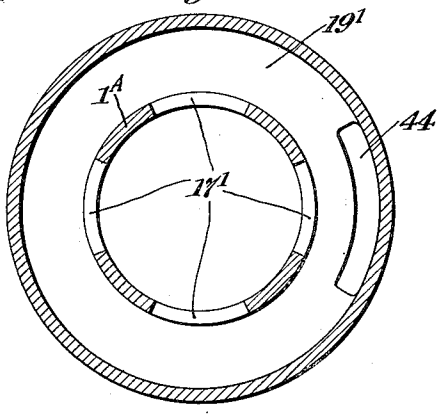


Fig. 8.



Inventor
Charles J. Tóth
By his Attorneys
Ward, Crosby and Smith

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C. J. TÓTH

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Fig. 10.

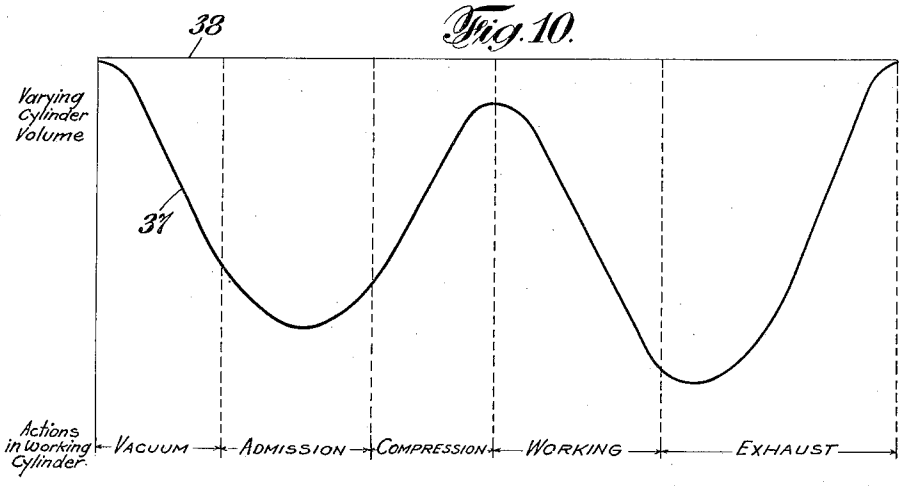
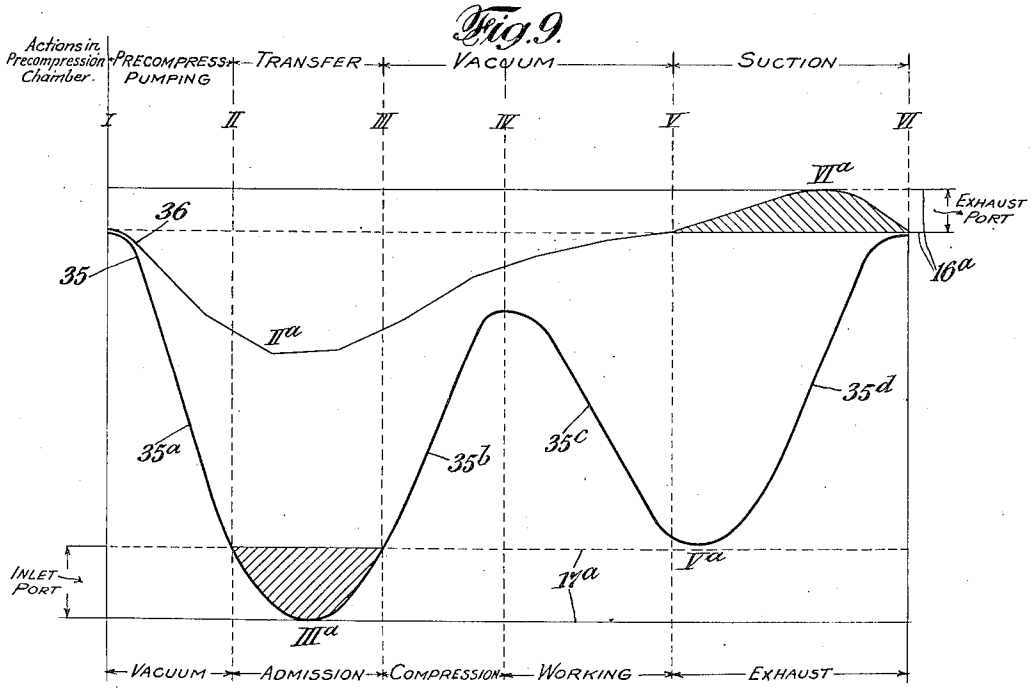


Fig. 9.



Inventor
Charles J. Tóth

By his Attorneys
Wood Crosby and Smith

Patented Dec. 4, 1923. 1,476,309

UNITED STATES PATENT OFFICE.

CHARLES J. TÓTH, OF STAPLETON, NEW YORK, ASSIGNOR TO INTERNATIONAL PROCESS AND ENGINEERING CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

INTERNAL-COMBUSTION ENGINE.

Application filed May 3, 1922. Serial No. 558,102.

To all whom it may concern:

Be it known that I, CHARLES J. TÓTH, a citizen of the Republic of Uruguay, and resident of Stapleton, New York city, county of Richmond, and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

The invention relates to improvements in internal combustion engines and includes among its objects the provision of novel structures of great simplicity of high economy and efficiency.

Another object of the invention is the provision of a four cycle internal combustion engine which may operate entirely without valves of any sort, the exhaust and inlet ports of the engine being controlled at suitable times by a pair of pistons. The two pistons in the preferred form of construction reciprocate towards and away from each other in a cylinder open at both ends so as to provide a combustion chamber between the same. The movements of these two pistons are caused and controlled by such means as to cover and uncover the exhaust and inlet ports at the proper times.

In the present invention, also, the construction is such, broadly speaking, that a pair of relatively movable members are mounted in the cylinder, at least one of which serves as a movable piston, the combustion chamber being established between the two members. The combustion space is varied in volume in such a manner that various desirable effects are obtained. One of these effects is that the volume of this space increases to a greater maximum during the working or expansion stroke of the engine, than it does during the admission stroke. The expanding charge performs useful work throughout its expansion. Accordingly the expansion of the compressed charge after explosion or combustion of the same will proceed to a greater degree than is possible with engines in which the maximum volume of the cylinder is the same during admission as during expansion, with resulting economy.

Another effect obtained by the construction is that the volume of the space between the two pistons may be made considerably less at the end of the exhaust stroke than it is at the time of the explosion of the charge at the end of the compression stroke. The two pistons may come practically together at the end of the exhaust stroke, to effect scavenging of practically 100% efficiency.

The effects referred to are obtained by connecting one piston to one crank shaft rotating at one speed and connecting the other piston to a second crank shaft rotating at a different speed. The movements of the two pistons are so timed as preferably to bring the pistons very close together at the end of the exhaust stroke to scavenge the cylinder positively and quite completely and to separate the pistons to one extent during admission and to separate them to a greater extent during expansion of the charge after explosion thereof so as to provide an increased expansion.

In accordance with one form of my present invention, also, means are provided whereby the intaken charge, comprising the usual mixture of gas and air, or of fresh air, may be precompressed in an effective manner before its admission into the combustion chamber of the cylinder.

Other features and advantages of the invention will be more fully described hereinafter. The objects of the invention include the provision of various combinations, and sub-combinations and features of construction all as will be more fully set forth hereinafter.

In order that the invention may be more clearly understood attention is hereby directed to the accompanying drawings illustrating by way of example one embodiment of the invention.

In the drawings—

Fig. 1 represents a vertical section taken through one form of construction embodying the invention;

Figs. 2 and 3 are horizontal sections taken respectively on line 2—2 and line 3—3 of Fig. 1;

Figs. 4 and 5 are vertical sections taken respectively on line 4—4 and line 5—5 of Fig. 1;

Fig. 6 is a partial vertical section taken through a modified form of construction embodying the invention;

Figs. 7 and 8 are horizontal sections taken respectively on lines 7—7 and 8—8 of Fig. 6;

Fig. 9 is a diagram representing the operation and working conditions of the engine illustrated in either Fig. 1 or Fig. 6, and

Fig. 10 is a diagram representing the

varying distances between the two pistons in the cylinder, or the varying volumes of the combustion chamber, during the operation of the engine.

Referring first to Figs. 1 to 5 of the drawings, an engine is represented comprising a duplex cylinder contained within a casting 1. The cylinder is represented as positioned vertically although it may be otherwise positioned. The cylinder may be provided with water jackets such as the water jacket indicated at 1^1 or it may, of course, be provided with properly designed cooling fins, if air cooling of the cylinder is preferred.

A pair of pistons 2 and 3 are arranged to reciprocate within the duplex cylinder towards and away from each other, a combustion chamber or space 15 being provided between the same. Piston 2 is connected by means of connecting rod 4 to the crank shaft 5 and piston 3 is connected by means of connecting rod 6 to the crank shaft 7. Crank shaft 5 is mounted in suitable bearings arranged in crank case 8 and crank shaft 7 is mounted in bearings in crank case 9. These crank casings may be suitably secured to or formed as continuations of the cylinder casting. As shown the lower crank case 8 may be integral with the cylinder casting while the upper crank case 9 may comprise a portion integral with the cylinder casting and a portion or portions secured thereto.

The two crank shafts are suitably connected together in such a manner as to cause one of the same to rotate at a fraction of the speed of the other. As shown a shaft 10 may be provided parallel to cylinder 1 and mounted in suitable bearings extending from the cylinder casting. Crank shaft 5 may be connected to shaft 10 by bevel gears 12 and 11 on the crank shaft and the lower end of shaft 10 respectively, which gears are of equal size. Crank shaft 7 is shown as connected to shaft 10 by bevel gears 14 and 13 on crank shaft 7 and the upper end of shaft 10 respectively, gear 14 having twice the number of teeth of the gear 13. Accordingly crank shaft 7 will rotate at one-half the speed of crank shaft 5. Shaft 10 may be the main driven shaft of the engine.

The combustion chamber 15 is contained within the inner wall of the cylinder casting between the faces of the working pistons 2 and 3. The cylinder casting has a series of openings 16 extending through the inner wall thereof for the purposes of exhaust (Fig. 2). It also has a series of openings 17 extending through its inner wall at a different point in the length of the cylinder, these being inlet openings (Fig. 3).

The exhaust openings 16 may be, and preferably are, equally spaced about the circumference of the cylinder. They lead into the annular space 18 between the inner and outer walls, 1^a and 1^b, respectively, of the casting. An opening 20 extends from this annular space into the open air, or may communicate with a suitable exhaust muffler. The intake openings 17 similarly may be and preferably are equally spaced around the periphery of the inner wall 1^a of the cylinder and lead into the annular space 19 between the inner and outer walls. An opening 21 extends through the outer wall of the cylinder into this annular space 19. It may communicate with a suitable carburetor or with the open air, it being understood that the engine may operate on the usual gaseous mixture, or may operate on fresh air, in case liquid fuel is injected into the combustion chamber at suitable times in the well known manner. An opening 22 is indicated as extending through the cylinder casting in which a spark plug or a fuel injection device may be positioned as the case may be; such opening being properly positioned to communicate with the combustion chamber at the times when the compressed mixture is to be fired, or when liquid fuel is to be injected into the charge of compressed air, as the case may be.

Inlet ports 17 are controlled entirely by piston 2 and exhaust ports 16 entirely by piston 3. In order to properly control the admission of charge to the cylinder, piston 2 must move in such a manner as to uncover the inlet ports towards the end of one outward stroke, and must keep these ports covered during all of the succeeding outward stroke. That is to say, piston 2, after the exhaust of burnt gases has been completed, will have an outward stroke towards the end of which the inlet ports will be uncovered. During the following inward stroke of piston 2 compression will take place in the combustion chamber, after which piston 2 moves outwardly again on its working or expansion stroke, which is followed by the inward or exhaust stroke of piston 2; and the outward working or expansion stroke must be so arranged as not to uncover the inlet ports. Piston 3 must be so moved as to keep exhaust ports 16 closed at all times except during the period of exhaust, when, as stated, piston 2 will be moving inwardly after its working or expansion stroke.

These movements are accomplished by operating piston 2 in such a manner that it will be given what may be termed a variable stroke while piston 3 will be operated in such a manner that it will be retarded in its outward stroke and accelerated in its inward stroke, as will be more fully explained hereafter.

The cylindrical portions of the pistons must be long enough to keep the ports covered at all proper times. Piston 2 is

shown as longer than piston 3, since piston 2 will be given a longer stroke than piston 3, as will be explained.

The movements of the pistons referred to are accomplished, in the embodiment of the invention illustrated herewith, in the following manner. The crank pin 23 of crank shaft 5 has an eccentric bushing 24 rotatably mounted thereon. This bushing is integral with or rigidly secured to a spur pinion 25 which is coaxial with crank pin 23, as is shown in Fig. 4. Pinion 25, concentric with crank pin 23, meshes with a pinion 26 which is fixed in position. Pinion 26 has a stub shaft 28 secured thereon or integral therewith, which extends through the portion 29 of crank shaft 5, portion 29 of the crank shaft having a bore therethrough within which stub shaft 28 is mounted, so that portion 29 of the crank shaft will be rotatable thereabout. Stub shaft 28 has an end portion 27 which extends beyond the end of the crank shaft and is fixedly mounted within the boss 8^1 of the crank case. The end portion 27 of the stub shaft may conveniently be squared and the opening in boss 8^1 made to fit the same so as to prevent rotation of the stub shaft and of pinion 26 thereon.

Pinion 26 may be of one-half the diameter and have one-half the number of teeth of pinion 25. Accordingly when crank shaft 5 rotates, gear 25 and eccentric bushing 24 will rotate about the crank pin 23 at one-half the speed of the crank shaft, that is to say, the bushing will make one complete revolution about the crank pin during every two revolutions of the latter about the axis of the crank shaft. Bushing 24 being eccentrically mounted upon the crank pin, as stated, its rotation about the crank pin will vary the angularity of connecting rod 4 and will correspondingly affect the reciprocation of piston 2.

It will be noted, for example, that in Fig. 1 the upper face of piston 2 has uncovered inlet openings 17, crank pin 23 being at its lower dead center position and the axis of bushing 24 being in its lowest position. At the end of the next downward movement of piston 2 the axis of bushing 24 will be above the axis of crank pin 23, in its highest position, and ports 17 will remain covered by piston 2, since the height of ports 17 is somewhat less than twice the distance betwen the axis of crank pin 23 and the axis of bushing 24 (see Figs. 1 and 4).

Crank pin 30 of crank shaft 7 is provided with an eccentric bushing 31 which is integral with or secured to a spur gear 32, concentric with the crank pin, the bushing and gear being rotatably mounted on the crank pin. Gear 32 constantly meshes with an internal gear 33 which is of twice its size, the internal gear being fixedly mounted. Gear 32 is co-axial with crank pin 30 while internal gear 33 is coaxial with the crank shaft. The pitch circle of gear 32 is the same in diameter as the stroke circle of crank pin 30. Accordingly when crank pin 30 rotates bushing 31 will rotate about the crank pin at twice the angular speed of the latter, gear 32 constantly meshing with internal gear 33. That is to say, the bushing will make two revolutions about the crank pin during each revolution of the latter about the axis of crank shaft 7. The rotation of the eccentric bushing about the crank pin will affect the angular position of connectind rod 6 and will accordingly vary the travel of piston 3. By properly proportioning the stroke of crank pin 30 and the amount of eccentricity of bushing 31 the result may be reached of causing piston 3 to move outwardly through a major portion of the crank shaft revolution. In the construction illustrated the piston 3 will move outwardly during approximately 240° of crank shaft revolution and will make its inward stroke during the remaining 120° of the crank shaft revolution. The stroke circle of crank 30 as shown is considerably smaller in radius than the stroke circle of crank 23.

The internal gear 33 may be fixed in position within crank case 9 in any suitable manner. As is shown in the drawings, it may be carried by a cylindrical member 34 which is secured in position within the crank case.

The operation of the engine as described will be more clearly understood in connection with the diagrams shown in Figs. 9 and 10 of the drawings. Fig. 9 illustrates graphically the travel of the two pistons and the control of the inlet and exhaust ports thereby during two complete revolutions of crank shaft 5 and the corresponding one revolution of crank shaft 7.

The travel of the variable stroke piston 2 is indicated by line 35. The first outward stroke of piston 2 is indicated by the downwardly extending portion 35^a of line 35, the next inward stroke of the piston by the portion 35^b, the next outward stroke by portion 35^c and the second inward stroke, completing the cycle, by portion 35^d of the line. It will be noted that the outward stroke indicated by portion 35^a of the line is longer than the next outward stroke represented by portion 35^c of line 35. At the end of the first outward stroke of piston 2 crank 23 of the lower crank shaft will be in its lower dead center position with eccentric bushing 24 in its lowest position, the parts being in the positions indicated in Figs. 1 and 4 of the drawings. This is the position indicated in Fig. 9 by the designation III^a. At the end of the next outward stroke of piston 2, at the position indicated by V^a in Fig.

9, the axis of eccentric bushing 24 will be in its uppermost position, so that piston 2 will not travel outwardly so far.

The line 36 represents the travel of the half speed piston 3. Beginning at the starting position I, the piston 3 will move inwardly or downwardly while piston 2 is moving outwardly or downwardly, piston 3 reaching its lowest position, that is its furthest inward position, at the position II^a. From this position piston 3 moves outwardly or upwardly on its retarded outward stroke until the position VI^a is reached a short time before the end of the last inward movement of piston 2 represented by portion 35^d on line 35. Piston 3 begins its accelerated inward stroke at position VI^a, this inward stroke extending through position VI at the end of the diagram, which represents the same point as does I at the beginning of the diagram, and from this position to the position II^a previously referred to.

With this explanation the operation of the engine may now be described further in detail. At the position I both pistons are close together and the volume of the combustion chamber contained between them at this point may be very slight, the pistons coming as close together as mechanical construction permits. The full speed piston 2 starts on what may be termed its long out stroke while, as stated, piston 3 is moving inward. The volume of the space between the two pistons will be rapidly increased in spite of the fact that both pistons are moving in the same direction. This increase in volume or distance separating the two pistons will, of course, occur because of the greater speed and also the greater stroke of piston 2 in comparison with piston 3. During this movement of the piston no openings communicating with the interior of the cylinder will be uncovered until piston 2 has traveled outwardly far enough to uncover inlet opening 17. Accordingly a comparatively high vacuum will be produced in the combustion chamber during this time, until the inlet ports are opened by piston 2.

It should be stated that the five successive conditions or states of action within the cylinder are indicated at the bottom of the diagrams Figs. 9 and 10, by the words "vacuum", "admission", "compression", "working", and "exhaust", these periods occurring respectively between the positions I and II, II and III, III and IV, IV and V, and V and VI. The wording at the top of Fig. 9 "Precompress. pumping", "Transfer", "Vacuum" and "Suction" refer to conditions in the precompression chamber of the modified form of construction shown in Figs. 6 to 8 of the drawings and may accordingly be ignored in connection with the present description.

At the position II the full speed piston begins to uncover inlet ports 17. These ports will be fully opened at position III^a and will again be fully closed at position III, when piston 2 has again moved inwardly on its succeeding inward stroke, sufficiently to cover these ports. Fresh charge will rush into the cylinder with considerable speed during all the time that the inlet ports are opened.

Piston 3 starts its outward stroke, as stated, at position II^a, during the time the inlet ports are open. Shortly thereafter both pistons will again be moving in the same direction, during the time that piston 2 is moving inwardly on its stroke indicated at 35^b. The piston 3, however, is moving with relatively slow speed and small travel and therefore, the volume of the space between the two pistons will be rapidly decreased and the intaken charge will be compressed between the two pistons until the position IV is reached. At, or near, this position the ignition of the compressed charge occurs.

The full speed piston 2 now starts its second outward stroke while the half speed piston continues its outward stroke. The expansion of the ignited charge now takes place performing work upon both pistons. The volume of the space contained between the two pistons will now rapidly be increased, because of the fact that both are moving outwardly or away from each other.

At position V piston 3 has moved outwardly far enough to begin to uncover the exhaust ports 16 and the exhaust of the burnt gases from the cylinder commences. Piston 2 completes its second outward stroke at position V^a, this occurring at or shortly after the time the exhaust ports begin to open. As has been stated, piston 2 does not move outwardly far enough at this time to uncover the inlet ports, its furthest outward movement extending only to a point at which the inner face of piston 2 is slightly above or inwardly with respect to the inlet ports. It will be understood that the width or height of the inlet ports is represented in the diagram, Fig. 9, by the distance between the two horizontal lines 17^a, while the height or width of the exhaust port openings is indicated by the distance between the two horizontal lines 16^a.

Piston 2 moves inwardly from position V^a until the position VI is reached. During this movement the exhaust port openings have been gradually opened by piston 3 from position V to VI^a and then more rapidly closed from position VI^a to position VI. At this last position the two pistons have moved very close together so that the cylinder volume is decreased almost to zero, and the burnt gases will have been entirely swept out from the interior of the cylinder. The two pistons moving towards each other dur-

ing the latter part of the exhaust period will act positively to scavenge or sweep the burnt gases from the cylinder.

In Fig. 10 I have illustrated graphically the varying cylinder volume during the operation of the engine. For this purpose the curve 37 has been plotted from a horizontal base line 38 so that the distance between the two pistons, or the volume of the combustion chamber at any time, will be given by the vertical distance between lines 37 and 38 at the point in question. It will be noted from this diagram that the volume of the combustion chamber at the end of the working stroke is greater than the maximum volume during the period of admission. It accordingly follows that the ignited charge, performing useful work upon both pistons, will expand to a greater volume than the maximum volume of the charge during its admission. In the well known prior constructions the expansion of the ignited charge is not carried to a greater volume than the maximum volume of the cylinder during the admission stroke. The increased expansion permitted by the construction described utilizes the power of the charge to a greater extent and increases the efficiency and economy of the engine correspondingly.

It will also be noted that the volume of the combustion chamber at the end of the exhaust period is considerably less than its volume at the end of the compression stroke, when the charge is ignited. With such a construction the exhaust is very efficient and may be made, in some cases, practically 100%. The efficient scavenging permits a correspondingly efficient admission, that is to say, the burnt gases having been entirely expelled, the cylinder will be filled practically entirely with fresh gases during the period of admission. Because of this construction greater power may be developed than is possible in an engine having the same stroke, bore of cylinder and other dimensions in which the scavenging and admission of fresh charge are not so efficient.

It will also be noted that the efficient exhaust which has been described enables the maintenance of an average working temperature considerably less than that employed in engines in which no such efficient exhaust is obtainable. It will also be noted that the cylinder may be fully charged with pure fresh mixture at every desirable rate of engine speed because of the extremely efficient scavenging and the extremely efficient production of vacuum in the cylinder during the period of admission.

A modified form of construction is shown in Figs. 6 to 8 of the drawings. The engine here illustrated is essentially the same as that which has previously been described, except for the fact that provision is made, additionally, for precompressing the intaken charge. A pair of pistons 2^1 and 3^1 are indicated as contained in the duplex cylinder 101. Piston 2^1 is intended to be connected by the connecting rod partly indicated at 4^1 to an eccentric bushing similar to the bushing 24 on a crank pin similar to crank pin 23 in the form of construction first described. Similarly piston 3^1 is operated by a connecting rod indicated at 6^1 which connecting rod is secured about an eccentric bushing similar to the bushing 31 on a crank pin similar to the crank pin 30 in the construction first described. Pistons 2^1 and 3^1 are operated in the same manner and by the same mechanism as has previously been described so that it is not deemed necessary to further illustrate the same. The two connecting rods of the construction will, of course, be synchronized, as by connection to a shaft such as the shaft 10 shown in Fig. 1, in the same manner as in the construction which has been described.

The full speed piston 2^1 is or may be the same as the full speed piston 2 of the form of construction first described, and controls the intake ports 17^1 of the combustion chamber. The half-speed piston 3^1, however, is formed as a differential piston. This piston is formed with an inner cylindrical portion 3^a and with an outer cylindrical portion 3^b of increased diameter at the rear thereof, these cylindrical portions being connected by an annular portion 3^c. The main piston portion 3^a reciprocates within the inner wall 1A of the cylinder casting, as does also piston 2^1. The enlarged portion 3^b of piston 3^1 slides within an enlarged bore 1B of the cylinder.

In the construction shown the outer wall portion 1B of the cylinder is provided with a series of ports 39 extending therethrough which ports may be and preferably are equally spaced around the periphery of the cylinder. These ports are adapted to connect the interior of the cylinder with an annular passage 40 contained within a boss 41 extending around the cylinder. Fresh charge of gaseous mixture from a carburetor or fresh air from the outside, as the case may be, enters annular space 40 through an opening 42. Ports 39 are closed by the apron or outer portion 3^b of piston 3^1 at all times except when piston 3^1 moves outwardly far enough to enable the annular portion 3^c of the differential piston to uncover these ports.

The cylinder casting is provided with an annular shoulder 43 at the inner end of the portion 1B of enlarged diameter of the cylinder bore. Accordingly an annular chamber will be formed between annular portion 3^c of the differential piston and the shoulder 43 of the casting which space serves as a precompression chamber. A passage 44 extends downwardly within the cylinder casting from the precompression chamber to

connect with the annular space 19^1 which extends between the inner and outer walls of the cylinder at this point (see Fig. 8). The inlet openings 17^1 for the combustion chamber are adapted to connect the combustion chamber 15^1 of the cylinder with annular space 19^1. Water jackets may be provided at suitable points such as are indicated at 45.

With this form of construction the diagram Fig. 9 may be used to illustrate the working conditions within the combustion chamber exactly the same as in the form of construction first described. Piston 2^1 will open the inlet ports 17^1 for the combustion chamber between the positions II and III in Fig. 9, and the working cylinder portion 3^a of piston 3^1 will open the exhaust ports 16^1 between positions V and VI of the diagram, the movements of the two pistons being the same as is indicated by lines 35 and 36 of the diagram.

The operations within the precompression chamber at the different stages of the cycle are indicated by the wording at the top of Fig. 9. Piston 3^1 opens the precompression chamber intake ports 39 at or about position V of Fig. 9 when annular portion 3^c of the piston begins to uncover ports 39, during its outer stroke. Ports 39 will remain open while piston 3^1 completes its outward stroke and moves somewhat inwardly on its return stroke, these ports being completely closed at position VI in Fig. 9. Ports 39 may be the same in height as the exhaust ports 16^1 and will be opened and closed in the same manner as are the exhaust ports, as is indicated by the portion of line 36 extending between the positions V and VI in Fig. 9.

The fresh charge will be sucked into the precompression chamber while ports 39 are being uncovered, and also, because of the rapidity of motion of piston 3^1, while they are being closed. During the following period in the operation of the engine, or until the inlet ports 17^1 of the working cylinder are opened at position II of the diagram, the intaken charge will be compressed in the precompression chamber and in passage 44. This is indicated on the diagram by the words "Precompress pumping", which indicates precompression pumping, or compression within the precompression chamber of the intaken charge. The portion 3^c of piston 3^1 will be moving inwardly during this period.

During the period in which the ports 17^1 are open, from position II to III, the precompressed charge will be transferred, or will expand, through ports 17^1 into the combustion chamber. Piston 3^1 will continue to move inwardly after the ports 17^1 have begun to open, and until position II^a on the diagram has been reached, so that the action of portion 3^c of the piston will be to tend to force the precompressed charge into the working cylinder during this time. The position of the parts illustrated in Fig. 6 is substantially the position which they occupy at point III^a in Fig. 9, at which time the height of the precompression space between portion 3^c of piston 3^1 and annular shoulder 43 of the cylinder casting has been reduced to a very small dimension. It will be noted from Fig. 9 that piston 3^1 moves outwardly from its innermost position a slight distance only until the cylinder inlet ports 17^1 have closed, and accordingly the precompression space will be enlarged no more than slightly while the precompressed charge is being transferred into the combustion chamber.

Between the positions III and V in Fig. 9 ports 17^1 and 39 will all be closed and piston 3^1 will be moving outwardly so as to create a vacuum in the precompression chamber. This period is followed, as stated, by the suction period in which a fresh charge is drawn into the precompression chamber.

Engines may of course be made up of units comprising cylinders such as have been described, in various arrangements.

It should be understood that while I have described certain forms and features of the invention with particularity, the invention is not limited to the exact details which have been described, but that various modifications may be employed as will be clear to those skilled in the art after reading this specification, the scope of the invention being indicated by the accompanying claims.

What I claim is:

1. In a four cycle internal combustion engine, the combination of a cylinder having inlet and exhaust ports therein, a pair of pistons, in axial alignment with each other in said cylinder, and movable towards and away from each other to establish a combustion chamber between them, a pair of crankshafts, movable at different speeds, and means comprising connections between said crankshafts and pistons, respectively, for so moving said pistons, cyclically, as to cause one of the same, singly, to open and close said inlet port, and the other to open and close said exhaust port, at suitable times.

2. In an internal combustion engine, the combination of a cylinder having an inlet port therein at one point and an exhaust port therein at another point, a pair of pistons in said cylinder movable towards and away from each other, one of said pistons controlling said inlet port, and means for causing said piston so to move as to cause it to uncover said inlet port on one outward stroke and to keep said port closed during all of the following outward stroke.

3. In an internal combustion engine, the combination of a cylinder having an inlet port therein at one point and an exhaust port therein at another point, a pair of pistons in said cylinder movable towards

and away from each other, one of said pistons controlling said inlet port, and the other controlling said exhaust port, and means for causing said first piston so to move as to cause it to uncover said inlet port on alternate outward strokes, and for causing said second piston so to move as to cause it to uncover said exhaust port during the inward strokes of said first piston immediately preceding the outward strokes during which the inlet port is opened.

4. In an internal combustion engine, the combination of a cylinder having an inlet port therein at one point and an exhaust port therein at another point, a pair of pistons in said cylinder, means for causing one of said pistons to reciprocate with a variable stroke, to cause it to uncover said inlet port during alternate outward strokes only and means for causing the other piston to reciprocate at a less speed than that of said first piston, in such manner as to uncover said exhaust port only at times shortly prior to the opening of the inlet port.

5. In an internal combustion engine, the combination of a cylinder having an inlet port therein at one point and an exhaust port therein at another point, a pair of pistons in said cylinder movable towards and away from each other, means for reciprocating one of said pistons with a stroke of variable length, to uncover said inlet port periodically, and means for reciprocating the other piston with a movement retarded on its out stroke and accelerated on its inward stroke, to uncover said exhaust port periodically.

6. In an internal combustion engine, the combination of a cylinder, having inlet and exhaust ports therein, a pair of pistons in said cylinder movable towards and away from each other, means for causing one of said pistons to move through a variable stroke to uncover and again cover the inlet port on alternate outward strokes, and means for causing the other piston to move at less speed and with a shorter travel than the first piston, and with a retarded outward stroke, to uncover and again cover the exhaust port towards the end of each outward stroke, before the inlet port is uncovered.

7. In an internal combustion engine, the combination of a cylinder, having inlet and exhaust ports therein, a pair of pistons in said cylinder movable towards and away from each other, a pair of crank shafts, means for causing one of the same to rotate at twice the speed of the other, means for connecting one of said pistons to the first named crank shaft in such manner as to cause said piston to open the inlet port on alternate outward strokes, only, and means for connecting the second piston to the second crankshaft in such manner as to cause it to open the exhaust port at the end of each outward stroke.

8. In a four cycle internal combustion engine, the combination of a cylinder having a pair of working pistons movable towards and away from each other to establish a combustion chamber therebetween, said cylinder having a precompression chamber and inlet ports for said combustion chamber and precompression chamber, and an exhaust port for said combustion chamber, and means for so moving said pistons, cyclically, as to cause one of them to open the inlet port for said precompression chamber, and compress the intaken charge in said chamber, to cause one of them to open the inlet port for the combustion chamber, said port communicating with the precompression chamber, and to cause one of them, after the working stroke of the pistons, to open the exhaust port.

9. In a four cycle internal combustion engine, the combination of a cylinder having a pair of working pistons movable towards and away from each other to establish a combustion chamber therebetween, said cylinder also having a precompression chamber with an inlet port extending from said precompression chamber to said combustion chamber, said cylinder also having an intake port for the precompression chamber, and means for causing one of said pistons to control the intake port for the precompression chamber and to compress the intaken charge in said chamber and means for causing the other piston to control said inlet port for the combustion chamber.

10. In a four cycle internal combustion engine, the combination of a cylinder having a pair of working pistons movable towards and away from each other to establish a combustion chamber therebetween, one of said pistons being a differential piston, the cylinder structure having a precompression space separate from the working cylinder, and means for causing said differential piston to control the inlet of charge into said space, periodically.

11. In a four cycle internal combustion engine, the combination of a cylinder having a pair of working pistons movable towards and away from each other to establish a combustion chamber therebetween, one of said pistons being a differential piston, the cylinder structure having a precompression space separate from the working cylinder, and means for causing said differential piston to precompress an intaken charge in said space, periodically.

12. In an internal combustion engine, the combination of a cylinder having portions of two diameters, a differential piston having a working portion movable in one of said portions and a second portion movable

in the other of said portions, the engine having a precompression space, and means for reciprocating said piston with an accelerated stroke in one direction and for causing it to precompress intaken mixture in said space during said accelerated stroke.

13. In an internal combustion engine, the combination of a cylinder having portions of two diameters, a differential piston having a working portion movable in one of said portions and a second portion movable in the other of said portions, the engine having a precompression space, and said cylinder having an exhaust port, and means for reciprocating said piston with an accelerated stroke in one direction, and for causing it to precompress intaken mixture in said space during said stroke, and for giving it a retarded stroke in the opposite direction, and causing it to open said exhaust port during said retarded stroke.

In testimony whereof I have signed my name to this specification, at New York, N. Y., this 26th day of April 1922.

CHARLES J. TÓTH.