Sept. 1, 1931. F. A. BULLINGTON 1,821,139

INTERNAL COMBUSTION ENGINE

Original Filed Aug. 24, 1925 3 Sheets-Sheet 1

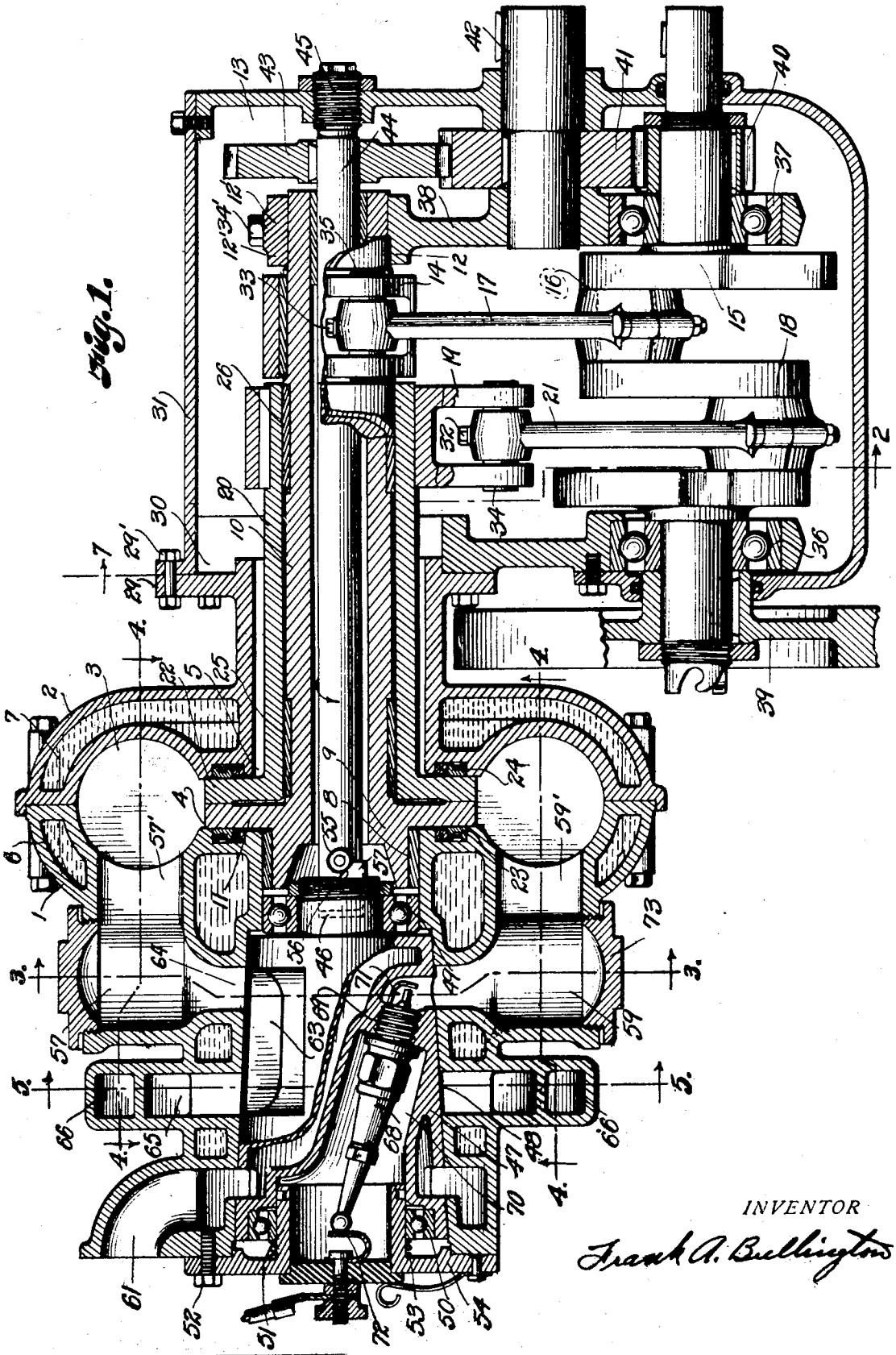


Fig. 1.

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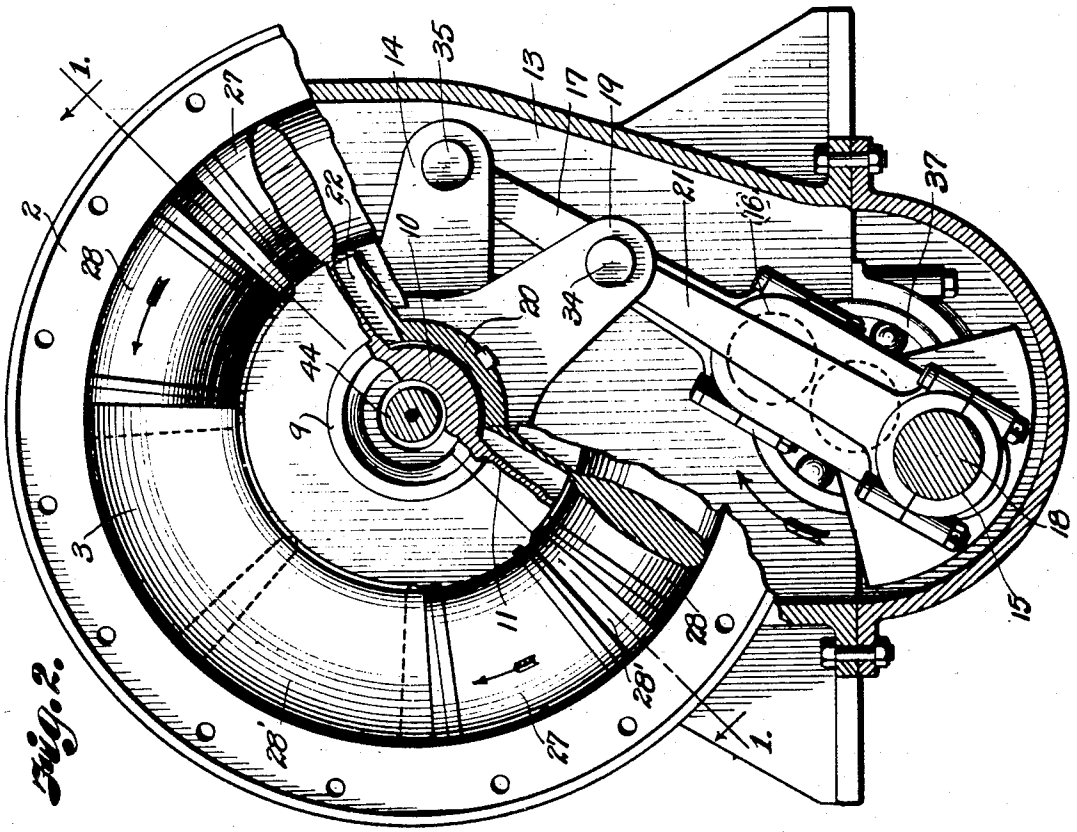


Fig. 2.

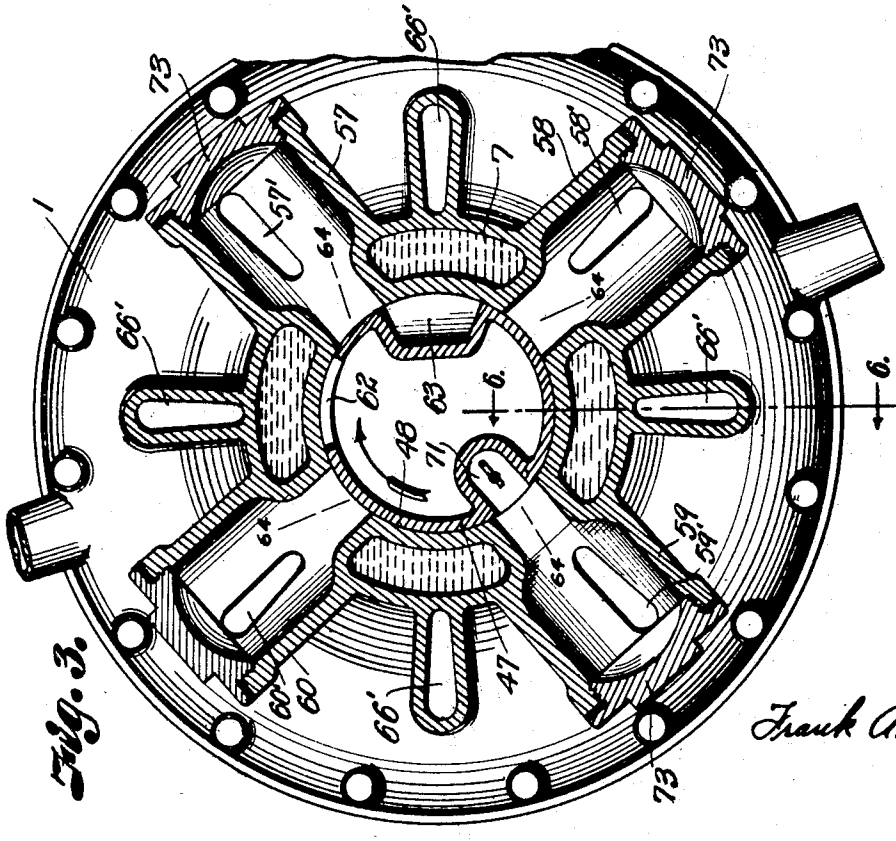


Fig. 3.

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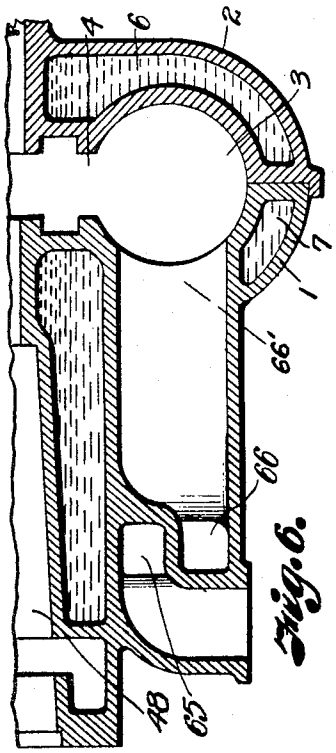


Fig. 6.

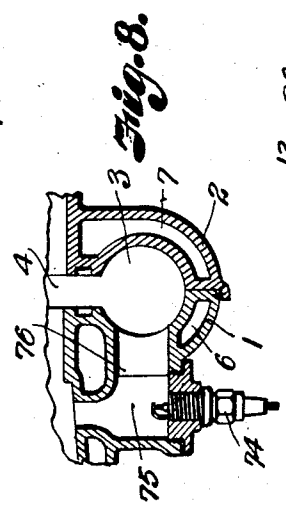


Fig. 8.

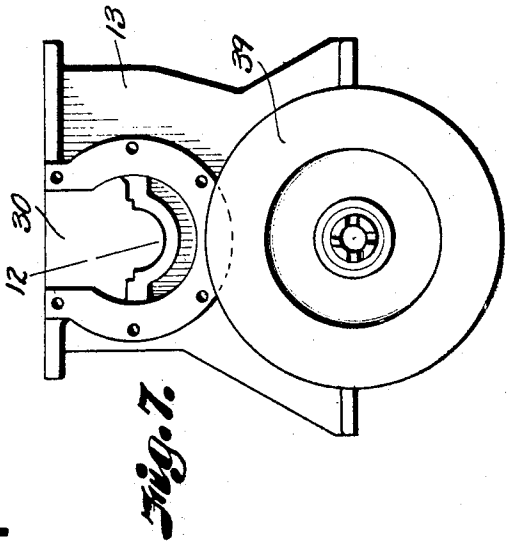


Fig. 7.

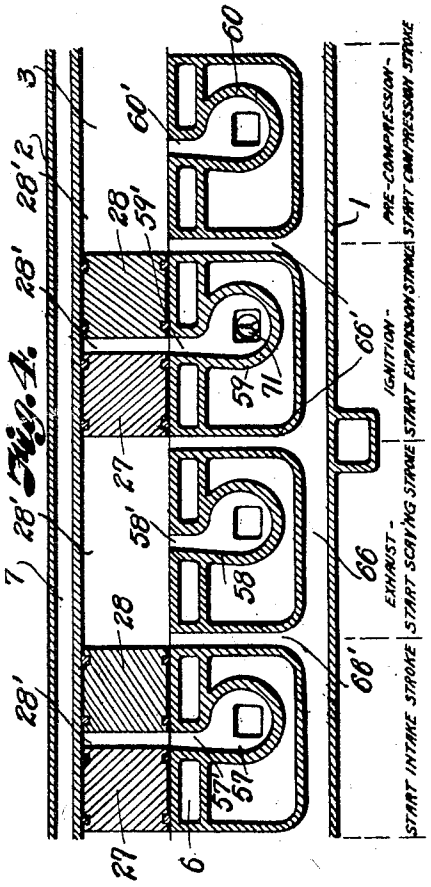


Fig. 4.

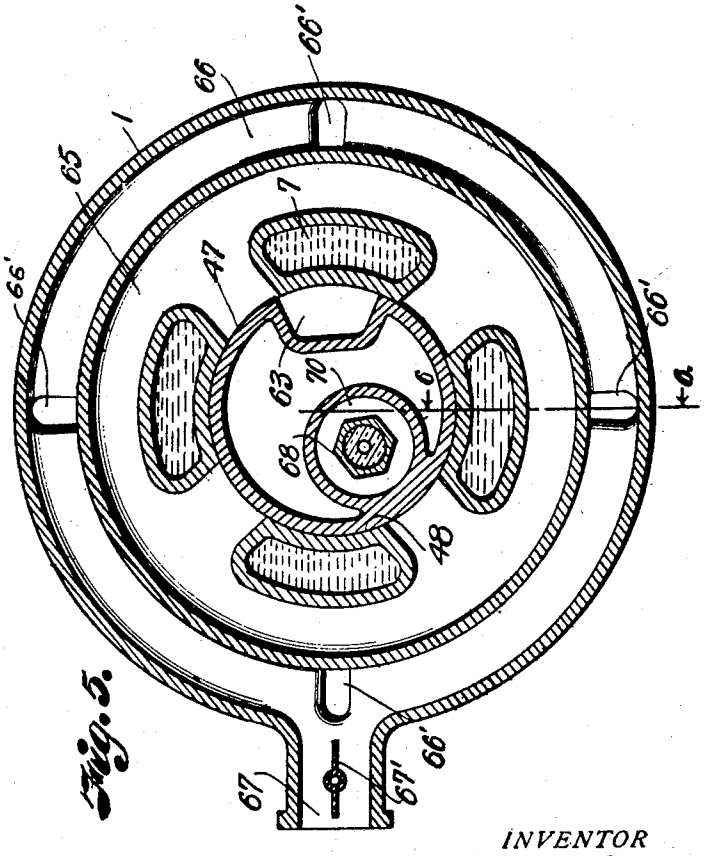


Fig. 5.

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Patented Sept. 1, 1931 1,821,139

UNITED STATES PATENT OFFICE

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INTERNAL COMBUSTION ENGINE

Application filed August 24, 1925, Serial No. 52,070. Renewed November 12, 1930.

This invention relates to internal combustion engines in which opposed pistons arranged in pairs work in an annular piston space or cylinder, the pistons of each pair oscillating through a fixed arcuate path in contra-distinction to those engines which include pistons rotating about a common axis and which accelerate and decelerate according to the functions to be performed in their operative cycles.

For example, in the present invention each piston of each pair on one rotor is complementary to both pistons of the other pair on a separate rotor to provide working spaces, this being due to the fact that the complementary pistons have equal and opposite actions so that any two opposed pistons move equal distances apart to take in a charge in the space between them; then move one toward the other to compress the charge, then move apart at the same relative speeds when the charge is burned to develop the power strokes of the pistons, and finally move one toward the other to exhaust the burned gases to complete the cycle of operations, generically conforming to the four cycle principle. All operations of each piston are confined to a fixed arc, each piston having a fixed amplitude of movement.

In the illustrated embodiment of the invention I have shown two pairs of pistons mounted upon two rotors, working in a cylinder or piston chamber carried by a stator, the two pistons which move clockwise during the pistons movements being carried by one rotor and the two pistons which move counter-clockwise being mounted upon the other rotor, so there is a balanced relation between the two rotors.

The two rotors are provided with piston arms connected to a two-pin crank shaft by connecting rods, the pins being 180 degrees apart so that there are two revolutions of the crank shaft for each operative cycle of the piston arrangement, and since the axes of the crank pins, connecting rod bearings, and connections between the piston arms and the connecting rods at dead center positions are all in a common plane passing through them to one side of the motor axis, balanced performance will be assured.

One of the important features of my invention is the provision of a separate combustion chamber for each working chamber (that is, the space between opposing pistons). This arrangement provides for the greater portion of the fuel charge being delivered and contained outside the piston working chamber at the end of the compression action, the combustion chamber serving as a compressed fuel charge receiving chamber. As a result the working strokes of the pistons are increased over what would be possible if the working chamber were large enough to contain all the fuel prior to ignition. An arrangement for causing turbulence to occur within the compression chamber is associated with a communicating passage between the combustion chamber and the working chamber corresponding thereto. All the combustion chambers are supplied with fuel from a common intake and all working chambers connect at proper intervals with a common exhaust.

There is means provided for introducing a non-combustible volumetric fluid into the working chambers to provide a pre-compression of the fuel charge prior to the compression actions of the pistons.

There are other important features of this invention which distinguish it from other known motors but these will be referred to hereinafter, reference being had to the accompanying drawings, in which

Fig. 1 is a longitudinal, sectional view through the motor, the section through the stator being taken on the line 1—1 of Fig. 2 and the section through the crank case being in a vertical plane.

Fig. 2 is a view of the stator with the front half removed.

Fig. 3 is a sectional view on the line 3—3 of Fig. 1.

Fig. 4 is a developed sectional view on the line 4—4 of Fig. 1.

Fig. 5 is a sectional view on the line 5—5 of Fig. 1.

Fig. 6 is a sectional view through the stator on the line 6—6 of Figs. 3 and 5.

Fig. 7 is a front, elevational view of the crank case, and

Fig. 8 is a fragmentary sectional view through a slightly modified form showing a separate spark plug for each combustion chamber.

The stator is shown as comprising two parts 1 and 2, secured together to provide an annular piston space or cylinder 3 having a slot 4 at its inner circumference communicating with the rotor chamber 5.

The parts 1 and 2 are provided with water jackets 6 and 7 to cool the stator in a well understood manner. The part 1 has a central bearing 8 to receive the end or hub 9 of the hollow shaft 10, which carries the rotor 11 in the rotor chamber 5. The opposite end of the shaft 10 is mounted in a bearing member 12 in the crank case 13 and on the shaft 10 is a piston arm 14, connected to the pin 16 of the crank shaft 15 by a connecting rod 17; it being understood that the crank shaft is a two-pin crank shaft, one pin being designated 16 and the other 18. The pin 18 is connected to a piston arm 19 on the hollow shaft 20 sleeved on shaft 10 by a connecting rod 21. The shaft 20 carries a rotor 22 in rotor chamber 5, the inner faces of the rotors 11 and 22 being in intimate contact and the outer faces being in contact with packings 23 and 24 in the rotor chamber 5. (See Fig 1.)

Suitable bearings may be provided between the shafts 10 and 20 as indicated at 25 and 26. The rotors 11 and 22 carry pistons 27 and 28. There are four pistons, two on each rotor. Those on one rotor overlap the other rotor and are secured to their respective rotors in a well understood manner. The movements of the pistons for their various operations will be clearly described hereinafter in connection with the method of admitting the fuel, compressing it, igniting it, and exhausting it, it being understood that the engine works on the four cycle principle.

The stator is provided with a flanged connection 29 bolted to the crank case by the bolts 29′. The crank case has a slot 30 in its end nearest to the stator so that by removing the cover 31, the screws 32 and 33 in the connecting rods, and the screws 34′ in bearing cap 12′, and removing the wrist pins 34 and 35, the stator with its entire piston and shaft assembly can be easily separated from the crank case.

The crank shaft 15 is shown as mounted in bearings 36 and 37 in the crank case and in the web member 38, which carries the bearing 12.

On one end of the crank shaft is a fly wheel 39, while at the other end is a pinion 40 meshing with a gear 41 on the stub shaft 42 in bearings in the web member 38 and the end of the crank case respectively. The stub shaft may be the driven shaft or power take-off, or power may be delivered direct from the crank shaft, dependent upon the gear ratio desired between the prime mover and the driven part, it being obvious that the shaft 42 will be rotated at a reduced speed with respect to the crank shaft 15.

The gear 41 meshes with a valve timing gear 43 on a shaft 44 within the shaft 10. One end of the shaft 44 abuts against an adjustable thrust bearing 45 in the end of the crank case. The other end of the shaft 44 is in a bearing 46 at the end of a truncated conical valve 47 in a truncated conical valve seat 48 in the part 1 of the stator. The bearing 46 is in the form of a journal or hub and rotates with the valve 47 in a bearing 49 in the part 1 of the stator. The other end of the valve 48 rotates on the bearing 50 carried by the removable collar 51 secured to the part 1 of the stator by bolts 52. The valve has a slight endwise or longitudinal movement, being urged to seating position by an expansion spring 53, one end of which bears against the end flange 54 of the collar and the other against the bearing 50. When the valve expands, it will tend to stick in its seat but this tendency will be overcome by the roller 55 on shaft 44, which will tend to ride upon the inclined face 56 of the lug 56′ to impart a slight longitudinal movement to the valve against the action of the spring 53, and inasmuch as the positive cam action of the roller against the lug will be greater than the yielding force of the spring, the valve will always be relieved from its tendency to stick When it is free to rotate, the lateral thrust of the roller 55 against the lug 56′ will be sufficient to rotate the valve so that its ports may register with the proper combustion chambers, exhaust ports, etc.

As heretofore pointed out, there is a separate combustion chamber for each working space in the stator and inasmuch as there are two pairs of pistons, one pair on each rotor with the pistons of each pair 180 degrees apart with the piston strokes equal toward and away one from the other, there will be four working spaces corresponding to four cylinders so the motor as shown will, in effect, be a four cycle, four cylinder motor. Since there are four working spaces there will be four combustion chambers, one for each working space. These are designated 57, 58, 59 and 60 (see Fig. 3). They are grouped about the valve seat 48 within which the valve 47 rotates and they communicate with their working spaces through the excentrically located passageways 57′, 58′, 59′ and 60′ (see Fig. 3). The hollow, truncated, conical valve receives the fuel from the intake port 61 and delivers the fuel to the respective combustion chambers through the port 62. The valve has a recess 63 providing a passage to establish communication between the port 64 and the manifold 65. The manifold 66 is adapted to communicate with

the working space through the ports 66′ when the opposing pistons reach the ends of their expansion strokes (see Fig. 4). Therefore, most of the burnt gases will exhaust through the manifold in the stator rather than through the pocket in the valve. This is important because if all the products of combustion exhausted through the valve, the high temperatures of the gases would tend to warp the valve. However, the only burnt gases which pass through the recess 63 into manifold 65 open to atmosphere are those displaced at practically atmospheric pressure when the opposing pistons are moving one toward the other during their scavenging strokes. The pressures at which the burnt gases are exhausted through the outlet 67 for the manifold 66 will be determined by the position of the valve 67′ in the outlet port 67. (See Fig. 5.)

If some of the burnt gases are trapped in the manifold 66 by partly closing the valve 67′, some of such gases will be taken into the working space between opposing pistons 27 and 28 when the pistons reach the limit of their intake strokes; the amount of non-combustible secondary volumetric fluid supplied to the working space is determined by the amount of vacuum in the working space between the pistons at the time the pistons reach the limit of their intake strokes and the pressure of the exhaust gas in the manifold 66, at which time they will open the ports 66′ to the working space between them, as shown in Fig. 4. In this figure the working spaces are all designated 28′, there being four shown because the figure is a developed view of the cylinder in the stator and the pistons. It will, therefore, be seen that the non-combustible secondary volumetric fluid is charged into the working spaces in strata with the combustible fluid between the charges of volumetric fluid.

When a rotary valve such as is shown in Fig. 1 is employed in an engine constructed in accordance with my invention, it is possible to utilize a single spark plug for all the combustion chambers. The plug 68 is screwed into the seat 69 in the end of the recess 70 in the valve 47 with its points or electrodes in the pocket 71, adapted to successively register with the respective combustion chambers 57 to 60, both inclusive. When the pistons are in positions to move on their expansion or power strokes to insure the combustion of the fuel taking place in each combustion chamber at the proper period during the operative cycle of the engine, current is supplied to the spark plug from an approved ignition system (not shown) to a contact 72, against which one end of the spark plug abuts, as shown in Fig. 1.

As shown in Fig. 3 the valve 47 is in position to supply fuel to the combustion chamber 57 through port 62 upon a slight clockwise movement of the valve, the pistons having just finished their exhaust strokes and are about to move away one from the other to take in the charge supplied to the combustion chamber 57. As fuel is being supplied to combustion chamber 57, chamber 58 will be exhausting, the fuel in chamber 59, having been ignited, will be expanding between the pistons associated therewith and the chamber 60 will be charged with fuel ready to be compressed and ignited when the spark plug pocket 71 registers with the chamber 60, it being understood that a suitable timer will be provided in the ignition system to cause a spark to jump the gap across the electrodes of the spark plug at proper intervals.

As heretofore explained, all pistons have the same amplitude of movement for any given speed of the engine and they move back and forth or oscillate in constantly recurring arcs, instead of advancing in a circular path about a common axis. With such a construction I am enabled to build an engine having certain advantages over other known motors. For example, practically perfect balanced performance is assured and a rotary valve may be employed for admitting the charges to the combustion chambers and exhausting some of the products of combustion, the larger volume of the products of combustion at the initial exhaust temperature being passed out through the ports 66′ into the manifold 66. The cooler gases during the scavenging strokes of the pistons are exhausted through the pocket 63 to the manifold 65 to atmosphere. Therefore, I term the manifold 66 the primary manifold or exhaust because the initial exhaust passes through it while the manifold 65 receives only the products of combustion displaced by the scavenging strokes of the pistons 27 and 28 at approximately atmospheric pressure, so it will be seen that the valve will not be subjected to the maximum temperatures resulting from the products of combustion. Consequently the tendency of the valve to warp will be reduced to a minimum.

The combustion chambers are preferably provided with removable cover members or plugs 73 so that the walls of the combustion chambers may be machined to provide smooth surfaces to reduce carbon deposits and promote maximum efficiency, as well as to permit removal of carbon and observation of the spark plug terminals when expedient. The passageway establishing communication between a working chamber and its respective combustion chamber is located excentrically in relation to the combustion chamber, so that a fuel charge being compressed in a working chamber will pass to the combustion chamber in a manner to cause turbulence in the compressed charge therein.

It is to be understood, of course, that this

invention does not depend entirely upon a rotary valve for successful operation but a rotary valve is recommended and while I prefer to employ a single spark plug for all the combustion chambers, it is possible to utilize a separate spark plug for each combustion chamber. One such plug is shown in Fig. 8. It is designated 74 and it is shown as screwed into the end of the combustion chamber 75 which communicates with the working space for which it is designed by a passageway 76 corresponding to the passageways 57′ to 60′ in Fig. 3.

Other modifications may be resorted to without changing the essential principle of my invention so I reserve the right to make changes without departing from the spirit of the invention.

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

1. In a four cycle internal combustion engine, a stator having an annular passage therein, pairs of pistons mounted for oscillation in said passage and defining working chambers therebetween, and positively operated means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation.

2. In a four cycle internal combustion engine, a stator having an annular passage therein, pairs of diametrically opposite pistons mounted for oscillation in said passage and defining working chambers therebetween, means controlling the movement of said pistons causing adjacent pistons to oscillate simultaneously in opposite directions and positively operated means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation.

3. In a four cycle internal combustion engine, a stator having an annular passage therein, pairs of pistons mounted for oscillation in said passage and defining a working chamber between each pair of adjacent pistons and means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation.

4. In a four cycle internal combustion engine, a stator having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port, and means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation.

5. In a four cycle internal combustion engine, a stator having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port, and means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation, said means comprising a power driven valve associated with said ports.

6. An internal combustion motor comprising a casing having an annular cylinder, oscillating pistons in the cylinder, all having the same amplitude of movement, means controlling the amplitude of movement of the pistons, a separate combustion chamber outside the annular cylinder for each space between opposing piston faces, means for establishing communication between said chambers and spaces, and a fluid distributing valve communicating with the intake for progressively admitting fluid into the respective combustion chambers.

7. An internal combustion motor comprising a casing having an annular cylinder, oscillating pistons in the cylinder, all having the same amplitude of movement, means controlling the amplitude of movement of the pistons, a separate combustion chamber outside the annular cylinder for each space between opposing piston faces, means for establishing communication between said chambers and spaces, and a fluid distributing conical rotary valve supported on journal bearings communicating with the intake for progressively admitting fluid into the respective combustion chambers.

8. An internal combustion motor comprising a casing having an annular cylinder, oscillating pistons in the cylinder, all having the same amplitude of movement, means controlling the amplitude of movement of the pistons, a separate combustion chamber outside the annular cylinder for each space between opposing piston faces, means for establishing communication between said chambers and spaces, a fluid distributing valve communicating with the intake for progressively admitting fluid into the respective combustion chambers, and a single spark plug carried by the valve, an ignition pocket successively registering with the respective combustion chambers, said spark plug having terminals in said pocket, a stationary terminal located substantially axially of said engine and means on said plug engaging therewith.

9. A four cycle internal combustion motor comprising a casing, pairs of oscillating pistons in the casing, the casing having exhaust ports adapted to be uncovered in pairs at the ends of the working strokes of the pistons, and positively operated means for admitting fuel into the spaces between the pistons.

10. A four cycle internal combustion motor

comprising a casing, pairs of oscillating pistons in the casing, the casing having primary exhaust ports adapted to be uncovered at the ends of the working strokes of the pistons, means for exhausting burnt gases at low pressure during the scavenging strokes of the pistons, said means being distinct from said ports, and means for admitting fuel into the spaces between the pistons.

11. A four cycle internal combustion engine comprising a casing having an annular chamber, an annular manifold about the chamber adapted to communicate therewith through spaced passageways, oscillating pistons in the chamber having simultaneous oscillating movements in fixed arcs and defining working spaces, the pistons having movements toward and away one from the other, the pistons uncovering the passageways when they move apart to establish communication between diametrically opposed working spaces, and means for supplying fuel to the spaces between the pistons, exhaust means for said engine, and a power delivery element connected to the pistons.

12. A four cycle internal combustion engine comprising a casing having an annular chamber, an annular manifold about the chamber adapted to communicate therewith through spaced passageways, oscillating pistons in the chamber having simultaneous oscillating movements in fixed arcs, the pistons having movements toward and away one from the other, the pistons uncovering the passageways when they move apart, means for supplying fuel to the spaces between the pistons, a power delivery element connected to the pistons, a manifold having an outlet opening to atmosphere, and a valve in the outlet.

13. A four cycle internal combustion engine comprising a casing having an annular piston chamber, oscillating pistons in the chamber having fixed amplitudes of movements, a manifold having ports communicating with the spaces between opposing faces of the pistons when the faces of opposing pistons are the greatest distances apart to exhaust burnt gases at the ends of the expansion strokes of the pistons into said manifold, and to admit some of the burnt gases from the manifold to the spaces between the pistons at the beginning of the compression strokes of the pistons, means for admitting fuel to the spaces between the pistons, a power delivery element, and connections between the pistons and the power delivery element.

14. A four cycle internal combustion engine comprising a casing having an annular piston chamber, oscillating pistons in the chamber having fixed amplitudes of movements, a manifold having ports communicating with the spaces between opposing faces of the pistons when the faces of opposing pistons are the greatest distances apart to exhaust burnt gases at the ends of the expansion strokes of the pitsons into said manifold, and to admit some of the burnt gases from the manifold to the spaces between the pistons at the beginning of the compression strokes of the pistons, means for admitting fuel to the spaces between the pistons, said means comprising a rotary valve common to all the spaces between the pistons, a valve-operating means, a power delivery means operated by the pistons, and means for operating the valve from the power delivery means.

15. A four cycle internal combustion engine comprising a casing having an annular piston chamber, oscillating pistons in the chamber having fixed amplitudes of movements, an exhaust manifold having ports communicating with the spaces between opposing faces of the pistons when the faces of opposing pistons are the greatest distances apart to exhaust burnt gases at the ends of the expansion strokes of the pistons and to admit some of the burnt gases from the manifold to the spaces between the pistons at the beginning of the compression strokes of the pistons, valve means for admitting fuel to the spaces between the pistons, a power delivery element, connections between the pistons and the power delivery element, and a spark plug carried by the valve means common to all the spaces between the pistons.

16. An internal combustion engine comprising a casing having an annular piston chamber, oscillating pistons in the chamber, all having the same amplitude of movement to provide working spaces between them, a separate combustion chamber for each working space, the combustion chambers being grouped about a common center, a rotary inlet valve having a port cutting to successively register with the combustion chambers, a spark plug carried by the valve to successively ignite the charges in the combustion chambers, the valve having an exhaust port to register with the combustion chambers, a power delivery means, and connections between the power delivery means and the pistons.

17. An internal combustion engine comprising a casing having an annular piston chamber, oscillating pistons in the chamber, all having the same amplitude of movement to provide working spaces between them, a separate combustion chamber for each working space, the combustion chambers being grouped about a common center, a rotary inlet valve having a port cutting to successively register with the combustion chambers, the casing having exhaust ports to register with the spaces between the pistons when the pistons are at the limits of the expansion stroke, a spark plug carried by the valve to successively ignite the charges in the combustion chambers, the valve having an exhaust port to register with the combustion chambers, a power delivery means, and connections be-

tween the power delivery means and the pistons.

18. An internal combustion engine comprising a casing having an annular piston chamber having inlets and outlets, oscillating pistons in the chamber having working spaces between them, a conical rotary inlet valve common to all the working spaces, a spring normally urging the valve upon its seat, a valve operating means loosely connected to the valve tending to urge the valve off its seat, and a power delivery means operated by the pistons.

19. An internal combustion engine comprising a casing having an annular piston chamber, oscillating pistons in the chamber providing working spaces between them, there being exhaust ports at the ends of the working spaces to be covered and uncovered by the pistons, combustion chambers for the working spaces, a valve for admitting fuel into the combustion chambers, a spark plug carried by the valve to ignite the fuel, and a power delivery means connected to the pistons.

20. In an internal combustion engine, a piston casing, a crank case and a piston carrying shaft extending from said casing into said crank case, the crank case having a slot therein to receive said shaft, and means detachably connecting the crank case and the piston casing with said slot adjacent said piston casing, whereby said shaft and the parts carried thereby may be assembled with said crank case and removed therefrom by passing said shaft through said slot.

21. In a four cycle internal combustion engine, a stator having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, said passage being provided with a series of combined inlet and exhaust ports, each associated with one of said working chambers and open thereto at all times, and combined inlet and exhaust valve means controlling the admittance of fuel to and the discharge of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation.

22. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port and auxiliary inlet means for admitting inert fluid in strata to said chamber after the fuel mixture has been drawn into the same.

23. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port and auxiliary inlet means for admitting inert fluid to said chamber adjacent the opposite ends thereof after the fuel mixture has been drawn into the same.

24. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port near the middle thereof and auxiliary inlet means for admitting inert fluid to said chamber adjacent the opposite ends thereof after the fuel mixture has been drawn into the same.

25. In a four cycle internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, said pistons separating from and approaching each other in pairs to define chambers of simultaneously increasing and decreasing capacity, and means for establishing communication between the chambers of increasing capacity near the ends of the separating strokes of the pistons defining the same.

26. In a four cycle internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, said pistons separating from and approaching each other in pairs to define chambers of simultaneously increasing and decreasing capacity, and means for establishing communication between both ends of each of the chambers of increasing capacity near the ends of the separating strokes of the pistons defining the same.

27. In a four cycle internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, said pistons separating from and approaching each other in pairs to define chambers of simultaneously increasing and decreasing capacity, one of said chambers being a suction chamber while another is an expansion chamber, and means for transferring secondary volumetric fluid under pressure from said expansion chamber to said suction chamber to give the fuel therein an initial compression.

28. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port, and auxiliary inlet means for admitting inert fluid in strata to said chamber after the fuel mixture has been drawn into the same, comprising ports opening into said passage, a pair thereof corresponding to each working chamber and being adapted to be uncovered by

said pistons at the ends of their suction strokes.

29. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port, and auxiliary inlet means for admitting inert fluid under pressure to said chamber after the fuel mixture has been drawn into the same, comprising ports opening into said passage, a pair thereof corresponding to each working chamber and being adapted to be uncovered by said pistons at the ends of their suction strokes, said combined inlet and exhaust ports alternating with said auxiliary inlet ports.

30. In a four cycle internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port and primary exhaust means, and means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers whereby each thereof has a four stroke cycle of operation.

31. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, each working chamber having a combined inlet and exhaust port and primary exhaust means comprising pairs of ports associated with each working chamber and uncovered by said pistons near the ends of the expansion strokes thereof, and means controlling the admittance of fuel to and the exhaust of the products of combustion from said working chambers, said combined inlet and exhaust ports being located substantially midway between said pairs of ports.

32. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween and combined inlet and exhaust means for each working chamber, comprising a separate combustion chamber, a port leading from said combustion chamber into the corresponding working chamber, and inlet and exhaust valve means associated with said combustion chamber.

33. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, inlet and exhaust means for each working chamber, a combustion chamber associated with each working chamber, spaced therefrom and having a capacity sufficient to contain the major portion of the fuel charge passing into the same from the corresponding working chamber under compression action of the pistons, a port loading from said combustion chamber into the corresponding working chamber and ignition means associated with said combustion chamber.

34. In an internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, a combustion chamber associated with each working chamber and a port leading from said combustion chamber into the corresponding working chamber, said port opening into said combustion chamber so as to set up a condition of turbulence therein.

35. In in internal combustion engine, a casing having an annular passage therein, pistons mounted for oscillation in said passage and defining working chambers therebetween, a combustion chamber associated with each working chamber, and a port leading from said combustion chamber into the corresponding working chamber, said port opening into said combustion chamber eccentrically thereof.

36. In an internal combustion engine, a stator having an annular passage therein and an annular slot connecting therewith, pistons mounted for oscillation in said passage in opposite directions, pairs of disks extending through said slot and carrying said oppositely moving pistons to be oscillated thereby, a crank case and driving shaft members on said disks extending into said crank case.

37. In an internal combustion engine, a cylinder member having an annular passage therein and an annular slot connecting therewith, pistons mounted for oscillation in said passage in opposite directions, pairs of disks extending through said slot and carrying said oppositely moving pistons to be oscillated thereby, a crank case and telescoping driving shaft members on said disks extending into said crank case, one of said shaft members being journalled at one end in the cylinder member and at the other end in a bearing in the crank case.

38. In an internal combustion engine, a cylinder member having an annular passage therein and an annular slot connecting therewith, pistons mounted for oscillation in said passage in opposite directions, a piston carrying disk extending through said slot, a hollow shaft extending from said disk and a valve operating member extending through said hollow shaft.

39. In an oscillating piston engine, a cylinder member having an annular passage therein and a slot connecting therewith, pistons mounted for oscillation in said passage in opposite directions, pairs of disks extending through said slot and carrying said oppositely moving pistons to be oscillated thereby, a crank case, telescoping driving members on said disks extending into said crank case, one

of said shafts being journalled at one end in the cylinder member and at the other end in a bearing in the crank case, the other of said shafts being journalled on said first named shaft, operating arms on said shafts, wrist pins in the arms at their outer ends, a crank shaft having two crank pins spaced diametrically apart, each crank pin in alignment with one of said wrist pins, and connecting rods connecting each crank pin with its aligning wrist pin and adapted to have substantially simultaneous dead center positions both on the same side of the crank shaft substantially in alignment with each other.

In testimony whereof I affix my signature.

FRANK A. BULLINGTON.