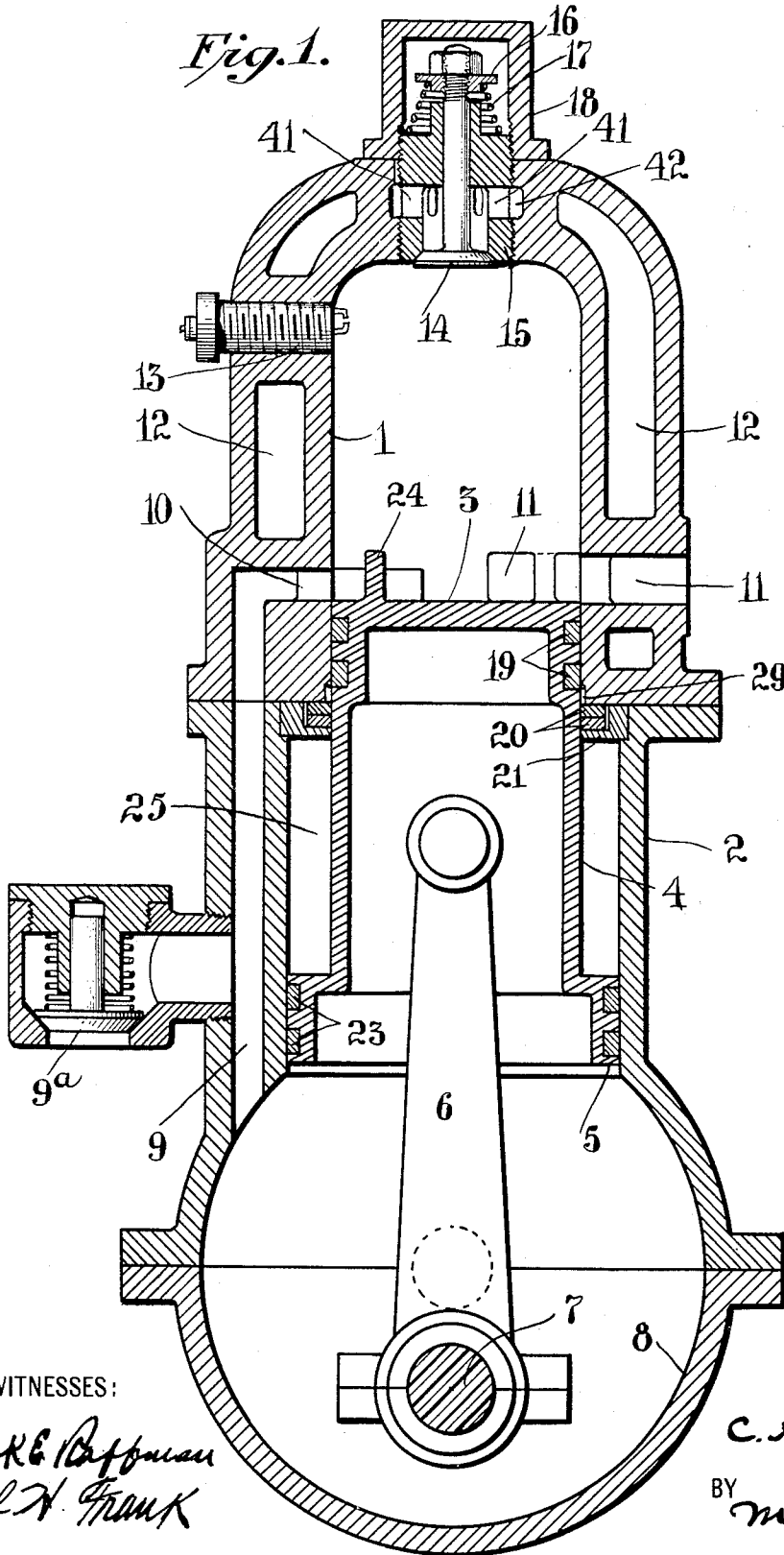


1,018,742.

Patented Feb. 27, 1912.

4 SHEETS—SHEET 1.



WITNESSES:

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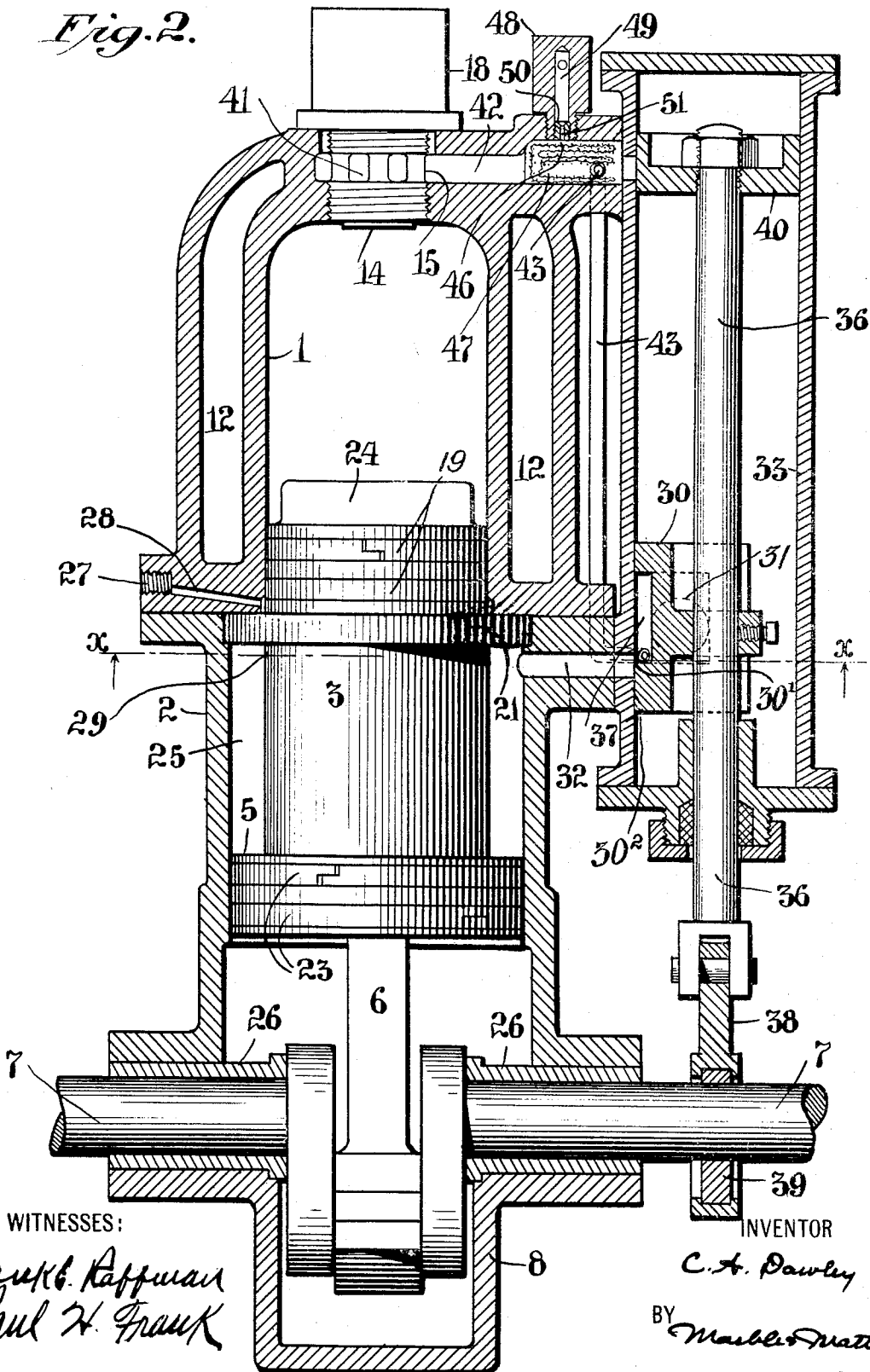
C. A. DAWLEY.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED SEPT. 3, 1908

1,018,742.

Patented Feb. 27, 1912.

4 SHEETS—SHEET 2.

Fig. 2.



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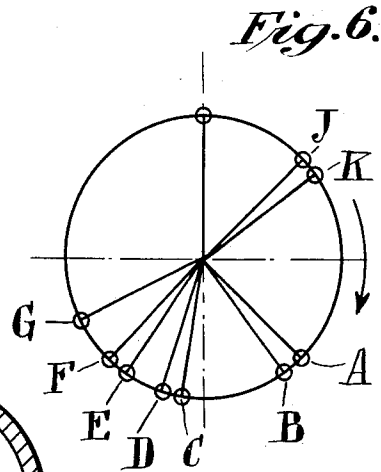
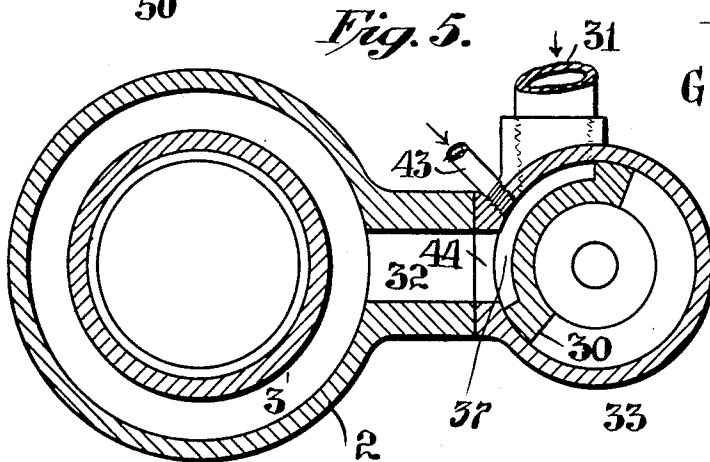
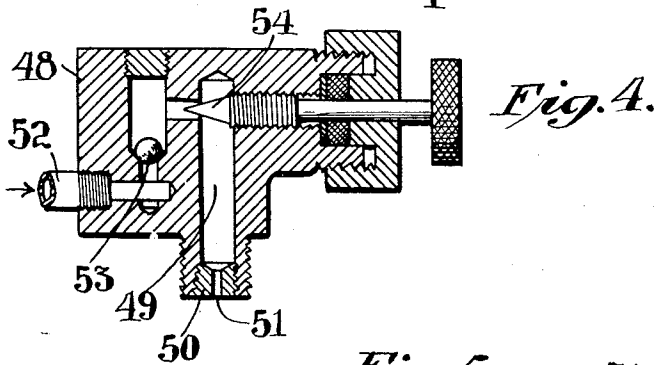
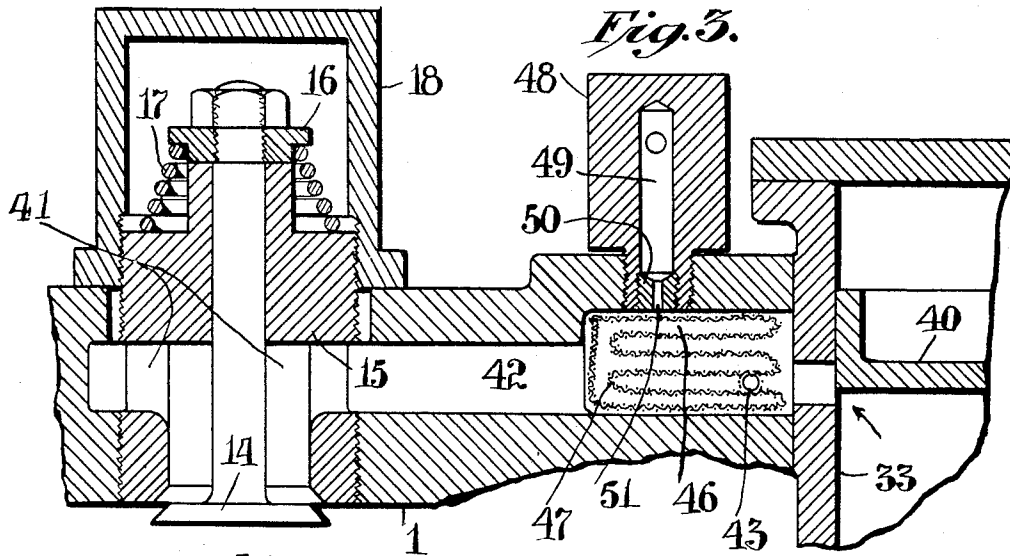
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4 SHEETS—SHEET 3.



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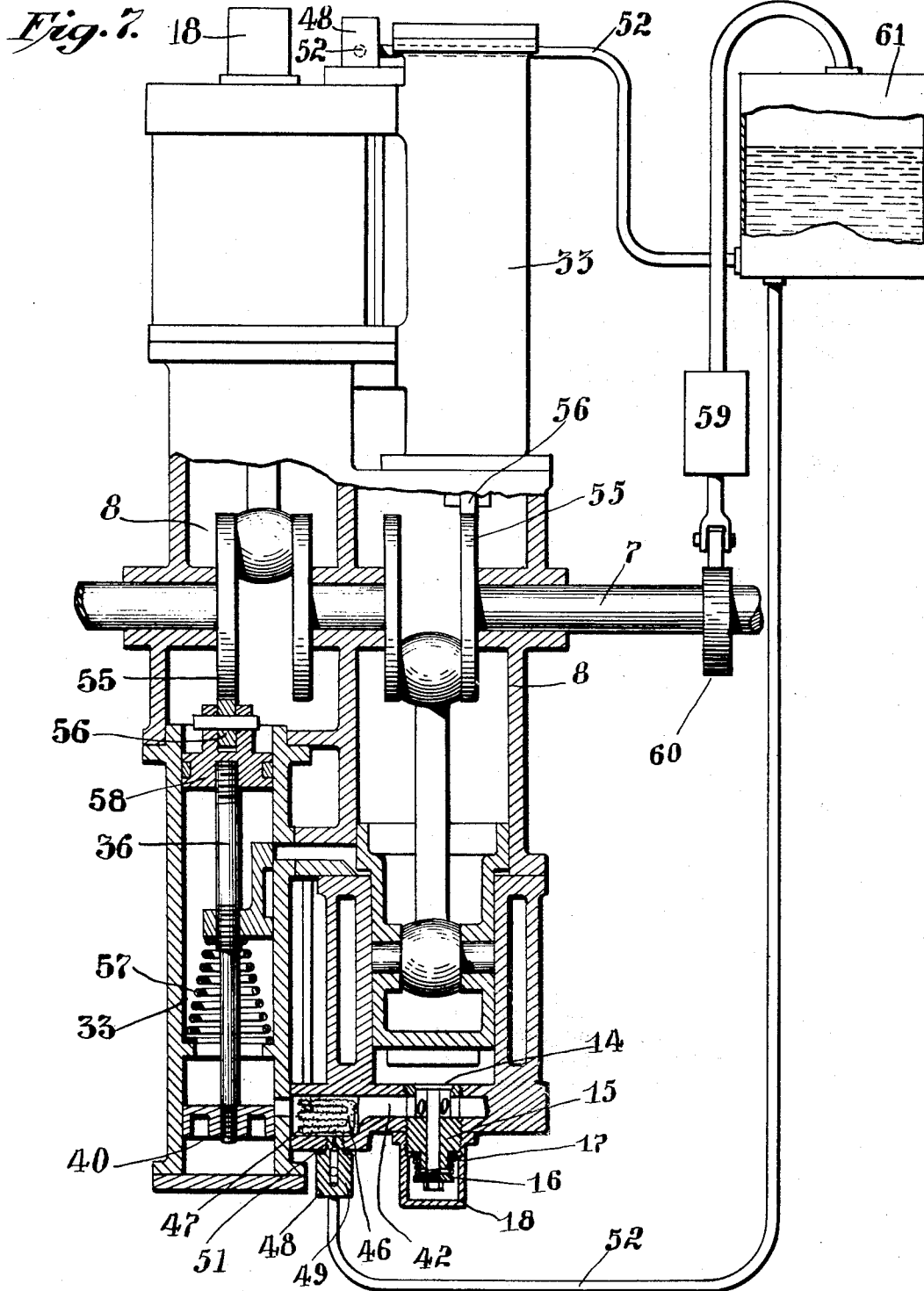
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C. A. DAWLEY.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED SEPT. 3, 1908.

1,018,742.

Patented Feb. 27, 1912.

4 SHEETS—SHEET 4.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

1,018,742.

Specification of Letters Patent.

Patented Feb. 27, 1912.

Application filed September 3, 1908. Serial No. 451,563.

To all whom it may concern:

Be it known that I, CLARENCE A. DAWLEY, a citizen of the United States of America, and a resident of Plainfield, Union county, New Jersey, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

My invention relates to improvements in internal combustion engines and particularly to improvements in the explosion type of such engines, and more particularly to the two cycle or two stroke type of such engines, wherein in each working cylinder there is a working impulse during each forward stroke of the piston.

My invention comprises improved means for delivering to the cylinder during and after exhaust, a scavenging blast of pure air; improved means for supplying the explosive charge to the engine; improved means for supplying relatively heavy fuel oils, such as kerosene or heavier oils, and mixing the same with an entering charge of air; and various other features all as hereinafter more fully described and particularly pointed out in the appended claims.

In the design and operation of explosion engines, and particularly engines of the two cycle or two stroke type, notable difficulties have been experienced in insuring practically complete exhaust of the burned gas prior to the admission of the gases of the succeeding charge, in admitting a sufficient explosive charge to the engine during the brief time ordinarily available for that purpose, in avoiding back pressure tending to impede the entrance of the charge, and in securing substantially the same mixture in the working cylinder regardless of variations in engine speed. Most two cycle engines as now made employ a closed crank case as an initial compression chamber, drawing a mixed charge of air and oil vapor or gas into this crank case, and compressing it initially therein to about five or six pounds pressure per square inch above the atmosphere. The piston of the engine opens an exhaust port in the cylinder wall near the conclusion of the forward stroke, and almost immediately thereafter opens an admission port leading to this closed crank chamber or initial compression space, the charge compressed in said crank case then passing through this admission port against a deflector provided on the piston and being

thereby deflected up or back into the cylinder so as to produce a swirling action tending to sweep out of such upper or rear portion of the cylinder the remaining burned gases, and to sweep them toward and out of the exhaust port. In the next succeeding rearward stroke of the piston said piston first closes said admission port and then the exhaust port. Since, as ordinarily constructed, the piston displaces no greater volume in the crank case, during the forward stroke, than it displaces in the cylinder during its backward stroke, and since the clearance space in the crank case, considered as a compression chamber, is necessarily large, it is a physical impossibility that the cylinder of a two-cycle engine as ordinarily constructed shall receive a cylinderful of charge at atmospheric pressure during each admission period. Instead, the cylinder can receive only a partial charge, as compared with what would be received in a corresponding four-cycle engine; which is one reason why in practice ordinary two-cycle engines do not develop as much power in proportion to the number of working strokes, as do well-designed four-cycle engines of corresponding size. In my improved engine, however, I have provided means whereby, during each admission period, the working cylinder may be completely filled with a charge at or even above atmospheric pressure.

It is extremely desirable that two-cycle engines be able to operate within wide ranges of speed; for example, to be able to operate at anywhere from one hundred to nine hundred or even more revolutions per minute; and it is obviously impossible to design an ordinary two-cycle engine so that there will be nearly complete escape of the burned gases with practically no escape through the exhaust port of the entering and as yet unburned charge, at both high and low speeds. And since only a very brief time is available for the admission of the charge to the engine cylinder, while the compression pressure in the crank case is practically the same both at high and at low speed, the engine receives less than its due proportion of charge at high speeds. The engine herein described is so constructed that there is practically complete scavenging both at high and at low speeds, without escape of fuel through the exhaust port, and that it receives the same charge at all times, independent of change

of speed, except as the charge may be affected by throttling or other regulating action.

In ordinary two-cycle engines it is practically impossible to maintain reasonable tightness at the crank shaft bearings after these bearings become worn, and as these bearings wear the leakage through them tends to increase progressively, so that for this reason there is usually a distinct odor of gas or gasoline about a two-cycle engine, and the escape from the crank shaft bearings may even be so great as to create a considerable fire risk. Gasoline vapor introduced into the crank case as described, has an exceedingly detrimental effect upon the lubricating oil commonly contained in the crank case and upon the lubricant employed in the crank shaft bearings, increasing the liability to cutting of crank pin bearings, the crank shaft bearings and the piston rings and walls of the cylinder.

Much difficulty has also been experienced in operating explosion engines, either of the two stroke or of the four stroke type, upon oils heavier than ordinary gasoline, owing to difficulty in securing a complete atomization of such heavier oils and an adequate mixture of the oil particles with the air, and owing to fouling of the engine cylinders due to deposit of liquid oil on the highly heated cylinder surfaces with resulting cracking of oil and deposit of carbon or thick carbonaceous compounds.

The objects of my invention are to overcome the difficulties mentioned, which have been experienced in the design and operation of two cycle engines and in the use of kerosene and heavier oils in explosion engines of either the two cycle or four cycle type, to supply full charges to the engine cylinder, and thereby obtain increased power, to insure substantially the same charge in the engine cylinder at whatever speed the engine may be operated, except as the charge may be affected by intentional throttling or other regulating action, to make the engine exceedingly flexible in operation, that is, to make it capable of operating with high efficiency through a wide range of speeds, to thoroughly scavenge the cylinder during each exhaust period and thereby prevent mixture of burned gases with the entering charge with resulting slowing down of combustion in the cylinder, to avoid introduction of the charge into the cylinder against material back pressure, to avoid escape of the charge through the exhaust port prior to closure thereof by the engine piston, to insure regularity of the explosions, to obtain regular and reliable operation, to reduce size and weight of the engine as compared with engines of corresponding speed and power as heretofore constructed, to avoid tendency to back fir-

ing and premature explosions, to provide for the use of liquid fuel, including kerosene and heavier oils, without the use of carbureters, or the like, and without mixture of the fuel with lubricant in the crank case or in the crank shaft bearings, to efficiently atomize the fuel and thoroughly mingle it with air, prior to its introduction into the working cylinder, to avoid storage of explosive mixture in the engine, and to avoid cams, gears, valve rods, etc., and their attendant complications.

I will now proceed to describe my invention with reference to the accompanying drawings in which certain constructions of engine embodying my invention are illustrated, and will then point out the novel features in claims.

In said drawings: Figure 1 shows a central vertical section of an engine of the vertical type embodying my invention, the section being taken in the plane of oscillation of the connecting rod. Fig. 2 shows a central vertical section of the same engine through the center of the crank shaft. Fig. 3 shows a detail vertical section on a larger scale through the admission passage and admission valve. Fig. 4 shows a detail section through the liquid fuel feeding device. Fig. 5 shows a cross section taken on the line $x-x$ of Fig. 2, that is to say, taken through the annular compression space. Fig. 6 is a crank diagram illustrating the preferred order of events in the cycle of operation. Fig. 7 shows a top view and partial central horizontal section of a two cylinder horizontal opposed engine embodying my invention.

In the preferred embodiments of my invention I employ a closed crank case as a compression chamber in which to compress air for scavenging, the fuel never entering this space and so never contaminating the lubricant therein or in the crank shaft bearings; and for compressing additional air, for the charge, I employ a separate compression space which preferably and usually is an annular space between the cylinder proper and the crank case, the piston being a stepped piston, that is to say, having two heads of different diameters, the smaller of which works in the cylinder proper and the larger of which works in the said annular compression space. In this annular compression space, ordinarily, (when the engine is operating on liquid fuel), only air is admitted and compressed, the fuel being mixed with the air so compressed, at another point. But if preferred, air and gas may be drawn together into this compression chamber and compressed therein, and thereafter discharged, stored, and delivered to the engine cylinder as hereinafter described with respect to air alone. I also provide in connection with the cylinder a valve and storage chamber or reservoir within which are two

valves, which in the instances shown are slide valves, one controlling admission of air, or air and gas, to the annular compression space and the delivery of such air when compressed, to the main portion of such storage chamber or reservoir, the other valve controlling the passage of this compressed air to the admission port of the cylinder; and I commonly mix the fuel with this air from the reservoir, just before it enters the cylinder. This admission port is located in the rear head of the engine cylinder and there is in this head a spring-closed valve which prevents back flow of gas within the engine cylinder into such admission port. In the housing and lower portion of the walls of the cylinder proper of the engine there is a scavenging duct leading to a port in the cylinder wall arranged to be uncovered by the piston and located approximately opposite an exhaust port in such cylinder wall, also arranged to be uncovered by the piston; and between these ports there is the usual deflector on the piston head. The piston itself does not control directly the admission of the explosive charge to the engine cylinder, such admission being controlled by one of the slide valves mentioned in the reservoir, and this valve is so operated that admission of the charge does not begin until shortly before the closure of the exhaust port. The exhaust gases having been swept from the cylinder by the scavenging air before admission of the charge begins, there is no opportunity for mixture of the charge with anything but the pure scavenging air, and by the time the cylinder has filled with the charge the exhaust port has been closed, so that there is no opportunity for escape of the charge through the exhaust port. Likewise, since practically the entire charge is admitted by, or just after, the closure of this exhaust port, such charge is completely admitted before any considerable back pressure has been produced by the rearward motion of the piston, the cylinder being thereby given full opportunity to fill to its fullest extent with the charge. This filling of the cylinder with the charge is further facilitated owing to the fact that the admission takes place through the rear head of the cylinder and not through a port in the side of the cylinder and near the outward limit of motion of the piston, as in most two cycle engines.

Owing to the diameter of the lower head of the piston being larger than that of the upper head, the volume displaced by the piston in the crank case or lower compression chamber, during the movement of the piston therein, is greater than the volume displaced by the piston in the working cylinder during its movement therein; for which reason, notwithstanding the considerable vol-

ume of clearance space in the crank case practically a complete cylinderful of air will pass from the crank case to the cylinder 1 during the scavenging period, a considerable portion of which air will remain in the cylinder after the closing of the exhaust port. The clearance space in the annular chamber being small, practically all of the air compressed in this annular space will be discharged into the reservoir and thence into the cylinder; the air so supplied from these two sources being ample to fill the cylinder completely at, or even slightly above, atmospheric pressure.

Referring now to the drawings, and at first to Figs. 1-6 inclusive, 1 designates the working cylinder, or cylinder proper, 2 the housing within which is the annular compression space above mentioned, and 3 designates the piston having in addition to the usual rear head, working within the cylinder 1, an enlarged or stepped annular head 5 working in the housing 2. The piston is connected by the usual connecting rod 6 to the crank pin of a crank shaft 7 working in bearings in the crank case 8.

In the walls of the housing 2 and cylinder 1 there is a scavenging duct 9 leading to a scavenging port 10 communicating with the cylinder 1; and opposite this scavenging port 10 there is the usual exhaust port 11, both the scavenging port and exhaust port being arranged to be alternately covered and uncovered by the piston 3. Air for scavenging is admitted to the crank case through port 9 and a check valve 9^a.

Cylinder 1 is provided with the usual cooling jacket 12 and also with suitable ignition means, as for example, an electric ignition plug 13. In the head of the cylinder 1 there is an admission valve 14 mounted in a removable valve cage 15 which, in the drawings, I have shown arranged to screw into the head of the cylinder. This valve, as shown, is arranged to open inwardly, and is normally held closed, against a valve seat formed on the valve cage 15, by a spring 17 bearing against said valve cage and against a head 16 carried by the stem of the valve 14. A cap 18 normally covers this valve stem, valve cage, and spring. The upper portion of piston 3 is provided with the usual spring packing rings 19 and between cylinder 1 and the annular compression space between the inner surface of housing 2 and the reduced portion of the piston 3, there are other spring packing rings 20 carried by a ring 21 resting in a counterbore of housing 2, these rings 20 bearing against the reduced portion of the piston and serving in connection with spring rings 19, to prevent leakage of air into cylinder 1 from the annular compression space. The larger portion of lower head 5 of the piston 3 is provided with other packing rings 23, 130

serving to prevent the passage of air or mixed air and gas from the annular compression space above this piston head 5 into the closed crank case. A port 27, connected
 5 by a duct 28 to a counter-bore 29, is provided for the supply of lubricant to the cylinder and piston. The piston has, between the scavenging port 10 and exhaust port 11, the usual deflector 24. The crank shaft
 10 bearings comprise the usual bushings 26 surrounding said shaft and fitting within the bearing openings in the crank case.

Adjacent to the cylinder there is a combined valve chest and reservoir or storage
 15 chamber 33 within which, in the construction referred to, are slide valves 30 and 40 operated by a valve rod 36, eccentric rod and strap 38 and eccentric 39 on crank shaft 7. Valve 30, within reservoir 33, is an ordinary D slide valve having a recess 37 adapted to connect and disconnect an admission
 20 port 31 in the side of reservoir 33 with a port 32 leading to the annular compression space 25 between the reduced portion 3 of the piston and the inner walls of housing 2.

42 is the admission port above referred to in the rear head of cylinder 1 and adapted to connect reservoir 33 with ports 41 in the sides of valve cage 15. Piston valve 40 on
 30 valve rod 36 opens and closes this port 42. Reservoir 33 is provided with the usual front and rear heads and with a stuffing box through which the valve rod 36 passes.

The operation of this engine is as follows:

35 During the up stroke of the piston a charge, previously admitted to cylinder 1, as hereinafter described, is compressed, and air, or air and gas, previously admitted to annular compression space 25, as hereinafter described, is also compressed, valve 30 closing
 40 early in this stroke and at about the time when the piston 3 closes exhaust port 11. At or near the conclusion of the compression stroke the charge is ignited in the usual manner and expands during the downward
 45 stroke of the piston 3. Early in this downward stroke and at about the point indicated by the letter J, Fig. 6, valve 30 places ports 31 and 32 in communication, air, or air and
 50 gas, being drawn from port 31 through port 32 into the annular compression space 25. During this downward stroke of the piston 3 air in the closed crank case 8 is compressed. Also, and at about the point indicated by
 55 letter K in Fig. 6, valve 40 closes admission port 42. Near the end of this expansion stroke and at about the point indicated by letter A, in Fig. 6, the piston 3 opens exhaust port 11, and shortly thereafter, and
 60 at about the point indicated by the letter B in Fig. 6, the scavenging port 10 is opened, the air compressed within the crank case 8 then passing up through duct 9 and port 10 into the cylinder 1 and being deflected by
 65 deflector 24 and caused to swirl up through

the cylinder, so sweeping out of the cylinder the burned gases and filling the same with pure air. Near the beginning of the next succeeding up or back stroke of the piston, and at about the point indicated by letter C
 70 in Fig. 6, valve 40 opens admission port 42 and permits previously compressed air, or air and gas, from reservoir 33 to pass through said port 42 into the valve cage 15 and thence past valve 14, which opens auto-
 75 matically owing to there being greater pressure on its rear side than on its front side, into cylinder 1; and as hereafter explained, this air in passing through port 42, takes up a proper proportion of fuel. Shortly there-
 80 after and at about the point indicated by the letter D in Fig. 6, the edge 30' of valve 30 closes port 32, and the air or mixture of air and gas or oil vapor previously admitted to compression space 25 as just described, is
 85 compressed during the up or back stroke of the piston. At about the point indicated by the letter E in Fig. 6, the scavenging port 10 is closed by the piston and at about the point indicated by the letter F in Fig. 6, piston 3 closes the exhaust port 11, this exhaust
 90 port closure occurring before there can have been any escape of the charge through the exhaust port; for as will be understood, the charge in entering the cylinder sweeps before it a portion of the scavenging air already filling the cylinder. Shortly there-
 95 after spring closed valve 14 closes, this valve closing as soon as the pressure in the cylinder 1 has nearly reached the pressure in the reservoir 33. During the upward motion of piston 3 valve 9^a opens, admitting more
 100 air to the crank case 8. At about the point indicated by letter G, in Fig. 6, the edge 30² of valve 30 opens port 32 into communication with the interior of reservoir 33, so admitting the air compressed in space 25 into reservoir 33.

The conical shape of valve 14 has an important influence upon the action of the engine, since it spreads out the entering charge, causing the same to fill the cylinder uniformly and to drive before it the scavenging
 110 air and products of combustion of the previous charge, besides mixing the entering charge thoroughly with scavenging air. Ordinarily, the air admitted as a part of the charge, through the admission port 42, is insufficient in proportion for combustion of the charge or to form an explosive mixture;
 115 the portion of the scavenging air remaining in the cylinder after closure of the exhaust port, supplying the remaining air required to form an explosive mixture and to effect combustion. Since the entering charge, dif-
 120 fused greatly by the action of the valve 14 as above described, meets the scavenging air moving upwardly and across the upper portion of the cylinder, the entering charge and this scavenging air are mingled very
 125 130

thoroughly—a condition especially favorable to good combustion of the fuel in the engine cylinder. It will be noted that the scavenging air, caused to sweep upward to the top of the cylinder and thence across, by the deflector 24, separates the entering charge from the burned gases remaining in the cylinder at the time of entry of the charge, so preventing dilution of the explosive mixture by the burned gases, and also effectively preventing escape of any portion of the explosive mixture with the burned gases during the exhaust period; for even should the exhaust port remain open after all the burned gases have passed out, the gas next to pass out will be a portion of the scavenging air as yet practically unmixed with the charge; and before that portion of the scavenging air which has been mixed with the charge reaches the exhaust port, that exhaust port will have been closed. Since, however, the exhaust port is still open at the time the charge begins to enter the cylinder past the valve 14, the entering charge materially helps to effect complete scavenging of the cylinder, by driving down in the cylinder the scavenging air, the scavenging air so driven down in turn driving down and out through the exhaust port the burned gases remaining in the cylinder. Owing to this action, very perfect scavenging is effected with a minimum of scavenging air. I provide a duct 43 leading from port 42 to the reservoir 33 at a point where it may be opened and closed by valve 30 and when open will communicate with valve recess 37. This duct serves as a relief port to reduce pressure in port 42 after valve 40 closes said port, so preventing the pressure in port 42 from opening spring-closed valve 14 before valve 40 opens said port 42 again. The reduction in pressure in port 42 also facilitates the spraying of oil into this port, as hereinafter described.

Obviously this engine may be operated by drawing in through port 31 a mixture of gas and air or oil vapor, alcohol vapor etc., and air; but preferably, when the engine is operated on liquid fuel, I admit only pure air through port 31, spraying the liquid fuel (gasolene, alcohol, kerosene, fuel oil, crude oil, etc.), into port 42 and there mixing it with the compressed air stored in reservoir 33 and admitted into port 42 when valve 40 opens said port. To this end I may use the device shown in Figs. 3-5 inclusive. In these figures 48 designates the casing of a feed valve to which oil or other liquid fuel under pressure is delivered by a pipe 52. 53 is a ball check valve within this casing, and 54 a needle valve.

49 is a storage receptacle within the valve casing of size sufficient to hold more than enough fuel for a single charge.

50 is a plug having a very small hole 51 through it.

This valve 48 connects with port 42 at a point 46, where said port is enlarged and contains wire gauze or equivalent material, 47, upon which the fuel may drift and spread out in thin films. In the operation of this oil feeding device supposing the gauze 47 to be already saturated with oil, air admitted into port 42 from reservoir 33, upon the opening of said port by valve 40, will rush through the gauze, picking up from it the liquid fuel thereon in the form of exceedingly fine drops; the fuel being in fact atomized by the passage of the air through the fine perforations of gauze. While there is air pressure in passage 42, the fuel will not feed down from storage receptacle 49 but to the contrary the air will work up into said receptacle. But when the pressure in passage 42 is relieved, by the opening of relief duct 43 by valve 30, the air which has so worked up into storage receptacle 49 will eject the fuel in such receptacle forcibly on to the gauze 47, said receptacle 49 being filled by fuel flowing from pipe 52 past valve 53. The needle valve 54 obviously regulates the rate of flow of the fuel, and therefore the amount of fuel which will flow into receptacle 49 during any one cycle of operation. The lower orifice of duct 43 is so located that it will be opened by valve 30 immediately after valve 40 has closed port 42.

Obviously my invention is not restricted to use in vertical-cylinder engines, and in Fig. 7 I have shown the invention embodied in a two cylinder engine of the horizontal opposed type. The construction of the several parts is substantially the same as in the engine shown in the preceding views except that I have shown each valve rod 36 operated by a cam 55 which is also one of the crank disks of the opposite cylinder, each valve rod having a friction roller 56 bearing against the edge of such cam crank-disk, the valve rod being pressed against such cam by a spring 57 within the reservoir 33. I have also shown the valve rod provided with a piston 58 closing the front end of the reservoir 33 instead of employing a stuffing box to close such end, as in the construction shown in the preceding view. The crank cases 8 of the two cylinders are of course separate.

It will be understood that it is immaterial in general whether the cylinder be above, below, or to one side of the crank shaft and therefore in the following claims I have used the term front end to denote that end of the cylinder nearest the crank shaft, and have used the term rear end to denote that end of the cylinder farthest from the crank shaft.

It is of course in a broad sense immaterial

whether air be compressed in the crank case and in an annular compression space, or in entirely separate cylinders having separate pistons; but for the sake of compactness, simplicity, reduction in cost of manufacture, and elimination of stresses in the structural engine, it is desirable to have the compression spaces arranged as shown.

In Fig. 7 I have also indicated means for supplying liquid fuel to the supply valves 48 comprising a pump 59 operated by an eccentric 60 on the engine shaft and arranged to produce pressure in a fuel supply reservoir 61 from which pipes 52 lead to the valves 48.

Since in this engine the scavenging is effected entirely independently of regulation of the entering charge, scavenging is practically as perfect when the engine is run on variable load with constant or nearly constant speed, (the volume of the charge being varied more or less automatically or otherwise, to maintain the speed where desired,) as when the engine is operating at full load and constant speed. In the ordinary two cycle engine, regulation of action of the engine to correspond with variable load is commonly accomplished by throttling the entering charge, which of course affects very greatly the scavenging of the cylinder. Regulation of speed of this engine will commonly be effected, when the fuel used is oil or other liquid, by throttling the oil supplied by means of needle valve 54. Or, if the fuel used is gas, the gas will be throttled in the ordinary way.

What I claim is:—

1. An internal combustion engine comprising in combination an engine cylinder having an admission port at its rear end and exhaust and scavenging ports near its front end, a piston in said cylinder arranged in its motion to open and close said exhaust and scavenging ports, a compression chamber, said piston having a secondary piston head working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, means connecting said compression chamber and the admission port of said cylinder, a valve controlling passage of fluid from said compression chamber to said admission port, valve mechanism for said valve arranged to open same prior to material compression in said cylinder during the rearward stroke of the piston, a check valve at the orifice of said admission port having flaring edges serving to distribute the entering charge across the cylinder, whereby the entering charge displaces before it the contents of the rear of the cylinder, said check valve arranged to prevent back flow from said cylinder toward said first named valve, and arranged to be closed by decrease in difference of pressure on the two

sides of said check valve during the compression period in said cylinder, and a second compression chamber in which said piston compresses during its forward motion, said second compression chamber connected to said scavenging port to supply scavenging air thereto, the valve mechanism of said first valve arranged to admit the charge prior to closure of the exhaust port, whereby the burned gases swept forward by the scavenging air are expelled by the air and charge behind.

2. An internal combustion engine comprising in combination an engine cylinder having an admission port at its rear end and an exhaust port near its front end, a piston in said cylinder arranged in its motion to open and close said exhaust port, a compression chamber, said piston having a secondary piston head working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, means connecting said compression chamber and the admission port of said cylinder, a valve controlling passage of fluid from said compression chamber to said admission port, valve mechanism for operating said valve arranged to open same prior to material compression in said cylinder during the rearward stroke of the piston, a check valve arranged to prevent back flow from said cylinder toward said first valve, and arranged to be closed by decrease in difference of pressure on the two sides of said check valve during the compression period in said cylinder, a relief port connected to said admission port between said valves, and valve means controlling the same.

3. An internal combustion engine comprising in combination a working cylinder having at its front end exhaust and scavenging ports and at its rear end an admission port, a piston in said cylinder arranged in its motion to open and close said exhaust and scavenging ports, a compression chamber connected to said admission port, said piston having a secondary piston head working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, a second compression chamber connected to said scavenging port, and in which said piston compresses during its forward motion, a valve controlling the admission of air from such first compression chamber to the working cylinder through such admission port, positive valve operating means therefor holding said valve closed during substantially the entire expansion period in said cylinder, and opening said valve prior to the beginning of material compression in said cylinder, means for introducing fuel to said admission port and there mingling it with air from said first compression cham-

ber, and a free check valve interposed between said admission port and the cylinder, and arranged to prevent back flow from said cylinder into said admission port.

5 4. An internal combustion engine comprising in combination an engine cylinder having an admission port at its rear end and exhaust and scavenging ports near its front
10 end, a piston in said cylinder arranged in its motion to open and close said exhaust and scavenging ports, a compression chamber, said piston having a secondary piston head
15 working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, means including a pressure reservoir
20 connecting said compression chamber and said admission port, valve means controlling the flow of air from said compression chamber to said reservoir, and from said reservoir to said admission port, means for introducing
25 fuel into said admission port and there mingling it with air from said compression chamber, a free check valve interposed between said admission port and the cylinder and arranged to prevent back flow
30 from said cylinder into said admission port, and a second compression chamber in which said piston compresses during its forward motion, said second compression chamber
connected to said scavenging port to supply scavenging air thereto.

5 5. An internal combustion engine comprising in combination an engine cylinder having
35 an admission port at its rear end and exhaust and scavenging ports near its front end, a piston in said cylinder arranged in its motion to open and close said exhaust and scavenging ports, a compression chamber,
40 said piston having a secondary piston head working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, means connecting said compression
45 chamber and said admission port, valve means including a positively operated valve controlling the flow of air from said compression chamber through such admission port to said engine cylinder, a liquid fuel
50 receptacle connected to said admission port and provided with means for delivering to said port liquid fuel under pressure, and further provided with valve means preventing back flow from said receptacle, a free
55 check valve interposed between the said admission port and cylinder and arranged to prevent back flow from said cylinder into said admission port, and a second compression chamber in which said piston compresses during its forward
60 motion, said second compression chamber connected to said scavenging port to supply scavenging air thereto.

65 6. An internal combustion engine comprising in combination an engine cylinder

having an admission port at its rear end and exhaust and scavenging ports near its front end, a piston in said cylinder arranged in its motion to open and close said exhaust and scavenging ports, a compression chamber, said piston having a secondary piston head working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, means connecting said compression chamber and said admission port, valve means including a positively operated valve controlling the flow of air from said compression chamber through such admission port to said engine cylinder, a liquid fuel receptacle having a restricted orifice connected to said admission port, said receptacle provided with means for delivering to said port liquid fuel under pressure, and further provided with valve means preventing back flow from said receptacle, a free check valve interposed between the said admission port and cylinder and arranged to prevent back flow from said cylinder into said admission port, and a second compression chamber in which said piston compresses during its forward motion, said second compression chamber connected to said scavenging port to supply scavenging air thereto.

7. An internal combustion engine comprising in combination an engine cylinder having an admission port at its rear end and exhaust and scavenging ports near its front end, a piston in said cylinder arranged in its motion to open and close said exhaust and scavenging ports, a compression chamber, said piston having a secondary piston head working in said compression chamber, whereby compression is effected in said chamber during rearward motion of the piston, means connecting said compression chamber and said admission port, a valve controlling passage from said admission port into said cylinder, valve means controlling passage of fluid from said compression chamber to said admission port, a liquid fuel receptacle connected to said admission port between said valves and provided with means for delivering to it liquid fuel under pressure, and with valve means preventing back flow from such receptacle, a relief port for said admission port connected thereto between the valves thereof, and adapted to relieve pressure in said admission port between its valves, valve means controlling said relief port, and a second compression chamber in which said piston compresses during its forward motion, said second compression chamber connected to said scavenging port to supply scavenging air thereto.

8. An internal combustion engine comprising in combination an engine cylinder having an admission port, a piston in said

cylinder, a compression chamber in which said piston also travels and compresses air, a pressure reservoir connected to said compression chamber and to said admission port, a liquid fuel receptacle connected to said admission port and having means for supplying to it liquid fuel under pressure, and means preventing back flow from said receptacle, and valve means controlling the flow of air from said compression chamber to said admission port and from said admission port to said cylinder, including a positively operated valve between the reservoir and admission port, and a free check valve between the cylinder and admission port.

9. An internal combustion engine comprising in combination an engine cylinder having an admission port, a piston in said cylinder, a compression chamber in which said piston also travels and compresses air, a pressure reservoir connected to said compression chamber and to said admission port, a check valve preventing back flow from said cylinder into said admission port, a liquid fuel receptacle connected to said admission port in rear of said check valve, and having means for supplying to it liquid fuel under pressure, and means for preventing back flow from said receptacle, valve means controlling the flow of air from said compression chamber to said reservoir and from said reservoir to said admission port, a relief port for said admission port, connected thereto between the valves thereof, and valve means controlling said relief port.

10. An internal combustion engine comprising in combination an engine cylinder having an admission port, a piston in said cylinder, a compression chamber, in which said piston also travels and compresses air, said compression chamber connected to said admission port, a liquid fuel receptacle connected to said admission port and having means for supplying to it liquid fuel under pressure, means in said admission port for receiving fuel from said receptacle, adapted to spread the same out into thin films, a relief port for said admission port, and valve means controlling the flow of air from said compression chamber to said admission port, and controlling said relief port.

11. An internal combustion engine comprising in combination an engine cylinder comprising two portions of different diameters, one portion constituting the main or working cylinder, the other constituting an annular compression chamber, a closed crank case, a stepped piston, one portion of which works in said main cylinder, the other of which works in said compression chamber, said main cylinder having in its front end exhaust and scavenging ports and in its rear end an admission port, said piston arranged in its motion to open and close said exhaust

and scavenging ports, said scavenging port connected to said crank case, a pressure reservoir connected to said compression chamber and to said admission port, valves controlling admission to said annular compression chamber and discharge from said annular compression chamber into said reservoir and controlling flow from said reservoir to the admission port of said cylinder, means for operating said valves, means for supplying fuel to said admission port, a check valve preventing back flow from said cylinder to said admission port, and a relief port for said admission port connected thereto between the valves thereof and serving to relieve pressure in said admission port after closure of said check valve, said relief port serving to relieve pressure in said admission port after closure of said check valve.

12. An internal combustion engine comprising in combination a crank shaft, engine cylinders on opposite sides thereof, separate closed crank chambers, one for each such cylinder, each such cylinder having at its front end exhaust and scavenging ports, and at its rear end an admission port, each such cylinder having two portions of different diameters, one portion constituting the main or working cylinder, the other constituting an annular compression chamber, a stepped piston, one portion of which works in said main cylinder, the other of which works in said compression chamber, said piston arranged in its motion to open and close said exhaust and scavenging ports, each closed crank chamber connected to a corresponding scavenging port, a pressure reservoir for each cylinder connected to the annular compression space of that cylinder and to the admission port of that cylinder, and located opposite the opposed cylinder, valves controlling the flow of fluid from the annular compression space of each cylinder to the corresponding reservoir, and from that reservoir to the corresponding admission port, and means for operating said valves.

13. An internal combustion engine comprising in combination a crank shaft, engine cylinders on opposite sides thereof, separate closed crank chambers, one for each such cylinder, each such cylinder having at its front end exhaust and scavenging ports, and at its rear end an admission port, each such cylinder having two portions of different diameters, one portion constituting the main or working cylinder, the other constituting an annular compression chamber, a stepped piston, one portion of which works in said main cylinder, the other of which works in said compression chamber, said piston arranged in its motion to open and close said exhaust and scavenging ports, each closed crank chamber connected to a corresponding scavenging port, a pressure reservoir for each cylinder connected to the annular com-

pression space of that cylinder and to the admission port of that cylinder and located opposite the opposed cylinder, valves controlling the flow of fluid from the annular
5 compression space of each cylinder to the corresponding reservoir, and from that reservoir to the corresponding admission port, valve rods for operating said valves, the crank shaft having a crank disk for each
10 cylinder forming a cam which actuates the

valve rod of the reservoir of the opposite cylinder.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

CLARENCE A. DAWLEY.

Witnesses:

H. M. MARBLE,
FRANK E. RAFFMAN.