

May 5, 1925.

1,536,780

O. H. ENSIGN

AUTOMOTIVE ENGINE ART

Filed Aug. 24, 1920

3 Sheets-Sheet 1

Fig. 1

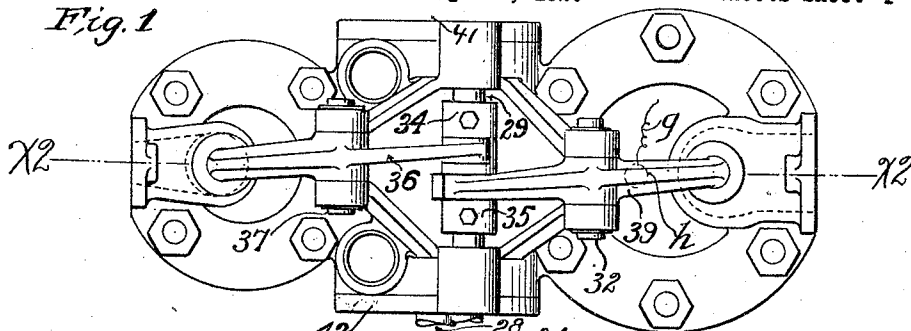


Fig. 2

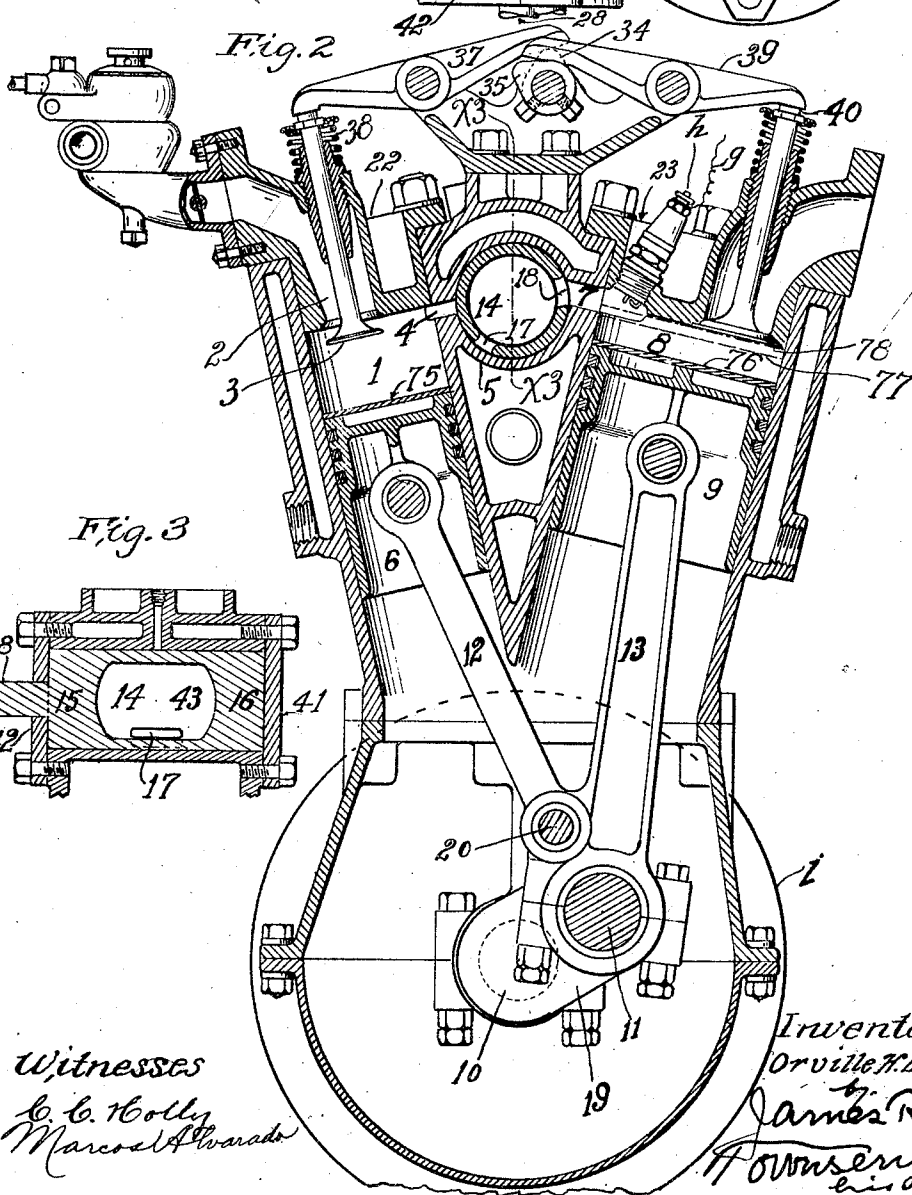
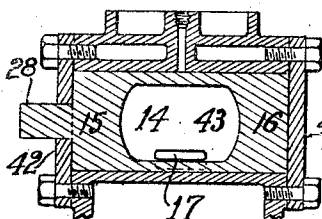


Fig. 3



Witnesses
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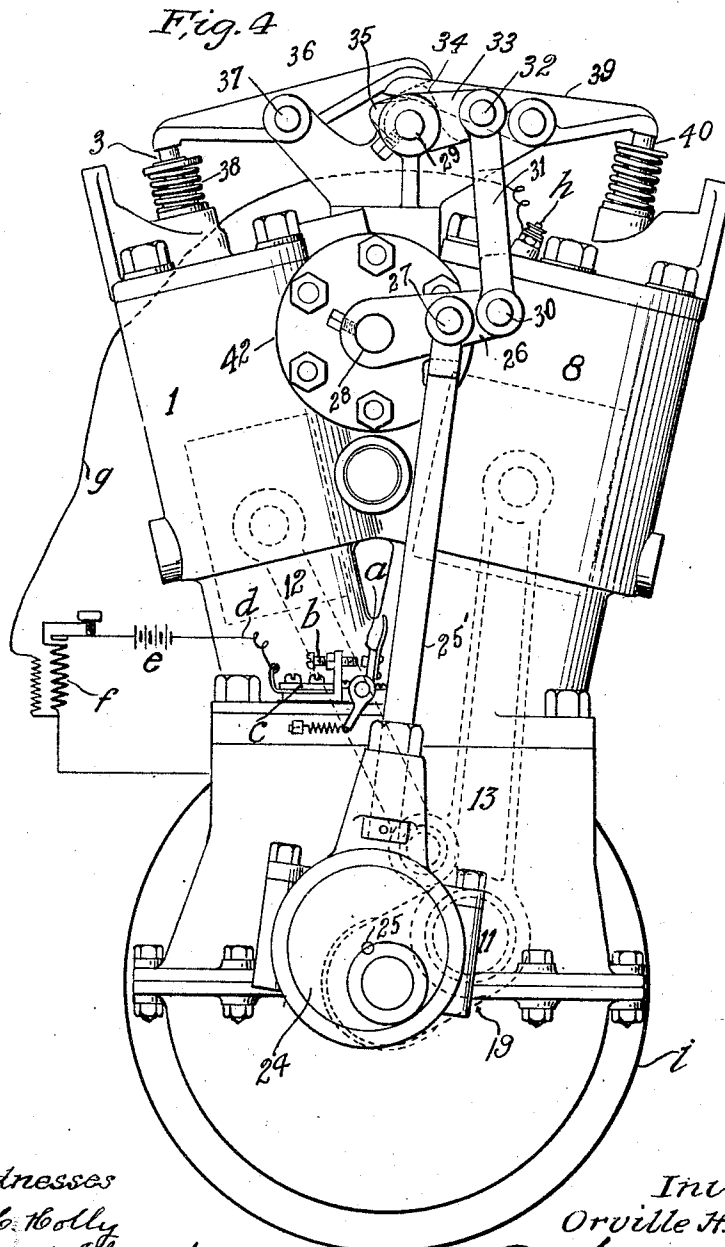
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3 Sheets-Sheet 2



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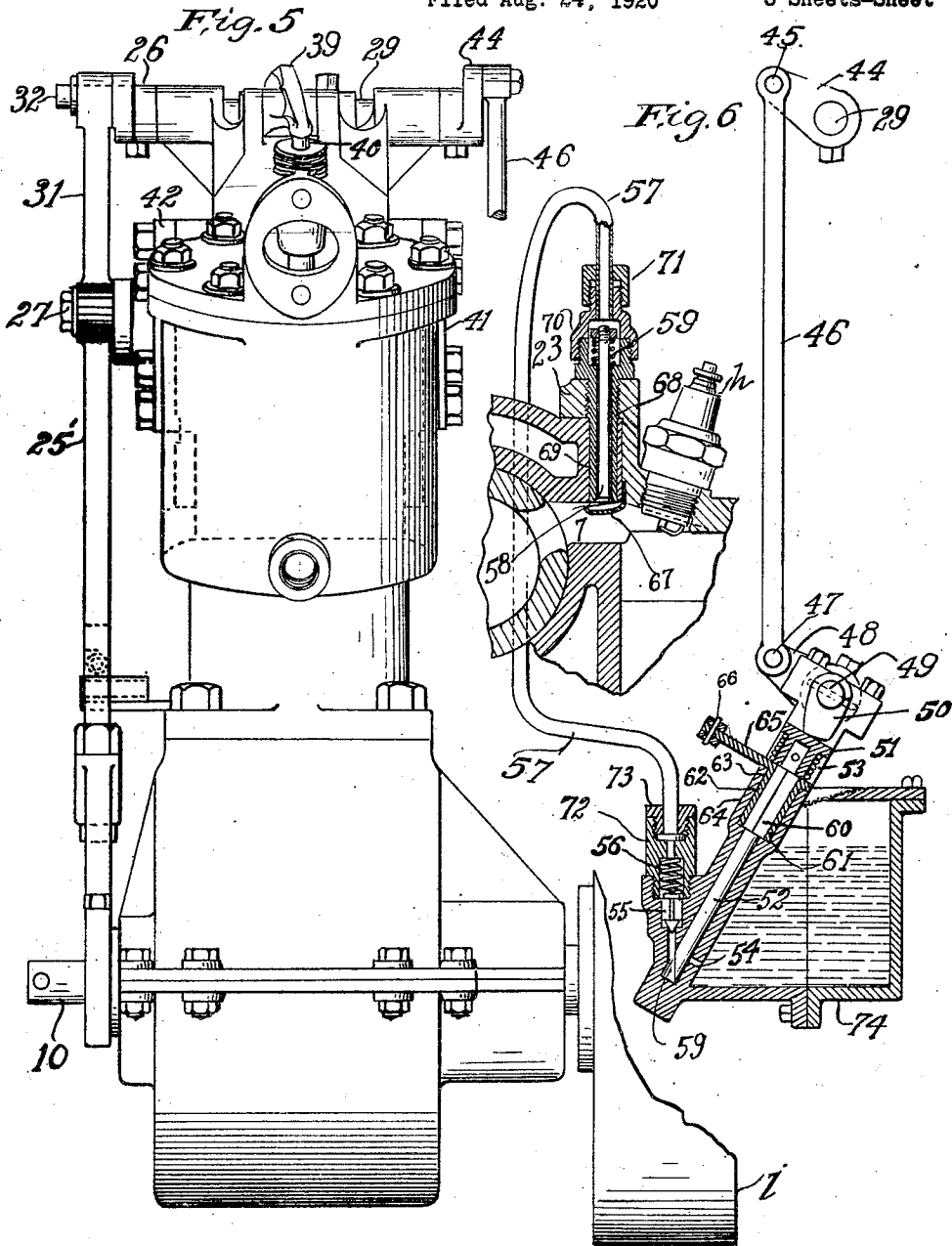
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AUTOMOTIVE ENGINE ART

Filed Aug. 24, 1920

3 Sheets-Sheet 3



Witnesses

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UNITED STATES PATENT OFFICE.

ORVILLE HIRAM ENSIGN, OF PASADENA, CALIFORNIA.

AUTOMOTIVE ENGINE ART.

Application filed August 24, 1920. Serial No. 405,720.

To all whom it may concern:

Be it known that I, ORVILLE HIRAM ENSIGN, a citizen of the United States, residing at Pasadena, in the county of Los Angeles and State of California, have invented and discovered new and useful Improvements in the Automotive Engine Art, of which the following is a specification.

This invention is an improvement in the art of utilizing internal combustion in the two stroke complete expansion constant volume cycle for power purposes and is broadly new, basic and pioneer in that I provide an oscillating clearance which is a combined combustion chamber and valve which receives a highly compressed charge from a compressor, isolates said charge from the compressor, and opens the charge to the working cylinder and I then combust the charge within the valve. The early Clerk engine is an illustration of the type of engine to which this improvement applies.

In carrying out this improvement in its preferred form, a compressor cylinder and piston and a power cylinder and piston having practically no piston clearance within the cylinders are provided with an oscillating clearance chamber alternately applicable to each, and in practice a cold comburent charge is drawn in and highly compressed, is then isolated from the compressor, and quickly combusted in communication with a working space which is expansible in large volumetric ratio and is there almost completely transformed into power through complete expansion; after which the burnt products are exhausted.

By this process the heat losses from beginning to end of the cycle are minimized.

In this invention, the charge of compressed comburent from the compressor cylinder is completely delivered into a movable clearance space and is instantly thereafter closed off from the compressor cylinder; and practically in the same instant it is opened to the power cylinder and is ignited, and combustion is completed; taking place exactly under the same initial pressure and temperature conditions as though the charge were compressed in the power cylinder itself. The conditions involved indicate that the efficiency that may be obtained by this method is possibly the highest that is practical in any heat engine of this type because the loss of heat of compression to the receiver walls is minimized and there is an

addition to the charge in the movable clearance chamber, of heat from previous combustion, thus compensating for any tendency to loss of heat of compression.

In the combpressor cylinder of an engine constructed in accordance with this invention, lowering of the weight of the charge does not occur in connection with this heated clearance space which is common to both cylinders, because the charge is drawn into the compressor cylinder while the alternating clearance is shut off from the compressor cylinder, and only opens at the beginning of the compression stroke after the inspiration charge is locked in the compressor cylinder. In two movements of comburent, viz, inspiration of cold comburent into the compressor cylinder, and delivery of the compressed comburent to the power cylinder, the operations are completed in such manner that stored heat from previous combustion does not alter the state of the charge in a detrimental manner. That is to say; the compressor cylinder fills without modification or interference with the charge weight by any heat except the heat of compression and that of the water jacket. The charge, after being locked in the compressor cylinder, is opened to and is then compressed into the movable clearance and is afterward opened up to the power cylinder after the working space has been brought to the point of minimum clearance and locked tight by its valves; and any heat that is picked up from the walls by the charge is regenerative heat recovered from the previous explosion or combustion.

An object of this invention is to make constant volume working more nearly possible, than in any two stroke high expansion engine heretofore proposed.

An object is to subject the comburent to excessive turbulence immediately previous to and during combustion.

Another object is to make it possible to build an automotive engine in which high compression can be brought about without difficulty.

An object of the invention is to make possible the use of fuel injection in an automotive engine of high compression and high rate of expansion, thus tending to maximize possible economy.

The invention relating to the apparatus is broadly new, basic and pioneer in that I have provided in combination with a crank

shaft and crank, a compressing cylinder and a power cylinder in such angular relation to each other as to provide between their heads a space adapted to accommodate a valve bearing containing an oscillating clearance chamber into which a charge of comburent from the compressor may be compressed. The angle that the compressor and power cylinder bear to each other may be made any desirable degree in order to obtain the proper timing of the relation between the completion of the compressing stroke and the beginning of the power stroke with its coordinating valve timing; said compressing cylinder having small displacement relative to the power cylinder; and I provide means whereby said clearance chamber is adapted to rapid oscillation and to the instantaneous reception and isolation of the compressed charge of comburent; quick communication with the power chamber, instant combustion while in communication with the power chamber; expansion to large volume and then exhaust of the burned gases. In this manner the heat losses are minimized in numerous ways. By this means and in carrying out the invention I have provided an oscillating clearance chamber timed with the pistons and arranged in said valve bearing; said oscillating clearance chamber being so constructed and arranged that the transfer and firing of the comburent is as direct as possible and that the expansion ratio can be made as high as may be found practical.

I am not aware that there has been constructed any practical engine in which the unlimited control of the expansion ratio within practical limits was possible.

The invention is interchangeably applicable to the use of carburization and to fuel injection; and both forms of fuel application will be described herein and it is understood that features of the invention are applicable to engines of the Diesel type.

Another object of the invention is to make possible the operation of a constant compression engine having a high compression and a high expansion ratio.

Another object of the invention is to provide by simple means an engine over which the control of the expansion ratio may be retained.

Another object of the invention is to create an engine with as few parts as possible with a large power output. The operation of all the valves of this invention is brought about through the medium of one excentric connecting to all the valves through rocker arms and rock shaft.

An object is to bring about a practical working engine of the Clerk general type with its attendant high capacity and high economy.

Other objects, advantages and features of

invention may appear from the accompanying drawings, the subjoined detail description and the appended claims.

The improvement in the art may be understood by reference to the accompanying drawings which illustrate one embodiment of this invention and its adaptation to operation with gas, with carburetion and with fuel injection.

Figure 1 is a fragmental developed plan of the top of a complete single engine constructed in accordance with this invention as applied to use with a carbureter.

Fig. 2 is a sectional elevation on line x^2 , Fig. 1 of the engine supplied with a carbureter.

Fig. 3 is a sectional detail of the combined receiving, transferring and combusting chamber, which is termed the oscillating clearance chamber, or alternating clearance.

Fig. 4 is an elevation of one side of the engine, omitting the carbureter and showing the valve and ignition action.

Fig. 5 is an edge elevation viewing the engine from the right of Figs. 1, 2 and 4.

Fig. 6 is a fragmental sectional diagram of the spray nozzle and metering pump connections for liquid fuel injection.

Set screws in some of the views are displaced with respect to the same in other views for convenience of full illustration.

The mechanical arrangements for the application of comburent or comburents in various forms will be such that gaseous fuel or liquid fuel used with a carbureter may be introduced with air; or that the air will be introduced alone, and after compression, opened to communication with the power cylinder, and then the fuel may be injected and the charge fired either by heat of compression or by the application of electric spark as will be understood from the following description.

The air compressor comprises a cylinder 1 having an inspiration port 2 and valve 3 in its head and a charge delivering port 4, opening through a wall of a valve bearing 5. Said compressor also comprises a piston 6 operating in the compressor cylinder 1 practically with no clearance between the compressor piston and the cylinder head.

The valve bearing is provided with a power cylinder admission port 7 opening into the power cylinder 8 in which the power piston 9 operates. Said compressor cylinder and power cylinder converge toward the crank shaft 10 at an angle which allows appropriate connection with the crank 11 of the connecting rods 12 and 13 for the compressor piston 6 and power piston 9.

Said pistons are each adapted to operate with practically no clearance between the pistons and the cylinder heads respectively. An oscillating alternating clearance cham-

ber 14, which is constructed as a hollow cylindrical oscillating valve having imperforate ends 15, 16 and provided with lateral receiving and discharging ports 17, 18, and serving as a charge receiving, transferring and combustion chamber is mounted inside said valve bearing 5; and the ports 17, 18 are adapted and arranged to communicate respectively with the compressor cylinder at one position through port 17, and with the power cylinder 8 through the delivery port 18, at another position.

The power piston 9 is connected by the connecting rod 13, crank pin 11 and crank arm 19 to the crank shaft 10. The compressor piston 6 is connected with the connecting rod 13 through the wrist pin 20 and the connecting rod 12, so that the movement of the crank shaft 10 actuated by the power piston 9 will operate the compressor piston 6 in timed relation.

The wrist pin 20 is attached to the lower end of the connecting rod in a manner common to V type engines.

The two cylinders are set at a convenient angle to allow for clearance of connecting rod 12 with the walls of the lower end of the cylinder 1. This angle also provides for the completion of the compressor stroke in time ahead of the completion of the exhaust stroke of the working cylinder so as to make possible the delivery of the compressed charge into the oscillating clearance chamber sufficiently in advance of the time of opening the same to communicate with the power cylinder, to allow closing the communication between the compressor cylinder and the clearance chamber for the purpose of isolating the compressed charge before opening communication with the power cylinder; thus protecting against leaks of the compressed charge back into the compressor cylinder when ignition and explosion take place in the clearance chamber which at that time operates as the combustion chamber. This is especially necessary because immediately that the compressor stroke is finished, the compressor piston starts downward on the intake stroke and opens communication with the atmosphere or other comburent source.

This advance of the closing of the compressor cylinder to the clearance chamber has been found to be in a practical way about 30° of the movement of the crank shaft. Closing communication between the compressor cylinder and the clearance chamber, 30° ahead of the completion of the return stroke of the power piston allows communication from the clearance chamber to be opened to the working cylinder 15° ahead of the dead center of the working cylinder; thus making possible that desired advance of ignition of the charge in communication

with the power cylinder which is so essential to complete combustion.

Port 4 opens flush with the compressor cylinder head 22; but port 7 is partly extended into head 23 of the power cylinder to avoid exposing any piston ring and to allow sufficient admission port area.

To bring about the proper timing of alternate communication of the clearance chamber with the compressor and power cylinders; the valve operating eccentric 24 is mounted upon the crank shaft with its working center 25, at right angles to the crank arm 19. This eccentric operates through the eccentric rod 25', the rocking arm 26 and rocker pin 27, to rock the valve stem 28, thus to move the clearance chamber 14 in timed oscillation. This position of the eccentric makes possible extremely rapid opening and closing of the delivery port 4 and admission port 7. The oscillating discharge ports 17 and 18, at the time of opening and closing, are being impelled by the eccentric while its center is moving through the vertical portion of its stroke; thus providing for an exceedingly quick opening and closure of ports on both sides of the oscillating chamber so that the time which elapses between the closing of communication with the compressor cylinder and opening communication to the power cylinder is minimized, thus holding the compressed charge in the clearance chamber the shortest possible length of time with the smallest possible loss of heat of compression to such walls.

To operate the intake and exhaust valves in proper time the rocker arm 26 is connected to the rock shaft 29 through the medium of the rock arm pin 30, the connecting rod 31, pin 32 and the rock shaft arm 33. The rock shaft 29 carries two cams 34 and 35. The cam 34 is shown in contact with the lever 36 which pivots about the pin 37 and is shown in Figs. 2 and 4 at the moment of depressing the inlet valve 3, and holding the same open against action of the spring 38 to admit air or mixture through the valve 3 while the piston 6 is moving on the intake stroke. The exhaust cam 35 is shown out of contact with the operating lever 39, but is so arranged that when the piston has completed its power stroke, it will move the lever 39 to open the spring closed exhaust valve 40 so as to hold open the exhaust valve during the whole of the exhaust stroke; allowing the same to be closed just before the piston reaches the end of the exhaust stroke, subject to the usual adjustment. This closure may take place at some point from $\frac{1}{4}$ to $\frac{1}{16}$ of an inch more or less from the end of the piston travel.

The clearance chamber 14 is mounted to freely oscillate in the valve bearing 5 which

is closed at one end by imperforate plate 41 and at the opposite end by the perforated plate 42 through which the valve stem 28 projects for engagement of the rocker arm 26.

The clearance chamber 14 constitutes a valve opening and closing to the two cylinders separately, and contains a cylindrical cavity 43 which is made of such capacity relative to that of compression cylinder 1, that the desired compression may be obtained. This chamber performs three functions; first, to receive the charge from the compressor; second, to isolate and hold the charge closed against the compressor cylinder until the proper time for admitting the charge to the power cylinder; and third, to afford the clearance necessary for combustion in connection with the power cylinder and it becomes a combustion chamber opening into the power cylinder when used with a carbureter; the combustion started in the admission port 7 moves through the discharge port 18 into the chamber 43, and combustion is completed in that manner.

The description just completed, applies to the method of operation when using a carbureter and delivering a mixture of air and liquid fuel spray through the inlet valve 3.

The engine may be supplied with fuel injected in liquid form into the cylinder admission port 7. To accomplish this the fuel pump shown in Fig. 6 is a metering pump arranged to feed, in timed relation to movements of the piston, the amount of fuel desired for each individual out stroke.

It is operated from the movement of the rock shaft 29 through the medium of the rocker arm 44, the pin 45, connecting rod 46, pin 47, arm 48 and the shaft 49.

These elements are so connected in time with the movement of the cylinders and the pistons that the cam 50 which is depressing tappet 51 which is mounted upon the end of the plunger 52, so that the plunger will be operated; and by displacement of the fuel at its lower end, will meter out the desired amount for each stroke.

The plunger 52 when released after being operated on by the cam 50, is returned on the suction stroke by the spring 53, and completely opens the suction port 54, allowing liquid fuel to fill the displacement space below the plunger; so that on the return stroke of the plunger, such fuel will be forced out past the spring closed check valve 55 and through the spring chamber 56, pipe 57 and injection valve 58 into the ignition port 7. The injection valve 58 is held against its seat with gentle pressure by means of spring 59, so that it will be closed through the major portion of every revolution of the engine and it is timed to open by oil pressure caused by the inward move-

ment of the plunger 52, and to immediately discharge the same amount of fuel that is displaced at the lower end of the plunger 52.

The lower end of the plunger 52 is aslant as at 59, at an acute angle to the axis of the plunger. The upper portion of the plunger 52 is provided with an angular body 60 which is preferably square and constitutes a guide for the plunger and moves in and out through the square hole 61 in the guide sleeve 62 which bears in the cylindrical bearing 63 in the pump body 64. The guide sleeve 62 is provided with an arm 65 and is operated by a reach rod 66 shown only in end section and pinned to the arm 65 to operate the same. This reach rod may connect in well known manner with a governor or with hand control, not shown, and through the arm 65, the guide sleeve may be turned through any desired, or necessary angle. If it is turned 180° from the position shown, the plunger on its downward stroke will not close off the suction port 54, while in the position shown, it will close it off early in the stroke and will deliver the maximum capacity of the pump at each engine stroke. By adjustment to any point between those two positions, any desired fractional amount of maximum fuel will be delivered through the injection valve 58 because of adjusted delayed closure of suction port 54; thus giving control over the amount of fuel injected at each cylinder stroke.

The timing of the delivery of fuel through the injection valve should be such that the delivery is completed just previous to opening the discharge port 18 to admission port 7 of the power cylinder.

If the fuel is completely delivered by this means in advance of the beginning of the opening of the outlet port 18 there will be some fuel sprayed out into the admission port 7 while the bulk of it remains in the cup 67; and this remainder will be blown into the port 7 and thus form a mixture with the air in and moving through the said port during the first movements of the piston after the clearance chamber is open to the power cylinder.

The complete operation will be as follows: Air inspiration, air compression, isolation of the compressed air, injection of a metered fuel charge into a space closed to the compressed air and opened to the power cylinder, delivery of a portion of the compressed air through such space to the power cylinder and thereby forcibly mixing portions of fuel and compressed air causing explosive action of the first increments of air and fuel causing a regurgitation of the ignited mass back to the main body of compressed air, thereby forming throughout the compressed air a rapidly burning mixture; said regurgitation and explosive action

thereby causing heating and expansion within the power cylinder. The regurgitation and explosive action entirely blows out of the cup 67 the fuel remaining therein and
 5 thoroughly completes the mixture for complete combustion.

The fuel pump tank 74 shown in Fig. 6, may be supplied with fuel oil by any well known means not shown; such as a pump
 10 with an overflow pipe to return the excess to the storage tank.

This invention is especially designed as a constant volume engine; that is, an engine in which explosion takes place when the piston is at the top of the stroke; and it is
 15 therefore more particularly adapted to the use of gasoline or kerosene or other refined oils from which an explosive mixture can be made. The idea of fuel injection is to enhance the economy by stratified mixtures
 20 instead of having the whole volume of the charge to constitute a mixture at each stroke.

The injection valve 58 is carried in a body 68 which is threaded into the cylinder head
 25 23 and passes through the engine structure in the fit 69 to the admission port 7. It is provided with a threaded cap 70 carrying a gland nut 71 for holding the pipe 57. The valve 58 is held in position through the medium of the spring 59 within the body 68.
 30

The compressor piston 6 is provided with a hot plate 75 and power cylinder 8 with a hot plate 76. Both plates are mounted so that heat resisting medium may be retained
 35 underneath them with sufficient strength to resist the pressure upon the surface of the plates.

As the combustion does not take place in the same cylinder in which compression
 40 takes place, pre-ignition from the hot piston heads cannot take place; therefore these hot plates provided with heat insulation underneath them are placed on both pistons. In the compressor piston they help hold the
 45 heat of compression from being dissipated to the piston proper while in the power piston the heat of the plate assists ignition and the heat stored at the beginning of the stroke at the highest temperature is given out on the expansion stroke and thus not lost to the piston. The cylinder heads are not
 50 water jacketed for the same reasons.

In power cylinder 8, dotted line 77 represents the position of the piston on the exhaust stroke when the exhaust valve 40
 55 would be closed and port 7 would be opened by the oscillating valve 14 through the port 18; and the dash and dot line 78 represents the top of the piston travel.

The ignition is supplied through the medium of a spring resisted arm *a* adapted to contact with the excentric rod 25' when it is in its extreme horizontal position when the crank pin 11 is at the extreme top position.
 60 This will deflect the arm *a* to bring about

contact with the contact screw *b* which is fastened to the insulated block *c* in contact with the terminal *d* which leads to the battery *e* and thence to the spark coil *f* from which a high tension wire *g* leads to the
 70 spark plug *h*. The contacting of the arm *a* will close the circuit and cause the spark to be made in the cylinder in the desired time for proper ignition.

In practical operation in use with a carbureter, a mixture of fuel and air will be drawn into the compressor cylinder through the inlet port 2 when the compressor piston 6 is on the suction stroke and the power piston 9 is on the power stroke; so that the expansion of the gases in cylinder 8 will furnish the power to draw the charge of fuel and air into the compressor cylinder. During this stroke the cylinder is closed to the clearance 43; on the return stroke
 80 completed by the fly wheel *i*, the valve 3 will be closed and the compressor piston will compress the charge in the compressor cylinder 1, into the interior of the alternating clearance space 43 within the oscillating
 85 valve 14, the port 17 being open during the compressing stroke. Said oscillating valve, when piston 6 is at the top of its stroke, moves at a high rate and on reaching the top of its stroke cuts off the opening between the discharge port 4 and the inlet port 17 locking the charge from the compressor cylinder within the clearance 43. This may occur 30° ahead of the completion of the power piston exhaust stroke. The rate of circular movement of the oscillating valve 14 around its axis is so timed that it will begin to open delivery port 18 to communicate through admission port 7 to the cylinder 8 at a point 15° on the crank travel
 100 before piston 9 reaches the top of its travel as shown by dash line 77 when the exhaust valve 40 is closed. At the same instant that this communication takes place, with the piston at line 77, ignition will occur at the ignition plug *h*. The oscillating valve 14 is still moving at a high rate and the delivery port 18 very quickly takes the position wide open to the admission port 7, as is shown by the position of port 18 and of piston 9, which on the drawing is shown on the downward travel about one-fifth the stroke with the complete alignment of the two ports. As the delivery port 18 opens with the piston at the position 77 and moving upward, a portion of the compressed charge goes into the locked cylinder and is ignited and immediately thereafter is forced back again by the completion of the piston travel to the dot and dash lines 78.
 125

This regurgitation of the ignited mixture greatly facilitates combustion and produces a high rate of turbulence which tends to prevent detonation of heavy fuels. Port 18 remains open and does not finally close
 130

until the piston 9 has completed its power stroke, and 30° after port 18 has closed, inlet port 17 again opens to the discharge port 4 and a new charge is being delivered from the compressor cylinder into the clearance space 43 for the repetition of the cycle of operations. The oscillating valve 14 is driven through these timed movements by means of excentric 24 and rod 25 operating through the arm 26; and by this common means the motion of the excentric rod is transmitted through arm 26 and through the rod 31 to the rock shaft arm 33 to rock the shaft 29 with the cams which control the movements of the intake valve 3 and exhaust valve 40.

The operation of this invention may also be carried out by the injection of fuel and such injection may be as shown in the drawings by means of the pump and injection nozzle shown in Fig. 6 or it may be carried out by the usual method of Diesel engines when the compression in cylinder 1 is sufficiently high to ignite the fuel by heat of compression.

Injection for refined fuels may be accomplished by means of a pump shown in Fig. 6 which operates to regulate either by hand or by governor the amount of fuel injected at each stroke into the admission port 7. The operation here, will be, so far as movement of the valves and pistons is concerned, identical with that adapted to use of the carbureter, except that the fuel is injected into a cup 67 from which it may be partly blown with the force of injection into the admission port 7; the first rush of compressed air upon opening of the oscillating valve 14, giving communication from clearance chamber 43 to cylinder 8 will be to cause ignition of a portion of this fuel in port to take place; as at this instant the piston will be at the position shown by line 77, and traveling upwards, the heat and explosive force, as well as the regurgitation caused by compression of the piston stroke to line 78 will blow the remainder of the fuel out of cup 67 forcing it violently toward and into the receiver chamber 43, causing a rapid production of mixture and combustion of the mixture, so that the engine will operate satisfactorily whether with a carbureter or by injection of fuels into compressed air adjacent to the clearance chamber, when ignition, combustion, expansion and exhaust will take place in the usual manner.

I claim:

1. In the art of producing power from internal combustion, the method set forth which comprises isolating a unit of highly compressed expansible comburent, in an oscillating clearance chamber to constitute an isolated compressed combustible charge; oscillating the clearance chamber to communi-

cate with an expansible chamber previously contracted to approximately zero and producing combustion of the charge and a consequent expansion within both chambers to a comparatively low pressure for moving a wall of the expansible chamber and producing power throughout a period of high expansion.

2. The production of power by internal combustion comprising periods of inspiration of a comburent, compression of the same to a pre-dimensioned body, isolation of such body in an oscillating chamber; opening such body to communication with a contracted expansible chamber; combustion of the comburent, and expansion of the products in both chambers, thereby moving a wall to produce power throughout a period of high expansion; and exhausting the products of combustion from the expanded chamber.

3. In the art of producing power by internal combustion, the method of applying an expansive medium to a power chamber; which comprises opening an isolated oscillating chamber containing a charge of comburent to such power chamber, and combusting the same at a period when piston clearance in the power chamber is approximately zero.

4. A two-stroke internal combustion engine comprising a compressor cylinder, and a power cylinder, the piston clearance of which is outside of said cylinders; an oscillating chamber constituting such clearance and provided only with lateral ports adapted to alternately open separately to the cylinders at the heads thereof; a crank shaft, a crank on said crank shaft, pistons operating in said cylinders through a common crank pin; means operable through said crank shaft to cause the clearance chamber to close to the compressor cylinder and open to the power cylinder when the clearance of each cylinder is at a minimum and vice versa at the return stroke of the pistons; and ignition means operable at the head stroke of the power piston to ignite a charge in the clearance when said clearance is open to said power piston.

5. A two-stroke internal combustion engine comprising a compressor cylinder, and a power cylinder, the piston clearances of which are outside of said cylinders; a chamber constituting such clearance and provided with ports connecting the cylinders at the heads thereof; a crank shaft, a crank on said crank shaft, pistons operating in said cylinders through a common crank pin; oscillating hollow valved means in such clearance chamber operable through said crank shaft to cause the clearance chamber to close to the compressor cylinder and open to the power cylinder when the clearance of each cylinder is at a minimum and vice versa at the return stroke of the pistons; and igni-

tion means operable at the head stroke of the power piston to ignite a charge in the clearance open to said power piston.

6. A two-stroke internal combustion engine comprising a compressor cylinder, and a power cylinder, the piston clearance of which is outside of said cylinders; a chamber constituting such clearance and provided with ports adapted to alternately open separately to the cylinders at the heads thereof; a crank shaft, a crank on said crank shaft, pistons operating in said cylinders through a common crank pin; means operable through said crank shaft to cause the clearance chamber to close to the compressor cylinder and open to the power cylinder at the head stroke of the pistons and vice versa at the return stroke of the pistons; said cylinder being arranged at the proper angle to produce the desired timing of the movement of the piston and the oscillating valved means to allow for the necessary advanced ignition of the charge.

7. The method of conducting internal combustion for power purposes substantially set forth; comprising introducing a cold charge of comburent in a compressor chamber that can be reduced to practically zero volume; opening an oscillating clearance to said chamber; compressing the whole of such charge into said movable clearance; moving such clearance to isolate such compressed charge; continuing the movement of the clearance to open such charge with a power chamber at the instant when it is of practically zero volume and combusting the comburent in that condition.

8. The method of conducting internal combustion for power purposes comprising introducing a cold charge of comburent in a compressor chamber that can be reduced to practically zero volume; opening an oscillating clearance to said chamber compressing the whole of such charge into said oscillating clearance; moving such clearance to isolate such compressed charge; continuing the movement of the clearance to open such charge to a power chamber when the same is approaching the condition of zero clearance, and completing ignition of the comburent while the clearance is approaching zero.

9. An internal combustion engine comprising a compressor cylinder and a working cylinder, the compressor cylinder being of smaller dimensions and smaller capacity than the working cylinder; an oscillating clearance for transferring the compressed charge from the compressor cylinder to the working cylinder and means for igniting the charge within the working cylinder as it leaves the oscillating valve.

10. An internal combustion engine comprising a compressor cylinder and a working cylinder, the compressor cylinder being

of smaller dimensions and smaller capacity than the working cylinder, both cylinders completing their displacement stroke with minimum clearance to the cylinder head at approximately the same instant; a rocking chamber with ports for receiving and isolating a charge of compressed mixture and for transferring the charge from the compressor cylinder to the working cylinder; and means for igniting the charge within the working cylinder as it leaves the rocking chamber.

11. An internal combustion engine comprising compressor and power cylinders; an alternating clearance between and for the compressor and power cylinders to receive the complete charge and isolate such charge of compressed comburent and to deliver said charge to the power cylinder; and means for igniting the delivered charge.

12. An internal combustion engine comprising an expansible chamber having a movable wall adapted to transmit power; a compressor adapted to compress comburent charges; means adapted to receive within itself and thereby isolate each single compressed charge of comburent from said compressor and to open the same to said expansible chamber by the movement of said means; and means to ignite the charge immediately it is opened to the expansible chamber.

13. The combination with an expansible combustion chamber; of a compressor adapted to compress comburent charges; means to receive and isolate each single charge of comburent from the compressor means to oscillate said receiving means and to thereby open said charge of comburent to the expansible chamber while said chamber is contracted; and means operable by the movement of a wall of said expansible chamber during expansion of said chamber to transmit power.

14. The combination with an expansible chamber of an internal combustion engine; of a compressor adapted to compress comburent charges; an oscillating valve between the compressor and the expansible chamber adapted to receive within itself the complete compressed charge of comburent from the compressor and to isolate the same and thereafter to open said isolated charge to the contracted expansible chamber; and means for igniting the comburent at the time it is so delivered.

15. The combination with a crank shaft; of an oscillating chamber having an inlet and an outlet port; a compressor adapted to compress comburent charges; cylinder having a discharge port arranged to register with the inlet port of the oscillating chamber in only one position of such chamber; an internal combustion engine cylinder hav-

ing an admission port arranged to register with the outlet port at another position of said oscillating chamber; a piston in the internal combustion cylinder; a main connecting rod connecting said piston with a crank; a piston in the compressor cylinder; a connecting rod connecting the compressor piston to the main connecting rod at an acute angle thereto; a valved inlet for the compressor cylinder; a valved exhaust for the internal combustion cylinder; and means for operating the oscillating chamber in time with the movements of the pistons of the two cylinders.

16. The combination with a crank shaft; of an oscillating chamber having an inlet and an outlet port; a compressor cylinder having a discharge port arranged to register with the inlet port of the oscillating chamber; an internal combustion engine cylinder having an admission port arranged to register with the outlet port at another position of said oscillating chamber; a piston in the internal combustion cylinder; a connecting rod connecting said piston with a crank of said shaft; a piston in the compressor cylinder; a connecting rod connected to the compressor piston and to the main connecting rod; a valved inlet for the compressor cylinder; a valved exhaust port for the combustion cylinder; means for operating the oscillating chamber in time with the movements of the pistons of the two cylinders; and means common to both compressor and power cylinders for operating the intake valve of the compressor, the oscillating valve and the exhaust valve of the power cylinder.

17. In a two-stroke internal combustion engine the combination of a compressor and power cylinder having pistons moving in differential timed relation, the compressor cylinder being fitted with an intake valve, and the power cylinder fitted with an exhaust valve; a clearance chamber between the two cylinders constructed and arranged to be moved to be alternately opened and closed to the cylinders separately and respectively so as to prevent the heat of the previous combustion from limiting the weight of working charges of comburent passing through the engine.

18. In a two-stroke internal combustion engine the combination of a compressor and a power cylinder having pistons moving in differential timed relation; the compressor cylinder being fitted with an intake valve, and the power cylinder fitted with an exhaust valve; a clearance chamber between the two cylinders constructed and arranged to be moved to be alternately opened and closed to the cylinders separately and respectively for the purpose of instant transfer of a compressed charge of comburent

from the compressor cylinder to communicate with the power cylinder for instant combustion therein without change of volume and a lowering of pressure.

19. In a two-stroke internal combustion engine the combination of a compressor and power cylinder having pistons moving in differential timed relation; the compressor cylinder fitted with an intake valve; the power cylinder fitted with an exhaust valve; a clearance chamber between the two cylinders constructed and arranged to be moved to alternately open to the cylinders separately and respectively to make possible compression of comburent in a separate cylinder of smaller volume than the power cylinder and transfer of the compressed charge to the power cylinder with extreme turbulence to facilitate combustion and control expansion ratio.

20. In a two-stroke internal combustion engine the combination of a compressor and power cylinder having pistons moving in differential timed relation; the compressor cylinder fitted with an intake valve; the power cylinder fitted with an exhaust valve; a clearance chamber between the two cylinders constructed and arranged to be moved to alternately open to the cylinders separately and respectively so as to allow for advanced admission and ignition of the charge in the power cylinder to make possible compression of comburent in a separate cylinder of smaller volume than the power cylinder and transfer of the compressed charge to the power cylinder with extreme turbulence to facilitate combustion and control expansion ratio.

21. An internal combustion engine comprising compressing and power cylinders each provided with intake and exhaust valves; movable clearance means between the compression and power cylinders to receive the whole of the charge from the compressing cylinder without leaving appreciable piston clearance; means to move said clearance to close communication with the compressor cylinder, and to open the compressed charge to the power cylinder, when the power cylinder is in position of practically no piston clearance; and means to ignite the compressed charge at the instant it is in contact with the power piston.

22. An internal combustion engine comprising compressing and power cylinders each provided with intake and exhaust valves; movable clearance means between the compressing and power cylinders to receive the whole charge of the compressing cylinder without leaving appreciable piston clearance; means to move said clearance to close communication with the compressing cylinder and open communication to the power cylinder to admit the compressed charge



thereto when the power cylinder is in position of practically no piston clearance; means to receive the desired increment of fuel for each compressed charge in such communication to the power cylinder, that will cause the movement of the compressed charge to blow the fuel into the stream of compressed air flowing to the power cylinder; and means to ignite the compressed charge at the instant it is in contact with the power piston.

23. In a two-stroke internal combustion engine the combination of a compressor and power cylinder having pistons moving in differential timed relation, the compressor cylinder being fitted with an intake valve, and the power cylinder fitted with an ex-

haust valve; a clearance chamber between the two cylinders constructed and arranged to be moved to be positively alternately opened and closed to the cylinders separately and respectively so as to prevent the heat of the previous combustion from limiting the weight of working charges of comburent passing through the engine and provided with means for timed introduction of fuel to such opened charge of comburent.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 19th day of August, 1920.

ORVILLE HIRAM ENSIGN.

Witness:

JAMES R. TOWNSEND.