W. I. TWOMBLY.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED SEPT. 12, 1910.

1,053,759.

Patented Feb. 18, 1913.

4 SHEETS—SHEET 1.

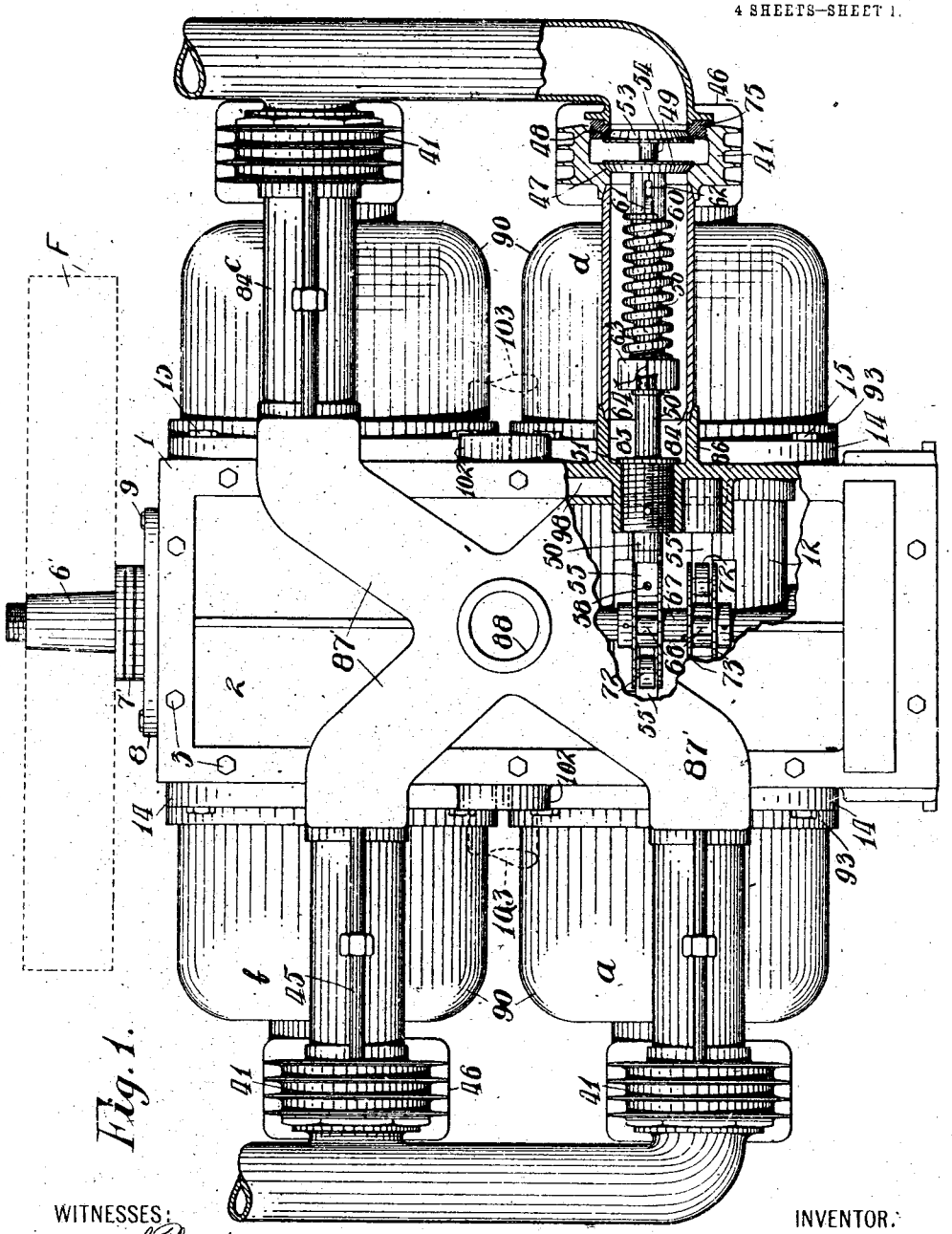

Fig. 1.

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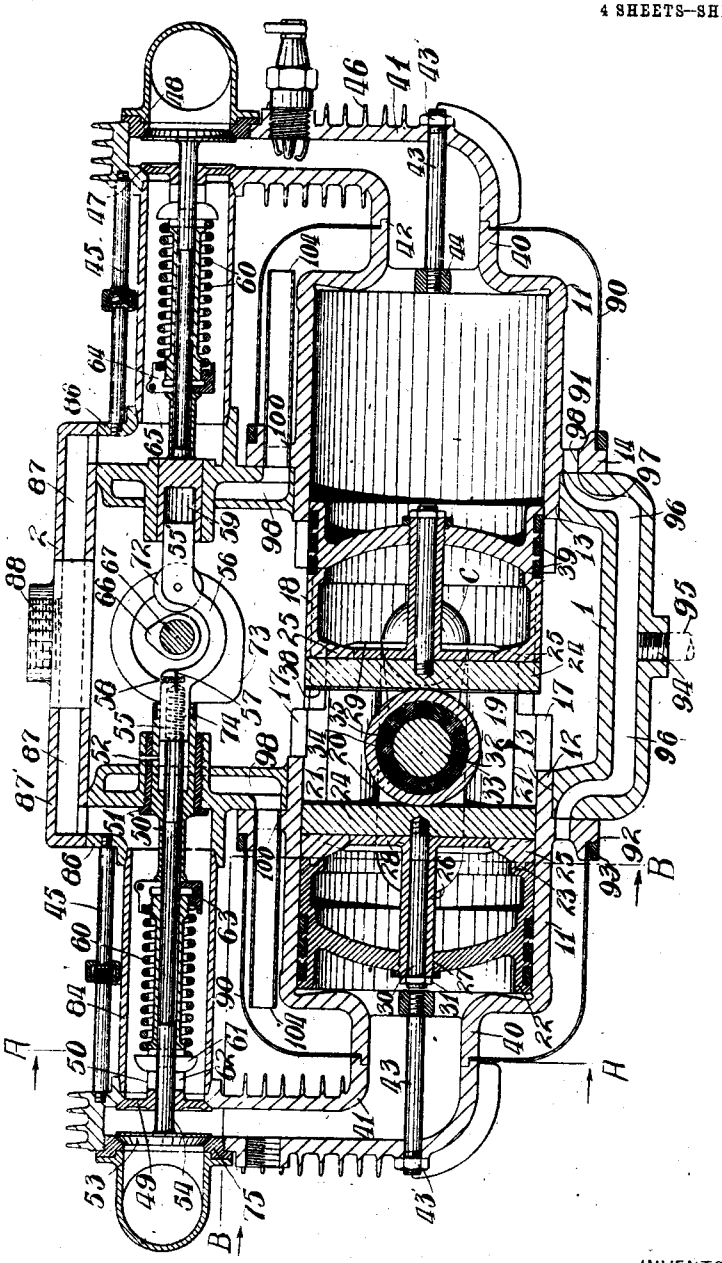
4 SHEETS—SHEET 2.

Fig. 2.



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4 SHEETS—SHEET 3.

Fig. 4.

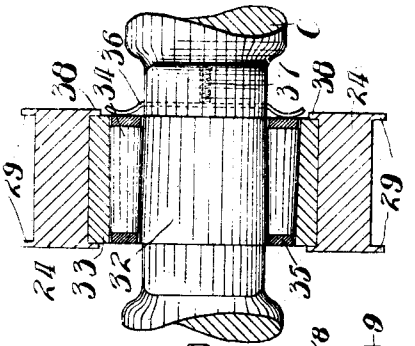
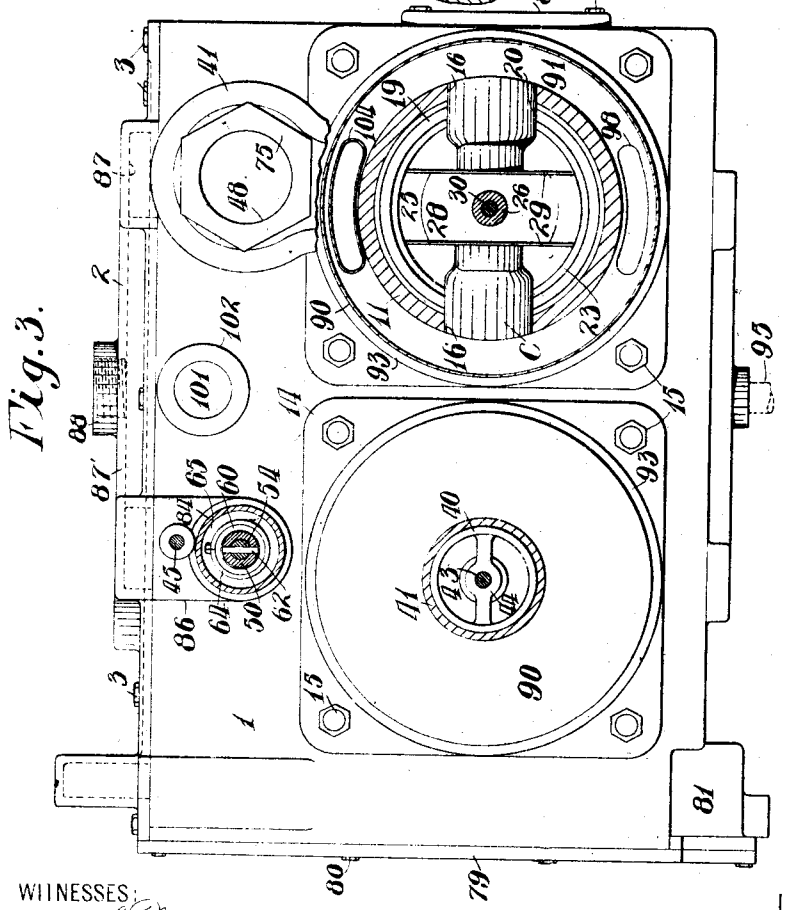


Fig. 3.



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4 SHEETS—SHEET 4.

Fig. 5.

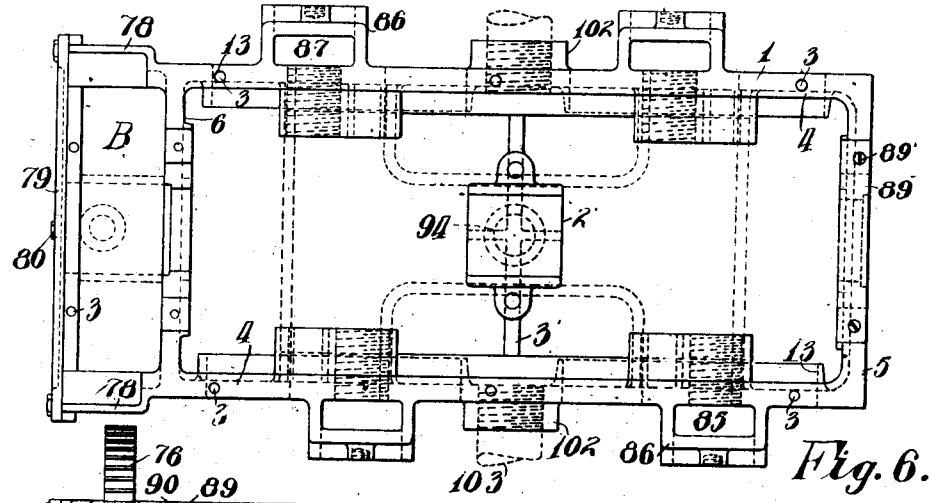
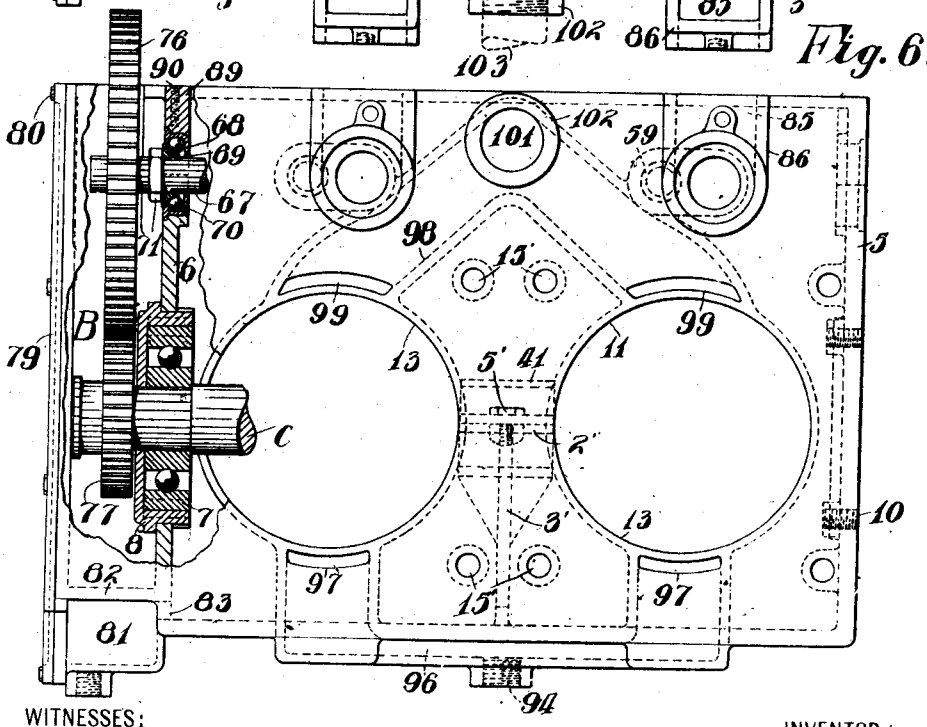


Fig. 6.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

1,053,759. Specification of Letters Patent. Patented Feb. 18, 1913.

Application filed September 12, 1910. Serial No. 581,633.

To all whom it may concern:

Be it known that I, WILLARD IRVING TWOMBLY, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented a new and useful Improvement in Internal-Combustion Engines, of which the following is a specification.

This invention relates to internal combustion engines, wherein a pair of opposed piston cylinders are connected in alinement to the crank case with a piston working in a pair of opposed cylinders, the crank shaft being mounted in the crank case transversely to the said cylinders and extending between the same, and the pistons connected to the crank shaft within the working portions of said pistons and the cylinders.

It is the primary object of the invention to provide a combined air and water cooled engine of this type which is simple, compact and especially light in construction, durable and efficient in operation, and comprising a small number of interchangeable parts so arranged as to be readily accessible and removable.

It is a further object of the invention to construct the piston cylinders with separate and readily releasable combustion chambers, whereby to facilitate the machining of the same, and at the same time provide a combustion chamber that is quickly and cheaply replaced, should the same become cracked, without replacing the entire cylinder, the said chambers having alined fuel inlet and exhaust ports in which are seated valves to control the charge of fuel to and the exhaust of the burnt gases from the cylinders. Furthermore, said chambers may be provided with outwardly-projecting fins which serve to air cool said chambers and also materially aid in strengthening the same.

A further object of the invention is to provide improved means to conduct fuel to the combustion chambers comprising fuel ducts in the crank case communicating with the fuel supply, and communicating with said ducts and also with the fuel inlet ports in the combustion chambers are removable members or fuel chambers to conduct the fuel from the source of supply through the ducts in the crank case to the said combustion chambers, said fuel chambers also serving as dust proof casings for the stems of the fuel-inlet and exhaust valves.

It is a still further object of the invention to provide improved means for water cooling the piston cylinders, comprising removable metal jackets inclosing the cylinders and secured thereto, a water inlet in the bottom of the crank case having ducts branching out therefrom with outlets communicating with said water jackets, and water outlet ducts in the side walls of the crank case have ports also communicating with the said water jackets and having a common outlet communicating with the source of supply, such as a cooler or the like. In the water inlet ports of the water outlet conduits in the crank case and communicating with the water jackets I seat tubes extending to the heads of the cylinders so as to assure the drawing off of the water from said heads.

Another object of the invention is to simplify and improve the connection of the pistons to the crank shaft, comprising roller bearings rotatable on the wrist pin of the crank shaft, and having a rolling engagement with a pair of tracks adjustably carried by the pistons at either side of said wrist pin bearings, the said roller bearings consisting of a ring internally beveled, the wrist pin also being tapered or beveled but the inclination of the bevel being reverse to that of the bevel of the ring, and tapered rollers and a roller-carrier mounted on the wrist pin and running in said ring; means, in the form of a spring carried by the wrist of the crank shaft, engaging with the roller carrier to automatically adjust the bearings to take up any wear or play between said bearings and the piston tracks.

Other objects and advantages will hereinafter appear.

In the drawings accompanying and forming a part of this specification, Figure 1 is a plan view of my improved engine, partly broken away to illustrate the construction and arrangement of the valve mechanism and the cams on the cam shaft to operate the valves. Fig. 2 is a sectional end elevation taken substantially midway through the valve mechanism and the piston and piston cylinders. Fig. 3 is a sectional end elevation the section of the piston cylinder and valve mechanism at the left being taken

substantially on the line A—A of Fig. 2 looking in the direction of the arrow; and the section of the cylinder at the right being taken substantially on the line B—B of said Fig. 2, looking in the direction of the arrow. Fig. 4 is an enlarged sectional view to illustrate the construction and mounting of the roller bearing on the wrist pin of the crank shaft and the engagement of said bearing with the piston tracks. Fig. 5 is a plan view of the crank case, the cover being removed; and Fig. 6 is a side elevation of the crank case, partly broken away to illustrate the manner of mounting the crank shaft and cam shaft therein.

Similar characters of reference designate like parts throughout the different views of the drawings.

As a preface to a further description of my improved engine, I desire to state that the same is shown as consisting of a combined air and water cooled four cycle engine, although it will be obvious that the same may be constructed as to be entirely cooled by water or air. Furthermore for the purpose of illustration the same is shown as comprising two pairs of opposed cylinders fixed in axial alinement to a crank case, and as an explosion takes place in one cylinder one of the cylinders will be exhausting, compression of combustible material or fuel taking place in another cylinder, and the other cylinder is taking or sucking in combustible material or fuel. However, it will be obvious that the engine will work just as efficiently if one pair or a multiple of pairs of cylinders are used.

In the embodiment of my invention illustrated in the drawings, the crank case consists of a rectangular or box-like structure 1 open at the top and provided with a removable cover 2, whereby to get access to the working parts of the engine within said crank case, said cover secured in place by means of screws or bolts 3 engaging in an inwardly-projecting flange 4 at the upper edge of the crank case.

The crank shaft C is placed in position in the crank case through openings in the end walls 5, 6 and rotatably mounted in said openings by means of ball bearings 7 of usual construction, the said bearings being carried in bushings 8 engaging in said openings and secured therein by screws or bolts 9 passing through flanges forming a part of said bushings and engaging in tapped holes 10 in the end walls 5, 6. The crank shaft is also journaled in a pillar block 2′ supported in a rib 3′ in the crank case, and held in said block by a cap 4′ engaging over the shaft and secured by bolts or screws 5′. To the projecting end 6′ of the crank shaft may be secured a fly wheel F, a thrust bearing 7′, preferably of the ball bearing type, being interposed between said fly wheel and the roller-bearing bushing 8 for the purpose of taking up any endwise thrust of said wheel. When the engine is used in connection with an aeroplane for aerial navigation, for which the engine is especially applicable, the propeller may be fixed to said projecting end 6′ of the crank shaft.

Opposed piston cylinders 11 are provided with sleeve portions 12 which engage in oppositely-disposed openings 13 in the crank case and have a lap-joint connection therein, the said cylinders also being provided with flanges 14 to abut against the side walls of said case and secured thereto by bolts 15 passing through said flanges and engaging with tapped holes 15′ in the crank case. The sleeve portions of the cylinders are provided with oppositely-disposed openings 16 to permit of the passage of the crank shaft, and have a second pair of oppositely disposed openings 17 substantially at right angles to the openings 16 to permit of the passage of the wrist of the crank shaft through its orbit of movement. The cylinder heads also have outwardly-projecting bosses 40 provided with openings communicating with the bore of the cylinders.

The pistons are in the nature of double pistons; that is, they are so constructed as to operate in a pair of opposed cylinders, and connected to the crank shaft within the working portion of the cylinders and comprise a pair of releasably connected heads 18, 22 having the usual rings 39. The head 18 is provided with a sleeve portion 19 cast integral with said head and having a tongue and groove connection 23 with the head 22. The sleeve portion 19 has a pair of oppositely-disposed openings or slots 20 cut through the end thereof to permit of the slipping of said pistons over the crank shaft and the reciprocation of the pistons transverse to the axis of the shaft, and to prevent rotation of the pistons within the piston cylinders. The sleeve portion 19 has a second pair of oppositely-disposed openings 21 substantially at right angles to the openings 20 to permit reciprocatory movement of the crank shaft wrist within the piston and the passage thereof through its orbit of movement, which in the present instance is greater than the diameter of the pistons.

The connection of the pistons to the crank shaft comprises a pair of tracks 24 carried within the sleeve portion 19 of the head 18 and on opposite sides of the wrist pin of the crank shaft with the ends engaging in the slots 21 and the backs abutting against inwardly-projecting lugs 25 on the sleeve portion, the said tracks being adjustably secured to the heads 18, 22 by means of a sleeve 26, one end of which sleeve has a screw-threaded engagement with the head, as at 27, and the other end provided with an enlarged portion 28 to abut against the

track, the lateral edges of said portion 28 engaging between the lugs 25 to prevent sliding or endwise displacement of said tracks, and also engaging between a pair of flanges or ledges 29 on the backs of the tracks to prevent sidewise movement of the latter. Bolts or tie rods 30 pass through said sleeves 26 and have a screw threaded engagement in the back of the tracks, said tie-rods projecting through the piston heads 18, 22 and having jam-nuts 31 to draw and lock the tracks up against the lugs 25 and the portion 28 of said sleeves. The tie rod 30 passing through head 22 also serves to connect said head to the sleeve 19.

The wrist pins 32 of the crank shaft have mounted thereon roller bearings to have rolling engagement with the faces of the tracks 24, the said roller bearings comprising a ring or casing 33 having an internal bevel or cone shape, the wrist pin also being beveled or tapered but in a direction opposite to the taper in the ring 33, tapered rollers 34 engaging between said ring and the wrist pin, and carried by a tapered roller carrier 35, the said roller carrier in the present instance being constructed of two pairs of semi-circular rings to facilitate the placing of said roller carrier and rollers upon the said wrist pins. Passing through an opening in the wrist pin is a springy or resilient member 36, the free ends of which member engage with the roller carrier 35 to force said carrier and rollers 34 between the ring and wrist pin to take up any wear or play therebetween, said member 36 being retained in the wrist by a set screw 37. The tracks 24 may be provided with ledges or guideways 38 between which the ring 33 of the roller bearing travels, the engagement of said ring between said ledges not only serving to guide said ring but also tends to prevent rotary movement of the pistons in the piston cylinders. Each of the cylinders are provided with a separate and removable combustion and ignition chamber 41, the said chamber having a lap-joint connection 42 with the boss 40 projecting out from the head of the piston cylinder, said joint consisting of annular seats formed in the outer end of said boss and also in the combustion chamber. The combustion chamber is releasably connected to the piston cylinder by means of a tie-rod 43, one end of which rod is screw threaded into a rib 44 extending across the opening in the cylinder boss 40, the other end passing through the wall of the combustion chamber, and a jam nut 43′ engaging with the projecting end outside of said chamber to draw and lock the latter against the cylinder boss 40. The upper ends of the combustion chambers are maintained in position by means of a turn buckle 45, one end of which is screw threaded into the combustion chamber and the other end having a screw threaded engagement with the crank case. The combustion chambers may be provided with outwardly-projecting fins 46 whereby to present a cooling area of considerable extent to the atmosphere to air cool said chambers and which also serve to strengthen said chambers. The combustion chambers project upwardly and at an angle from the piston cylinders, so that the upper end of one combustion chamber of one cylinder will be arranged out of line with the upper end of the combustion chamber of the opposed cylinder, and provided in said upper end with a fuel-inlet port 47 and an exhaust port 48 in axial alinement with the fuel port 47.

For the purpose of controlling the supply of fuel mixture to the combustion chambers 41 and the exhaust of the products of combustion therefrom I provide each chamber with suitable valve mechanism, comprising a valve 49 seated in the inlet port 47 for the control of the fuel-intake, the stem 50 of said valve being hollow and at the end provided with a lock nut 63. Slidably mounted in a bushing 51 screw threaded into the side wall of the crank case is a tappet or cam follower 50′ in the form of a tubular member, one end of which abuts against the nut 63 and the other end projecting into the crank case, the said member 50′ has an oil hole 52 for the purpose of supplying lubricant to the interior thereof. The said nut 63 also acts as a means to adjust the stem of the fuel valve to compensate for regrinding of said valve or the valve seat.

An exhaust valve 53 is seated in the port 48, the stem 54 of which valve is slidably mounted in the stem of the fuel-intake valve 49 and the tappet 50′ and the free end screw threaded into a laterally-projecting portion 55 of one arm of a yoke member 56, said end also having a saw cut 57 therein with a set screw 58 engaging in a tapped hole passing through the saw cut to draw the same together and lock the stem in engagement with the yoke arm 55. The other arm of the yoke 56 has a laterally projecting portion 55′ slidably mounted in a bushing 59 in the opposite wall of the crank case. The screw threaded engagement of the valve stem with the yoke 56 also acts as a means to adjust the exhaust valve. The fuel-intake and exhaust valves are normally maintained closed or seated in the ports 47, 48 by means of a double-acting spring 60 coiled about the stem 50 of the fuel-intake valve 49 and confined between the projecting ends of a key 61 passing through a slot in the stem of the exhaust valve and slidable in a slot 62 in the stem of the fuel-intake valve and the nut 63, the said nut having a cup-shaped portion in which said spring is

seated. This nut 63 is provided with a saw cut 64, a screw 65 passing through that portion of the nut in which the saw cut is located to draw the nut firmly together and prevent accidental rotation thereof on the valve stem.

To open the exhaust valves 53 I provide cams 66 on a cam shaft 67 journaled, by means of ball bearings of usual construction, in bearing blocks formed in the end walls 5, 6 of the crank case said ball bearings each consisting of a cup-shaped bushing 68 and a bevel collar 69 on the shaft 67, the bevel of said collar and the bushing 68 constituting a raceway for a series of balls 70. The collars 69 are secured in place in any suitable manner, and in the present instance by nuts 71 (Fig. 6.) The cams 66 engage with wheels or rolls 72 rotatively carried in the portion 55′ of the yoke member 56, thereby forcing the valves 53 away from their seats and against the tension of the springs 60.

To open the fuel valves 49 for the purpose of controlling the supply of fuel, I provide a pair of cams 73 for each valve located on the cam shaft 67 at opposite sides of the cams 66 and engaging with hardened metal collars or rings 74 on the ends of the tappets 50′ which tappets abut against the stems of the fuel-intake valves 49, causing the said valves to slide upon the stems of the exhaust valves to force them away from their seats in the ports 47 and against the tension of the springs 60. It will be noted that as either one of the valves 49 or 53 is opened by its cam or cams the opening movement of said valve will compress the spring 60 increasing the tension thereof and thereby exerting an increased closing pressure on the other valve.

For the purpose of readily removing the fuel-intake and exhaust valves, I construct the seats for the exhaust valves in bushings 75 screw threaded into the combustion chambers, and in which bushings manifold exhaust pipes may engage for the purpose of leading off the spent products of combustion. By constructing the seats for said exhaust valves in this manner it also serves to facilitate the grinding of said seats. To remove the valves it is only necessary to remove the bushings 75, the screw 58 is then released when the exhaust valve may be freely rotated to disconnect it out of screw threaded engagement with the projection 55 of the yoke member 56, when the valves may be pulled out through the opening in which the bushing 75 engages. To remove the exhaust valves 53 the nut 63 is released to decrease the tension of the spring 60 when the key 61 is slipped through the slot in the exhaust valve stem 54 and said valve stem drawn out from the valve stem 50. The combustion chambers are also provided with screw threaded openings 105 for the insertion of spark plugs 5. Said openings are just below the exhaust port 48 so that the spark points of the plug will project into the path of the incoming combustible material or fuel through ports 47 and will always be in a fresh mixture of combustible material which will be readily fired by a spark generated by said plug.

The cam shaft is gear driven from the crank shaft and has fixed thereon a gear 76 meshing with a gear 77 fixed to the crank shaft, the ratio of said gearing being two to one, that is, two revolutions of the crank shaft will impart one revolution to the cam shaft, and the cams 66, 73 are so located on the cam shaft and timed to alternately open the exhaust and fuel-intake valves. It will be noted that the gears 76, 77 are the only gears employed in the engine and are arranged exterior to the crank case 1, being inclosed in a chamber or compartment separate from the crank case proper (designated in a general way by B,) but constructed integral with the case 1 by extending the side walls thereof, as at 78, said chamber B being open at the end, and provided with a removable plate 79 secured in place by bolts 80. This chamber B is also constructed with an oil well 81 in the bottom thereof into which may extend a suitable pump, (not shown) said pump being secured to the bottom 82 of said chamber, whereby to mechanically oil the working parts of the engine. An opening 83 between the bottom of the wall 6 and the bottom of the crank case permits the draining of the oil from the crank case into the oil well.

The cam shaft 67 is secured in place by means of caps 89 which engage over the ball bearings and may be retained in place by the cover 2 when the latter is secured to the crank case. However, I prefer to secure said caps 89 by screws 89′ passing through said caps and screw threaded into the crank case. To remove the crank shaft with the cams to get ready and easy access to the working parts of the engine in the crank case below the cam shaft, it is only necessary to remove the cover 2 and the caps 89 when the cam shaft may be lifted out from the case.

In an engine constructed as shown in the drawings with two pairs of opposed cylinders in alinement, the valve cams for the different cylinders are so timed that when an explosion takes place in one cylinder upon a further rotation of the crank shaft of approximately 180 degrees or one half of a revolution, the valves in one of the combustion chambers of the piston cylinders will be closed and the compression of combustible material or fuel taking place therein, while in another chamber the exhaust valve will be open and the spent products of combustion being forced therefrom, and in

the other combustion chamber the fuel intake valve will be open and the piston sucking or taking in a fresh charge of fuel or explosive mixture. As already stated, the upper end or valve chamber of one of the combustion chambers 41 is offset or arranged out of line with the valve chamber of the combustion chamber of an opposed piston cylinder, but in a plane parallel with the axis of the cylinder, (Fig. 1,) this construction permitting of the securing of the cylinders in alinement and the proper locating of the cams on the cam shaft.

For the purpose of supplying or conducting combustible material or fuel to the combustion chambers 41, I provide removable fuel chambers preferably in the form of cylindrical or tubular sleeves 84, one end of which sleeves engage in the fuel intake ports 47 in the combustion chambers and the other end communicating with ducts 85 in bosses 86 projecting outwardly from and formed integral with the crank case, the said ducts 85 communicating with ducts 87 in ribs 87′ cast *en bloc* with, and at the top of, the cover 2, said ducts 87 branching out from a common inlet 88 to which may be connected a carbureter. (Not shown). The said sleeves 84 also serve as dust proof casings for the stems of the valves and the valve springs, and are held in place by the removable combustion chambers 41.

As already stated, the engine is in the nature of a combined air and water cool engine, the combustion chambers 41 being provided with the outwardly-projecting fins 46 to present a large cooling area to the atmosphere. The piston cylinders, however, are water cooled, and for this purpose I provide sheet metal jackets 90 preferably made of light spun copper surrounding the heads of the cylinders, and spaced therefrom to form water chambers 91. The jackets are snugly fitted upon angular annular seats 92 in the cylinder flanges, and have shrunk thereover steel rings 93 so as to form water-tight joints. The heads of the jackets are provided with perforations or openings for the passage of the cylinder bosses 40, the edges of said openings being clamped in the connections 42 of the combustion chambers 41 with said cylinder bosses 40 in water-tight joints. To maintain a water circulation through said jackets 90 there is provided in the bottom of the crank case 1 a water inlet 94 to which may be connected a pipe or conduit 95 leading from the source of supply, such as a water cooler. (Not shown.) Branching out from said inlet 94 are ducts or channels having outlets 97 below the openings in the crank case for the piston cylinders and communicating with ports 98 in the cylinder flanges for the water chambers 91. Also cast *en bloc* with the crank case in the inner wall thereof are water outlet ducts or channels 98′ having water inlets 99 above the openings in the crank case for the piston cylinders and communicating with outlet ports 100 in the piston cylinder flanges for the water chambers 91, the said ducts 98′ having a common outlet 101 in a boss 102 projecting outwardly from the crank case, a pipe or conduit 103 being connected to said outlet leading back to the source of supply. To assure the drawing off of the water from the heads of the cylinders, I provide tubular members 104, one end of which is seated in the outlet ports 100 in the cylinder flanges for the water chambers 91, the other end projecting outwardly substantially to the ends of the cylinder heads. As is well-known in this type of engine the greatest heat is developed at the heads of the cylinders, and consequently the water is heated at this point to a very high degree, the water at the base of the cylinders remaining comparatively cool compared with the water at the heads. Should the water jackets of the cylinders be provided only with the usual outlets at the base before the water at the heads of the cylinders is displaced the cool water at the base and contiguous to the outlet will be drawn off, and as the combustion of fuel is almost continuous the water at the heads will become so hot as to score the cylinders. The water circulating system may be either of the thermo syphonic type, or a suitable pump may be provided. The crank portion of the crank shaft for two of the cylinders is diametrically opposite to the crank portion for the other two cylinders, and by this arrangement during the cycle of operations as set forth, there will be a power stroke for each reciprocating motion in either direction or two power strokes for every revolution.

The operation of my improved engine is substantially as follows: As already stated, for the purpose of illustration, I have shown in the present instance only two pairs of opposed cylinders 11 in which the explosion of combustible material takes place in the order indicated by *a*, *b*, *c*, and *d*. (Fig. 1.) Assuming that an explosion has taken place in the cylinder *d*, and a compression of fuel in the cylinder *a*, the piston in said cylinders being in the position indicated in Fig. 2, the products of combustion having been exhausted from the cylinder *c*, and a charge of fresh fuel drawn into cylinder *b*. As the explosion takes place in cylinder *a*, the spent products of combustion will be forced from cylinder *d*, (the previous explosion having taken place in said cylinder,) compression of fuel in cylinder *b*, and a fresh charge of fuel drawn into cylinder *c*. The next explosion will take place in cylinder *b*, compression of fuel in cylinder *c*, a fresh charge of fuel drawn into cylinder *d*, and the spent products of combustion exhausted from cyl-

inder *a*. The next explosion takes place in cylinder *c*, compression of fuel in cylinder *d*, a fresh charge of fuel drawn into cylinder *a* and the spent products of combustion exhausted from cylinder *b*. The last explosion in the complete cycle of operations will take place in cylinder *d*, compression of fuel in cylinder *a*, a fresh charge of fuel drawn into cylinder *b*, and the spent products of combustion exhausted from cylinder *c*, when the cycle of operations is repeated.

From the foregoing description it will be obvious that an explosion takes place in each cylinder during a complete cycle of operations or during two revolutions of the crank shaft.

Variations may be resorted to within the scope of my invention.

Having thus described my invention, I claim:

1. An internal combustion engine, comprising in combination a crank case having a duct connected to the source of fuel supply; a piston cylinder fixed to said case having an offset combustion chamber; alined fuel-intake and exhaust ports in said chamber; oppositely seated valves in said ports to control the charge of fuel to and the exhaust from the cylinder, one of which valves and its stem is slidably supported upon the stem of the other valve; a spring to normally seat both of said valves; and means communicating with the fuel-intake port and the duct in the crank case to connect the cylinder to the source of fuel supply, said means also serving as a covering for the valve stems and spring.

2. An internal combustion engine, comprising in combination a crank case provided with a duct connected to the source of fuel supply; a piston cylinder fixed to said case having an opening in the head thereof; a combined combustion and valve chamber releasably connected to the head of the cylinder and communicating with the opening therein; alined fuel-intake and exhaust ports in said chamber; oppositely seated valves in said ports to control the charge of fuel to and the exhaust from the cylinder, one of which valves is slidably supported upon the stem of the other valve; a spring to normally seat both of said valves; and means communicating with the intake port and the duct in the crank case to connect the cylinder with the source of fuel supply, said means also serving as a covering for the valve stems and spring.

3. An internal combustion engine, comprising in combination a crank case having a duct connected with the source of fuel supply; a piston cylinder fixed to said case having an opening in the head thereof; a combustion chamber releasably connected to the head of the cylinder and communicating with the opening therein, said chamber having a laterally projecting portion; alined fuel-intake and exhaust ports in said laterally projecting portion; oppositely seated valves in said ports to control the charge of fuel to and the exhaust from the cylinder, one of which valves is slidably supported upon the stem of the other valve; a spring to normally seat both of said valves; means to connect the intake port with the duct in the crank case whereby to connect the cylinder with the source of fuel supply, said means also serving as a covering for the valve stems and spring; and means to connect the combustion chamber to the cylinder comprising a tie rod passing through said chamber and having screw threaded engagement with a rib extending across the opening in the cylinder head, and a second tie rod connected to the laterally projecting portion of said chamber adjacent to the ports and to the crank case, said latter rod provided with a turn buckle to firmly draw the chamber up against the cylinder.

4. An internal combustion engine, comprising in combination a rectangular crank case open at the top; a cover for said case having ducts connected to the source of fuel supply and registering with ducts in the crank case when placed in position; a crank shaft journaled in said case; cylinders fixed to said case in opposed pairs; a duplex piston to operate in a pair of opposed cylinders and connected to the shaft; alined fuel-intake and exhaust ports in a laterally projecting portion of each of said cylinders; oppositely seated valves in said ports to control the charge of fuel to and the exhaust from the cylinders; and tubular members one end of each member engaging in a fuel-intake port and the other end in a duct in the crank case, whereby to connect the cylinders with the source of fuel supply.

5. In an internal combustion engine, the combination of a crank case having fuel ducts communicating with the source of fuel supply; a crank shaft journaled in said case; opposed piston cylinders fixed in alinement to said case and provided with outwardly-projecting bosses having openings communicating with the bores of the cylinders; ribs in the ends of the cylinders extending across the openings therein; pistons in said cylinders connected to the crank shaft; combustion chambers releasably connected to the cylinders and having communication with the openings in the cylinder bosses, said chambers having co-axial fuel-inlet and exhaust ports; mechanically operated valves seated in said ports to control the charge of fuel to and the exhaust from the cylinders; fuel chambers communicating with the inlet ports and the fuel ducts in the crank case to conduct fuel to the combustion chambers; and means to secure the combustion

chambers, comprising tie-rods passing through the walls of said chambers and screw threaded into the ribs extending across the openings in the cylinder bosses, and jam-nuts on the rods outside of the chambers to draw and lock the same against the cylinder bosses.

6. In an internal combustion engine, the combination of a crank case having fuel ducts communicating with the source of fuel supply; a crank shaft journaled in said case; opposed piston cylinders fixed in alinement to said case and provided with outwardly-projecting bosses having openings communicating with the bores of the cylinders; ribs in the heads of the cylinders extending across said openings; pistons in said cylinders and connected to the crank shaft; combustion chambers releasably connected to the cylinders and communicating with the openings in the cylinder bosses, said chambers having co-axial fuel-inlet and exhaust ports in upwardly-projecting portions thereof; mechanically operated valves seated in said ports to control the charge of fuel to and the exhaust of the burnt gases from the cylinders, the stem of one of which valves passes through the other valve and its stem; tubular fuel chambers communicating with the fuel inlets of the combustion chambers and the fuel ducts in the crank case to conduct fuel to the combustion chambers, said chambers also serving as dust-tight casings for the valve stems; and means to releasably connect said combustion chambers to the cylinders, comprising tie-rods passing through the walls of said combustion chambers and screw threaded into the ribs extending across the openings in the cylinder bosses, jam-nuts on said rods outside of the combustion chambers to draw and lock the same against the cylinder bosses, a rod one end of which is fixed to the upwardly-projecting portion of the combustion chamber, a second rod one end of which is fixed to the crank case, and a turn buckle to engage with the free ends of said rods to draw the upper end of each of the combustion chambers toward the crank case and maintain it in rigid position, and also maintain the fuel chambers in place.

7. In an internal combustion engine, the combination of a crank case provided with fuel ducts; opposed cylinders fixed thereto; combustion chambers releasably connected to the cylinders, each chamber having alined fuel inlet and exhaust ports in an upwardly projecting portion thereof; mechanically operated valves in said ports to control the charge of fuel to and the exhaust from the cylinders, one of which valves and its stem is slidably supported on the stem of the other valve, and the valves of one chamber being out of line with the valves of the chamber of the opposed cylinder; a cam shaft extending between the valve stems of a pair of opposed cylinders; cams on said shaft to engage with the stems of the valves to operate the same; and tubular members connected to the intake ports of the combustion chambers and the ducts in the crank case to lead the fuel to the cylinders, said members also serving to inclose the stems of the valves.

8. In an internal combustion engine, the combination of a crank case substantially rectangular in shape and open at the top; a cover for said case having a fuel-inlet port with ducts branching out therefrom, the outlets of said ducts communicating with fuel ducts in the crank case; a crank shaft mounted in the crank case; opposed cylinders fixed to said crank case and having openings in the heads thereof; a double piston to work in a pair of opposed cylinders and connected to the crank shaft, within the working portions of said cylinders; and combustion chambers releasably connected to the cylinders and communicating with the openings therein, said chambers having fuel-inlet and exhaust ports; and tubular sleeve members one end engaging in the fuel-inlet ports in the combustion chambers and the other end in the outlets of the fuel ducts in the crank case to conduct fuel to the combustion chambers.

9. In an internal combustion engine, the combination of a crank case substantially rectangular in shape and open at the top provided with fuel ducts; a cover for said case having a fuel-inlet port with ducts branching out therefrom, the outlets of said ducts communicating with the fuel ducts in the crank case; opposed cylinders fixed to said case having openings in the heads thereof; a crank shaft journaled in the crank case and extending between the cylinders; a double piston to work in a pair of opposed cylinders and connected to the crank shaft within the working portions of said piston and cylinders; combustion chambers releasably connected to the cylinders and communicating with the openings therein, said chambers having co-axial fuel-inlet and exhaust ports; mechanically operated valves seated in said ports to control the charge of fuel to and the exhaust of the burnt gases from the cylinders, the stem of one of which valves passes through the other valve and its stem; and tubular sleeve members, one end of which engage in the fuel-inlet ports of the combustion chambers and the other end in the fuel ducts in the crank case to conduct fuel to the combustion chambers; said members also serving as dust-tight casings for the valve stems.

10. In an internal combustion engine, the combination of a crank case substantially rectangular in shape open at the top and provided with fuel ducts; a cover for said case having a fuel-inlet port with ducts

branching out from said ports, the outlets of said ducts communicating with the fuel ducts in the crank case, a crank shaft mounted in the crank case; opposed cylinders fixed to said crank case and having openings in the heads thereof; a double piston to work in a pair of opposed cylinders and connected to the crank shaft within the working portions of the cylinders; combustion chambers releasably connected to the cylinders and communicating with the openings therein, said chambers having fuel-inlet and exhaust ports; and removable fuel chambers one end of which engage in the fuel-inlet ports in the combustion chambers and the other end in the outlets of the fuel ducts in the crank case.

11. An internal combustion engine, comprising a crank case substantially rectangular in shape and provided with ducts communicating with the source of fuel supply; a water inlet in the bottom of the case having ducts branching out therefrom with outlets in the side walls of the case; water outlet ducts in the side walls of the case; piston cylinders having flanges to abut against and whereby they are fixed to the sides of the case in opposed pairs; water jackets for said cylinders having inlet and outlet ducts in the cylinder flanges adapted to register with the water inlet and outlet ducts in the case as the cylinders are fixed thereto; alined fuel-intake and exhaust ports in an integral part of said cylinders; valves for said ports with the stem of one of the valves passing through the other valve and its stem; and tubular members communicating with the inlet ports to the cylinders and the fuel ducts in the crank case to conduct the fuel to the cylinders.

12. An internal combustion engine, comprising a crank case substantially rectangular in shape and provided with ducts communicating with the source of fuel supply; a water inlet in the bottom of the case having ducts branching out therefrom with outlets in the side walls of the case; water outlet ducts in the side walls of the case; piston cylinders having flanges to abut against and whereby they are fixed to the sides of the case, said flanges having ports to register with the water inlet and outlet ducts in the crank case; bosses on the cylinder heads having openings communicating with the cylinders; removable hoods inclosing and spaced from the cylinders to constitute water jackets for the cylinders, each hood having an opening with the edges engaging in an angular recess in the cylinder bosses, and the ends engaging in an angular recess in the cylinder flanges; rings shrunk over the hoods and also seated in the flange seats of the cylinders to retain the hoods in place; combustion chambers releasably secured to the cylinder bosses; alined fuel inlet and exhaust ports in said chambers; oppositely seated valves in said ports with the stem of one valve passing through the other valve and its stem; and tubular members communicating with the fuel ducts in the crank case and with the fuel-inlet ports of the combustion chambers to conduct the fuel to the cylinders.

13. An internal combustion engine, comprising a crank case substantially rectangular in shape; a water inlet in the bottom of said case adapted to be connected to the source of supply and having ducts branching out therefrom with outlets in the side walls of the case; water outlet ducts in the side walls of the case and leading back to the source of supply; opposed cylinders having flanges whereby they are fixed to the sides of the crank case; removable water jackets inclosing and spaced from the cylinders to constitute water jackets for the latter; water inlet and outlet ports for the water jackets in the cylinder flanges to register with the water inlet and outlet ducts in the case when the cylinders are secured in place; and tubes within the water jackets engaging in the outlets in the water jackets and projecting to the heads of the cylinders whereby to displace the water at the heads of the cylinders.

14. An internal combustion engine, comprising in combination a crank case substantially rectangular in shape and open at the top, said case provided with fuel ducts; a cover for said case having a fuel-inlet adapted to be connected to the source of fuel supply, with ducts branching out from said inlet and communicating with the fuel ducts in the crank case when the cover is placed in position; piston cylinders fixed to said case; combustion chambers releasably connected to the ends of the cylinders; alined fuel intake and exhaust ports in said chambers; oppositely seated valves in said ports to control the charge of fuel to and the exhaust of the burnt gases from the cylinders, the stem of one valve passing through the other valve and its stem; a spring to normally maintain both valves of each combustion chamber closed; and a fuel duct for each combustion chamber, said ducts communicating with the fuel-intake ports of the combustion chambers and with the fuel-ducts in the crank case to conduct the fuel to the cylinders, said ducts also serving as coverings for the valve stems and springs.

15. An internal combustion engine, comprising a crank case having a fuel duct connected with the source of fuel supply; a piston cylinder fixed to said case; a combustion chamber releasably connected to the head of the cylinder, said chamber having alined fuel intake and exhaust ports in an integral laterally projecting portion; mechanically operated valves for said ports to control the charge of fuel to and the exhaust of the burnt gases from the cylinder, the stem of

one of which valves passes through the other valve and its stem; a spring coöperating with both valve stems to normally maintain both valves closed; and a tubular sleeve, one end of which engages in the fuel-intake port of the combustion chamber and the other end in the fuel duct in the case whereby to conduct the fuel to the cylinder, said sleeve also serving as a covering for the valve stems and spring.

16. In an internal combustion engine, the combination of a crank case having fuel ducts communicating with the source of fuel supply; opposed piston cylinders fixed to said case; combustion chambers releasably connected to the cylinders; alined fuel-inlet and exhaust valves in each of said combustion chambers; stems for the respective valves, the stem of one of which valves passes through the other valve and its stem; and tubular sleeves inclosing the valve stems, one end of said sleeves communicating with the ports of the fuel-inlet valves and the other end with the fuel ducts in the crank case to conduct fuel to the combustion chambers.

17. In an internal combustion engine, the combination of a crank case having fuel inlet ducts communicating with the source of fuel supply; opposed cylinders fixed to said case; combustion chambers releasably connected to said cylinders and communicating with the ports thereof, said combustion chambers having axially alined fuel-intake and exhaust valves; a spring to normally maintain both valves of each cylinder closed; and a removable member inclosing the valve stems and spring of each cylinder, said members communicating with the fuel-inlet port in the combustion chambers and with the fuel ducts in the crank case to conduct fuel to the combustion chambers.

18. In an internal combustion engine, the combination of a crank case having ducts communicating with the source of fuel supply; opposed cylinders fixed to said case; water jackets releasably connected to the cylinders; combustion chambers releasably connected to, and communicating with the bore of, said cylinders, said combustion chambers having fuel-inlet and exhaust ports; oppositely seated valves for said ports to control the charge of fuel to and the exhaust from the cylinders; stems for the respective valves, the stem of one valve passing through the other valve and its stem; removable fuel chambers communicating with the fuel-inlet ports of the combustion chambers and the fuel ducts in the crank case, said chambers also inclosing the stems of the valves.

19. In an internal combustion engine, the combination of a rectangular crank case open at the top and provided with fuel conduits; a removable cover having fuel conduits communicating with the fuel supply and with the fuel conduits in the crank case; opposed cylinders secured to the case in axially alined pairs; water jackets releasably connected to the cylinders; combustion chambers releasably connected to, and communicating with the bore of said cylinders, said chambers having axially alined fuel-inlet and exhaust ports; valves in said ports to control the charge of fuel to and the exhaust of the burnt gases from the cylinders, the valves for the one chamber arranged out of line with the valves of the combustion chamber of the opposed cylinder; and removable fuel chambers communicating with the fuel inlets in the combustion chambers and with the fuel conduits in the crank case to conduct fuel to the combustion chambers.

WILLARD IRVING TWOMBLY.

Witnesses:
JOHN O. SEIFERT,
E. PODSENICK.